Hebron Project Report Cover : Layout 1 6/7/10 3:10 PM Page 1

Hebron

HEBRON PROJECT

Comprehensive Study Report
September 2011

ExxonMobil Chevron SUNCOR ENERGY Statoil nalcor energy

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Hebron Project Comprehensive Study Report

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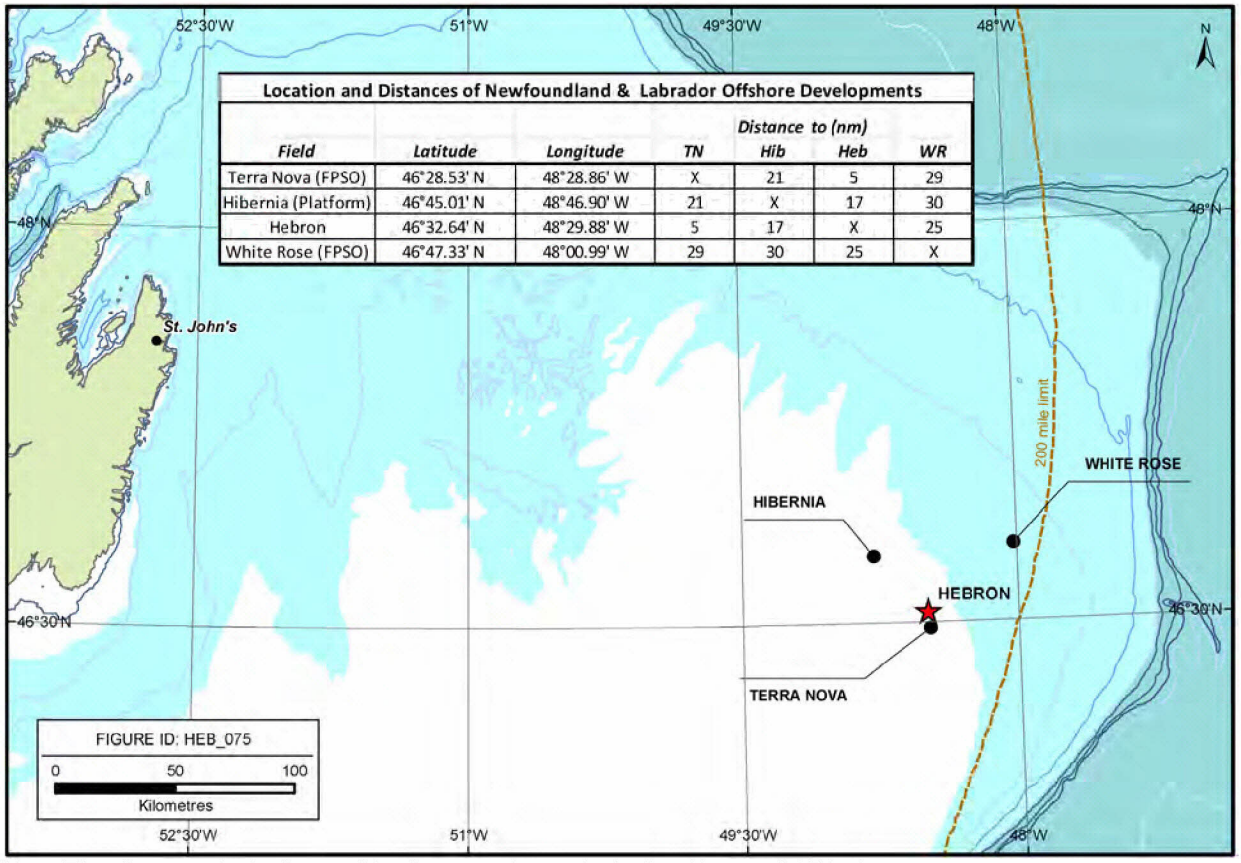
PROJECT OVERVIEW

The Hebron Project (the Project) is a proposed oil and gas development located offshore Newfoundland and Labrador, approximately 340 km east of St. John's. ExxonMobil Canada Properties (EMCP), as Operator, is leading development of the Project on behalf of the Hebron Project Proponents: ExxonMobil Canada Ltd.; Chevron Canada Limited; Petro-Canada Hebron Partnership through its managing partner Suncor Energy Inc. (Suncor); Statoil Canada Ltd.; and Nalcor Energy – Oil and Gas Inc.

The Hebron Platform will be situated approximately 9 km north of the Terra Nova Field, 32 km southeast of the Hibernia development and 46 km southwest of White Rose (Figure 1).



Location and Distances of Newfoundland & Labrador Offshore Developments

Field	Latitude	Longitude	Distance to (nm) TN	Hib	Heb	WR
Terra Nova (FPSO)	46°28.53' N	48°28.86' W	X	21	5	29
Hibernia (Platform)	46°45.01' N	48°46.90' W	21	X	17	30
Hebron	46°32.64' N	48°29.88' W	5	17	X	25
White Rose (FPSO)	46°47.33' N	48°00.99' W	29	30	25	X

Note: The distances in the inset table above are in nautical miles (1 nm = 1.85 km)

Figure 1 Location of the Hebron Field

The Hebron Project will be the fourth stand-alone development project on the Grand Banks and, considering the two tieback projects to the Hibernia and White Rose facilities, the sixth offshore petroleum project. If approved, the Hebron Project will extend the life of the offshore oil and gas industry in Newfoundland and Labrador. It represents an important next step in the development of a sustainable offshore oil and gas industry in Newfoundland and Labrador.

The intent is to develop the Hebron oil field using a concrete Gravity Base Structure (GBS) similar in concept to the existing Hibernia platform (Figure 2).

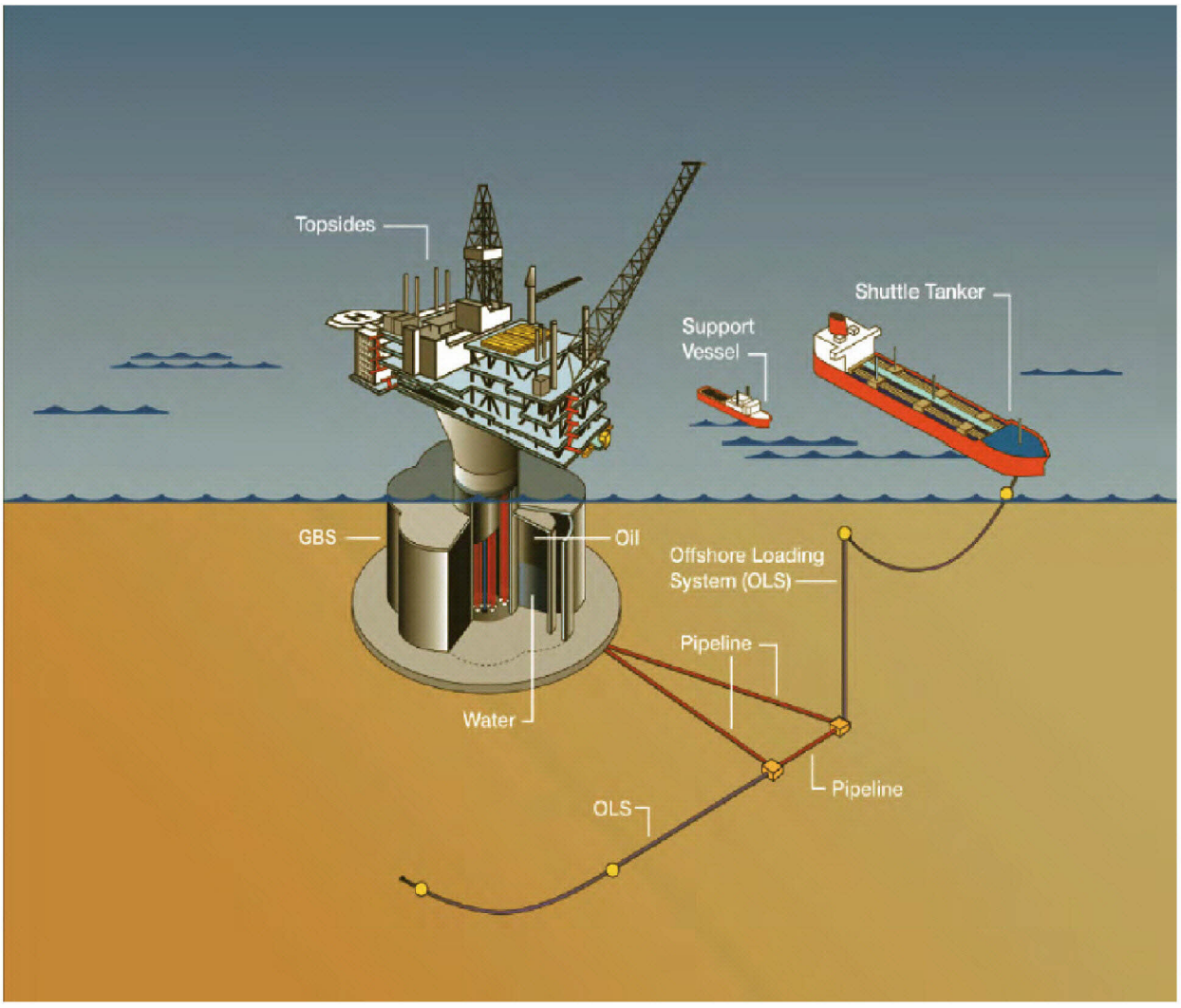


Figure 2 Stand-alone Gravity Base Structure Preliminary Development Layout

The GBS for the Hebron Project will be a reinforced concrete structure designed to withstand impacts from sea ice and icebergs and the meteorological and oceanographic conditions at the Hebron Field. It will accommodate up to 52 well slots with J-tubes inside the central shaft connected to the base of the GBS for potential future expansion. The GBS will be designed to store approximately 190,000 m^3 (1.2 Mbbl) of crude oil in multiple separate storage compartments. The currently planned Offshore Loading System (OLS) consists of two main offshore pipelines running from the GBS to separate riser bases (pipe line end manifolds) with an interconnecting offshore pipeline connecting the two pipe line end manifolds. The notional offloading rate of the system is 8,000 m^3/hr (50,300 bbl/hr).

The Topsides will hold the drilling support module, drilling equipment set, utilities and production module, flare boom and living quarters, including helideck and lifeboat stations. The Hebron production facilities will have the capacity to handle the predicted life-of-field production stream for 30 plus years. Based on the current initial development phase, it is expected the facility will be designed to accommodate an estimated production rate of 23,900 m^3/day of oil (150 kbd).

Construction activity is scheduled to begin at the existing site in Trinity Bay, the Nalcor Energy-Bull Arm Fabrication site, in 2011, with construction and fabrication continuing for approximately five years (at Bull Arm and other sites) and first oil targeted for 2017. Forecasted cumulative oil recovery for the initial development phase after 30 years of producing life ranges from 87 Mm^3 (548 MBO) to 140 Mm^3 (883 MBO) from an anticipated 41 wells. The Ben Nevis Pool within the Hebron Field is the core of the Hebron Project, and is anticipated to produce approximately 80 percent of the Hebron Project's crude oil.

PROJECT AREAS

Activities associated with the Hebron Project will occur in two distinct phases and Project Areas: the nearshore construction area at Bull Arm, Trinity Bay, for the GBS construction, Topsides assembly, installation and commissioning; and the offshore area on the Grand Banks, where the completed Hebron Platform will be installed and production of crude oil will occur.

NEARSHORE PROJECT AREA

The GBS will be constructed at the Bull Arm Facility, an existing fabrication facility owned by Nalcor Energy-Bull Arm Fabrication, with capabilities for steel and concrete construction, outfitting, fabrication, installation, at-shore hook-up and commissioning. The drydock site for GBS construction is situated at the Bull Arm Facility in Great Mosquito Cove (Figure 3).

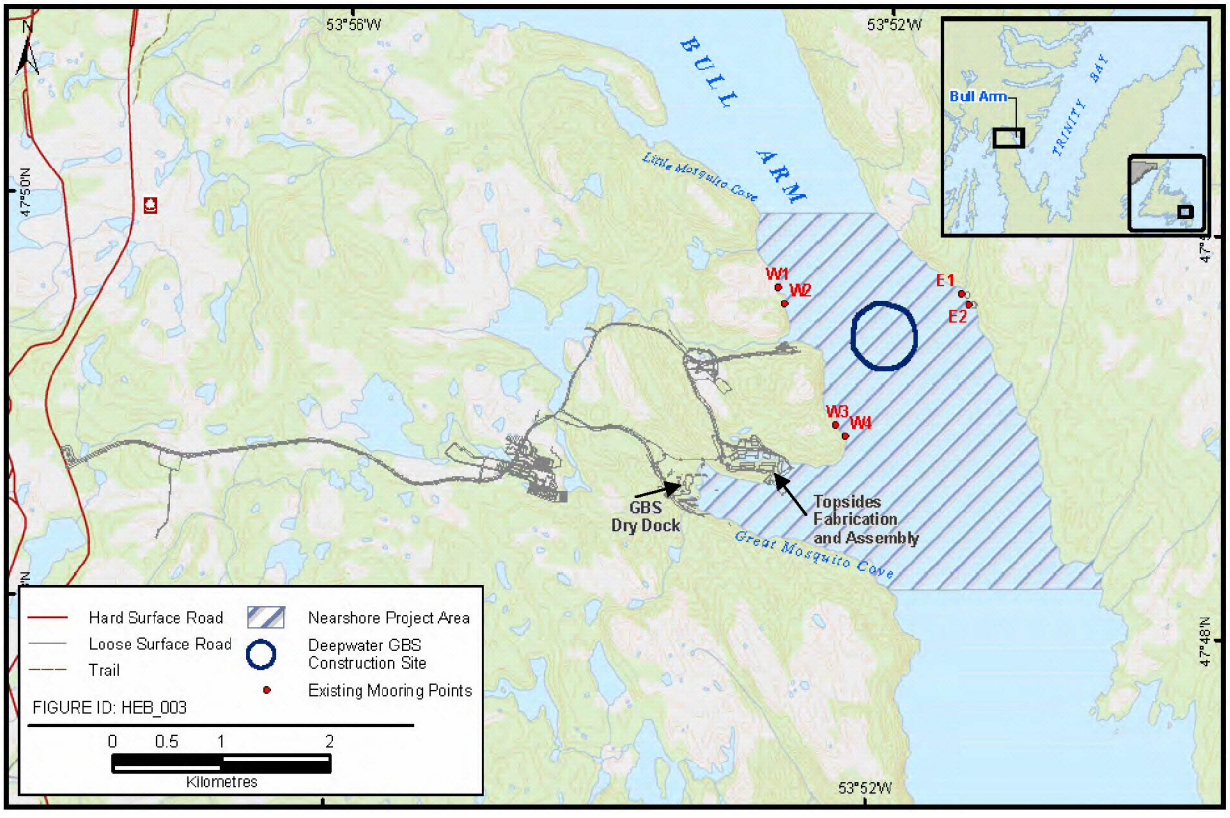


Figure 3 Nearshore Project Area

The current concept is to construct a rock-fill dike (or bund wall) with a centre impermeable core comprised of a cement slurry across the cove to form the wall of the basin; the drydock and immediate channel for towing the GBS out of Great Mosquito Cove may have to be enlarged. The pier in Back Cove, which is the site of the ferry terminal to transport workers to the GBS in the deepwater site, may require upgrading. After completion of the GBS base slab and lower caisson, the partially constructed GBS will be floated out of the drydock and towed to the deepwater site in Bull Arm itself, where it will be moored during final construction of the GBS. The requirement for additional moorings will be determined at the FEED stage. If additional moorings are required at the deepwater site, they will be constructed on land. Selected Topsides components will be fabricated at the Bull Arm fabrication facility; others will be fabricated offsite and will be transported to the Bull Arm fabrication facility for assembly. Following assembly and hook-up at the Topsides pier, the Topsides will be towed out to the deepwater site and mated with the GBS to form the Hebron Platform.

OFFSHORE PROJECT AREA

Once completed, the Hebron Platform will be towed offshore and installed at the Hebron Field (Figure 4). Offshore activities may include: site and clearance surveys; Platform commissioning and production operations; drilling of up to 52 wells from the Hebron Platform; construction, installation and operation of the OLS and tankers; supporting activities including remotely-operated vehicle surveys; and operation of support craft (*e.g.*, various vessels, and helicopters).

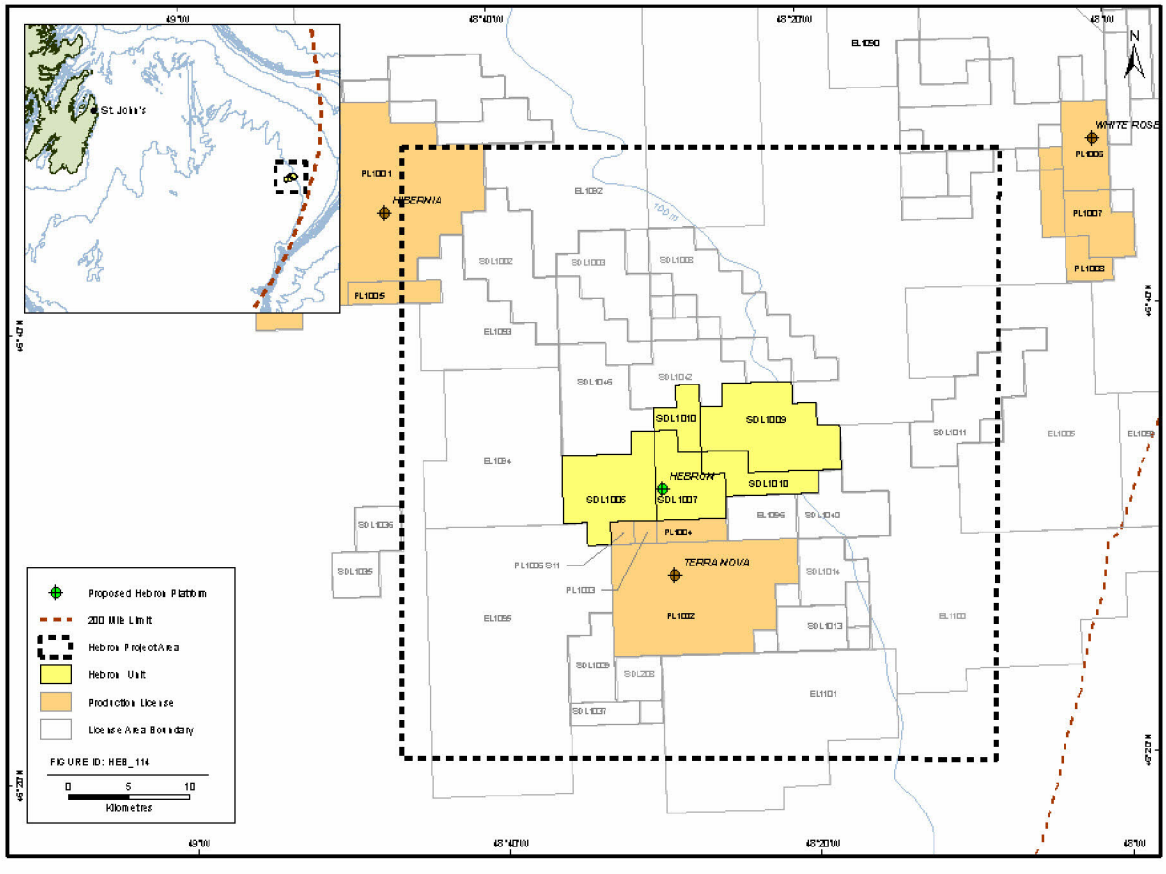


Figure 4 Hebron Offshore Project Area

Potential future developments, as part of the Hebron Project, include construction and installation of one or more excavated drill centres and subsea infrastructure, flowline installation and tieback to the Hebron Platform, as well as drilling activities by mobile offshore drilling units (MODUs). Potential modification of the Hebron Platform may also be required as well as the associated activities of environmental, geophysical and/or geotechnical surveys and support from vessels and helicopters.

ENVIRONMENTAL MANAGEMENT

EMCP, as operator of the Hebron Project, maintains a strong commitment to health, safety and environmental stewardship. The company conducts its business activities with a progressive approach and is committed to monitoring and continually improving its performance. Central to this commitment is a corporate Safety, Security, Health and Environment management system within the overall Operations Integrity Management System.

A Project-specific Environmental Management Plan will be developed for the Hebron Project based on detailed information and assessment of the Project. It will be supported by topic-specific plans such as a Waste Management Plan, Oil Spill Response Plan and Community Liaison Plan.

During construction, EMCP will implement an Environmental Protection Plan (EPP) for all activities at the Bull Arm Site. This EPP will be developed in consultation with regulators and area residents, in particular the commercial fish harvesters. The EPP will be approved by the Newfoundland and Labrador Department of Environment and Conservation and will be available to the public through the Department.

Offshore production activities are regulated pursuant to the *Canada-Newfoundland Atlantic Accord Implementation Act* (S.C. 1987, c.3) and the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (R.S.N.L. 1990, c. C-2) (Atlantic Accord Acts) and regulations prescribed thereunder and any guidelines provided by the C-NLOPB (*e.g.*, *Offshore Waste Treatment Guidelines* (OWTG) (National Energy Board (NEB) *et al.* 2010). The Hebron Project will develop and implement an EPP as per regulations issued under the *Accord Acts*.

ExxonMobil has a mature Operations Integrity Management System (OIMS) that emphasizes relentless attention to Safety and Environmental Protection, and is designed to minimize and mitigate accidental events from occurring. EMCP's emergency response philosophy is to minimize the impact of an emergency on people, environment and the corporation. Prior to commencement of drilling and production operations, EMCP will develop contingency plans that will serve as the guidelines for the company's response to an emergency at the Hebron Project. Contingency plans will be developed to address emergencies that will be identified in operations-specific hazard and risk analyses. The plans will outline the necessary procedures, personnel, equipment and logistics support required to respond to an emergency incident in a safe, prompt, and coordinated manner. The plans will be distributed to designated personnel who will be responsible for emergency response actions. The content of the plans will contain sufficient detail to enable personnel to respond in a coordinated and effective manner.

ENVIRONMENTAL ASSESSMENT

REGULATORY CONTEXT

Under the federal *Canadian Environmental Assessment Act*, the Hebron Project requires environmental assessment at a comprehensive study-level of assessment. The C-NLOPB and other federal Responsible Authorities have set out the required scope of this environmental assessment in a Scoping Document released in June 2009 (C-NLOPB *et al.* 2009). This Comprehensive Study Report (CSR) meets these requirements, as well as meeting the requirements of the C-NLOPB *Development Plan Guidelines* (C-NLOPB 2006).

CONSULTATION

EMCP recognizes the importance of communications with federal, provincial and municipal regulatory agencies, stakeholders and the public and accordingly, has conducted an extensive public and stakeholder consultation program associated with the Project. The program focused primarily on the geographic regions most likely to be affected by the Project, including the Isthmus region of the Island (Marystown and St. John's). However, a wider audience was reached through a number of meetings in other communities such as Corner Brook.

Meetings were held with environmental interest groups in the St. John's area. Most participants indicated a level of familiarity with the offshore petroleum industry and the environmental assessment process and acknowledged that many of the issues raised in previous assessments of offshore projects had been addressed by industry. Nonetheless, there is continuing concern regarding ongoing potential for an oil spill from a platform or tanker, as well as the incidence of sheens around platforms as a result of platform discharges (even when treated to regulated levels). These groups are interested in accessing raw data from monitoring programs, in addition to the environmental effects monitoring (EEM) program reports that are released to the public by the C-NLOPB.

Consultation has also been initiated with commercial fish harvesters (both those using the Bull Arm area and the offshore area), the Fish, Food and Allied Workers Union (FFAW) and One Ocean. In Bull Arm, the concerns are around potential interference with fishing activities during Platform construction. Offshore commercial fishers are concerned at the increasing level of offshore oil and gas activity as it affects their travel routes to and from fishing grounds and, to some extent, the placement and security of fishing gear. One Ocean, the fishing industry / offshore petroleum industry liaison organization, is addressing some of these concerns through the efforts of a working group.

ASSESSMENT METHODOLOGY

The scope of the Project includes a combination of works and activities that will take place in both the nearshore (construction) and offshore (installation and operations) environments. The potential environmental effects of each Project phase have been evaluated for each of the selected Valued Ecosystem Components (VECs). VECs are those components of the environment that are valued socially, economically, culturally

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and/or scientifically and are of interest when considering the potential environmental effects of the Project.

VECs for this CSR reflect the issues raised by stakeholders, while providing a focus for the environmental assessment so that effects can be meaningfully evaluated. The VECs include Air Quality, Fish and Fish Habitat, Commercial Fisheries, Marine Birds, Marine Mammals and Sea Turtles, Species at Risk (SAR) and Sensitive or Special Areas.

The purpose of environmental assessment is to determine whether the Project is likely to result in a significant adverse residual environmental effect on the environment, as considered through the VECs. The criteria considered in this CSR include geographic extent, magnitude, duration, frequency and reversibility, as well as ecological or social context and the level of certainty in making the assessment of environmental effect. The environmental assessment of each VEC incorporates consideration of mitigation measures, accidental events and cumulative environmental effects.

THE PROJECT ENVIRONMENT

THE NEARSHORE STUDY AREA

The Bull Arm Facility is located at Bull Arm, a steep-sided narrow arm near the bottom of Trinity Bay. Trinity Bay is a large bay on the northeastern coast of Newfoundland with a length of approximately 100 km, orientated towards the northeast. Most of the shoreline is rocky and treed to the high tide mark before dropping off into relatively deep water. The tidal zone is mostly narrow and rocky. The shoreline is affected by landfast and pack ice. Eastern Newfoundland coastal areas are dominated by the southward flowing inner branch of the Labrador Current. The Nearshore Study Area is illustrated in Figure 5.

The east coast of Newfoundland experiences predominately southwest to west air flow throughout the year. However, local topography has a large influence on the wind direction and speed experienced within Bull Arm, Trinity Bay. Low pressure systems crossing the area are more intense during the winter months. As a result, mean wind speeds tend to peak during winter. Nearshore air temperatures are coldest in January and February, and warmest in August.

In Bull Arm, the following species of finfish are commonly found and commercially fished: cod (a COSEWIC-assessed at-risk species), capelin, herring and mackerel. Greenland halibut may be present in deeper water (200 to 300 m) outside Bull Arm. Other species include wolffish (a *Species at Risk Act* (SARA)-listed at-risk species), eelpout, lumpfish, skate and cunners. Great Mosquito Cove and “The Brood” in Bellevue are locally known as a spawning ground for herring. Shellfish that occur in the area include sea scallop, snow crab, lobster and squid. Capelin, mackerel, herring, crab and lobster have generated over 90 percent of all fishing income from species caught in Trinity Bay. Cod, sea urchin, squid and lumpfish make up most of the remaining portion of their annual earnings.

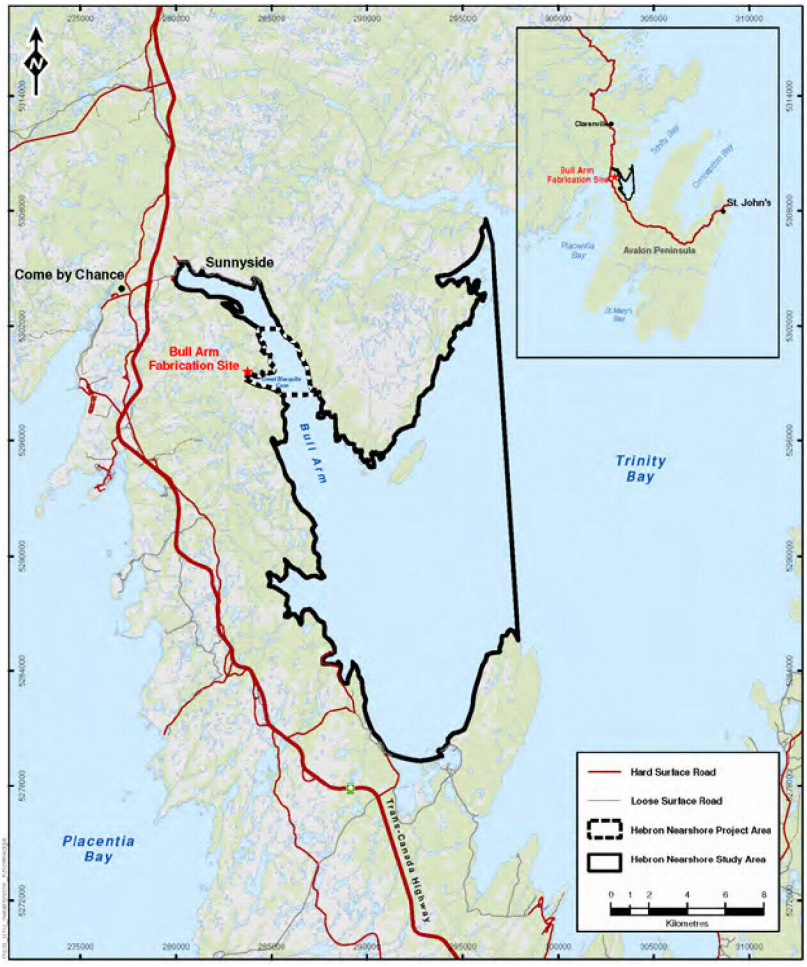


Figure 5 Nearshore Study Area

Habitat for shorebirds (Charadriiformes), such as shoreline deposits of fine sediments and tidal flats, is limited in the Nearshore Study Area. Bellevue Beach, located at the southern boundary of the Nearshore Study Area, is an important habitat for marine birds, including the Red Knot (a COSEWIC-assessed at-risk species). A strong tidal current flowing over a mud flat at the south end of Bellevue Beach creates a rich marine habitat. Gulls, terns, shorebirds and Ospreys are common here in season. There is a nesting colony of gulls and terns on Bellevue Island, 0.5 km from the tidal flats. Approximately 15 species of migrating shorebirds occur regularly on the Bellevue Beach tidal flats during south-bound migration.

A total of 21 marine mammals, including five baleen whales (mysticetes), 12 toothed whales (odontocetes), and four true seals (phocids), are known to occur in the Nearshore Study Area. Four species may be rare visitors in the Study Area: the beluga whale (a SARA-listed at-risk species); North Atlantic right whale (a SARA-listed at-risk species); ringed seal; and bearded seal. Seals occur year-round in waters off Newfoundland and Labrador, including populations of grey, harp and hooded seals.

There are potentially a number of at-risk species (either assessed by COSEWIC or listed on SARA) that may occur in the Nearshore Study Area. Wolffish species are the marine fish SAR most likely to occur in the Hebron Nearshore Study Area. Bird SAR that could occur in the Hebron Nearshore Project Area are the Red Knot (a shore bird)

and Ivory Gull (a marine bird). The marine mammal SAR that is likely to occur in the Hebron Nearshore Study Area is the fin whale; blue whale may occur in small numbers. The sea turtle species at-risk likely to occur in the Nearshore Study Area are the leatherback and loggerhead sea turtles. Sensitive or Special Areas include capelin beaches (*e.g.*, Bellevue Beach) and eelgrass beds (used by juvenile Atlantic cod, among others).

OFFSHORE STUDY AREA

The Hebron Platform will be situated within the Jeanne d'Arc Basin, one of the major sedimentary basins within the eastern Canadian offshore. The Grand Banks form a series of shallow outer banks separated from the Newfoundland coast by irregular inner shelf basins (Avalon and St. Pierre Channels). Water depth in the area ranges from 88 to 102 m. The Grand Banks has an overall area of 100,000 km^2. The Hebron Platform will be situated on the northeast margin of the Grand Banks, within approximately 98 m water depth. The Offshore Study Area is illustrated in Figure 6.

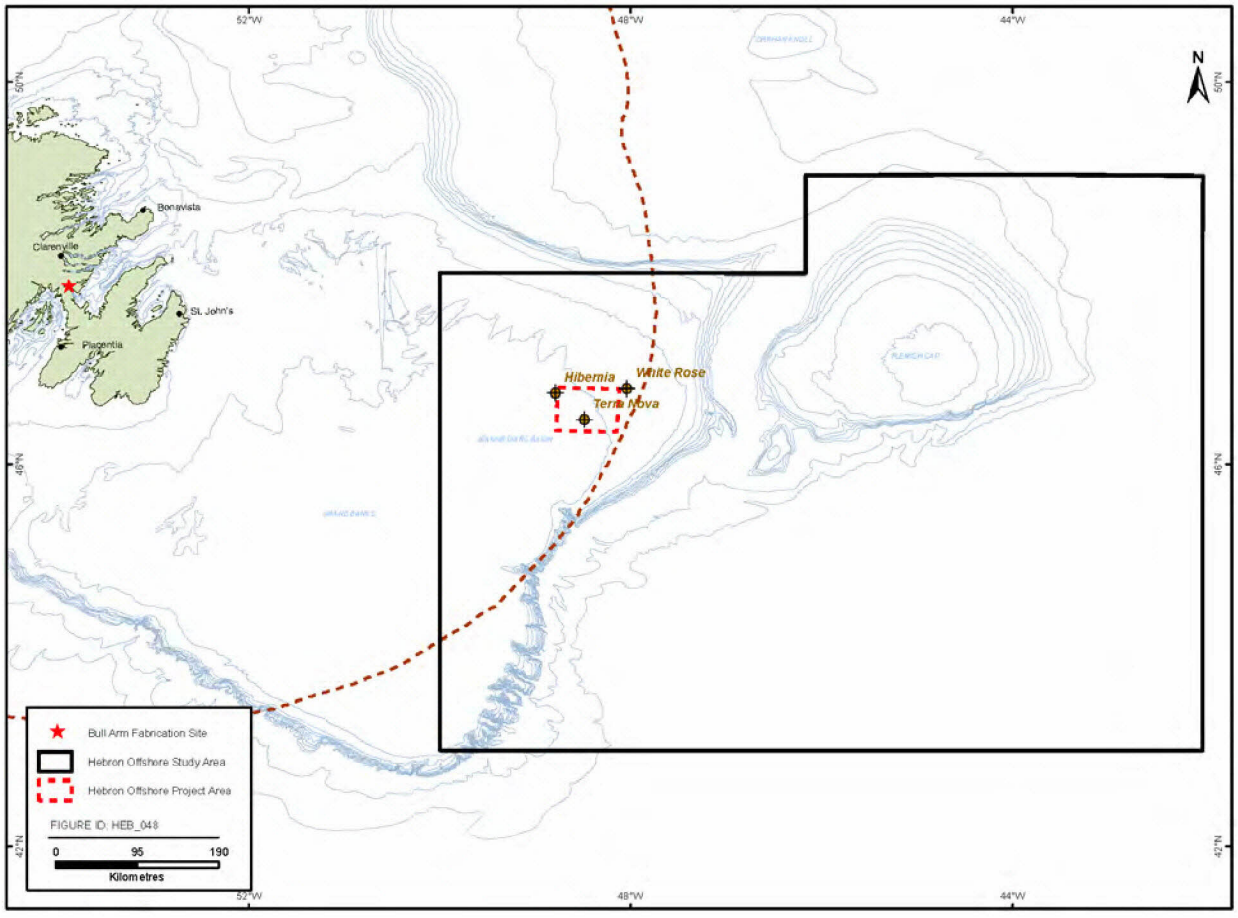


Figure 6 Offshore Study Area

The climate of the Grand Banks is dynamic and influenced by maritime, Arctic and tropical air masses. The area typically has cold and dry winters (with respect to humidity) and cool and moist summers. Weather systems are often intense, and include a wide range of precipitation types, particularly in fall and winter. In winter, spring and fall, the dominant winds in the area are westerly and in summer,

southwesterly. Air temperatures in the vicinity of the Hebron Platform are generally lower in summer and higher in winter compared to St. John's because of the oceanic environment. February is the coldest month and August is the warmest month both onshore and offshore.

The Grand Banks region is the wettest in eastern Canada, with over 1,000 mm of precipitation per year. The occurrence of precipitation is highest in January and lowest in July. Rainfall is most likely in autumn, with moderate to heavy rainfall occurring most frequently from September to January. Snow is most likely to occur in January through March. Moderate to heavy snowfall is most likely to occur in January and February. Fog frequently occurs in the vicinity of the Hebron Platform, with the foggiest period occurring between May and July. In July, the foggiest month, visibility is often reduced to less than 1 km. The highest waves occur from December to February.

Snow crab, shrimp and Iceland scallop occur on the Grand Banks in the vicinity of the Hebron Platform. Other species occurring in the area include sand lance, capelin, mailed sculpin, sea urchin, sand dollar, soft-shelled clams, toad crab and sea stars. Historically, the most abundant species in the vicinity of the Hebron Platform were American plaice (a COSEWIC-assessed at-risk species) and cod, but these species are also widely distributed throughout the Grand Banks. The dominant commercial fish in the vicinity of the Hebron Platform include snow crab, shrimp, American plaice and Iceland scallop.

The Grand Banks provides important habitat for millions of marine birds. Over 60 species have been reported. Approximately 19 of these species are pelagic and could occur in the Offshore Project Area. In the spring and summer, the most common species include the Northern Fulmar, Shearwaters, Storm-petrels, Jaegers, Black-legged Kittiwake, Gulls, Skuas and Dovekies.

Several species of whales may be found on the Grand Banks, including humpback, minke, sei, Atlantic pilot, sperm and northern bottlenose. Many species are mostly summer residents, transients, or both. There are only a few permanent residents, including the Atlantic pilot whale. There is one not-at-risk species of sea turtle known to occur near the Hebron Platform, the Kemp's ridley.

There are potentially a number of at-risk species (either assessed by COSEWIC or listed on SARA) that may occur in the Offshore Study Area. Schedule 1 SARA species known to occur in the Offshore Study Area include Atlantic wolffish, northern wolffish, spotted wolffish, Ivory Gull, blue whale, fin whale and leatherback sea turtle. The North Atlantic right whale, a Schedule 1 listed species, is not considered likely to occur in the Offshore Project Area. Some of the COSEWIC-assessed at-risk species include Atlantic cod, Atlantic plaice, redfish and loggerhead sea turtle.

Offshore Sensitive or Special Areas include those designated by the Northwest Atlantic Fisheries Organization, specifically the Southeast Shoal Vulnerable Marine Ecosystem and various canyon areas and seamount and knoll vulnerable marine ecosystems . In addition, the following Ecologically and Biologically Significant Areas, as identified by Fisheries and Oceans Canada (DFO), occur within the Offshore Study Area: Northeast Shelf and Slope; Virgin Rocks (immediately adjacent to the Offshore Study Area); Lily Canyon-Carson Canyon; and Southeast Shoal and Tail of the Banks.

KEY FINDINGS OF THE ASSESSMENT

AIR QUALITY

To assess potential effects on air quality in the nearshore and offshore environments, an emissions inventory and modelling were used. The emissions inventory was used to predict the annual emissions released and the dispersion modelling was used to estimate the maximum ground-level concentrations.

Typical air emissions from Project activities include carbon monoxide, nitrous oxides, total suspended particulate, volatile organic compounds and greenhouse gases (GHGs).

Nearshore

The air emissions associated with grinding, welding and concrete production include total suspended particulate. However, such emissions will be temporary in nature and are considered to be localized, such as welding, or relatively minor in quantity and environmental effect. Vessels will emit carbon monoxide, nitrous oxides, total suspended particulate, volatile organic compounds and GHGs. However, these emissions are small in quantity, temporary and localized. They can be mitigated by reducing the amount of time the vessels are in idle mode, connecting to electrical power whenever possible, and other mitigation measures.

Offshore

The air dispersion modelling shows that the emissions produced from the Hebron Project alone, as well as in conjunction with emissions from existing platforms, would generally meet air quality criteria (*i.e.*, the stipulated National Ambient Air Quality objectives) in the short-term, the long-term, and in near-field and far-field locations. Fugitive emissions from operational sources (*e.g.*, leaking valves, pump seals, compressor seals, flanges / connectors, and pressure relief valves) may occur during operation of the Platform and have been considered quantitatively in this assessment. Mitigation measures include maintenance and inspection programs to repair equipment and machinery.

Findings

By implementing appropriate mitigation measures, the environmental effects on Air Quality during the construction and operations phases of the Project, including accidental events and cumulative environmental effects, is determined to be not significant. With respect to GHG, the magnitude is ranked as medium for both the construction and operations phases; however, the predicted emissions are consistent with those currently being reported for other similar facilities in the Newfoundland offshore and are rated as not significant. In the unlikely event of a large-scale accident or malfunction, the Project's GHG emissions will be temporarily increased. The percent contribution of GHGs from the Hebron Project to the overall national total is small in magnitude.

FISH AND FISH HABITAT

Nearshore

In the Nearshore Project Area, changes in fish habitat will occur in Bull Arm during construction of the bund wall and drydock and if dredging and/or ocean disposal is required. In accordance with the DFO policy of no net loss of fish habitat, a habitat compensation program will be developed in conjunction with DFO to compensate for any loss of fish habitat. As its preferred option for HADD compensation, EMCP is proposing to enhance fish habitat in Bull Arm by re-locating bund wall material to featureless sedimentary areas of the sea floor, which currently have low commercial fish productivity.

Increased levels of suspended sediments and underwater noise can also be expected within the Nearshore Project Area. Mitigation measures will include the use of settlement basins and/or containment areas for concrete washwater. EMCP will also investigate the use of washed-rock for bund wall construction, as well as the use of silt and bubble curtains. While some fish egg and larval mortality may occur as a result of in-water blasting, any in-water blasting will adhere to DFO's *Guidelines for Use of Explosives in Canadian Fisheries Waters* to reduce the chance of injury to fish. Some mortality of benthic species is expected as a result of infilling for the bund wall, drydock construction, dredging, and spoils disposal (if required), but these benthic invertebrates are ubiquitous throughout the area and will re-colonize within a few years of construction.

Offshore

In the Offshore Project Area, access to the substrate in the footprint of the Hebron Platform and OLS and its flowlines may be lost to fish and shellfish. If excavated drill centres are constructed as part of the Hebron Project, fish habitat will be affected. For this associated affect on fish habitat, fish habitat compensation may be required. Seismic activities associated with the Project will adhere to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* as appended to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011).

Discharges from Project operations will be managed under an EPP and will adhere to the OWTG (NEB *et al.* 2010). During operations at the Hebron Platform, water-based cuttings will be discharged overboard from the Hebron Platform and synthetic-based cuttings will be reinjected into the formation. If a MODU is used, both water-based and synthetic-based cuttings would be discharged overboard in accordance with the OWTG (NEB *et al.* 2010). The discharge of drill cuttings released on the Grand Banks have been monitored through various EEM programs and scientific studies, confirming that no significant environmental effect on the marine environment from discharged mud or cuttings occurred for these projects.

The feasibility of produced water re-injection is being investigated. If re-injection is not feasible, produced water, meeting the requirements of the OWTG (NEB *et al.* 2010), will be discharged from the Hebron Platform along with cooling water. Any associated effects are expected to be undetectable at a distance greater than 500 m from the

Hebron Platform. Within 500 m, survival, growth and fertilization success of some species can be affected.

Findings

Based on the nature of the effects, planned mitigation, including fish habitat compensation, and knowledge gained from other offshore projects, no significant adverse residual environmental effects are predicted as a result of any of the Project phases. The cumulative environmental effects are also predicted to be not significant.

An accidental event is considered adverse but not significant and not likely to occur. Natural recruitment is expected to re-establish the population to its original level and avoidance of the area is expected to be temporary should an accidental event occur.

COMMERCIAL FISHERIES

Nearshore

Establishment of marine construction safety zones at the Bull Arm Facility will create a temporary loss of access to fishing grounds (Figure 7) and possibly interfere with vessel transit. EMCP will establish an overall Project agreement with commercial fishers using the Bull Arm area that addresses safe operations and compensation.

Marine traffic associated with Project construction will use designated routes. EMCP will consult with the area fish harvesters to discuss and agree on an appropriate Vessel Traffic Management Plan for the safe and efficient operation of Project marine traffic and fishing vessel operations in the Nearshore Project Area. Communications will be maintained directly at sea by Project vessels via marine radio to facilitate information exchange with fisheries participants. Relevant information about marine operations occurring outside the safety zones will also be publicized, when appropriate, using established communications mechanisms, such as the Notices to Shipping (Continuous Marine Broadcast and NavTex) and CBC Radio's (Newfoundland and Labrador) Fisheries Broadcast.

EMCP will also discuss the timing of in-water blasting operations if required and other activities that will create loud underwater noise. Activities will be planned to the extent possible to avoid finfish harvesting times.

EMCP will work with fishers active in the area and time period affected by platform tow-out from Bull Arm and through Trinity Bay to the offshore location to ensure safety and minimize disturbance.

Offshore

As part of the planning for offshore operations, EMCP will establish ongoing consultations and communications with relevant area fishers as well as with FFAW and One Ocean. EMCP will also have in place a fishing gear compensation program to cover loss of or damage to fishing gear associated with Project activities.

Any survey activity associated with the Project will follow guidance provided in the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) for minimizing effects on commercial fish harvesting.

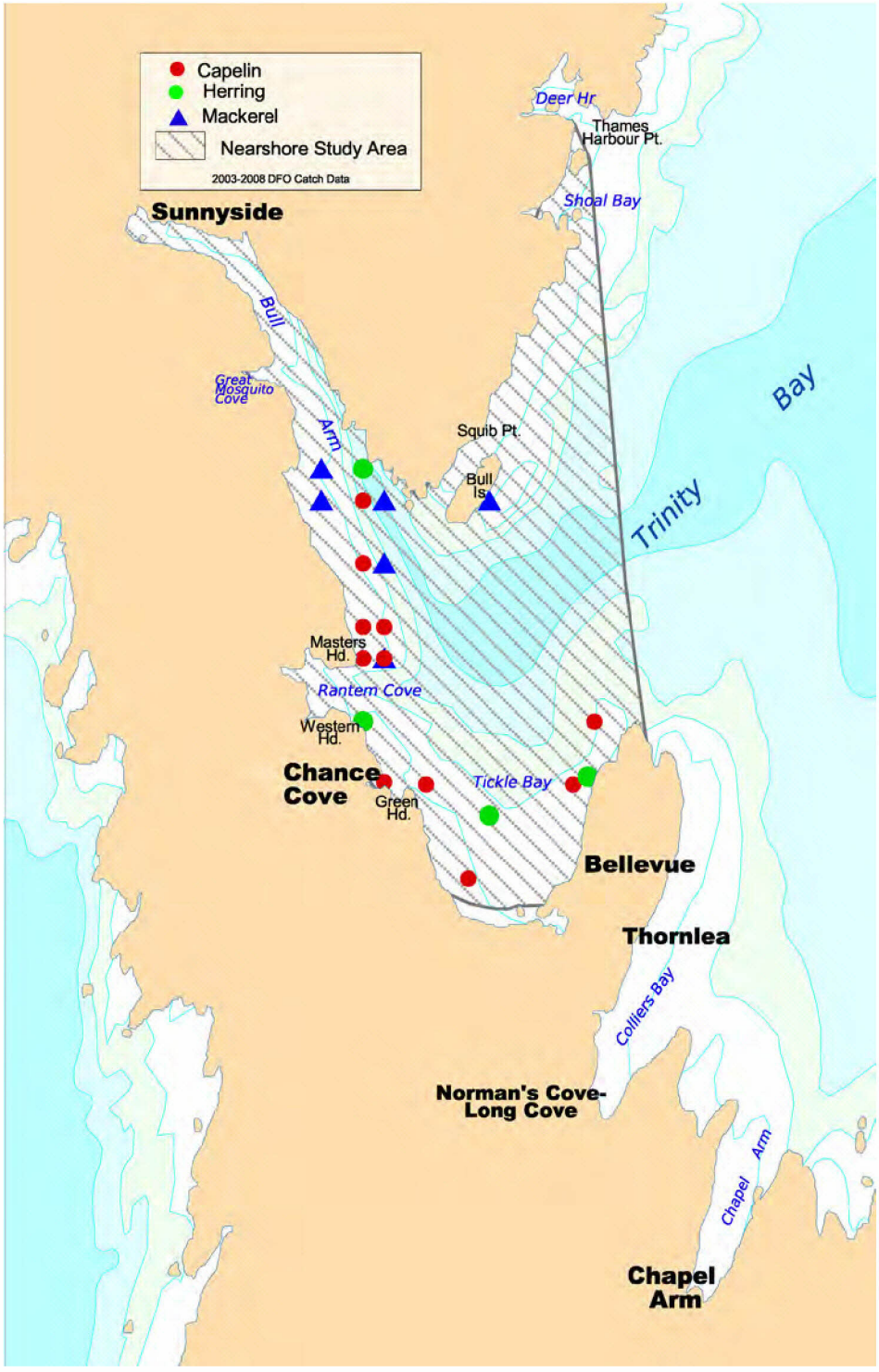
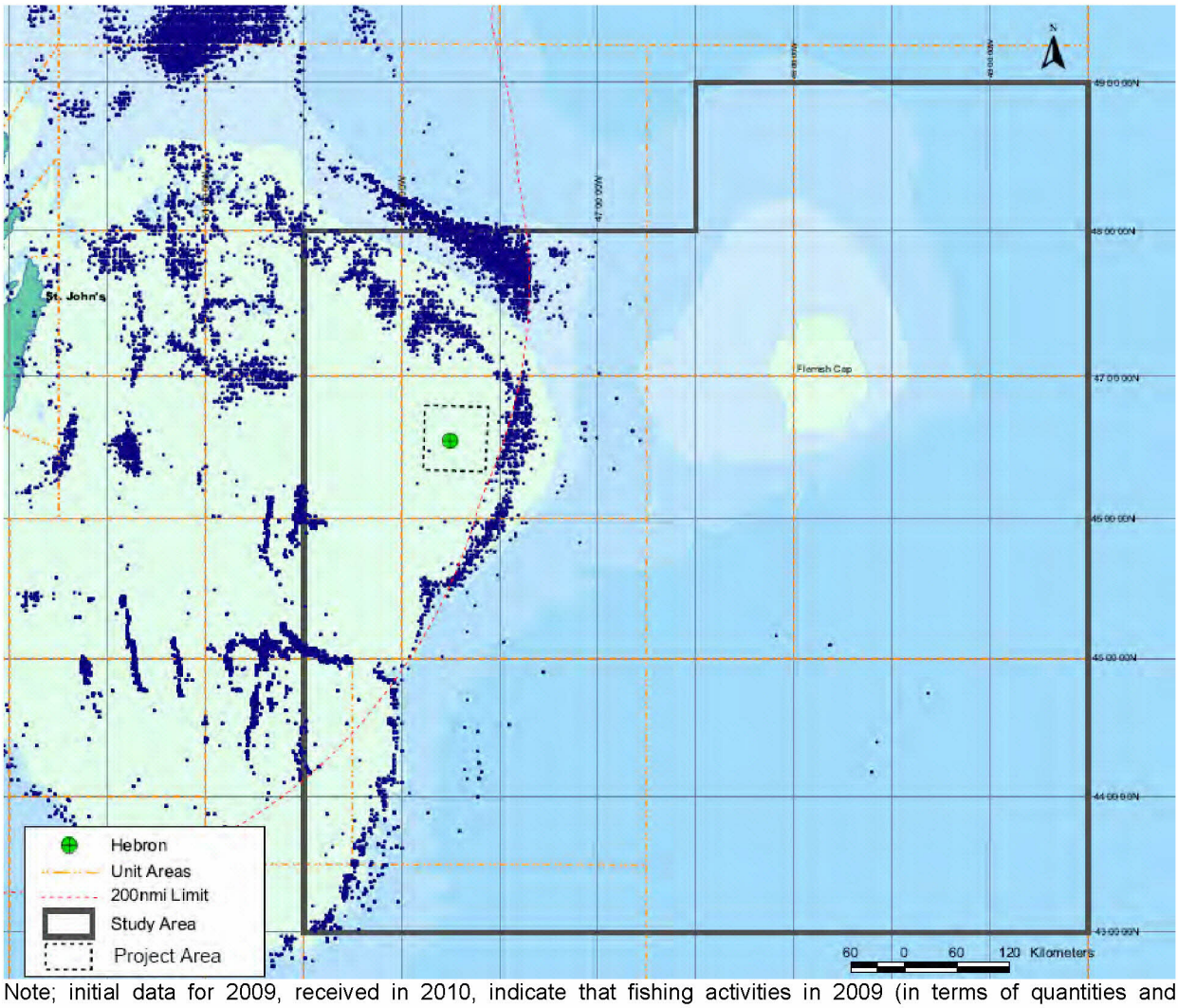


Figure 7 Nearshore Study Area Harvesting Locations for Key Pelagic Species, 2006 to 2008

Considering the relatively low level of fish harvesting in the Offshore Project Area (Figure 8), and the type of fisheries in recent decades, few gear conflicts or catchability effects are likely to occur during operations. EMCP will maintain effective liaison with the offshore fishing industry and will meet as necessary during the operation and maintenance phase to continue communications with relevant area fishers and to help mitigate all aspects of potential fisheries effects.



Note; initial data for 2009, received in 2010, indicate that fishing activities in 2009 (in terms of quantities and harvesting locations) were consistent with those in recent years (*i.e.*, 2004 to 2008).

Figure 8 Domestic Harvesting Locations, 2008

Findings

With the proposed mitigation measures in place, the adverse residual environmental effects from all Project phases are predicted to be not significant. An accidental spill could temporarily limit access to fishing grounds, cause damage to fishing gear or result in a negative effect on the marketability of fish products. A fishing gear compensation program and fisheries compensation plan will be developed.

With regard to offshore activities and potential interactions with commercial fishers, EMCP is committed to work with the One Ocean Working Group, relevant offshore fishers, FFAW representatives and other agencies to ensure good relations, cooperation and partnering between all offshore marine user groups.

MARINE BIRDS

Nearshore

There are no nesting or feeding concentrations of marine birds expected to occur in the Nearshore Project Area. If in-water blasting is required, an observer will monitor for diving marine birds occurring within a specified safety zone of the blast location and protocols will be developed to reduce potential effects on marine birds. Blasts will be delayed until birds move outside the designated safety zone. Disturbance to birds in the area will be short-term and bird behaviour will likely return to normal shortly after the completion of these activities (if disturbed at all).

Offshore

In offshore Newfoundland waters, marine birds, primarily Leach's Storm-Petrels, are often attracted to lights and may become disoriented or injured by flying directly into the source of light or associated infrastructure. Structures and vessels that remain lit overnight will be searched for stranded birds in the morning. Recovered birds will be handled with care and released according to established protocols.

Gas flaring at night may also attract birds; however, the heat and noise generated by the flare may deter marine birds from the immediate area under most nighttime conditions. While there is no known mitigation, flaring is expected to have minimal effect on marine bird populations over the duration of the Project. EMCP is committed to undertaking a research program that, when designed, would provide scientifically defensible information regarding seabird attraction to offshore facilities.

Shearwaters, Northern Fulmars and gulls are the species most likely to be attracted to the Hebron Pplatform and may rest on the water nearby. During Project operation and maintenance, produced water will be discharged below the thermocline whenever possible to minimize the occurrence of sheens that may be associated with this discharge.

During any seismic surveys, the approach of the seismic vessel would likely flush the birds from the area prior to being exposed to any airgun sounds or occurring in close proximity to operating airguns. For birds that do remain in the immediate area, seismic activity could result in hearing impairment to marine birds spending considerable amounts of time below the surface of the water and if in close proximity to airgun pulses; for example, alcids that secure food by diving and swimming under the water. Other offshore construction activities may cause temporary and localized disturbance of marine birds. These activities are not expected to occur near any known nesting colonies, so they should not affect that portion of marine bird life cycles. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

Findings

With the planned mitigation in place, the potential adverse residual environmental effects for all phases of the Project are predicted to be not significant. Cumulative environmental effects are also predicted to be not significant.

Should an accidental oil spill occur, marine birds are the biota most at-risk. Reported environmental effects vary with species, type of oil, weather conditions, time of year and duration of the spill. Exposure to oil causes several physiological effects and/or thermal and buoyancy deficiencies that may lead to death. Although significant at the individual level, the adverse residual environmental effects are predicted to be reversible at the population level. Nevertheless, these adverse residual environmental effects are predicted to be significant, although unlikely to occur. Mitigation for accidental events will include an oil spill response plan. ExxonMobil's philosophy is focused on prevention using safety and risk management systems, management of change procedures, and global standards. There will be an emphasis on accident prevention at all phases of the Project. These procedures will minimize the potential mortality from such accidental events.

MARINE MAMMALS AND SEA TURTLES

Nearshore

During construction, in-water blasting without proper mitigation has the most potential to cause physical effects in marine mammals. If in-water blasting is required, a blast impact assessment will be undertaken to determine appropriate marine mammal and sea turtle exclusion zones. These zones will be monitored by a trained observer prior to and during in-water blasting operations in the marine environment, and in-water blasting operations will be temporarily suspended or halted if a marine mammal or sea turtle is sighted within or about to enter the zone. Activities will not resume until the animal(s) has left the zone or it has not been re-sighted for 30 minutes.

Offshore

In the offshore, the primary construction activity with potential to interact with marine mammals is seismic surveys. While there is uncertainty about the potential for survey sounds to cause either auditory impairment or other non-auditory physical effects in marine mammals or sea turtles, mitigation measures will follow those outlined in the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011).

There is limited potential for direct mortality of marine mammals or sea turtles as a result of collisions with vessels associated with any of the Project phases. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions. Speed will be minimized whenever possible and vessels will deviate from their course to avoid concentrations of marine mammals and sea turtles in their path.

Findings

Given that Project activities are localized, and with the application of mitigation measures, it is predicted that the adverse residual environmental effects on Marine Mammals and Sea Turtles are not significant.

In the unlikely case of an accidental event, marine mammals and sea turtles are not considered to be at high risk from the environmental effects of oil exposure. For marine

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mammals and sea turtles, it is probable that only small proportions of populations are at risk at any one time (in either the nearshore or offshore).

Underwater sound associated with Project activities will likely have the greatest potential cumulative environmental effect on marine mammals and sea turtles, particularly cetaceans. Most species will be able to hear sounds, if they are close enough, and will be able to avoid them if they so choose. Mitigation measures associated with seismic surveys are designed to reduce potential effects to marine mammals or sea turtles. Individual mammals travelling near one or more of the offshore developments or in proximity to other offshore exploration activities may be subject to cumulative environmental effects. However, these environmental effects would most likely be limited to behavioural effects (*i.e.*, localized avoidance).

SPECIES AT RISK

For the purposes of this CSR, SAR refers to those species of marine fish, mammals, birds and reptiles listed federally under SARA, and/or assessed as at-risk by COSEWIC, which could potentially occur in either the Hebron Nearshore or Offshore Study Areas. The environmental assessment includes the associated habitats that these species rely upon, as protected under SARA.

Potential interactions between the Project and SAR are similar to those described above for non-listed species. The key differences between listed SAR and non-listed species are abundance and spatial and temporal presence. SAR are typically less abundant and are more widely dispersed in the marine environment, making it less likely that Project activities will interact with SAR and their respective habitats.

MARINE FISH SPECIES AT RISK

Nearshore

The marine fish SAR most likely to occur in the Hebron Nearshore Study Area are described above under the Fish and Fish Habitat setting. For these species, habitat in the Nearshore Project Area has not been identified as critical habitat. For marine fish SAR, the pelagic eggs and larvae of finfish may be more susceptible to Project activities than the adult stage. Fish SAR are not known to spawn within the Hebron Nearshore Project Area. The mitigation measures described above for all Project activities for Fish and Fish Habitat are considered applicable to marine fish SAR.

Offshore

The marine fish SAR likely to occur in the Hebron Offshore Study Area are described above under the Fish and Fish Habitat setting. The Hebron Offshore Project Area has not been identified as critical habitat for any of these species.

The potential environmental effects for SAR associated with Project activities, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine fish species.

Findings

The adverse residual environmental effects on marine fish SAR for all Project phases, including cumulative environmental effects, are predicted to be not significant. Due to the reversibility and limited duration of an accidental event, potential environmental effects of a spill on marine fish SAR and fish habitat are also considered adverse but not significant and not likely to occur. Natural recruitment is expected to re-establish the population to its original level and avoidance of the area is expected to be temporary should an accidental event occur.

MARINE MAMMAL AND SEA TURTLE SPECIES AT RISK

Nearshore

The marine mammal and sea turtle SAR most likely to occur in the Hebron Nearshore Study Area are described above in the Marine Mammal and Sea Turtle setting. The issues of concern with respect to environmental effects for marine mammal and sea turtle SAR, as well as mitigation measures and management strategies, are similar to those presented for marine mammal and sea turtle species considered not at-risk. In-water blasting, if required, has the most potential to cause physical effects in marine mammals, and the mitigation described above for not at-risk species is considered appropriate for SAR species.

Offshore

The marine mammal and sea turtle SAR most likely to occur in the Hebron Offshore Study Area are described above in the Marine Mammal and Sea Turtle setting. The key Project activity with the potential to result in injury or mortality of marine mammal and sea turtle SAR is the operation of vessels. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Vessels will reduce speed whenever possible and deviate their course to avoid marine animals.

During seismic programs, mitigation measures outlined in the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) will be followed to reduce environmental effects on marine mammals and sea turtles, including SAR.

Findings

The adverse residual environmental effects for all Project phases including cumulative environmental effects and accidental events are predicted to be not significant.

BIRD SPECIES AT RISK

Nearshore

The bird SAR most likely to occur in the Hebron Nearshore Study Area are described above in the Marine Birds setting. Many of the issues of concern with respect to environmental effects for bird SAR, as well as mitigation measures and management

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strategies, are similar to those presented for bird species considered not at risk. The most likely interaction with bird SAR is noise associated with Project activities.

Offshore

The only bird SAR likely to occur in the Offshore Project Area is the Ivory Gull. It has a circumpolar breeding distribution and is associated with pack ice throughout the year. As such, individuals may occasionally reach the northern part of the Offshore Study Area in late winter or early spring when sea ice reaches its maximum southern extremity. The potential environmental effects and Project mitigation measures would be as described for species considered not at risk.

Findings

The potential adverse residual environmental effects from all Project phases on marine bird SAR including cumulative environmental effects are predicted to be not significant. The potential effects associated with accidental events are similar to those described above for non-SAR Marine Birds.

SENSITIVE OR SPECIAL AREAS

Nearshore

In the Nearshore Study Area, Sensitive or Special Areas include capelin beaches (*e.g.*, Bellevue Beach) and eelgrass beds. There is considerable distance between the Bull Arm Site and the nearest areas of eelgrass and capelin spawning beach and this limits the potential interaction with routine Project activities. Therefore, the only potential interaction is associated with an accidental event.

Offshore

As with the Nearshore Study Area, the distance between the Project and the Sensitive or Special Areas limits the potential interaction with routine Project activities. Therefore, the only potential interaction is associated with an accidental event.

Findings

For all Sensitive or Special Areas, the physical distance of these areas from the Project Areas limits the potential for interaction with routine Project activities. Therefore, the assessment focused on accidental events.

In the Nearshore Study Area, in the unlikely event of an accidental event where hydrocarbons reached eelgrass beds, the ability for eelgrass beds to function as a nursery and feeding area for juvenile fish may be affected. With regard to capelin beaches, there is potential for hydrocarbons to sink into the beach sediments and become buried. In this unlikely scenario, hydrocarbon contamination can persist for years, continuing to affect sensitive life stages of eggs and larvae and, therefore, the productivity. Using a precautionary approach, it is concluded that there is potential for a significant adverse residual environmental effect to the Sensitive or Special Areas in the Nearshore Study Area. However, the likelihood of a significant adverse residual environmental effect occurring is considered low.

Offshore, the effects of a spill on the biota that may be using these areas were assessed in their respective VECs and determined to be not significant. Therefore, the adverse residual environmental effect of accidental event on the Sensitive or Special Areas identified in the Offshore Study Area was determined to be not significant.

EFFECTS OF THE ENVIRONMENT ON THE PROJECT

Hebron Project design and planning will benefit from the years of physical data collection in the general area of the offshore Project location, as well as the experience gained during comparable construction and fabrication activities at Bull Arm for the Hibernia GBS platform in the early 1990s.

Several aspects of the physical environment affect Project design, construction / fabrication activities and operations in the Nearshore and Offshore Study Areas, including: water depth and seabed profile (bathymetry); wind, waves and currents; tsunamis; tides, water levels and storm surge; temperature; sea ice and icebergs; geohazards; and climate change.

Mitigation measures to be applied to minimize the effects of the environment on the Project include (but are not limited to) the following:

- Engineering design will adhere to national standards and codes
- Site-specific weather and oceanographic data will be collected
- An ice management plan will be implemented

FOLLOW-UP AND MONITORING

EMCP will include EEM programs for the nearshore and offshore Project activities as a part of its overall Environmental Management System.

EMCP will implement a nearshore EEM program to verify impact predictions in the marine environment in Bull Arm. The details of the nearshore EEM program will be developed in consultation with regulatory agencies and key stakeholders. If in-water blasting is required, a monitoring and observation program will be implemented in the Nearshore Project Area.

In the Offshore Project Area, an EEM program for production operations will be developed and will build on the experience of the existing offshore oil and gas production EEM programs. Marine birds and mammal data will be collected opportunistically during drilling operations from MODUs and from supply vessels where space is available. Weather and sea ice conditions will be recorded as part of the oceanographic monitoring program.

EMCP is committed to a fish habitat compensation follow-up monitoring program for fish habitat compensation in the Nearshore and Offshore Project Areas.

SUMMARY AND CONCLUSIONS

The Hebron Project will benefit from the experience of the existing production projects offshore Newfoundland, with respect to many key items including reducing resource conflicts with commercial fishers, development of effective monitoring programs, and effective emergency response planning. Standard mitigation measures will reduce the potential for adverse environmental effects from most routine construction and operation

activities. EMCP will comply with legislative requirements and adhere to guidelines and/or codes of practice that have been specifically developed to address environmental protection practices in the Newfoundland and Labrador Offshore Area.

A summary of the residual environmental effects assessment for each of the identified VECs is provided in Table 1.

Table 1 Significant (S) and Not Significant (NS) Residual Environmental Effects on Valued Ecosystem Components

VEC	Significance of Residual Environmental Effect					
	Construction / Installation	Operation and Maintenance	Decommissioning and Abandonment	Accidents, Malfunctions and Unplanned Events	Project Overall	Cumulative Environmental Effects
Air Quality	NS	NS	NS	NS	NS	NS
Fish and Fish Habitat	NS	NS	NS	NS	NS	NS
Commercial Fisheries	NS	NS	NS	NS	NS	NS
Marine Birds	NS	NS	NS	S	NS	NS
Marine Mammals and Sea Turtles	NS	NS	NS	NS	NS	NS
SAR: Marine Fish	NS	NS	NS	NS	NS	NS
SAR: Marine Mammals and Sea Turtles	NS	NS	NS	NS	NS	NS
SAR: Birds	NS	NS	NS	S	NS	NS
Sensitive or Special Areas	NS	NS	NS	S	NS	NS

The only potential for significant adverse residual environmental effects as a result of the Hebron Project is in association with an accidental event. In such an unlikely event, significant adverse environmental effects have been predicted for Marine Birds, Bird SAR and nearshore Sensitive or Special Areas. Emphasis on both pollution prevention and effective response planning will further reduce the potential for these unlikely significant environmental effects to occur.

EMCP's commitment is to plan and execute the Hebron Project as an environmentally responsible development and one that successfully balances environmental and economic needs. The Hebron Project will be designed, built and operated within the ExxonMobil policy of environmental responsibility, summarized as *Protect Tomorrow. Today.*

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1 INTRODUCTION

ExxonMobil Canada Properties (EMCP), as Operator, on behalf of the Hebron Project Proponents, ExxonMobil Canada Ltd., Chevron Canada Limited (Chevron), Petro-Canada Hebron Partnership through its managing partner Suncor Energy Inc. (Suncor), Statoil Canada Ltd. (Statoil) and Nalcor Energy - Oil and Gas Inc. (Nalcor), is leading the development of the Hebron Project. The Hebron Project includes offshore surveys, engineering, procurement, construction, installation, commissioning, development drilling, production, operations and maintenance and decommissioning of an offshore oil / gas production system and associated facilities.

1.1 Hebron Project Area

The Hebron Project is divided into two Project Areas for the purposes of environmental assessment: a nearshore construction area at Bull Arm, Trinity Bay for the Gravity Base Structure (GBS) construction, Topsides assembly, installation and commissioning; and an offshore area located on the Grand Banks where the completed Hebron Platform will be installed and production of crude oil will occur for at least 30 years.

1.1.1 Nearshore Project Area

The Bull Arm Site is located 150 km northwest of St. John's, Newfoundland and Labrador. The site is owned and operated by Nalcor Energy-Bull Arm Fabrication. The site was originally built for the construction of the Hibernia GBS and is an ideal location for the construction of the Hebron GBS. The Nearshore Project Area is the marine environment within the Bull Arm site property boundary as illustrated in Figure 1-1.

The Bull Arm Site is a self-contained facility with capabilities for steel and concrete construction and fabrication, outfitting, installation, at-shore hook-up and commissioning. The site is connected to the Province's main highway (Trans-Canada Highway) and has more than 16 km of paved roads.

The GBS drydock site is situated in Great Mosquito Cove. The cove is 1.5 km long and has an average width of 500 m. The GBS drydock area is approximately 16.5 m deep and has a diameter of 180 m. To re-establish a drydock, the inner cove will be enclosed by a bund wall, which may include a row(s) of sheet piles, and will be dewatered. The partially constructed GBS will be floated out of the drydock and towed to the deepwater site, where it will be moored for final construction.

The deepwater GBS construction site is located in Bull Arm with a water depth of 180 m; it is equipped with six mooring points. The water depth in Bull Arm increases towards the mouth of the arm, where it reaches approximately 250 m, as it enters Trinity Bay.

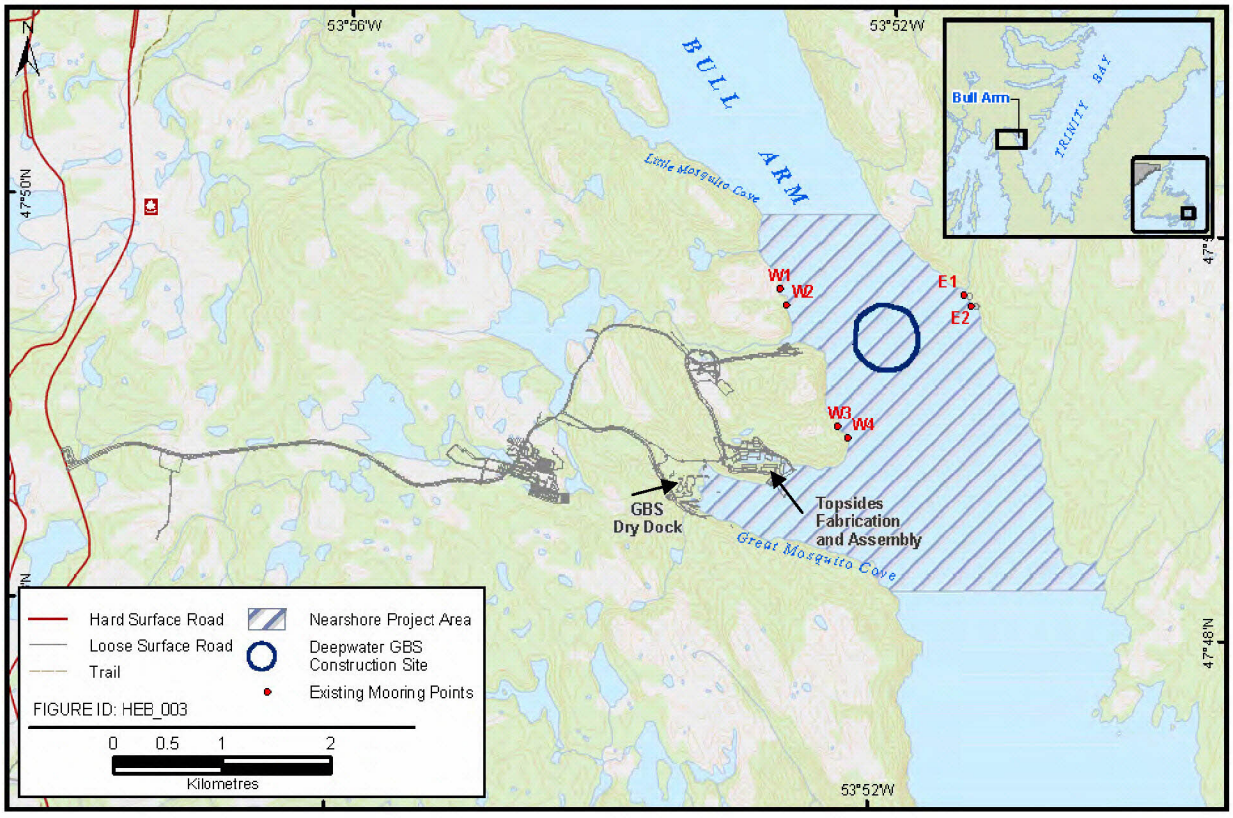

Figure 1-1 Nearshore Project Area

The Topsides fabrication and assembly area is located on the north side of Great Mosquito Cove. Selected Topsides components will be fabricated at the Bull Arm Site; others will be fabricated offsite and will be transported to the Bull Arm Site. All modules and components will be integrated at the pier. Hook-up and commissioning activities with the fully integrated Topsides will begin at the pier prior to float out and mating with the GBS at the deepwater site and continue after mating.

1.1.2 Offshore Project Area

The Hebron Offshore Project Area is located in the Jeanne d'Arc Basin (centred at approximately 46°32.64344' N; 48°29.88379' W), 340 km offshore of St. John's, Newfoundland and Labrador, approximately 9 km north of the Terra Nova Field and 32 km southeast of the Hibernia development. The water depth ranges from 88 to 102 m.

The Hebron Unit currently contains three discovered fields (the Hebron Field; the West Ben Nevis Field and the Ben Nevis Field) and incorporates four Significant Discovery Licenses (SDLs) (SDL 1006, SDL 1007, SDL 1009 and SDL 1010) (Figure 1-2), with ownership varying in each SDL. These four SDLs contain the most likely extent of the oil for the delineated pools within the Hebron Unit. The Hebron Unit could be expanded if additional studies, seismic surveys or, exploration and/or delineation drilling prove that economically recoverable oil pool accumulations extend beyond the currently envisioned boundaries of the Hebron Unit.

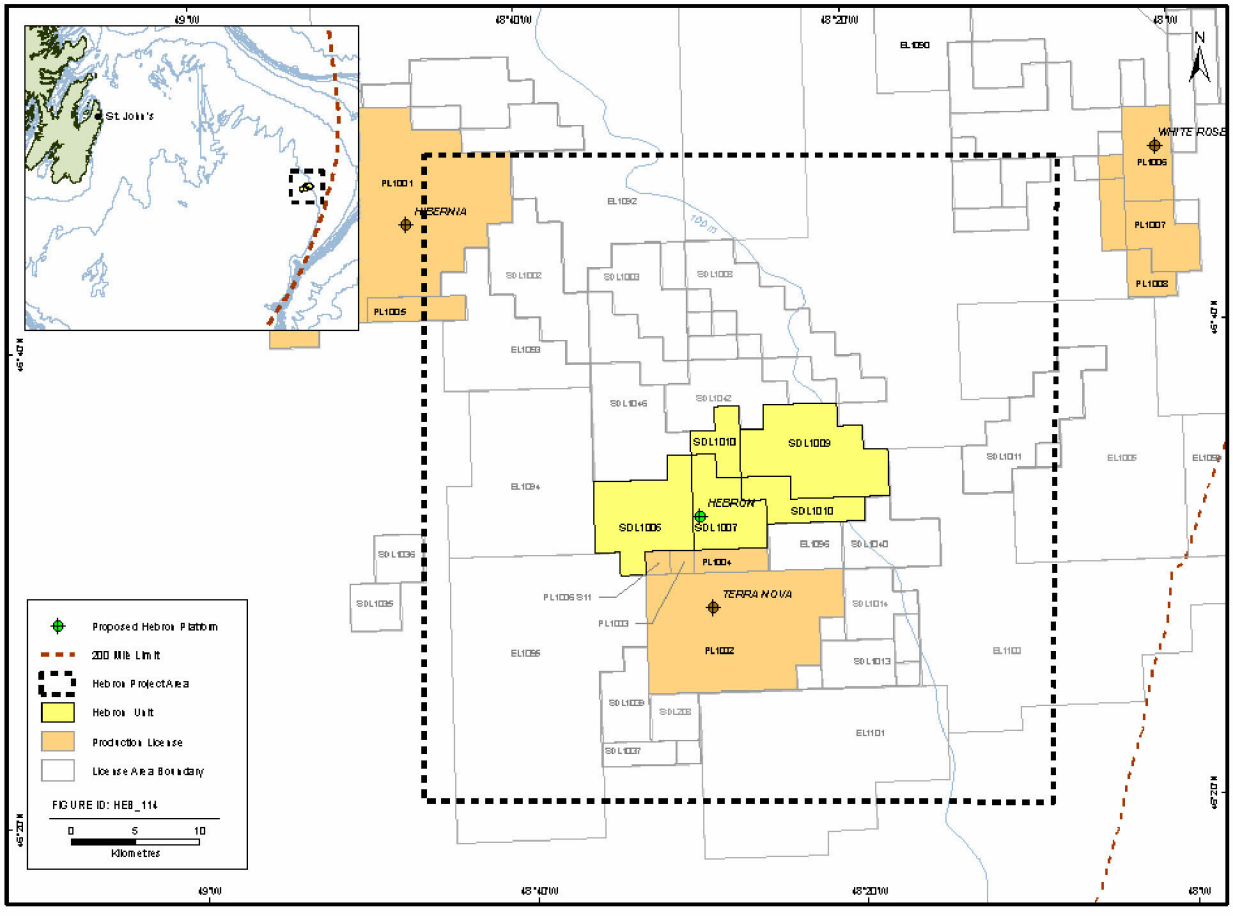

Figure 1-2 Offshore Project Area

Some Project activities (e.g., ice studies, geotechnical, geophysical, geological, and/or environmental surveys, vessel support) may occur within and outside the Hebron Unit. Therefore, the Hebron Offshore Project Area, as defined in this document, encompasses the area surrounding the Hebron Unit, as shown in Figure 1-2.

1.2 Project Proponents

The Hebron Project Proponents have varying participating interests in the four SDLs comprising the Hebron Unit. The Project owners and their respective share in the Hebron Project are identified in Table 1-1.

Table 1-1 Owners' Participating Interest

Owners	Share (%)
ExxonMobil Canada Properties	36.0
Chevron Canada Limited	26.7
Petro-Canada Hebron Partnership	22.7
Statoil Canada Ltd.	9.7
Nalcor Energy – Oil and Gas Inc.	4.9

Contacts to obtain additional information regarding the Hebron Project are indicated below:

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1.3 Regulatory Context

Offshore oil and gas exploration and development activities in the Newfoundland and Labrador offshore area are regulated under the Canada-Newfoundland Atlantic Accord Implementation Act (S.C. 1987, c.3) and the Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act (R.S.N.L. 1990, c. C-2) (Atlantic Accord Acts). Pursuant to Canadian Environmental Assessment Act (CEAA), the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and other Responsible Authorities (RAs) are required to conduct an environmental assessment of a proposed project before the requisite authorizations, permits and licenses can be issued. Under section 5 of CEAA, an environmental assessment is required in relation to this project because the C-NLOPB may issue a permit or license under paragraph 139(4)(a) of the Canada-Newfoundland Atlantic Accord Implementation Act and may issue a permit or license under paragraph 138(1)(b) of the Canada-Newfoundland Atlantic Accord Implementation Act; Environment Canada may issue a permit or license under subsection 127(1) of the Canadian Environmental Protection Act; Fisheries and Oceans Canada (DFO) may issue a permit or license under subsection 35(2) of the Fisheries Act; Industry Canada may issue a permit or license under paragraph 5(1)(f) of the Radiocommunication Act and Transport Canada may issue an approval under Part 1, Section 5 of the Navigable Waters Protection Act.

The Comprehensive Study List Regulations under CEAA prescribe a comprehensive study-level of environmental assessment for an offshore oil and gas development project. Pursuant to the Atlantic Accord Acts, proponents of offshore oil development projects are required to submit a Development Application. An Environmental Impact Statement (EIS) is required as a component of this Application. The Comprehensive Study Report (CSR) fulfils the requirement of the EIS supporting document for approval. Therefore, this environmental assessment of the Hebron Project will address the requirements of CEAA and the Atlantic Accord Acts.

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The C-NLOPB and the Canadian Environmental Assessment Agency (CEA Agency) have established a single harmonized process for addressing the environmental assessment requirements for offshore oil and gas development projects. The environmental assessment process for the Hebron Project will be assessed under this harmonized process.

The C-NLOPB and the following federal departments and agencies have identified an interest in the Project, and will participate in the federal review in relation to the proposed Project as follows:

- The C-NLOPB has regulatory and statutory responsibilities under the Canada-Newfoundland Atlantic Accord Implementation Act and, pursuant to CEAA, is a RA. The C-NLOPB may be in possession of specialist or expert information or knowledge with respect to the Project and, on request, shall make available that information or knowledge to RAs
- DFO has regulatory and statutory responsibilities under the Fisheries Act and, pursuant to CEAA, is an RA. DFO may be in possession of specialist or expert information or knowledge with respect to the Project and, on request, shall make available that information or knowledge to RAs
- TC has regulatory and statutory responsibilities under the Navigable Waters Protection Act and, pursuant to CEAA, is an RA. Transport Canada may be in possession of specialist or expert information or knowledge with respect to the Project and, on request, shall make available that information or knowledge to RAs
- Environment Canada has regulatory and statutory responsibilities under the Canadian Environmental Protection Act, 1999 (CEPA 1999) and, pursuant to CEAA, is an RA. Environment Canada may be in possession of specialist or expert information or knowledge with respect to the Project and, on request, shall make available that information or knowledge to RAs
- Industry Canada has regulatory and statutory responsibilities under the Radiocommunication Act and, pursuant to CEAA, is an RA
- Natural Resources Canada and Health Canada are federal authorities pursuant to CEAA and may be in possession of specialist or expert information with respect to the Project (expert Federal Authority) and, upon request, shall make available that information or knowledge to RAs

The CEA Agency has administrative and advisory responsibilities pursuant to CEAA in support of the environmental assessment. The CEA Agency will act as the Environmental Assessment Manager, the Crown Consultation Coordinator for the environmental assessment in relation to the Project, and will coordinate input into the review that is being undertaken pursuant to the Atlantic Accord Acts, to the extent possible.

The Major Projects Management Office has administrative and advisory responsibilities under the Cabinet Directive on Improving the Performance of the Regulatory System for Major Resource Projects and the associated Memorandum of Understanding. The Major Projects Management Office will provide oversight and advice throughout the entire federal review in relation to the Project to ensure adherence to the service standards and roles and

responsibilities of all Parties. Additionally, the Major Projects Management Office will provide selective intervention to help address identified challenges and, in collaboration with the Parties, will play an oversight role throughout the federal review in regard to Aboriginal engagement and consultation.

The Newfoundland and Labrador Department of Environment and Conservation (NLDEC) will require an Environmental Protection Plan (EPP) for the Bull Arm Site. This EPP will be submitted by EMCP to the NLDEC for approval in 2010.

The CEA Agency administers a Participant Funding Program that supports individuals and non-profit organizations interested in participating in certain types of federal environmental assessment. The CEA Agency will provide up to a total of $30,000 in participant funding, should this particular environmental assessment proceed as a comprehensive study. Notification of the availability of participant funding was provided by the Agency in conjunction with the RAs' advertisement of the Scoping Document comment period. The closing date for applications was May 22, 2009. No applications were received.

The RAs must also recommend to the Minister of the Environment whether the environmental assessment should continue by means of a comprehensive study or whether the project should be referred to a mediator or review panel. This report, known as the Environmental Assessment Track Report, was jointly issued on June 18, 2009. The RAs, in consultation with the CEA Agency and expert Federal Authorities and taking into consideration public comments received, concluded that a Comprehensive Study can effectively address issues related to the proposed Project and recommended that the environmental assessment process should continue as a Comprehensive Study.

After considering the subsection 21(2) report and recommendation, the Minister of the Environment is required to decide whether to refer the project back to the RAs to continue with the comprehensive study process, or refer the project to a mediator or review panel. If the Minister of the Environment decides that the project should continue as a comprehensive study, then the project cannot be referred to either a mediator or review panel at a later date. On July 22, 2009, the Minister of the Environment announced his decision that this Project would proceed as a comprehensive study. Based on this decision by the Minister, the environmental assessment process has continued as a comprehensive study with the RAs coordinating to prepare a single CSR. For this Project, the RAs have delegated preparation of the CSR (this report) to the Proponent. The public has been and will be given an opportunity to participate during the comprehensive study process.

Consultations conducted to date during the preparation of the comprehensive study are detailed in Chapter 5. EMCP will continue open dialogue with any stakeholders with questions or concerns. Ongoing meeting are planned with the fishing industry and non-governmental organizations.

1.4 Purpose of the Comprehensive Study Report

This CSR was prepared in the context of the Hebron Development Project Canadian Environmental Assessment Act Scoping Document (dated June 2009), and in fulfillment of regulatory requirements to assess the significance of potential environmental effects and reduce adverse environmental effects resulting from the Project under CEAA and the Atlantic Accord Acts. This report addresses the requirements for a comprehensive study level of assessment pursuant to CEAA and the EIS for the C-NLOPB Development Plan Guidelines (C-NLOPB 2006).

1.5 Scope of the Project

The scope of the project is defined as the components of a proposed undertaking relating to a physical work, or a proposed physical activity not relating to a physical work, that are determined to be part of the project for the purposes of the environmental assessment (CEA Agency 2006).

The scope of the Project includes a combination of works and activities that will take place in the Nearshore and Offshore Areas, necessary for the construction and operation of an offshore oil production system and associated facilities. In accordance with Section 15 of CEAA, the RAs have therefore agreed that the scope of the proposed Project, for purposes of preparation of this CSR, includes the following Project components.

1.5.1 Project Components - Nearshore Project Area

Project activities within or affecting the marine environment in the nearshore area may include:

a) Dredging and construction of a marine bund wall for the drydock in Great Mosquito Cove (associated activities may include: sheet pile / driving, dredging, blasting, grouting, dewatering of the drydock, ocean disposal of bund wall material)
b) Construction of the GBS in the drydock
c) Construction of additional and/or strengthened mooring points at the deepwater site (activities may include chain laying and connection)
d) Decommissioning of the bund wall and tow-out of GBS to deepwater site
e) Completion of GBS construction at the deepwater site and mating of the GBS with topside components and ancillary activities (may include solid ballasting)
f) Hook-up and commissioning of topside modules with GBS at deepwater site in Bull Arm
g) Tow-out of the platform to its offshore location through Trinity Bay (dredging activities may be required before tow-out)
h) Operation of support craft associated with the above activities, including but not limited to heavy lift vessels, construction vessels, supply vessels, helicopters, tow vessels, barges

i) Associated surveys for all above activities, including: remotely-operated vehicle (ROV) surveys, diving programs, geotechnical programs, geophysical programs, geological programs, environmental surveys

1.5.2 Project Components - Offshore Project Area

Project activities within or affecting the marine environment in the offshore area may include:

a) Tow-out of platform to offshore site
b) Offshore site and clearance surveys
c) Installation of the platform at its offshore location (may include site preparation activities such as clearance dredging, seafloor levelling, underbase grouting, offshore solid ballasting, piles and mooring points, and placement of rock scour on the seafloor)
d) Platform commissioning
e) Operation, production, maintenance, modifications, decommissioning of the platform petroleum production facility
f) Drilling operations (exploration and development drilling), from the GBS of up to 52 wells, including well testing, well completions and workovers and data logging
g) Construction, installation, operation, maintenance of an offshore loading system (OLS) (may include dredging activities, pile driving, installation and insulation of riser and OLS (rock dumping, concrete mattress pads)
h) Supporting activities, including diving programs, and operation of support craft associated with the above activities, including but not limited to dredging vessels, shuttle tankers, shuttle tankers connecting / disconnecting to OLS, mobile offshore drilling units (MODUs), platform supply and standby vessels and helicopters
i) Associated surveys for all above activities, including: ROV surveys, diving programs, geotechnical programs, geophysical programs (e.g., 2D/3D/4D seismic, Vertical Seismic Profiles (VSPs), geohazard/wellsite surveys), geological programs, environmental surveys (including iceberg surveys)

1.5.3 Potential Expansion Opportunities

a) Construction and abandonment/decommissioning of up to four excavated drill centres within the Hebron Field; may include the disposal of dredged material at one or more offshore locations
b) Installation, operation and maintenance, an abandonment / decommissioning of subsea infrastructure within excavated drill centres
c) Construction (including trenching, excavation, covering and/or spoil deposition), installation, maintenance, protection and abandonment / decommissioning of subsea flowlines and tieback to the GBS
d) Drilling operations from one or more MODUs
e) Supporting activities, including diving programs, ROV surveys and operation of support craft associated with the above activities, including but not limited to dredging vessels, MODUs, platform supply and standby vessels and helicopters

f) Seismic programs (2D/3D/4D surveys) and other geotechnical and/or geophysical activities (VSP surveys, geohazard/well site surveys)

1.6 Document Organization

This CSR is organized into the following chapters.

- Chapter 1 - Introduction: Provides a description of the Nearshore and Offshore Project Areas, identifies the Project proponents, indicates the regulatory context and the purpose of this environmental assessment, details the scope of the Project and the nearshore and offshore Project Components and describes the organization of this CSR
- Chapter 2 - Project Description: Provides the justification and need for the Project, discusses the alternatives to the Project, discusses and evaluates the alternatives within the project and discusses in detail the preferred concept for the Project in terms of construction in the Nearshore and Offshore Project Areas and operation and maintenance and decommissioning and abandonment in the Offshore Project Area discusses potential future development
- Chapter 3 - Physical Environment Setting: Describes the nearshore and offshore physical environment setting, including the atmospheric environment, oceanic environment, wind and wave extremes, sea ice and icebergs, geotechnical and geological conditions and climate change
- Chapter 4 - Environmental Assessment Methods: Details the scope of the environmental assessment and the scope of the factors to be considered in the environmental assessment; provides the nine-step method used in conducting the environmental effects assessment of the Project on identified Valued Ecosystem Components
- Chapter 5 - Consultations: Provides details on the consultations conducted in support of the CSR, including consultation with the public, meetings with government departments and agencies, other consultations methods used, media briefings and tracking, and the use of the Project website and telecommunications
- Chapter 6 - Air Quality: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Air Quality
- Chapter 7 - Fish and Fish Habitat: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Fish and Fish Habitat
- Chapter 8 - Commercial Fisheries: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Commercial Fisheries

- Chapter 9 - Marine Birds: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Marine Birds
- Chapter 10 - Marine Mammals and Sea Turtles: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Marine Mammals and Sea Turtles
- Chapter 11 - Species at Risk: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Species at Risk
- Chapter 12 - Sensitive or Special Areas: Describes the existing environment, potential interactions, proposed mitigation measures and assesses the potential environmental effects of the Project (including cumulative environmental effects and accidents and malfunctions) on Sensitive Areas
- Chapter 13 - Effects of the Environment on the Project: Describes the potential effects of the environment on the Project in both the nearshore and offshore, including bathymetry, wind, waves and currents, tsunamis, tides, water levels and storm surge, sea temperature, geohazards, and climate change and the mitigation measures that will be applied
- Chapter 14 - Accidental Hydrocarbon Spill Events: Provides oil spill probabilities and nearshore and offshore oil spill trajectory modelling results, as well as contingency plans in the event of an oil spill (or other accidental event)
- Chapter 15 – Follow-up and Monitoring: Provides the framework for the follow-up programs (including environmental effects monitoring) and environmental compliance that will be conducted for this Project, as well as environmental assessment validation
- Chapter 16 - Environmental Management: Details the environmental management procedures that EMCP will apply to the Hebron Project
- Chapter 17 – Summary and Conclusions: Provides the conclusions of the effect of the Project resulting from the environmental effects assessment
- Chapter 18 - References: Provides the personal communications and literature cited used to prepare the CSR
- Chapter 19 - Glossary, Acronyms and Abbreviations: Provides definitions of key words, acronyms and abbreviations

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2 PROJECT DESCRIPTION

This Chapter describes the attributes of the Project and discusses the review of Project alternatives that lead to the preferred development strategy from construction through operations to decommissioning and abandonment. The Project schedule is also provided.

2.1 Project Need and Justification

The Hebron Project will be a major contributor to the economic development of Newfoundland and Labrador, as well as to Canada. The Hebron Project will be Newfoundland and Labrador's fourth offshore oilfield development project. As such, it will build on and contribute to the multi-phase offshore petroleum industry in the province. In particular, the Project will provide substantial benefit through diversity programs, employment and training opportunities, business opportunities for the local service and supply community, and research and development opportunities, further expanding the Province's industrial capabilities.

In 2008, the Project Proponents and the Province signed a Benefits Agreement. Through this Agreement, the Hebron Project has made significant commitments to the people and government of the Province for engineering work, diversity programs, education and training, research and development, and construction and fabrication in the Province.

The Project has committed to providing significant person-hours of work in Newfoundland and Labrador during the six-year design, fabrication and construction phase, including local Project management, front-end engineering and design (FEED), detailed design and construction of the Gravity Base Structure (GBS), with additional employment during construction of Topsides modules.

During the operations phase, there will be employment opportunities in areas such as logistics, engineering and technical support, drilling and production, marine support vessels (helicopters, supply vessels, tankers), catering, and similar onshore support. These opportunities during construction and operations will further develop the capabilities of Newfoundland and Labrador companies and individuals working on the Project, and thereby enable local companies and individuals to develop capabilities to compete internationally on future opportunities.

Throughout its operations, the Project will also contribute substantial revenues to the provincial government through corporate taxes and royalty payments. If approved, the Hebron Project will extend the life of the offshore oil and gas industry in Newfoundland and Labrador. It represents an important next step in the development of a sustainable offshore oil and gas industry in Newfoundland and Labrador.

2.2 The Hebron Asset

The Hebron Asset is composed of four reservoir intervals organized into several normal fault-bounded fault blocks. The central horst block is the Hebron field, and the down-dropped fault blocks to the northeast are the West Ben Nevis and Ben Nevis fields. The down-dropped fault block to the southwest forms the Southwest Graben (Figure 2-1). The four stratigraphic units are the Late Jurassic Jeanne d'Arc formation, the Early Cretaceous Hibernia formation, the Early Cretaceous Avalon formation and Early Cretaceous Ben Nevis formation.

The four vertically stacked reservoirs and multiple fault blocks contribute to the complexity of the multiple hydrocarbon columns with different contacts at the Hebron Asset. To simplify communication, the Hebron Asset is currently divided into five major pools (although other hydrocarbon-bearing pools beyond these exist). The pools, shown in Figure 2-1, are defined as follows:

- Pool 1: Hebron Field, Ben Nevis Reservoir, including the fault block penetrated by the D-94 and M-04 wells and the fault block penetrated by the I-13 well
- Pool 2: West Ben Nevis Field, Ben Nevis Reservoir, penetrated by the B-75 well
- Pool 3: West Ben Nevis Field, Avalon Reservoir, encountered in the B-75 well and the Ben Nevis Field, Ben Nevis Reservoir, encountered in the L-55 and I-45 wells
- Pool 4: Hebron Field, Jeanne d'Arc Reservoir, including the isolated B, D, G and H hydrocarbon-bearing sands, encountered in the I-13 and M-04 wells
- Pool 5: Hebron Field, Hibernia Reservoir, encountered in the I-13 and M-04 wells

The Ben Nevis Reservoir within the Hebron Field (Pool 1) is the core of the Hebron Project, and is anticipated to produce approximately 80 percent of the Hebron Project's crude oil. However, the 20 API crude in this reservoir presents production challenges, as the viscosity can be 10 to 20 times higher than that of water.

The Jeanne d'Arc and Hibernia Reservoirs within the Hebron Field (Pools 4 and 5) are also part of the Hebron Project. Relative to the Hebron-Ben Nevis Pool, the Jeanne d'Arc and Hibernia Reservoirs have higher oil quality but decreased reservoir quality consistent with deeper burial and cementation. The Jeanne d'Arc Formation has lower reservoir quality than the Jeanne d'Arc Formation of the Terra Nova Field, just as the Hibernia Formation at Hebron has lower reservoir quality than the Hibernia Formation of the Hibernia Field.

A depletion strategy for each of the reservoirs in the Hebron Project Area has been formulated. The depletion strategy balances economic value, risk mitigation and overall development flexibility to allow the reservoirs to be effectively managed over the life of the field. All reservoirs within the Hebron Asset are being evaluated with respect to risked production performance.

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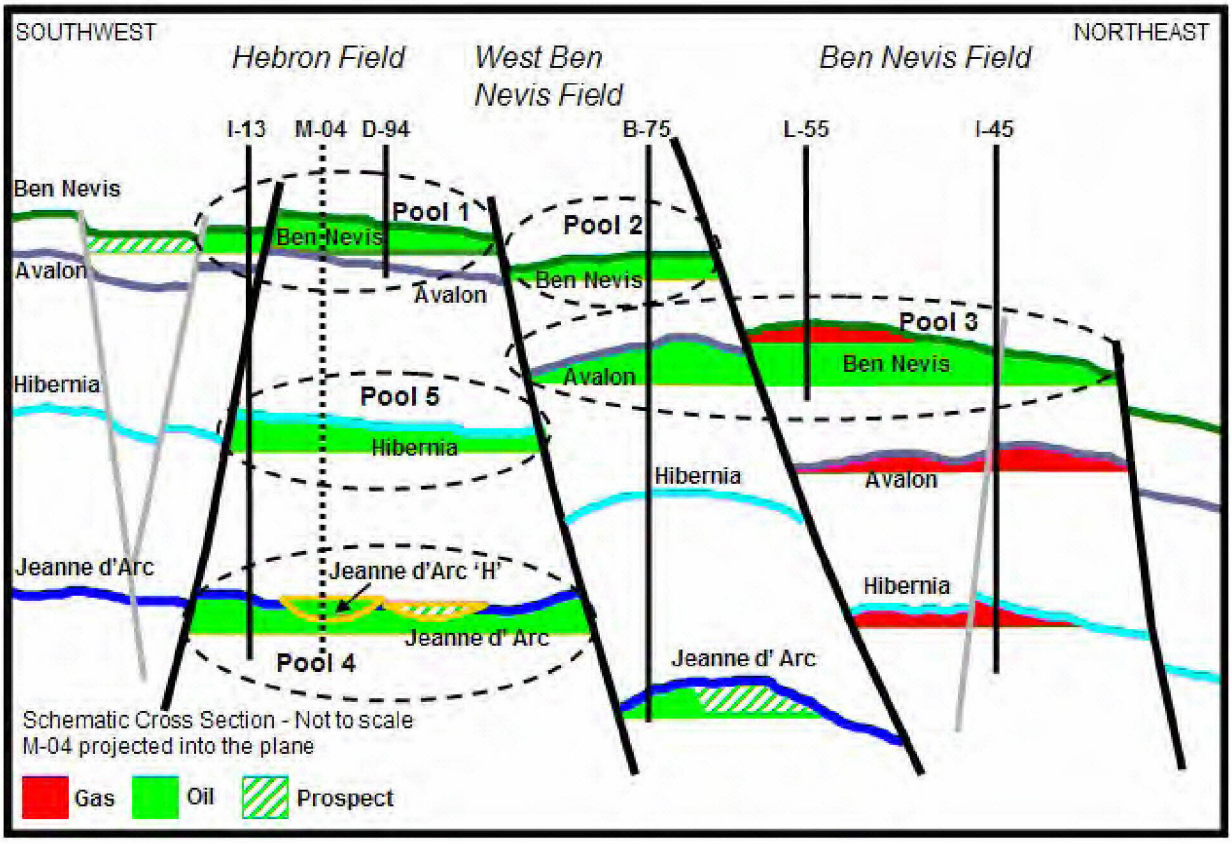

Figure 2-1 Schematic Cross-section across the Hebron Asset

The initial development phase consists of developing oil resources from the Ben Nevis, Hibernia and Jeanne d'Arc H and B Reservoirs within the Hebron Field, and gas storage in either the Ben Nevis Reservoir of the Hebron Field or in the Ben Nevis Reservoir of the West Ben Nevis Field. Water injection is planned as the primary drive mechanism for the Hebron Field to improve overall oil recovery. Forecasted cumulative oil recovery for the initial development phase after 30 years of producing life ranges from 87 Mm^3 (548 MBO) to 140 Mm^3 (883 MBO) from an anticipated 41 wells.

In addition to the initial development phase, there is opportunity for the development of additional pools in the Hebron Project Area, depending on the results of further drilling, production performance (of wells from the initial development), studies, possible delineation wells, additional seismic data or some combination of these. In anticipation of potential expansion development, the GBS will be designed to include 52 well slots. To maximize resource development, slots may later be reclaimed for re-use. Expansion development could also occur via sub-sea tie back(s) from seafloor drill centres. The platform will have space available for future installation of production facilities and J-tubes and/or risers to allow for such future expansion. For example, the Ben Nevis Reservoir in the Ben Nevis Field is being evaluated as a potential future subsea development that would tie back to the planned Hebron Platform.

Oil in the principal Ben Nevis Reservoir of Hebron Field contains a relatively low amount of associated gas. Even so, it is anticipated that during a portion of this field's productive life, the level of gas production will temporarily exceed the amount of gas that can be beneficially used in facilitating oil production. An integrated plan is being developed to ensure both efficient use of produced gas and a means of storing and conserving gas during temporary periods of surplus gas production. Later in field life, the gas production rate is expected to decrease in conjunction with a natural decline in oil production as water cut increases, and the gas previously stored may need to be withdrawn in order to provide fuel for platform operations. The gas management plan will take into account a number of considerations, including:

- Use of associated gas in applying artificial lift to oil producing wells
- Fuel requirements are expected to vary with time
- Down-time gas flaring (not continuous)
- Prospective subsurface location(s) for storing any temporary surplus of produced gas
- Potential need to withdraw gas that has previously been stored in order to provide fuel for platform operations
- Potential for using gas in any enhanced oil recovery method in the Hebron Offshore Project Area, should such a method be deemed technically and commercially viable
- Potential for future commercial gas production

2.3 Alternatives to the Proposed Project

As required under Section 16(2)(b) of the Canadian Environmental Assessment Act (CEAA), project alternatives must be considered for a comprehensive study-level of assessment. There are no economically or technically viable alternatives to the Project.

The significance of each of the environmental effects, including accidental events, proceeding with the Project is assessed in Chapters 6 to 12 of this Comprehensive Study Report (CSR).

2.4 Alternative Means of Carrying out the Project: Concept Selection

2.4.1 Alternative Means of Offshore Development

The selection of the preferred concept for development of the Hebron Project included consideration of environmental effects, safety, capital and operating cost, reliability, energy efficiency, constructability, and schedule for construction. Four potential concepts were considered in detail:

- Subsea wells tied back to Hibernia Platform
- Floating Production, Storage and Offloading (FPSO) facility in combination with subsea wellheads (wet tree), manifolds, pipelines and risers

- FPSO in combination with wellhead gravity base structure (WHGBS)
- GBS (with or without pre-drill alternative)

2.4.1.1 Tieback to Hibernia

In this concept (Figure 2-2), subsea wells would be drilled by a mobile offshore drilling unit (MODU) over the life of the Hebron field. Subsea equipment, including metering facilities, would be installed in two excavated drill centres, one for the Ben Nevis horizon wells and another for the Hibernia and Jeanne d'Arc wells. The produced fluids would be delivered to the Hibernia Platform (31.5 km to the north) from the excavated drill centres by two insulated, subsea, multi-phase, production lines using multiphase pumps.

The production lines would have round-trip pigging capability. The power for the multiphase pumps would be supplied by two independent power cables from the Hibernia Platform. Two umbilicals would control the subsea wells and isolation valves. Gas lift would be delivered from the Hibernia Platform to the subsea wells. Injection water would be supplied from the Hibernia Platform via a water injection line. All the flow lines, power cables and umbilicals would be installed in trenches to protect them from iceberg scour. Modifications to the separation, compression, power generation and water injection systems on the Hibernia Platform would be required.

2.4.1.2 FPSO with Subsea Wellheads

A FPSO with subsea satellite wells concept would entail subsea wells being drilled using a MODU (Figure 2-3). Subsea wells would be located in excavated drill centres to protect them from iceberg scour. Production fluids would be transferred to a FPSO via flowlines and flexible risers.

The FPSO would be double-hulled and double-bottomed, with appropriate storage capacity for crude oil, thrusters (for heading control), and would house the oil treatment, gas compression, gas lift, water injection and utility equipment, including power generation. It would also include quarters to house operations and maintenance personnel. The FPSO would stay on station by means of an internal, disconnectable turret anchored to the sea floor. In the event of an encroaching iceberg or dense pack ice, the FPSO would be able to disconnect and depart from the field. Stabilized crude oil would be stored in the FPSO prior to tandem loading onto ice-strengthened tankers for shipment to market or to the Newfoundland Transshipment Terminal.

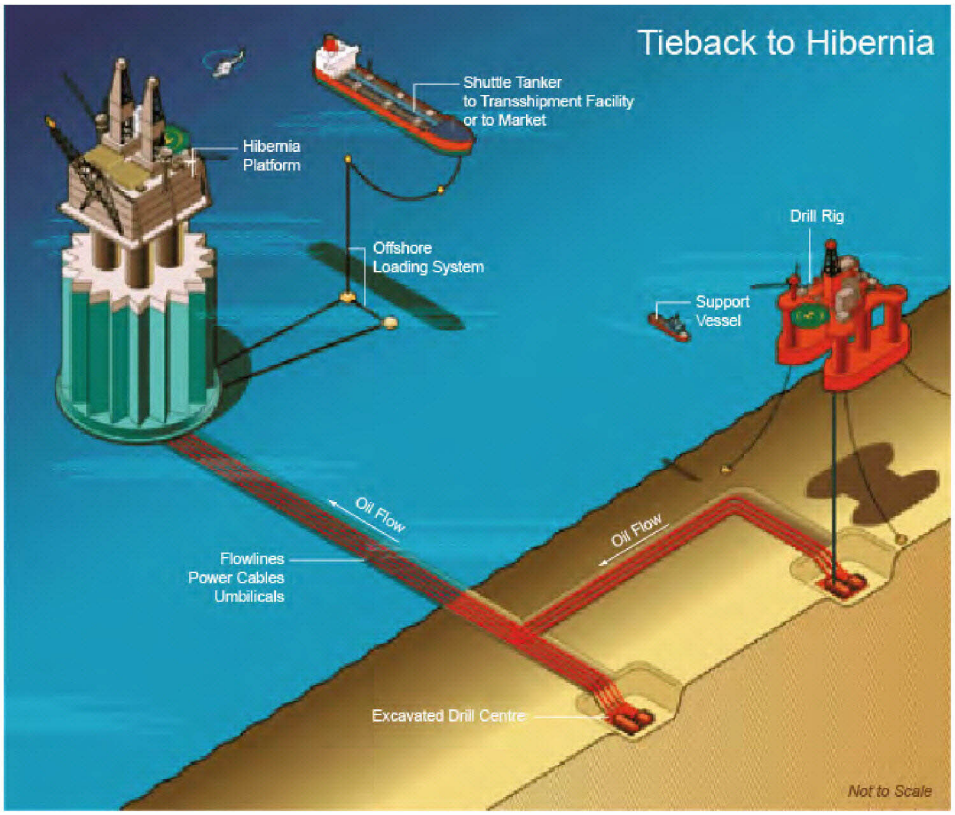

Figure 2-2 Tieback to Hibernia

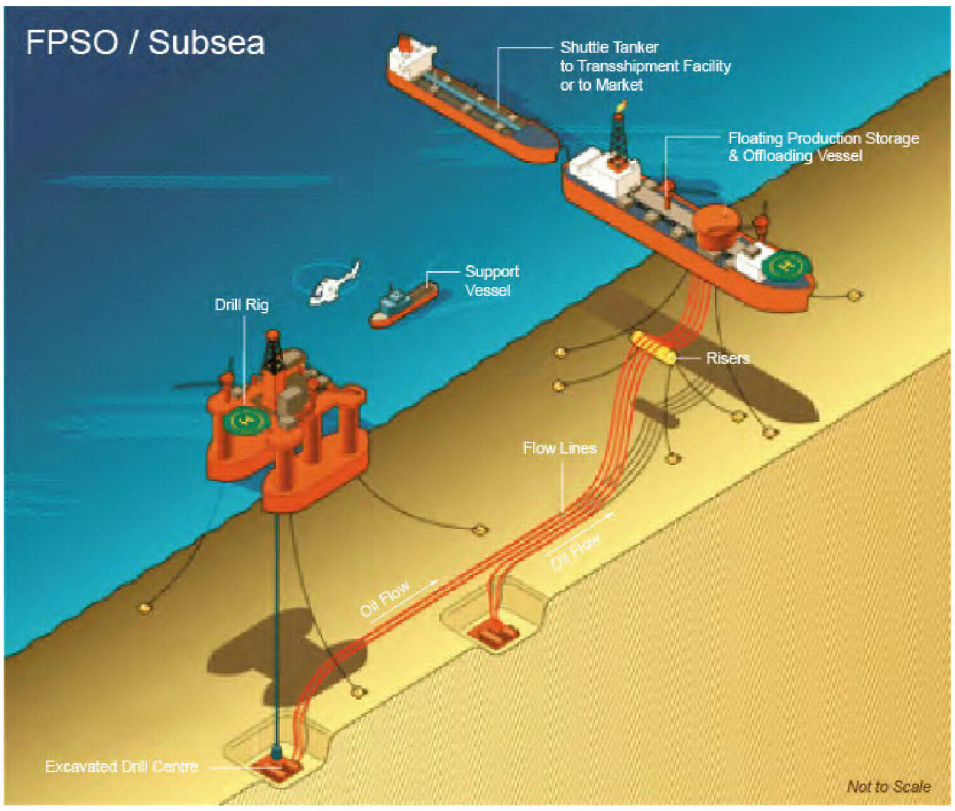

Figure 2-3 Floating Production, Storage and Offloading Facility and Subsea Infrastructure

2.4.1.3 FPSO with Wellhead Gravity Base Structure

This concept requires wells to be drilled from a concrete mono-tower WHGBS using a MODU in a tender assist mode (Figure 2-4). All wells (producers and injectors) would be drilled from the WHGBS. The WHGBS would be constructed and installed approximately two years prior to FPSO completion to enable pre-drilling and, hence, improved production ramp-up.

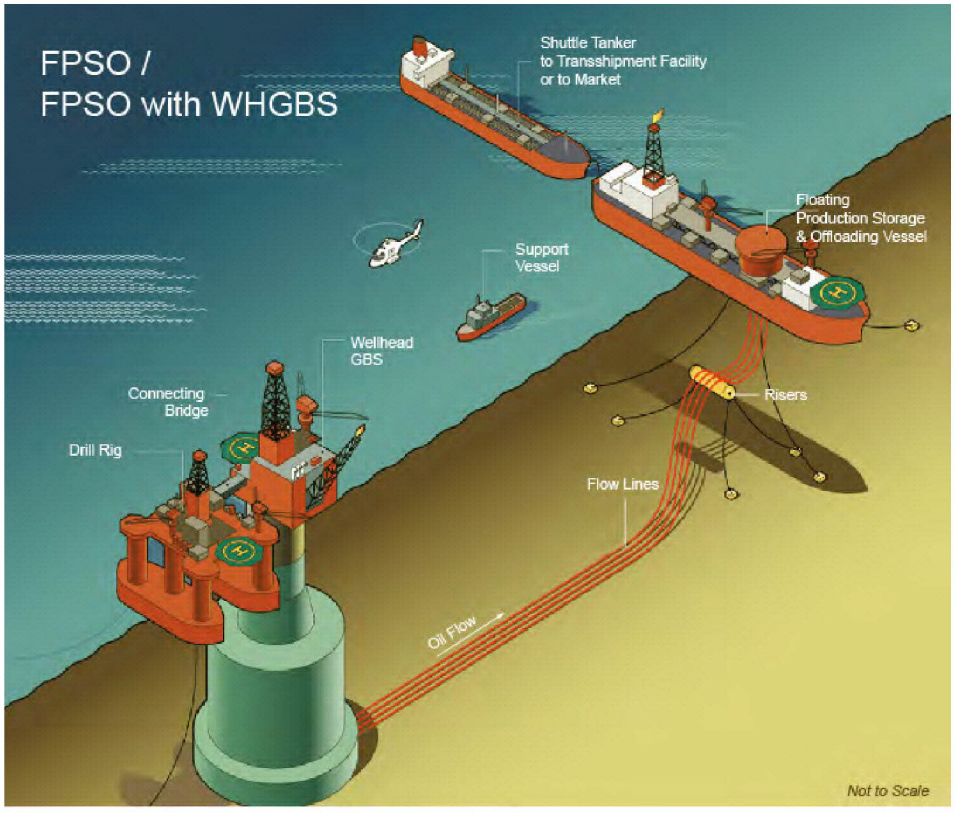

Figure 2-4 Floating Production, Storage and Offloading Facility with Wellhead Gravity Base Structure

The WHGBS would be configured with minimal topsides processing functionality to reduce the numbers of personnel on the structure. WHGBS process equipment would be limited to manifolding and well testing via multiphase meters. Utility systems, notably those involving rotating equipment, would be limited. Trenched pipelines, with riser base manifolding, would be used to tie the WHGBS to the FPSO. Injection water, gas lift and power to the WHGBS would be supplied by the FPSO. Oil export would be undertaken with ice-strengthened shuttle tankers loading in tandem off the stern of the FPSO.

2.4.1.4 Gravity Base Structure

The stand-alone GBS production facilities concept is similar to Hibernia and includes a concrete GBS with associated topsides (Figure 2-5). The GBS and topsides would be constructed separately and then mated at an inshore site prior to towing and installing the Platform at the Hebron site.

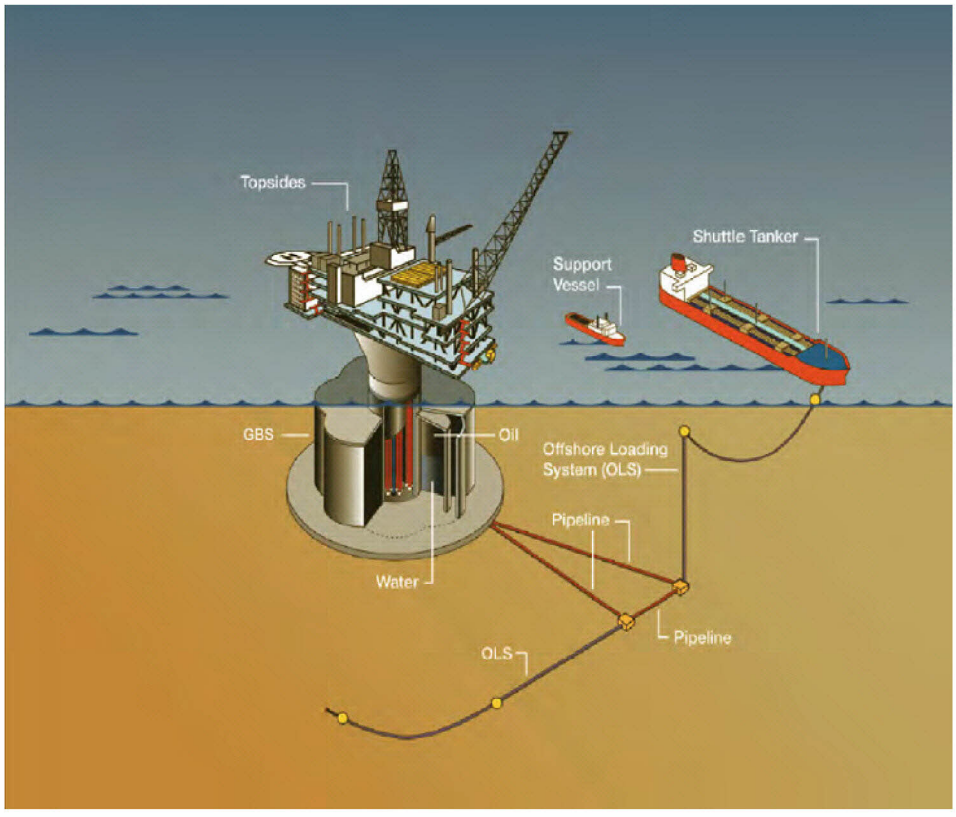

Figure 2-5 Stand-alone Gravity Base Structure Preliminary Development Layout

All wells (producers and injectors) would be drilled by the platform rig. Treated oil would be stored in the Hebron Platform prior to custody transfer metering and subsequent shipment. An offshore loading system (OLS), complete with a looped pipeline and two separate loading points, would be installed to offload the oil onto tankers for transport.

Pre-Drill Alternative

Within the stand-alone GBS option, consideration has been given to a pre-drill alternative, where some wells would be drilled prior to the arrival of the platform, through a pre-drill template.

With the pre-drill alternative, a MODU would be used to drill and partially complete the pre-start-up wells prior to the installation of the Hebron Platform. However, an excavated drill centre would not be constructed for the pre-drill option; the platform cannot be installed over an excavated drill centre. Rather, the well heads would remain, unprotected, above the sea floor until the platform was installed over the well heads. Drill cuttings, both water-based and non-aqueous fluid (NAF) based, would be processed and discharged overboard in accordance with Offshore Waste Treatment Guidelines (OWTG) (NEB et al., 2010).

Once the pre-drill has been completed, the platform is installed by floating the platform structure over the template, and lowering the platform to the seafloor. The pre-drilled wells would be connected to the platform topsides and then

completed from the platform. The remaining wells would then be drilled by the platform rig in parallel with operations.

2.4.2 Alternative Means for Nearshore Construction

Construction of a drydock at a new greenfield site would have resulted in a measurable increase in the consumption of raw materials, fuel, energy, resources and resulted in higher environmental risks and greater environmental effects associated with the necessary dredging of a new graving dock and construction of required supporting infrastructure. Therefore, refurbishment of the existing Bull Arm Site was determined to be the preferred option for the site at which to construct the GBS, as well as Topsides integration work, hook-up and commissioning activities.

2.5 Preferred Concept: Hebron Project

The Project Proponents, using a concept selection strategy, evaluated the alternative modes of development, and determined that the preferred concept is to develop the Hebron Asset using a stand-alone concrete GBS (no pre-drill option) and topsides, and an OLS. No other option provides technical and economic certainty. Based on current Project requirements, the GBS (no pre-drill) is the only technologically and economically feasible option with comparable environmental effects, as illustrated in Table 2-1.

Table 2-1 Summary of Analysis of Alternate Means of Carrying Out the Project Showing Determination of Risk

Alternative Considered	Technical Feasibility	Economic Feasibility	Environmental Effects
Subsea tieback to Hibernia			
Subsea tieback to FPSO			
FPSO with WHGBS			
Stand-alone GBS (with pre-drill)			
Stand-alone GBS (no pre-drill)			
High - red; Medium - yellow; Low - green			

Neither FEED nor detailed design for the Topsides and GBS have been completed. However, the main criteria upon which the detailed design will be based are provided in Section 2.6.

2.6 Hebron Project Concept and Design

2.6.1 Hebron Project Concept

The GBS for the Hebron Project will be a post-tensioned reinforced concrete structure designed to withstand impacts from sea ice and icebergs, and the meteorological and oceanographic conditions at the Hebron Project Area. It will accommodate up to 52 well slots with J-tubes and/or risers for potential future expansion.

The GBS will be designed to store approximately 190,000 m^3 (1.2 Mbbl) of crude oil in multiple separate storage compartments. It will have a single main shaft supporting the topsides and will encompass all wells to be drilled from the platform. The GBS will be designed for an in-service life of 50 or more years. The Topsides facilities will include the following modules:

- Drilling Support Module (DSM)
- Drilling Equipment Set
- Flare Boom
- Utilities and Processing Module (UPM)
- Living Quarters, including helideck and lifeboat stations

A schematic of a typical GBS and Topsides layout are provided in Figures 2-6 and 2-7, respectively.

Production facilities will have the capacity to handle the requirements of drilling and production of crude oil, storage and export, gas management, water injection, and the management of produced water, for a production life of 30 or more years.

The Hebron Project will include an OLS to offload crude oil onto tankers for transfer to the Newfoundland Transshipment Terminal or directly to market. The currently planned OLS system, as shown in Figure 2-5, consists of two main offshore pipelines running from the GBS to separate riser bases (Pipe Line End Manifolds with an interconnecting offshore pipeline connecting the two pipe line end manifolds. OLS bases may be anchored to the seabed by piles, or other suitable means, to provide a stable connection for the OLS risers. Rock dumping, or other suitable insulation material, may be required for off-loading line protection and insulation.

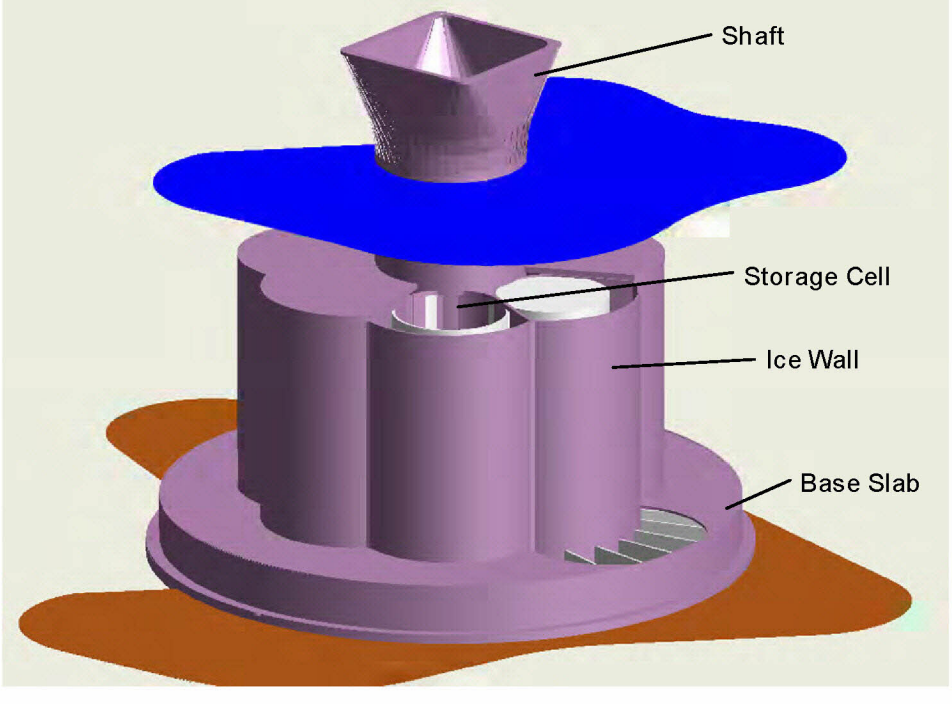

Figure 2-6 Schematic of Gravity Base Structure

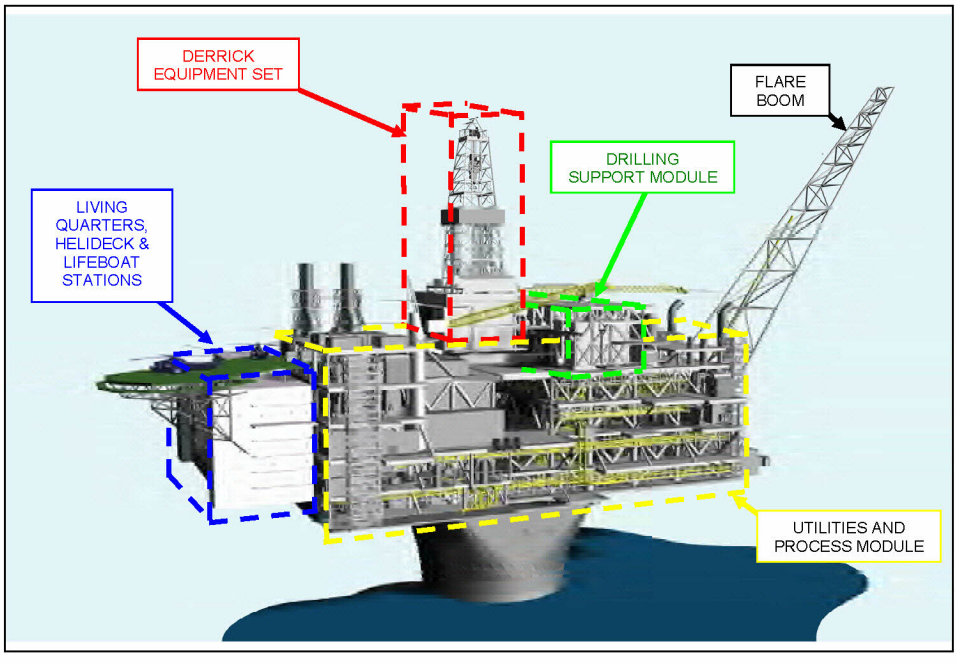

Figure 2-7 Schematic of Topsides

The closed loop arrangement is planned to allow round-trip intelligent pigging and flushing operations through the pipelines and pipe line end manifolds if an iceberg threatens the loading facilities.

During loading, the riser will be connected to the dynamically-positioned, bow-loading shuttle tanker.

A Direct Offloading system for cargo transfer from GBS to tankers is being studied as an alternative to the OLS. If the Direct Offloading option is selected, the system will likely consist of a hose reel integrated with the topsides, extending from the northeast side of the topsides structure, together with an approximately 340 m long, 508 mm (20") diameter marine hose with buoyancy elements. The hose will remain on the reel between offloadings and, during offloading, will be connected to a dynamically positioned, bow-loading shuttle tanker. During offloading, the tanker will maintain its position in a safe zone approximately 250 m from the Platform using its thrusters. The hose connecting the Platform storage tanks with the tanker storage tanks will take a "Lazy-W" configuration in the water (see Figures 2-8 and 2-9). The hose ends enter the water almost vertically and the intermediate hose sections float at approximately mid-water column height at an approximate water depth of 38 m. No subsea equipment is required for Direct Offloading.

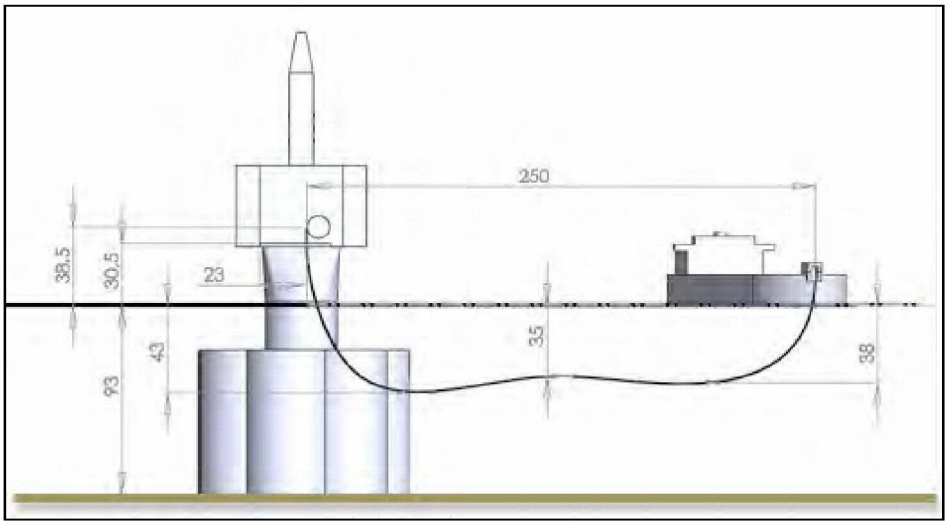

Figure 2-8 Configuration of Offloading Hose

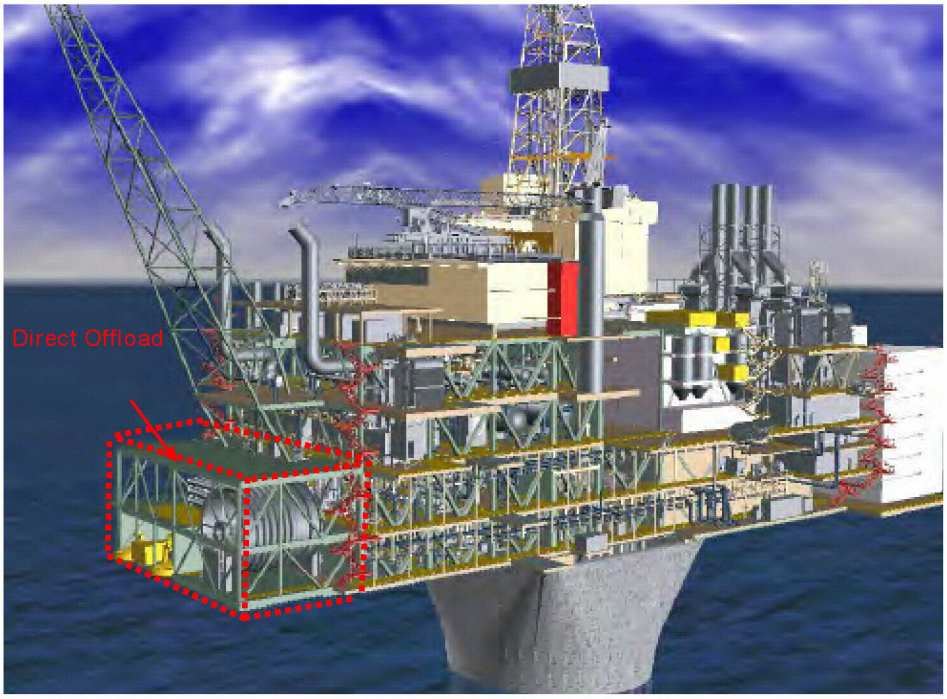

Figure 2-9 Platform Location of Direct Offloading Equipment

2.6.2 Hebron Project Design Criteria

An overview of the Hebron GBS and Topsides design criteria is provided in the following paragraphs. The following design criteria are based on current estimated project requirements. However, during FEED and detailed design and engineering, some of these elements may be modified. The following description provides for ranges in design criteria to allow for any modifications to project design.

The Hebron production facilities will have the capacity to handle the predicted life-of-field production stream for 30 plus years. Based on the current initial development phase, it is expected the facility will be designed to accommodate an estimated production rate of 23,900 m^3/day of oil (150 kbd). It is anticipated that, with de-bottlenecking and production optimization post-start-up, that the total capacity of the facility could potentially be raised to 28,600 m^3/day (180 kbd). The produced water system will be designed to process and discharge up to 56,000 m^3/day (approximately 350 kbd) of produced water and inject up to 74,000 m^3/day (470 kbd) of water. Gas handling of up to 8,500 km^3/day (300 MSCFD) will be required to accommodate gas re-injection and artificial lift gas.

An overview of the design basis for the Hebron Project is provided in Table 2-2. These design rates may change as the reservoir depletion strategy and initial development phase are finalized. The design basis values listed are representative of peak production. The environmental assessment will, therefore, use the upper limit of these ranges in its effects assessment.

Table 2-2 Hebron Project Attributes

Project Component	Attribute
Platform Location	46°32'64344' N; 48°29'88379' W
Life of Field	Greater than 30 years
Well Slots	Up to 52
Measured Well Depths	2,300 to 6,500 m measured depth
Topsides Design Basis Summary	
Preliminary Topsides Weight	30,000 to 44,000 tonnes
Crude Oil Production	23,900 to 28,600 m^3/d (approximately 150 to kbd)
Water Production	31,800 to 56,000 m^3/d (approximately 200 to 350 kbd)
Water Injection	43,000 to 74,000 m^3/d (approximately 270 to 470 kbd)
Gas Handling (includes associated gas and gas-lift gas)	6,000 to 8,500 km^3/d (approximately 215 to 300 MSCFD)
GBS Notional Design Metrics	
Concrete GBS Structure	Reinforced concrete with post tensioning
Overall Height (seabed to top of central shaft)	Approximately 120 to 130 m (394 to 427 ft)
Foundation Diameter	122 to 133 m (400 to 436 ft)
Caisson Diameter	100 to 110 m (328 to 361 ft)
Shaft internal diameter	Approximately 33 t m (108 ft)
GBS Dry Weight	300,000 to 340,000 tonnes
Solid Ballasting	50,000 to 100,000 tonnes
Concrete Volume	115,000 to 126,000 m^3 (150,300 to 164,700 cubic yards)
Reinforcing Steel	33,000 to 50,000 tonnes
Post Tensioning Steel	3,700 to 5,000 tonnes
Topsides Support during tow-out	Up to 44,500 tonnes
Base Storage	7 storage cells Approximately 190,000 m^3 (1.2 M bbl)
Life Expectancy of GBS	Approximately 50 years

Project Component	Attribute
Potential Field Expansion	J-tubes and spare well slots (approximately 6 to 15) Future options may include reclamation of slots and over 70 wells in total through platform and sub-sea wells
Water Quality	
Produced Water Handling (Offshore Waste Treatment Guidelines) (OWTG) (National Energy Board et al., 2010)	≤30 mg/L 30-day average; ≤60 mg/L 24-hour average
Storage Displacement water (oil content – OWTG)	≤15 mg/L
Ballast / Bilge Water (oil content – OWTG)	≤15 mg/L
Deck (open) Drainage (oil content – OWTG)	≤15 mg/L
Well Treatment Fluids	≤30 mg/L; strongly acidic fluids should be treated with neutralizing agent to a pH of at least 5.0 prior to discharge
Cooling Water	As approved by Chief Conservation Officer
Desalination Brine	No discharge limit
Fire Control Systems Test Water	No discharge limit
Sewage and Food Waste	Macerated to ≤6 mm
Water-based Drill Solids	No discharge limit
NAF-based Solids	Re-injected where possible; if not, ≤ 6.9 g/100 g on wet solids
Offshore Loading System	
OLS Location	Approximately 2 km north-northeast of platform
Transfer Rate	Up to 8,000 m^3/h (50,312 bbls/hour)
Off-loading line length (each)	2 km (approximate) (6,560 ft)
Interconnecting off-loading line Length	500 m (approximate) (3,280 ft)
Export vessels	Anticipated use of existing shuttle tankers

2.6.3 Gravity Base Structure Systems

The GBS will be designed to have temporary and permanent mechanical systems installed as follows:

- Up to 52 well slots and associated conductor guides and J-tubes and/or risers
- Two shale chutes, routed down the inside of the structure, maintaining a sufficient angle so cuttings run down the chute and are deposited beyond the outer storage cell walls
- Seven crude oil storage compartments, including associated booster pump(s) to lift the oil for offloading, and level monitoring equipment
- Seawater systems including storage displacement water, cooling water and firewater, will likely include:
  - a large-diameter caisson for return of seawater to the marine environment
  - separate lift pumps to supply the firewater and seawater systems; firewater pumps will be segregated to ensure that no single point of failure can cause loss of firewater supply
  - storage displacement water from the crude oil storage compartments will pass through a buffer cell before horizontal discharge

- Corrosion protection system to protect metal elements against corrosion and biological growth where seawater is present. The discharge from the hypochlorite system will be treated in accordance with the Offshore Waste Treatment Guidelines (OWTG) (National Energy Board (NEB) et al. 2010)
- A separate sewage disposal line may route water from the sewage treatment unit to the marine environment. Merits of combined disposal will be addressed during detailed engineering design work. Sewage will be discharged overboard in accordance with the OWTG (NEB et al. 2010)
- Systems to minimize the occurrence of flammable gases and flammable or combustible liquids entering the shaft and allowance for removing any accumulations of gas
- Fire and gas detection system
- Control and monitoring systems including instrumentation to control crude oil levels, monitor corrosion systems and monitor foundation integrity
- Cooling system to ensure proper temperature maintenance of the GBS shaft over the life of the project
- Grounding / Earthing System including cables running through the GBS

2.6.4 Topsides Systems

- The Topsides will include all equipment required for the drilling, processing and power generation for the Hebron Project

2.6.4.1 Drilling Facilities

Based on preliminary design work, drilling facilities on-board the Hebron Platform will consist of the following systems:

- Mechanical drilling systems, including drawworks and pipehandling
- Well-control system consisting of a blowout preventer (BOP) stack, complete with diverter assembly, hydraulic control system, kill and choke manifold, trip tank, atmospheric separator (de-gasser)
- Bulk material and storage system, including storage tanks and surge tanks for dry bulk materials
- Mud storage, mixing and high pressure system, including liquid storage tanks, mixing equipment, and mixing, transfer, pre-charge and high-pressure mud pumps
- Mud return and reconditioning system, including shaker distribution box, shale shakers, degassers, centrifuges / dryers and associated tanks and pumps
- Onboard gravel pack equipment
- Cementing system, including a dual high-pressure pump unit, a batch mixing unit and a liquid additive system
- Driller's cabin containing drilling controls as well as monitoring capabilities for all drilling, pipe handling, mud handling and cement handling operations
- Cuttings re-injection system for NAF-based muds and cuttings. NAF-based muds and cuttings will be re-injected into the subsurface via a re-injection well. There will be no NAF-based cuttings treatment on the

platform. The cuttings re-injection system will be designed with dual redundancy; there will be a minimum of two wells for re-injection. All water-based drill muds and cuttings will be discharged overboard, as per the OWTG (NEB et al. 2010). There will be two shale chutes for water-based cuttings discharge

Water-based mud (WBM) cuttings are currently planned to be used on the first three hole sections of the Hebron wellbores.

For the first hole section (conductor section), it is planned to return the WBM cuttings to the GBS shaft. Soil strengths immediately below the GBS base slab are anticipated to be very weak and unable to sustain the additional hydrostatic load that would be introduced should the cuttings be returned to the Drilling Support Module (DSM) for re-injection. It is anticipated the DSM will be ±50 m above mean sea level. The returning fluid column would exert this equivalent hydrostatic head on the soils in the conductor hole section. Based on operational experience at ExxonMobil operations, it is anticipated this would result in significant fluid losses while drilling, subsequently creating a hole enlargement. This would pose potential risk to subsequent cementing operations of the conductor, overall well integrity and, potentially, stability of the soils beneath the base slab.

Similarly, the second hole section (surface casing) is anticipated to encounter weak sands and soils. It is currently planned to return these cuttings to the lower levels of the Platform, where they will be routed to the shale chutes for overboard discharge. Attempting to route the returns to the higher elevation of the cuttings re-injection system would introduce hydrostatic head that could also result in hole enlargement and risk to wellbore integrity.

The third hole section (intermediate casing) will also be drilled with WBM systems. However, the geologic intervals to be penetrated typically return cuttings that tend to be tacky in texture and result in large masses, or clumps, of cuttings, that can best be defined as 'sticky'. These masses are not well suited to cuttings re-injection as they require large surface systems to dissolve the cuttings prior to routing to subsurface injection.

Finally, at the current Project stage, analysis has been performed to identify candidate subsurface zones for cuttings re-injection. Modelling is currently planned to be completed to ensure containment can be maintained for the NAF-based mud drill cuttings and avoid out of zone fracture. Injection of large volumes of WBM cuttings potentially poses a risk for out-of-zone fracture and the subsequent loss of containment of NAF materials. Thus, the proposed plan of water-based discharge provides a balanced approach that minimizes overall risk of environmental damage.

The anticipated drill cuttings management information is shown in Table 2-3. The estimated cuttings volume per chute is approximately 4,453 m^3. Cuttings from the 838 mm hole section will be deposited inside the GBS shaft. The growth of anaerobic bacteria and the resulting production of hydrogen sulphide could be potential health issues in addition to being corrosive to facilities. Anaerobic bacteria require very low or no oxygen in their environment in order to survive and grow. The GBS shaft for Hebron will be

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designed with a passive seawater circulation system using natural convection. Cold seawater will enter from the bottom of the shaft and warmer water will exit at the top of the shaft, with direct discharge to the ocean. The constant replenishment of fresh seawater (containing dissolved oxygen) will minimize the possibility for developing the anaerobic conditions suitable for growth of anaerobic bacteria, thereby minimizing the growth of anaerobic bacteria action in the GBS without the need for to add biocides. This circulation system design will account for drill cuttings that may be discharged at the shaft bottom.

Table 2-3 Estimate of Drill Cuttings Volumes

Hole Size (mm)	Start Depth (m)	End Depth (m)	Hole Length (m)	Volume per Well (m^3)
838 (33 in)	135	300	165	91
660 (26 in)	300	500	200	171
432 (17 in)	500	2,300	1,800	260

Cuttings from the 660 mm hole section will be returned to the surface and routed overboard via the shale chutes. Cuttings from the 432 mm hole section will be drilled with water-based drilling mud and will be discharged overboard.

2.6.4.2 Process Systems

The main function of the production facility will be to stabilize the produced crude by separating out the water and gas from the oil, sending the crude oil to storage, and treating and managing the separated gas and water and associated components such as sand. The following is a list of the main systems employed in the process and utilities during crude oil processing.

- Three-stage separation system: While a three-stage separation system is presently envisaged, alternative processes will be reviewed during FEED

  The high-pressure separator will receive the fluids from Hibernia and Jeanne d'Arc Pools, where the gas will be separated out. The liquids will be mixed with the fluids from the Ben Nevis Reservoir fluids prior to entering the medium-pressure separator, which separates out the water and the gas. The oil will then flow to the low-pressure separator, where additional gas will be released. From the low-pressure separator, the oil will flow to the coalescers, where more water will be removed such that it meets its oil-in-water sales specification. To achieve effective separation between oil and water, fluids will be heated prior to entering the medium-pressure and low-pressure separators. Water from the medium-pressure and low-pressure separators and coalescers will be routed through additional treatment equipment to remove residual oil prior to being discharged overboard. Discharged water will be in adherence with the OWTG (NEB et al. 2010). Gas from the high-pressure, medium-pressure and low-pressure separators will be compressed, dehydrated, re-circulated for gas lift, used for fuel for platform operations or injected into a gas storage reservoir for conservation purposes. The final

separation and compression system will be configured during detailed design

- Water Injection system: filtered, de-aerated and treated seawater will be metered and injected into the reservoir to maintain reservoir pressure to maximize oil recovery
- Current design includes the provision for overboard disposal of produced water, following treatment in accordance with the OWTG (NEB et al. 2010). Produced water will be discharged from a single point source below the summer thermocline at an approximate 50 m water depth. Water treatment technology was evaluated, and Compact Flotation Units (CFUs) were identified as the most advanced proven water treatment technologies available on the market for offshore application. The Hebron produced water treatment system includes CFUs in addition to hydrocyclones operating in series. The heavy, API 20 Hebron crude is expected to be difficult to separate from produced water. Thus, both hydrocyclones and CFUs are expected to be necessary to meet OWTG 2010 guidelines. EMCP is investigating various treatment options to reduce oil in water content for produced water, and is analyzing the feasibility of injecting produced water into the subsurface
- Vent and flare system: The Hebron flare system design is not yet complete. The flare system will implement a design that uses appropriate, available, proven technology to minimize smoke production. The system will be designed for pressure relief to prevent over-pressurization of equipment during process upset conditions. The flare will dispose of associated gas from the low pressure separator when the low pressure compressor is down for maintenance, during process upsets such as for brief periods after a medium pressure / high pressure (MP/HP) compressor trip, during emergency depressurization or other emergency events and during well tests. Small amounts of fuel gas will be continuously used for flare pilots and flare head purging. In the event of an emergency, gas from pressurized systems will be routed to the flare system. A flare knock-out drum will drop-out the liquids from the stream to be flared. This knock-out drum will be sized to remove liquids from the stream to be flared. Other systems operating at or near atmospheric pressure will be vented via an atmospheric vent header, located on the flare tower
- Design definition of utility systems, such as atmospheric tanks, is not well developed at this conceptual engineering phase. Definition will increase as engineering progresses. However, the low pressure atmospheric tanks that will be vented generally contain low vapour pressure sources (e.g., diesel, methanol) or non-hydrocarbon sources (e.g., glycol, fresh water, drill water, potable water. Most venting will occur during tank transfers and tank breathing. Vented volumes are expected to be minimal
- Oily water treatment: pressurized (closed) and open-to-atmosphere (open) drain systems will be used to collect fluids drained from equipment and run-off from the platform deck. The closed system will include separation and pressure reduction equipment to separate oil, gas and water. Oil will be recycled back into the process stream, gas will be vented to the flare

system and water will be treated prior to being discharged in accordance with OWTG (NEB et al. 2010). The open drain system will also separate oil using a recycle separation system, and water will be discharged overboard in accordance with OWTG (NEB et al. 2010)

- Chemical injection: chemical injection requirement details will be determined during the FEED phase and adjusted based on actual performance. EMCP will implement a chemical management system in accordance with the Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands (NEB et al. 2009). All chemicals will be screened according to the protocols established in the chemical management system. Typical chemical injection requirements for offshore oil and gas production facilities are:
  - Scale Inhibitor
  - Asphalthene Inhibitor
  - Defoamer
  - Biocide
  - Flocculant
  - Methanol
  - Corrosion Inhibitor
  - Oxygen Scavenger
  - Demulsifier
  - Pour Point Depressants
  - Drag Reducing Agents
  - Viscosity Reducing Agents
  - Wax Inhibitors
- Seawater lift: seawater will be required for injection into the reservoir to maintain reservoir pressure and to remove heat from the cooling medium. Seawater will be filtered and sodium hypochlorite will be added to prevent biological growth in the cooling water pipe
- Power generation: although subject to final design, EMCP plans to install four turbine-driven main generators (at least two of which will have dual-fueled capability), each capable of producing up to approximately 30 megawatts (MW) for a 4 x 33 percent configuration, as well as separate emergency and essential diesel generators
- Fuel gas: process gas will be taken from the gas compression stream for use as fuel gas. A diesel fuel system will provide backup in periods of process facilities shutdown and at initial start-up until gas compression is operable
- Process cooling: a closed loop cooling system is planned
- Crude oil offloading and metering system where crude oil will be lifted, pumped to full pressure and metered through a custody transfer quality metering system prior to being offloaded to shuttle tankers via the OLS
- Potable and service water: potable and freshwater generators are planned for the production of potable and service water
- Fire suppression systems: fire and gas detection and emergency shutdown systems will be installed to notify personnel and automatically

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respond to emergency situations. A combination of area seawater deluge, local vessel seawater spray, pressurized hose reels, fire monitors, foam systems and portable fire extinguishers will provide active fire suppression to the process areas of the platform. Active fire protection systems for the living quarters, utility, machinery, and electrical spaces may include sprinkler systems, foam systems, pressurized hose reels, portable fire extinguishers, water mist systems and inert gas systems. Passive fire protection may include fire and blast walls and decks and coatings on certain structural members and vessels

- Escape, evacuation, and rescue facilities: Escape routes to the fire-protected temporary safe refuge and lifeboat muster areas will be included in the platform layout per regulation. Evacuation facilities including lifeboats, life rafts and immersion suits will be provided per regulation. Rescue capability will be managed by platform support vessels and training of platform personnel
- Jet fuel storage: a jet fuel bulk storage and pumping system will be installed to provide refuelling capability for the helicopters servicing the installation
- Diesel fuel storage: a diesel fuel bulk storage, treating, and distribution system will be installed to provide fuel for power generation, as required (i.e., during start-up, shutdown periods)
- Hydraulic power: a central hydraulic fluid storage, pumping and distribution system may be installed to provide high pressure hydraulic fluid
- Heating, Ventilating and Air Conditioning: a heating and cooling system will be installed for heating, ventilating and air conditioning systems

2.6.4.3 Produced Water Management

Introduction

The management of water during Hebron production operations will be one of the most technically complex and challenging operations for an offshore production facility. Produced water discharge rates from the Hebron Platform are estimated at up to 56,000 m^3/d. The management of such high water volumes requires extensive equipment and associated piping which contributes significantly to topsides weight and costs as well as operational complexity.

As part of its overall water management strategy the operator is investigating the feasibility of injecting produced water mixed with seawater, into the reservoir for pressure maintenance. A mix of seawater and produced water is required, as the volumes of produced water are insufficient to maintain reservoir pressure.

EMCP has completed its initial assessment of produced water re-injection (PWRI) into the producing formations and has concluded there are unacceptable risks associated with initiating PWRI until factors associated with these risks are better known. Initial assessment indicates that PWRI into the producing formations for pressure maintenance purposes may be technically feasible, if technical risks can be reduced through further data

acquisition and studies post start-up. ExxonMobil is committed to adopting PWRI once it is demonstrated that the risks and costs are manageable.

Preliminary studies identified several potential risks to adopting PWRI:

- Souring potential is up to 50 percent greater than with injecting seawater only due to temperature and the presence of volatile fatty acids (VFAs)
- WRI could result in greater than predicted increases in injection pressure (potentially beyond pressure limits)
- Fracture containment could be compromised with increasing use of produced water
- Scaling potential is increased when injecting produced water into the formation

Confirming that these risks are manageable requires additional data that can only be obtained and analyzed post start-up and after several years of operation. For example, VFA content is highly variable across reservoirs and more produced water samples are required. Further, only a very small number of formation water samples are currently available – more are needed to draw firm conclusions.

The operator examined the potential to inject produced water (including partial re-injection) into dedicated disposal reservoir(s). Based on a this evaluation, suitable reservoir capacity to accept the produced water was limited. The cumulative volume of water produced in 30 years is approximately 366 million m^3. Over-pressuring of the disposal formation would also be a significant risk. With regard to partial re-injection, such an approach would require a duplication of the pumping facilities and associated piping currently required for seawater injection, additional well slots, and increased power generation capacity. The topsides design includes approximately 100 MW of power generation. Adding separate pumping facilities would require an increase in power generation of approximately 25 percent, and thereby increase the emissions. Produced water injection into dedicated reservoirs would exacerbate the weight, cost and operational challenges already inherent in offshore processing of a heavy crude. The added pumps and power generation equipment, as well as the use of well slots for additional dedicated injection wells, is not technically feasible, economically viable, nor environmentally sound.

Produced Water Management Strategy

Hebron will initially operate with marine discharge of produced water at start-up. As more wells come on-line and production data and experience is gathered, further testing on rock properties and produced water / seawater / reservoir compatibility will be carried out as additional core samples and produced water become available. Hebron will switch to PWRI for routine operations, once testing and studies (post-start-up) demonstrate that the risk and impacts of PWRI are understood and acceptable. When PWRI is adopted, the facility will maintain flexibility for marine discharge during unplanned events (e.g., equipment failure) or planned maintenance. In addition, it will be necessary to preserve the option to return to marine

discharge if unexpected complications arise with PWRI (e.g., loss of oil recovery, reservoir souring, scaling, plugging).

In the base design, the water injection system is designed to inject at the predicted pressures required for PWRI. The Topsides facilities include space and connections for the future installation of the low pressure incremental equipment required to route produced water into the water injection system.

Produced Water Re-injection Feasibility Studies

Large volumes of seawater will be needed for pressure maintenance and the design team investigated if produced water could be used to satisfy a portion of those needs. Several risks arise when mixing produced water with seawater and injecting into a producing formation that need to be well understood before committing to produced water re-injection:

- Compatibility of seawater and produced water with each other and the reservoir
- Potential to "plug" the formation
- Potential for injection pressures to increase with produced water / seawater mix compared to seawater only injection
- Potential for bacterial contamination of the producing formation

The proceeding sections summarize the studies completed to date, and further work to be completed.

Injectivity

Water injectivity (the ability to inject water into the producing formation) can be impaired over time by injecting produced water with higher concentrations of suspended solids and even relatively low concentrations of oil-in-water. Both of these would increase the risk of plugging pore throats in the near-well region where the injected water first enters the formation. In turn, such plugging may accelerate the rate of fracture growth and extend fractures beyond desired boundaries, leading to a potential loss of conformance and thereby reduced effectiveness in supporting reservoir pressure.

Thermal effects of PWRI may also influence water injectivity since PWRI is likely to raise the injected water temperature (compared to seawater-only) and thus increase the fracture extension pressure, leading to a reduction in injectivity index.

An injectivity study was conducted to assess the required injection pressure to achieve fracture injection for all potential injection wells in Hebron and how the injection requirements may change PWRI versus seawater injection.

The injectivity study found that PWRI is technically feasible from an injectivity standpoint; however, there are several vulnerabilities that require additional operational data to confirm. A key area of risk is that fracture pressure will increase through time with PWRI, and increasing fracture pressures can lead to a greater risk for loss of fracture containment during injection.

Scaling

Both seawater and produced water are a complex solution of dissolved components (many types of "salts"). Upon mixing, the positive and negative ions in each must reach a new balance and sometimes they combine to form a solid that precipitates out of solution. Some of these chemical reactions take time to occur and precipitation can occur during injection process, as pressure and temperature changes take place. The rock fractures and pore spaces can then get plugged by these solids and hinder or prevent future injection.

The only way to obtain a clear answer on the compatibility of Hebron produced water with seawater from the Grand Banks is to mix the two waters in a laboratory study and observe what happens under different temperature and pressure conditions. Such a definitive study cannot be done as yet, since there are no production wells available to sample. The produced water at the Hebron Platform will be a mix of produced water from several different reservoirs and, therefore, is not presently available for study.

However, the Project does have small samples of what is now "aged" water produced from individual reservoirs. These samples were obtained during production testing of individual wells from individual reservoirs in the late 1990s. These are now considered "aged" samples and, although ionic composition is the same, the potential loss of volatile organics and possible changes in organic composition could alter ionic reactions when mixed with seawater. Using these samples, the Project has proceeded with a small-scale study to obtain a preliminary understanding regarding the compatibility of the two waters.

The results of this small-scale study suggest with low certainty that mixing produced water and seawater is possible. However, further investigation is required, using samples of Hebron produced water from actual production wells, to confirm and validate these preliminary compatibility test results.

Souring (bacterial contamination)

In the oil producing reservoir, bacteria are present. Hydrogen sulphides (H_2S) act as an energy source and VFAs are the nutrient source. An increase in growth of bacteria could result in a plugging of the formation, or souring of the reservoir. Levels of souring are dependent upon VFA concentration in formation water.

An initial study of Pool 1 (Ben Nevis reservoir) souring susceptibility was conducted in 2005, using a range of levels of souring nutrients (VFAs) in formation water. Pool 1 predictions indicate potential for substantial total-wellstream mass of H_2S, and that the sulphide content forecast for mixed produced water / seawater injection is up to 50 percent higher than that for seawater-only injection.

PWRI is likely to increase the souring susceptibility of Pool 1 verses seawater only injection; however, further studies are required to determine the effects

and extent of souring from PWRI and if mitigations are available to control bacterial contamination, and prevent reservoir souring.

Disposal Reservoir

An evaluation was made to identify non-producing subsurface formations that could potentially serve as repositories for produced water. Ideally, such formations would be relatively thick and laterally continuous with high capacity for accepting a large volume of fluid, and would provide minimal potential for migration of injected fluid into other formations, or for entering subsurface faults that are conductive in character.

Screening of wireline well logs and mud logs revealed only one prospective non-producing formation that would merit quantitative analysis of its potential water storage capacity. A unit of porcelaneous mudstone (also known as the Tilton Member) exists in the Paleocene section approximately 300 m above the top of the Ben Nevis formation in the Hebron initial development area, and this unit was subjected to preliminary investigation as a possible storage compartment for Hebron produced water. Screening-level calculations were performed to estimate the thickness trend, average net-to-gross, average porosity and, subsequently, the net pore volume of this formation within the Hebron Unit boundary.

Results indicated that the porcelaneous mudstone unit is predicted to have far too little storage capacity to accept the forecasted volume of produced water over the life of the Hebron Project (an estimated 366 million m^3 plus additional produced water if future expansions are developed).

A screening assessment of the implications for topside facilities design indicated a requirement for additional dedicated pumping facilities and associated piping, additional well slots, and increased power generation capacity. This would exacerbate the weight, cost and operational challenges already inherent in offshore processing of a heavy crude and result in increased carbon dioxide emissions (approximately 150,000 tonnes of carbon dioxide equivalents) released into the atmosphere annually (4.5 million tonnes over 30 years).

The overall conclusion of the Project's evaluation is that disposal of produced water into Hebron non-producing formation(s) is not feasible when considering technical and economic factors. The operator's preferred approach is re-injection into the producing formation when all operational, technical, environmental, regulatory compliance, and economic factors are considered.

Plan for Completing further Produced Water Re-injection Feasibility Assessment

In order to complete an assessment of PWRI and ensure all risks are understood, additional formation water samples are required. This can only be completed post start-up and analyses will include measuring produced water compositions for each distinct hydrocarbon resource and determining the degree of intra-reservoir variability in water compositions. Produced

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water from a few geographically-distributed wells is likely to provide the highest-confidence data.

Further testing of produced water is required to confirm the scaling tendency / severity of seawater / produced water for both in-situ reservoir conditions and for operating conditions of wells / facilities. The concentration of VFA nutrients in produced water is needed for better forecasting of souring behaviour and additional measurements of variability will aid in characterizing the effects of mixed produced water / seawater.

Further testing is also required on the reservoir rock properties, and some fresh core material will be acquired in select new wells to enable lab displacement measurements of mixed-produced water- / seawater-waterflooding.

Topsides Facilities

The Hebron Topsides facilities include the best commercially proven water treatment technology and equipment for offshore applications. Heavy oil separation challenges warrant a robust produced water treatment system that includes hydrocyclones, CFUs, and degassing drum.

In addition, Hebron will include Vessel Internal Electrostatic Coalsescer technology, which minimizes emulsion layer thickness and creates a better defined oil / water interface, helping to mitigate oil carry-under from separators to the produced water treating system.

Pre-investment has been made in the water injections system to allow for PWRI to be initiated at a later date. Design elements include:

- System designed to inject at predicted pressures required for PWRI
- Inclusion of manifolds to blend produced water with seawater make-up
- Injection pump seals designed for the fine particles in produced water (a specialist application)
- Include space and connections for the future installation of the low pressure incremental equipment required to route produced water into the water injection system (i.e., low pressure booster pumps and filters)

Summary

ExxonMobil is committed to adopting PWRI for routine operations once it is demonstrated that the associated risks are acceptable.

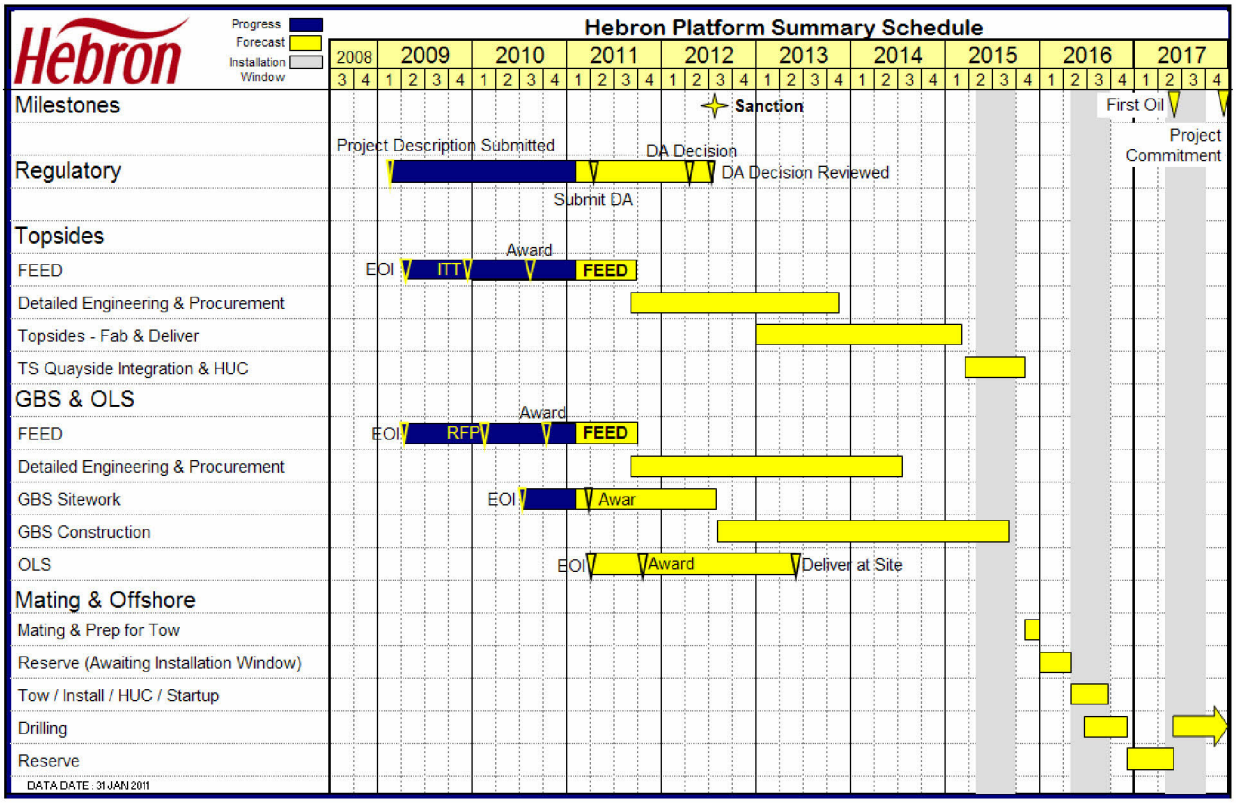
The Produced Water management strategy will be to operate with marine discharge of produced water at start-up using the best proven treatment technology available today. Hebron will switch to PWRI for routine operations, if testing and studies demonstrate that the risk and impacts of PWRI are understood and acceptable. The option will be preserved to return to marine discharge if unexpected complications arise with PWRI (e.g., loss of oil recovery, reservoir souring, scaling, plugging).

The Hebron water injection system will be designed to inject at predicted pressures required for PWRI, and include pre-investment for potential

establishment of PWRI (space and connections for additional PWRI equipment). A post-start-up study and testing plan will be developed to address uncertainties.

2.7 Project Schedule

The overall project development schedule is presented in Figure 2-10. The Hebron Project is committed to achieving first oil prior to the end of 2017.



Notes:

* DA - Development Application includes Development Plan, Benefits Plan, CSR, Socio-economic Impact Statement and other supporting documents as determined by the C-NLOPB

** This is the initial development schedule (base case) and does not include additional drilling / development for future developments

Figure 2-10 Hebron Project Development Schedule

2.8 Hebron Project: Construction and Installation

All shore-based construction activities are planned to take place (as far as practical) at established existing facilities in Bull Arm, Trinity Bay, or elsewhere in Newfoundland and Labrador at existing facilities. No new onshore facilities are planned; however, some of those existing facilities at the Bull Arm or other sites may need to be refurbished or expanded.

The Bull Arm Site will be used for the following activities: GBS construction, fabrication of selected Topsides modules, integration of all Topsides modules,

mating of integrated Topsides with the GBS, and hook-up and commissioning of the mated platform. Site preparation activities at Bull Arm will be required in order to ready the site for GBS construction and Topsides fabrication and integration. Various repairs and upgrades will be required to make the marine site suitable for construction and fabrication of Hebron Platform components. Some of the major work anticipated includes re-establishment of the bund wall and drydock, replacement of concrete batch plant and dredging of tow-out channel and blasting, if needed. Early works activities are scheduled to commence in 2011. The construction of the GBS is scheduled to commence 2012.

An estimate of the duration of activities associated with the GBS construction, Topsides fabrication, Topsides integration, tow-out and commissioning offshore is provided in Table 2-4. The following project durations are estimated timeframes. Some of the activities may occur concurrent with, or overlap with, other project activities.

Table 2-4 Hebron Estimated Maximum Project Durations

Activity	Estimated Duration
Drydock Preparation and Bund Wall Construction	6 to 18 months
GBS 'Dry' Construction	12 to 18 months
GBS 'Wet' Construction	12 to 18 months
Topsides Fabrication	18 to 24 months
Topsides 'Dry' Integration	7 to 12 months
Topsides 'Wet' Mating	1 to 2 months
Hook-up and Commissioning activities following mating (but prior to tow to field)	1 to 2 months
Tow to Site	10 to 14 days
Facility Installation	3 to 6 months
OLS Installation	3 to 6 months
Final Hook-up and Commissioning	3 to 9 months

2.8.1 Great Mosquito Cove: Drydock Construction

The existing Bull Arm drydock in Great Mosquito Cove will be re-established prior to starting construction of the GBS. The current concept is to construct a rock-fill dike (or bund wall) with a centre impermeable core comprised of a cement slurry across the cove to form the wall of the basin. It will be protected on the outside faces by a layer of crushed rock (e.g., quarried conglomerates and sandstones). It is estimated that the bund wall may be up to 500 m in length, and the area of the drydock at approximately 35,000 to 40,000 m^2. Exact configurations and designs will be determined during FEED.

Once the bund wall is in place, the drydock will be de-watered and the access roads rebuilt or replaced and the construction support infrastructure (offices, cranes, laydown areas) put in place. Additional infrastructure outside of the drydock itself will also be either refurbished or built to support GBS construction.

A list of potential marine activities and potential emissions and discharges, associated with the construction of the drydock is provided in Table 2-5.

Table 2-5 Potential Activities and Potential Discharges / Emissions / Wastes during Construction in the Drydock

Potential Activities	Potential Environmental Interactions / Discharges / Emissions / Wastes
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Air emissions • Bilge / ballast water • Onshore site runoff • Disposal / discharge of stormwater, potable water, fire water, and industrial water) • Elevated suspended solids • Substrate disturbance • Loss of subtidal habitat and organisms • Potential localized water column contamination • Sedimentation • Solid, construction, hazardous, domestic and sanitary waste disposal • Lights • Noise (including underwater) • Potential physical impacts (e.g., blasting)
Inwater Blasting	
Dewater Drydock / Prep Drydock Area	
Concrete Production (floating batch plant)	
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	
Lighting	
Air Emissions	
Safety Zone	
Surveys (e.g., geophysical, geological, geotechnical, environmental, Remotely Operated Vehicle (ROV), diving)	
Removal of Bund wall and Disposal (blasting, dredging / ocean disposal)	
Tow-out of GBS to Bull Arm deepwater site	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)[A]	
GBS Ballasting and De-ballasting (seawater only)	
[A] Pending requirements determined by bathymetry survey	

Bund wall design and selection of construction methods are ongoing. Alternative construction methods are being considered that may eliminate or reduce underwater blasting and dredging during construction.

Dredging and ocean disposal of the dredged spoils and/or bund wall may be required in association with the partial removal of the bund wall and to ensure adequate depth for navigation and tow-out of the GBS to the deepwater site. Dredging of shallow areas near the Topsides pier identified by detailed bathymetry, may be required, depending on the vessels chartered for load-out of the Topsides.

The disposal area in Great Mosquito Cove is unknown at this time. Work is ongoing to identify an area that has the least potential for habitat disturbance and that can accommodate the volume of spoils to be disposed. Based on preliminary review of the bathymetry and fish habitat information for Great Mosquito Cove, a likely candidate area is located at approximately 40 to 45 m water depth on the south side of Great Mosquito Cove. EMCP will consult with DFO and other federal authorities regarding the selection of the spoils disposal area. In addition, Transport Canada requirements regarding navigability of water channels will be included in the selection process.

2.8.2 Gravity Base Structure Construction at Drydock

GBS 'dry' construction in the drydock may include: skirts; base slab including mechanical outfitting and cantilevered base slab roof; and conventional and slip forming of the cantilever walls including the storage cell walls and ice walls with mechanical outfitting. Construction will continue to a height sufficient to allow floatout from the drydock and to maintain floating stability throughout. Once the drydock is flooded, the bund wall will be removed, and the partially constructed GBS will be towed to the deepwater site.

The first stage in the construction of the GBS is the installation of the skirts. The GBS base slab will be underlain by concrete or steel partitions, called skirts. The purpose of the skirts is to assist with sliding resistance of the GBS and to provide a containment system for the grout materials to be installed when the Hebron Platform is positioned offshore. The skirts may be prefabricated outside of the drydock and transported to the basin.

Construction of the base slab will begin once the skirts are positioned. Post tensioning ducts, anchors and other embedments will be installed simultaneously with rebar as the concrete work proceeds. Conventional methods will be used to construct the base slab.

The reinforced concrete walls above the base slab, including the ice walls, and crude oil storage tanks will be built by slipforming. Slipforming is a process of continually pouring high-strength concrete, reinforced with steel (rebar), into a form or mould that moves vertically with the assistance of hydraulic or screw jacks. The jacks are spaced at equal intervals to lift the form gradually, at a predetermined rate. In the case of a GBS, where a cavity is required in the concrete structure, inner and outer forms are used to create the cavity and concrete walls. Inside the walls, rebar is tied together vertically and horizontally to reinforce the concrete walls as they are poured. Post tensioning ducts are also placed in the forms and this reinforcement is tensioned after the concrete has reached sufficient strength. As the form rises, the section of previously poured concrete hardens and acts as support; strong enough to withstand the weight of the concrete being poured on top of it. Pouring is continued until the desired height is reached.

Some of the activities involved in slipforming include the following:

- Placing and compacting concrete in controlled layers
- Placing reinforcement, post tensioning ducts and anchors
- Installation of embedded mechanical outfitting items (e.g., pipe penetrations, instrumentation)
- Installation of embedment plates and block outs, sleeves / manholes
- Repairing deficient concrete surfaces
- Curing of cast concrete
- Dimensional control / verification and as-built measuring
- Civil and mechanical quality control

In the drydock, skirts will be installed; base slab, including mechanical outfitting and cantilevered base slab roof will be completed, and the storage cell walls and ice walls will be constructed. Mechanical and marine outfitting

will proceed in the lower levels of the GBS, with installation of permanent and temporary access systems, ballasting systems, grouting systems, safety systems, electrical and instrumentation systems, corrosion protection, and structures for marine towing and mooring. Once the walls are complete, the conductor frames will be lifted and placed in the GBS.

Once the base slab, cantilever and lower portions of the walls of the GBS are constructed, the casting basin will be cleared of infrastructure and filled with seawater to the level of Great Mosquito Cove. The bund wall will be removed (likely by clamshell dredge or dragline and extracting the sheet piles) to allow passage of the GBS out of the basin. The GBS will be towed out and moored at the deepwater site where construction will continue.

Some of the steps involved in the construction of a typical GBS are illustrated in Figure 2-11.

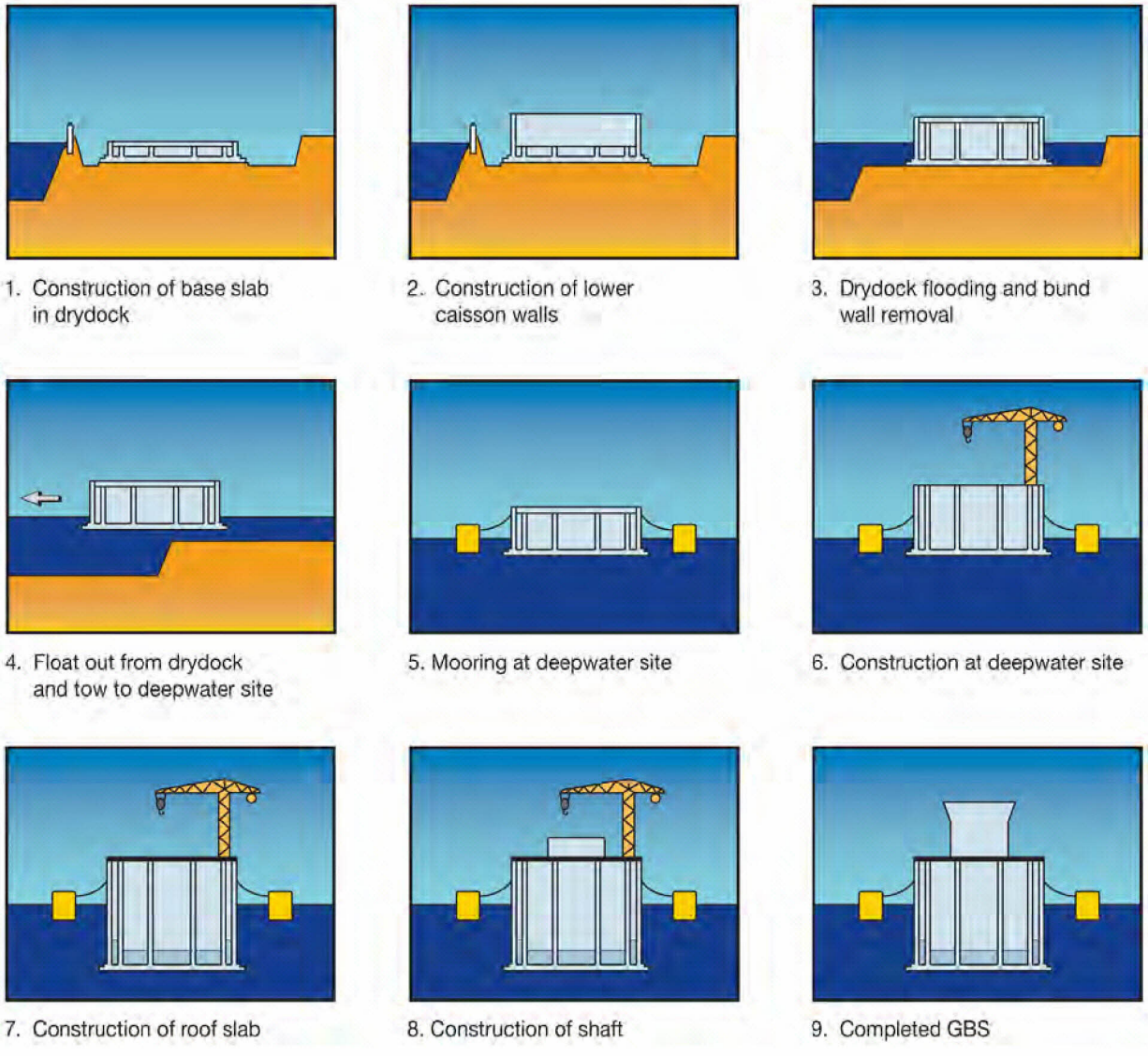


Figure 2-11 Schematic of Building a Gravity Base Structure

2.8.3 Deepwater Site Construction

Once moored at the deepwater site, slip forming of the storage cell walls and ice walls and mechanical completions continue to full caisson height. The Roof slab is constructed and slip forming and conventional construction of the remainder of the shaft continues to full height of GBS.

Construction of the caisson walls and the centre shaft walls by slip-forming, will be completed once the GBS is secured at the deepwater site in Bull Arm. It is anticipated that existing deepwater moorings will be used; however, additional moorings may be required. The requirement for additional moorings will be determined at the FEED stage. If additional moorings are required at the deepwater site, they will likely be constructed on land. The Hebron Project will consult with Transport Canada and DFO, and other federal authorities as may be required, regarding additional moorings at Bull Arm. The Environmental Protection Plan for Bull Arm (EMCP, 2011) includes mitigation measures for any land-based construction.

At the Topsides pier, temporary underwater moorings (or anchors) may be required to position the heavy lift vessel for Topsides tow-out. Details regarding the requirement for moorings, or the type of moorings that may be required are unknown at this time, as the Project is in the early stages of Project design. However, the Hebron HADD Strategy addresses all potential activities at Bull Arm, and any effects on fish habitat at this site, will be included in the fish habitat compensation plan, if warranted.

The GBS construction process will be similar to the slip-forming completed in the drydock and will require a number of support barges. The height of the walls will be extended to full height, requiring a floating concrete batch-plant, work barges and other support vessels on-site. Once the caisson walls reach full height and mechanical outfitting of the caisson is complete, a concrete roof slab will be constructed. The roof slab will be followed by construction of the centre support shaft. This shaft will support the Topsides facility.

The pier in Back Cove, which is the site of the ferry terminal to transport workers to the GBS in the deepwater site, may require upgrading. The details regarding the upgrades are unknown at this time, but likely will include a temporary replacement of the pier. As more information becomes available during FEED, EMCP will consult with DFO regarding construction activities. Design changes or mitigations will be considered to reduce potential impacts to the stream that flows into the cove. Currently proposed upgrades are anticipated to remain within the footprint of the original dock structure.

Support and transport barges are required at the floating construction site. One or two barges will be used to locate construction offices, tool cribs and other support buildings. Another barge will carry the floating concrete batch plant. Lastly, a series of transport barges will be used to ferry cement, aggregate, reinforcing bars, steel embedment and mechanical outfitting to the deepwater site. These barges will be moored to each other and to the structure with a series of attachment points which progressively move up the structure as it is built. Tugs will move transport barges to and from the deepwater site. Ferries or large crew boats will be used to transfer personnel

from shore to the deepwater site and back. A water supply floating pipe will be installed, from shore to the deepwater site. An underwater cable will provide electricity and communications.

The floating concrete batch plant will be designed to prevent release of untreated washwater and spoiled concrete into the environment. Washwater will be retained and directed to settling basins.

Once the vertical walls of the caisson are constructed, the permanent solid ballast will be placed. A portion of the ballast may be placed between the external ice wall and internal oil storage tank walls and another portion may go into the bottom of the storage cells themselves. Solid ballast is brought to the site on bulk carrier barges. A series of conveyors or a pumping system is then used to transfer and drop the ballast into the cells. In the storage cells, the material will be levelled and capped with a non-structural slab of concrete. Once complete, the ballasted GBS will undergo submergence testing and be prepared for mating with the Topsides.

A list of potential marine activities at the deep water construction site and associated emissions and discharges is provided in Table 2-6.

Table 2-6 Potential Activities and Potential Discharges / Emissions / Waste during Construction at the Deepwater Site

Potential Activities	Potential Environmental Interactions / Discharges / Emissions / Wastes
Re-establish Moorings at Bull Arm deepwater site Potential construction of new moorings, likely on-land	• Air emissions • Bilge / ballast water • Deck drainage • Disposal / discharge of stormwater, potable water, fire water, industrial water • Suspended solids • Noise (including underwater) • Sedimentation • Discharges associated with floating batch plant • Solid, construction, hazardous, domestic and sanitary waste disposal • Substrate disturbance • Lights • Discharges associated with hook-up and commissioning
Ballasting and/or Deballasting of GBS	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	
Power Generation	
Slipforming (operation of floating batch plant)	
Re-fueling of Vessels and/or Generators and other Equipment	
Upgrade Ferry Terminal in Back Cove (to transport workers to the GBS in the deepwater site)	
Operation of Passenger Ferries, Supply, Support, Standby, Mooring and Tow Vessels / Barges / ROVs and Possibly Helicopter during Commissioning of Helideck	
Mating of Topsides and GBS	
Hook-up and Commissoning of Topsides	
Mechanical Outfitting and Commissioning of GBS	
Tow Platform (GBS and Topsides) to Offshore Location (clearance dredging may be needed based on outcome of future studies)	
Lighting	
Air Emissions	
Safety Zone	

2.8.4 Topsides Fabrication and Assembly

It is intended that the helideck, lifeboat stations and flare boom will be constructed in Newfoundland and Labrador. Other modules will be constructed in Newfoundland and Labrador, subject to capacity and resource considerations. The UPM will be competitively bid internationally.

The Topsides design is based on the concept of an integrated deck (the UPM). The UPM reduces the amount of inter-module piping, electrical and instrumentation connections and maximizes the extent of pre-commissioning while at the fabrication site. Typical equipment and/or facilities in the UPM may include processing and utilities systems, switchgear, instrument rooms, and workshops. Space will be provided on the integrated deck for the installation of the remaining Topsides modules.

All modules will be assembled and integrated at Bull Arm on the Topsides integration pier. The various steps in Topsides assembly, integration and tow-out for mating are shown in Figure 2-12.

2.8.5 Topsides Mating and Commissioning

All modules are received, assembled and integrated on the assembly pier at Bull Arm. The use of an integrated UPM design will minimize the extent of physical hook-up needed during integration with the other modules. It is anticipated that individual modules will have considerable commissioning accomplished prior to integration.

Prior to mating, the completed GBS will be ballasted using a combination of solid ballast and seawater to the required depth while maintaining a freeboard. The Topsides will be floated on barges to the GBS in catamaran formation. Once positioned, the GBS will be de-ballasted until connection is made with the Topsides. Hook-up and commissioning will continue after mating.

It is expected that Topsides fabrication will take approximately 30 months at a number of different fabrication facilities, with assembly and integration of all modules accomplished at the Bull Arm Topsides integration pier. Hook-up, commissioning and tow-out to field preparations continue over the one to two months following mating.

2.8.6 Offshore Site Preparation

Ship-based environmental and engineering surveys may be required prior to offshore installation of the platform. Geophysical, geological and geotechnical surveys may require the use of seismic, multibeam, echosounder, sidescan sonar, and or subbottom profiler techniques and equipment. Pending further engineering and design, all of these surveys may not be required and some may occur during other Project stages.

Environmental surveys may include meteorology, oceanography, fish and sediment sample collection, habitat surveys by ROV and iceberg surveys.

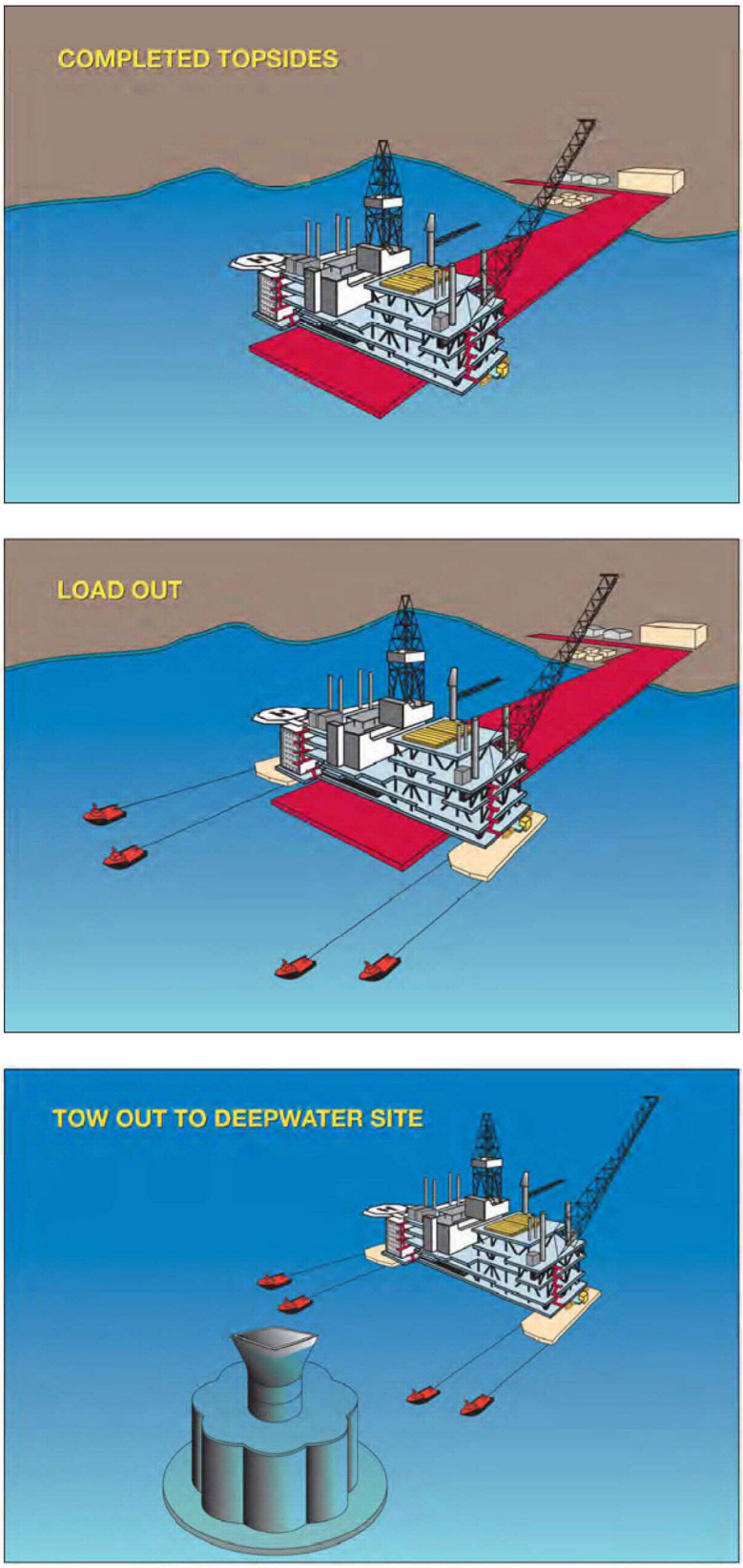


Figure 2-12 Example of Hebron Topsides Integration onto Gravity Base Structure

2.8.7 Platform Tow-out and Offshore Installation

The completed Hebron Platform (GBS and Topsides) will be towed to the permanent site, 340 km offshore. The weather window for tow out from the deepwater site to the Hebron field is ideally from May through September. For tow-out, the GBS will be de-ballasted to maintain a required freeboard.

After de-ballasting the GBS to ensure the necessary under keel clearance, the Hebron Platform will be released from its moorings at the deepwater site and the tow will begin using first class towing vessels (high performance tugs) in a similar configuration to that used for Hibernia tow-out. During towing, there will be tugs running ahead of the platform, with other tugs following for back up, if needed. The tow of the platform to site is anticipated to take between 10 and 14 days.

The Hebron Platform will be set in place on site on the Grand Banks. Skirt penetration into the seabed may be assisted by a skirt evacuation system to assist with release of entrapped air and water in the skirt compartments. Additional seawater ballast will be added to the platform. Grouting around the base of the Hebron Platform may be required to increase uniformity in foundation bearing pressure and increasing the platform stability in situ. Final hook-up and commissioning may take between three to nine months.

Potential activities that may be associated with offshore site preparation, tow-out, and installation of the platform and potential environmental interactions are listed in Table 2-7.

Table 2-7 Potential Activities and Potential Discharges / Emissions / Wastes during Hebron Platform Tow-out and Installation

Potential Activities	Potential Environmental Interactions / Discharges / Emissions / Wastes
Clearance Surveys (e.g., geohazard, sidescan sonar, diving, ROV, prior to installation of platform, OLS, potential excavated drill centres in the future)	• Air emissions • Bilge / Ballast water • Deck drainage • Disposal / discharge of stormwater, potable water, fire water, cooling water and industrial water • Elevated suspended solids • Marine / underwater noise • Potential loss of benthic habitat and organisms • Potential substrate disturbance • Potential water column effects • Fish habitat disturbance • Sedimentation • Lights • Discharges associated with hook-up and commissioning
Installation of Temporary Moorings	
Tow-out / Offshore Installation	
Possible Clearance Dredging	
Seafloor Levelling for Platform Installation	
Placement of Platform at Offshore Site Location	
Underbase Grouting	
Possible Offshore Solid Ballasting	
Placement of Rock Scour Protection on Seafloor around Final Platform Location	
Operation of Helicopters, Supply, Support, Standby and Tow Vessels / Barges	
Hook-up, Production Testing and Commissioning	
Hydrostatic Testing (OLS and offloading lines)	
Possible Flaring during Production Testing	
Lighting	
Air Emissions	
Safety Zone	

2.8.8 Offshore Loading System Construction and Installation

The OLS off-loading lines and risers will be placed at their location, approximately 2 km from the platform, either before or after Platform installation. Methods to be used for the installation of the OLS will depend on the final design of the OLS. It is anticipated that the OLS off-loading lines will be placed using conventional pipe lay techniques; trenching or burial is not anticipated. OLS bases may be anchored to the seabed by piles, or other suitable means, to provide a stable connection for the OLS risers. Rock dumping and/or concrete mattress pads may be required for insulation and stability. Support vessels (diving, supply vessels) will likely be required.

Potential activities that may be associated with OLS, construction and installation and potential environmental interactions are listed in Table 2-8.

Table 2-8 Potential Activities and Potential Discharges / Emissions / Wastes during Offshore Loading System Construction and Installation

Potential Activities	Potential Environmental Interactions / Discharges / Emissions / Wastes
Clearance Surveys (e.g., sidescan sonar, diving, ROV) prior to Installation of Platform, OLS	• Air emissions • Bilge / Ballast water • Elevated suspended solids • Marine / underwater noise • Potential loss of benthic habitat and organisms • Potential substrate disturbance • Potential water column contamination • Sedimentation • Solid, construction, hazardous, domestic and sanitary waste disposal • Lights
Operation of Helicopters, Supply, Support, Standby and Tow Vessels / Barges or Specialized Pipe-lay Vessel	
Anchor OLS Bases to Seabed by Piles	
Installation of OLS (may may be trenched to protect offloading flowlines; may be installed using diving vessels)	
Placement of Insulation / Stabilization (rock or concrete mattress pads) on the Seafloor over the OLS Offloading Lines	
Install OLS Riser	
Install Tie-ins to Platform	
Integration Testing Programs between the OLS Risers and OLS Bases and between the OLS Risers and Tanker Loading Equipment	
Hydrostatic Testing (OLS and pipelines)	
Possible Use of Corrosion Inhibitors or Biocides (OLS or flowlines)	
Lighting	
Air Emissions	
Safety Zone	

2.9 Hebron Project Operations

The Hebron Project operations will be managed by EMCP as Operator, employing both Company and third-party services. The Project will be managed and operational decisions will be made from offices in St. John's, Newfoundland and Labrador.

2.9.1 Production Operations and Maintenance

Potential activities that may be associated with production operation and maintenance activities and potential environmental interactions are listed in Table 2-9.

Table 2-9 Potential Activities and Potential Discharges / Emissions / Wastes during Production

Potential Activities	Potential Environmental Interactions / Discharges / Emissions / Wastes
Operation of the Platform and OLS	• Air emissions • Bilge / ballast water • Changes to water quality in receiving environment • Deck drainage • Disposal / discharge of stormwater, potable water, fire water, cooling water, and industrial water • Drilling fluids and cuttings (WBM / synthetic-based mud (SBM)) disposal • Produced water discharge • Seawater / Firewater • Storage Displacement Water Discharges • Well treatment fluids Elevated TSS levels • Noise (including underwater noise) • Possible substrate disturbance • Possible loss of fish habitat • Lights • Safety zone
Maintenance Activities	
Power Generation and Flaring	
Normal Platform and OLS Operational Activities	
Operation of Seawater Systems (cooling, firewater)	
Operation of Oil Storage / Storage Displacement Water System	
Water Requirements (potable water, fire water, cooling water and industrial water)	
Waste Generated (domestic waste, construction waste, hazardous, sanitary waste)[A]	
Operation of Produced Water Treatment / Disposal System[B]	
Corrosion Protection System	
Use of Corrosion Inhibitors or Biocides (e.g., hypochlorite)[C]	
Grey Water and Black Disposal	
Chemical / Fuel Management and Storage	
Operation of Helicoptors, Supply, Support, Standby and Tow Vessels / Barges / ROVs	
Offloading of Produced Crude	
Well Workovers (e.g., drilling, completing, testing)	
Preparation and Storage of Drilling Fluids	
Managment of Drilling Fluids and Cuttings (reconditioning, discharge or injection)[D]	
Management and Storage of BOP Fluids and Well Treatment Fluids	
Cementing and Completing Wells	
Operation of Possible Disposal Well(s)	
Oil Processing Systems	
Seawater Injection System (to maintain reservoir pressure)	
Gas Injection Systems	
Artificial Lift (gas lift, electric submersible pumps or a combination)	
Oily Water Treatment[E]	
Produced sand management[F]	
Vent and Flare System[G]	
Diving Activities	

A Hazardous and non-hazardous wastes will be managed to avoid interactions with the marine environment
B Produced water will be discharged in accordance with OWTG
C The Operator will evaluate the use of biocides other than chlorine. The discharge from the hypochlorite system will be treated to meet a limit approved by the C-NLOPB's Chief Conservation Officer
D WBM cuttings will be discharged overboard in accordance with the OWTG; SBM cuttings will be re-injected into a designated well bore
E Operational discharges will be treated prior to being discharged overboard in accordance with OWTG
F Current drilling designs are focused on the prevention of produced sand to Topsides (downhole sand control). Produced fines are expected. Topsides sand management will be focused on the handling of these fines. In the unlikely event of failure of the downhole sand control system, management of the produced sand will be required (singular event)
G Small amounts of fuel gas will be used for flare pilots and may also be used to sweep the flare system piping or burn excess gas

2.9.2 Operational Support

The onshore organization will include engineering, technical support, Safety, Security, Health and Environment, logistics, financial and administrative personnel. Onshore support for docking, warehouse space, helicopter operations and product transshipment will be carried out at existing worksites in Newfoundland and Labrador. The Hebron Project will look to optimize existing operations at EMCP, through the sharing of resources, contracts, where feasible.

2.9.3 Logistics and Other Support

Four key areas of logistical support required during the operation and maintenance of the Project are shorebase support, personnel movements, vessel support and ice management. Where practical, the Operator will consider possible synergies with existing Grand Banks operators. The Project will also be supported by Oil Spill Response personnel.

Shorebase Support: Marine shorebase and warehouse facilities using existing facilities in St. John's and surrounding areas capable of providing Project support activities will be used. Existing port facilities are capable of servicing multiple operations, including wharfage, office space, crane support, bulk storage, consumable (fuel, water) storage and delivery capability.

Personnel Movements: Helicopters will be the primary method to transfer personnel between St. John's and the offshore platform. Personnel may also be transferred using supply vessels, when required (i.e., weather or other logistical delays). The Operator will consider and discuss possible shared services with other Grand Banks operators with a view to optimizing the fleet configurations of all operations and providing the safest and most efficient and effective service. There were 280 crew change flights during Hibernia operations in 2008.

Vessel Support: Supply and stand-by vessels will be required to service the operational needs of the platform and drilling units in the Hebron Field. Supply vessels may also be required to conduct components of the Environmental Effects Monitoring (EEM) program and for oil spill response support, training and exercising. The Operator will consider and discuss possible synergies with other Grand Banks operators, where practical, with a view to optimizing the fleet configurations of all operations and providing the safest and most efficient and effective service. As with current operations, vessels associated with the Hebron Project will operate within established shipping corridors between St. John's and the Offshore Project Area. As an estimate of vessel frequency that may apply to the Hebron Project, there were 122 vessel sailings from St. John's to Hibernia in 2008.

Ice Management: The Grand Banks Ice Management Plan has been developed by existing operators and the Hebron Project is expected to participate in this program. Reliable systems for the detection, monitoring and management of icebergs and pack ice, including towing techniques, have been developed for the Grand Banks area.

2.9.4 Communications

Offshore telecommunications systems to support the Hebron Project may include the following systems:

- Private Automatic Branch Exchange and emergency telephone systems
- Public Address and General Alarm system
- Radio systems – platform trunked, marine, aeronautical
- Radio console system
- Radio antenna tower
- C-Band Satellite system
- Inmarsat A satellite terminal
- GMDSS system
- Lifeboat radio systems
- Racon
- Crane radio system
- Metocean / Ice Management Radar Monitoring system
- Collision-avoidance Radar / navigational
- Differential GPS system
- Tanker telemetry system
- Closed Circuit Television
- Inter- / Intra-platform telephone system
- Microwave radio to Hibernia
- Inter- / Intra-platform LAN / WAN data communications network
- Entertainment system
- Security system
- Telemed system
- Additional telecommunication systems, which may be required, will be investigated during FEED and detailed design

These systems must operate and be suitable for a remote installation in all weather and atmospheric conditions anticipated on the Grand Banks. The systems must be fully available and operable during both steady state conditions and during all platform emergencies and power outages. Uninterruptible power supplies must be incorporated as required, in order to achieve this requirement. The applicable onshore components must also incorporate the same availability and operability standards.

2.9.5 Shipping / Transportation

Crude oil from the Hebron Platform will be transported to the Newfoundland Transshipment Terminal or direct to market. Assuming a peak production of 24,000 m^3/day, it is estimated that Hebron will require one tanker loading every six days, for a total of approximately 60 tanker loadings per year. Based on these estimates, it is anticipated that the existing tanker fleet (three tankers) currently servicing Hibernia and Terra Nova will be used; no additional tankers are anticipated to be required. Tankers will use existing international shipping lanes (as shown in Figure 2-13 and established shipping lanes when transitting to the transshipment facility in Placentia Bay.

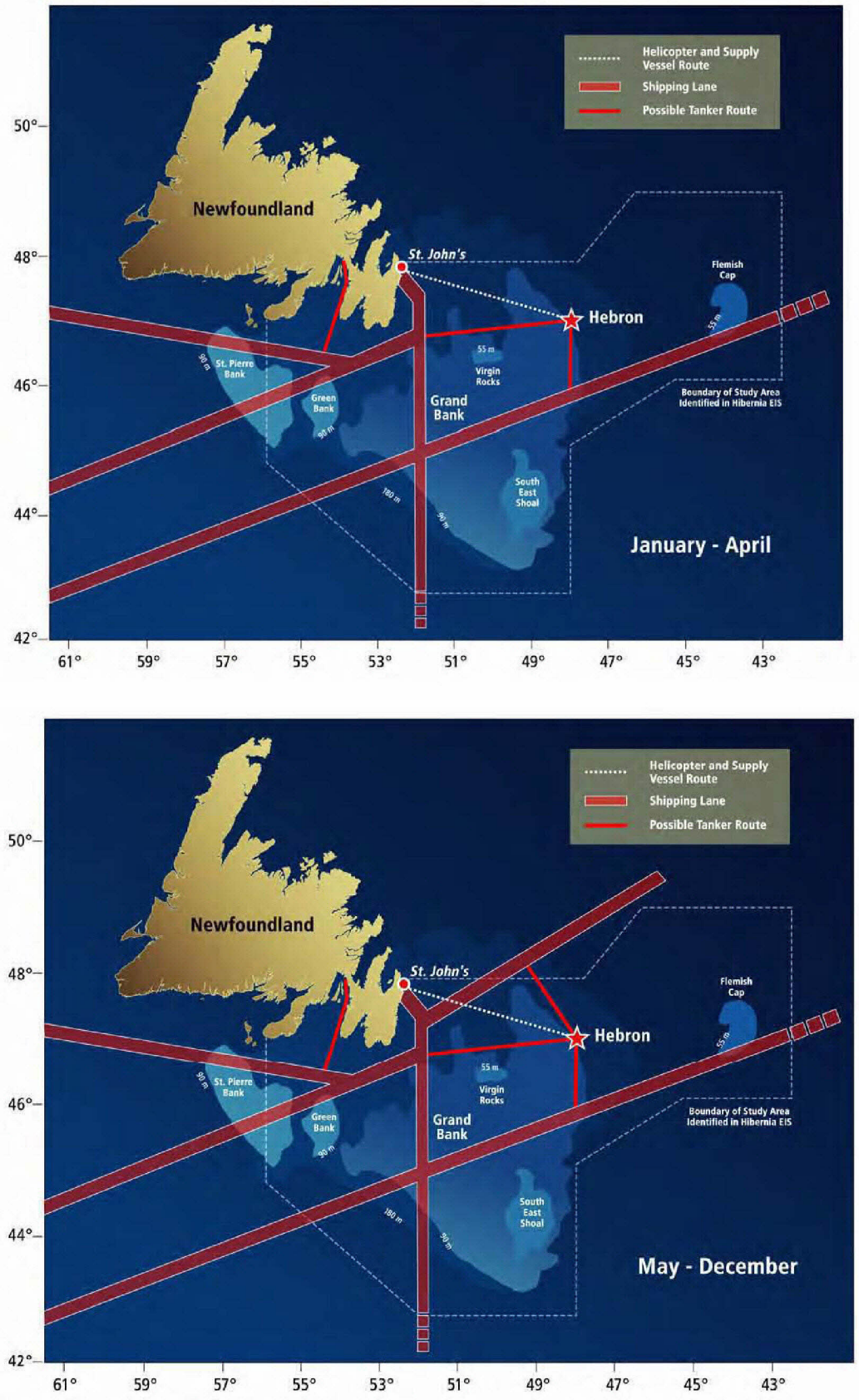


Figure 2-13 Transportation Routes Relevant to the Hebron Field

2.9.6 Surveys and Field Work

2.9.6.1 Seismic Surveys

Seismic surveys are a technique used to map rock layers and properties with sound propagation and related echo mapping (includes seismic mapping). The goal of a seismic survey is to develop an image of the subsurface geology and of the features where hydrocarbon reserves could accumulate (i.e., subsurface strata and structures).

Seismic surveys are undertaken by a specialized vessel towing a submerged, compressed air-driven gun (sound source) array to produce short bursts of sound energy. The acoustic pressure pulse travels into the seafloor and reflects off various seafloor layers. Hydrophone assemblies are towed as streamers behind a vessel to record the reflected sound waves.

There can be between six to ten streamers towed in typical 3D surveys. Typically, one streamer is towed in a 2D survey. Each streamer contains a dense array of hydrophone groups that collect and pass to recorders echoes of sound from reflecting layers. The depths of the reflecting layers are calculated from the time taken for the sound to reach the hydrophones via the reflector; this is known as the two-way travel time. Positional and signal return-time data are collected over a grid pattern and analyzed to develop an image of the geological layering beneath the seabed, allowing potential hydrocarbon traps to be identified. A 2D survey typically covers a larger area than a 3D survey, which tows more streamers over a finer grid pattern than a 2D survey. Typical seismic surveys are able to map rock layers over 10 km deep (CEF 1998).

Seismic airguns release most of the acoustic energy focused in a vertically downward direction. The noise associated with airguns can range between approximately 215 and 235 dB re 1 µPa-m for a single airgun and approximately 235 to 260 dB re 1 µPa-m for arrays (Richardson et al. 1995). Source levels off to the sides of the array in the horizontal are generally lower.

The arrays and hydrophones are usually towed several metres below the sea surface. A typical seismic survey lasts several weeks and covers a range of approximately 555 to 1,110 km. The ship towing the array is typically 60 to 90 m long and moves through the water at speeds usually in the range of 8 to 10 km/h (4.5 to 5.5 knots).

In general, the frequency output of an airgun depends on its volume: larger airguns generate lower-frequency impulses. However, due to the pulsive nature of the source, airguns inevitably generate sound energy at higher frequencies, above 200 Hz, although the energy output at these frequencies is substantially less than at low frequencies.

2.9.6.2 Geohazard Surveys

Well site or geohazard surveys may be used to identify and avoid unstable areas (e.g., shallow gas deposits) or hazards (e.g., shipwrecks) prior to drilling. The well site survey may use a combination of video and a small

acoustic array and/or sonar over the well location. Although a variety of seismic sources may be used for such a wellsite / geohazard survey, a typical source is a 160 cu. in. four-gun ladder array of sleeveguns with an estimated source level of 238 dB re 1µPa @ 1m (zero to peak) towed at a depth of 3 m. This equates to 244 dB re 1µPa @ 1m (peak to peak).

2.9.6.3 Geotechnical Surveys

Geotechnical programs are those surveys involving the measurement of physical properties of the seabed and soil. Seabed surveys using geophysical and geotechnical methods are used to determine the nature of the seafloor and underlying sediments. These surveys assist in the positioning of wells, pipelines and production facilities.

Substrate properties often need to be characterized prior to installation of any equipment on the substrate (such as the Platform and flowlines). Geotechnical investigations primarily involve the physical collection of sediment samples, and may also include collection of geophysical data (i.e., side-scan sonar), as described in Section 2.9.6.1. Methods to collect sediment samples include drilled boreholes and grab samples. Boreholes are drilled at each of the potential site to a specified depth, which is program specific and depends on data requirements.

Due to the shallow nature of most boreholes, they are usually entirely in soils (unconsolidated sands, silts, and clays) and will not penetrate hydrocarbon-bearing formations. Cuttings will be expelled at the seafloor. Approximately 1 m^3 cuttings is typically generated per borehole.

2.9.6.4 Vertical Seismic Profiling Surveys

VSP may be also conducted as part of the drilling and production activities using an airgun array. VSPs are a collection of well bore measurements (seismograms) recorded by geophones inside the wellbore using sound sources at the surface near the well. A VSP is used to correlate well data with surface seismic data, to obtain images of higher resolution than surface seismic images and to collect data ahead of the drill bit. The array is similar to that employed by 2D or 3D seismic surveys, but is typically smaller and deployed in a smaller area over a shorter time period, often only 12 to 36 hours, but occasionally up to several days. An airgun similar to that employed for surface seismic collection is used as the seismic source.

An imaging toolstring is run in the wellbore and is anchored at successive points as required to cover the entire recording depth. With a zero-offset VSP, a seismic source array is deployed over the side of the drilling platform. The source is activated (typically three to five times) to create a sonic wave that is picked up by geophones in the toolstring.

Typically, only one zero-offset VSP is conducted on each well when total depth has been reached. An operator may elect to conduct two zero-offset VSPs per well, when the intermediate and lower hole sections have been drilled. An operator may also elect to conduct a walkaway VSP concurrent to the intermediate hole section zero-offset VSP. A walkaway VSP is a type of

VSP in which the source is moved to progressively farther offset at the surface and receivers are held in a fixed location, effectively providing a mini-2D seismic line that can be of higher resolution than surface seismic data and provides more continuous coverage than an offset VSP. 3D walkaways, using a surface grid of source positions, provide 3D images in areas where the surface seismic data do not provide an adequate image due to near-surface effects or surface obstructions. If a walkaway VSP is used, the two source arrays would not be activated concurrently.

2.9.6.5 Environmental Surveys

Environmental surveys are those surveys involving the study of physical, chemical and biological elements of the site. They may involve collection of data on ice and icebergs, weather, biota, sediments or water. Methods of data collection include direct observation, onsite weather station, core or surficial sediment sample collection, or fish sampling by various methods. Environmental surveys also include environmental effects monitoring programs.

2.10 Decommissioning and Abandonment

The Operator will decommission and abandon the Hebron production facility according to regulatory requirements in place at the time of end of Project life. The Hebron Platform infrastructure will be decommissioned and the wells will be plugged and abandoned. The Hebron Platform structure will be designed for removal at the end of its useful life.

2.11 Potential Expansion Opportunities

Future development of resources is anticipated within the four Significant Discovery Licenses, and/or on adjacent land that may be acquired by Project Proponents. These expansion developments may be produced from the platform or through tie-back using subsea flowlines. Such developments may require the addition of one or more excavated (s) within the Project Area. J-tubes and/or risers will be incorporated into the GBS design to accommodate this tie-back option. The excavated drill centres would be situated within the Hebron Project Area as required over the duration of the Project.

For any excavated drill centre that may be constructed, final locations will be adjusted based upon future engineering, seismic, geotechnical and geohazard investigations. The conceptual well and flowline configurations described below are tentative and subject to further review before the final design is determined. These possible expansion developments may involve, but are not limited to, the following activities:

- Construction, installation, operation, maintenance, modification, abandonment and decommissioning of up to four excavated drill centres (up to approximately 70 m x 70 m x 10 m in size) that contain the equipment necessary to support the extraction of petroleum resources:

  - Each of the excavated drill centres could contain a number of injection or production wells
  - Would be excavated using proven construction methods for the Grand Banks
  - Excavated drill centre dredge spoils disposal in one or more approved areas

- Construction, installation, protection, operation, maintenance, modification, abandonment and decommissioning of subsea flowlines / umbilicals and associated equipment (inclusive of water, gas and oil flowlines) tied back to the Hebron Platform:
  - This includes any associated seabed trenching, excavation, covering and/or soil deposition
  - Concrete mattresses positioned over the flowlines near the platform may be installed by a diving support vessel or another vessel of opportunity
  - Well tie-ins may be performed by an installation vessel and/or a MODU (with ROV support) during the subsea construction program
  - Trees, templates, and manifolds would be installed by installation vessel, whereas pipeline-to-manifold tie-ins may be made by divers and/or ROV
- Possible requirement for additional topsides equipment located on the Hebron Platform to provide additional process capacity
- Drilling, completion and workovers of subsea wells; may be undertaken from one or more MODUs
- Geophysical (seismic (2D/3D/4D), geohazard / wellsite, VSP) surveys and/or geotechnical investigations
- Supporting activities including ROV surveys and Diving Programs and operation of support craft associated with the above activities including but not limited to vessels for excavated drill centre excavation, offshore drilling platforms, supply vessels, standby vessels and helicopters

It is anticipated that the excavated drill centres will be constructed using proved methods and will be of similar design to those already in-place on the Grand Banks. Each of the excavated drill centres could contain a number of injection or production wells. The installation of subsea infrastructure would be by installation vessel, divers, and/or ROV. If required, concrete mattresses will be positioned over the flowlines near the Hebron Platform may be installed by a diving support vessel or another vessel as appropriate. Measures to protect flowlines from iceberg scour will be identified and implemented where required.

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3 PHYSICAL ENVIRONMENT SETTING

3.1 Nearshore Environment (Bull Arm Area)

The Hebron Gravity Base Structure (GBS) construction site is located at Bull Arm, Trinity Bay. Bull Arm is approximately 16 km in length, with an average width of 1.6 km, located at the northwest end of the head of Trinity Bay at the isthmus that connects the Avalon Peninsula with the main body of the Island of Newfoundland. Trinity Bay is a large bay on the northeastern coast of Newfoundland with a length of approximately 100 km, orientated towards the northeast.

Eastern Newfoundland coastal areas are dominated by the southward flowing inner branch of the Labrador Current with typical speeds of 0.72 km/h (20 cm/s) (Petrie and Anderson 1983; Petrie 1991; Narayanan et al. 1996). The combination of the longshore drift, tidal currents and undertows results in southward flows along headlands and other exposed coastlines that can, at times, be considerably larger than mean flows.

Local circulation can be markedly different within major coastline bays than that on the outer coast. The mean current speeds are lower in Trinity Bay (Yao 1986) and Conception Bay (deYoung et al. 1993; deYoung and Sanderson 1995) than those along the outer coastlines. Flow speeds are controlled by the local underwater topography in most of the area; basin shape also plays an important role. Tidal flows in the bays are also weak, with typical speeds of a few centimetres per second or less. Exposure to ocean waves is much reduced within the larger embayments and in areas sheltered by offshore islands, resulting in much different beach types.

The shoreline environment is also seasonally affected by sea ice through bottom scouring during break-up. Landfast ice cover can also protect the shoreline from waves and strong currents in more sheltered locations. Pack ice often covers the shoreline from mid-March to late April, moving quickly along the exposed offshore shorelines due to local winds and currents and remaining in the major bays for extended periods. More detail on the nearshore physical environment of Trinity Bay can be found in ExxonMobil Canada Properties (EMCP 2010).

3.1.1 Atmospheric Environment

3.1.1.1 Wind Climatology

The east coast of Newfoundland experiences predominately southwest to west flow throughout the year. However, local topography has a large influence on the wind direction and speed experienced within Bull Arm, Trinity Bay. The nearest MSC50 Climatology Station to Bull Arm is Grid Point M12874 (47.7°N, 53.8°W) (Figure 3-1).

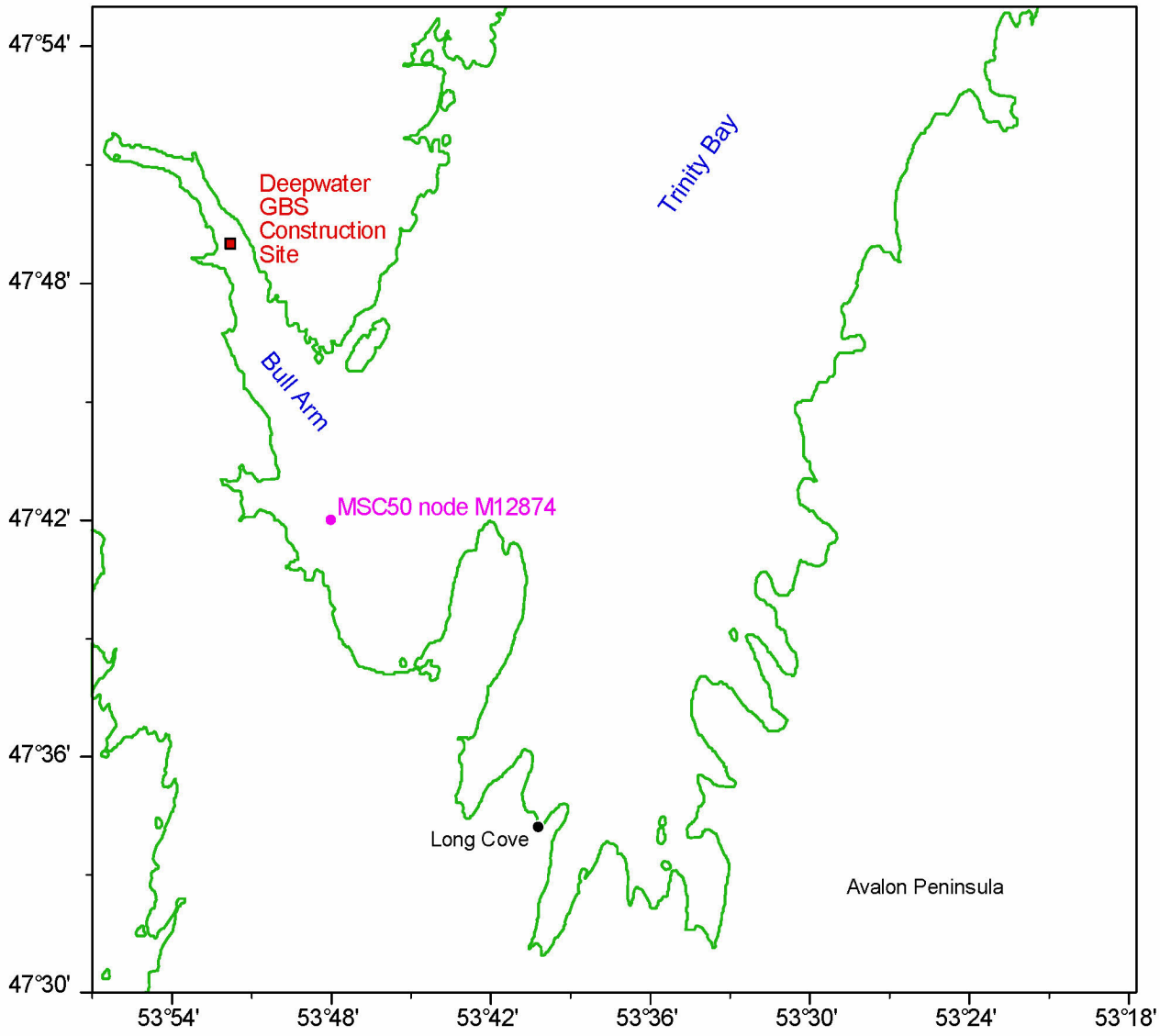


Figure 3-1 MSC50 Climatology Grid Point (M6012874)

Wind roses of the annual wind speed from Grid Point M12874 (Figure 3-2) and the Bull Arm weather station (Figure 3-3) highlight the differences between the climatologically winds and those measured within Bull Arm. The generally west to southwest flow typical of the climatology of the region is more northwesterly due to the effects the topography. More detail on the data sources used to the nearshore wind climatology can be found in EMCP (2010).

Data sources for Grid Point M12874 and other observation points are provided in Table 3-1.

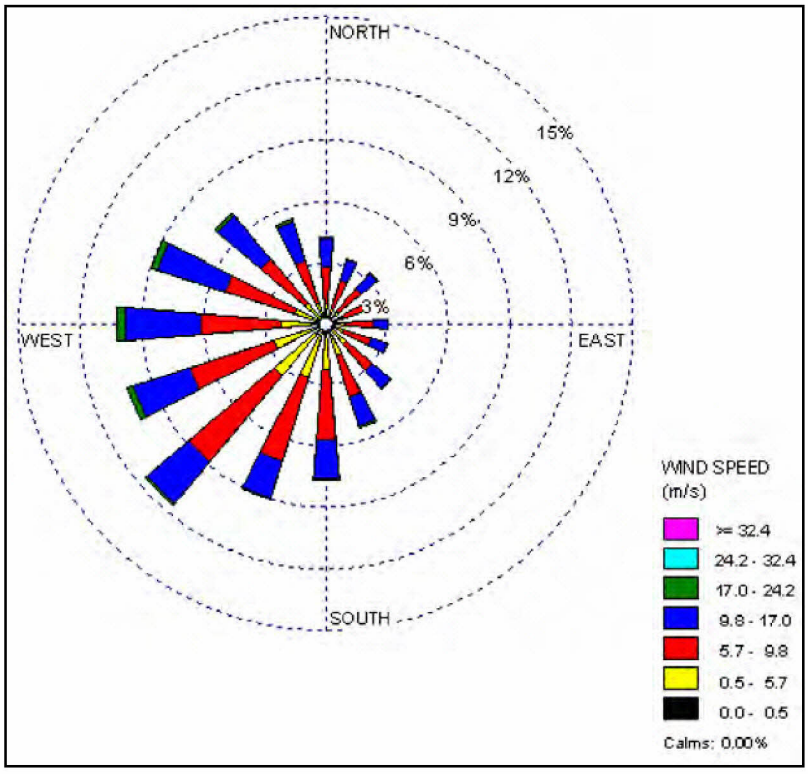


Figure 3-2 Annual Wind Rose for MSC50 Grid Point M12874, 1954 to 2005

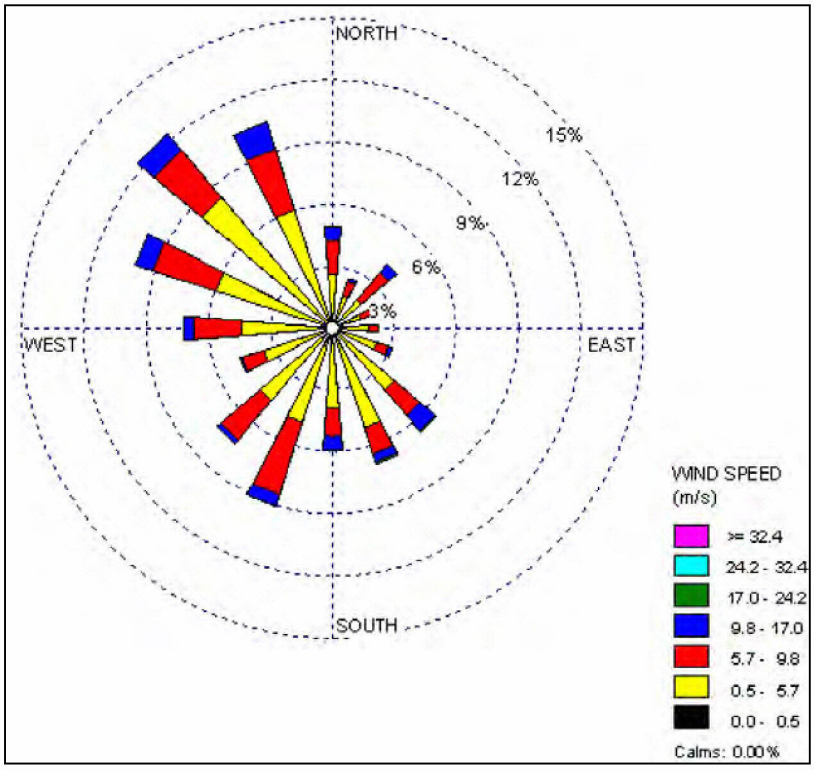


Figure 3-3 Annual Wind Rose for the Bull Arm Weather Station, January 1995 to May 1997

Table 3-1 Data Sources

Source	Period	Location	Station Elevation (m asl)	Anemometer Height (asl)[A]	Water Depth (m)
M12874	January 01, 1954 to December 31, 2005	47.70°N; -53.80°W			140.89
Environment Canada Bull Arm	June 08, 1994 to May 28, 1997	47.82°N; -53.90°W	119.0	129.0	
Oceans Bull Arm (Wind)	January 26, 1995 to May 27, 1997	47.82°N; -53.86°W	1.0	11.0	
Oceans Bull Arm (Wave)	May 15, 1995 to January 31, 1996	47.82°N; -53.86°W			155.00
Argentia, NL	January 01, 1953 to May 25, 1970	47.30°N; -54.00°W	13.7	23.7	
	May 01, 1976 to October 31, 1986	47.30°N; -54.00°W	15.5	25.5	
	January 01, 1987 to July 26, 2006	47.30°N; -54.00°W	19.0	29.0	
Arnold's Cove, NL	July 01, 1971 to July 01, 1993	47.78°N; -54.00°W	15.2	25.2	

A Anemometer heights for the Environment Canada stations assume that the standard 10 m anemometer height was used

Low pressure systems crossing the area are more intense during the winter months. As a result, mean wind speeds tend to peak during winter. Mean wind speeds at Grid Point M12874 and in the observation data sets peak during the winter months (Table 3-2); wind speeds measured at Bull Arm are lower than those of other stations surrounding it. These lower wind speeds are probably due to the effects of local topography; however, they may also be an artefact of the smaller data set. The smaller difference in wind speed during the winter months would indicate that topography is the main cause of the weaker winds, especially during the predominant southwest winds in the summer. The percentage occurrence of wind speeds within specific categories is presented in Figure 3-4, which shows that moderate winds are predominant at Grid Point M12874, and that wind speeds higher than strong rarely occur.

Intense mid-latitude low pressure systems occur frequently from early autumn to late spring. In addition, remnants of tropical systems have passed near Newfoundland between spring and late fall. Therefore, while mean wind speeds tend to peak during the winter months, maximum wind speeds may occur at anytime during the year. Monthly maximum wind speeds for each of the data sets is presented in Table 3-3.

The highest wind speed of 27.8 m/s recorded at the Environment Canada station in Bull Arm occurred on February 13, 1995. During this event, a mid-latitude low pressure system tracked eastward across Newfoundland, and deepened rapidly as it moved over the cold North Atlantic Ocean. During this same event, the Oceans Bull Arm weather station reported wind speeds of 15.9 m/s. Unfortunately, the waverider buoy at Bull Arm was not reporting during this event.

Table 3-2 Mean Wind Speed Statistics

Month	MSC50 Grid Point 12874	Bull Arm Environment Canada	Bull Arm Oceans	Argentia	Arnold's Cove
January	10.6	7.7	6.7	7.9	6.9
February	9.9	7.5	5.7	7.5	6.8
March	9.2	7.1	5.7	7.0	6.4
April	8.0	6.3	5.3	6.3	5.4
May	6.4	5.9	4.5	5.5	4.8
June	5.7	5.8	4.0	5.5	4.8
July	5.4	6.0	4.0	5.2	4.6
August	6.0	5.6	3.4	5.4	4.8
September	7.3	6.2	4.7	5.8	5.2
October	8.6	6.5	4.5	6.6	5.9
November	9.5	7.4	5.2	7.1	6.6
December	10.4	7.1	5.7	7.8	7.2

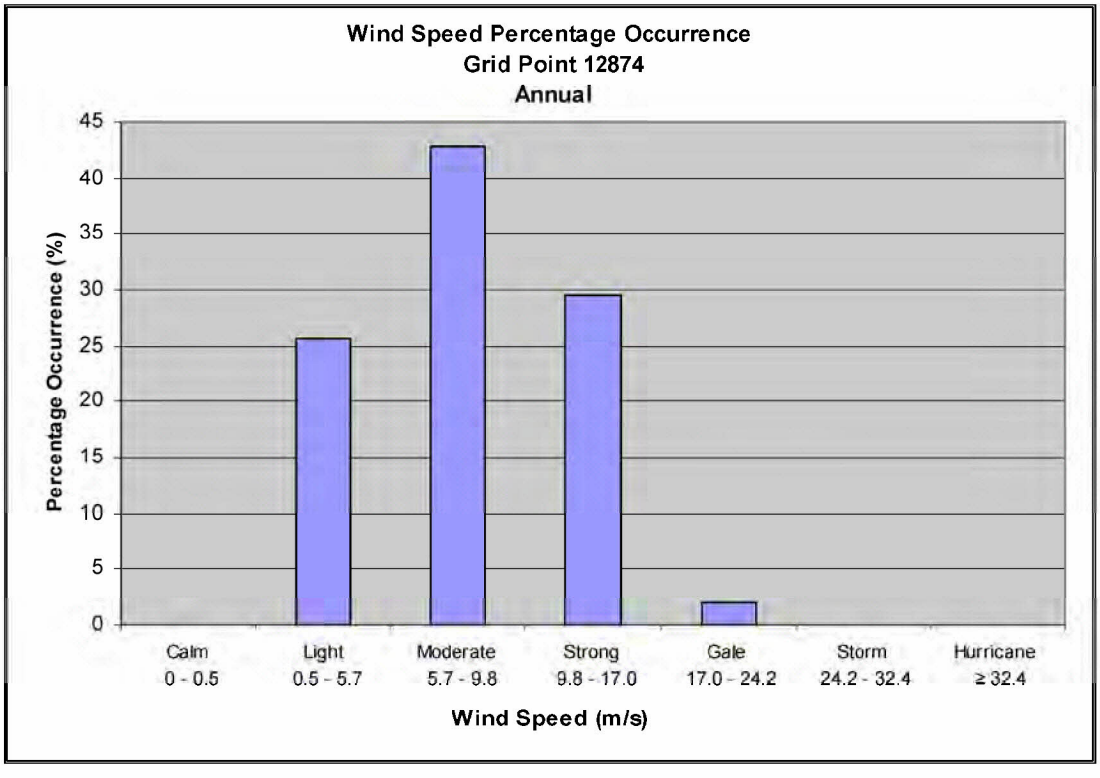


Figure 3-4 Annual Percentage Frequency of Wind Speeds for MSC50 Grid Point 12874,1954 to 2005

Table 3-3 Maximum Wind Speeds Statistics

Month	MSC50 Grid Point M12874 (m/s)	Bull Arm Environment Canada (m/s)	Bull Arm Oceans (m/s)	Argentia (m/s)	Arnold's Cove (m/s)
January	27.6	24.7	19.6	30.3	25.6
February	26.8	27.8	19.6	30.8	25.0
March	25.7	22.6	20.6	24.2	22.2
April	20.5	17.5	16.5	25.8	22.0
May	19.5	19.6	15.4	23.4	19.2
June	19.6	16.5	14.4	20.6	18.9
July	21.6	17.0	16.0	21.7	18.3
August	22.1	17.5	11.3	22.2	23.4
September	25.2	21.1	16.5	24.7	18.3
October	26.3	18.5	15.4	28.6	22.8
November	24.0	21.1	17.5	28.0	23.4
December	24.5	27.3	19.0	30.0	25.8

Rapidly deepening storm systems known as weather bombs frequently cross Newfoundland. These storms typically experience explosive deepening in the warm waters off Cape Hatteras and move northeast across the Grand Banks. Some of these storms move across the island of Newfoundland. During one such event on February 22, 1967, Argentia wind speeds peaked at 25.0 m/s from the west-southwest, while wind speeds at MSC50 Grid Point M12874 peaked at 24.4 m/s.

3.1.1.2 Temperature

The moderating influence of the ocean serves to limit both the diurnal and the annual temperature variation along the coast of Newfoundland. Diurnal temperature variations due to the day / night cycles are very small. Short-term, random temperature changes are due mainly to a change of air mass following a warm or cold frontal passage. In general, air mass temperature contrasts across frontal zones are greater during the winter than during the summer season.

Air and sea surface temperatures for the area were extracted from the Bull Arm weather station. Temperature statistics presented in Table 3-4 show that the atmosphere is coldest in January and February, and warmest in August.

Monthly mean daily maximum and minimum temperature statistics are also presented. Mean temperatures for each month are the mean of all temperatures recorded at the site during that month. The maximum and minimum temperatures are the highest and lowest temperatures, respectively, recorded during the month over the entire data set. The mean daily maximum is the average of all maximum temperatures recorded during the specified month, while the mean daily minimum is the average of all minimum temperatures recorded during the specified month.

Table 3-4 Bull Arm Air Temperature Statistics

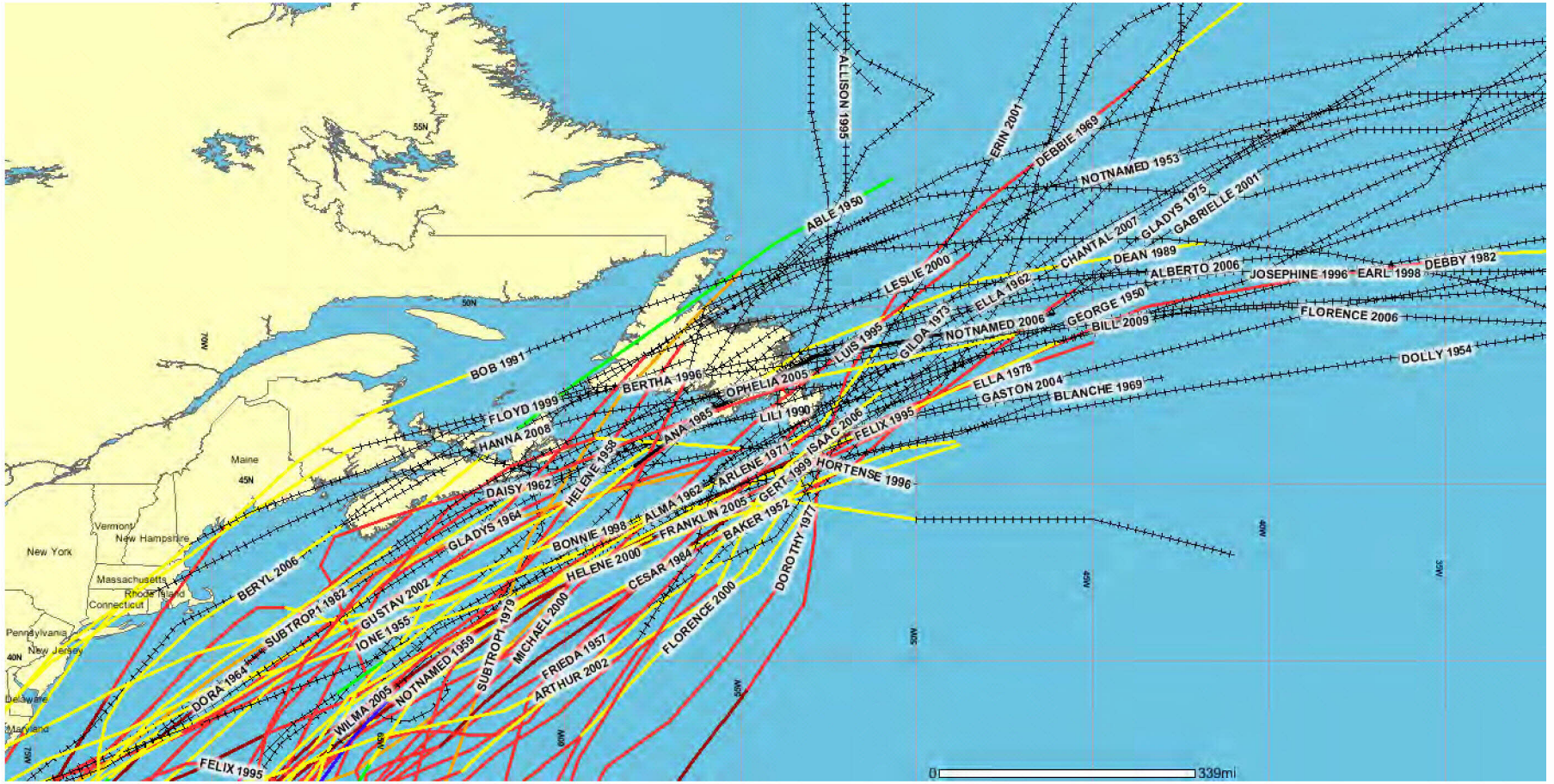
Month	Mean (°C)	Maximum (°C)	Minimum (°C)	Standard Deviation (°C)	Mean Daily Maximum (°C)	Mean Daily Minimum (°C)
January	-4.7	9.0	-16.0	5.09	-1.2	-7.5
February	-4.6	11.2	-16.6	5.43	-0.7	-8.1
March	-3.3	8.7	-17.1	4.94	0.11	-7.37
April	2.2	14.46	-11.31	3.09	5	-0.29
May	5.02	14.8	-2.03	2.50	8.45	2.49
June	9.13	21.36	0.05	3.16	13.43	5.62
July	13.92	23.57	5.33	3.17	17.56	11.25
August	15.33	27.64	6.89	3.39	19.4	12.21
September	12.01	22.64	2.84	3.34	15.14	9.16
October	8.03	16.54	0.25	2.90	10.31	5.98
November	3.59	14.24	-7.99	3.83	6.6	1.34
December	-0.6	12.7	-14.0	4.78	2.3	-3.17
Source: Oceans Ltd. weather station in Bull Arm 01/95-04/97						

3.1.1.3 Tropical Systems

During the 59-year period from 1950 to 2009, 60 tropical systems have passed within 278 km of Bull Arm. The tracks over Trinity Bay are shown in Figure 3-5 and the names of each hurricane are listed in Table 3-5.

It must be noted that the values in Table 3-5 are the maximum 1-minute mean wind speeds occurring within the tropical system at the 10-m reference level as it passed.

On occasion, these systems still maintain their tropical characteristics when they reach Newfoundland. On September 11, 1995, Hurricane Luis made landfall as a Category 1 near Argentia with maximum sustained winds of 41.2 m/s and a central pressure of 963 mb. Hurricane Luis then tracked northeast across the Bay de Verde Peninsula and into the Atlantic. Wind speeds at Argentia peaked at 18.6 m/s, while wind speeds from the MSC50 Grid Point M12874 peaked at 25.2 m/s as this system passed. During this same event, the Bull Arm weather station only recorded wind speeds of 8.7 m/s. This may be the result of a number of factors, including local effects and distance of the site from the storm centre. Significant wave heights measured by the waverider buoy peak near 0.5 m shortly after the storm passed.



Source: National Oceanic and Atmospheric Administration (NOAA) Coastal Services Centre Archive No Date

Figure 3-5 Storm Tracks of Tropical Systems Passing within 370 km of 47.8°N 53.9°W, 1950 to 2009

C0814-095

Table 3-5 Tropical Systems Passing within 370 km of 47.8°N 53.9°W, 1950 to 2009

Year	Month	Day	Hour	Name	Lat	Long	Wind (m/s)	Pressure (mb)	Category
1950	8	22	0600Z	Able	49.8	-56.8	12.9	N/A	Tropical Depression
1950	10	5	1200Z	George	47.0	-51.9	30.9	N/A	Extratropical
1952	9	8	0600Z	Baker	45.6	-51.7	33.4	N/A	Category 1
1953	10	8	1800Z	Not Named	49.1	-57.0	30.9	N/A	Extratropical
1954	9	3	0600Z	Dolly	45.8	-51.9	28.3	N/A	Extratropical
1955	9	22	0000Z	Oione	48.4	-55.8	23.1	N/A	Extratropical
1957	9	27	0600Z	Frieda	46.3	-52.8	18.0	N/A	Extratropical
1958	9	29	1800Z	Helene	49.0	-56.6	33.4	968	Extratropical
1959	6	21	1200Z	Not Named	47.3	-53.7	23.1	N/A	Extratropical
1962	9	2	1200Z	Alma	42.2	-61.0	7.7	N/A	Extratropical
1962	10	9	0000Z	Daisy	45.5	-57.7	25.7	N/A	Extratropical
1962	10	22	1200Z	Ella	46.7	-53.4	30.9	N/A	Extratropical
1964	9	15	1800Z	Dora	47.6	-55.6	28.3	N/A	Extratropical
1964	9	24	1800Z	Gladys	44.7	-60.3	30.9	990	Extratropical
1969	8	12	1800Z	Blanche	46.0	-54.9	30.9	N/A	Extratropical
1969	8	24	1200Z	Debbie	48.0	-52.0	36.0	N/A	Category 1
1970	10	17	1800Z	Not Named	42.5	-57.5	36.0	980	Category 1
1971	7	7	1800Z	Arlene	46.5	-53.0	23.1	N/A	Extratropical
1973	10	28	0600Z	Gilda	47.5	-51.5	28.3	968	Extratropical
1975	10	3	1200Z	Gladys	46.6	-50.6	43.7	960	Category 2
1977	9	30	0000Z	Dorothy	47.0	-51.0	25.7	995	Extratropical
1978	9	5	0000Z	Ella	45.0	-55.0	54.0	960	Category 3
1979	10	25	0600Z	Sub Tropical 1	47.5	-58.4	25.7	982	SubTropical
1982	6	20	1200Z	Sub Tropical 1	44.5	-60.0	30.9	984	SubTropical
1982	9	19	0000Z	Debby	45.3	-53.5	46.3	970	Category 2
1984	9	2	0000Z	Cesar	44.9	-53.3	23.1	998	Tropical Storm
1985	7	19	0600Z	Ana	46.0	-57.6	28.3	996	Extratropical
1989	8	8	1800Z	Dean	48.8	-53.2	23.1	995	Tropical Storm
1990	10	15	0600Z	Lili	46.6	-56.4	20.6	994	Extratropical
1991	8	21	0600Z	Bob	50.9	-54.9	20.6	1008	Extratropical
1995	6	9	0600Z	Allison	48.1	-55.9	20.6	996	Extratropical
1995	8	22	1200Z	Felix	46.8	-50.8	25.7	985	Tropical Storm
1995	9	11	0600Z	Luis	47.1	-54.2	41.2	963	Category 1
1996	7	15	0600Z	Bertha	49.0	-52.0	23.1	996	Extratropical
1996	9	16	0000Z	Hortense	46.0	-54.0	20.6	998	Extratropical
1996	10	10	1200Z	Josephine	49.5	-55.0	23.1	983	Extratropical
1998	8	30	1200Z	Bonnie	44.5	-53.5	23.1	1000	Tropical Storm
1998	9	6	0000Z	Earl	47.0	-54.0	25.7	979	Extratropical
1999	9	19	0600Z	Floyd	48.5	-52.5	18.0	994	Extratropical
1999	9	23	0600Z	Gert	44.6	-54.5	30.9	968	Tropical Storm
2000	9	17	1200Z	Florence	42.5	-55.0	25.7	1000	Tropical Storm

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Year	Month	Day	Hour	Name	Lat	Long	Wind (m/s)	Pressure (mb)	Category
2000	9	25	1200Z	Helene	44.0	-55.5	28.3	988	Tropical Storm
2000	10	8	1800Z	Leslie	49.0	-54.0	18.0	1005	Extratropical
2000	10	20	0000Z	Michael	48.0	-56.5	38.6	966	Extratropical
2001	9	15	0000Z	Erin	46.7	-52.7	30.9	981	Tropical Storm
2001	9	19	1800Z	Gabrielle	46.5	-52.0	30.9	986	Extratropical
2002	7	17	1200Z	Arthur	48.0	-54.0	20.6	1002	Extratropical
2002	9	12	1800Z	Gustav	50.1	-55.5	30.9	967	Extratropical
2004	9	1	1800Z	Gaston	45.0	-55.0	23.1	998	Extratropical
2005	7	30	1200Z	Franklin	45.8	-51.7	20.6	1005	Extratropical
2005	9	19	0000Z	Ophelia	48.4	-52.3	23.1	1000	Extratropical
2005	10	26	1200Z	Wilma	45.0	-55.0	25.7	986	Extratropical
2006	6	16	1200Z	Alberto	47.4	-55.0	23.1	985	Extratropical
2006	7	19	0000Z	Not Named	48.6	-52.9	12.9	1012	Tropical Low
2006	7	22	0600Z	Beryl	47.2	-60.0	18.0	1003	Extratropical
2006	9	13	1800Z	Florence	46.4	-54.0	36.0	963	Extratropical
2006	10	2	1800Z	Isaac	45.5	-53.7	28.3	995	Tropical Storm
2007	8	1	1200Z	Chantal	46.0	-54.5	28.3	990	Extratropical
2008	9	8	0600Z	Hanna	47.5	-55.4	20.6	996	Extratropical
2009	8	24	0600Z	Bill	48.0	-53.0	30.9	980	Tropical Storm

3.1.2 Oceanic Environment

3.1.2.1 Bathymetry

The bathymetry within Bull Arm and the head of Trinity Bay (Canadian Hydrographic Services (CHS) 1997) is illustrated in Figure 3-6. The range of depths within this area is from 1 to 2 m near shore to between 260 and 300 m at the head of Trinity Bay. Bull Arm has a deep centre channel reaching depths of over 200 m where it merges into Trinity Bay.

3.1.2.2 Waves

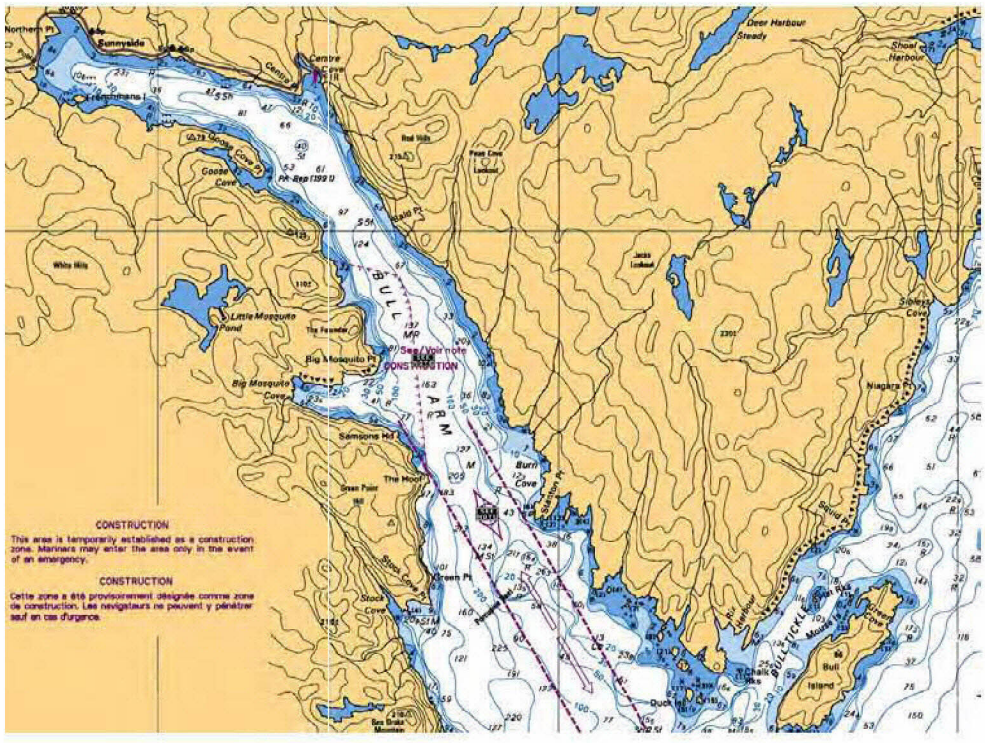
Two primary wave data sources for the nearshore environment include waves measured in Bull Arm over a nine-month interval from the Hibernia GBS construction period, and the multi-year MSC50 Grid Point M12874 wave hindcast for a location outside Bull Arm[1]. The MSC50 Grid Point would be influenced by northeasterly swell energy propagating into Trinity Bay. Due to its orientation with Trinity Bay, Bull Arm would see little swell energy. However, caution should be taken with respect to this Grid Point, due to its proximity to land and the resolution of the MSC50 model.

The MSC50 waves were partitioned using a Pierson-Moskowitz spectrum into a primary and secondary partition, where the primary partition is

[1] Water depths: Trinity Bay MSC50 grid point M12874: 141 m; Bull Arm Waverider buoy: 153 m and (redeployed) 155 m.

representative of the wind wave, and the secondary partition is representative of swell.

A



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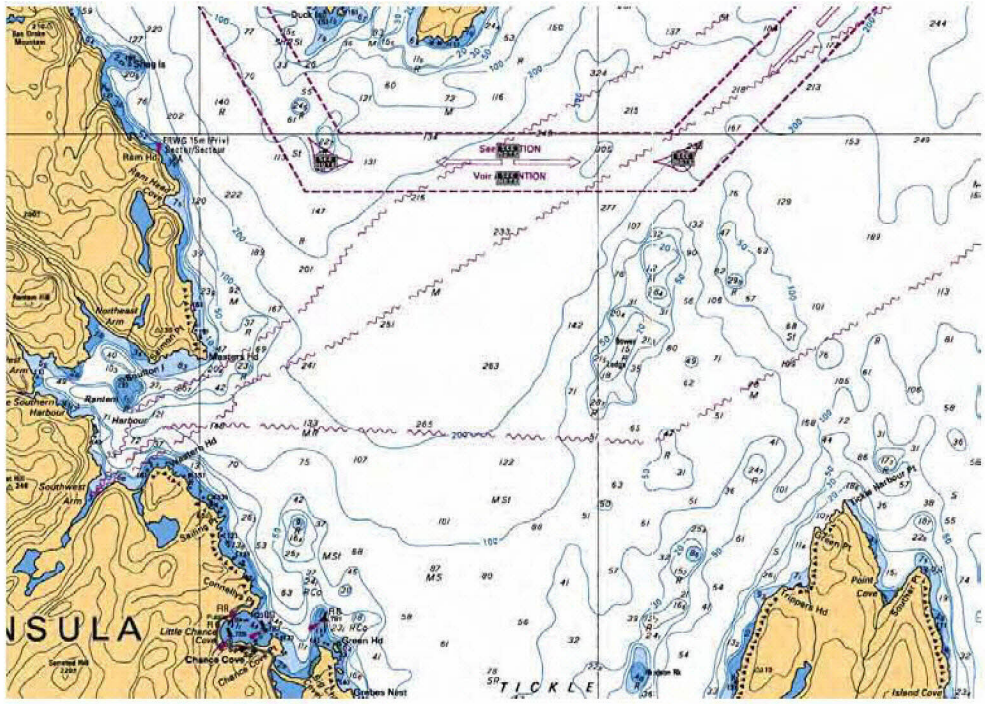


Source: CHS 1997, Chart #485101

Note: Depth in metres. Scale 1:60,000

Figure 3-6 Bathymetry in Bull Arm (A) and Head of Trinity Bay (B), Newfoundland

Table 3-6 Mean Monthly Significant Wave Height Statistics (m) for the MSC50 Data Set

	MSC50 Grid Point M12874 Combined Sea	MSC50 Grid Point M12874 Wind Wave	Oceans Wave Buoy
January	0.64	0.60	0.17
February	0.57	0.54	0.21
March	0.52	0.49	No measurement
April	0.41	0.39	No measurement
May	0.29	0.26	0.14
June	0.23	0.21	0.15
July	0.21	0.19	0.09
August	0.25	0.23	0.05
September	0.36	0.33	0.11
October	0.47	0.44	0.12
November	0.55	0.52	0.14
December	0.62	0.58	0.14

Table 3-7 Maximum Significant Wave Height Statistics (m) for the MSC50 Data Set

	MSC50 Grid Point M12874 Combined Sea	MSC50 Grid Point M12874 Wind Wave	Oceans Wave Buoy
January	1.90	1.88	1.37
February	1.53	1.52	1.22
March	1.71	1.62	No measurement
April	1.48	1.46	No measurement
May	1.52	1.50	0.76
June	1.29	1.28	1.69*
July	1.21	1.17	0.49
August	1.22	1.18	0.22
September	1.41	1.37	0.53
October	1.58	1.57	0.66
November	1.53	1.48	1.21
December	1.92	1.91	1.17

Significant wave heights (Hs) at the head of Trinity Bay peak during the winter months with Grid Point M12874 having a mean monthly significant wave height of 0.64 m in January. The lowest significant wave heights occur in the summer with July having a mean monthly significant wave height of only 0.21 m (Table 3-6).

Maximum combined significant wave heights also peak during the winter months; however significant wave heights of 1.2 m may occur at any time throughout the year due to tropical systems passing through the area. A quality control was done on the Oceans Ltd. Waverider data set, and numerous spikes in the data set were removed.

Wave roses for MSC50 Grid Point M12874 and the wave height statistics are provided in EMCP (2010).

The Hs ranges from near-calm conditions to 1.9 m, with the largest waves occurring in January and December. Over one-third of all waves (38 percent) are 0.3 m or less. During the summer months, waves are most frequently from the south-southwest. By fall, westerly waves most frequently propagate into the area. The peak wave period (Tp) ranges from just less than 4 s on average to 25 s, with most periods (81 percent) between 2 and 4 s.

As presented in the previous section, wave buoy measurements for a nine-month interval in 1995-1996 are available from the Hibernia GBS construction period.

By way of comparison, time-series plots for two months, July and December 1995, are presented in Figures 3-7 and 3-8, (wind and wave direction are both shown as direction from to facilitate comparison) which show wave height, wave period and, to assist in interpreting directional influences, wind speed and wind direction. The MSC50 wave direction is superimposed in blue on the wind direction panel. While the wave conditions are clearly less in Bull Arm compared with the Trinity Bay (Tickle Bay) location, during episodes of moderate or strong southeast winds, e.g., December 7th and 9th/10th, wave heights are of comparable magnitude.

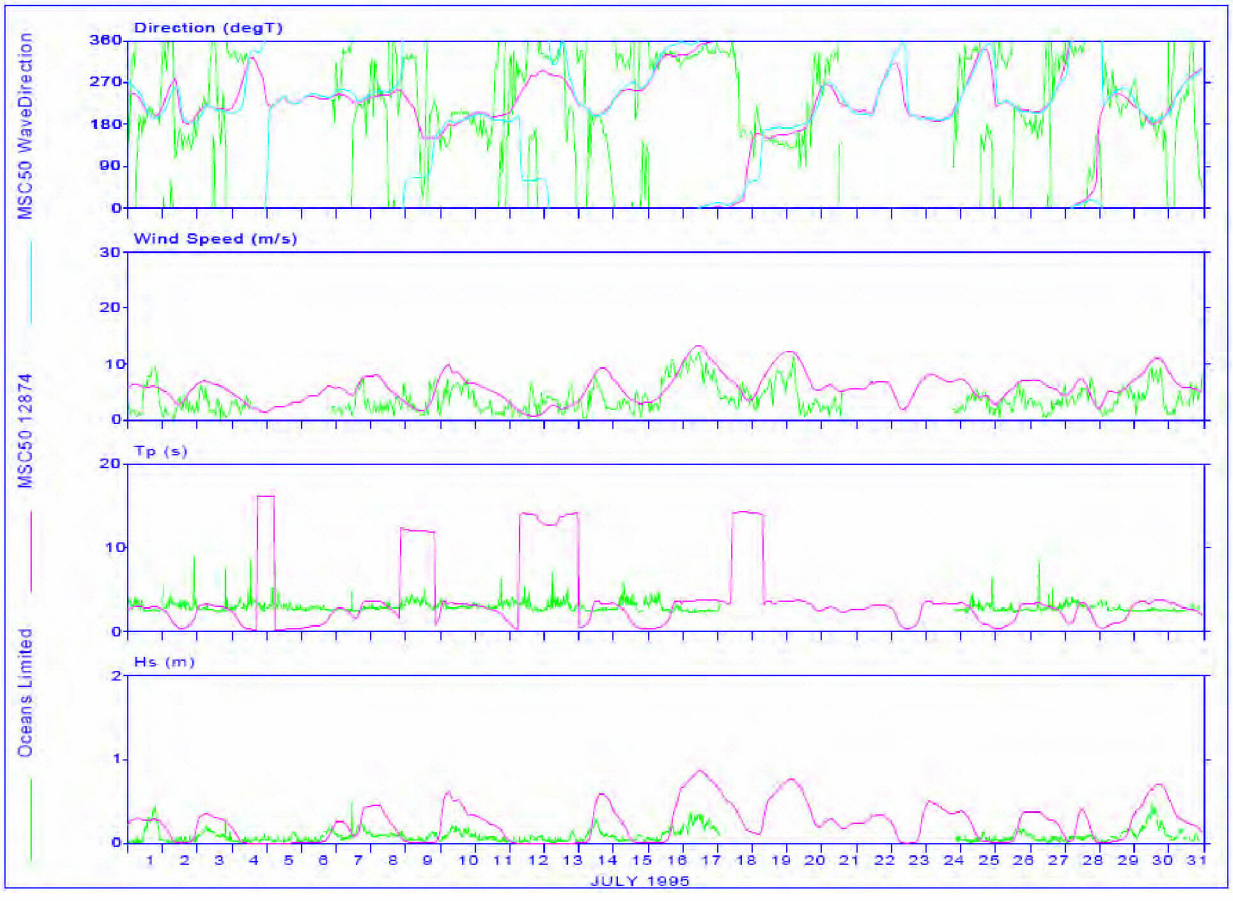


Figure 3-7 Wave and Wind Comparison, July 1995, Oceans Waverider Buoy and Weather Station, Bull Arm, and MSC50 Grid Point M12874 in Trinity Bay

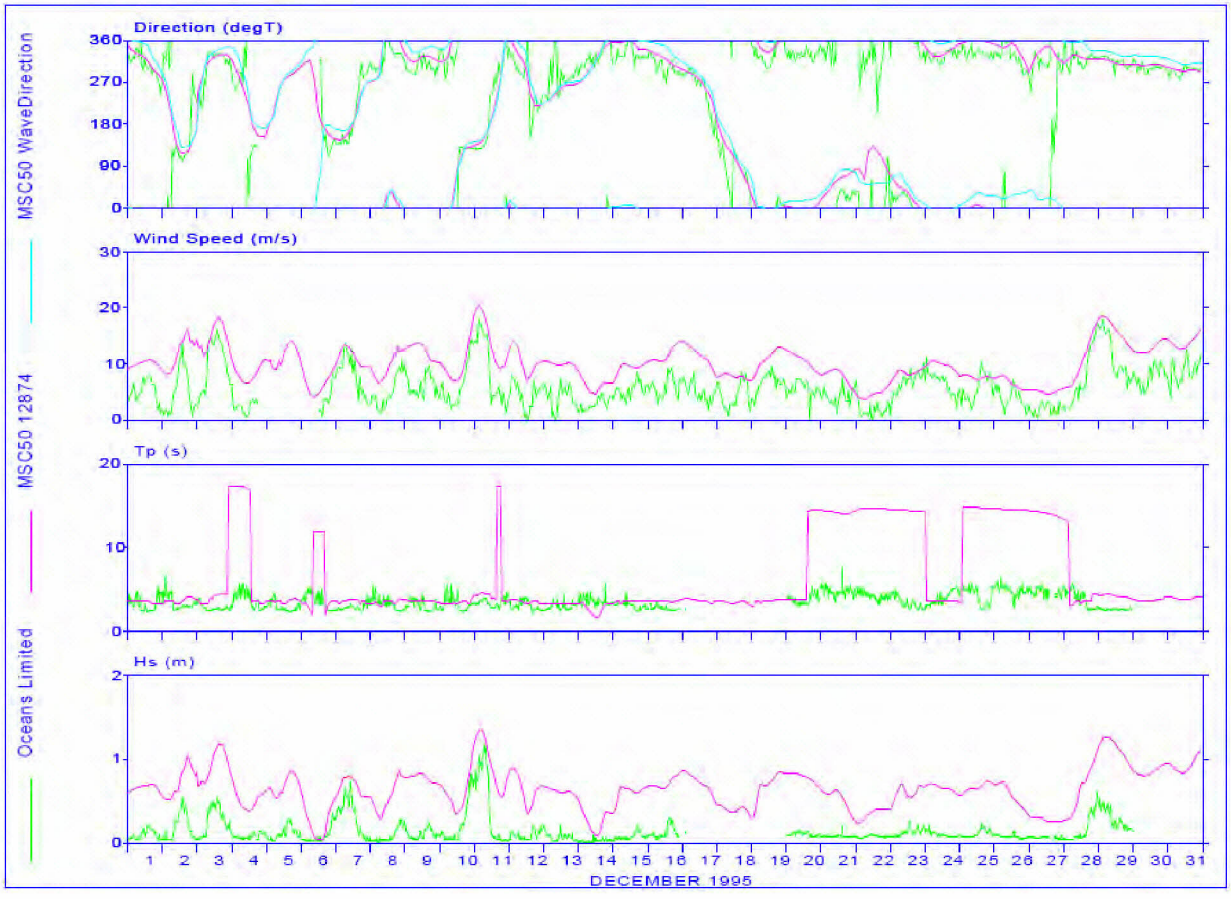


Figure 3-8 Wave and Wind Comparison, December 1995, Oceans Waverider Buoy and Weather Station, Bull Arm, and MSC50 Grid Point M12874 in Trinity Bay

Monthly mean and maximum Hs are shown in Figure 3-9. Mean wave heights are greater for the MSC50 source in all months. In December through January, the Bull Arm waves are slightly larger than those for Trinity Bay; from June through October the Trinity Bay wave heights are larger and in May and June maximum Hs values are the same.

Monthly median and maximum peak wave periods are shown in Figure 3-10. Median wave periods are usually less than 4 s for both sites. Maximum wave periods for Trinity Bay and the MSC50 M12874 Grid Point are consistently greater than those in Bull Arm. This is to be expected; given the location of the Grid Point it would be exposed to longer period swells from the full reaches of Trinity Bay.

Tsunamis generated by earthquakes generally originate from what is referred to as far-field sources; they are sometime called teletsunamis. Tsunamis resulting from the deformation of the sea floor caused by an earthquake can travel far, while tsunamis generated by other mechanisms generally dissipate quickly, only affecting areas close to the source. Not all earthquakes generate tsunamis (Fisheries and Oceans Canada (DFO) 2008a).

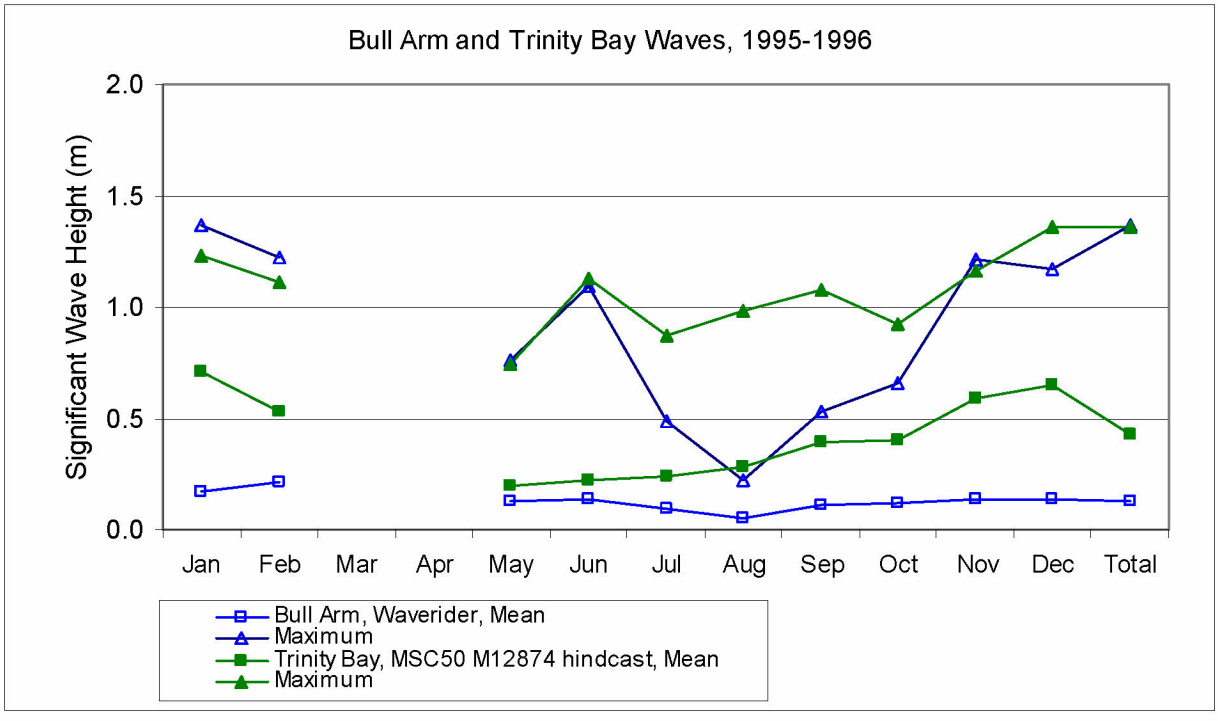


Figure 3-9 Bull Arm and Trinity Bay Waves, 1995-1996: Monthly Significant Wave Height

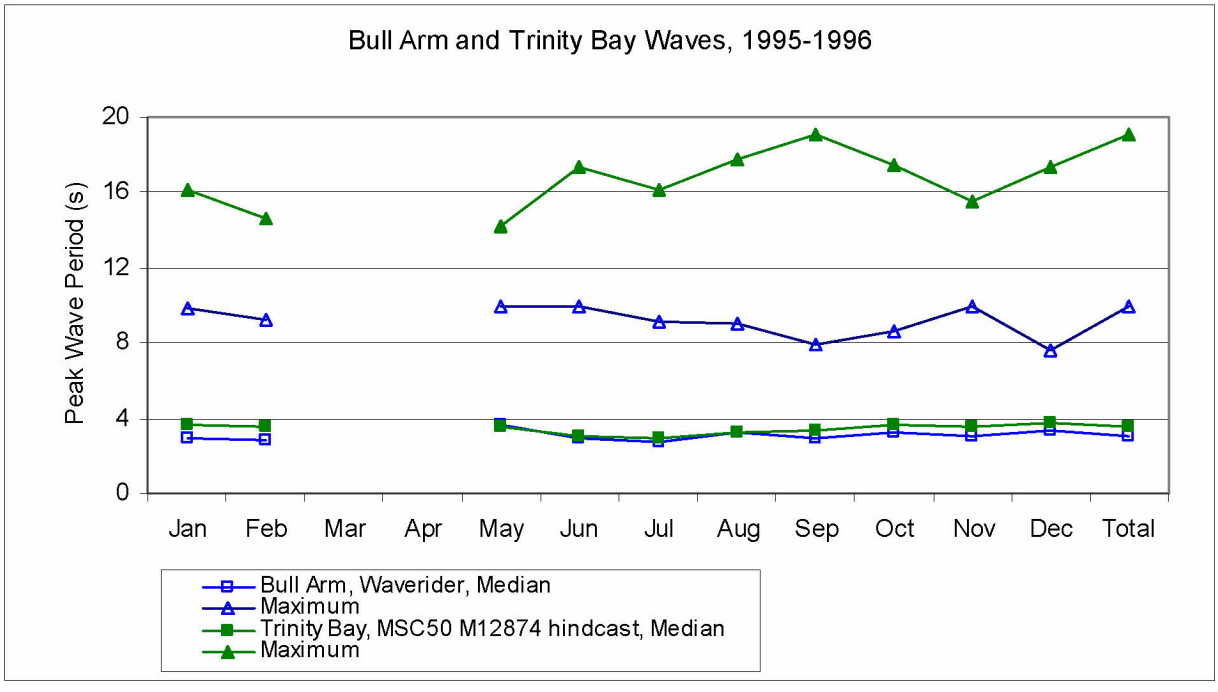
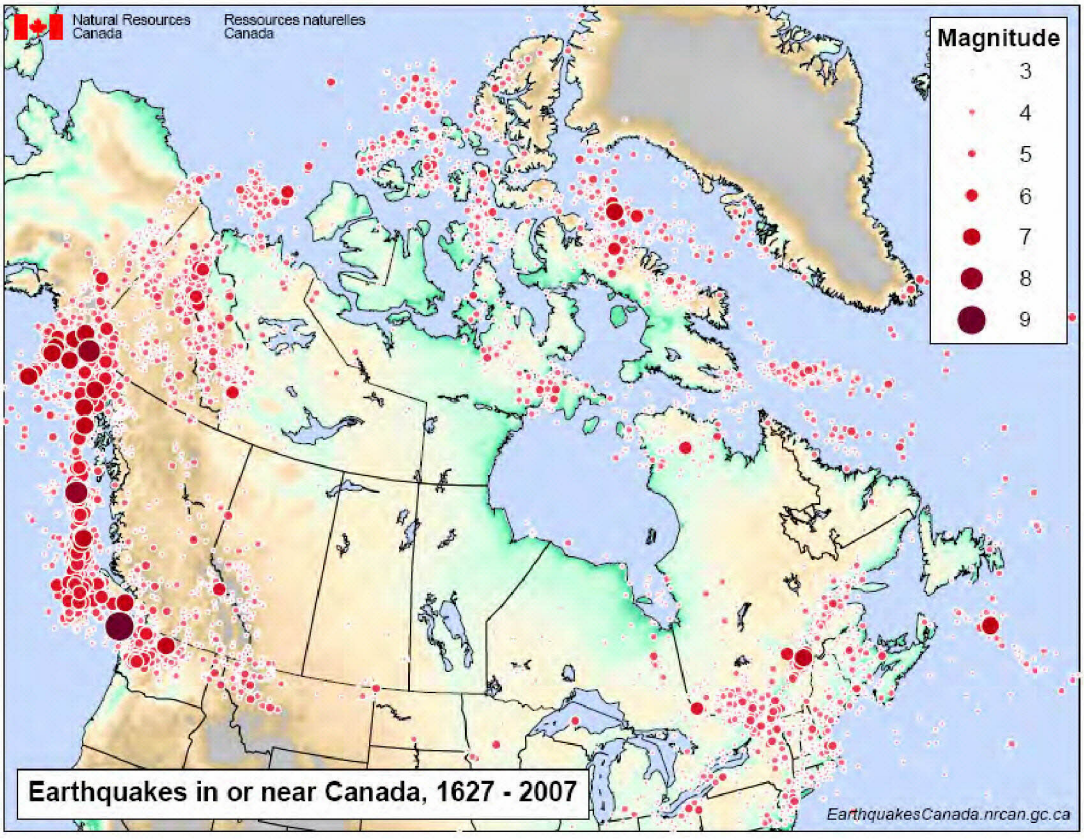


Figure 3-10 Bull Arm and Trinity Bay Waves, 1995-1996: Monthly Peak Wave Period

3.1.2.3 Tsunamis

It has been found that earthquakes of approximately magnitude 6.5 are necessary to induce offsets and rupture lengths sufficient to induce significant tsunami waves (e.g., Gonzalez et al. 2007). As shown in Figure 3-11, the Newfoundland region is geologically stable where the largest measured seismic activity results in only small earthquakes typically of magnitude 3 or 4.



Source: Earthquakes in or near Canada, 1627-2007. Via Natural Resources Canada website at http://earthquakescanada.nrcan.gc.ca/historic_eq/images/caneqmap_e.pdf

Figure 3-11 Earthquakes in or Near Canada, 1627 to 2007

There has been one confirmed tsunami near Newfoundland on November 18, 1929. An earthquake of magnitude 7.2 occurred approximately 250 km south of Newfoundland along the southern edge of the Grand Banks, at 5:02 PM local time. "The earthquake triggered a large submarine slump (an estimated volume of 200 cubic km of material was moved on the Laurentian slope) which ruptured 12 transatlantic cables in multiple places, and generated a tsunami. The tsunami was recorded along the eastern seaboard as far south as South Carolina and across the Atlantic Ocean in Portugal." Approximately 2.5 hours after the earthquake, tsunami waves struck the Burin Peninsula in three main pulses, causing the local sea level to rise between 2 and 7 m, with waters as high as 13 m in some bays on the Burin. The tsunami claimed 28 lives and destroyed or moved many buildings. Effects on Trinity Bay are not documented but: "The tsunami refracted counterclockwise around the

Avalon Peninsula to arrive in the Bonavista area about 1:30 am N.S.T." on November 20. "It appears that the water in Bonavista Harbour drained out completely, and then overflowed part of the community upon its return" (Natural Resources Canada 2008; NOAA 2009).

The recorded coastal flooding events in Newfoundland and Labrador from 1755 to 1992 indicate no flooding in Trinity Bay (Newfoundland and Labrador Heritage 2000). There is a relatively low tsunami risk hazard for the construction site in Bull Arm. This is due to activities taking place over a short time period, approximately four years, whereas consideration of observed tsunamis might indicate a return period on the order of 50 to 100 years for Newfoundland, likely longer for Bull Arm, and even longer for a destructive tsunami such as the 1929 event. Bull Arm is also very sheltered from the open ocean.

3.1.2.4 Currents

Ocean current studies and data are limited for Bull Arm. Data was collected in the late 1980s and early 1990s to support the construction of the Hibernia Development Project. Studies have also been conducted in Trinity Bay, primarily related to the commercial fisheries in the area. Seaconsult Marine Research Ltd. conducted an oceanographic data collection program in support of the Hibernia Development Project.

The study completed by Seaconsult (1991) reports current data for 5 to 75 m depths from February 9, 1991, to March 13, 1991, near the construction site for the Hibernia GBS (47°49'N, 53°53'W). Ocean current data are presented in Table 3-8. The maximum mean current of 0.074 m/s occurred at the surface; however, the overall maximum current of 0.399 m/s was observed at 47 m. The most frequent direction is northwest at all depths except at the surface, where the flow can be moderated by local wind forcing.

Table 3-8 Ocean Currents for 5 to 75 m from February 9, 1991, to March 13, 1991, Near the Construction Site for the Hibernia Gravity Base Structure

Depth (m)	Mean (m/s)	Maximum (m/s)	St. Dev.	Most Frequent Direction
5	0.074	0.313	0.054	S (150-165)
15	0.039	0.216	0.03	NW (330-345)
25	0.03	0.188	0.022	NW (330-345)
36	0.029	0.178	0.031	NW (300-315)
47	0.037	0.399	0.042	NW (300-315)
55	0.033	0.192	0.031	NW, N (330-345)
66	0.037	0.245	0.032	NW (315-330)
76	0.032	0.211	0.034	NW (330-345)
Source: Seaconsult 1991				

Table 3-9 Hibernia Development Project Environmental Specifications 100- Year Extreme Current Profiles for deepwater sites, Bull Arm

Depth (m)	Probable Maximum Current in Downwind Direction (m/s)	
	Location: 47°49'23"N 53°52'37"W (deepwater site)	Location: 47°48'42"N 53°52'24"W (Great Mosquito Cove)
Surface	0.6	0.4
5	1.0	0.8
10	1.0	0.8
20	1.0	0.8
30	1.0	0.8
40	1.0	0.8
50	1.0	0.8
60	1.0	0.8
70	1.0	0.8
80	1.0	0.7
90	0.9	0.7
100	0.9	0.5
Source: Topside Engineering 1992		

The report completed by Topside Engineering (1992) presents the environmental design criteria for the Hibernia Development Project. The 100-year extreme current profiles for deepwater site and mouth of Great Mosquito Cove in Bull Arm are shown in Table 3-9. The estimated extreme currents are all higher than the measured currents reported by Seaconsult (1991) (range from 1 m/s from 5 to 80 m to 0.4 m/s at the surface).

The ocean current studies for Trinity Bay are summarized by Dalley et al. (2002), wherein they cite several studies. Bailey (1958) concluded that mean currents from the inshore branch of the Labrador Current entered the Bay on the northwest side and exited on the southeast side. Yao (1986) also found that incoming currents in the northwest corner are at times stronger than outflowing surface currents, produced by the prevailing southwesterly winds blowing out of the Bay, so despite prolonged offshore wind events, a net current into the bay may prevail as a result of the Labrador Current.

3.1.2.5 Tides and Storm Surges

The tidal levels in Trinity Bay have been reported by several sources for different locations. Forecast tides for Heart's Content and Clarenville show a tidal range of about 1.2 m (CHS 2008). Observations at Long Cove (47°49'23"N, 53°52'37"W at the southern end of Trinity Bay) over a one month period showed a water level variation attributed to tidal forcing of approximately 1.6 m (DFO 2009a). The DFO WebTide model (Dupont et al. 2002; DFO 2010a) was employed at a location at the head of Trinity Bay (47°42'00"N, 53°48'00"W) for the period 2000 to 2009, and the resulting tidal range was found to be approximately 1.26 m (variation from 0.067 m to 1.33 m).

Marex (1992) conducted a study on water levels in Bull Arm using data collected from January to August 1991. The measurements were conducted

using a tide gauge at location GULL, a site adjacent to the GULL survey monument located on a rocky headland on the southern shore of Great Mosquito Cove. This study identified the mean water level (MWL), the range of water levels associated with astronomical tides, as well as estimates of probable extreme surges (Table 3-10).

The best estimate for the tidal range, the difference between highest and lowest astronomical tide levels, in Bull Arm is 1.71 m. This range is relatively higher than those reported at other locations in Trinity Bay, but it is consistent with the constrained geometry of Bull Arm relative to the wider area of Trinity Bay.

This study also provided estimates of the extreme maximum and extreme minimum still water levels in Bull Arm by combining the tide and surge extreme values. These estimates of extreme water level for the 100-year condition (Table 3-10) include a contingency allowance to the 95 percent confidence limits. The estimated extreme maximum water level is +1.52 m relative to the MWL, and includes the standard deviation of the MWL, the tide (including the mean higher high water and the mean lower low water levels), the 50 year surge and the standard deviation on the 50 year surge. The extreme minimum water level is -1.2 m relative to the MWL and includes the same parameter levels as the extreme maximum.

Table 3-10 Mean and Extreme Tide and Surge Levels, Bull Arm

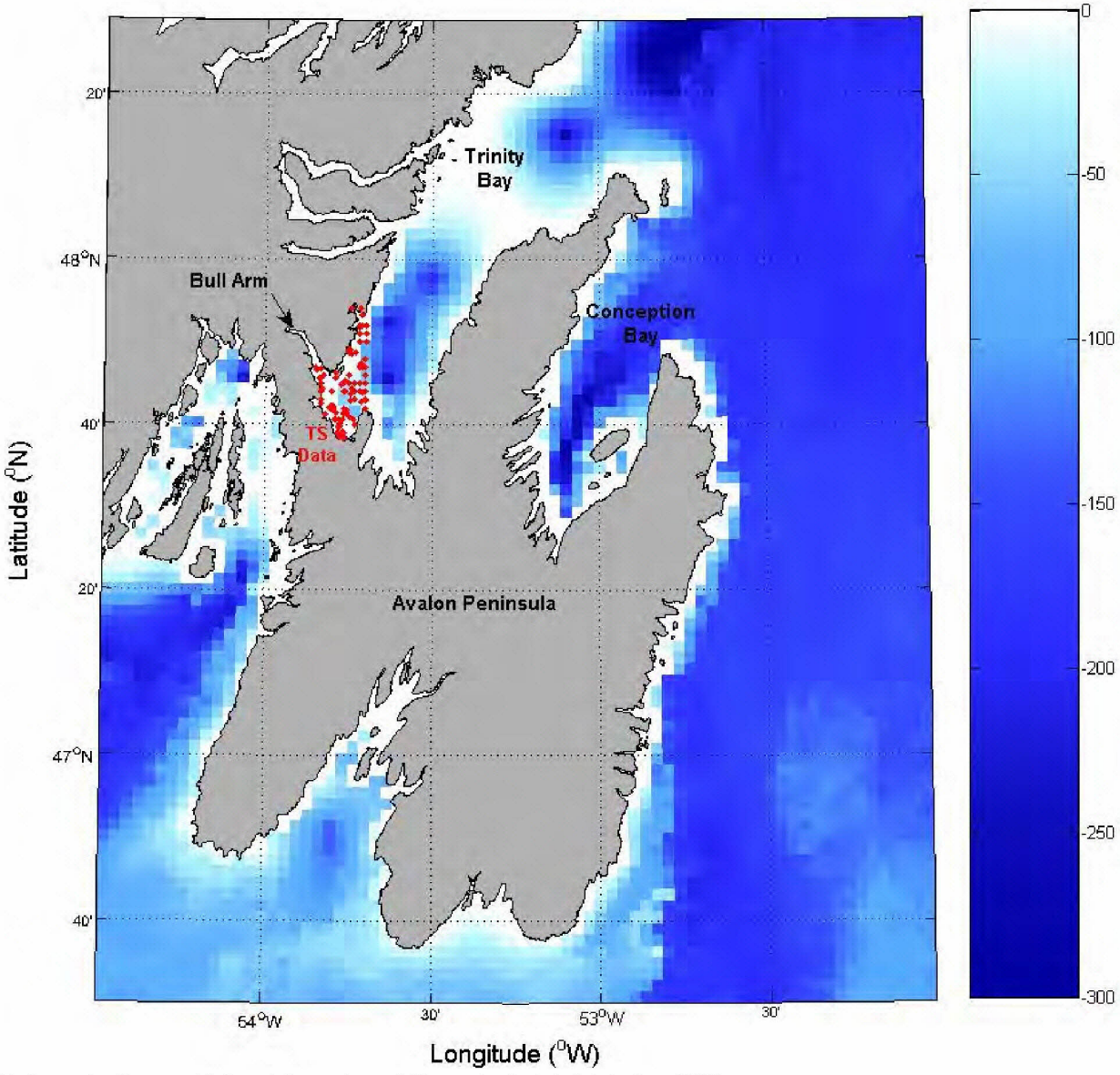
	Level (m)
Highest Astronomical Tide	0.80
Mean Water Level	0.00
Lowest Astronomical Tide	-0.91
Extreme Maximum Still Water Level (100-Year Total Level)	1.52
Extreme Minimum Still Water Level (100-Year Total Level)	-1.20
Mean Positive Surge Amplitude (100-Year Surge)	0.88
Mean Negative Surge Amplitude (100-Year Surge)	-0.54
Note: GULL benchmark, Bull Arm, Trinity Bay is located 3.2 m above CHS chart datum and 2.24 m above mean water level Source: Marex 1992	

3.1.2.6 Physical and Chemical Properties

Temperature and salinity data were extracted from the DFO hydrographic database (DFO 2009a). The data come from a variety of sources from 1910 to the present, including hydrographic bottles casts, CTD casts, spatially and temporally averaged Batfish tows and expendable digital or mechanical bathythermographs. Near real-time data are in the form of IGOSS (Integrated Global Ocean Services System) Bathy or Tesac messages (codes for oceanographic data).

The geographic limits used for this study are 47.6°N, 48°N, 53.85°W and 53.7 W. Approximately 4,074 measurements are available within this area of Trinity Bay from the DFO database. The locations of the measurements are presented in Figure 3-12 and the results in Table 3-11. Monthly data statistics

are provided in EMCP (2010). There are no data for February, and data in March are sparse.



Bathymetry Source: National Oceanic and Atmospheric Administration 2009

Figure 3-12 Temperature and Salinity Measurement Locations for Bull Arm

Table 3-11 Temperature and Salinity Statistics

Depth (m)	Temperature (oC)					Salinity (psu)				
	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
January										
0	0.42	1.73	1.05	0.49	8	31.51	31.97	31.75	0.16	8
20	-0.38	2.57	1.20	0.85	13	31.61	32.26	32.01	0.19	10
50	0.38	2.01	1.26	0.52	18	31.76	32.33	32.07	0.22	15
100	-0.05	1.22	0.96	0.42	8	32.20	32.59	32.46	0.14	6
200	-0.32	-0.32	-0.32	0.00	1	33.07	33.07	33.07	0.00	1
February - No Data										
March										
0	0.00	0.71	0.23	0.33	4	31.67	31.67	31.67	0.00	1
20	0.70	0.70	0.70	0.00	1	31.69	31.69	31.69	0.00	1
50	-0.50	0.26	-0.12	0.54	2	31.89	31.89	31.89	0.00	1
100	-0.31	-0.31	-0.31	0.00	1	32.36	32.36	32.36	0.00	1
200	-	-	-	-	-	32.95	32.95	32.95	0.00	1
April										
0	0.40	3.25	2.10	1.02	12	29.30	31.87	30.16	1.48	3
20	-0.42	0.71	0.03	0.39	7	31.90	32.43	32.15	0.24	5
50	-0.97	1.10	-0.07	0.62	10	32.07	32.45	32.33	0.15	5
100	-1.00	0.00	-0.53	0.43	4	32.62	32.80	32.69	0.09	3
200	-0.64	0.90	0.13	1.09	2	33.12	33.12	33.12	0.00	1
May										
0	-0.10	5.60	2.83	1.84	17	30.53	31.63	31.32	0.53	4
20	-0.74	5.06	2.23	1.54	12	31.46	32.63	31.86	0.52	4
50	-0.92	2.49	0.27	1.16	13	32.24	32.70	32.43	0.19	5
100	-1.36	1.29	-0.33	0.94	7	32.66	32.66	32.66	0.00	1
200	-0.66	-0.66	-0.66	0.00	1	-	-	-	-	-
June										
0	-0.60	9.73	5.48	2.51	60	30.75	33.06	31.94	0.58	48
20	-1.07	9.96	3.55	2.85	73	31.34	32.78	32.10	0.39	60
50	-1.37	5.83	0.31	1.87	71	31.77	32.87	32.54	0.27	60
100	-1.36	-0.40	-1.08	0.31	9	32.61	32.71	32.66	0.07	2
200	-0.47	0.36	-0.03	0.42	3	33.31	33.31	33.31	0.00	2
July										
0	-0.10	12.90	7.75	2.82	148	29.80	33.69	31.52	0.77	131
20	-0.73	10.79	3.94	2.63	166	31.09	32.78	31.95	0.39	150
50	-1.25	5.71	0.11	1.17	159	31.88	32.84	32.55	0.17	145
100	-0.80	-0.38	-0.55	0.19	4	32.56	32.69	32.63	0.07	3
140	0.04	0.04	0.04	0.00	1	33.12	33.12	33.12	0.00	1

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Depth (m)	Temperature (oC)					Salinity (psu)				
	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
August										
0	0.88	14.77	10.23	3.10	110	29.81	33.12	31.29	0.64	108
20	-0.85	12.51	5.32	3.57	122	30.45	32.47	31.75	0.52	120
50	-1.19	3.95	0.74	1.47	119	31.67	32.88	32.41	0.24	117
100	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-
September										
0	9.25	14.10	11.00	1.55	27	30.96	31.58	31.29	0.19	18
20	3.05	14.03	9.72	2.87	24	30.97	32.57	31.49	0.33	22
50	-0.23	9.20	4.92	2.85	30	31.67	32.48	32.06	0.28	22
100	-1.11	0.25	-0.49	0.41	11	32.57	32.88	32.75	0.10	9
200	-0.15	0.00	-0.08	0.11	2	33.37	33.37	33.37	0.00	1
October										
0	7.15	11.80	8.42	1.69	27	31.08	31.43	31.30	0.11	21
20	6.23	11.74	8.06	1.84	20	31.12	31.78	31.49	0.18	16
50	1.86	11.37	4.97	3.07	12	31.16	32.30	31.99	0.43	7
100	-1.04	3.10	0.67	1.76	4	32.40	32.72	32.56	0.23	2
140	-0.41	-0.41	-0.41	0.00	1	32.71	32.71	32.71	0.00	1
November										
0	2.89	7.17	5.27	2.01	6	30.55	32.25	31.35	0.85	3
20	1.65	7.85	4.48	2.58	7	32.12	32.27	32.20	0.11	2
50	1.07	3.52	2.26	1.18	5	32.32	32.33	32.33	0.01	2
100	-0.89	0.60	-0.45	0.70	4	32.68	32.68	32.68	0.00	1
200	-0.82	-0.82	-0.82	0.00	1	-	-	-	-	-
December										
0	3.40	4.07	3.74	0.47	2	31.58	31.58	31.58	0.00	1
20	-	-	-	-	-	-	-	-	-	-
50	2.66	2.66	2.66	0.00	1	31.92	31.92	31.92	0.00	1
100	-	-	-	-	-	-	-	-	-	-
200	-0.78	-0.78	-0.78	0.00	1	32.96	32.96	32.96	0.00	1
Source: DFO 2009a										

In summer, the system becomes thermally stratified with the development of a distinct surface layer to about 60 m, with average temperatures reaching between 14°C and 15°C and average salinities between 31.3 and 32 psu. By November, the system returns to one nearly homogeneous layer which is colder and saltier than the conditions in the summer. In fall, the average temperatures range from 5.3°C (November) for the surface layer to -0.8°C (December) and the average salinities range from 31.4 psu at the surface to 32.7 psu near bottom. In the deeper layer, below 60 m, the average temperatures range between -0.32°C and 1°C and average salinities between 32 and 33 psu.

3.1.3 Wind and Waves Extremes

3.1.3.1 Wind

The extreme value estimates for wind were calculated using Oceanweather's Osmosis software program for the return periods of 1-year, 10-years, 25-years, 50-years and 100-years. The calculated annual and monthly values for 1-hour, 10-minutes and 1-minute are presented in Tables 3-12 to 3-14. The analysis used hourly mean wind values for the reference height of 10 m above sea level (asl). These values were converted to 10-minute and 1-minute wind values using a constant ration of 1.06 and 1.22, respectively (US Geological Survey 1979). The annual 100-year extreme 1-hour wind speed was determined to be 28.3 m/s for Grid Point M12874. Monthly, the highest 100-year extreme winds of 27.7 m/s occur during February.

Table 3-12 1-hr Extreme Wind Speed Estimates (m/s) for Return Periods of 1, 10, 25, 50 and 100 Years

Month	Grid Point M12874				
	1	10	25	50	100
January	19.1	23.7	24.9	25.8	26.7
February	17.6	23.7	25.3	26.5	27.7
March	17.0	21.5	22.8	23.7	24.6
April	15.5	19.0	19.9	20.6	21.3
May	12.9	17.6	18.9	19.9	20.8
June	11.7	16.0	17.1	18.0	18.9
July	9.8	15.5	17.0	18.2	19.3
August	11.3	16.2	17.5	18.5	19.5
September	13.2	20.7	22.8	24.3	25.8
October	15.3	21.4	23.0	24.2	25.5
November	17.3	21.4	22.5	23.4	24.2
December	19.0	23.0	24.1	24.9	25.7
Annual	22.1	25.2	26.4	27.4	28.3

Table 3-13 10-minute Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

Month	Grid Point M12874				
	1	10	25	50	100
January	20.3	25.1	26.4	27.3	28.3
February	18.7	25.1	26.8	28.1	29.4
March	18.0	22.8	24.1	25.1	26.1
April	16.4	20.1	21.1	21.8	22.6
May	13.7	18.7	20.1	21.1	22.1
June	12.3	16.9	18.2	19.1	20.0
July	10.4	16.4	18.1	19.3	20.5
August	11.9	17.2	18.6	19.6	20.7
September	13.9	22.0	24.1	25.8	27.4
October	16.3	22.7	24.4	25.7	27.0
November	18.4	22.7	23.9	24.8	25.6
December	20.1	24.4	25.5	26.4	27.3
Annual	23.4	26.7	28.0	29.0	29.9

Table 3-14 1-minute Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

Month	Grid Point M12874				
	1	10	25	50	100
January	23.4	28.9	30.4	31.5	32.6
February	21.5	28.9	30.8	32.3	33.8
March	20.7	26.3	27.8	28.9	30.0
April	18.9	23.1	24.3	25.1	26.0
May	15.8	21.5	23.1	24.2	25.4
June	14.2	19.5	20.9	22.0	23.0
July	12.0	18.9	20.8	22.2	23.6
August	13.7	19.7	21.4	22.6	23.8
September	16.0	25.3	27.8	29.6	31.5
October	18.7	26.1	28.1	29.6	31.0
November	21.2	26.1	27.5	28.5	29.5
December	23.1	28.0	29.4	30.4	31.4
Annual	26.9	30.8	32.3	33.4	34.5

3.1.3.2 Waves

The annual and monthly extreme value estimates for Hs for return periods of 1 year, 10 years, 25 years, 50 years and 100 years are presented in Table 3-15. The annual 100-year extreme Hs was 1.9 m at Grid Point M12874 (located outside of Bull Arm (but well inside Trinity Bay) at 47.7°N 53.8°W). On a monthly basis, the highest extreme Hs of 1.8 m is predicted to occur during the months of December and January.

Table 3-15 Extreme Significant Wave Height Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

Month	Grid Point M12874				
	1	10	25	50	100
January	1.3	1.6	1.7	1.7	1.8
February	1.2	1.5	1.6	1.6	1.7
March	1.1	1.4	1.5	1.6	1.6
April	1.0	1.3	1.4	1.4	1.5
May	0.9	1.2	1.3	1.3	1.4
June	0.8	1.0	1.1	1.1	1.2
July	0.7	0.9	1.0	1.0	1.1
August	0.8	1.0	1.1	1.1	1.2
September	1.0	1.2	1.3	1.4	1.5
October	1.1	1.4	1.5	1.5	1.6
November	1.2	1.4	1.5	1.5	1.6
December	1.3	1.5	1.6	1.7	1.8
Annual	1.4	1.6	1.7	1.8	1.9

The maximum individual wave heights and extreme associated peak periods are presented in Tables 3-16 and 3-17. Maximum individual wave heights and the extreme associated peak periods, peak during the month of February.

Table 3-16 Extreme Maximum Wave Height Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

Month	Grid Point M12874				
	1	10	25	50	100
January	2.5	3.0	3.2	3.3	3.4
February	2.3	2.9	3.1	3.2	3.4
March	2.2	2.8	3.0	3.2	3.3
April	2.0	2.5	2.7	2.9	3.0
May	1.7	2.3	2.5	2.7	2.8
June	1.5	1.9	2.1	2.2	2.3
July	1.4	1.8	1.9	2.0	2.1
August	1.5	1.9	2.0	2.1	2.2
September	1.9	2.3	2.5	2.6	2.8
October	2.1	2.7	2.9	3.0	3.2
November	2.3	2.8	2.9	3.0	3.1
December	2.5	3.0	3.2	3.3	3.4
Annual	2.8	3.2	3.4	3.5	3.6

Table 3-17 Extreme Associated Peak Period Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

Month	Grid Point M12874				
	1	10	25	50	100
January	5.2	5.7	5.9	6.0	6.1
February	4.4	4.8	4.9	5.0	5.1
March	4.3	4.7	4.8	4.9	5.0
April	4.2	4.6	4.7	4.8	4.8
May	3.9	4.5	4.6	4.8	4.9
June	3.7	4.2	4.4	4.5	4.6
July	3.6	4.0	4.1	4.2	4.3
August	3.9	4.4	4.5	4.6	4.7
September	4.1	4.5	4.7	4.8	4.9
October	4.3	4.7	4.9	4.9	5.1
November	4.4	4.8	4.9	5.0	5.1
December	4.5	4.9	5.1	5.2	5.3
Annual	4.8	5.2	5.3	5.4	5.5

Additional Wave Estimates

The Hibernia Development Project Environmental Specifications report (Topside Engineering 1992) presents estimates of the 100-year extreme waves for two deepwater sites in Bull Arm, which were near the construction site for the Hibernia GBS (47°49'23"N, 53°52'37"W and 47°48'42"N, 53°52'37"W). Results are shown below in Table 3-18. The maximum Hs estimated at 2.6 m for the fall and winter for a 100-year interval. This value is approximately 35 percent greater than the maximum of 1.92 m from the 50-year interval of the MSC50 hindcast. The 100-year peak periods for Bull Arm as estimated here are lower than the maximum Tp values from the MSC50 Grid Point; this is not surprising given the smaller fetches in Bull Arm, compared with those in Trinity Bay.

Table 3-18 100-Year Extreme Wave Heights at the deepwater sites (Hibernia GBS Construction Site), Bull Arm

	Location: 47°49'23"N 53°52'37"W		Location: 47°48'42"N 53°52'37"W	
	October to February	March	October to February	March
Extreme Height (m)	4.8	3.9	4.5	3.7
Associated Crest to Crest Period (s)	6.5	6.0	6.2	5.8
Significant Height (m)	2.6	2.1	2.4	2.0
Peak Period (s)	6.5	6.0	6.2	5.8
Zero Crossing Period (s)	5.1	4.7	4.8	4.5
Mean Period (s)	5.4	5.0	5.2	4.8
Source: Topside Engineering 1992				

3.1.3.3 Extreme Temperature Analysis

For the minimum temperature analysis, the daily minimum temperature was found for each day in the data set. The lowest minimum temperature event chosen was -17.1°C, which occurred on March 10, 1997. These temperature events were fitted to a Gumbel distribution and extreme value estimates for minimum temperature were calculated for return periods of 2 years, 10 years and 25 years. These values are given in Table 3-19. The 95 percent confidence interval is also given.

Table 3-19 Extreme Minimum Temperature Estimates for Return Periods of 2, 10 and 25 Years

Return Period (years)	Extreme Mimimum Temperature (°C)	95% Lower Confidence Bound (°C)	95% Upper Confidence Bound (°C)
2	-12.63	-13.43	-11.84
10	-16.69	-18.68	-14.71
25	-18.74	-21.45	-16.02

For the maximum temperature analysis, the daily maximum temperature was found for each day in the data set. The highest maximum temperature event chosen was 27.6°C, which occurred on August 7, 1996. These temperature events were fitted to a Gumbel distribution and extreme value estimates for maximum temperature were calculated for return periods of 2 years, 10 years and 25 years. These values are given in Table 3-20. The 95 percent confidence interval is also given.

Table 3-20 Extreme Maximum Temperature Estimates for Return Periods of 2, 10 and 25 Years

Return Period (years)	Extreme Maximum Temperature (°C)	95% Lower Confidence Bound (°C)	95% Upper Confidence Bound (°C)
2	20.17	19.27	21.06
10	24.76	22.51	27.01
25	27.08	24.00	30.15

3.1.4 Sea Ice and Icebergs

Much like the offshore areas, pack ice presence in Trinity Bay from year to year is variable, based on a review of the weekly Canadian Ice Service (CIS) charts from 1983 to 2008 inclusive (Environment Canada CIS 2010).

The frequency of presence of sea ice in Trinity Bay by week is shown in Table 3-21 and Figure 3-13, as from the Environment Canada CIS Climactic Atlas (CIS 2001). For this analysis, the frequency of sea ice in the mouth (most seaward point) of the bay and at the bottom (most landward point) of the bay over a 30-year period was reviewed.

3.1.4.1 Ice Type

There are few quantifiable data on the exact thickness of the sea ice in Trinity Bay. As a result, the analysis uses the upper limit for the standard thickness-ranges of the ice types present to derive sea ice thickness (Table 3-22). As with the offshore area, most sea ice that occurs within the bay is formed off southern Labrador and drifts south to enter the bay around the mid-March timeframe.

Table 3-21 Frequency of Presence of Sea Ice

Date	Frequency of Presence of Sea Ice (max % for category)	
	Bottom	Mouth
Jan 01	0	0
Jan 08	0	15
Jan 15	0	15
Jan 22	15	15
Jan 29	15	33
Feb 05	33	50
Feb 12	33	50
Feb 19	33	50
Feb 26	50	66
Mar 05	50	66
Mar 12	50	50
Mar 19	33	50
Mar 26	15	33
Apr 02	33	33
Apr 09	15	33
Apr 16	15	33
Apr 23	15	33
Apr 30	15	33
May 07	15	15
May 14	15	15
May 21	0	15
May 28	0	15
Jun 04	0	0

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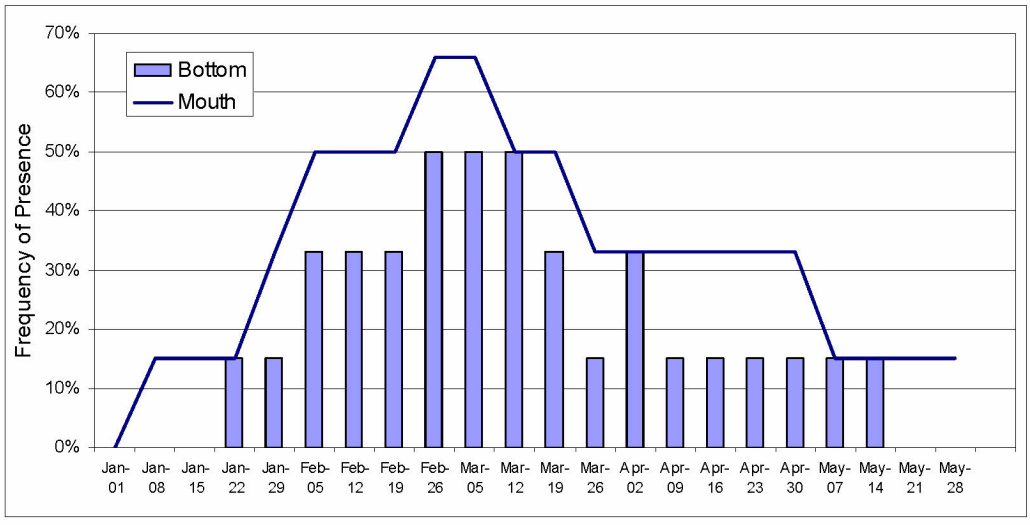
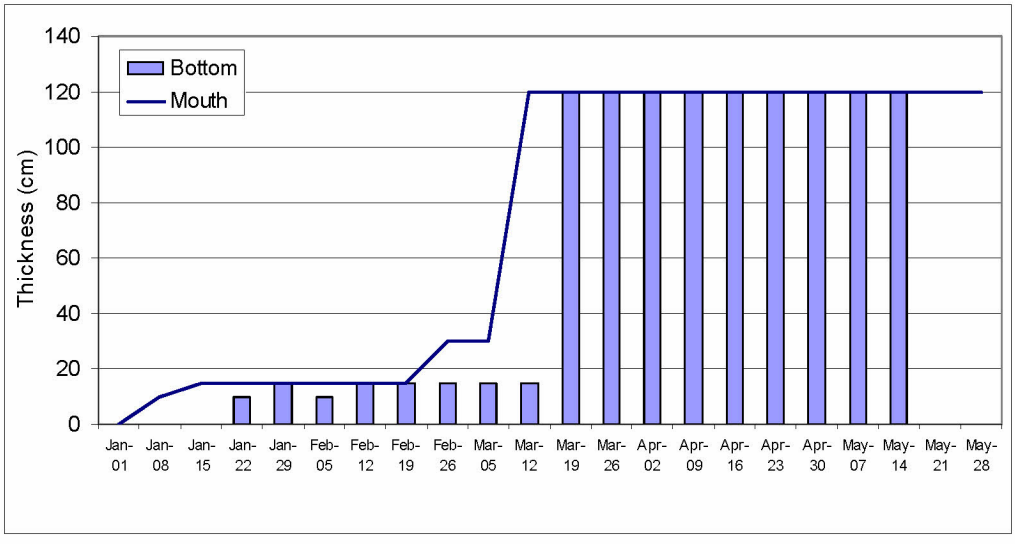


Source: Canadian Ice Service 2001

Figure 3-13 Frequency Presence of Sea Ice in Trinity Bay

Table 3-22 Derived Ice Thickness Based on Medium Ice Type

Date	Derived Ice Thickness Based on the Medium Ice Type (max cm for category)	
	Bottom	Mouth
Jan 01	0	0
Jan 08	0	10
Jan 15	0	15
Jan 22	10	15
Jan 29	10-15	15
Feb 05	10	15
Feb 12	10	15
Feb 19	10	15
Feb 26	10	30
Mar 05	15	30
Mar 12	15	120
Mar 19	120	120
Mar 26	120	120
Apr 02	120	120
Apr 09	120	120
Apr 16	120	120
Apr 23	120	120
Apr 30	120	120
May 07	120	120
May 14	120	120
May 21	0	120
May 28	0	120
Jun 04	0	0



Source: Canadian Ice Service (Ice Charts) 2001

Figure 3-14 Derived Sea Ice Thickness at the Mouth and Bottom of Trinity Bay

The bay experiences first-year ice from mid-March through early May, which can range in thickness from 30 cm to greater than 120 cm.

As with the offshore area, most sea ice that occurs within the bay is formed off southern Labrador and drifts south to enter the bay near the end of February, with the thickest ice occurring from mid-March to mid-May.

This analysis includes the sea ice at the mouth and bottom of the bay over the 25-year period of 1983 to 2008 inclusive (Figure 3-14).

3.1.4.2 Iceberg Conditions in Trinity Bay

Data on iceberg sightings within Trinity Bay were extracted from the Provincial Airlines Limited (PAL) database, which was queried by year of sightings and then by size classification. Iceberg distribution can fluctuate greatly from year to year. The maximum number of icebergs sighted in one year over the period of study was 129 in 1997, while the mean annual number for Trinity Bay is 32. In the area of Trinity Bay, the number of icebergs detected from year to year may be an underestimation of what is actually present as the Trinity Bay region does not lie on a primary route for aerial ice reconnaissance.

3.1.4.3 Iceberg Distribution by Year

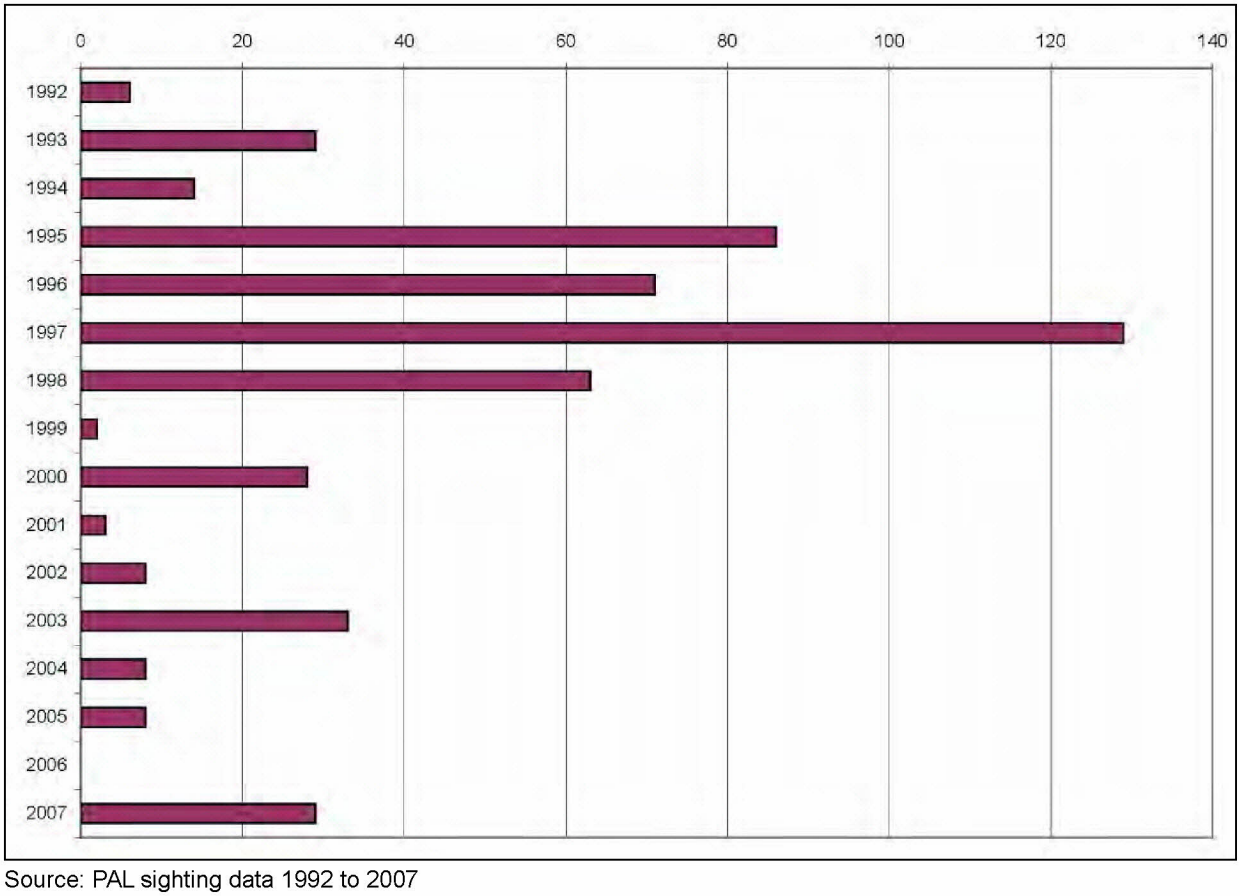
Considerable fluctuations in the yearly iceberg distribution are evident in the PAL data. However, the same is true when considering any one-degree block off Canada's East Coast. The yearly iceberg distribution is shown in Figure 3-15, based on the PAL sighting database. Data from 1992 through to 2007 were used because data in the Trinity Bay region were variable, as it does not lie on a regular flight route for iceberg surveillance. Data prior to 1992 are not well-documented and are not as of solid quality as those data logged from 1992 onwards.

3.1.4.4 Iceberg Distribution by Month

Data on monthly iceberg distribution for Trinity Bay were compiled from the PAL sighting data. These data show peak iceberg flux in the month of May. The monthly occurrence of icebergs in Trinity Bay is shown in Figure 3-16 as a percentage of the yearly total.

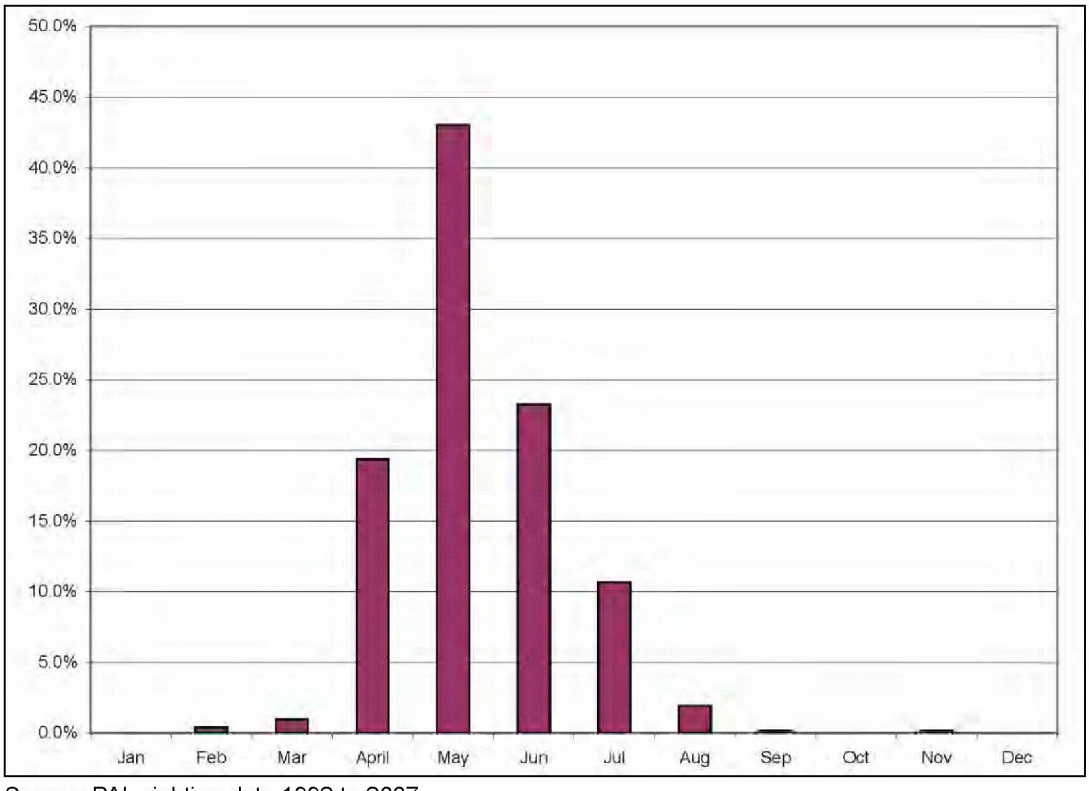
3.1.4.5 Iceberg Size Distribution

In the data on icebergs extracted from the PAL database, most icebergs had associated size classifications (Tables 3-23 and 3-24; Figure 3-17) while very few were recorded as unknown. Most size data in the PAL databases are based on visual estimations. This methodology has been used on many previous studies and reports and is, for the most part, the only data available for the area.



Source: PAL sighting data 1992 to 2007

Figure 3-15 Iceberg Distribution in Trinity Bay by Year



Source: PAL sighting data 1992 to 2007

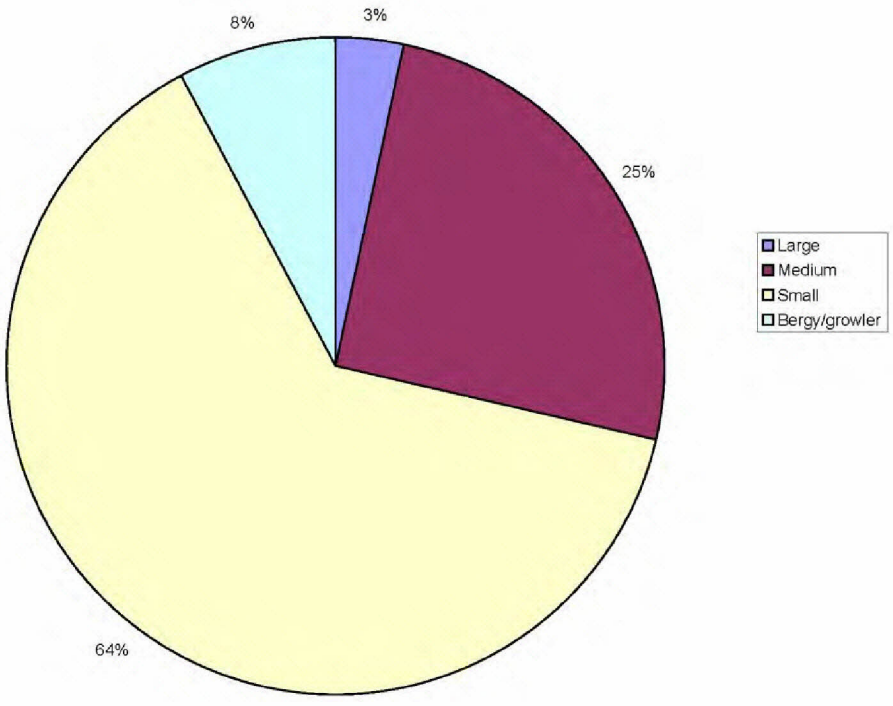
Figure 3-16 Monthly Iceberg Distributions in Trinity Bay

Table 3-23 Iceberg Size

Category	Height (m)	Length (m)	Approx. Mass (T)
Very Large	>75	>200	<10 Million
Large	45 to 75	120 to 200	2 to 10 Million
Medium	15 to 45	60 to 120	100,000 - <2 Million
Small	5 to 15	15 to 60	100,000
Bergy Bit	1.0 to 5	5 to 15	10,000
Growler	<1.0	<5	1,000
Source: Meteorological Service of Canada Canadian Ice Service MANICE 2005.			

Table 3-24 Iceberg Size Classification

Classification	Percentage of Total
Large	3
Medium	25
Small	64
Bergy Bit / Growler	8



Source: PAL sighting data 1992 to 2007

Figure 3-17 Iceberg Size Distributions for Trinity Bay

In general terms, this size distribution is very similar to other areas studied and is consistent with the general distributions of iceberg size south of 48°N.

3.1.5 Geology of the Bull Arm (Great Mosquito Cove) Area

The majority of the detailed marine geoscientific (geological and geotechnical) information available from the Bull Arm area comes from site investigations conducted on behalf of Mobil Oil Canada Properties (Newfoundland Geosciences Limited 1989a, 1989b) and NODECO (Newfoundland Geosciences Limited 1991). These two studies acquired a high density of marine borehole and geophysical data for use in the engineering of the construction site.

The marine surficial geology of Great Mosquito Cove was modified during the construction of the drydock for the Hibernia GBS and during the dredging of the bund wall at the end of the drydock phase, when large quantities of the constructed bund wall were removed and disposed of within the outer cove. This sediment may be a mixture of poorly sorted sand and gravel from the middle of the bund wall, or coarse debris that was laid down near the base. There may also be areas of redeposited fine grained sediment, winnowed from dredge spoils by currents. The resultant sediment distribution within present day Great Mosquito Cove has not been mapped to date. The 2005 monitoring study provided some point data from the mid-region of the cove and a “reference location” in the outer cove. Observations are fairly generalized, and indicate that some reworked fine grained sediments appear to have settled out over the dumped spoils (Environment Canada 2005).

A geologic survey along Great Mosquito Cove and a portion of Bull Arm will be conducted to define the present bathymetry.

The marine surficial geology of Bull Arm has been mapped with geophysical survey systems and geotechnical boreholes during pre-construction site investigations for the previous Hibernia and current Hebron projects (Newfoundland Geosciences Limited 1989a, 1989b, 1991; Fugro Jacques GeoSurveys Inc. 2010; Stantec 2011 (see Section 3.1.5.2)).

3.1.5.1 Surficial Geology

Surficial sediments within the marine environment were mapped with geophysical survey systems and geotechnical boreholes as part of the pre-construction site investigations (Newfoundland Geosciences Limited 1989a, 1989b, 1991). Surficial marine sediments within Great Mosquito Cove are comprised of localized occurrences of loose organic sand and gravel, on top of glacial till. The loose organic sediments were noted to be up to 1.7 m thick, and comprised predominantly (50 to 60 percent) of sand (Newfoundland Geosciences Limited 1991).

The underlying till was noted to be a poorly sorted mix of sands, gravels, cobbles and boulders, with variable amounts of fine-grained sediment (silts and clays) (Newfoundland Geosciences Limited 1991).

The bathymetry and seabed morphology in the nearshore area are characterized by both anthropogenic and naturally-occurring features. Within the drydock area, the seabed is predominantly flat, with average water depth of approximately 16 m. Seabed sediments in the drydock area are interpreted to range from silt to gravel. The bund wall area extends approximately 200 m southeast of the drydock area, with water depths on the order of 15 to 17 m. The seabed in this area has been reworked by the bund wall construction and demolition, and displays a rough seabed character with <1 m relief. Seabed sediments are mixed, consisting mainly of sand and gravel with cobble and boulders.

Seaward of the bund wall area, water depths increase rapidly to >20 m, with occasional shoals formed by bedrock outcrops. Sediment thickness varies from 0 m in areas of locally exposed bedrock to <6 m in occasional sediment-filled depressions. Seabed sediments are interpreted to be mainly sand and gravel with minor silt in low-lying areas; with cobble-boulder occurrences noted on thinly covered bedrock highs. The bathymetry exhibits a general deepening trend progressing seaward through Great Mosquito Cove, with the exception of several knolls in the vicinity of the Topsides assembly pier, rising to approximately 20 m water depth. The bathymetry of the Bull Arm channel is characterized by a naturally-occurring trough running in a northwest / southeast direction and deepening to approximately 203 m. Water depth at the deep water mating site is approximately 145 m.

3.1.5.2 Geotechnical Data

Two marine geotechnical programs were conducted within Bull Arm (Great Mosquito Cove) prior to the Hibernia GBS construction. A program by

Newfoundland Geosciences Limited (1989a, 1989b) on behalf of Mobil Oil Canada Properties acquired 21 boreholes. An additional program was conducted by Newfoundland Geosciences Limited in 1991, on behalf of NODECO. This program acquired 31 additional boreholes, again focused on the western (inner) end of the cove, and the northern shoreline near the proposed Topsides assembly area.

The geotechnical program identified four soil types, where present over bedrock (Newfoundland Geosciences Limited 1991):

- Very loose to compact sand and gravel with organic silt
- Dense cobbles and boulders in sand, gravel and silt matrix (TILL)
- Compact to very dense sand and gravel, some silt (TILL)
- Stiff to hard silt and sand with some gravel to silty clayey gravel and sand

A geotechnical investigation is scheduled to be conducted to define the soil and rock conditions presently existing at the location of the new bund wall.

Subsurface conditions at the Bull Arm Site were investigated in two phases (Stantec 2010a, 2011). The nearshore survey area of the Bull Arm Fabrication Site is characterized by varying thicknesses of fill in the areas of the north and south Hibernia bund wall abutments, which overlay glacial tills and occasional glaciomarine sediments. In areas where no fill was encountered (within tow channel), glacial till was generally observed at the seabed surface. The bund wall location, east of the original Hibernia bund wall alignment, is characterized by limited occurrences of fill in the areas of the north Hibernia bund wall abutment, which overlay glacial tills and occasional glaciomarine sediments. In areas where no fill was encountered (the majority of this area), glacial till was generally observed at the seabed surface. Thicknesses of overburden soils ranged from approximately 0.9 to 12 m.

3.2 Offshore

3.2.1 Atmospheric Environment

3.2.1.1 Climatology

The climate of the Grand Banks is very dynamic, largely governed by the passage of high and low pressure circulation systems. These circulation systems are embedded in, and steered by, the prevailing westerly flow that typifies the upper levels of the atmosphere in the mid-latitudes, which arises because of the normal tropical-to-polar temperature gradient. The mean strength of the westerly flow is a function of the intensity of this gradient and, as a consequence, is considerably stronger in the winter months than during the summer months[2], due to an increase in the south-to-north temperature gradient.

Spring warming results in a decrease in the north-south temperature gradient. Due to this weaker temperature gradient during the summer, storms tend to

[2] Note that meteorological convention defines seasons by quarters (e.g., winter is December, January, February, etc.).

be weaker and not as frequent. Furthermore, the weaker tropical-to-polar temperature gradient in the summer results in the storm tracks moving further north. With the low pressure systems passing to the north of the region, the prevailing wind direction during the summer months is from the southwest to south. As a result, the incidences of gale- or storm-force winds are relatively infrequent over Newfoundland during the summer.

The hurricane season in the North Atlantic basin normally extends from June through November, although tropical storm systems occasionally occur outside this period. As the hurricanes move northward over the colder ocean waters, they begin to lose their tropical characteristics. By the time these weakening cyclones reach Newfoundland, they are usually embedded into a mid-latitude low and their tropical characteristics are usually lost. The likelihood that a tropical hurricane will transition increases toward the second half of the tropical season, with October having the highest probability of transition. In the Atlantic, extratropical transition occurs at lower altitudes in the early and late hurricane season and during the peak of the season at higher latitudes (Hart and Evans 2001).

3.2.1.2 Wind Climatology

The Grand Banks experiences predominately southwest to west flow throughout the year. West to northwest winds that are prevalent during the winter months begin to shift counter-clockwise during March and April, resulting in a predominant southwest wind by the summer months. As autumn approaches, the tropical-to-polar temperature gradient strengthens and the winds shift slightly, becoming predominately westerly again by late fall and into winter.

Low pressure systems crossing the area are more intense during the winter months. As a result, mean wind speeds tend to peak during this season. Mean wind speeds at Grid Point 10632 (approximately 5 km south of the Hebron Platform location) and in the MANMAR (refers to reports generated in ship code format (World Meteorological Organization (WMO)-FM13) for transmission on the Global Telecommunications System (GTS)) data sets peak during the month of January (Table 3-25). A description of the data sources used is provided in EMCP (2010).

Wind speed typically increases with increasing heights above sea level. Statistics provided in Table 3-25 are presented in order of increasing height, with the MSC50 data set being the lowest (10 m) and the Hibernia Platform being the highest (anemometer heights for each platform may be found in Table 3-25). Statistics for each anemometer level are presented to give a better idea of winds at varying levels above sea level. Furthermore, methods to reduce wind speeds from anemometer level to 10 m have proven ineffective due to atmospheric stability issues.

MANMAR data sets are 10-minute average winds. For consistency, maximum wind speeds from the MSC50 data set have been adjusted to 10-minute maximum wind speeds. The adjustment factor to convert from peak 1-hour mean values to peak 10-minute mean values is usually taken as 1.06

(US Geological Survey 1979). Oceans Ltd. archives, based on MANMAR data, are the source for the Platform winds.

Table 3-25 Mean Wind Speed Statistics

Month	MSC50 Grid Point 10632 (m/s)	Terra Nova FPSO (m/s)	Glomar Grand Banks[A] (m/s)	GSF Grand Banks[A] (m/s)	Henry Goodrich (m/s)	Hibernia (m/s)
January	10.9	14.5	12.9	13.7	15.2	16.0
February	10.8	13.9	11.9	12.9	14.9	15.4
March	9.8	13.3	11.9	13.6	13.6	14.6
April	8.3	12.0	11.4	11.3	12.6	13.3
May	6.9	10.7	9.7	11.1	11.7	12.1
June	6.5	9.3	9.4	8.3	11.2	11.4
July	6.0	8.9	9.5	9.2	10.9	10.8
August	6.4	9.6	8.4	9.1	9.8	10.5
September	7.5	9.9	10.3	9.3	10.3	11.2
October	8.8	11.0	12.8	9.7	12.0	13.0
November	9.5	12.7	11.0	11.6	12.7	13.5
December	10.5	15.0	12.6	13.0	14.5	15.5

A Glomar Grand Banks and GSF Grand Banks were the same platform, reporting at different periods under different names.

Note: The height measurements are collected is 139 m at Hibernia GBS, 50 m at Terra Nova FPSO and 82.5 m at GFS Grand Banks

A wind rose of the annual wind speed and histogram of the wind speed frequency from Grid Point 10632 is presented in Figures 3-18 and 3-19. Monthly wind roses along with histograms of the frequency distributions of wind speeds for Grid Point 10632 can be found in EMCP (2010). There is a marked increase in the occurrence of winds from the west to northwest in the winter months as opposed to the summer months, which is consistent with the wind climatology of the area.

Intense mid-latitude low pressure systems occur frequently from early autumn to late spring. In addition, remnants of tropical systems have passed near Newfoundland between spring and late fall. Therefore, while mean wind speeds tend to peak during the winter months, maximum wind speeds may occur at anytime during the year. A table of monthly maximum wind speeds for each of the data sets is presented in Table 3-26.

3.2.1.3 Air and Sea Temperature

The moderating influence of the ocean serves to limit both the diurnal and the annual temperature variation on the Grand Banks. Diurnal temperature variations due to the day / night cycles are very small. Short-term, random temperature changes are due mainly to a change of air mass following a warm or cold frontal passage. In general, air mass temperature contrasts across frontal zones are greater during the winter than during the summer season.

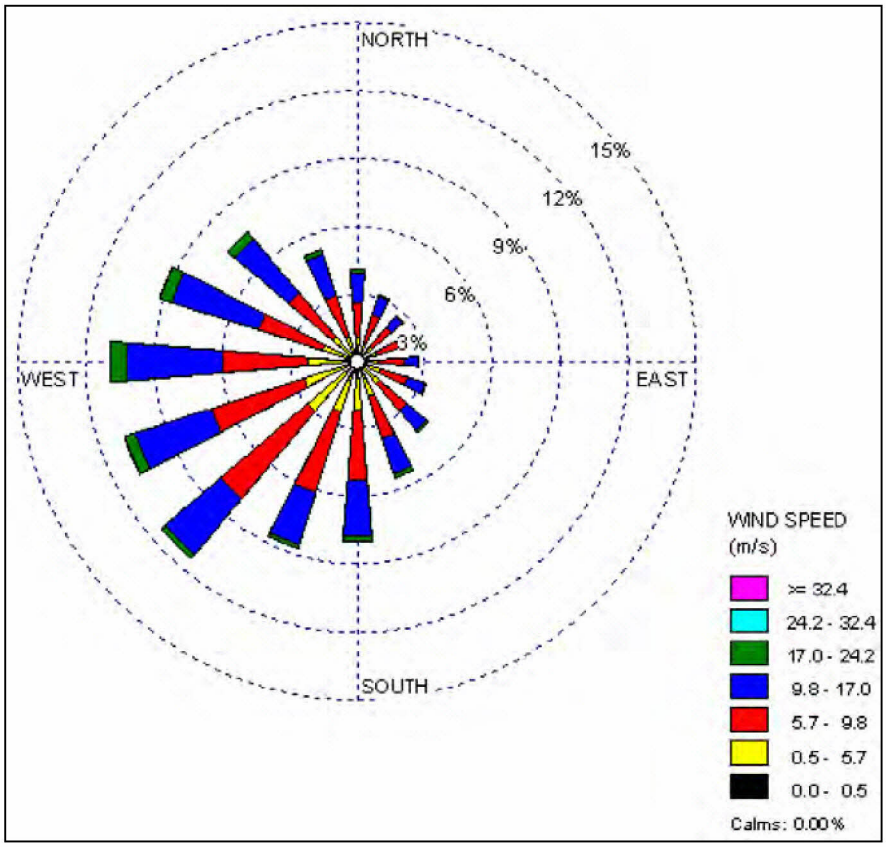


Figure 3-18 Annual Wind Rose for MSC50 Grid Point M10632, 1954 to 2005

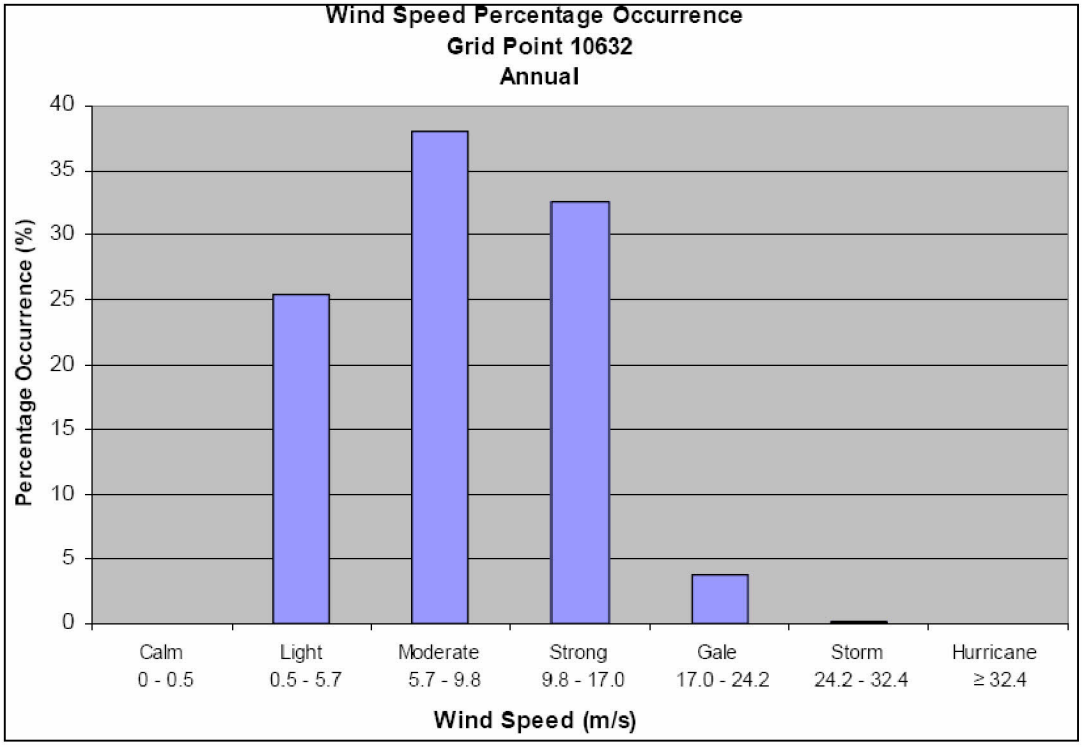


Figure 3-19 Annual Percentage Frequency of Wind Speeds for MSC50 Grid Point M10632, 1954 to 2005

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Table 3-26 Maximum Wind Speeds Statistics

Month	MSC50 Grid Point 10632 (m/s)	Terra Nova FPSO (m/s)	Glomar Grand Banks[A] (m/s)	GSF Grand Banks[A] (m/s)	Henry Goodrich (m/s)	Hibernia (m/s)
January	29	32	31	38	44	43
February	32	31	27	28	52	49
March	29	30	24	29	33	38
April	26	23	27	21	31	33
May	23	25	22	26	33	32
June	24	23	21	23	28	31
July	21	19	20	17	26	30
August	30	28	26	26	29	36
September	25	22	29	22	28	38
October	29	32	33	31	32	41
November	29	28	26	24	32	38
December	31	33	27	29	38	39

A Glomar Grand Banks and GSF Grand Banks were the same platform, reporting at different periods under different names.

Air temperature, sea surface temperature, precipitation, visibility and icing statistics for the area were compiled using data from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). A subset of global marine surface observations from ships, drilling rigs, and buoys encompassing the Offshore Project Area from 46.09°N to 47.04°N to 47.88°W to 49.02°W and covering the period from January 1950 to December 2006 was used in this report. This region was chosen by extending the Project Area by 0.25 degrees in all directions in order to include observations from various offshore installations that fall outside of the defined Project Area. It should be noted that temperature data from the Terra Nova Field would be included in the ICOADS data set; however, due to the inconsistencies in the ICOADS data set noted earlier, the Terra Nova data were analyzed separately.

A monthly plot of air temperature versus sea surface temperature is presented in Figure 3-20. Temperature statistics presented in Tables 3-27 and 3-28 show that the atmosphere is coldest in February, and warmest in August, similarly sea surface temperature is warmest in August and coldest in February. The mean sea surface temperature is in the range of 0.4°C to 1.4°C cooler than the mean air temperature from March to August, with the greatest difference occurring in the month of June. From September to February, sea surface temperatures are in the range of 0.3°C to 0.8°C warmer than the mean air temperature. The colder sea surface temperatures from March to August have a cooling effect on the atmosphere, while relatively warmer sea surface temperatures from September to February tends to warm the overlying atmosphere.

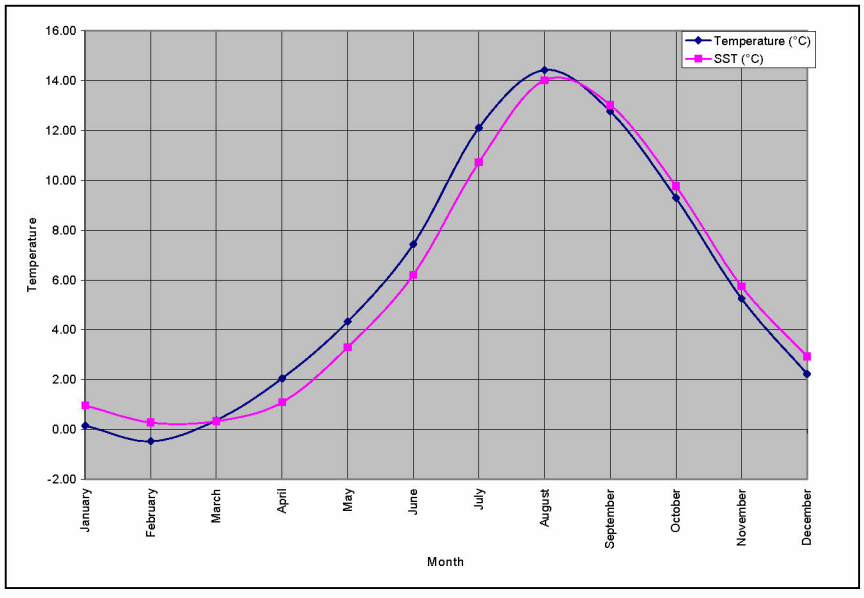

Figure 3-20 ICOADS Monthly Mean Air and Sea Surface Temperature

Table 3-27 ICOADS Air Temperature (°C) Statistics

Month	Mean	Maximum	Minimum	Standard Deviation	Mean Daily Maximum	Mean Daily Minimum
January	0.15	10.30	-13.80	3.11	1.86	-1.00
February	-0.48	10.40	-13.60	3.24	1.40	-1.58
March	0.37	17.00	-17.30	2.77	2.13	-0.53
April	2.05	13.40	-7.30	2.40	3.51	1.07
May	4.33	18.50	-3.20	2.43	5.66	3.17
June	7.43	22.80	-1.00	2.61	9.15	6.44
July	12.10	27.50	0.00	2.53	13.44	10.80
August	14.42	25.00	0.00	2.36	15.74	13.06
September	12.75	25.00	3.50	2.36	14.16	11.67
October	9.29	20.60	-1.00	2.99	10.67	8.07
November	5.25	18.10	-4.60	2.97	6.98	4.27
December	2.23	18.80	-12.80	3.27	3.81	1.04

Table 3-28 ICOADS Sea Surface Temperature Statistics

Month	Mean (°C)	Maximum (°C)	Minimum (°C)	Standard Deviation (°C)	Mean Daily Maximum (°C)	Mean Daily Minimum (°C)
January	0.96	10.00	-1.90	1.32	1.91	0.89
February	0.28	7.80	-2.10	1.05	1.08	0.12
March	0.33	15.30	-2.00	1.22	1046	0.37
April	1.09	17.00	-1.90	1.39	2.02	0.88
May	3.30	18.00	-0.60	1.84	4.01	2.67
June	6.21	21.50	0.00	2.02	7.17	5.58
July	10.27	24.50	4.00	2.29	11.55	10.13
August	14.01	25.00	7.80	2.03	14.62	13.22
September	13.02	25.00	3.50	1.94	13.81	12.27
October	9.76	21.00	2.00	2.29	10.47	8.86
November	5.74	19.50	0.00	2.26	6.82	5.21
December	2.93	18.60	-1.90	1.87	3.98	2.69

Monthly mean daily maximum and minimum temperature statistics are presented for both the ICOADS data set and the Terra Nova field (Table 3-29). Mean temperatures for each month are the mean of all temperatures recorded at the site during that month. The maximum and minimum temperatures are the highest and lowest temperatures respectively, recorded during the month over the entire data set. The mean daily maximum is the average of all maximum temperatures recorded during the specified month, while the mean daily minimum is the average of all minimum temperatures recorded during the specified month.

3.2.1.4 Precipitation

Precipitation can come in three forms:

- Liquid precipitation (drizzle, rain)
- Freezing precipitation (freezing drizzle, freezing rain)
- Frozen precipitation (snow, snow pellets, snow grains, ice pellets, hail, ice crystals)

Table 3-29 Monthly Air Temperature Statistics for the Terra Nova Field located at 46.4°N, 48.4°W

Month	Mean (°C)	Maximum (°C)	Minimum (°C)	Standard Deviation (°C)	Mean Daily Maximum (°C)	Mean Daily Minimum (°C)
January	0.65	9.10	-11.00	2.76	2.56	-0.91
February	-0.09	14.60	-11.10	2.76	1.66	-1.51
March	0.44	10.40	-8.00	2.34	1.94	-0.83
April	1.85	8.20	-5.30	2.06	3.10	0.78
May	4.01	10.70	-3.70	1.88	5.16	2.96
June	7.17	13.90	-6.00	2.25	8.31	6.12
July	12.33	18.20	4.20	2.37	13.39	11.35
August	14.88	19.40	9.00	1.89	15.95	13.87
September	13.52	20.00	7.00	2.10	14.76	12.30
October	10.16	16.40	1.00	2.58	11.49	8.91
November	6.53	14.10	-0.80	2.87	7.97	5.23
December	2.91	12.80	-6.20	3.09	4.66	1.38

Frequency of Precipitation Types

The frequency of precipitation type for each region was calculated using data from the ICOADS data set, with each occurrence counting as one event. Precipitation statistics for these regions may be low due to a fair weather bias. That is, ships tend to either avoid regions of inclement weather, or simply do not report during these events.

The frequency of precipitation type (Table 3-30) shows that annually, precipitation occurs 22.0 percent of the time within the ICOADS region. Winter has the highest frequency of precipitation, with 35.0 percent of the observations reporting precipitation. Snow accounts for the majority of precipitation during the winter months, accounting for 59.4 percent of the occurrences of winter precipitation. Summer has the lowest frequency of

precipitation, with a total frequency of occurrence of 12.7 percent. Snow has been reported in each month from September to May.

3.2.1.5 Icing

Freezing Precipitation

Freezing precipitation occurs when rain or drizzle aloft enters negative air temperatures near the surface and becomes super-cooled, so that the droplets freeze upon impact with the surface. This situation typically arises ahead of a warm front extending from low pressure systems passing west of the area.

The percentage of occurrences of freezing precipitation (Table 3-30) was calculated using the ICOADS data set. Since negative air temperatures are required for freezing precipitation, statistics show the frequency of freezing precipitation occurs only during the winter and spring months, with seasons experiencing freezing precipitation 0.4 percent of the time. On a monthly basis, March has the highest frequency of freezing precipitation; however, it only occurs less than 1.0 percent of the time.

Table 3-30 Percentage Frequency (%) Distribution of Precipitation

Month	Rain / Drizzle	Freezing Rain / Drizzle	Rain / Snow Mixed	Snow	Hail	Total
January	12.7	0.5	0.5	24.1	0.2	38.0
February	9.9	0.8	0.3	24.3	0.1	35.4
March	12.5	1.0	14.8	16.1	0.0	26.8
April	13.5	0.2	0.2	5.1	0.1	19.2
May	14.2	0.0	0.1	0.9	0.0	15.3
June	12.7	0.0	0.0	0.0	0.0	12.8
July	10.9	0.0	0.0	0.0	0.0	10.9
August	14.3	0.0	0.0	0.0	0.0	14.4
September	16.5	0.0	0.0	0.1	0.0	16.6
October	20.6	0.0	0.1	1.1	0.2	21.9
November	19.4	0.1	0.4	6.0	0.2	26.0
December	15.8	0.1	0.7	15.0	0.3	31.9
Winter	13.0	0.4	0.5	20.5	0.2	35.0
Spring	13.5	0.4	0.2	6.4	0.0	20.5
Summer	12.6	0.0	0.0	0.0	0.0	12.7
Autumn	18.8	0.0	0.2	2.4	0.1	21.4
Total	14.4	0.2	0.2	7.1	0.1	22.0

Sea Spray Vessel Icing

Spray icing can accumulate on vessels and shore structures when air temperatures are below the freezing temperature of water and there is potential for spray generation. In addition to air temperature, icing severity depends on water temperature, wave conditions and wind speed, all of which influence the amount of spray and the cooling rate of droplets. A review of the spray icing hazard is provided by Minsk (1977). The frequency of potential icing conditions and its severity was estimated from the algorithm proposed by Overland et al. (1986) and subsequently updated by Overland (1990).

The algorithm generates an icing predictor based on air temperature, wind speed and sea surface temperature, which was empirically related to observed icing rates of fishing vessels in the Gulf of Alaska. This method provides conservative estimates of icing severity in the Offshore Study Area, as winter sea surface temperatures are colder and wave conditions are lower in the Offshore Study Area compared to the Gulf of Alaska, where the algorithm was calibrated (Makkonen et al. 1991). Potential icing rates were calculated using wind speed and air sea surface temperature observations from the ICOADS data set. A total of 114,067 observations from vessels within the Offshore Study Area from January 1954 to December 2006 were used to calculate the percentage frequency of icing occurrence and severity for the Offshore Project Area. Monthly, seasonal and annual summaries are presented in Table 3-31 and Figure 3-21.

Potential sea spray icing conditions start in the Offshore Project Area during November, with a frequency of icing potential of just 0.3 percent. As temperatures cool throughout the winter, the frequency of icing potential increases to a maximum of 30.9 percent of the time in February. Extreme sea spray icing conditions were calculated to occur 5 percent of the time during February. Icing potential decreases rapidly after February in response to warming air and sea surface temperatures and by June, the frequency of icing conditions is 0.0 percent.

Table 3-31 Percentage Frequency of Potential Spray Icing Conditions

Month	None (0 cm/hr)	Light (<0.7 cm/hr)	Moderate (0.7 to 2.0 cm/hr)	Heavy (2.0 to 4.0 cm/hr)	Extreme (>4.0 cm/hr)
January	76.3	16.5	5.0	1.6	0.6
February	69.1	20.3	6.8	2.4	1.5
March	83.8	11.4	3.1	1.0	0.7
April	96.6	2.9	0.4	0.1	0.0
May	100.0	0.0	0.0	0.0	0.0
June	100.0	0.0	0.0	0.0	0.0
July	100.0	0.0	0.0	0.0	0.0
August	100.0	0.0	0.0	0.0	0.0
September	100.0	0.0	0.0	0.0	0.0
October	100.0	0.0	0.0	0.0	0.0
November	99.7	0.3	0.0	0.0	0.0
December	91.7	6.7	1.3	0.2	0.2
Winter	79.0	14.5	4.4	1.4	0.8
Spring	93.5	4.8	1.2	0.4	0.2
Summer	100.0	0.0	0.0	0.0	0.0
Autumn	99.9	0.1	0.0	0.0	0.0
Annual	76.3	16.5	5.0	1.6	0.6

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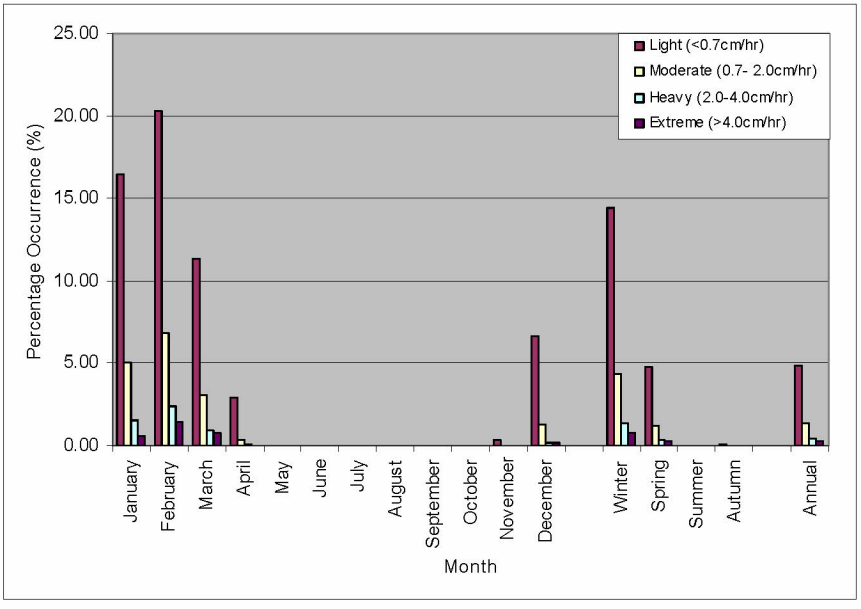


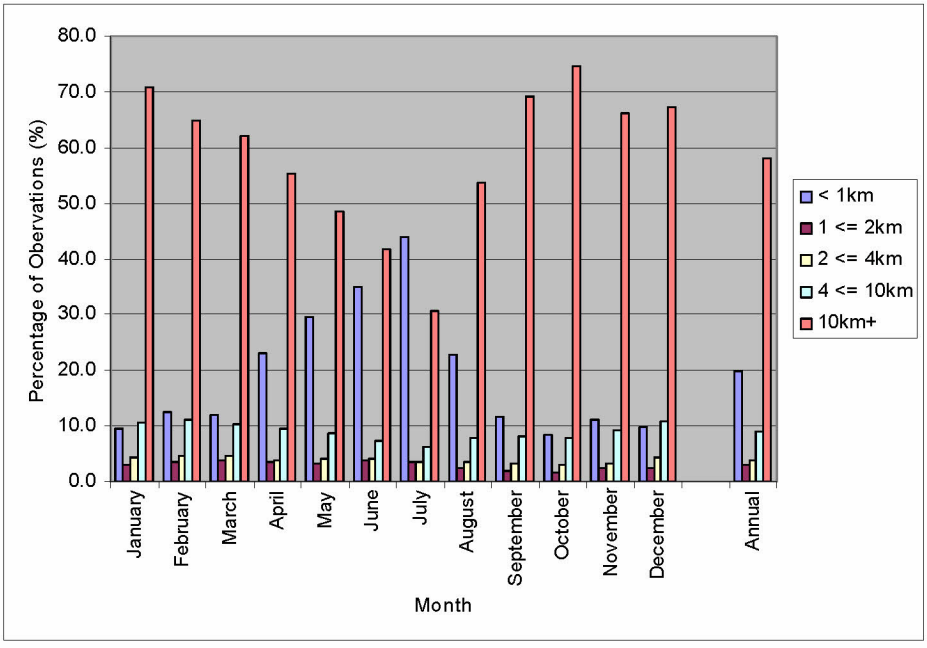
Figure 3-21 Percentage Frequency of Potential Spray Icing Conditions

3.2.1.6 Visibility

Visibility is defined as the greatest distance at which objects of suitable dimensions can be seen and identified. Horizontal visibility may be reduced by any of the following phenomena, either alone or in combination:

- Fog
- Mist
- Haze
- Smoke
- Liquid precipitation (e.g., drizzle)
- Freezing precipitation (e.g., freezing rain)
- Frozen precipitation (e.g., snow)
- Blowing snow

A plot of the frequency distribution of visibility from the ICOADS data set is presented in Figure 3-22; obstructions to vision can occur in any month. Annually, 15.5 percent of the recorded observations had reduced visibilities. During the winter months, the main obstruction is snow; however, mist and fog may also reduce visibilities at times. As spring approaches, the amount of visibility reduction attributed to snow decreases. As the air temperature increases, so does the occurrence of advection fog. Advection fog forms when warm moist air moves over the cooler waters of the Labrador Current. The presence of advection fog increases from April through July, with July having the highest percentage (57.0 percent) of obscuration to visibility, most of which is in the form of advection fog. On average, fog reduces visibility below 1 km 43.9 percent of the time in July. In August, the temperature difference between the air and the sea begins to narrow and by September,



Source: ICOADS Data set

Figure 3-22 Monthly and Annual Percentage Occurrence of Visibility
Source: ICOADS Data Set (1950 to 2006)

the air temperature begins to fall below the sea surface temperature. As the air temperature drops, the occurrence of fog decreases. Reduction in visibility during autumn and winter is relatively low and is mainly attributed to the passage of low-pressure systems. Fog is mainly the cause of the reduced visibilities in autumn. October has the lowest occurrence of reduced visibility (21.0 percent), since the air temperature has, on average, decreased below the sea surface temperature and it is not yet cold enough for snow.

3.2.1.7 Tropical Systems

A position located at 46.5°N, 48.5°W (located approximately 5 km due south of the proposed Hebron Platform location) was used to represent the Hebron Project Area. During the 59-year period from 1950 to 2007, 83 tropical systems have passed within 278 km of this location. The names of each cyclone are provided in Table 3-32 and the tracks over the Project Area are shown in Figure 3-23. It must be noted that the values in Table 3-32 are the maximum 1-minute mean wind speeds occurring within the tropical system at the 10-m reference level as it passed.

On occasion, these systems still maintain their tropical characteristics when they reach Newfoundland. On October 2, 1975, Hurricane Gladys, a Category 4 Hurricane as it passed east of Cape Hatteras, tracked northeast towards the Grand Banks. Gladys, still a Category 2 Hurricane with 43.7 m/s winds and a central pressure of 960 mb on October 3, moved northeast across the Grand Banks and maintained hurricane strength until it moved north of 50° latitude, when it weakened to a post-tropical storm.

More recently, in 2006, Category 1 hurricane Florence began undergoing extratropical transition on September 13, 2006 near 40.5°N 57.9°W (approximately 420 nm south-southwest of Cape Race, Newfoundland). The system then tracked northeast, passing near Cape Race late on September 13, 2006, then across the Northern Grand Banks September 14, 2006. As this system passed, wind speeds of 23.1 m/s were recorded by the Cape Race weather station and 37.6 and 28.3 m/s were recorded by the Hibernia and Henry Goodrich platforms, respectively.

There has been a substantial increase in the number of hurricanes that have developed within the Atlantic Basin within the last 15 years. This increase in activity has been attributed to the tropical multi-decadal signal (Bell and Chelliah 2006). As a result of the increase in tropical activity in the Atlantic Basin, there has also been an increase in tropical storms or their remnants entering the Canadian Hurricane Centre Response zone and, consequently, a slight increase in the number of tropical storms entering the Grand Banks (Figure 3-23). It should be noted that the unusually high number of tropical storms in 2005 may be skewing the results for the 2005 to 2008 season. The average number of storms for the three year period of 2006 to 2008 is only 14.7, as opposed to 18.5 storms for the four-year period of 2005 to 2008.

A substantial number of tropical cyclones which move into the mid-latitudes transition into extratropical cyclones. On average, 46 percent of tropical cyclones which formed in the Atlantic transition into extratropical cyclones. During this transformation, the system loses tropical characteristics and becomes more extratropical in nature resulting in an increase in the area which produces large waves, gale to hurricane force winds and intense rainfall. The likelihood that a tropical cyclone will transition increases toward the second half of the tropical season, with October having the highest probability of transition. In the Atlantic, extratropical transition occurs at lower altitudes in the early and late hurricane season and at higher latitudes during the peak of the season (Hart and Evans 2001).

A discussion of the long-term variability of climate on the Grand Banks is provided in EMCP (2010).

Table 3-32 Tropical Systems Passing within 370 km of 46.58°N 48.5°W, 1950 to 2009

Year	Month	Day	Hour	Name	Lat	Long	Wind (m/s)	Pressure (mb)	Category
1950	9	5	0600Z	Charlie	41.700	-54.700	23.1	N/A	Extratropical
1950	9	14	1200Z	Dog	43.100	-50.000	25.7	N/A	Extratropical
1950	10	5	1200Z	George	47.000	-51.900	30.9	N/A	Extratropical
1951	10	7	1200Z	How	42.600	-46.000	30.9	N/A	Extratropical
1952	9	8	1200Z	Baker	47.800	-49.300	30.9	N/A	Extratropical
1953	10	12	1200Z	Hazel	42.700	-53.200	18.0	N/A	Extratropical
1954	9	3	1200Z	Dolly	46.800	-47.400	25.7	N/A	Extratropical
1955	8	21	1200Z	Diane	45.000	-49.300	18.0	N/A	Extratropical
1956	8	19	1200Z	Betsy	43.200	-48.600	23.1	N/A	Extratropical
1956	9	11	0600Z	Carla	41.800	-53.000	12.9	N/A	Tropical Depression
1957	9	27	0600Z	Frieda	46.300	-52.800	18.0	N/A	Extratropical
1958	8	31	0000Z	Daisy	41.000	-49.600	23.1	N/A	Extratropical
1959	6	21	1200Z	Not Named	47.300	-53.700	23.1	N/A	Extratropical
1961	10	22	1200Z	Gerda	44.000	-49.000	15.4	N/A	Extratropical
1962	9	2	1200Z	Alma	42.200	-61.000	7.7	N/A	Extratropical
1962	10	9	0000Z	Daisy	45.500	-57.700	25.7	N/A	Extratropical
1962	10	22	1800Z	Ella	49.000	-50.000	30.9	N/A	Extratropical
1963	8	11	0000Z	Arlene	42.500	-52.000	33.4	N/A	Extratropical
1963	10	12	1800Z	Flora	45.200	-47.500	38.6	N/A	Extratropical
1964	9	4	1800Z	Cleo	46.900	-49.800	36.0	N/A	Category 1
1964	9	15	0000Z	Ethel	44.000	-49.000	38.6	N/A	Category 1
1964	9	24	1800Z	Gladys	44.700	-60.300	30.9	990	Extratropical
1966	7	3	0600Z	Becky	43.100	-55.000	28.3	N/A	Tropical Storm
1967	9	4	0600Z	Arlene	45.800	-48.600	30.9	N/A	Tropical Storm
1967	9	18	0000Z	Chloe	42.300	-47.800	41.2	N/A	Category 1
1969	8	4	1800Z	Anna	43.000	-47.000	23.1	N/A	Extratropical
1969	8	13	0000Z	Blanche	47.100	-49.000	25.7	N/A	Extratropical
1969	8	22	0600Z	Camille	40.800	-58.200	28.3	N/A	Tropical Storm
1969	8	24	1200Z	Debbie	48.000	-52.000	36.0	N/A	Category 1
1969	9	25	1800Z	Not Named	43.400	-57.900	33.4	N/A	Category 1
1969	10	18	0600Z	Kara	45.200	-45.300	41.2	980	Category 1
1970	10	17	1800Z	Not Named	42.500	-57.500	36.0	980	Category 1
1971	7	7	1800Z	Arlene	46.500	-53.000	23.1	N/A	Extratropical
1971	8	6	1200Z	Not Named	46.000	-49.000	38.6	974	Category 1
1973	10	28	0600Z	Gilda	47.500	-51.500	28.3	968	Extratropical
1974	9	1	1200Z	Becky	42.700	-47.800	41.2	N/A	Category 1
1975	7	4	0600Z	Amy	44.500	-51.600	25.7	986	Tropical Storm
1975	9	29	0000Z	Faye	42.800	-46.000	36.0	977	Category 1
1975	10	3	1200Z	Gladys	46.600	-50.600	43.7	960	Category 2
1976	8	24	0000Z	Candice	45.900	-48.700	41.2	N/A	Category 1
1977	9	30	0000Z	Dorothy	47.000	-51.000	25.7	995	Extratropical
1978	9	5	0600Z	Ella	47.200	-50.200	41.2	975	Category 1

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Year	Month	Day	Hour	Name	Lat	Long	Wind (m/s)	Pressure (mb)	Category
1980	9	8	1200Z	Georges	45.600	-51.100	35.0	993	Category 1
1981	8	5	0600Z	Cindy	43.300	-52.700	20.6	1006	Tropical Storm
1981	9	8	0600Z	Emily	42.900	-52.500	30.9	984	Tropical Storm
1982	9	19	0600Z	Debby	47.000	-50.500	38.6	979	Category 1
1984	8	20	1200Z	Sub Tropical 1	43.700	-48.300	25.7	1001	Subtropical
1984	9	2	1200Z	Cesar	46.000	-50.400	25.7	994	Tropical Storm
1984	10	20	0600Z	Josephine	41.800	-48.500	15.4	996	Extratropical
1986	8	22	0000Z	Charley	41.300	-49.400	23.1	990	Extratropical
1989	9	13	0600Z	Gabrielle	42.700	-53.500	15.4	1010	Tropical Depression
1990	10	15	0600Z	Lili	46.600	-56.400	20.6	994	Extratropical
1991	10	29	0600Z	Not Named	42.500	-55.500	23.1	992	Extratropical
1993	9	10	0600Z	Floyd	45.400	-48.300	33.4	990	Category 1
1994	8	23	1200Z	Chris	42.200	-55.500	23.1	1003	Tropical Storm
1995	7	20	1800Z	Chantal	45.400	-48.800	25.7	1000	Extratropical
1995	8	22	1200Z	Felix	46.800	-50.800	25.7	985	Tropical Storm
1995	9	11	1200Z	Luis	51.500	-48.500	36.0	960	Extratropical
1996	9	5	1800Z	Edouard	43.700	-47.500	23.1	995	Extratropical
1996	9	16	0000Z	Hortense	46.000	-54.000	20.6	998	Extratropical
1997	7	13	0000Z	Bill	41.600	-55.400	30.9	990	Tropical Storm
1997	7	27	0600Z	Danny	42.800	-56.000	20.6	1004	Extratropical
1998	8	30	1800Z	Bonnie	44.000	-50.000	23.1	998	Extratropical
1998	9	4	0000Z	Danielle	44.800	-48.500	33.4	975	Extratropical
1998	9	6	1800Z	Earl	49.500	-50.000	28.3	966	Extratropical
1999	9	23	0600Z	Gert	44.600	-54.500	30.9	968	Tropical Storm
1999	10	19	1200Z	Irene	48.000	-48.000	41.2	968	Extratropical
2000	9	17	1200Z	Florence	42.500	-55.000	25.7	1000	Tropical Storm
2001	8	29	0000Z	Dean	47.000	-48.500	23.1	999	Extratropical
2001	9	15	0600Z	Erin	49.000	-51.000	30.9	981	Extratropical
2001	9	20	0000Z	Gabrielle	48.500	-48.500	30.9	988	Extratropical
2001	9	27	1200Z	Humberto	42.200	-47.500	30.9	994	Tropical Storm
2002	7	17	0000Z	Arthur	44.500	-53.000	25.7	998	Extratropical
2004	8	6	0600Z	Alex	44.500	-49.300	38.6	978	Category 1
2004	9	2	0000Z	Gaston	47.000	-50.000	23.1	997	Extratropical
2005	7	30	1800Z	Franklin	46.400	-48.800	20.6	1006	Extratropical
2005	10	26	1200Z	Wilma	45.000	-55.000	25.7	986	Extratropical
2006	6	16	1800Z	Alberto	49.300	-51.500	20.6	990	Extratropical
2006	9	14	0600Z	Florence	48.600	-48.300	30.9	967	Extratropical
2006	10	3	0600Z	Isaac	48.600	-49.000	23.1	998	Extratropical
2007	8	1	1800Z	Chantal	49.000	-49.500	30.9	988	Extratropical
2008	9	8	0600Z	Hanna	47.500	-55.400	20.6	996	Extratropical
2009	8	24	1200Z	Bill	49.200	-47.200	30.9	980	Extratropical

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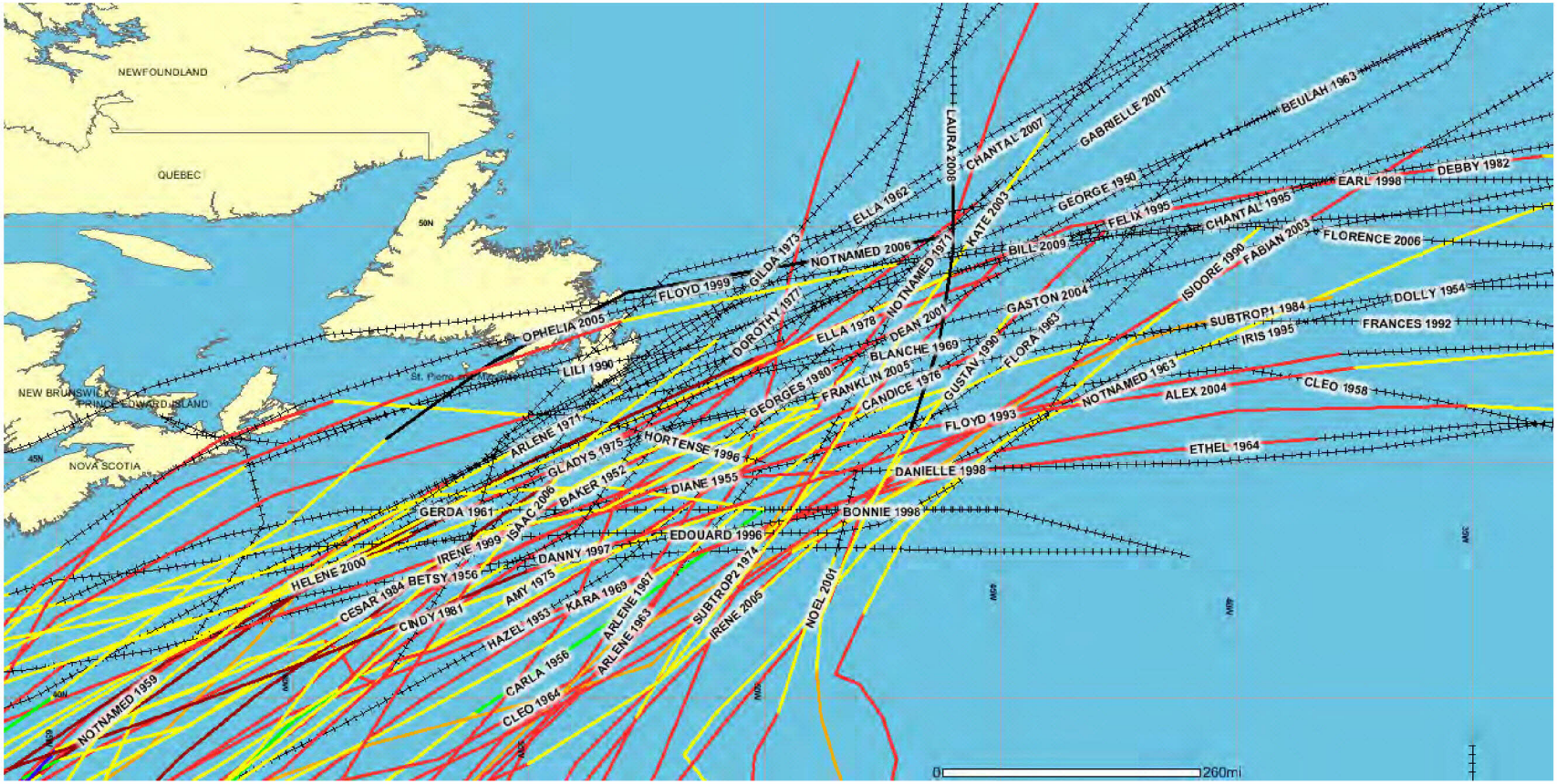


Source: NOAA Coastal Services Centre Archive No Date

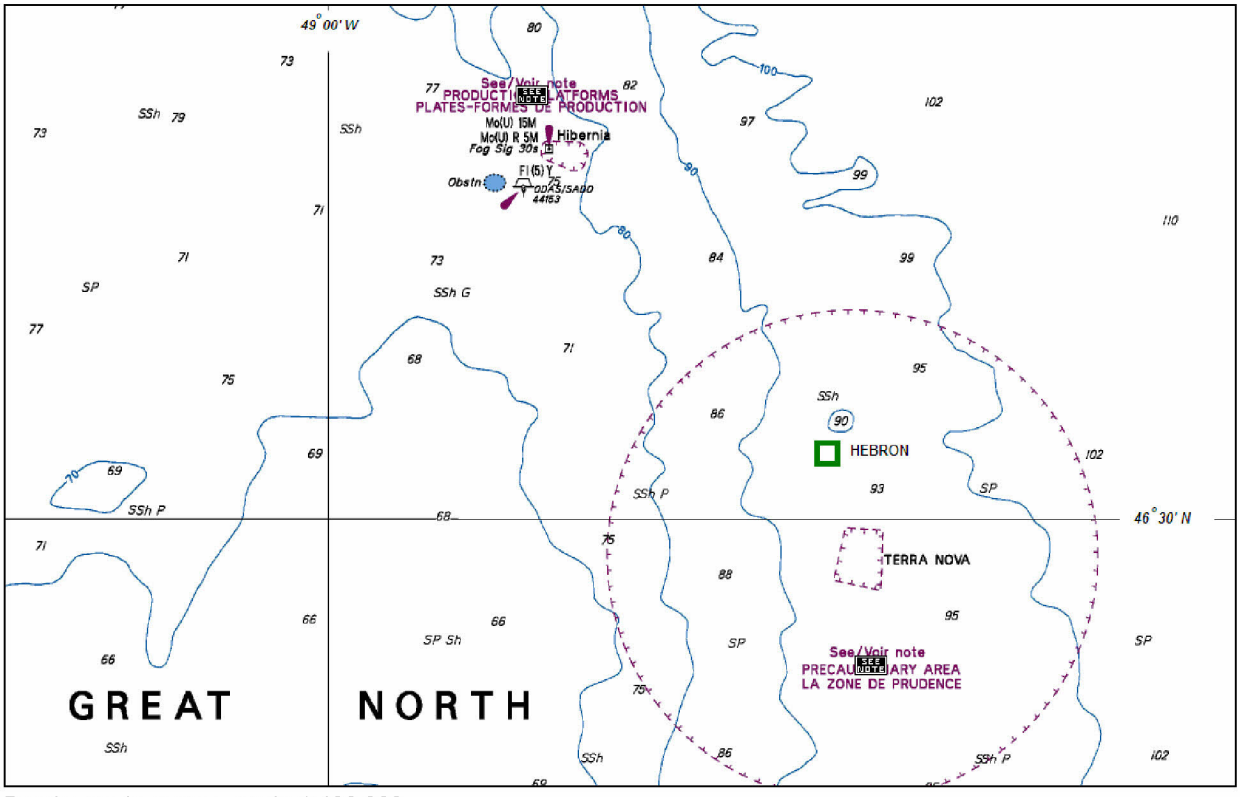
Figure 3-23 Storm Tracks of Tropical Systems Passing within 370 km of 46.5°N 48.5°W, 1950 to 2009

3.2.2 Oceanic Environment

3.2.2.1 Bathymetry

The Grand Banks extend almost 500 km offshore and cover an area of approximately 270,000 km^2. The bank is relatively flat, with typical water depths of 100 m or less. East of the bank is the Flemish Pass, which separates the Grand Banks from the Flemish Cap. The Flemish Pass reaches depths of over 1,000 m, while the Flemish Cap has a radius of approximately 200 km and depths as shallow as about 140 m. East and south of the Flemish Pass is the slope of the Newfoundland Shelf and the Atlantic Basin at depths exceeding 3,000 m. The Offshore Study Area encompasses the eastern portion of the Grand Banks from just north of the tail to the south at about 43°N, and north to 48°N, just south of the nose. The western portion extends in over the Grand Banks about 100 km to the west.

The Hebron Project Area is situated between the Hibernia, White Rose and Terra Nova development areas, and encompasses the Hebron, West Ben Nevis and Ben Nevis Significant Discovery License in a region approximately 30 km (east-west) by 15 km (north-south) on the eastern edge of the Grand Banks, near the 100 m bathymetry contour (see Figure 3-24). In this area, the depth ranges from approximately 88 m in the west to 102 m in the east (EMCP 2009).



Depths are in metres, scale 1:400,000

Source: CHS 1995, Chart #404901. Approximate Hebron location has been annotated

Figure 3-24 Offshore Project Area Bathymetry

3.2.2.2 Waves

Characterizations of normal and extreme wave conditions are available from three primary sources: the multi-year MSC50 wave hindcast, design criteria prepared for the Hebron Project (ExxonMobil Upstream Research Company 2009), and wave measurements from nearby Grand Banks oil production sites.

The MSC50 Grid Point M10834 is located at 46.6°N, 48.5°W, at a water depth of 93.4 m, approximately 5.7 km north of the Hebron Platform location (see Figure 3-25). MSC50 hindcast model data were extracted for this Grid Point from which to derive the wave climate summary plots and statistics presented below.

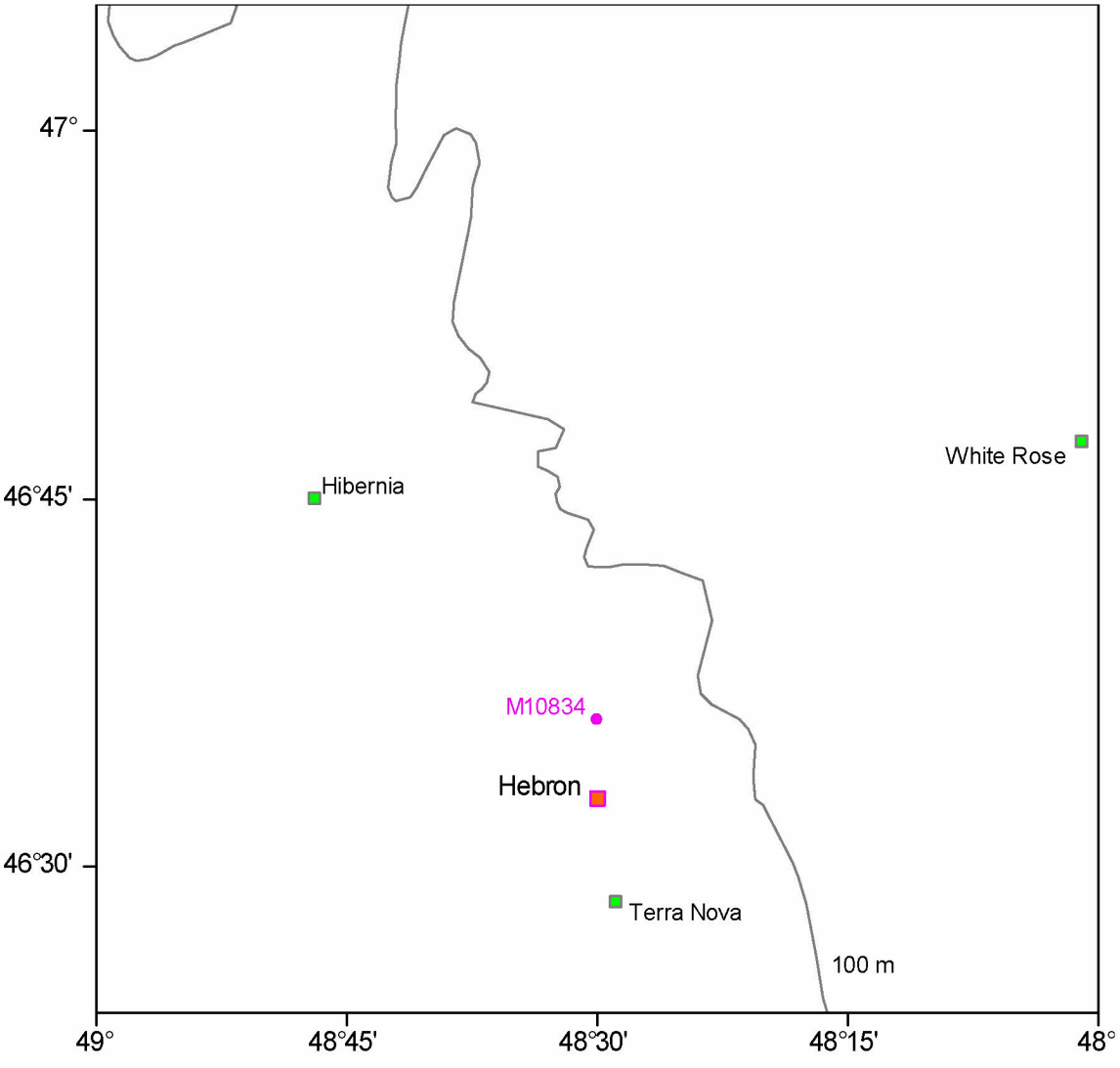


Figure 3-25 MSC50 Climatology Grid Point M10834 on the Grand Banks

Table 3-33 Monthly and Annual Significant Wave Height and Peak Wave Period Statistics, from MSC50 Grid Point M10834

Month	Significant Wave Height (m)				Peak Wave Period (s)		
	Minimum[A]	Mean	Maximum	Most Frequent Direction (from)	Minimum[A]	Mean	Maximum
Jan	-	3.9	12.9	WSW	-	10.2	17.3
Feb	-	3.7	13.7	WSW	-	10.0	17.0
Mar	-	3.2	11.2	WSW	-	9.2	17.7
Apr	-	2.7	10.7	SW	-	9.0	17.1
May	-	2.2	9.9	SW	-	8.6	17.3
Jun	0.5	1.9	9.7	SW	3.4	7.9	14.4
Jul	0.6	1.7	6.2	SW	3.6	7.6	17.2
Aug	0.6	1.8	8.5	SW	3.6	7.7	16.1
Sep	0.7	2.4	10.8	WSW	3.6	8.9	17.3
Oct	0.9	2.9	11.8	NNW	3.7	9.4	17.6
Nov	0.6	3.3	11.2	WSW	3.7	9.8	16.0
Dec	1.1	3.9	13.5	WSW	4.2	10.3	16.0
Year	-	2.8	13.7	SW	-	9.0	17.7

A Historical minimum wave conditions in winter / spring are zero due to the possible presence of ice

Table 3-34 Annual Significant Wave Height vs. Peak Wave Period, from MSC50 Grid Point M10834

Peak Period (s)	Significant Wave Height (m)							
	0-2	2-4	4-6	6-8	8-10	10-14	Total	% Total
2-4	4950	0	0	0	0	0	4950	1.1
4-6	17563	2892	1	0	0	0	20456	4.5
6-8	62894	55559	875	0	0	0	119328	26.2
8-10	57420	86395	24925	325	0	0	169065	37.1
10-12	9561	60338	24795	7981	664	0	103339	22.7
12-14	2756	14021	9220	3068	2561	557	32183	7.1
14-16	433	2634	2452	403	108	290	6320	1.4
16-18	78	76	36	1	0	0	191	0.04
Total	155655	221915	62304	11778	3333	847	455832	100
% Exceed	65.9	17.2	3.5	0.9	0.2	0	0	0

Wave parameters in the MSC50[3] hindcast include Hs[4] and Tp[5]. Monthly and annual wave height statistics are shown in Table 3-33. Mean Hs values range from 1.7 m in July to 3.9 m in December and January. The annual mean Hs is 2.8 m. Hs is greatest at 13.7 m in February and 13.5 m in December.

[3] MSC50 parameters include wind speed, wind direction, Hs, Tp (several estimates), wave direction, wave spread and spectral moments

[4] Wave height is the vertical distance from trough to crest of a wave. Hs is a descriptive wave height measure defined as the average height of the highest one-third of the waves. Hs can also be estimated from a measured or hindcast wave spectrum as $4\sqrt{mo}$, where mo is the variance of the wave spectrum. The MSC50 employs this latter definition for Hs

[5] Tp is the period of waves with the most energy (i.e., 1/fp, where fp is the peak frequency of the wave spectrum)

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During the summer the maximum Hs ranges from 6.2 m in July to 8.5 m in August and 10.8 m in September. In winter (December through February), Hs is less than 2 m for 7 percent of the time, between 2 and 4 m for 55 percent of the time, and greater than 6 m for 9 percent of the time. By contrast, in summer (June through August), Hs is less than 2 m for 71 percent of the time, between 2 and 4 m for 27 percent of the time, and greater than 6 m for 0.4 percent of the time. Annually, 49 percent of waves have a Hs between 2 and 4 m (Table 3-34).

Seasonal wave roses (showing direction waves travel to, the seasons are abbreviated with the months considered (e.g., DJF for December, January, February)) for MSC50 Grid Point M10834 are presented in Figure 3-26. During the summer, waves are most frequently from the southwest, for 55 percent of the time. In the fall, winds switch around to the northwest, and by winter, waves are now from the southwest 28 percent of the time and from the west through north-northwest 36 percent of the time (15 percent in summer). In spring, the pattern reverses and while southwest winds are still the most frequent, there is no strongly predominant wind direction, each of the 16 wind directions occur from approximately 4 to 12 percent of the time. Monthly and annual wave roses are provided in EMCP (2010).

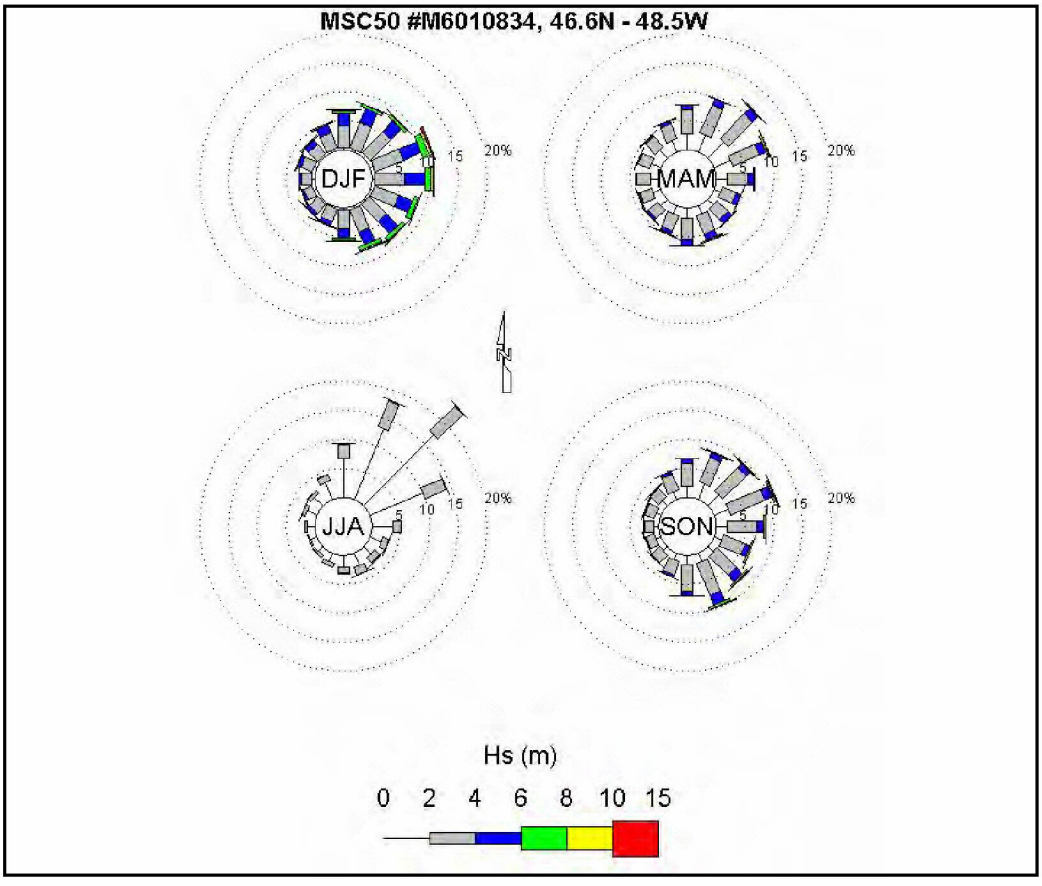

Figure 3-26 Seasonal Frequency of Significant Wave Height by Direction for the MSC50 Grid Point M10834

ExxonMobil Upstream Research Company has prepared a Metocean Criteria for the Hebron Project including operational[6] and extreme wave conditions based on the MSC50 hindcast at the same Grid Point M10834 (ExxonMobil Upstream Research Company 2009). In that work, the peaks-over-threshold approach was applied to fit storm peak wave values to a Weibull probability distribution from which long return value, or extreme, estimates could be made. The Hs values were first calibrated to Hibernia measurements. The hindcast wave data have been previously calibrated based on measurements at Hibernia from 1999 through 2005 (Berek and Wang 2009). The following calibration is used:

$$Hs_{,calibrated} = 1.0507 * Hs_{,hindcast} - 0.4793$$

The calibration leads to a reduced operational criteria and increased extreme criteria.

Non-exceedance values (95 and 99 percent upper limit), together with 1- to 100-year return period estimates, are provided in Table 3-35. In addition to Hs, Tp, the maximum individual wave height (Hmax, calculated as 1.88 times Hs), the wave period associated with Hmax (THmax) and the associated wind speed are also reported in Table 3-35. Further details of the data and methods employed to derive these values are provided by ExxonMobil Upstream Research Company (2009). From these statistics, it is estimated that 5 percent of waves near the Hebron Platform location have a Hs of 5.3 m or above, and corresponding maximum wave heights of 10 m or greater. For a 50-year return period, a Hs of 14.3 m and corresponding Hmax of 26.9 m could be expected.

Table 3-35 Extreme Wave Statistics

Return Period	Hs (m)	Tp (s) (± 10% range)	Hmax (m)	THmax (s) (± 10% range)	1-h associated wind speed at 10 m (m/s)
95% upper limit	5.3	9.3 – 11.4	10.0	8.5 – 10.4	17.6
99% upper limit	7.8	10.7 – 13.0	14.7	9.7 – 11.8	21.7
1-year	10.5	12.1 – 14.8	19.7	11.0 – 13.5	26.2
5-year	12.2	13.1 – 16.0	22.9	11.9 – 14.6	29.0
10-year	12.9	13.5 – 16.5	24.3	12.3 – 15.0	30.1
25-year	13.7	13.9 – 17.0	25.8	12.6 – 15.5	31.4
50-year	14.3	14.2 – 17.4	26.9	12.9 – 15.8	32.4
100-year	14.8	14.5 – 17.7	27.8	13.2 – 16.1	33.2
Source: ExxonMobil Upstream Research Company 2009					

ExxonMobil Upstream Research Company also provides directional scale factors for extreme waves. Due to the fact that the various return period wave height values of Table 3-35 (Table 3-32 in June 2010 CSR) are based on observations from all directions, scaling factors were determined to enable estimation of extreme wave heights expected for a particular wave direction.

[6] Annual and monthly tables of wave height vs. wave direction, wave height vs. wave period, exceedance of wave height (monthly only), and wave roses

The MSC50 Grid Point M10834 Hs were segregated into eight 45° bins and a directional scaling factor was calculated for each bin. This was accomplished by dividing the maximum Hs for a given bin by the maximum Hs from all bins (directions), to yield eight directional factors (ExxonMobil Upstream Research Company 2009). These factors are reproduced in Table 3-36 (Table 3-33 in June 2010 CSR) and could be applied to an extreme wave value such as those reported in Table 3-35 (Table 3-32 in June 2010 CSR).

Table 3-36 Wave Height Directional Weighting Factors

Wave Direction (to)	N	NE	E	SE	S	SW	W	NW
Wave Height Scale Factor	0.90	1.00	0.95	0.95	0.95	0.75	0.70	0.70
Source: ExxonMobil Upstream Research Company 2009								

Physical monitoring data from offshore production activities on the Jeanne d'Arc Basin have been collected for more than 10 years. There are presently three oil-producing fields in the North Atlantic: Hibernia; Terra Nova; and White Rose (e.g., Table 3-37 (or Figure 3-25)). Water depths range from approximately 85 m at Hibernia to 95 m at Terra Nova to 120 m at White Rose. The Hebron Field is located in the Jeanne d'Arc Basin, approximately 9 km north of Terra Nova and approximately 35 km southeast of Hibernia. Numerous exploration drilling programs and associated oceanographic monitoring programs at these and other Grand Banks locations have also been completed from the late 1970s through to the present. A summary of selected sources available for comparison of Grand Banks wave conditions is provided in Table 3-37. A series of Hs and Tp monthly and annual, and annual Hs vs Tp bivariate statistics for these sources are presented in to Tables 3-38 to 3-43.

Table 3-37 Grand Banks Selected Wave Measurement Sources

Site	Instrument	Time Period	Description
Hibernia	Waverider buoy	1980 to 1988	Assembled from Waverider buoy measurements from drill sites near Hibernia. Waveriders are sea surface-following accelerometer buoys (twice integrated the measurements yield sea surface elevation, hence wave height). Gap filling was accomplished with a wind / wave correlation model, and (for 1985 to 1988, which saw substantially lower drilling activity) an operational wave hindcast model (McClintock 1993).
Hibernia	MIROS surface radar system	1998 to 1999	"The Hibernia platform-mounted MIROS Wave Radar system monitors sea state and surface currents. MIROS makes use of active microwave remote sensing techniques to collect sea state (waves and currents) information from the ocean surface. MIROS operates in C-band. The frequency of operation is 5.8 GHz and the corresponding wavelength is 5.17 cm. The sea surface is illuminated by the radar antenna pointing almost horizontally, with a grazing angle of approximately 10°. MIROS scans a 180° swath of ocean extending some 100 m out from the Platform" (AMEC 2003)

Site	Instrument	Time Period	Description
Terra Nova	Waverider buoy	1999 to 2009	Datawell Waverider buoy as noted above for earlier Grand Banks exploration drilling.
White Rose	TRIAXYS directional wave buoy	2003 to 2007	Similar and acceptable wave measurement as per Waverider: has three accelerometers, three rate gyros. Benefits include directional wave information and rugged buoy design as a practical benefit.

Notes:

- Hm0, significant wave height, is estimated from the spectral moment, m0
- Tp, peak period, is defined as $1/f_p$ where f_p is the frequency at which the wave spectrum has its maximum value
- These parameters correspond to VCAR, Characteristic significant wave height, and VTPK, wave spectrum peak period, as reported by DFO (2010b)
- The reader interested in details of these and other particular wave instrumentation and/or data measurements should consult the appropriate data repositories (e.g., DFO 2010c) and end-of-well or annual oceanographic data reports (e.g., from Operator or C-NLOPB library).

Table 3-38 Monthly and Annual Significant Wave Height and Peak Period Statistics at Hibernia for January 1980 to December 1988, and January 1998 to December 1999

Month	Significant Wave Height (m)			Peak Wave Period (s)		
	Min	Mean	Max	Min	Mean	Max
Jan	0.5	4.0	13.7	3.3	11.0	18.2
Feb	0.0	3.1	11.4	2.0	10.3	22.7
Mar	0.1	2.8	9.1	3.0	10.4	21.5
Apr	0.7	2.8	9.4	3.3	11.1	23.0
May	0.1	2.1	6.4	3.3	9.6	23.1
Jun	0.5	1.8	5.2	3.3	8.9	23.0
Jul	0.1	1.6	6.4	3.4	8.5	22.6
Aug	0.1	1.7	5.8	3.3	8.7	22.9
Sep	0.0	2.5	9.9	2.0	10.2	23.1
Oct	0.1	3.2	13.0	3.3	10.4	21.8
Nov	0.4	3.3	11.5	3.8	10.3	21.4
Dec	0.1	3.8	13.8	3.3	10.8	21.7
Year	0.0	2.7	13.8	2.0	10.0	23.1

Source:

1980-1988 (McClintock 1993)

1998-1999 (DFO 2010c)

Note: Data sampled at 3 hour intervals during 1980 to 1988, and at 20 minute intervals during 1998 to 1999.

Table 3-39 Annual Significant Wave Height vs. Peak Wave Period at Hibernia for January 1980 to December 1988, and January 1998 to December 1999

Peak Period (s)	Significant Wave Height (m)							
	0-2	2-4	4-6	6-8	8-10	10-15	Total	% Total
2-4	189	215	1	0	0	0	405	0.6
4-6	2,076	853	17	3	3	0	2,952	4.0
6-8	5,392	4,927	371	18	5	2	10,715	14.5
8-10	10,129	9,345	2,643	209	14	9	22,349	30.2
10-12	5,505	12,723	3,663	735	121	33	22,780	30.8
12-14	1,761	5,143	1,777	498	191	47	9,417	12.7
14-16	717	1,948	834	138	71	7	3,715	5.0
16+	512	720	125	20	0	5	1,382	1.9
Total	26,281	35,874	9,431	1,621	405	103	73,715	99.6
% Exceed	35.5	48.5	12.7	2.2	0.6	0.1	99.6	0

Source:

1980-1988 (McClintock 1993)

1998-1999 (DFO 2010c)

Note: Data sampled at three- hour intervals during 1980 to 1988, and at 20-mininute intervals during 1998 to 1999.

Table 3-40 Monthly and Annual Significant Wave Height and Peak Period Statistics at Terra Nova for July 1999 to September 2009

Month	Significant Wave Height (m)			Peak Wave Period (s)		
	Min	Mean	Max	Min	Mean	Max
Jan	1.5	4.0	12.5	4.6	10.0	18.2
Feb	1.0	3.8	14.6	4.2	9.8	16.7
Mar	0.8	3.3	9.4	4.4	9.6	16.7
Apr	0.6	2.6	7.1	3.7	9.3	14.3
May	0.6	2.2	6.3	2.9	8.5	14.3
Jun	0.6	1.8	6.5	3.0	7.9	14.3
Jul	0.6	1.5	4.1	3.2	7.8	14.3
Aug	0.5	1.8	8.0	3.2	8.0	25.0
Sep	0.7	2.3	10.4	2.8	9.0	18.2
Oct	0.8	3.0	10.4	3.9	9.7	18.2
Nov	1.0	3.0	10.2	4.0	9.6	18.2
Dec	1.2	3.8	11.7	4.2	9.8	14.3
Year	0.5	2.7	14.6	2.8	9.1	25.0

Source: DFO 2010c

Terra Nova WEL IDs: 411 (G-90), 426 (F-88), 436 (G-90), 437 (L-98), 438 (C-69), 439 (F-100), 448 (FPSO)

Note: Data sampled at 20 minute intervals until February 2000, and subsequently at 30 minute intervals. Data gaps include parts of September-October 2002; January-April 2004.

Table 3-41 Annual Significant Wave Height vs. Peak Wave Period at Terra Nova for July 1999 to September 2009

Peak Period (s)	Significant Wave Height (m)							
	0-2	2-4	4-6	6-8	8-10	10-15	Total	% Total
2-4	144	0	0	0	0	0	144	0.1
4-6	6,408	1,946	1	0	0	0	8,355	5.0
6-8	23,999	16,389	972	7	0	0	41,367	24.7
8-10	18,866	27,159	5,439	377	9	0	51,849	30.9
10-12	9,315	31,157	12,115	2,364	415	30	55,396	33.0
12-14	799	4,110	2,414	470	124	46	7,963	4.7
14-16	337	1,193	801	285	64	6	2,686	1.6
16+	3	54	10	7	3	0	77	0.1
Total	59,871	82,008	21,751	3,510	615	82	167,837	100
% Exceed	35.7	48.9	13.0	2.1	0.4	0.1	100	0

Source: DFO 2010c

Terra Nova WEL IDs: 411 (G-90), 426 (F-88), 436 (G-90), 437 (L-98), 438 (C-69), 439 (F-100), 448 (FPSO)

Table 3-42 Monthly and Annual Significant Wave Height and Peak Wave Period Statistics at White Rose for October 2003 to August 2007

Month	Significant Wave Height (m)			Peak Wave Period (s)		
	Min	Mean	Max	Min	Mean	Max
Jan	1.5	4.2	11.2	5.6	11.4	16.7
Feb	1.4	3.5	9.4	5.0	11.0	16.7
Mar	1.2	3.5	10.0	5.0	11.6	16.7
Apr	0.8	2.6	7.1	4.6	10.5	16.7
May	0.6	2.2	5.9	3.5	9.7	16.7
Jun	0.7	1.8	6.8	3.2	8.6	16.7
Jul	0.6	1.4	3.5	3.3	8.3	16.7
Aug	0.7	1.8	7.5	3.5	8.9	16.7
Sep	0.7	2.4	10.2	4.4	10.3	16.7
Oct	0.9	3.0	12.2	4.8	11.1	16.7
Nov	1.1	3.2	11.2	4.8	11.4	16.7
Dec	1.4	3.4	11.1	4.8	10.7	16.7
Year	0.6	2.7	12.2	3.2	10.2	16.7

Source: DFO 2010b

Note: Data sampled at 30 minute intervals. Data gaps include parts of February-May 2004; August-September 2004; February 2006; January-February 2007;

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Table 3-43 Annual Significant Wave Height vs. Peak Wave Period at White Rose for October 2003 to August 2007

Peak Period (s)	Significant Wave Height (m)							
	0-2	2-4	4-6	6-8	8-10	10-15	Total	% Total
2-4	32	0	0	0	0	0	32	0.1
4-6	1,366	212	0	0	0	0	1,578	3.1
6-8	4,656	2,689	51	0	0	0	7,396	14.4
8-10	6,161	5,101	499	8	0	0	11,769	23.0
10-12	4,379	10,420	2,379	314	13	0	17,505	34.1
12-14	873	4,400	1,748	395	95	3	7,514	14.7
14-16	325	2,290	1,267	291	79	19	4,271	8.3
16+	100	333	381	160	56	10	1,040	2.0
Total	17,892	25,445	6,325	1,168	243	32	51,105	99.7
% Exceed	34.9	49.6	12.3	2.3	0.5	0.1	99.7	0
Source: DFO 2010b								

A comparison of the MSC50 hindcast with these measurements is presented in Figure 3-27, where mean and 95 percent upper limit (estimated, assuming a normal distribution, as mean +1.96 x standard deviation) are shown.

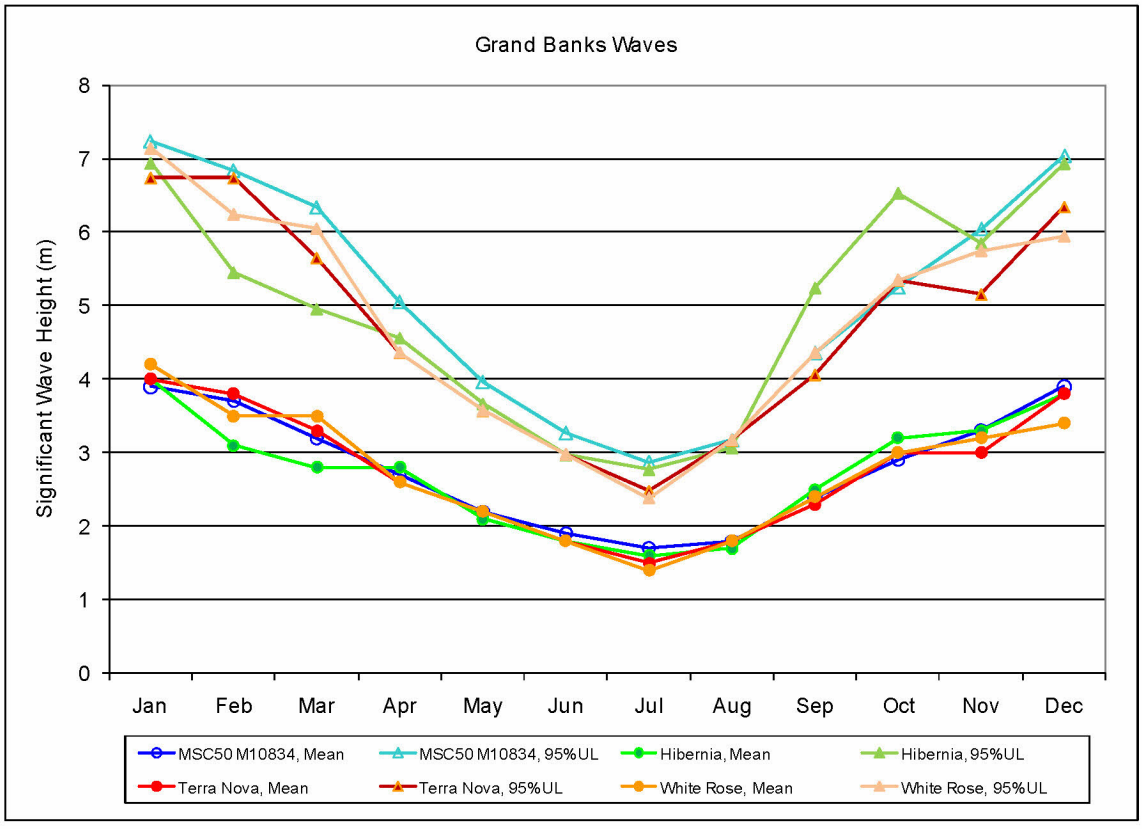

Figure 3-27 Significant Wave Height Comparison: MSC50 Grid Point M6010834 Hindcast, and Hibernia, Terra Nova, and White Rose, Measurements

This is clearly not a complete list, nor exhaustive analysis or comparison; however, it focuses on providing a continuous record from the 1980s, together with record of the most recent measurements available from Hibernia, Terra Nova and White Rose. The history also shows the various wave instruments employed.

The locations of wave observations are provided in Table 3-44.

The combined Hs height statistics for the MSC50 data set are provided in Table 3-45.

Table 3-44 Locations of Wave Observations

Location	Latitude	Longitude	Period
Terra Nova	46.4°N	48.4°W	July 13, 1999 to March 31, 2007
Ocean Ranger	46.5°N	48.4°W	December 04, 1980 to February 09, 1982
Hibernia	46.7°N	48.7°W	January 01, 1998 to December 08, 2004
Hibernia	46.7°N	48.7°W	January 01, 2004 to December 31, 2008

Table 3-45 Combined Significant Wave Height Statistics (m) for the MSC50 Data Set

Month	MSC50 Grid Point 10632	Terra Nova	Hibernia (1998 to 2004)	Hibernia (2005 to 2008)	Ocean Ranger
January	3.9	4.1	4.0	3.9	5.2
February	3.7	3.9	3.7	3.4	4.4
March	3.2	3.4	3.6	3.1	4.7
April	2.7	2.6	2.8	2.3	3.7
May	2.2	2.2	2.3	1.8	1.7
June	1.9	1.8	2.0	1.8	1.5
July	1.7	1.5	1.6	1.6	1.8
August	1.8	1.7	1.9	1.8	1.8
September	2.4	2.3	2.3	2.4	3.8
October	2.9	3.0	2.6	3.2	3.0
November	3.3	3.2	3.2	2.9	4.8
December	3.9	3.7	3.8	3.6	4.6

3.2.2.3 Wind and Waves Extremes

Rapidly deepening storm systems, known as weather bombs, frequently cross the Grand Banks. These storm systems typically develop in the warm waters of Cape Hatteras and move northeast across the Grand Banks. On February 11, 2003, wind speeds at Grid Point M10632 peaked at 29.9 m/s, while wave heights peaked four to five hours later at 13.6 m. Wind speeds of 49.4 and 52.5 m/s from the southwest were recorded by the Hibernia and the Henry Goodrich anemometers, respectively, as this system passed. During this same event, wave heights of 14.66 m were recorded over a 20-minute interval by a waverider buoy in the area. During this storm, a low pressure developing off Cape Hatteras on February 10, rapidly deepened to 949 mb as it tracked northeast across the Avalon Peninsula around 18 GMT on February 11.

Another intense storm that developed south of the region passed east of the area on December 16, 1961. This storm resulted in wind speeds similar to that produced during the February 11, 2003, storm. During this event, Grid Point 10632 had wind speeds of 29.7 m/s.

While mid-latitude low pressure systems account for the majority of the peak wind events on the Grand Banks, storms of tropical origin can also on occasion pass over the region. On October 19, 1999, the remnants of Category 2 Hurricane Irene passed approximately 40 nm west of the region as a tropical storm, with maximum sustained 1-minute wind speeds of 41.1 m/s, which converts to a 10-minute wind speed of 35.8 m/s. During this event, the 10-minute average wind speeds in the MSC50 data set peaked at 28.8 m/s from the south-southwest. The Hibernia Platform reported a measured wind speed 41.2 m/s (US Geological Survey 1979).

An analysis of extreme wind and waves was performed using Grid Point M10632 of the MSC50 data set. This data set was determined to be the most representative of the available data sets (including the ICOADS data set as well as MANMAR observations from platforms within the region), as it provides a continuous 52-year period of hourly data for the study area. The extreme values for wind and waves were calculated using the peak-over-threshold method and, after considering four different distributions, the Gumbel distribution was chosen to be the most representative as it provided the best fit to the data.

Since extreme values can vary depending on how well the data fit the distribution, a sensitivity analysis was carried out to determine the number storms to use. The number of storms determined to provide the best fit annually and monthly for Grid Point M10623 are presented in Table 3-46.

Table 3-46 Number of Storms Providing Best Fit for Extreme Value Analysis of Winds and Waves for Grid Point 10632

	Annually	Monthly
Wind	435	96
Wave	317	72

Extreme Value Estimates for Winds from the Gumbel Distribution

The extreme value estimates for wind were calculated using Oceanweather Inc's Osmosis software program for the return periods of 1 year, 10 years, 25 years, 50 years and 100 years. The calculated annual and monthly values for 1-hour, 10-minutes and 1-minute are presented in Tables 3-47 to 3-49. The analysis used hourly mean wind values for the reference height of 10 m asl. These values were converted to 10-minute and 1-minute wind values using a constant ratio of 1.06 and 1.22, respectively (US Geological Survey 1979). The annual 100-year extreme 1-hour wind speed was determined to be 31.7 m/s for Grid Point M10632. Monthly, the highest 100-year extreme winds of 31.0 m/s occur during February.

Table 3-47 1-hr Extreme Wind Speed Estimates (m/s) for Return Periods of 1, 10, 25, 50 and 100 Years for Grid Point M10632

Month	1	10	25	50	100
January	22.2	25.5	26.7	27.5	28.4
February	22.0	26.8	28.5	29.8	31.0
March	20.2	24.4	25.9	27.0	28.2
April	18.0	22.1	23.6	24.7	25.7
May	15.3	19.1	20.4	21.4	22.4
June	14.2	17.8	19.1	20.1	21.1
July	13.2	16.8	18.1	19.0	20.0
August	14.3	20.0	22.0	23.5	25.0
September	16.9	21.9	23.7	25.0	26.3
October	18.2	23.2	24.9	26.3	27.6
November	19.8	24.3	25.9	27.0	28.2
December	21.5	26.0	27.6	28.8	30.0
Annual	24.6	28.2	29.6	30.6	31.7

Table 3-48 10-minute Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years for Grid Point 10632

Month	1	10	25	50	100
January	23.6	27.0	28.3	29.2	30.1
February	23.3	28.4	30.2	31.5	32.9
March	21.4	25.9	27.5	28.7	29.8
April	19.1	23.4	25.0	26.1	27.3
May	16.3	20.3	21.7	22.7	23.8
June	15.1	18.9	20.3	21.3	22.3
July	14.0	17.8	19.2	20.2	21.2
August	15.1	21.2	23.3	24.9	26.5
September	17.9	23.2	25.1	26.5	27.9
October	19.3	24.6	26.4	27.8	29.2
November	21.0	25.7	27.4	28.7	29.9
December	22.8	27.6	29.3	30.5	31.8
Annual	26.1	29.8	31.3	32.4	33.6

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Table 3-49 1-minute Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years for Grid Point 10632

Month	1	10	25	50	100
January	27.1	31.1	32.5	33.6	34.6
February	26.8	32.7	34.7	36.3	37.8
March	24.6	29.8	31.6	33.0	34.3
April	21.9	27.0	28.7	30.1	31.4
May	18.7	23.3	24.9	26.2	27.4
June	17.3	21.8	23.3	24.5	25.7
July	16.1	20.5	22.1	23.2	24.4
August	17.4	24.4	26.8	28.7	30.5
September	20.6	26.7	28.9	30.5	32.1
October	22.2	28.3	30.4	32.0	33.6
November	24.2	29.6	31.5	33.0	34.4
December	26.3	31.8	33.7	35.2	36.6
Annual	30.0	34.4	36.1	37.3	38.6

A comparison of these values with actual values measured by platforms on the Grand Banks was not possible. Logarithmic profiles for adjusting wind speeds from anemometer height to the surface are valid only in neutral or unstable conditions. Observations from platforms on the Grand Banks over the past 10 years frequently show stable conditions in which the surface layer wind speed profiles are not valid. Using a logarithmic profile to adjust wind speeds between the 10-m and anemometer level would therefore introduce an unnecessary source of error in the results.

Extreme Value Estimates for Waves from a Gumbel Distribution

The annual and monthly extreme value estimates for Hs for return periods of 1 year, 10 years, 25 years, 50 years and 100 years are provided in Table 3-50. The maximum individual wave heights, extreme associated peak periods and joint wave height and period combinations values are presented in EMCP (2010). The annual 50-year extreme Hs was 14.4 m at Grid Point M10632, while the annual 100-year extreme was 15.1 m. An Hs of 14.66 m recorded over a 20-minute interval by a waverider buoy in the area on February 11, 2003, lies somewhere between these extreme estimates. A storm with a return period of 100 years means that the calculated Hs will occur once every 100 years, averaged over a long period of time. It is entirely possible that this event was a 100-year or longer return period storm. The value recorded on February 11, 2003, was the highest recorded Hs in a near continuous waverider data set extending back to early 1999. The previous highest recorded value in this data set was 12.47 m, which occurred on January 25, 2003. The maximum Hs measured during the Ocean Ranger storm of 1982 was approximately 12 m. If more occurrences of an event of this magnitude were observed, the calculated statistics would consequently begin to increase.

Table 3-50 Extreme Significant Wave Height Estimates for Return Periods of 1, 10, 25, 50 and 100 Years for Grid Point 10632

Month	1	10	25	50	100
January	8.7	11.7	12.7	13.5	14.2
February	8.2	11.9	13.1	14.0	14.9
March	7.1	10.0	11.0	11.7	12.4
April	5.7	8.5	9.4	10.1	10.8
May	4.6	7.0	7.8	8.4	9.0
June	3.7	5.9	6.5	7.1	7.6
July	3.4	5.3	5.9	6.4	6.9
August	3.8	6.1	6.9	7.5	8.1
September	5.2	8.6	9.7	10.6	11.4
October	6.2	9.6	10.7	11.6	12.4
November	7.4	10.2	11.2	11.9	12.5
December	8.6	11.5	12.4	13.1	13.8
Annual	10.5	12.8	13.7	14.4	15.1

During a storm event on January 8, 2007, a maximum individual wave height of 22.63 m was recorded by a waverider in the Terra Nova field. This is slightly lower than the January 25-year return period estimate of 23.5 m. The Hs during this event was 9.72 m.

Extreme Temperature Analysis

The extreme temperature analysis was carried out using the ICOADS data set, supplemented by observations from different vessels and rigs at or near the Offshore Project Area (spanning from February 1984 to August 1988) that were not included in the ICOADS data set.

Minimum Temperature

For the minimum temperature analysis, the daily minimum temperature was found for each day in the data set. The 50 lowest minimum temperature events were then chosen with one restriction; no event could occur within five days of another. This restriction ensures that all the chosen events were independent of each other. The lowest minimum temperature event chosen was -17.3°C, which occurred on March 10, 1986. These temperature events were fitted to a Gumbel distribution and extreme value estimates for minimum temperature were calculated for return periods of 2 years, 10 years, 25 years, 50 years and 100 years. These values are provided in Table 3-51; the 95 percent confidence interval is also provided.

Table 3-51 Extreme Minimum Temperature Estimates for Return Periods of 2, 10, 25, 50 and 100 Years

Return Period (years)	Extreme Mimimum Temperature (°C)	95% Lower Confidence Bound (°C)	95% Upper Confidence Bound (°C)
2	-9.88	-10.37	-9.38
10	-13.00	-14.20	-11.80
25	-14.58	-16.21	-12.94
50	-15.74	-17.70	-13.78
100	-16.90	-19.19	14.61

Maximum Temperature

For the maximum temperature analysis, the daily maximum temperature was found for each day in the data set. The 50 highest maximum temperature events were then chosen with one restriction; no event could occur within five days of another. This restriction ensures that all the chosen events were independent of each other. The highest maximum temperature event chosen was 27.5°C, which occurred on July 2, 1972. These temperature events were fitted to a Gumbel distribution and extreme value estimates for maximum temperature were calculated for return periods of 2 years, 10 years, 25 years, 50 years and 100 years. These values are provided in Table 3-52; the 95 percent confidence interval is also provided.

Table 3-52 Extreme Maximum Temperature Estimates for Return Periods of 2, 10, 25, 50 and 100 Years

Return Period (years)	Extreme Maximum Temperature (°C)	95% Lower Confidence Bound (°C)	95% Upper Confidence Bound (°C)
2	22.65	22.28	23.02
10	25.00	24.10	25.90
25	26.18	24.96	27.41
50	27.06	25.59	28.54
100	27.93	26.21	29.65

3.2.2.4 Tsunamis

As described in Section 3.1.2.3, tsunamis are long-period gravity waves generated in a body of water by an impulsive disturbance that vertically displaces the water column. The most relevant far field sources effecting Newfoundland and the Grand Banks are the Azores-Gibraltar Ridge zone, the Mid-Atlantic Ridge and the north side of the Caribbean Arc. Tsunamis generated by other mechanisms generally originate from near-field sources such as the Laurentian Channel, the origin of the 1929 Grand Banks tsunami.

Over the open ocean, tsunamis generally have amplitudes below 1 m, wave length of 10 to 500 km and periods of five minutes to one hour. As tsunamis are shallow water waves, they slow down when moving over shallower water such as the Grand Banks. As energy is conserved, shoaling leads to increased wave height. However, a rapid bathymetry change can lead to partial reflection of the wave energy and height (DFO 2008a).

A Physical Environmental Data report for Production Systems at Terra Nova (Seaconsult Ltd. 1988) estimates maximum theoretical tsunami amplitude of 2 m for Terra Nova, with expected amplitude 0.7 to 1.2 m over a 100-year return period. Tsunami waves induce currents of nearly uniform speed from bottom to surface. The expected current speed is 35 cm/s over a 100-year return period, with maximum velocity of 70 cm/s for a 2 m tsunami wave.

3.2.2.5 Currents

The general circulation on the Grand Banks is well understood based on geostrophic calculations, drifter data, current modelling and measurements. The dominant currents in Eastern Canada are the West Greenland, Baffin, Labrador and Nova Scotia currents. There are also two major deep basin currents, the warm Gulf Stream and the North Atlantic Current.

The Labrador Current is the major current that is closest to the eastern Grand Banks. It is a combination of the West Greenland Current, the Baffin Island Current and flow from Hudson Bay. The Labrador Current is divided into two streams: an inshore stream consisting of water from Hudson Strait and the Baffin Current; and an offshore stream consisting of water from the West Greenland current. Mean currents are generally weak (<10 cm/s) and southward-dominated by wind-induced and tidal current variability over those areas of the Grand Banks with water depths less than 100 m (Seaconsult Ltd. 1988).

Characterizations of ocean current conditions are available from three primary sources: an archive database of Grand Banks current measurements that provides a regional picture; current measurements from a Hebron exploration well drilled in 1999; and from the nearby Terra Nova location, and design criteria prepared for the Hebron Project.

Current statistics for all current meter data on the Grand Banks from the Bedford Institute of Oceanography (BIO) prior to 1996 are presented in Gregory et al. (1996) and these provide a good representation of the regional current regime. The current measurements were grouped into three water depths ranges: near-surface (<30 m); mid-depth (30 to 80 m); and near-bottom (>80 m). The mean annual current speed and direction for the Grand Banks and corresponding seasonal currents are provided in EMCP (2010). The mean near-surface currents in the eastern Grand Banks region are strongest along the slope of the Banks where the direction is to the south-southwest, and generally follows the 200 m contour. For mid-depth currents are mainly to the south-southwest. Near-bottom, mean annual currents are to the south-southwest through south-southeast with strongest currents directed to the south. A seasonal summary of mean current speed and directions is presented in Table 3-53.

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Table 3-53 Grand Banks Mean Currents

Water Depth	Winter	Spring	Summer	Fall
Surface 0 to 30 m	~0.10 m/s to the SE	<0.10 m/s to the SE or SW	~0.10 m/s to the SSE	0.10 to 0.20 m/s to the SE
Mid Depth 30 to 80 m	~0.15 m/s to the SSW	~0.10 m/s to the SSW	<0.10 m/s to the S	~0.10 m/s to the S
Deep 80 to bottom	0.05 to 0.10 m/s to the SE-SW	~0.05 to the E	~0.05 to the S	0.05 to 0.10 m/s to the S
Source: based on review of Gregory et al. 1996				

Gregory et al. (1996) also present monthly mean and maximum statistics for all months and all depths. From a review of the region 46°N and 47°N and 48°W and 49°W, which encompasses Hibernia, White Rose, Terra Nova, and Hebron projects, the largest mean and maximum currents and associated depths could be determined. The largest near-surface current speeds reached 0.25 m/s, with an associated maximum speed of 0.96 m/s in September at a depth of 18 m. At mid-depth, the largest mean currents reached 0.15 m/s in February (at 45 m) and the maximum speed was 0.96 m/s in December (at 47 m). Near-bottom, the mean current speed reached a maximum of 0.06 m/s in May and October at 101 and 98 m, respectively, and a maximum speed of 0.70 m/s was observed in November at 98 m. The strongest surface and mid-depth currents occur in the fall to winter; the strongest currents near-bottom occur in the spring and fall.

Current statistics for current meter data collected at the Hebron Project Area by Oceans Ltd. from January 6 to April 23, 1999, are presented in Table 3-54 (Oceans Ltd. 1999). The maximum currents speeds are lower than those from the BIO data report (Gregory et al. 1996); however, summer and fall are not included in the Oceans Ltd. data, which is when the maximum speeds were measured in the BIO data. The mean speeds at mid and bottom depths are high compared to the BIO data.

Table 3-54 Currents Measured at the Hebron Project Area from January 6 to April 23, 1999

Instrument Depth	20 m	45 m	84 m
Period of record (199)	Jan 6 to Feb 20	Jan 6 to Apr 23	Jan 6 to Apr 23
Location	46°35'00"N 48°29'56"N	46°34'54"N 48°29'58"N	46°34'54"N 48°29'58"N
Water Depth (m)	94	94	94
Mean Speed (m/s)	0.156	0.182	0.116
Maximum Speed (m/s)	0.503	0.537	0.320
Source: Oceans Ltd. 1999			

Extreme and operational[7] design criteria for currents for the Hebron Project are presented in the Hebron Metocean Criteria (ExxonMobil Upstream Research Company 2009). The data used to establish the criteria were taken from 10 years of current measurements at Terra Nova (July 1999 to October 2008). The measurements are 20-minute values and for three water depth bins near-surface (16 to 24 m); mid-depth (47 to 52 m); and near-bottom (84 to 89 m). Maximum values measured from the 10-year Terra Nova record are 0.94, 0.74, and 0.48 m/s for near-surface, mid-depth, and near-bottom respectively. Both annual and seasonal extremes were estimated. Annual non-exceedance levels or percent limits for current speeds at the three depths (e.g., near-surface speeds are 0.19 cm/s or less for 75 percent of the time) are provided in Table 3-55.

Table 3-55 Extreme Current Speed Statistics

Statistic	Near-surface (m/s)	Mid-depth (m/s)	Near-bottom (m/s)
50% upper limit	0.13	0.09	0.09
75% upper limit	0.19	0.13	0.14
90% upper limit	0.26	0.19	0.18
95% upper limit	0.32	0.22	0.21
99% upper limit	0.44	0.32	0.28
Source: ExxonMobil Upstream Research Company 2009			

Annual and seasonal 1- to 100-year return period current speeds are presented in Table 3-56, together with Terra Nova current extreme estimates. Two seasons were selected by ExxonMobil Upstream Research Company: a 'spring / summer' season during which the ocean is stratified due to solar heating of the surface and storm activity is reduced; and a 'fall / winter' season when the summer stratification is broken down and there is a much more uniform current response from the surface to the bottom (due to the increased frequency and intensity of storms). These seasons are considered to be from August to October (summer / spring) and from November to July (fall / winter) for the near-surface and correspondingly April to August, and September to March for mid-depth and near-bottom. The strongest near-surface current is in summer, while the strongest mid-depth and bottom currents occur in winter. For a 50-year return period, annual extreme current speeds of 1.01, 0.73, and 0.63 m/s for near-surface, mid-depth, and near-bottom, respectively, could be expected.

These values are generally comparable to the maximum current speeds reported by Gregory et al. (1996) and noted above, although the mid-depth current there of 0.96 cm/s is larger than the 0.63 m/s 50-year estimate for the Hebron Project Area.

The Hebron Design Criteria prepared by ExxonMobil Upstream Research Company estimates a maximum storm surge of 0.8 m, spring and neap tidal amplitudes of 0.5 and 0.3 m respectively, and a tidal amplitude of 1 m

[7] Annual and monthly tables of current speed vs. direction (near-surface, mid-depth, and near-bottom)

(ExxonMobil Upstream Research Company 2009). These estimates are in keeping with the Terra Nova.

Table 3-56 Extreme Current Speeds for 1 to 100 Year Return Periods for Hebron and Terra Nova Project Areas

	Current Speed (m/s) (and direction towards) Return Period (Years)				
HEBRON [A]					
	Depth (m)	1	10	50	100
Surface (Annual and Aug-Oct)	20	0.64 (SW, W, NW)	0.91	1.01	1.16
Mid (Annual and Sep-Mar)	50	0.46 (SW)	0.66	0.73	0.79
Bottom (Annual and Sep-Mar)	85	0.42 (S)	0.55	0.63	0.66
Surface (Nov-Jul)	20	0.64 (SE)	0.91	1.01	0.7
Mid (Apr-Aug)	50	0.51 (N, NW)	0.56	0.6	0.62
Bottom (Apr-Aug)	85	0.46 (N,E,SW)	0.51	0.54	0.55
TERRA NOVA [B]					
Annual	Depth (m)	1	10	50	100
Surface	20	0.75 (W)	0.79	-	0.96
Mid	45	0.76 (SW)	0.87	-	0.99
Bottom	70	0.61 (SE)	0.74	-	0.87

Source:
A ExxonMobil Upstream Research Company 2009
B Petro-Canada 1995 (Table 3.2-7)

3.2.2.6 Tides and Storm Surges

From time-series of hourly water level measurement at two locations near Hibernia, the highest water levels measured from the zero mark were 1.0 and 1.04 m, respectively (DFO 2009b).

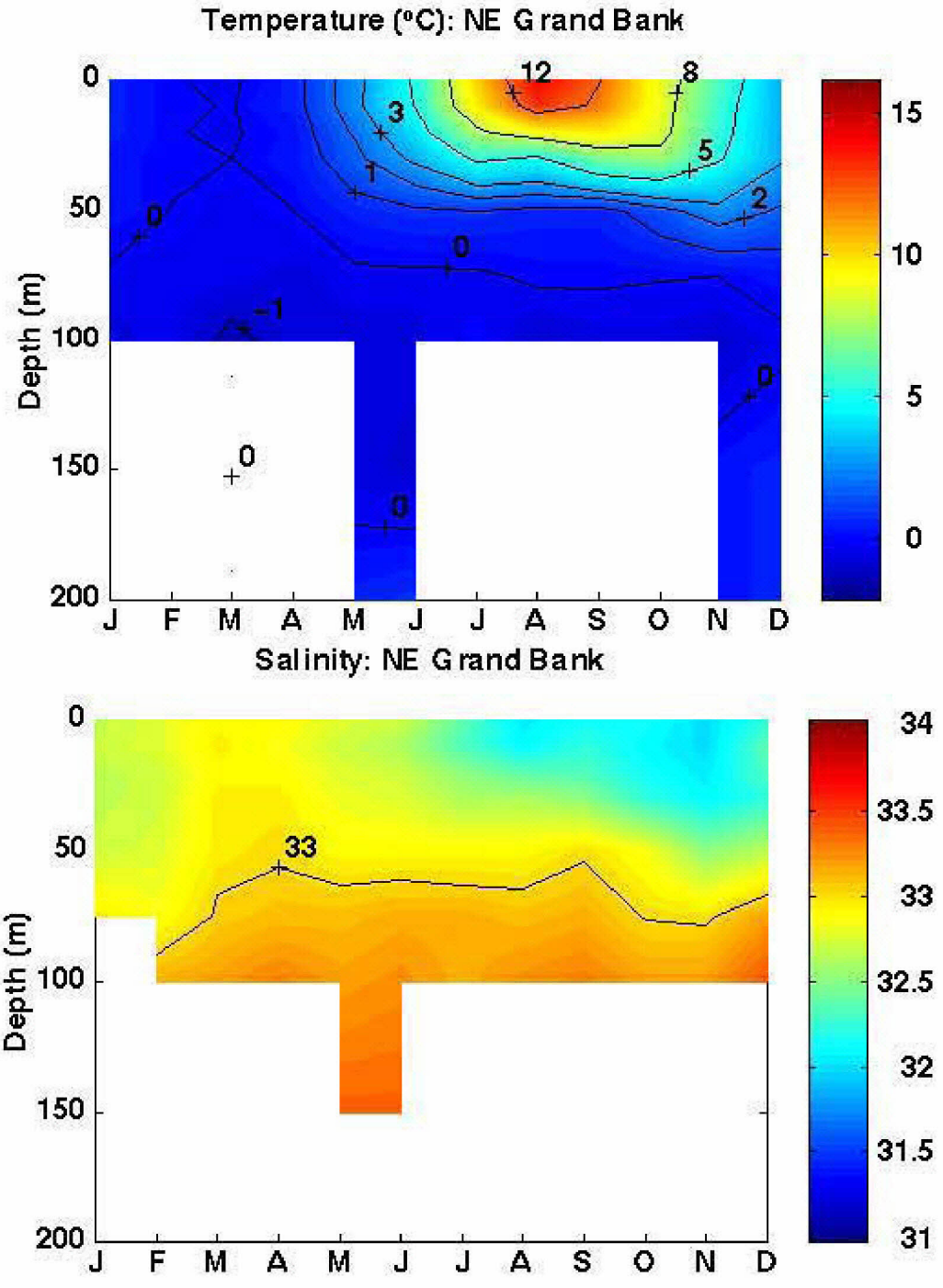
The report by Seaconsult Ltd. (1988) summarizes tidal data from a study in December 1983 to April 1984 at 46°46.0'N and 48°50.9'W. The maximum tidal amplitude above the mean water level was 0.53 m and the minimum tidal amplitude below the mean water level was -0.51, resulting in a total range of 1.04 m. Seaconsult Ltd. (1988) also determined the storm surge for Terra Nova (Table 3-57).

Table 3-57 Extreme Storm Surge and Tide Levels at Terra Nova

Return Period (years)	Surge Levels (cm)			Tide Levels (cm)
	Mean Water Level above / below	Expected	95% Upper Limit	
1	above	50	64	53
	below	54	69	51
10	above	61	75	53
	below	66	81	51
25	above	66	79	53
	below	71	85	51
50	above	70	83	53
	below	75	89	51
100	above	73	86	53
	below	79	92	51
Source: Seaconsult Ltd. 1988				

3.2.2.7 Physical and Chemical Properties

Sea temperature and salinity distributions are available from the Ocean and Ecosystem Science Branch (DFO 2007a). A monthly vertical section for temperature and salinity is shown in Figure 3-28. Data for depth ranges greater than 100 m are sparse, as illustrated by the 'whited-out' areas; however, this is not unexpected, given most of the Northeast Grand Bank climatology Subarea 46 is at a depth of approximately 100 m. The associated temperature and salinity statistics for this subarea are presented in Table 3-58. Four seasonal collections of surface and bottom temperature and salinity maps that cover the entire Newfoundland East Coast (including the Hebron Offshore Project Area) are provided in EMCP (2010).



Source: DFO 2007a (Subarea 46)

Figure 3-28 Contours of Temperature and Salinity for Northeastern Grand Banks

Table 3-58 Temperature and Salinity Statistics for Northeastern Grand Banks

Depth (m)	Temperature (°C)			Salinity (psu)		
	Mean	Std Dev	Total Count	Mean	Std Dev	Total Count
January						
0	0.57	0.64	164	32.66	0.28	25
20	0.56	0.66	134	32.66	0.3	13
50	0.43	0.53	125	32.7	0.3	13
100	-0.57	0.67	13			
200						
February						
0	0.05	0.38	240	32.78	0.23	13
20	0.04	0.42	146	32.7	0.2	8
50	-0.02	0.43	151	32.77	0.23	10
100	-0.07	0.51	15	33.12		2
200						
March						
0	-0.14	0.91	141	32.89	0.17	58
20	-0.11	0.95	176	32.91	0.16	104
50	-0.23	0.88	157	32.96	0.18	94
100	-1.38	0.26	17	33.2		9
200	1.31		1			
April						
0	0.65	0.84	515	32.89	0.21	239
20	0.49	0.79	495	32.91	0.23	282
50	-0.01	0.68	698	32.97	0.21	377
100	-0.42	0.4	29	33.25	0.28	18
200	0.65	0.84	515			
May						
0	2.58	1.39	1145	32.77	0.24	387
20	2.1	1.24	1491	32.78	0.22	454
50	0.61	0.72	1509	32.92	0.18	550
100	-0.44	0.65	107	33.19	0.17	23
200	0.66	0.45	8			
June						
0	5.25	1.72	682	32.7	0.27	270
20	4.16	1.46	969	32.72	0.24	240
50	0.86	0.99	804	32.91	0.19	287
100	-0.36	0.62	52	33.21	0.15	15
200	0.92		1	33.72		1
July						
0	10.22	1.96	512	32.36	0.31	213
20	7.64	1.83	1423	32.53	0.24	290
50	1	1.08	664	32.88	0.16	296
100	-0.03	0.83	79	33.14	0.17	21
200						

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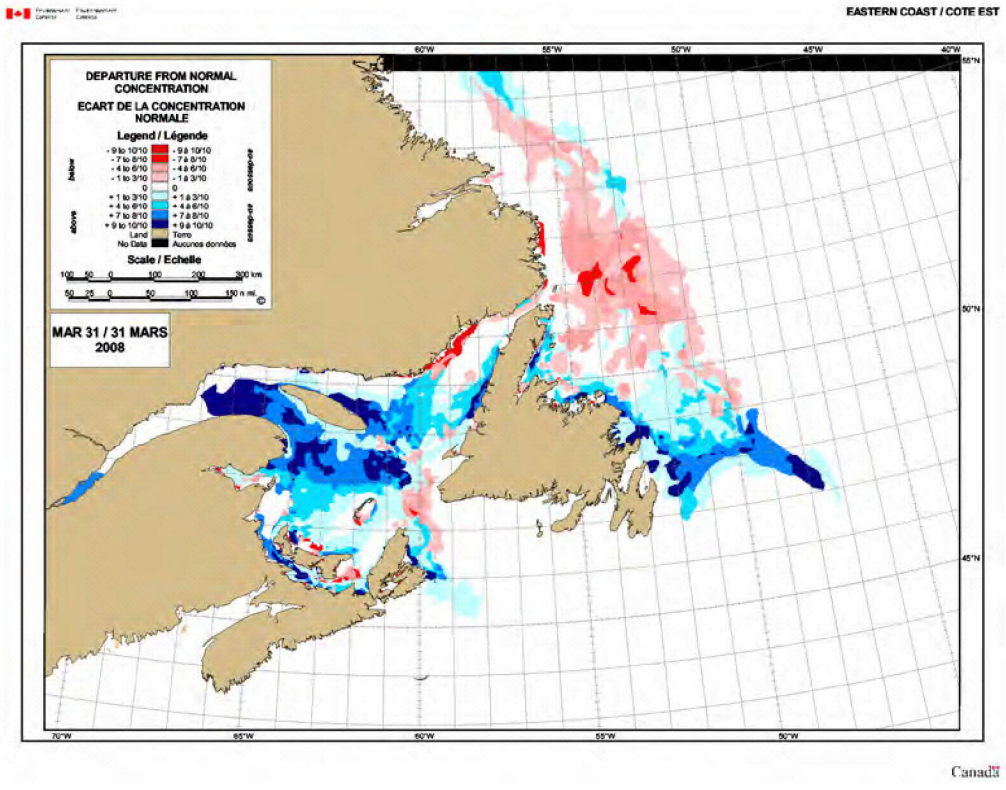
Depth (m)	Temperature (°C)			Salinity (psu)		
	Mean	Std Dev	Total Count	Mean	Std Dev	Total Count
August						
0	13.84	1.89	480	32.07	0.41	49
20	9.14	2.45	2088	32.37	0.27	132
50	0.68	1.12	645	32.9	0.16	105
100	-0.61	0.77	49	33.23	0.16	7
200						
September						
0	12.07	1.8	353	32.17	0.28	75
20	9.63	2.58	598	32.35	0.32	131
50	0.59	1.44	396	32.98	0.16	165
100	-0.41	1.09	32	33.27	0.07	9
200						
October						
0	8.91	1.82	374	32.13	0.17	77
20	8.55	2.25	441	32.14	0.16	189
50	1.59	1.59	1208	32.87	0.24	415
100	-0.55	0.57	34	33.19		1
200						
November						
0	6.08	1.61	568	32	0.17	109
20	5.55	1.5	471	32.04	0.13	78
50	2.63	1.37	1397	32.52	0.25	160
100	-0.61	0.5	70	33.17	0.12	6
200	0.47	3	0.61			
December						
0				32.24	0.22	22
20				32.35	0.11	14
50				32.66	0.22	44
100				33.41	0.07	7
200	0.33	3				
Source: DFO 2007a (Subarea 46)						

3.2.3 Sea Ice and Icebergs

This description of the ice environment surrounding the Hebron Offshore Project Area uses as its base, information and data published in the Terra Nova Development Environmental Impact Assessment (Petro-Canada 1995) and the White Rose Environmental Impact Assessment (Husky Oil Ltd.2000). Those data have been supplemented with subsequent data and reports from 2000 to 2008. Most of the regional data and associated descriptions remain unchanged from the base document; however, a reworking of the site-specific information was undertaken to account for the different ice regime at the Hebron Project Area. The approach used in this report was to conduct analysis on the more recent data and then provide a comparison to those data reported in both the Terra Nova and White Rose studies. This approach

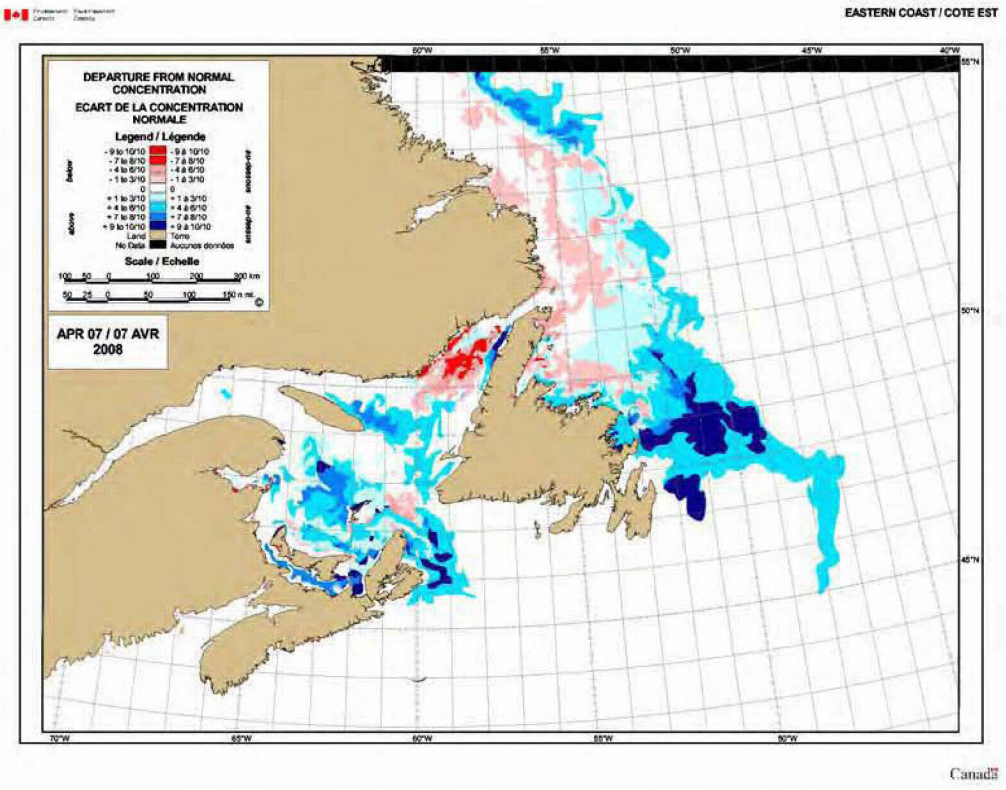
provides insight into the effects on ice and icebergs on the Grand Banks as a result of global weather pattern changes over the past decade.

The Hebron Offshore Project Area is located on the eastern slope of the Continental Shelf, making it susceptible to seasonal incursions of ice. Two different forms of floating ice - sea ice and icebergs - are present in this marine environment. Sea ice is produced when the ocean's surface layer freezes. In the Hebron Project Area, sea ice is loosely packed and pressure-free. Floes are small and generally in advanced stages of deterioration, permitting easy vessel movement. Despite this, sea ice can interfere with iceberg detection and management operations, and can force a facility to reduce operations if the quantity of pack ice near the facility exceeds the amounts in which evacuation equipment can be safely deployed and used. Departure-from-normal concentration sea ice charts showing the encroaching sea ice in the White Rose area over the period spanning end-of-March through April 2008 are illustrated in Figures 3-29 to 3-32. Sea ice is also known to carry embedded icebergs, and should these bergs start free drifting near a facility, implications may follow. Icebergs are freshwater ice made from snow compacted in a glacier. When the leading edge of a glacier reaches the sea, slabs of ice fall from it, creating icebergs. Grand Banks icebergs originate primarily from the glaciers of West Greenland. Ice management efforts focus on icebergs as they can pose a hazard to offshore production facilities.



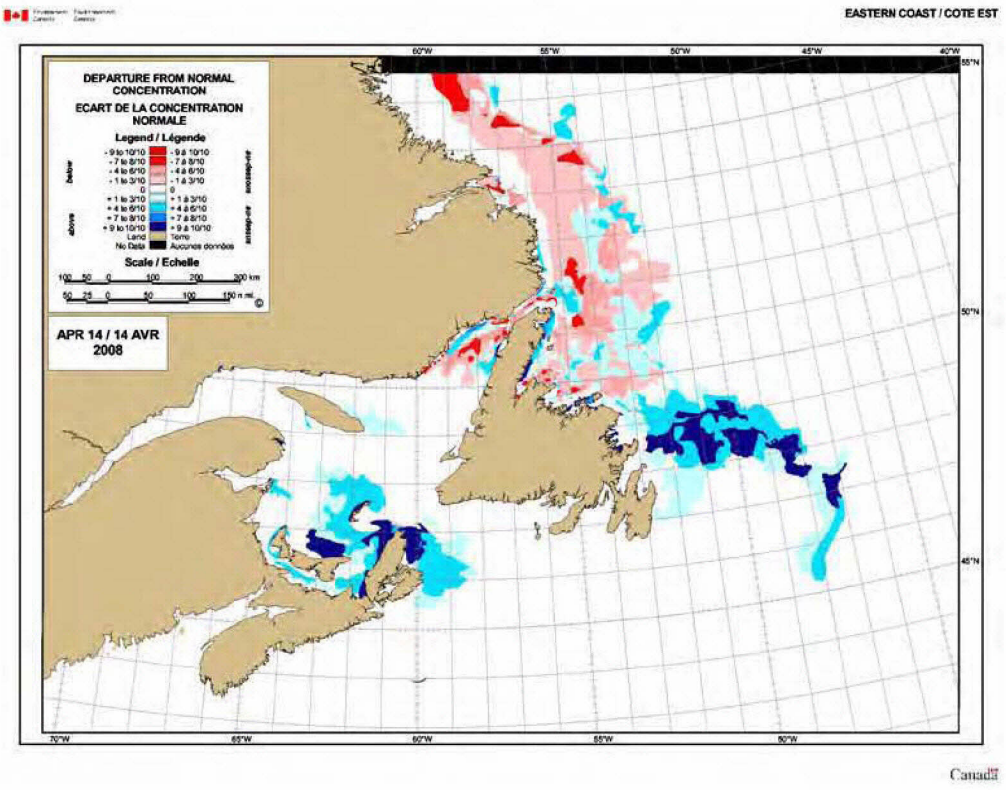
Source: Canadian Ice Service 2010

Figure 3-29 Departure-from-normal Sea Ice Concentrations around White Rose, March 31, 2008



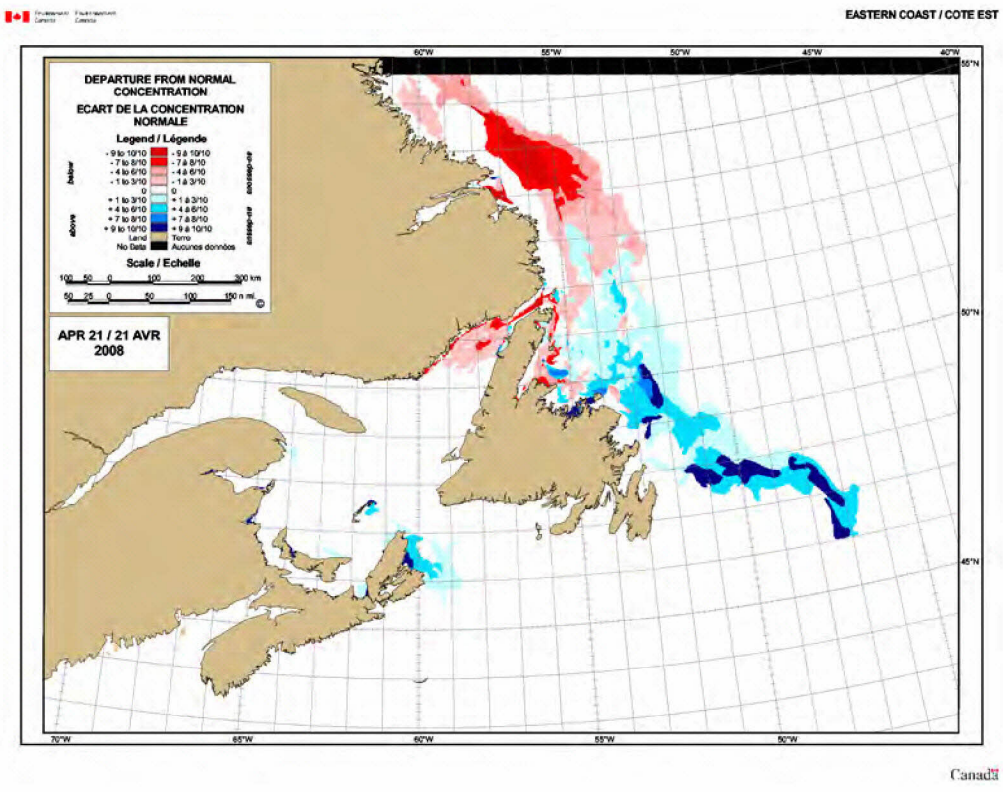
Source: Canadian Ice Service 2010

Figure 3-30 Departure-from-normal Sea Ice Concentrations around White Rose, April 7, 2008



Source: Canadian Ice Service 2010

Figure 3-31 Departure-from-normal Sea Ice Concentrations around White Rose, April 14, 2008



Source: Canadian Ice Service 2010

Figure 3-32 Departure-from-normal Sea Ice Concentrations around White Rose, April 21, 2008

The description of the ice regime at the Hebron Project Area includes an explanation of the databases used, a summary of the characteristics of the sea ice cover, a description of icebergs and a summary of ice management practices. Extreme conditions are included because they illustrate how the ice regime varies over time and space. Such variability is important when assessing the impact of ice on offshore development.

3.2.3.1 Sea Ice

Formation, Growth and Thickness

Major categories of sea ice age and thickness are listed in Table 3-59. Almost all of the ice occurring near Hebron Platform location is either young (grey and grey-white ice between 10 and 30 cm in thickness) or first-year ice between 30 cm and 100 cm thickness. Some thicker first-year ice also occurs. Ice thicknesses significantly greater than 100 cm are usually only associated with deformed first-year ice at the Hebron Project Area. Old ice, which is ice that has survived one or more summer melt seasons, appears very rarely in the region. It is denser and harder than regular sea ice because it has been re-frozen many times and much of its brine has leached out. Old ice is difficult to detect within the ice pack, but in practical terms, poses the same threat to vessels as growler (small glacial ice mass less than 5 m in length) and bergy bit-sized (small glacial ice mass with a length of between 5 to 15 m) iceberg fragments.

Table 3-59 Characterization of Sea Ice by Type, Thickness and Age

Ice Type / Stage of Development	Thickness (cm)	Age / Period of Formation
New Ice	<10	Seasonal ice: Earliest stage of development
Young (Grey) Ice	10 to 15	Seasonal ice: Generally early season
Young (Grey-White) Ice	15 to 30	Seasonal ice: Generally early to mid-season
Thin First-Year (White) Ice	30 to 70	Seasonal ice: Generally mid- to late-season
Medium First-Year Ice	70 to 120	Seasonal ice: Generally late-season
Thick First-Year Ice	>120	Seasonal ice: Generally late-season
Second-Year / Multi-Year / Old	>120	Perennial ice
Source: Meteorological Service of Canada Canadian Ice Service MANICE (2005)		

Spatial Distribution

The Hebron Platform location lies close to the extreme southern limit of the regional ice pack. In this area, relatively high water temperatures dissipate the last remnants of ice that have drifted south from original ice growth areas in Baffin Bay, Davis Strait, and the Labrador Sea.

The maximum mid-month ice extents for January through May, southeast of Newfoundland, are indicated by the yellow areas in Figures 3-33 to 3-37. These maximum extents are composites of the most advanced ice edges recorded over the 1971 to 2000 period. The Hebron Platform location, indicated by a star on Figures 3-33 to 3-37, lies within the limit of the maximum recorded ice extent during the months of February, March and April. However, based on 1971 to 2000 data and as is indicated by the colours on the charts, the probability that this location will lie within the maximum limit is 1 to 15 percent in February and April, and 16 to 33 percent in March.

Ice conditions in the preceding four decades for the Grand Banks area are shown in Figure 3-38. These data show normalized ice coverage for the Hebron Platform location and its approaches.

Based on 1969 to 2010 data (Figure 3-39), ice is only present in the area in approximately 19 years out of every 42 years (or in approximately 45 percent of the years). Based on 1971 to 2000 data, ice was present in that area in 57 percent of the years. The springs of 2008 and 2009 represented the first time ice was seen in that area within the last 15 years. Note that the ice graph below shows an “Accumulated Ice Coverage” for the entire January to May period. Naturally, the “frequency of presence of sea ice” for the January to May period is higher than that for any individual month as shown in Figures 3-33 to 3-37).

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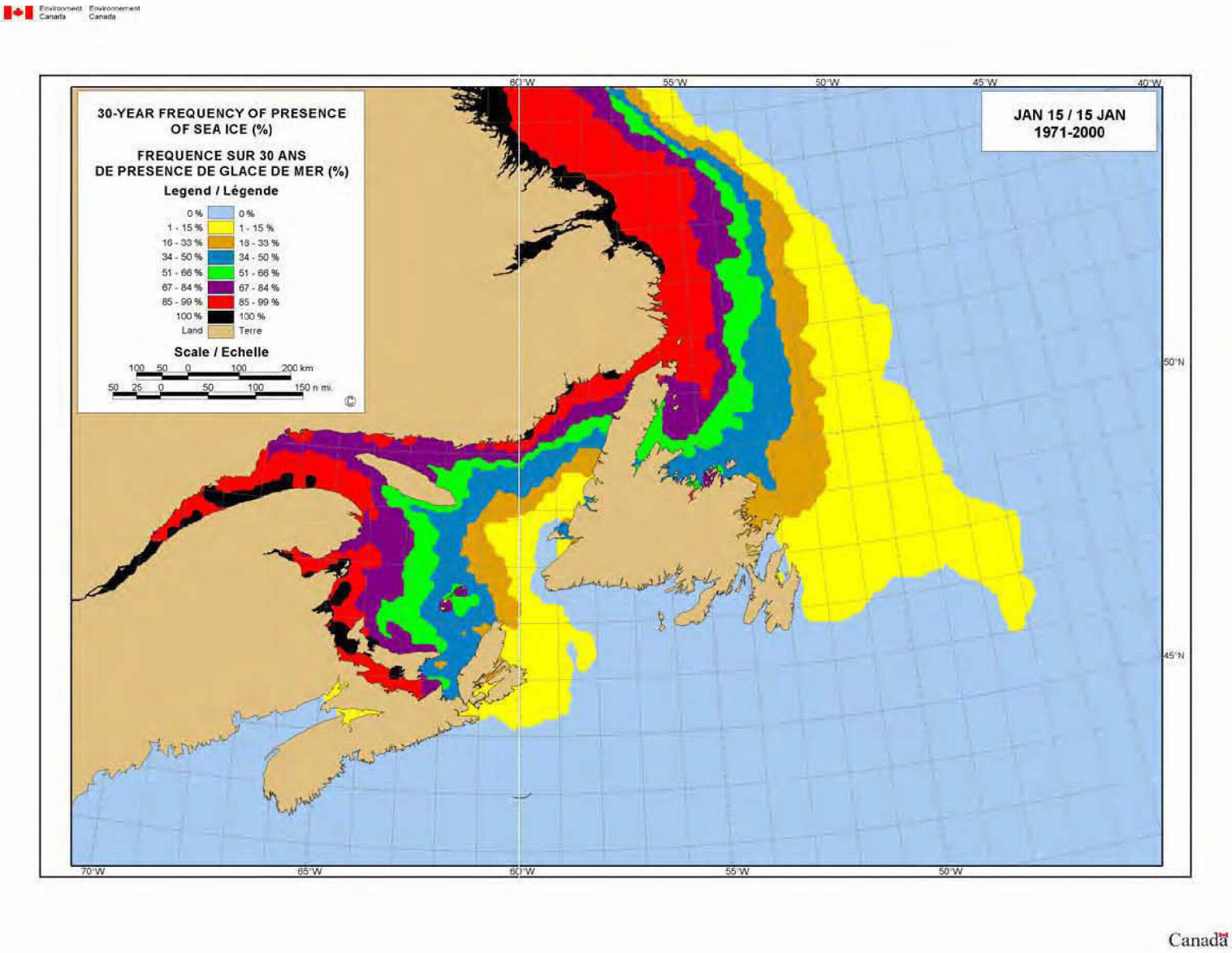

Source: Environment Canada Canadian Ice Service 2001

Figure 3-33 Frequency of Pack Ice Cover: Week of January 15, 1971 to 2000

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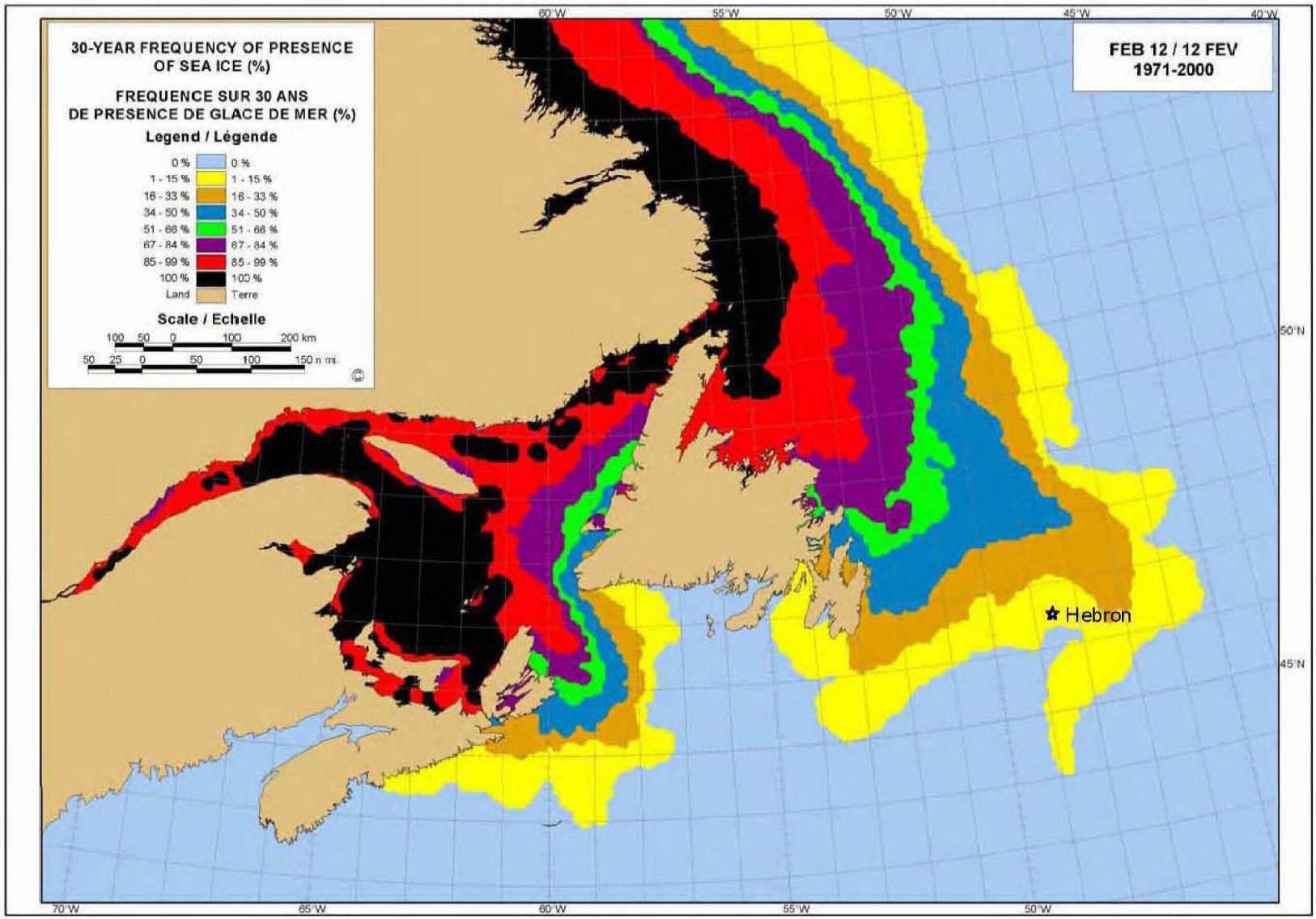
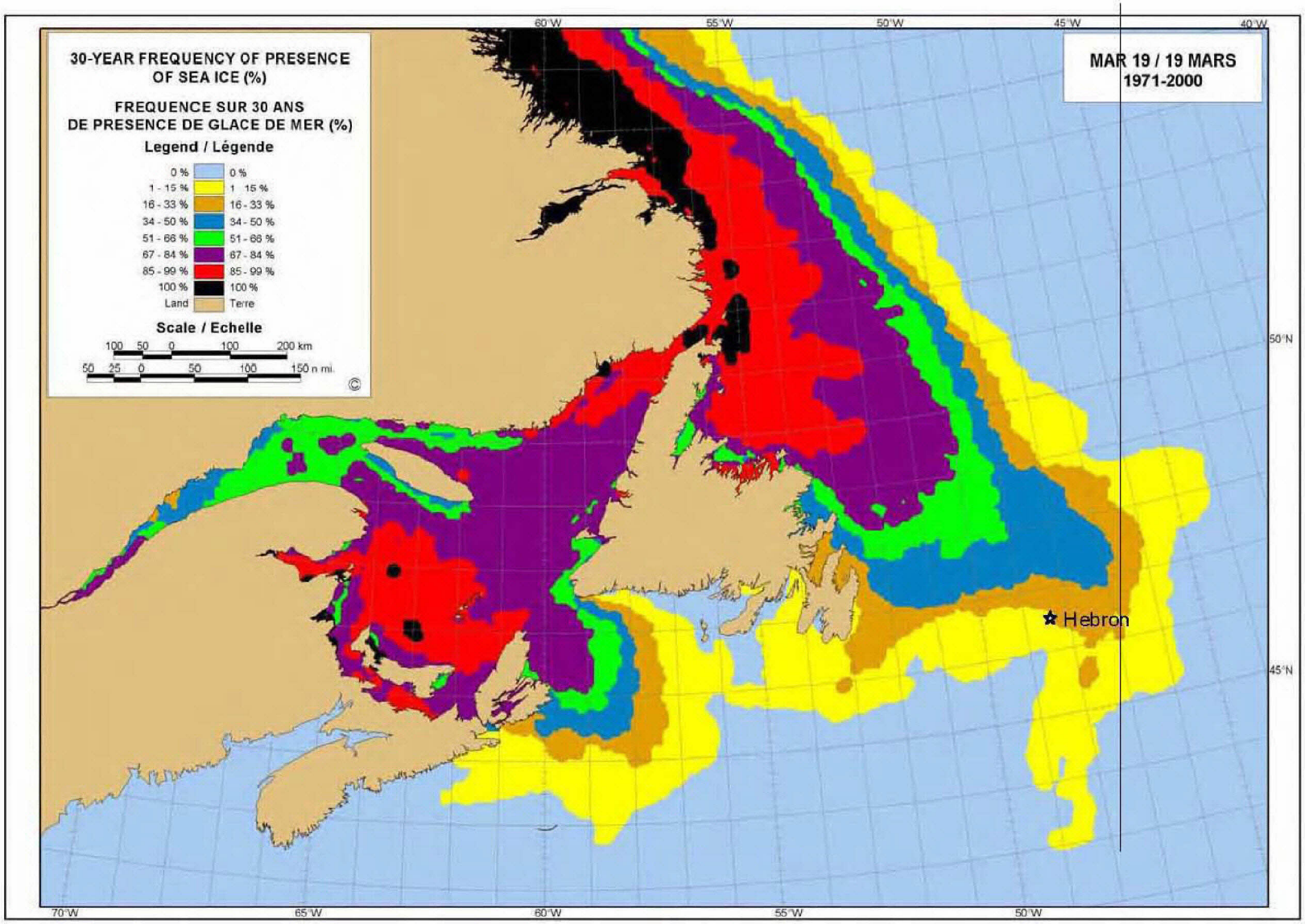


Source: Environment Canada Canadian Ice Service 2001

Figure 3-34 Frequency of Pack Ice Cover: Week of February 12, 1971 to 2000



Source: Environment Canada Canadian Ice Service 2001

Figure 3-35 Frequency of Pack Ice Cover: Week of March 19, 1971 to 2000

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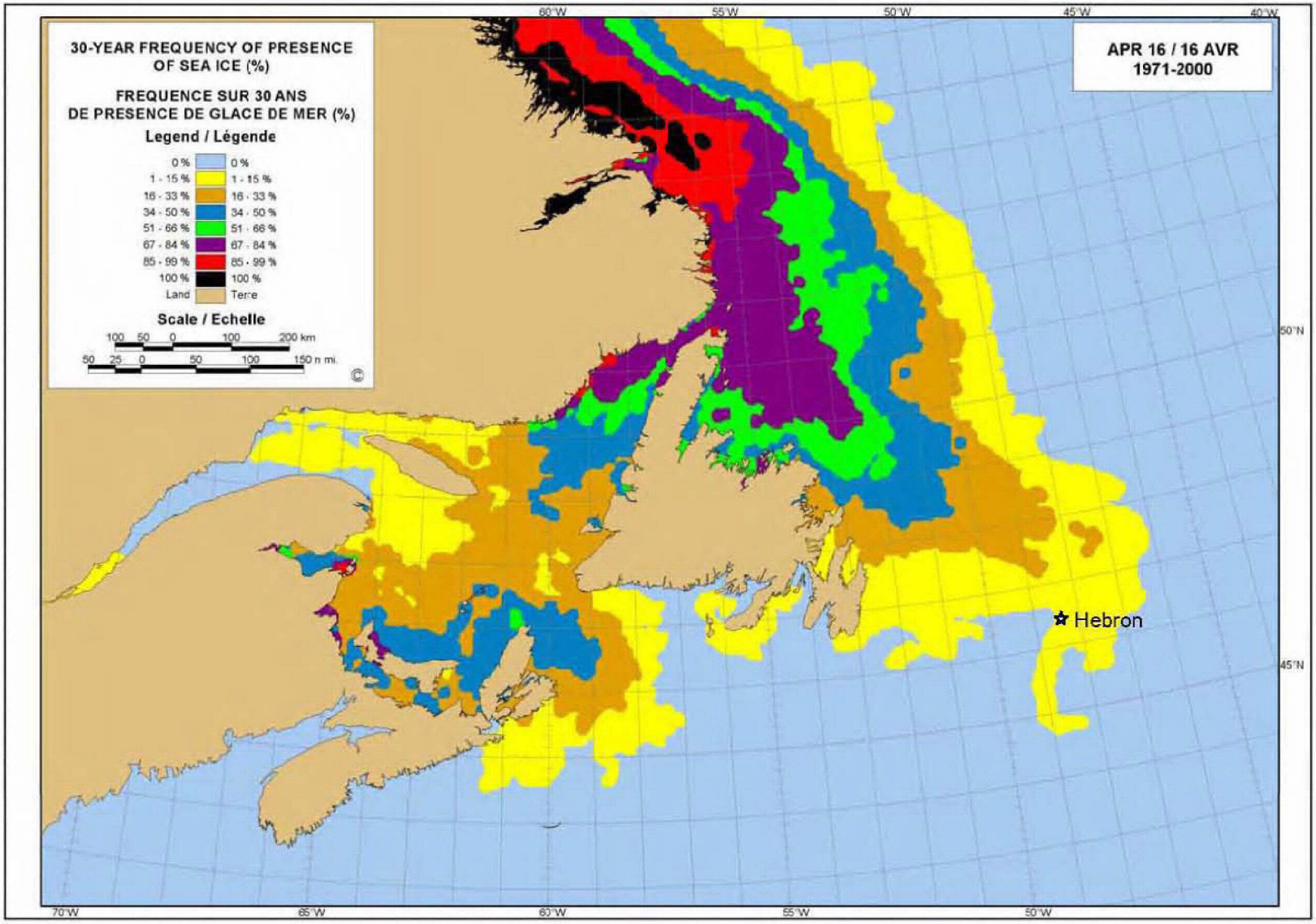

Source: Environment Canada Canadian Ice Service 2001

Figure 3-36 Frequency of Pack Ice Cover: Week of April 16, 1971 to 2000

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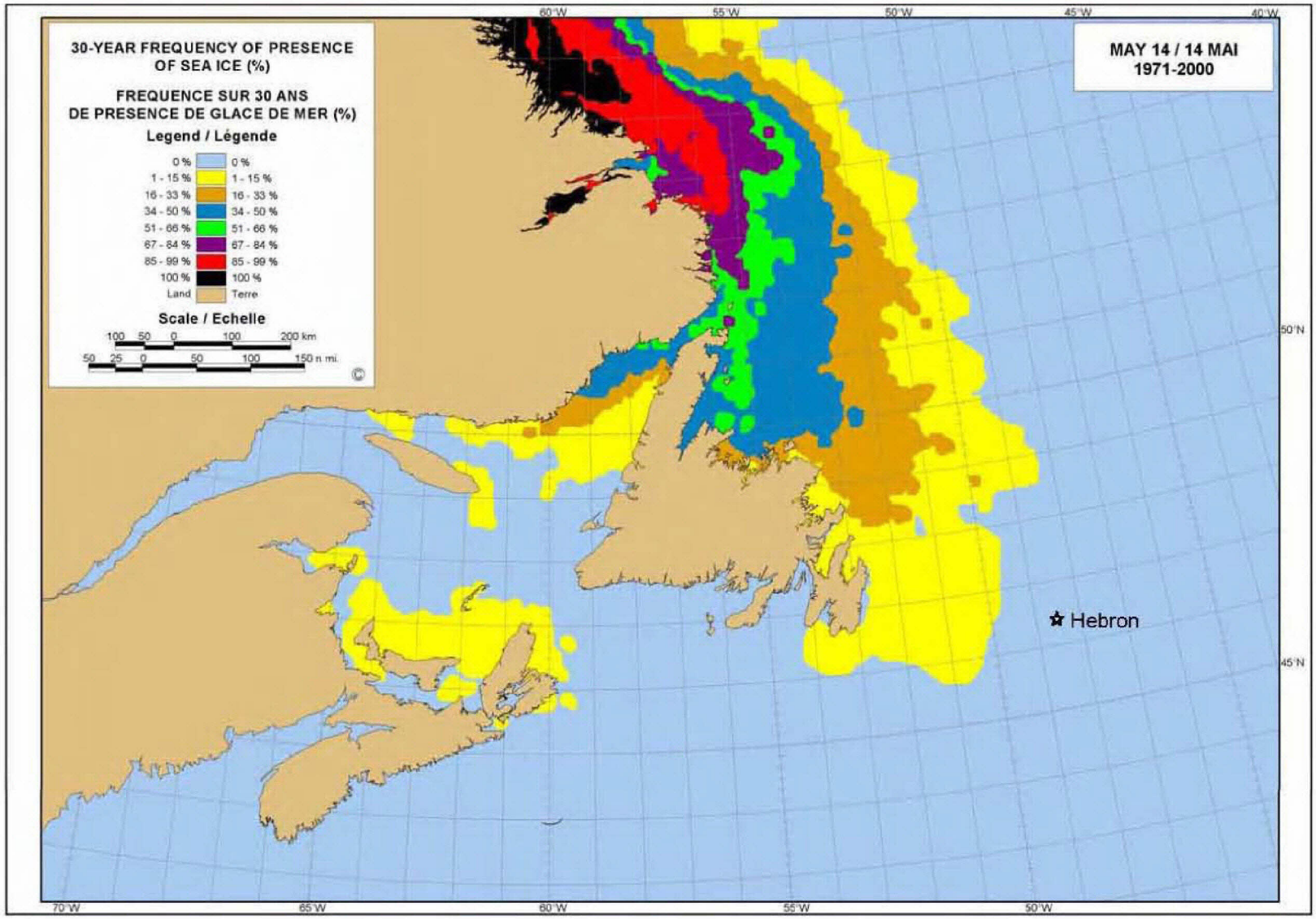
C0814-168



Source: Environment Canada Canadian Ice Service 2001

Figure 3-37 Frequency of Pack Ice Cover: Week of May 14, 1971 to 2000

C0814-169

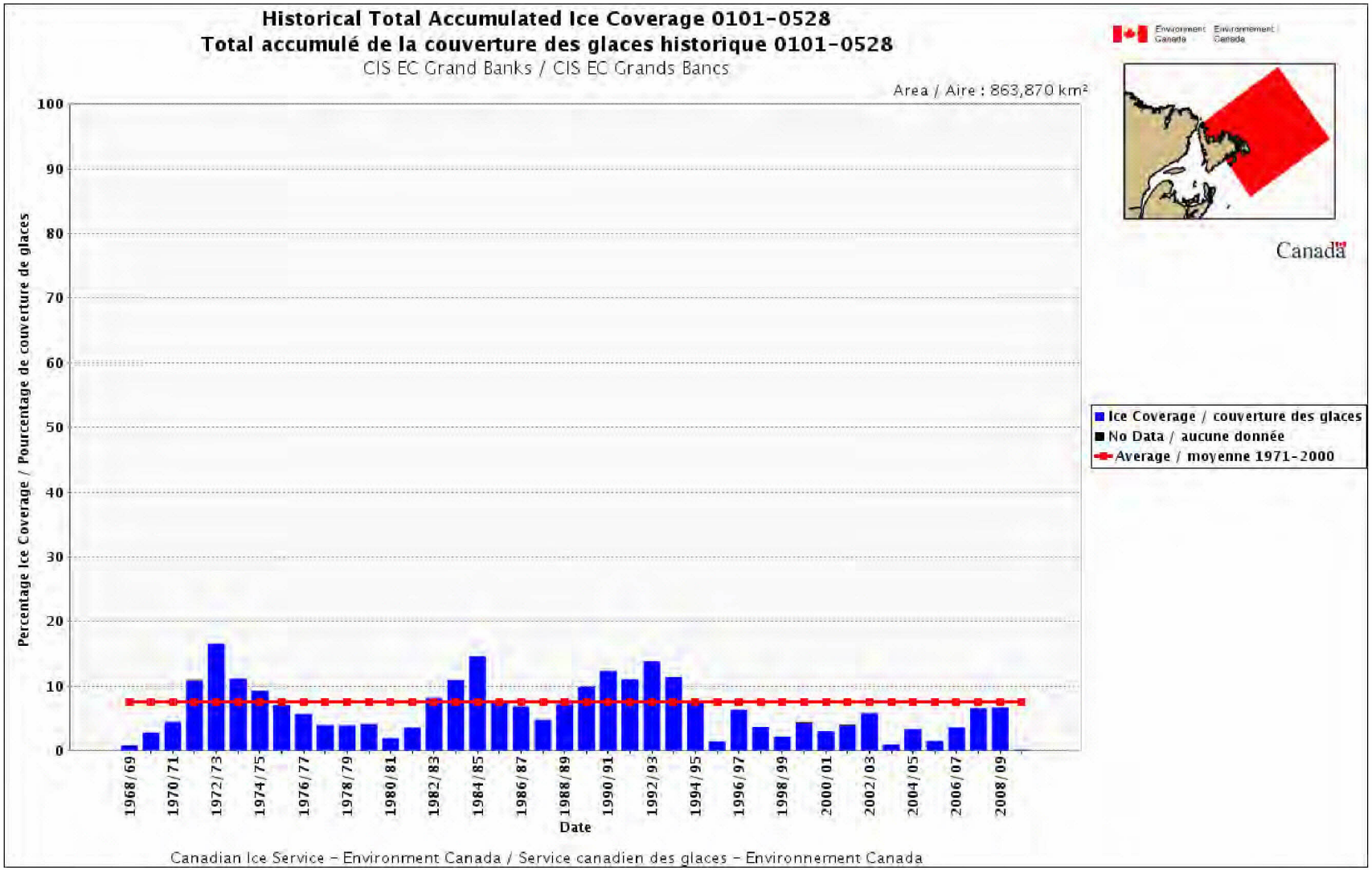
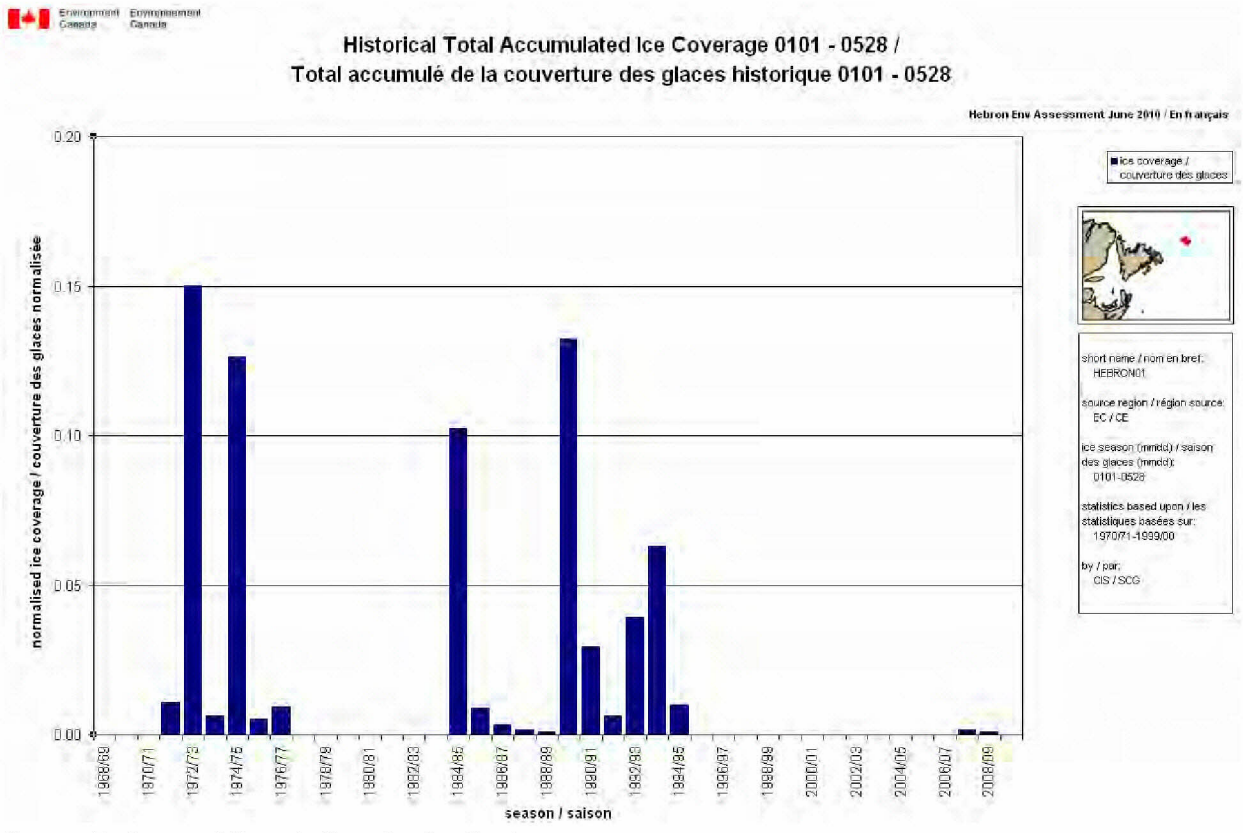


Figure 3-38 Historical Accumulated Ice Cover for the Grand Banks Area by Season 1970/71 to 2008/09



Source: Environment Canada Canadian Ice Service

Figure 3-39 Historical Total Accumulated Ice Coverage for the January to May Period

The annual timings of all ice incursions within 28 km of the Hebron Platform location from 1972 to 2008 are shown in Figure 3-40. These data show the onset (approximately between 1983 and 1994) of higher incursion together with the ice incursions centered broadly in mid-March. This period was then followed by a time of no pack ice cover that lasted to 2008.

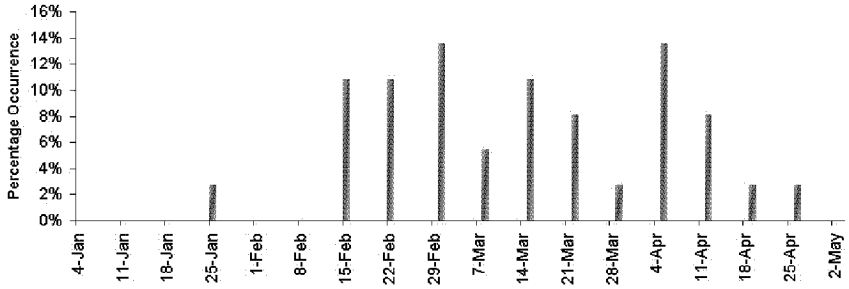
The Hebron Platform location experienced sea ice incursions in 11 of the 37 years examined in Figure 3-39. This is equivalent to a rate of one in every three to four years. Weekly probabilities, which peak at 14 percent, show two maxima: the first in the last week of February; and the second on the first week of April. The duration of the incursions vary from a minimum of one week to a maximum of seven weeks. Of the 11 years that ice was present, the average duration was three weeks.

3.2.3.2 Sea Ice Movement

The Hebron Platform location is at the extreme southern limit of the regional ice pack; however, it does lie just to the west of the path of the ice tongue that is formed by the loose pack ice being swept around the Grand Banks by the offshore branch of the Labrador Current.

Drift speed and direction distribution are shown in Figure 3-41, as derived from drift buoy data in 1985.

Percentage Occurrence of Sea Ice within 28 km of Hebron, by Week, 1972 - 2008



Year	Mean Concentrations of Sea Ice within 28 km of Hebron																		Mean Concentration	Weeks of Coverage
	4-Jan	11-Jan	18-Jan	25-Jan	1-Feb	8-Feb	15-Feb	22-Feb	1-Mar	8-Mar	15-Mar	22-Mar	29-Mar	5-Apr	12-Apr	19-Apr	26-Apr	3-May	10-May	
2008										4		1								3 2
2007																				
2006																				
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1993							6							3	6					5 3
1992											9									9 1
1991							1		9			4								5 3
1990								1	9		8	9	6	6						7 6
1989																				
1988																				
1987																				
1986																				
1985								9		5	9			2	5					6 5
1984									3											3 1
1983														9						9 1
1982																				
1981																				
1980																				
1979																				
1978																				
1977																				
1976																				
1975																				
1974							3	9	5											6 3
1973				8			8				8			5	9	9	9			8 7
1972																				
% Occurrence	0%	0%	0%	3%	0%	0%	11%	11%	14%	5%	11%	8%	3%	14%	8%	3%	3%	0%	0%	6 3
Years of Data	37																			

Source: Field Observations (1972 to 2008) and CIS Ice Charts

Figure 3-40 Weekly Incursions of Sea Ice within 28 km of Hebron Platform Location

021999

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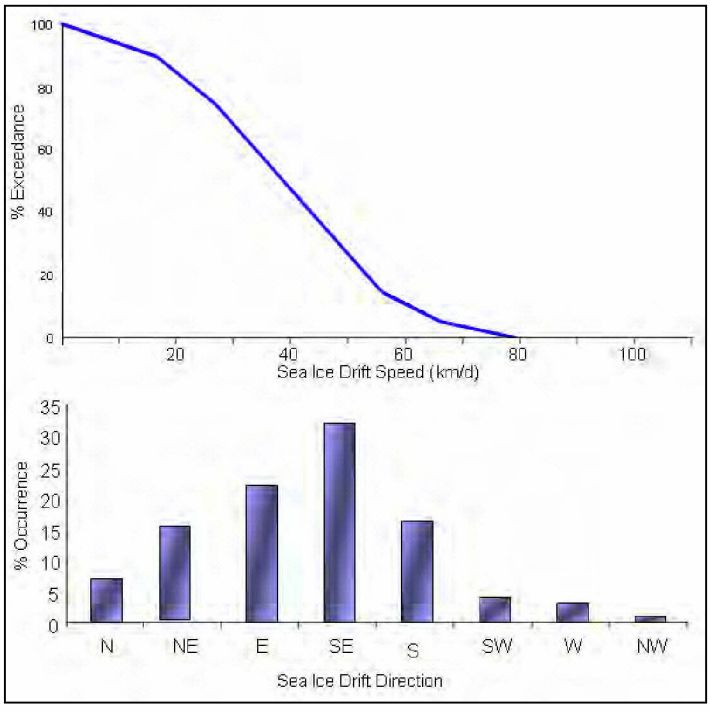


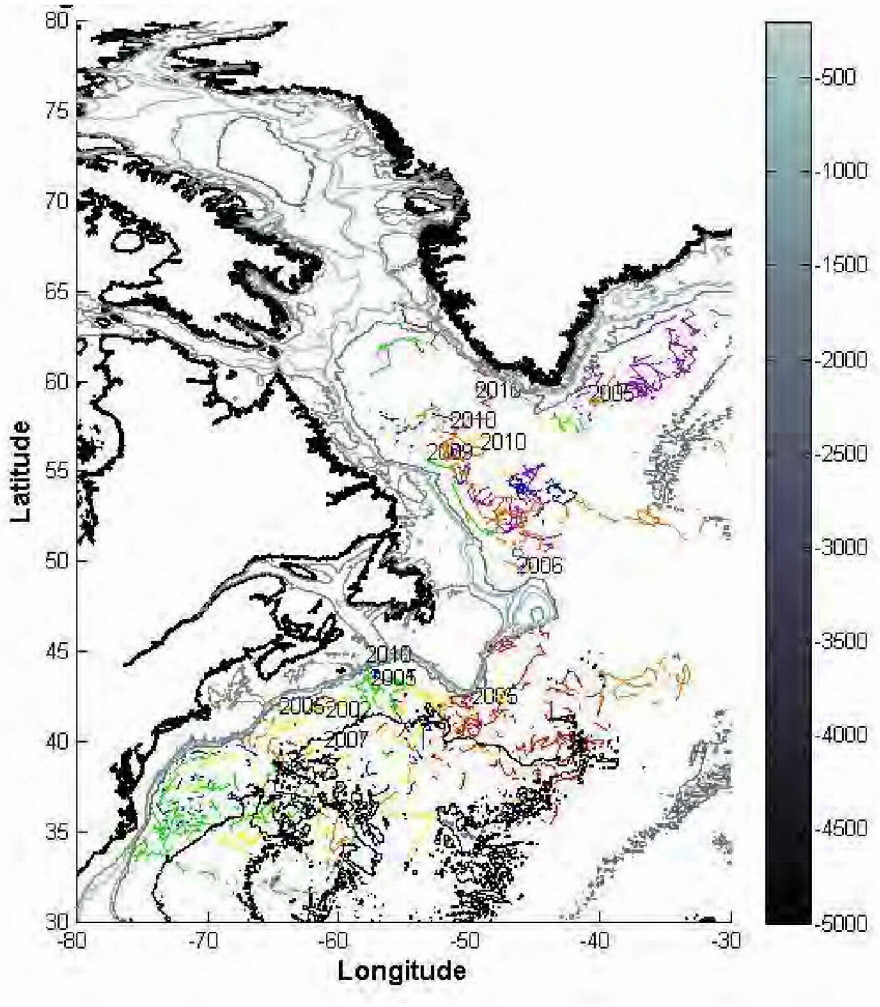
Figure 3-41 Percent Exceedance of Mean Daily Drift Speed and Distribution of Drift Direction

A verification study of surface current drift speed and direction was carried out by Provincial Aerospace Environmental Services Division with 18 Argo drifters from the years 2002 to 2010 in the North Atlantic Ocean (Figure 3-42), as obtained from the Integrated Science Data Management department of DFO.

Argo drifters were chosen as they are representative of pack ice drift. The drift speeds (Figure 3-43) of the Argos drifters as studied by PAL was observed to be marginally higher overall than those observed by Fissel et al. (1985). This may be attributed to the fact that the 2002 to 2010 data were collected year-round while the 1985 study focussed on just one season (spring 1985). Similarly, there was no predominant direction of drift (Figure 3-44) in the PAL study, but the Fissel et al. (1985) study found that southeast drift was most common. This may be a result of both seasonal drift and geographic distribution of the drifters under study. The PAL study was widely distributed across the North Atlantic and undoubtedly captured less of the Labrador Current flow that Fissel et al. (1985) was focussed on, leading to the observation of multi-directional drift.

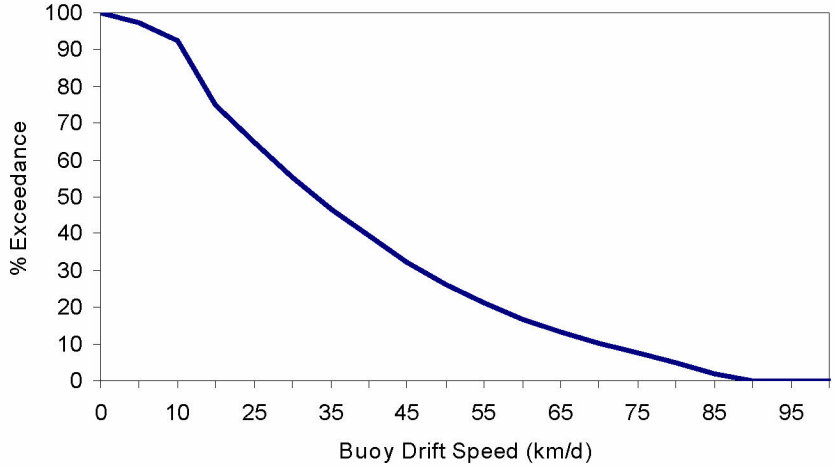
3.2.3.3 Concentrations

The median sea ice concentrations for the Grand Banks south of 49°N are usually between 4 and 6/10ths by early February and continue to be present in the region through early-April, after which they slowly decrease to 1-3/10ths coverage and recede to above 49°N as per Figure 3-45. In Figure 3-45, the term “Central Value” is determined by averaging the minimum and maximum median concentrations of sea ice found below 49°N on each given week over the 30-year period between 1971 and 2000.



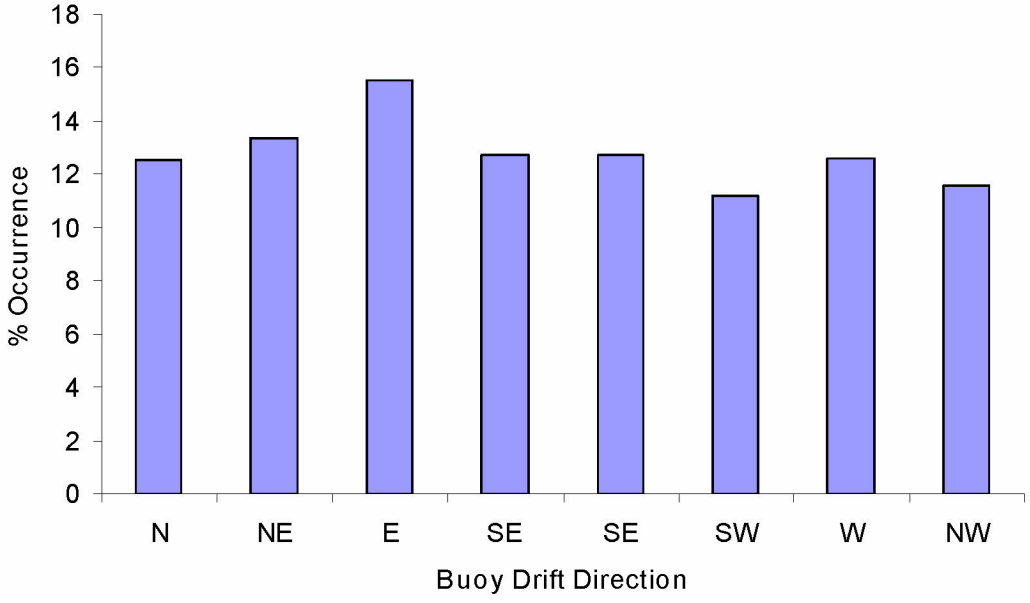
Source: Integrated Science Data Management 2010

Figure 3-42 Tracks of Argo Drifter, 2002 to 2010



Source: Integrated Science Data Management 2010

Figure 3-43 Buoy Drift Speed



Source: Integrated Science Data Management 2010

Figure 3-44 Buoy Drift

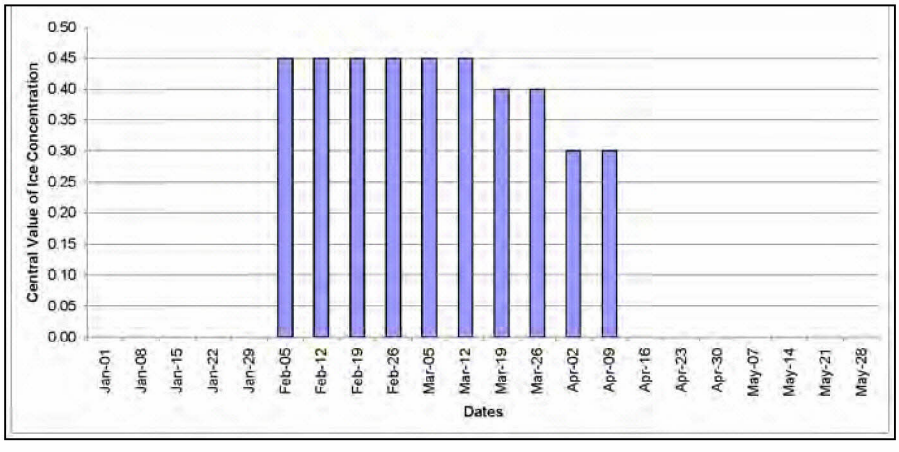


Figure 3-45 Central Values of 30-Year Median Ice Concentrations South of 49°N on the Grand Banks

Analysis of CIS ice charts for the years 1979 to 2008 shows that, for the years when ice was present, the mean overall ice concentration within 28 km of Hebron was 7/10ths.

Weekly ice coverage for the Hebron Platform-specific area is provided in Figure 3-46. The area on the Ice Graph covers a 1°X1° or 111 km north-south X 76.5 km east-west box).

3.2.3.4 Floe Size

The horizontal dimensions of individual ice floes are influenced by:

- Ice history
- Concentration
- Thickness
- Water temperature
- Sea state
- Proximity to land

In Newfoundland waters, floe sizes tend to decrease from north to south and from west to east, towards the outer margins of the ice pack. Enhanced melt and disintegration of the ice floes occurs at the outer ice pack margins as a result of larger amplitude waves (not damped by the ice pack proper) and warmer sea surface temperatures.

In both offshore regimes (north and south of the 49°N boundary of the Grand Banks), floe size decreases from west to east because of progressive decreases in wave amplitudes propagating into the pack ice from the open ocean.

Atmospheric Environment Service, now called the Meteorological Service of Canada supports a branch called the CIS, which compiles composite ice chart data. For 1968 to 1987, these charts indicate that, within 50 km of the Hebron Platform location, floes larger than 100 m are present only 10 percent of the time. Estimates made in several earlier studies (Blenkarn and Knapp 1969; Nolte and Trethart 1971; LeDrew and Culshaw 1977; Dobrocky Seatech 1985) indicate that mean floe diameters in offshore areas south of 49°N are less than 30 m. Only a few floes with diameters larger than 60 m were observed.

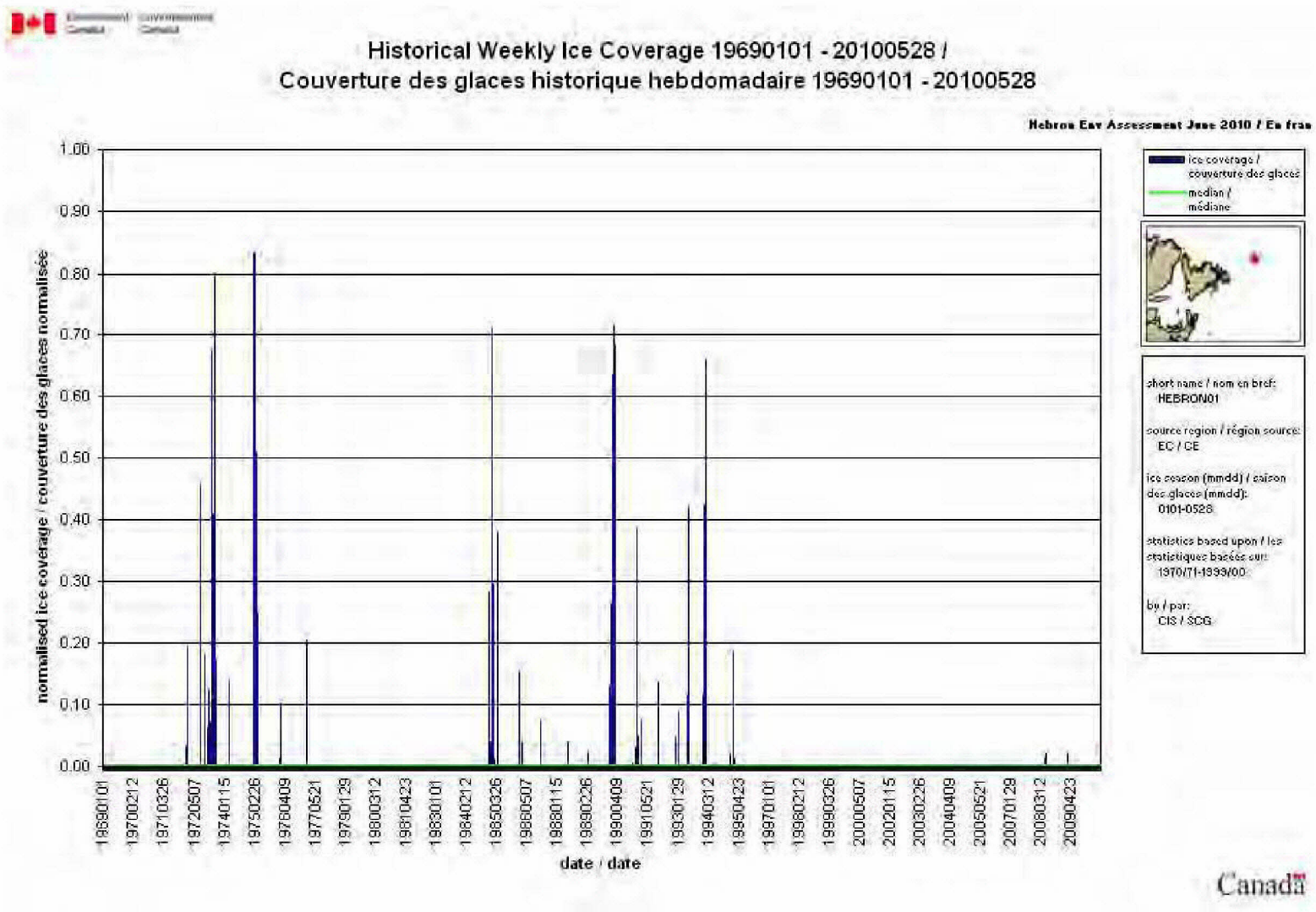
A northwest-to-southeast size gradient also was identified (Dobrocky Seatech 1985). Mean and maximum floe diameters decreased from 8 m and 37 m, respectively, at 49°N, 51°W to 1 m and 3 m in the vicinity of the Hebron Platform location (Seaconsult Ltd. 1988). Mean and maximum diameters may exceed these values by an order of magnitude or more (Seaconsult Ltd. 1988) when the ice extent is close to its seasonal maximum in years of exceptionally severe ice conditions.

3.2.3.5 Thickness and Deformation

Ice on the northern Grand Banks that is thicker than approximately 50 cm has drifted from colder, more northern areas, as noted earlier, or is present through ice deformation.

Quantitative data on deformed ice are usually confined to ridge-type deformations because they can be easily characterized by:

- Frequency (number of ridges/km)
- Length
- Width
- Maximum top-to-bottom thickness (sail height plus keel depth)



Source: Canadian Ice Service 2010

Figure 3-46 Historical Weekly Ice Overage for the Hebron Platform Area

C0814-176

Few quantitative data are available for the Grand Banks region, in part because linear ridge formations of the type commonly observed in Arctic areas are relatively rare here. Instead, the deformed pack ice consists of fields of confused jumbles of uplifted and broken floes (Petro-Canada 1995). Observations indicate that maximum sail heights, corresponding to local peak heights in such fields, are approximately 2 m (Dobrocky Seatech 1985). Nolte and Trethart (1971) calculated average ridge heights of approximately 1 m. These estimates are reasonably consistent with airborne electromagnetic sensor measurements in Newfoundland areas farther inshore (Prinsenberg et al. 1993).

Ridge thicknesses for the Grand Banks have also been estimated from data gathered off southern Labrador during February and early March and extrapolated to the Grand Banks (Seaconsult Ltd. 1988). These estimates indicate that ridges or rubble fields with sails as large as 3.5 m could form on the Grand Banks (Bradford 1972; NORDCO Ltd. 1977). However, these estimates are offset by the fact that the farther south the ice deformations occur, the faster the rafted and upturned floes, as well as the thin binding ice between the floes, will melt. As the melting occurs, structural fragility and ice porosity increase. This reduces the operational hazards of any ridge or rubble field fragments surviving to well below those associated with smaller pieces of old or glacial ice.

In some years, thick multi-year ice floes originating from the Arctic Ocean can drift southwards into Newfoundland waters. Because of their thickness and low-salinity (which makes the ice nearly as hard as glacier-derived ice), these ice floes can pose considerable danger to ships in the area – similar to the risks posed by icebergs. These ice floes are slow to melt because of their thickness and may or may not reach the Hebron Project Area. Once individual multi-year floes are left behind by the main (melting and retreating first-year) pack as they drift south, they would be indistinguishable from bergy bits or growlers.

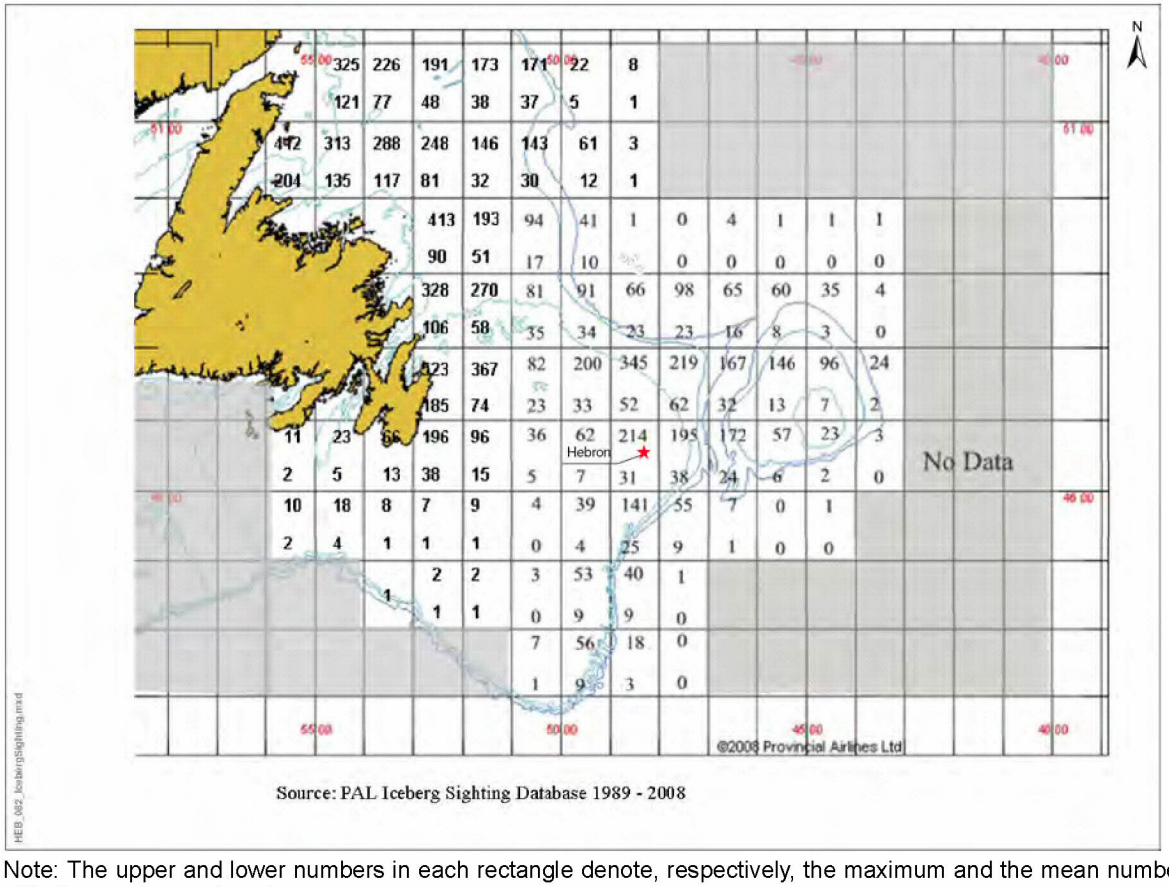
3.2.3.6 Icebergs

According to the International Ice Patrol (IIP) and PAL, the number of icebergs reaching the Grand Banks each year varied from a low of zero in 1966 and 2006 to a high of 2,202 in 1984. Of these, only a small proportion will pass through the Hebron Project Area. Over the last 10 years, the average annual number of icebergs sighted in the 1° grid containing the Hebron Platform location has been 31. Although the IIP database of icebergs drifting south of 48°N extends from 1900 to the present, substantial changes in technology have improved the quality of the data over time. In particular, in 1983, the IIP began using Side Looking Airborne Radar for iceberg detection, and the system was further enhanced in 1993 with the addition of Forward Looking Airborne Radar. The iceberg design basis for Hebron is based on data from the 1984 to 2008 period.

The iceberg load for the Hebron GBS is calculated with a probabilistic simulation and, as such, there is no single "design iceberg". The design load is calculated from an energy approach in which the kinetic energy of the

impacting iceberg is arrested by the work done in crushing the ice against the GBS. The key parameters that affect the load are the iceberg's mass, velocity, strength and local shape in the impact zone. These parameters are all described by statistical distributions, which allow for a wide range of possible scenarios that may lead to the design load. Based on this approach, the 10,000 year overall horizontal iceberg load on the pre-FEED GBS geometry is 517 MN, and can, for example, be caused by a 3.13 million tonne iceberg with 250 m waterline length and drifting at a 0.72 m/s velocity. This load will be updated during FEED and detailed design when the GBS geometry is finalized.

A plot of annual iceberg numbers in other 1° grids between 45°N and 53°N (using 1989 to 2008 PAL data showing the regional iceberg distribution) is shown in Figure 3-47. The maximum numbers provide a worst-case representation of local annual iceberg severities. However, not all iceberg maximum numbers occurred in the same year. The PAL iceberg database contains over 43,000 visually confirmed iceberg sightings made between 42°N and 55°N. Of these, approximately 23 percent were made south of 48°N. The maximum number of iceberg sightings (214) for the grid containing the Hebron Platform location was observed in 1990. This number, though high, is substantiated by the iceberg tracking records from Petro-Canada's King's Cove A-26 well site.



Note: The upper and lower numbers in each rectangle denote, respectively, the maximum and the mean numbers of icebergs observed each year

Figure 3-47 Maximum and Mean Annual Numbers of Icebergs Observed

In general, these data show that icebergs are most frequent in the Avalon Channel adjacent to Newfoundland and over the northern and eastern slopes of the Grand Banks. These are regions where branches of the Labrador Current are strongest. The largest numbers of icebergs immediately adjacent to the grid containing the Hebron Platform location tend to appear in the 1° grid immediately to the northeast. This area is traversed by the 200 m contour, which is associated with the approximate inshore edge of the outer branch of the Labrador Current.

Variations in Local and Regional Iceberg Numbers

The number of icebergs crossing any given latitude off Eastern Canada varies considerably both annually and monthly. Prior to 1999, the long-term record indicated a trend towards a larger number. However, there was a severe drop in the number of icebergs south of 48°N early in this decade. These low numbers were attributed to a combination of higher than normal water temperatures on the Grand Banks, very light sea ice coverage and prolonged periods of onshore easterly winds during the spring months, which drove the bergs onto the Labrador Coast where they grounded. As a result, ice was not free to drift south into Newfoundland waters. This trend for light iceberg distribution south of 48°N ended with the 2008 season, which saw large numbers of icebergs, and the trend continued into the 2009 season (PAL unpublished data).

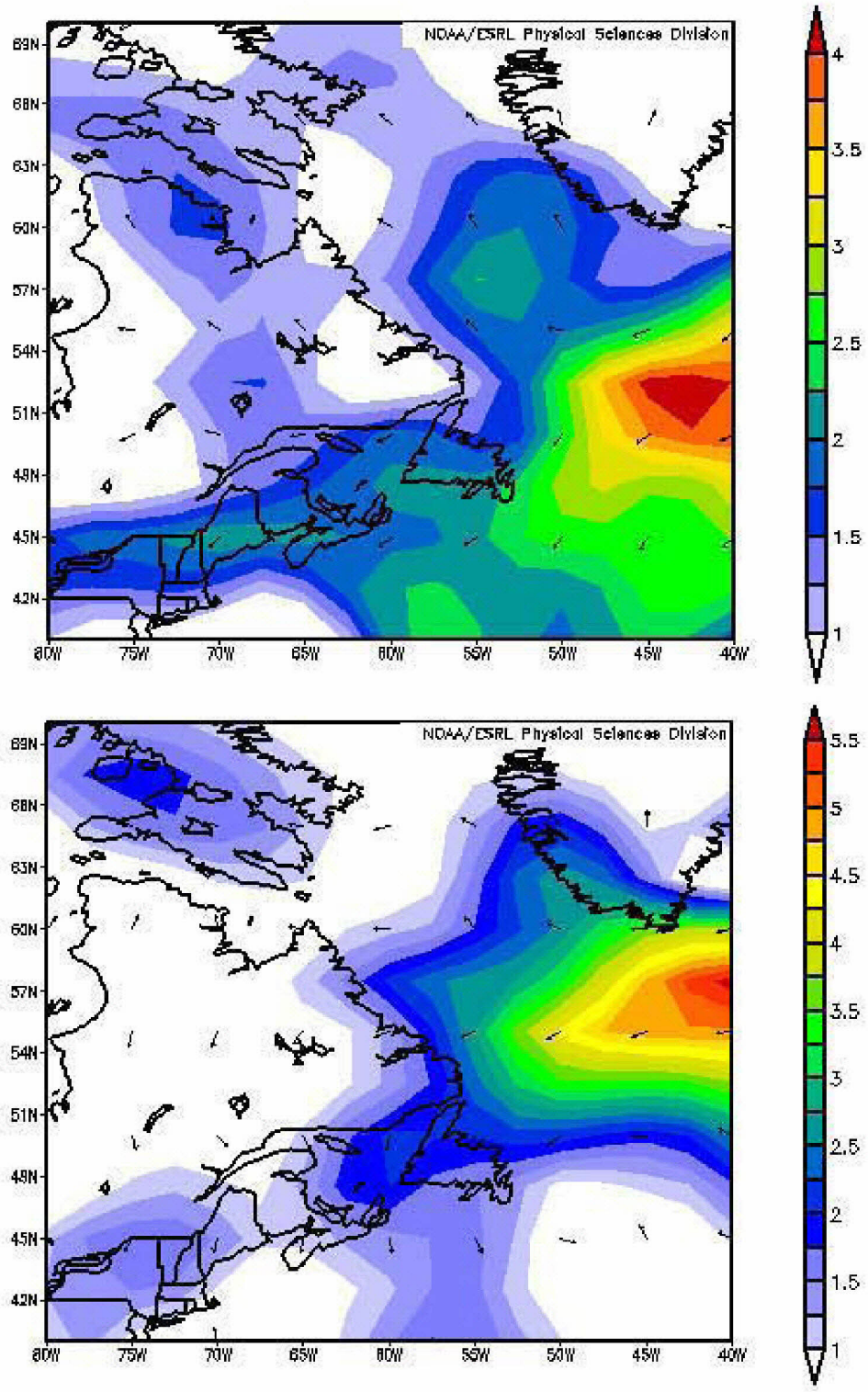
This situation is not unique. Within the past century, there have been several periods where the record indicates fewer than a dozen icebergs. In fact, there are several consecutive seasons with very low numbers. The record indicates that these periods are usually followed by a return to the “normal”. It appears these low numbers were just part of the long-term variability in the annual count.

The vector wind anomaly plots for March to May (wind speeds in m/s), created from National Centers for Environmental Prediction re-analysis data on the Earth System Research Laboratory website are provided in Figure 3-48, along with the Canadian Ice Service daily iceberg charts from May 2005 (Figure 3-49).

At 48°N, (i.e., an area extending up to 185 km (100 nautical miles) to the northwest of the Hebron Project Area, from where the majority of icebergs approach), long-term averages of data compiled by PAL from 1989 to 2008 in Figure 3-50 show that regardless of how many icebergs arrive, the number peaks in April but is at high levels from March to June.

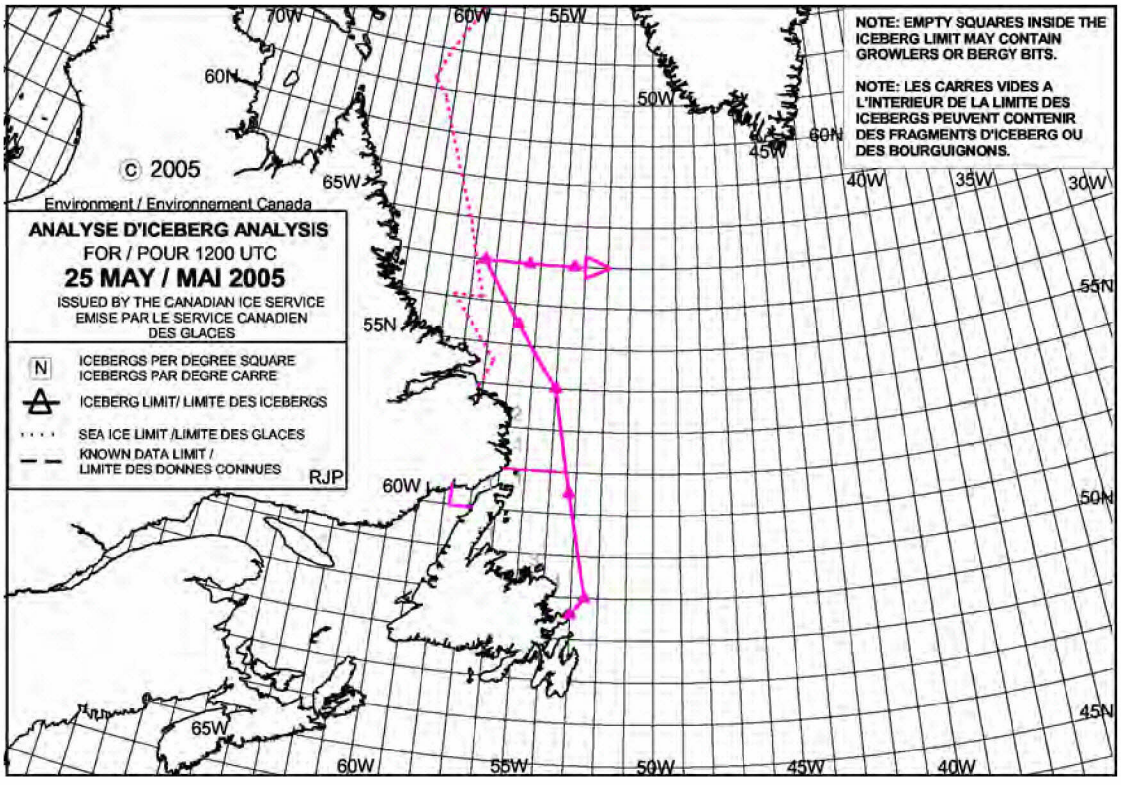
While the major iceberg flux falls into the March to June period, iceberg sightings on the approaches to the Hebron Project Area have been made at least once in each month, from January through December. In 1993, approximately 20 percent of the icebergs crossed 48°N in February.

Variations in the timing of iceberg influxes reflect annual differences in southward ice drift rates, iceberg drift rates and wind fields. Winds, along with the offshore position and extent of the ice pack, heavily influence iceberg drift rates.



Source: National Centers for Environmental Prediction 2010

Figure 3-48 Vector Wind Anomaly Plots for March to May



Source: Canadian Ice Service 2010

Figure 3-49 Daily Iceberg Charts from May, 2005

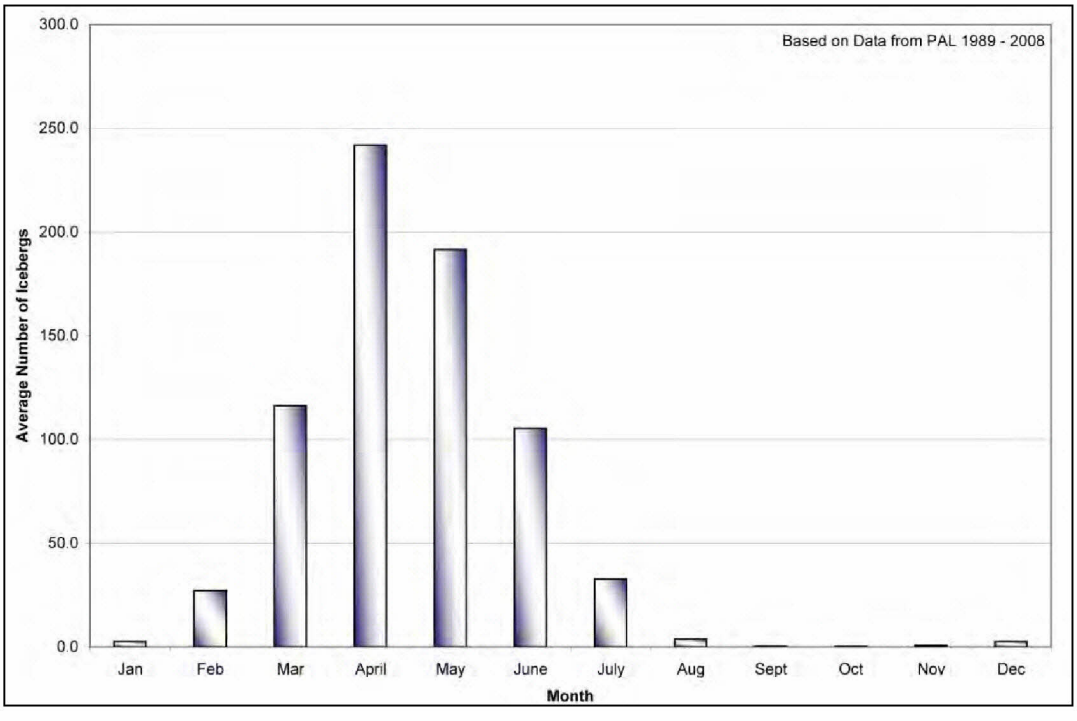


Figure 3-50 Average Number of Icebergs South of 48°N by Month

It should be noted that very low (less than 12) to iceberg-free conditions appear over 6 percent of the 118-year record and 15 percent when looking at only the past 20-years south of 48°N. Sightings within the same region over the past two ice seasons (2008-2009) have returned to the levels seen in the early 1990s.

Drift

In the vicinity of the Hebron Platform location, an area generally characterized by low-to-moderate concentrations of relatively thin sea ice, icebergs tend to move independently of the sea ice, reflecting the influence of deeper currents.

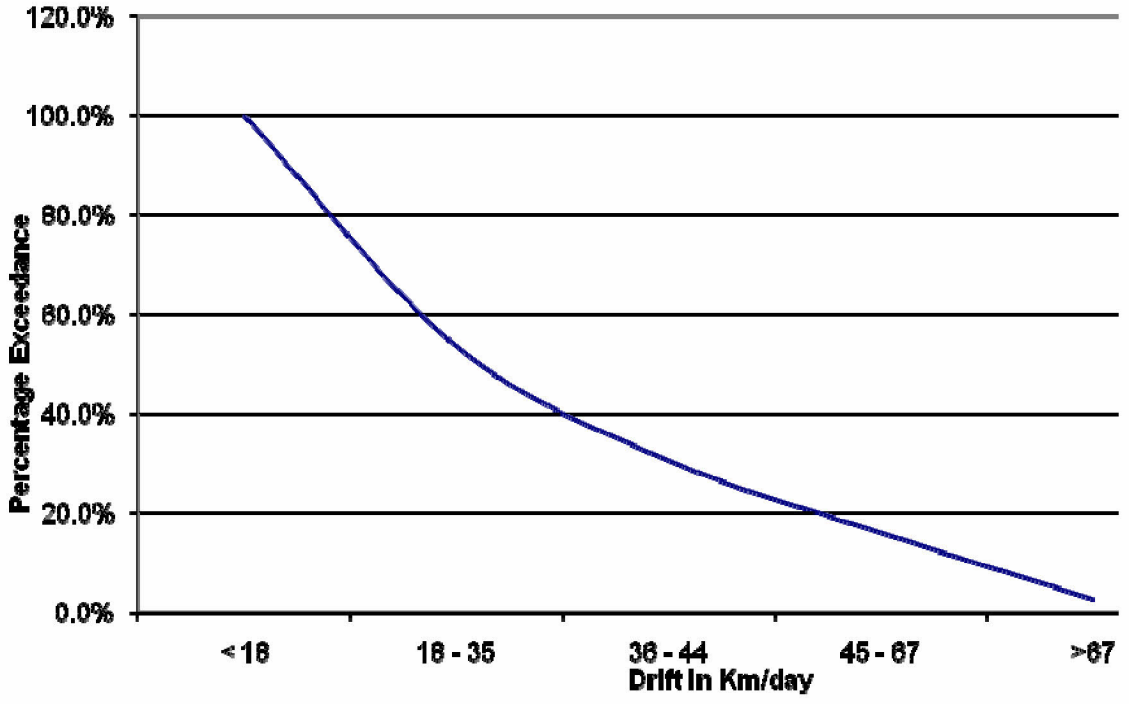
Iceberg speeds and drift directions on the Grand Banks (Figure 3-51) as measured over one- to three-hour time intervals in the years 2000 to 2008 (PAL 2008), are qualitatively similar to mean sea ice velocity fields. Approximately 65 percent of the measured speeds were less than 30 km/day and most with a southerly component, with southeast drift being the most prevalent at 19.5 percent. Though there are few fast-moving icebergs, these can still be problematic to a fixed platform, as size and speed are both major factors in the effects an iceberg can have, and management of such icebergs may be more difficult.

Size Distributions

Icebergs are categorized by size (as defined in Table 3-21). These general size classifications have been in use for the past 30 years by all collectors of iceberg data (IIP, CIS and PAL). However, the accuracy of size distributions extracted from the various databases is questionable, because most data are based on visual estimations and unspecified selection criteria.

Over the past eight years, over 500 icebergs have been monitored and recorded in the Ice Season Reports by the offshore facilities on the Grand Banks. This data set more accurately reflects the distribution within the Hebron Platform location, and as such it forms the bases of the following analysis.

The data sets show that the majority (73 percent) of the icebergs south of 48°N fall within the small to medium categories as illustrated in Figure 3-52. These results are comparable to those indicated in both the White Rose Comprehensive Study (Husky Oil Ltd. 2000) and Terra Nova Environmental Impact Study (Petro-Canada 1995).



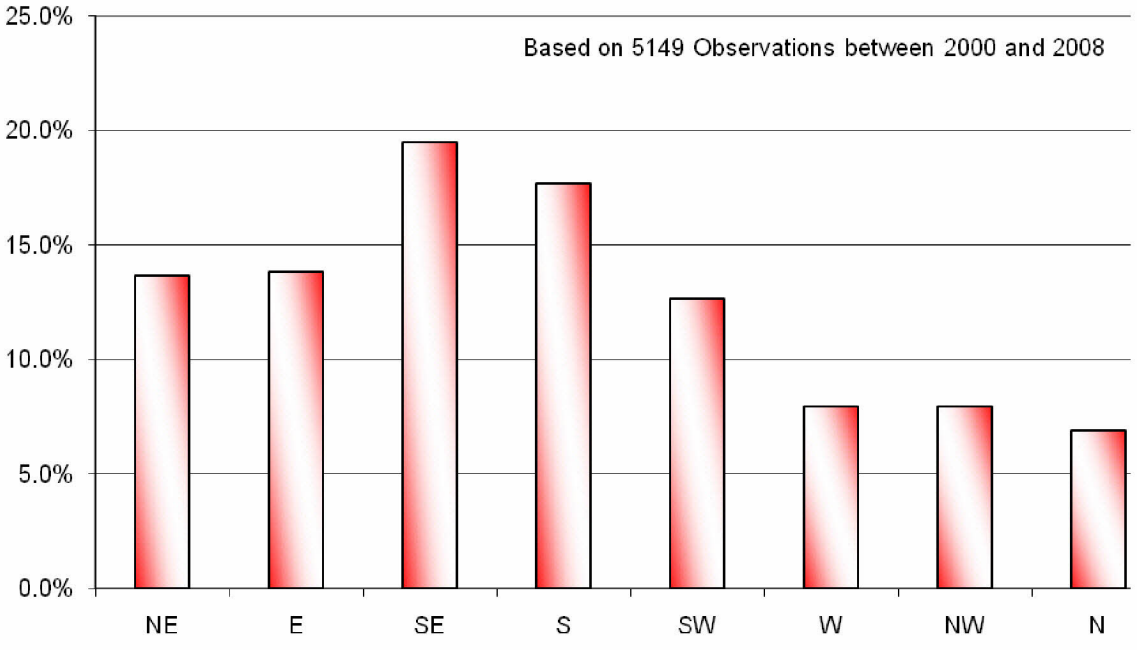
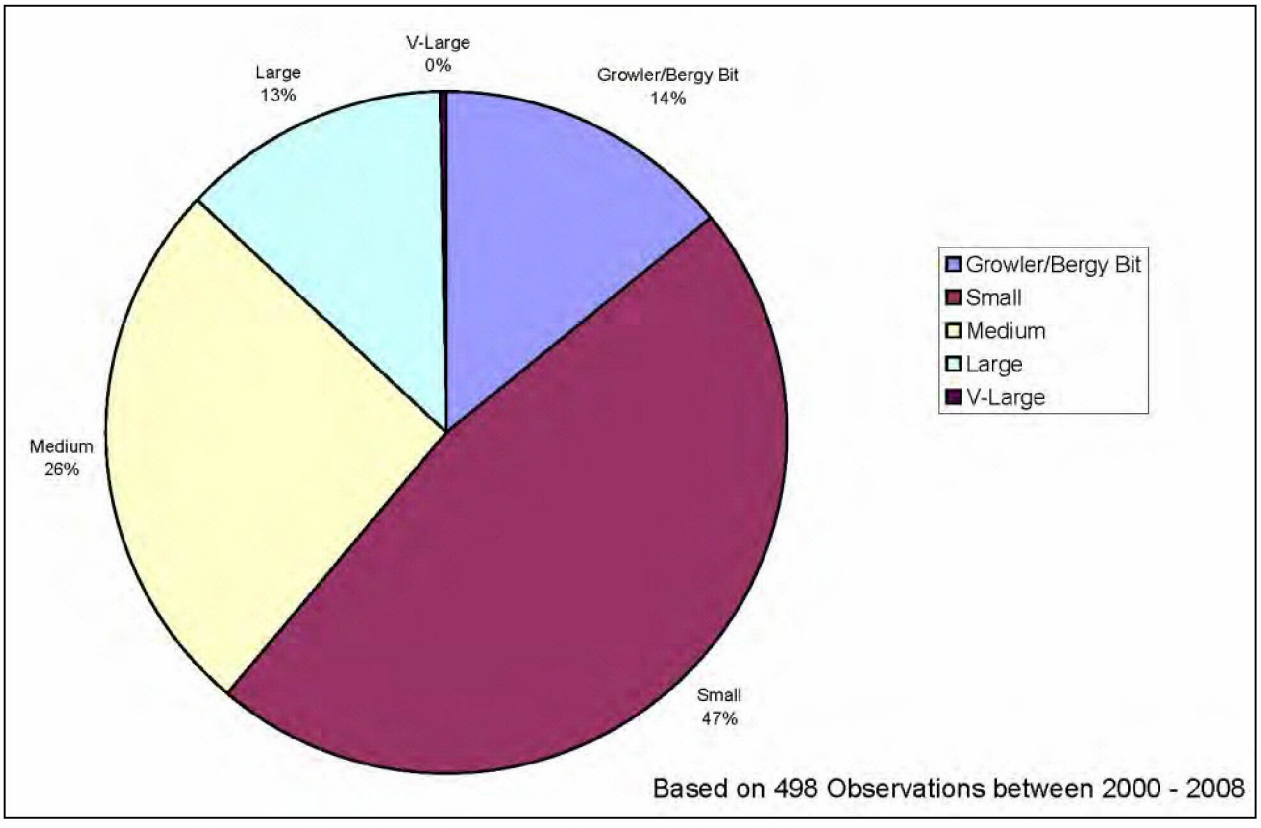


Figure 3-51 Speed Exceedance and Velocity Direction Distributions



Source: Source: PAL 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008

Note: A few of the icebergs that were tracked (monitored) did not have a size assigned so were left out of the distribution figure

Figure 3-52 Iceberg Size Distribution Based on 498 Observations

3.2.4 Geotechnical and Geological Conditions

3.2.4.1 Regional Nearsurface Stratigraphy

The Hebron Offshore Project Area is situated within the Jeanne d'Arc Basin, one of the major (Mesozoic) sedimentary basins within the eastern Canadian offshore.

The Grand Banks form a series of shallow outer banks separated from the Newfoundland coast by irregular inner shelf basins (Avalon and St. Pierre Channels). The Grand Banks has an overall area of 100,000 km^2. The Hebron Offshore Project Area is situated on the northeast margin of the Grand Banks, within approximately 93 m water depth. The seabed slopes gently to the east-northeast.

A near-surface stratigraphic sub-division for the northeastern margin of Grand Bank has been developed for the upper 100 m on the basis of geophysical profiles and borehole correlations (Zawadski 1991; Taylor et al. 1993; Sonnichsen et al. 1994; Terraquest Associates 1995; Sonnichsen and Cumming 1996; Sonnichsen and King 2005). The differentiation of three main stratigraphic units has been primarily based upon the recognition of well-defined progradational sequences of clinoform reflections (including the

"Hibernia Delta"), and the gently dipping, near-parallel sequences that overlie and underlie them (the Upper and Lower Parallel Reflection Sequences). The clinoform sequences have been interpreted as a pro-glacial outwash delta or, alternately, as bank-spillover deposits of Late Tertiary age (King and Sonnichsen 2000). The aggradational sequences are associated with transgressive phases (Zawadski 1991; Sonnichsen and Cumming 1996; Miller 1999; Sonnichsen and King 2005). The Clinoform Reflection Sequence (Unit 2, also known as the "Hibernia Delta") sub-crops in a wide band northwest and southwest of Hibernia, and thins with a transition from foresets to bottomsets approximately 7 km west of the Terra Nova Field.

The sequence overlying the Clinoform unit has been termed the "Upper Parallel Reflection Sequence" (Unit 1) and is interpreted to consist of interlayered marine sands, silts and clays. Research by Sonnichsen and King (2005) indicate that this sequence is comprised of four regional unconformity-bound sub-units (a to d). The sub-units subcrop in a pattern of narrow, east-arcing bands below thin surficial deposits east of Hibernia. Underlying the Clinoform unit is the Lower Parallel Reflection Sequence (Unit 3), which forms the approximate base of the near-surface stratigraphy, is bound at the top by a distinct, locally incised angular unconformity. This unit outcrops west of the Hibernia and Terra Nova Fields, and dips towards the east-northeast.

Regional Surficial Sediments

The surficial distribution of sediments on the northeastern Grand Banks has been well studied over the past few decades, both by staff of the Geological Survey of Canada - Atlantic and by private geophysical contractors. At present, the accepted view is that the top of the Grand Banks (everything above the present 110 m bathymetric contour) was sub-aerially exposed during the late-Wisconsin (approximately 15,000 years ago). Sea level subsequently rose, the surficial sediments were reworked, and the result was a relatively thin (average 1 to 3 m) veneer of sand and gravel that overlies the truncated Tertiary Banquereau Formation (Fader and King 1981; Stoffyn-Egli et al. 1992; Sonnichsen and King 2005), or glaciogenic sediment, where present. A surface transgressive lag deposit of gravel and cobbles is present, which is overlain by occurrences of discontinuous sandy bedforms. These surficial sands and lag gravels are categorized as the "Grand Banks Sand and Gravel" (Fader and Miller 1986). Iceberg scours and pits are common on the margins and regions of the Grand Banks. Scours observed in water depths of <110 m, such as those within the Hebron Offshore Study Area, are considered to have formed since the exposure and transgression of the bank top (Fader and Miller 1986). Boulders may be present at the seabed, or within nearsurface sediments (Sonnichsen and King 2005).

Areas deeper than 110 m present day water depth (seaward of the Hebron Offshore Project Area) were not sub-aerially exposed during the last sea level low-stand, but equated with a shallow marine environment. Conditions were likely very dynamic, reflecting coastal reworking and the presence of significant volumes of icebergs and pack ice. These areas received deposits of sand (Adolphus Sand) (Fader and Miller 1986) winnowed from shallower

regions during transgressive reworking. The White Rose field is located within an area of Adolphus Sand.

3.2.4.2 Hebron Offshore Project Area Nearsurface Geology

As discussed, surficial sediments on the bank top are composed of the Grand Banks Sand and Gravel (Fader and Miller 1986). The proposed Hebron Platform location is situated near the middle of a large sand ridge. A transgressive lag deposit of gravel and cobbles (the "Grand Banks Gravel") underlies the sand, and comprises the seabed in areas where sands are absent. Beneath the surficial sands and gravels, the very nearsurface stratigraphy (i.e., less than 15 m sub-seabed) within the region is commonly thought to reflect episodes of Quaternary glaciation, as well as associated relative sea level changes, and varying degrees of rework by icebergs (e.g., Sonnichsen and King 2005).

Fugro Jacques GeoSurveys (2001a) conducted a desktop study review of existing sub-bottom profiler and geotechnical data from the Hebron Project Area and dredging history experience. There is a limited amount of high-resolution sub-bottom data available. Huntec Deep Tow System profiles (McGregor 1997) provided insight into the uppermost 25 to 30 m of the sediment column, illustrating a discontinuous reflector at 10 to 15 m depth, and occasional buried channels. This was relatively consistent with other stratigraphies interpreted from geophysics and generally supported by geotechnical data from the region.

Fugro Jacques GeoSurveys (2001b) predicted that unconsolidated surficial sands (designated as Stratum I; Grand Banks Sand) would be 0.5 to 2 m thick, in association with the sand ridge. Underlying sediments (designated Stratum II), to depths of 12 to 20 m sub-seabed, were predicted to be highly variable in nature, reflecting the influences of glacial erosion, deposition, compaction, sub-aerial exposure and diagenetic modification. The presence of boulders and cemented horizons (hardpan) was considered possible. Sands present were predicted to be dense to very dense, with variable silt, clay and gravel content, with occasional cobbles and boulders. Nearsurface channels were also noted as possible occurrences. Sediments below the surficial, seemingly highly variable sequence were inferred to be interlayered marine silts and clays of the Tertiary "Upper Parallel Reflection Sequence" (Stratum III), and underlying units (Clinoform Reflection Sequence, Lower Parallel Reflection Sequence), as per the regional seismostratigraphy (Fugro Jacques Geosurveys 2001a).

Previous exploration and development activities at Terra Nova and White Rose have documented the existence of a discontinuous, cemented "hard-pan" layer within near-surface strata on the Grand Banks within water depths similar to those within the Hebron Project Area (Sonnichsen et al. 1994; Hewitt 1999). Recognition and mapping of this phenomenon has proven difficult, due in large part to the inability of typical geophysical survey tools to penetrate the acoustically (and physically) hard seabed. It is speculated that the development of this material is linked to diagenetic effects during one or more episodes of sub-aerial exposure (Coniglio 1996; King and

Sonnichsen 2000). The extent to which this phenomenon is limited to areas affected by the last sea level lowstand (i.e., areas above 110 m present day water depth) is uncertain, and localized occurrences may occur to present day water depths of up to 160 m (King and Sonnichsen 2000).

It was concluded that the nearsurface stratigraphy at the Hebron Platform location would be similar to that of Terra Nova, given evidence from the limited sub-bottom profiler data, geotechnical data, similar water depths and proximity of the sites.

In terms of other constraints to development, no shallow faults have been identified which penetrate the nearsurface stratigraphy within the vicinity of the Hebron Project Area. Potential shallow gas pockets have not been identified within the upper 100 m or more of the sediment column (McGregor and Fugro Jacques GeoSurveys 1998; Sonnichsen and King 2005). As noted above, boulders may be present at, or beneath the seabed, and potentially at depths of tens of metres sub-seabed (Sonnichsen and King 2005). As noted, and evidenced in seismic profiles, there is potential for nearsurface channels within the Hebron Project Area.

Comparison with Geotechnical Data

It is considered likely that the poorly graded fine sands of Stratum I are part of the surficial sand ridge upon which the Hebron Platform will be situated. This feature has been inferred (based on relative seabed topography) to be on the order of 1 to 2 m thick (McGregor and Fugro Jacques Geosurveys 1998; Fugro Jacques Geosurveys 2001c). These sands would equate with the sand component of the Grand Banks Sand and Gravel.

Coarse Stratum II sediments are likely similar to coarse nearsurface intervals observed at Terra Nova (Newfoundland Geosciences Limited 1988; Jacques McLelland Geosciences Inc. 1997a, 1997b; Hewitt 1999), as well as within other industry boreholes in the region (Sonnichsen and King 2005). These sediments may well equate with the Grand Banks Drift, a blanket of ground moraine (or diamict). The Grand Banks Drift (where previously interpreted to be present (e.g., Sonnichsen and King 2005)), has been interpreted as over-consolidated, perhaps related to ice loading. Iceberg scours formed under marine conditions can be preserved on the surface of the Grand Banks Drift (e.g., at White Rose). As noted in the 1997 Huntec data (McGregor 1997; Fugro Jacques Geosurveys 2001b), channels can be present within the nearsurface.

It is quite probable that the very dense sand (Stratum II) Grand Banks Drift is blanketing the glacially incised and/or channelled top of the Banquereau Formation marine sediments (Stratum III and deeper). These sediments would equate with the gently dipping “Upper Parallel Reflection Sequence” within the Banquereau (e.g., Sonnichsen et al. 1994; Terraquest Associates 1995; Sonnichsen and Cumming 1996; King and Sonnichsen 2000; Sonnichsen and King 2005).

3.2.4.3 Hebron Offshore Study Area Surficial Geology

The distribution of surficial sediments on northeast Grand Bank is displayed on Figure 3-53 (King et al. 2001). This map reflects regional mapping exercises by the Geological Survey of Canada, as well as oil and gas wellsite and development site investigations. As illustrated, the Hibernia, Terra Nova and Hebron projects are all situated on the bank top, in areas of Grand Banks Sand and Gravel (Fader and Miller 1986). As previously described, the Grand Banks Gravel is a lag deposit, reflecting the removal of finer sediments by transgressive processes as sea levels rose. The overlying Grand Banks Sand is present as large-scale sand ridges and smaller scale sand waves, ribbons and megaripples, reflecting both relict, and to a minor extent, modern sedimentary processes (Sonnichsen et al. 1994) on top of the lag deposit. The Hebron Offshore Study Area is dominated by large sand bodies (ridges), predominantly oriented north-south, with significant areas of gravel between. The margins of the sand ridges display secondary bedforms of varying scale (ripples to sand waves). The eastern margins of sand waves (and ridges) are fairly well defined and sharp, whereas the western margins are diffuse (Figure 3-54). This may suggest some gradual mobility to the southwest, although repeat surveys have suggested that bedforms are very stable over observation periods.

The seabed near the Hebron Platform location is relatively flat (gently dipping to the south-southwest). Bedform troughs are apparent to the northeast. Seabed video and sediment samples indicate that the seabed within the Hebron Platform area is comprised primarily of featureless, fine / medium sands. Occurrences of coarser sediments (likely gravels and cobbles) are situated southwest of the defined area, as well as to the northeast (associated with bedform troughs) (McGregor and Fugro Jacques GeoSurveys 1998). No point targets (e.g., potential boulders) have been noted within the proposed Hebron Platform area.

Site surveys from the larger Hebron Offshore Project Area (McGregor 1997; McGregor and Fugro Jacques GeoSurveys 1998) identified occasional sonar point targets, interpreted as boulders of 1 to 2 m diameter. These were noted to be primarily apparent on areas of coarse seabed, as opposed to the relatively featureless sand ridges. Boulders were also noted by Fader and Miller (1986) and Sonnichsen et al. (1994) within the region. In addition, a series of shallow, flat-bottomed depressions of unknown origin were noted (McGregor and Fugro Jacques GeoSurveys 1998), primarily within areas of Grand Banks Gravel. No such features were observed in areas of sand, such as in the present Hebron Project Area.

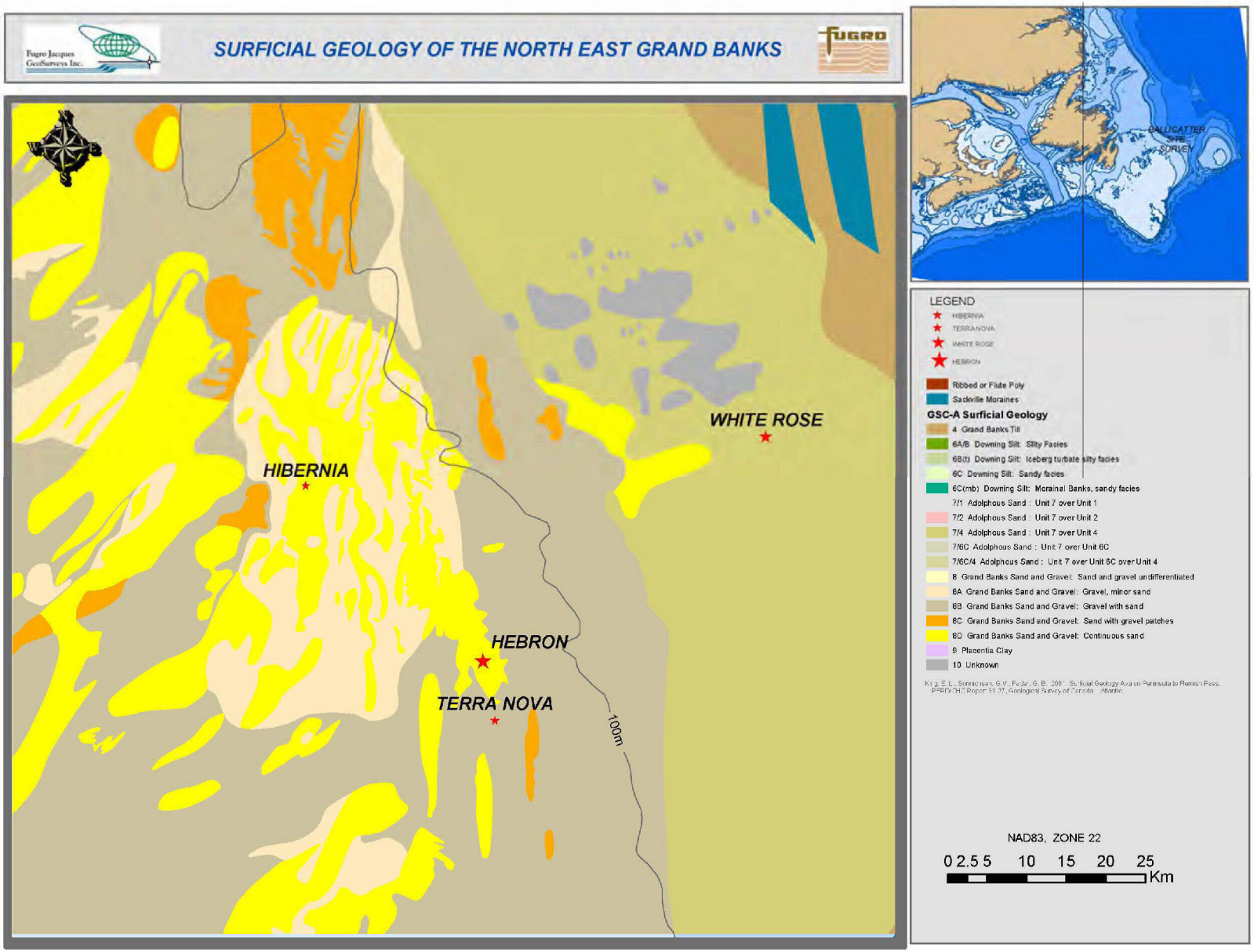


Figure 3-53 Hebron Surficial Geology from Geological Survey of Canada - Atlantic

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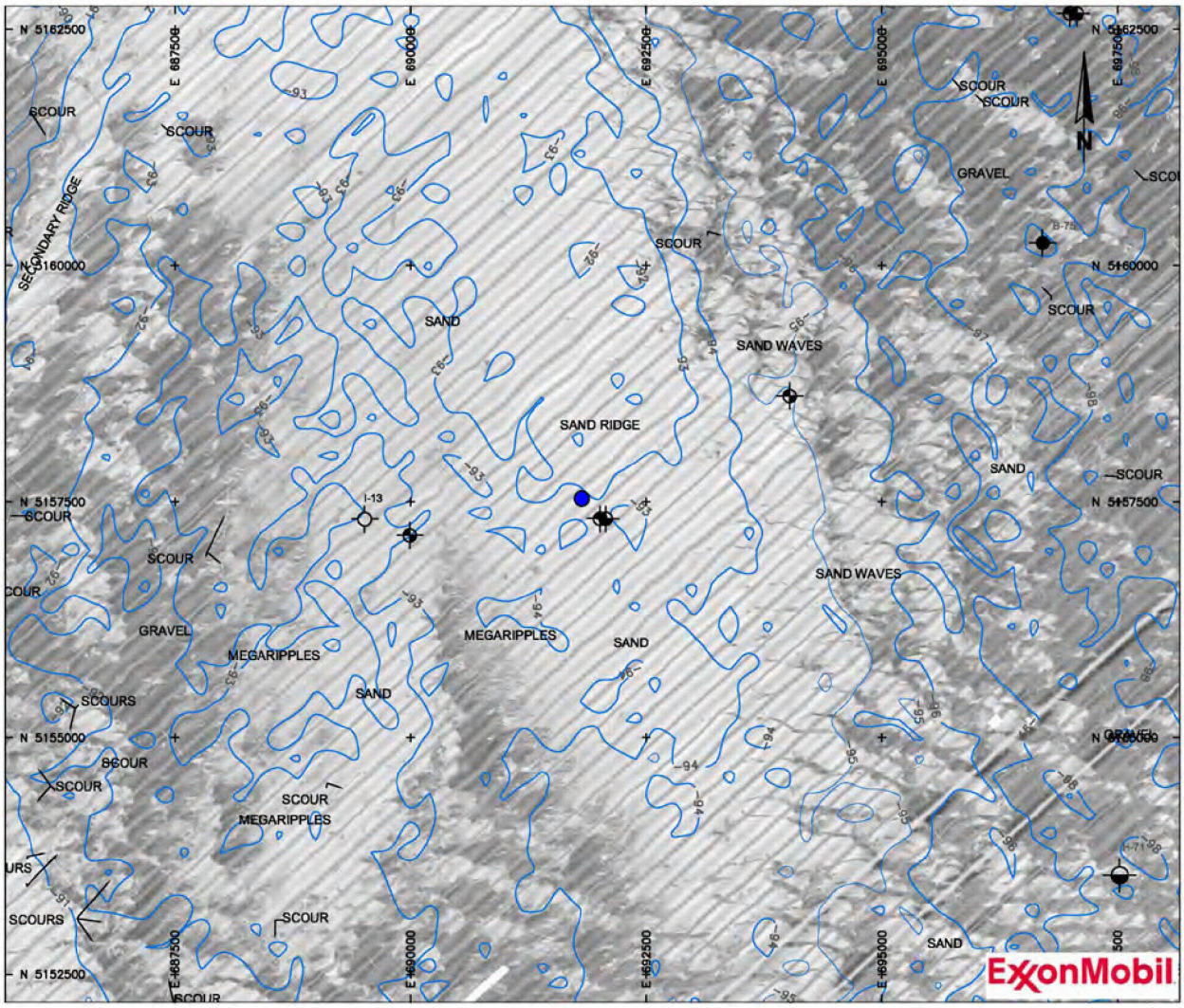


Figure 3-54 Hebron Sidescan Mosaic

3.2.4.4 Geotechnical Data from the Hebron Platform Location

In 2005, Fugro Jacques GeoSurveys conducted an extensive geotechnical investigation within the proposed Hebron Project Area (Fugro Jacques GeoSurveys 2005). Multiple boreholes of cone penetration testing and sampling as well as just cone penetration testing were conducted at the proposed Hebron Platform location. Some boreholes encountered refusal due to inferred boulders, cobbles and gravels and had to be redrilled nearby. The overall surficial and nearsurface findings are as follows:

- Stratum I: 0 to 2 m - Loose to dense SAND with shell fragments
- Stratum II: 0 to 8 m - Very dense SAND, gravel and cobbles to SAND to SAND with silt
- Stratum III: 3 to 10 m - Very stiff to hard CLAY to clayey SAND
- Stratum IV: 8 to 12 m - Dense SAND and clayey SAND
- Stratum V: 12 to 20 m - Very stiff to hard CLAY to sandy CLAY

The variability of the depths each stratum was encountered is illustrated by the overlapping of tops and bottoms of each stratum depth. The variability is further exemplified as one understands that these variations were observed within a 65 m radius.

Three sets of boreholes were acquired in 2005 at potential mooring pile locations. The overall surficial and nearsurface findings for each set are as follows (Fugro Jacques Geosurveys 2005):

Mooring Pile 1 & 1a

- Stratum I: 0 to 0.4 m - Loose to medium dense SAND
- Stratum II: 0 to 5.4 m - Dense gravelly SAND with cobbles
- Stratum III: 3.9 to 11.5 m - Interbedded very stiff CLAY to hard sandy CLAY
- Stratum IV: 11 to 14.3 m - Interbedded medium dense to dense clayey SAND and very stiff CLAY
- Stratum V: 14 to 22.7 m - Very stiff to hard CLAY

Mooring Pile 2 & 2a

- Stratum I: 0 to 1.1 m - Loose to dense SAND
- Stratum II: 0 to 7.7 m - Dense to very dense SAND with gravel to gravelly SAND with cobbles
- Stratum III: 7.2 to 9.7 m - Very stiff to CLAY to sandy CLAY
- Stratum IV: 9.5 to 13 m - Interbedded very stiff CLAY and medium dense to dense SAND to clayey SAND
- Stratum V: 13 to 20.3 m - Very stiff to hard CLAY to CLAY with sand

Mooring Pile 3 & 3a

- Stratum I: 0 to 0.5 m - Loose to dense SAND
- Stratum II: 0 to 4.1 m - Very dense gravelly SAND with cobbles to clayey SAND
- Stratum III: 2.8 to 8 m - Very stiff CLAY and sandy CLAY
- Stratum IV: 7.4 to 12 m - Interbedded medium dense to very dense clayey SAND and very stiff CLAY
- Stratum V: 11 to 19.2 m - Very stiff to hard CLAY

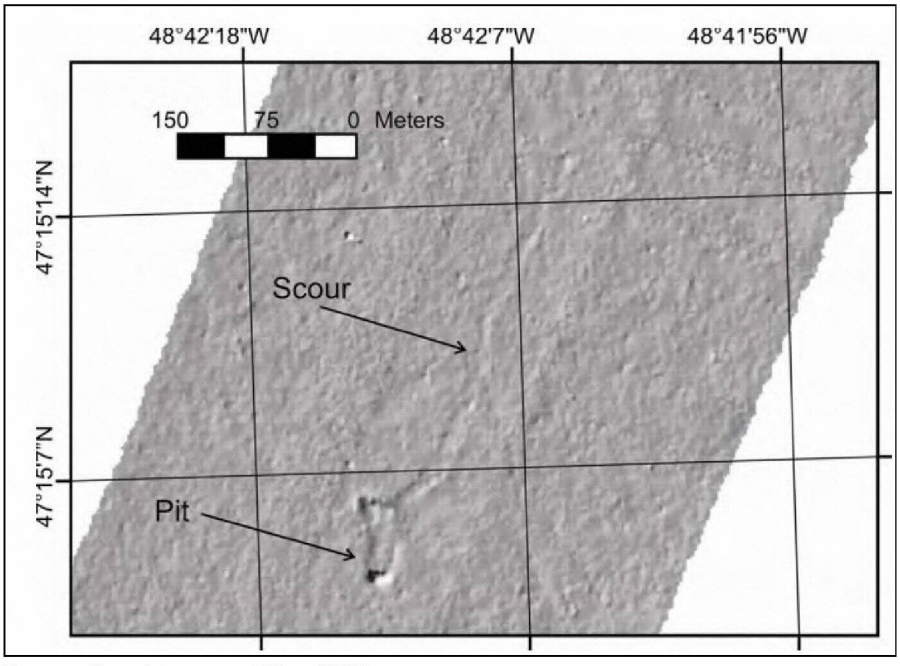
3.2.4.5 Anthropogenic Obstructions

Based on the information that Marine Forces Atlantic, also know as MARLANT, currently holds, there are no concerns with shipwrecks or unexploded ordinates in this area.

3.2.5 Ice Scour Data for the Hebron Offshore Study Area

Icebergs whose drafts exceed their water depths scrape along the sea floor, creating continuous or interrupted gouges and pits and may eventually become grounded in the seabed. These phenomena are known as “iceberg

scours". An iceberg scour is typically composed of a linear furrow with a trough and side walls. Occasionally, the furrow terminates in a semi-circular pit (Figure 3-55) formed when the scouring iceberg stops drifting and remains stationary. The pits on the Grand Banks are deeper and wider than furrows, and typically have higher side walls.



Source: Sonnichsen and King 2005

Figure 3-55 Shaded Relief Image of Multibeam Bathymetric Data over Scour 00-18

The seabed of the Grand Banks, within the vicinity of the Hebron site, experiences regular contact with drifting icebergs. An average of 400 icebergs per year (albeit highly variable) reach Grand Bank (Sonnichsen and King 2005). Sidescan sonar and multibeam bathymetry data from the bank top display frequent linear ice scour (or furrows) from grounded icebergs (Figure 3-55). In addition, icebergs calving or rolling, or remaining in one location for an extended period, can produce large semicircular pits (Lewis and Blasco 1990; Parrott et al. 1990).

While details of the scouring process are only partially known, it certainly depends on the following:

- Sea bottom shape and composition
- Iceberg shape and stability
- Strength of the current, wind and sea ice vector forces acting on the iceberg

Scours down to approximately 200 m water depth have been observed on the Northeastern Grand Bank. Iceberg draft measurements collected to date, while limited, also support this.

The dimensions and frequency of occurrence of iceberg scours have been studied to assess the likelihood of an iceberg affecting oil production facilities on or below the sea floor. Scour depths and probabilities have been assessed using a variety of techniques and various mixtures of data, including:

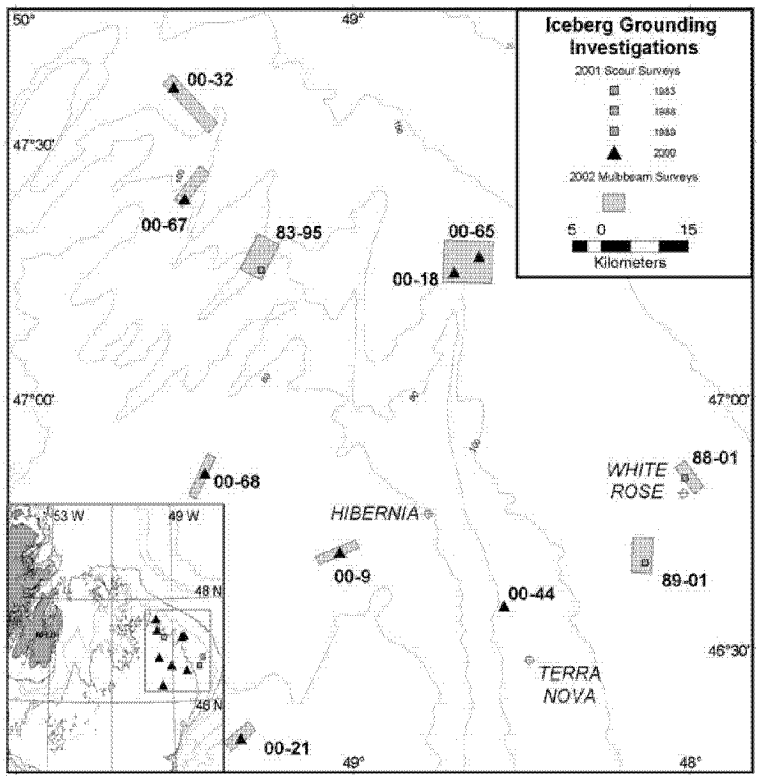
- Sedimentation rates
- Iceberg numbers, drafts, velocities and densities
- Age of existing scours

Recent studies using data from high resolution seismic side scan sonar and remotely operated vehicles (ROV) surveys documented iceberg scours from known iceberg groundings (Figure 3-55) since 2000 and updated earlier documented scours. These studies have provided a better understanding of scours on the Northeast Grand Banks and have confirmed past estimates of average scour statistics.

Relict seabed iceberg scours have been observed to 650 m below sea level off Grand bank (Sonnichsen and King 2005). Modern seabed scouring icebergs have been documented to 127 m (Sonnichsen et al. 2005), but based on measured iceberg keel drafts, iceberg scouring is predicted to occur to depths in excess of 200 m, possibly to 230 m. However, bathymetry has an impact upon the size of icebergs that can reach a particular site, as draft cannot substantially exceed the water depth. Water depth at Hebron is approximately 90 to 95 m. Similarly, the presence of shallower regions "upstream" can result in bathymetric sheltering (Lewis and Blasco 1990; Sonnichsen and King 2005). In addition, the use of ice management techniques within a region (such as the Jeanne d'Arc basin) will result in a reduction of iceberg contacts. A location map of iceberg groundings in the Grand Banks of Newfoundland and areas is provided in Figure 3-56.

Sonnichsen and King (2005) reports that for the northeastern Grand Banks (which includes the Hebron Project Area), the maximum furrow depth is 1.5 m, while pits as deep as 9 m have been recorded. Other scour statistics included mean scour depth of 0.4 m, a mean pit depth of 1.8 m, and a mean scour length of 829 m and mean scour width of 22 m.

Between 0 and 2,202 icebergs reach the Grand Banks each year as recorded by PAL and the IIP. Bathymetric sheltering limits the number that can cross the banktop region, and enter the Hebron region. Sidescan sonar and multibeam bathymetry data from the bank top display frequent linear ice scour (or furrows) from grounded icebergs. In addition, icebergs calving or rolling, or remaining in one location for an extended period, can produce large semicircular pits (Lewis and Blasco 1990; Parrott et al. 1990). Scours mapped (with sidescan sonar) within the Hebron Project Area are indicated in Figure 3-55. Some of those evident are infilled with sand, and are likely old (although establishing absolute age of ice scour features is a challenge). See below for predicted occurrence rates of ice scour.

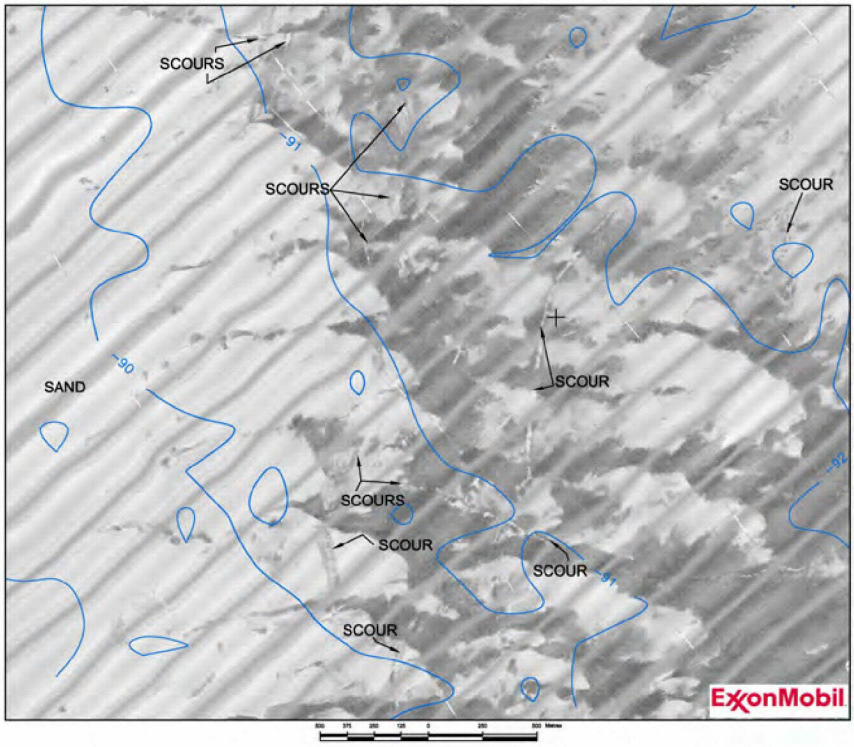


Source: Sonnichsen and King 2005

Figure 3-56 Location Map of Iceberg Groundings on the Grand Banks of Newfoundland and Areas

As noted, surficial sediments in the Hebron region are composed of the Grand Banks Sand and Gravel (Fader and Miller 1986; Sonnichsen and King 2005). The gravels are a lag deposit, reflecting the removal of finer sediments by transgressive processes. Sands often form large-scale sand ridges and smaller-scale sand waves, ribbons and megaripples, reflecting both relict, and to a minor extent, modern sedimentary processes (Sonnichsen et al. 1994). The hard "armoured" gravel / cobble surface, at or near the seabed, serves to limit the depth of ice scour through the bank top region. Linear furrows are most apparent in areas of sand, where they are generally deeper, or in areas of gravel substrate where there is infilling by sand (often only on the basis of the textural contrast). Scours mapped (with sidescan sonar) within the Hebron region are shown in Figure 3-57.

Scour depth (from original seafloor to base of incision) for linear scour features was noted (C-CORE 2001) to be an average of 0.44 m (with a standard deviation of 0.43 m). As noted, this was based upon a reduced density of available information (492 scour crossings). Sonnichsen and King (2005) examined a different subset of data, and established an average (linear) scour depth of 0.4 m. Fugro Jacques GeoSurveys (2004) examined 1,557 scours mapped with multibeam, north of Hebron, and noted that typical scour depths were less than 0.5 m. Pit depth was noted by C-CORE (2001) to be 1.2 m (maximum depth noted was 7 m). Sonnichsen and King reported an average pit depth of 1.8 m. A pit of 9.3 m depth has been noted within the region (Fugro Jacques GeoSurveys 2004).



Source: McGregor and Fugro Jacques Geosurveys 1998

Figure 3-57 Iceberg Scour in the Hebron Offshore Study Area

Scour width (measured from side wall crest to side wall crest) is a function of water depth (larger icebergs being able to enter deeper water) (C-CORE 2001). Within the Hebron Project Area, the mean scour width is 22.8 m, with standard deviation of 14.5 m. Maximum observed scour width is 118 m. Mean pit size is 60 m (C-CORE 2001). Over the larger Jeanne d'Arc region, Sonnichsen and King (2005) reported a mean width of 22 m, and a maximum of 157 m. Average pit width was noted to be 50 m.

Scour lengths as recorded within databases are highly dependent on the systems used for mapping, and the completeness of the imagery along a single linear scour. Sonnichsen and King (2005) examined scours from large area mosaics, and determined a mean length of 829 m.

Scour orientation was noted to be predominantly north-to-south to northeast-to-southwest (Sonnichsen and King 2005). On the basis of current directions, it is generally assumed that most scouring occurs with along a south-trending trajectory. C-CORE (2001) presented a rose diagram illustrating scour orientation.

The parameter of scour density can be calculated for a given region with sufficient coverage. Overall, the reported mean scour density for water depths of 90 to 100 m on Grand Bank is 1.17 scours per square kilometre (Croasdale and Associates 2000; Sonnichsen and King 2005). C-CORE (2001) report a scour density of 0.9 to 1.08 scours per square kilometre for the Hebron Project Area, based largely on the large area sidescan mosaic acquired for Chevron Canada Resources (McGregor and Fugro Jacques

Geosurveys 1998). However, a more important parameter is perhaps the inferred scour frequency. Estimates on the order of 4×10^{-4} scours per square kilometre per year have been developed and are considered reasonable for the Jeanne d'Arc region (Lewis and Parrott 1987; Croasdale and Associates 2000; Sonnichsen and King 2005). C-CORE (2001) noted that this estimate may not reflect short term (decadal or longer scale) fluctuations.

3.2.6 Climate Change

3.2.6.1 Sea-Level Rise

It is generally accepted that the global sea level will rise in a warming world. This section discusses some of the literature on the subject and what possible changes might occur on the Grand Banks.

Kolker and Hameed (2007) examined meteorological drivers of the long-term trends in global sea level rise. They found that atmospheric indices like the North Atlantic Oscillation explain a major fraction of the variability and trend at five Atlantic Ocean tide gauges since 1900. Kolker and Hameed (2007) state that "debate has centred on the relative contribution of fresh water fluxes, thermal expansion and anomalies in Earth's rotation". They also note that variability in local Mean Sea Level from year-to-year is one or two orders of magnitude greater than the long-term trend, with the cause of the variability unknown. When they subtracted out factors such as the NOA from their analysis of the long-term rise, they found that the "residual" sea level rise was between 0.49±0.25 mm per year, and 0.93±0.39 mm per year. This residual rise could be due to rising global temperatures (Kolker and Hameed 2007).

In 2007, the Intergovernmental Panel on Climate Control (IPCC) noted that "Global average sea level rose at an average rate of 1.8 (1.3 to 2.3) mm per year over 1961 to 2003. The rate was faster over 1993 to 2003: approximately 3.1 (2.4 to 3.8) mm per year. Whether the faster rate for 1993 to 2003 reflects decadal variability or an increase in the longer-term trend is unclear." The IPCC is predicting a worldwide increase of 18 to 58 cm by 2100.

A study by Hu et al. (2009) found that moderate to high rates of ice melt from Greenland could cause sea levels off the northeast coast of North America to rise by 30 to 51 cm more than other coastal areas. They also found that oceans will not rise uniformly as the world warms, since ocean dynamics would push water in different directions (Hu et al. 2009).

More recently, Vermeer and Rahmstorf (2009) used a semi-empirical model to estimate sea-level rise over the next century based on emission scenarios from the 2007 IPCC assessment. They derived a relationship between historical global temperature and sea-level rise, and used this to obtain revised sea-level projections. This semi-empirical method implicitly accounts for the effects of the recent rapid glacial melt, and differs from physical, more explicit methods, that generally have much greater complexity but are limited because physical processes like glacial melt are still not fully understood.

According to Rahmstorf (2010), these new results have found wide recognition in the scientific community.

Scientists are generally cautious about predictions of sea-level change, in part because ice sheet dynamics are complex and not well understood. In addition, some studies indicate that inter-annual variability in sea level could be due in part to long-term atmospheric states like the North Atlantic Oscillation. From the studies referenced above, estimates of the rise globally over the next 100 years due to global warming alone are from 5 cm to as much as 190 cm.

However, over the time period of 2010 to 2050, the expected total rise has a central estimate of 45 cm and an upper limit of about 70 cm (based on a rate of 1.7 cm per year as per Vermeer and Rahmstorf (2009)).

The basis of design for calculating loads due to increased water depth from sea level rise and wave motion are accounted for in the safety factors used to determine minimum deck height and wave crest heights. An evaluation of design loads on the Hebron Platform due to the metocean environment will be conducted during the next stage of design (FEED) and will account for metocean uncertainties.

3.2.6.2 Waves

Waves are perhaps the most significant marine variable of interest to look at when examining climate change in the Grand Banks. A study by Wang and Swail (2001) looked at trends in extreme Hs based on a 40-year hindcast. They found statistically significant trends only in the winter months, and these were found to be connected with the North Atlantic Oscillation. If the period of study is extended back 100 years, no statistically significant trends were found. A later study by Wang et al. (2004) extended their results to an examination of wave heights in the North Atlantic under accepted climate change scenarios. They found that statistically significant increases in wave height were expected in the northeast North Atlantic (closer to Europe), but that negligible or negative increases were found in the vicinity of the Grand Banks.

Perrie et al. (2004) used high-resolution modelling on a current data set of winter storms, and then produced simulations of storms based on a climate change scenario for the period 2041 to 2060. They found that while there were fewer total storms in the climate change scenario, there were more numerous strong storms with larger waves, and fewer weaker storms with associated lower wave heights (Perrie et al. 2004). Another study by Lambert (2004) had very similar findings. While it did not explicitly examine wave heights, it found that while there were fewer cyclones in a warmer world, there were an increased number of intense events. One could infer from this that there would also be associated higher Hs. These results make sense, in that a warmer world would mean a decreased pole-equator temperature gradient, and less total energy available for storms. However, it is not clear what might be driving greater intensity of storms. One possibility would be more frequent

tropical storms, since presumably there would be a larger pool of warm water available to support tropical systems.

It should be noted that the Grand Banks would be more susceptible to tropical storms in a warmer climate. Typically storms die out when hitting colder ocean water south of Nova Scotia. In a warmer climate, they would be able to maintain intensity farther northward, and would likely be more intense on average as they track over the Grand Banks. This would suggest higher associated peak wave heights. Since the tropical hurricane season lasts from June until November, with a peak in August and September, one would expect to see an increase in peak wave heights during the summer months and also in late fall.

3.2.6.3 Sea Surface Temperatures

It is generally accepted that sea surface temperatures will increase by 1°C to 2°C over the next several decades if global warming continues. However, this could be negated to some extent over the Grand Banks, since the Labrador Current flows through the area. With increased glacial melt from Greenland, the Labrador Current would tend to maintain an abundant flow of cold water into the region.

3.2.6.4 Sea Ice and Icebergs

Since the early 2000s, the number of observed icebergs has increased in the North Atlantic Ocean (Rudkin et al. 2005). This may be a result of increased sea and air temperatures, but may also be a product of improved technologies for observing glacial sources. Should sea and air temperatures increase north of the Grand Banks, the number of icebergs entering the project area would likely increase initially due to increased calving of glaciers and ice islands. The size and presence of the icebergs would eventually decrease due to melt as the bergs drifted into the warmer waters. Similarly, the number of bergs could decrease as the lack of pack ice that helps carry and sustain the bergs on the Grand Banks would decrease, providing no insulation for the icebergs in the warmer waters.

The volume of iceberg production from the Greenland glaciers increases as the temperatures warm. Subsequently, the glacial acceleration results in thinning of the glaciers and leads to increased fracturing and the production of more icebergs, but they would be expected to have smaller drafts. However, the warmer sea water temperatures along the iceberg's drift path from the parent glacier to the Grand Banks increase the rate of iceberg destruction and reduces the arrival rate for icebergs at the Grand Banks. A competing effect is that years with substantive pack ice on the east coast of Canada tend to keep the sea water cool and thus allow more icebergs to reach the Grand Banks prior to melting. When this happened in 2008 and 2009, the Grand Banks iceberg population was still within the range of that observed in the past decades. Competing factors could affect the Grand Banks iceberg environment, but present data do not suggest a substantial departure from that experienced in the past two decades. A more detailed analysis can be found in McClintock et al. (2007).

Whether this effect would be cyclical or permanent, or if it will transpire at all, remains to be seen. There is currently no reliable way of predicting the future occurrence and movement of sea ice and icebergs.

3.2.6.5 Summary

In general, the science is inconclusive about what changes to the marine environment will be felt over the Grand Banks due to global warming. Climate simulations for the next century show almost no change in peak Hs for the western North Atlantic, consistent with recent trends in observed data. Other studies show fewer storms in general, but more numerous strong storms with attendant increased peak Hs. In a warmer world, more tropical storms can be expected to survive farther north, bringing with them higher waves during the tropical storm season. For sea level rise, there is good agreement that sea levels will continue to rise, but disagreement as to how much. Estimates range from less than 5 cm over the next 50 years to as much as 15 cm. Finally, there is considerable uncertainty as to the question of warming sea surface temperatures, since glacial melt north of Newfoundland would exert a cooling influence on the offshore waters.

Climate is naturally variable and can change over a range of time scales. Short-term meteorological variations are largely a consequence of the passage of synoptic scale weather systems: low pressure systems, high pressure systems, troughs and ridges. Energetics of these features varies seasonally in accordance with the changes in the strength of the mean tropical-polar temperature gradient. Long-term changes occur in response to small and large-scale changes of atmospheric circulation patterns. In the past, changes in Northern Hemisphere atmospheric circulation patterns were mainly the result of changes in the North Atlantic Oscillation. While the North Atlantic Oscillation still has an effect on climate patterns, there is a general consensus amongst the scientific community that greenhouse gas emissions have played a significant role in the climate during the last 50 years. However, the high degree of naturally experienced climate variation makes the identification of trends that are a direct result of climate change uncertain (Environment Canada 1997).

As the Operator, ExxonMobil does use risk management methods throughout the various aspects of its business, including facility design. The basis of design for calculating loads due to increased water depth from sea level rise and wave motion are accounted for in the safety factors used to determine minimum deck height and wave crest heights. An evaluation of design loads on the Hebron Platform, due to the metocean environment and associated uncertainties, will be conducted during FEED, and further refined during detailed design.

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4 EFFECTS ASSESSMENT METHODS

The methods used to assess potential environmental effects of the Hebron Project (the Project) are described in this Chapter.

4.1 Types of Environmental Effects

The types of effects considered in this Comprehensive Study Report (CSR) are:

- The environmental effects of the Project on the environment
- The effects of the environment on the Project
- Environmental effects are defined in Section 2(1) of the Canadian Environmental Assessment Act (CEAA) as:

  a) any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the Species at Risk Act,

  b) any effect of any change referred to in paragraph (a) on

     (i) health and socio-economic conditions,
     (ii) physical and cultural heritage,
     (iii) the current use of lands and resources for traditional purposes by aboriginal persons, or
     (iv) any structure, site or thing that is of historical, archaeological, paleontological or architectural significance, or

  c) any change to the project that may be caused by the environment, whether any such change or effect occurs within or outside Canada

The potential environmental effects of each Project phase have been evaluated for each of the selected Valued Ecosystem Components (VECs). The environmental effects analyses also include both direct and indirect effects. Cumulative environmental effects have been evaluated in accordance with CEAA and its guidance documentation (Hegmann et al. 1999). As required by the Development Plan Guidelines (C-NLOPB 2006) and CEAA, residual environmental effects, or those environmental effects remaining after the application of mitigation measures, are presented.

The analyses of the effects of the environment, particularly the physical environment, on the Project include the effects of oceanographic and climatic conditions, among other environmental factors, and the subsequent implications for Project design.

Socio-economic effects resulting from environmental effects are described herein.

4.2 Scope of the Environmental Assessment

The scope of the Hebron Project includes surveys (geophysical, geotechnical, geohazard and environmental), construction, installation, commissioning, development drilling, production, operations and maintenance and decommissioning of an offshore oil / gas production system and associated facilities.

4.2.1 Factors to be Considered

This CSR includes a consideration of the following factors, as prescribed by Section 16 of CEAA:

- Purpose of and need for the Project
- Alternatives to the Project
- Alternative means of carrying out the Project which are technically and economically feasible and the environmental effects of any such alternative means
- The environmental effects of the Project, including those due to malfunctions or accidents that may occur in connection with the Project and any cumulative environmental effects that are likely to result from the Project in combination with other projects or activities that have been or will be carried out, and the significance of these effects (the term "environmental effects" is defined in Section 2 of CEAA, and Section 137 of the Species at Risk Act (SARA))
- Measures, including contingency and compensation measures as appropriate, that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the Project
- The significance of adverse environmental effects following the employment of mitigative measures
- The need for, and the requirements of, any follow-up program in respect of the Project (refer to the Canadian Environmental Assessment Agency's (CEA Agency) "Operational Policy Statement" regarding Follow-up Programs (CEA Agency 2007a))
- The capacity of renewable resources that are likely to be significantly affected by the Project to meet the needs of the present and those of the future
- Report on consultations undertaken by ExxonMobil Canada Properties (EMCP) with interested parties who may be affected by the Project and comments that are received from interested parties and the general public respecting any of the matters described above

4.2.2 Scope of the Factors to be Considered

This CSR addresses the CEAA factors listed above, as well as the matters listed in the appropriate sections of the Development Plan Guidelines (C-NLOPB 2006), the Scoping Document (C-NLOPB 2009), and issues and concerns identified and documented by EMCP through public consultation, including consultation with regulators and key stakeholders.

With regard to the current use of land and resources by aboriginal persons, as per the definition of environmental effect, these factors were not considered in the environmental assessment. The Hebron study area and Project area have not historically been identified as those with Aboriginal use or title. There are no land claims before the Government of Canada or the Government of Newfoundland and Labrador for these areas. Based on this assessment, current use of land and resources by aboriginal persons was not considered in the CSR.

4.3 Environmental Assessment Methods

This section describes the methodological approach used in the environmental assessment and scoping for the Hebron Project. The methodological framework is based on Barnes et al. (2000) and guidance documents produced by the CEA Agency (1994a,b, 2007b). The following discussion provides an overview of the approach as it was applied to the Hebron Project.

4.3.1 Step 1 – Scoping Issues and Selecting Valued Ecosystem Components

To focus or "scope" an environmental assessment, it is standard practice to identify a concise list of those components of the environment that are "valued" (socially, economically, culturally and/or scientifically), and of interest when considering the potential environmental effects of a project. In this process, information from public, regulatory and stakeholder consultation is summarized and synthesized into a list of overall issues and concerns. The Scoping Document (C-NLOPB 2009) for the environmental assessment of the Hebron Project provides the scope of Project, the scope of the assessment and the factors to be considered in the assessment. It reflects the comprehensive public and regulatory consultation process and provides guidance for the scope of the environmental assessment.

The Hebron Project study team conducted public and stakeholder consultation in preparation of the CSR and Development Plan. A summary of the consultation process is provided in Chapter 5. Where those issues are related to the scope of the Project under environmental assessment, they have been addressed in this CSR. For the convenience of readers and reviewers, the location where each issue is addressed in the CSR is provided in Chapter 5.

Each VEC has been selected based on the issues that have been raised throughout the consultation process and as reflected in the Scoping Document and based on the professional experience of the study team. The selected VECs comprehensively reflect the issues, while providing a focus for the environmental assessment so that effects can be meaningfully evaluated. The VECs included in the assessment are as follows:

Air Quality

Air Quality has been selected as a VEC for the following reasons:

- Air quality has an intrinsic or natural value, in that it is needed to sustain life and maintain the health and well-being of humans, wildlife, vegetation and other biota
- If not properly managed, release of air contaminants to the atmosphere from the Project may be harmful to human health and other biological resources in the vicinity of the Project
- Greenhouse gas (GHG) emissions can accumulate in the atmosphere and are believed to be a major factor in climate change

Fish and Fish Habitat

Fish and Fish Habitat has been selected as a VEC for the following reasons:

- Provisions of the Fisheries Act pertaining to the harmful alteration, disruption or destruction of fish habitat require that environmental effects to fish and fish habitat be fully evaluated
- The potential for interaction with the Project
- Marine fish and fish habitat are ecologically, recreationally and commercially important

The Fish and Fish Habitat VEC includes marine fish, shellfish, benthos, plankton, water and sediment that are not considered at risk species by SARA or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). These components are intrinsically related to one another and together they allow a holistic approach to the assessment of potential effects in the marine environment.

Marine Birds

Marine Birds have been selected as a VEC for the following reasons:

- They are abundant in the Nearshore and Offshore Study Areas
- They are sensitive to oiling
- They are protected under the Migratory Birds Convention Act, 1994 (migratory birds)
- As high-level predators, marine birds can play an ecologically important role in indicating the health of the marine ecosystem

The Marine Birds VEC includes species of birds that typically use the nearshore / coastal marine and offshore environments that are not considered at risk species by SARA or COSEWIC. The groups considered under the Marine Birds VEC are waterfowl (geese and ducks), cormorants, fulmars and other shearwaters, storm-petrels, gannets, phalaropes and other shorebirds, larids (jaegers, skuas, gulls, and terns) and alcids (e.g., dovekie, murres, and puffins).

Marine Mammals and Sea Turtles

Marine Mammals and Sea Turtles have been selected as a VEC for the following reasons:

- Populations of marine mammals and some sea turtle species migrate to the Offshore Study Area primarily to forage for food
- The potential for interaction with Project activities
- As high-level predators, marine mammals and sea turtles play an ecologically important role by serving as indicators of changes in the marine ecosystem

The Marine Mammal and Sea Turtle VEC includes cetaceans (whales, dolphins, and porpoises), pinnipeds (seals), and sea turtles that are not considered at risk species by SARA or COSEWIC.

Species at Risk

Species at Risk (SAR) has been selected as a VEC for the following reasons:

- SAR and their habitat are legally protected under federal legislation (SARA) and/or have been assessed by COSEWIC
- Due to their nature, SAR can be more vulnerable to human-induced changes in their habitat or population levels and therefore require special consideration with respect to mitigation strategies
- Several federally-listed and/or COSEWIC-assessed marine SAR could potentially occur in the Study Areas

Commercial Fisheries

Commercial fisheries have been selected as a VEC due to its cultural and economic importance, and the potential for interactions with the Project.

Sensitive or Special Areas

Sensitive or Special Areas has been selected as a VEC primarily due to stakeholder and regulatory concerns about the vulnerability of sensitive or special areas to potential Project-related effects, including potential exposure to contaminants from operational discharges and accidental spills from the Project.

Sensitive or Special Areas are often associated with rare or unique marine habitat features, habitat that supports sensitive life stages of valued marine resources, and/or critical habitat for species of special conservation status. As per the Scoping Document (C-NLOPB 2009), Sensitive or Special Areas include:

- Important or essential habitat to support marine resources
- Areas identified through the Placentia Bay-Grand Banks Large Ocean Management Area Integrated Management Plan Initiative

In the nearshore, these Sensitive or Special Areas include capelin beaches (e.g., Bellevue Beach) and eelgrass. Offshore Sensitive or Special Areas

include the Northwest Atlantic Fisheries Organization (NAFO) proposed Southeast Shoal Vulnerable Marine Ecosystem (VME) and various canyon areas and seamount and knoll VMEs. In addition, ecologically and biologically significant areas identified by Fisheries and Oceans Canada (DFO) occur within the Hebron Offshore Study Area (i.e., Northeast Shelf and Slope; Virgin Rocks (immediately adjacent to the Hebron Offshore Study Area); Lily Canyon-Carson Canyon and Southeast Shoal and Tail of the Banks). These areas are described in Chapter 12. The Bonavista Cod Box is located outside of the Hebron Offshore Study Area and is therefore not considered.

4.3.2 Step 2 – Establishing Boundaries

An important aspect of an environmental assessment is determining boundaries, as they help focus the scope of the assessment and allow for a meaningful analysis of potential environmental effects associated with the Project. The setting of boundaries also aids in determining the most effective use of available study resources.

4.3.2.1 Spatial Boundaries

The spatial boundaries as described below have been defined based on predicted Project-environment interactions, modelling results and a consideration of VEC-specific boundaries, as per the CEA Agency Operational Statement (2003b). In accordance with the Scoping Document, the following spatial boundaries have been used in this CSR:

Nearshore

- Project Area: The marine area within Bull Arm in which all Project activities and works are to occur. It is defined by the marine areas of the Bull Arm property boundary (see Figure 4-1 and Figure 1-1 in Chapter 1)
- Affected Area: The area which could potentially be affected by Project works or activities within or beyond the Project Area. The Affected Area boundary varies with the component being considered (e.g., air emissions Affected Area and the fish and fish habitat Affected Area), the nature of the VEC and the sensitivity of different species within the VEC. The Affected Areas for several Project activities have been determined by modelling (see the following Supporting Documents: Noise (JASCO 2010) Drill Cuttings Deposition and Produced Water Dispersion (AMEC 2010) and Spill Modelling (ASA 2011a, 2011b))
- Study Area: The Nearshore Study Area (see Figure 4-1) has been defined by modelling Project-environment interactions, such as accidental events, and considers all Project-environment interactions. This is the area within which significance will be determined for nearshore activities and it represents a compilation of the various nearshore Affected Areas for all Project works and activities and VECs

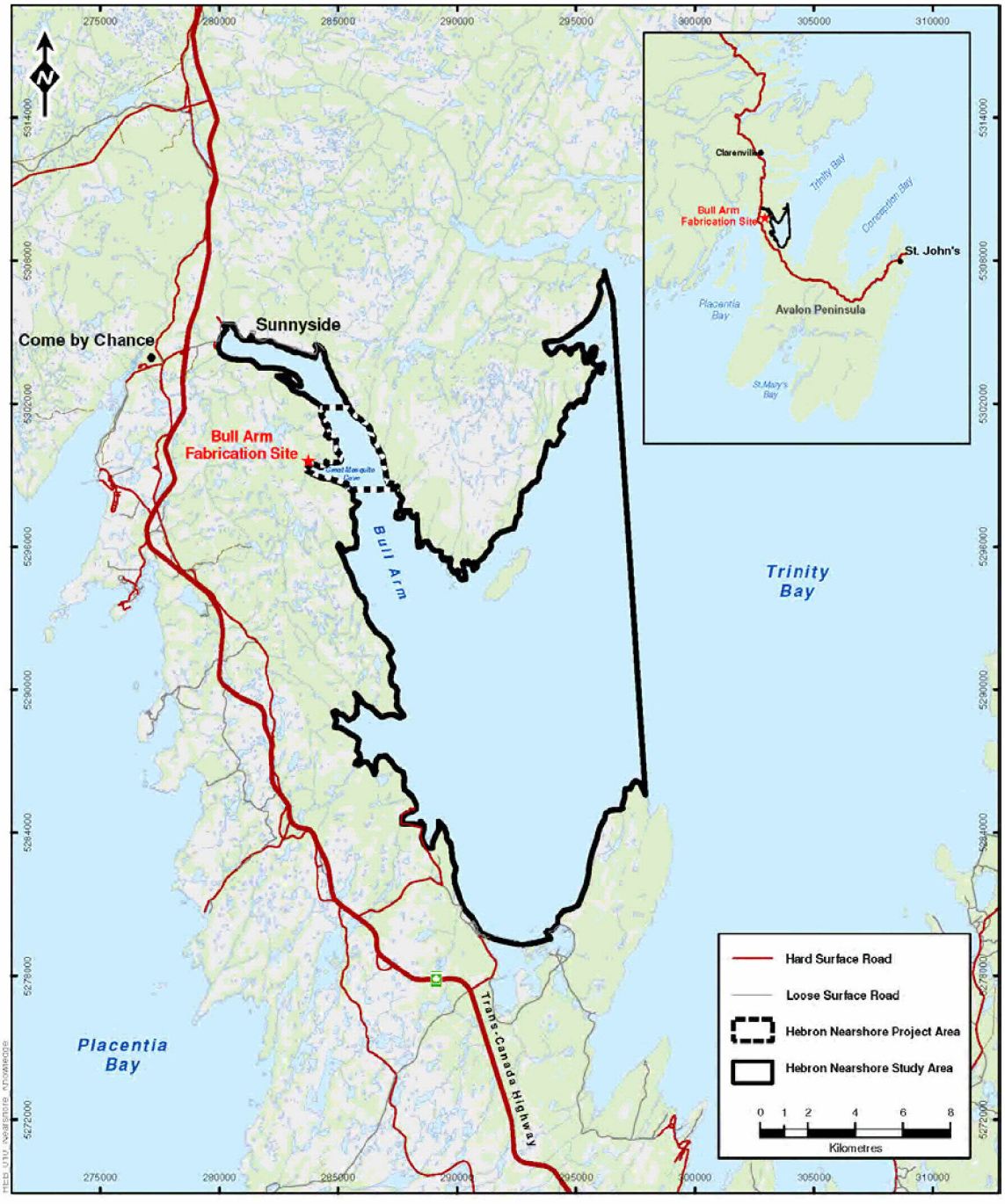

Figure 4-1 Nearshore Study and Project Areas

Offshore

- Project Area: The marine area within which all offshore Project works and activities are to occur (as defined in Chapter 2). The Offshore Project Area (see Figure 4-2 and Figure 1-2 in Chapter 1) is defined by the four Significant Discovery Licenses (SDLs) (Hebron SDL 1006, Hebron SDL 1007, Ben Nevis SDL 1009 and West Ben Nevis SDL 1010) and area required by the turning radius of seismic vessels

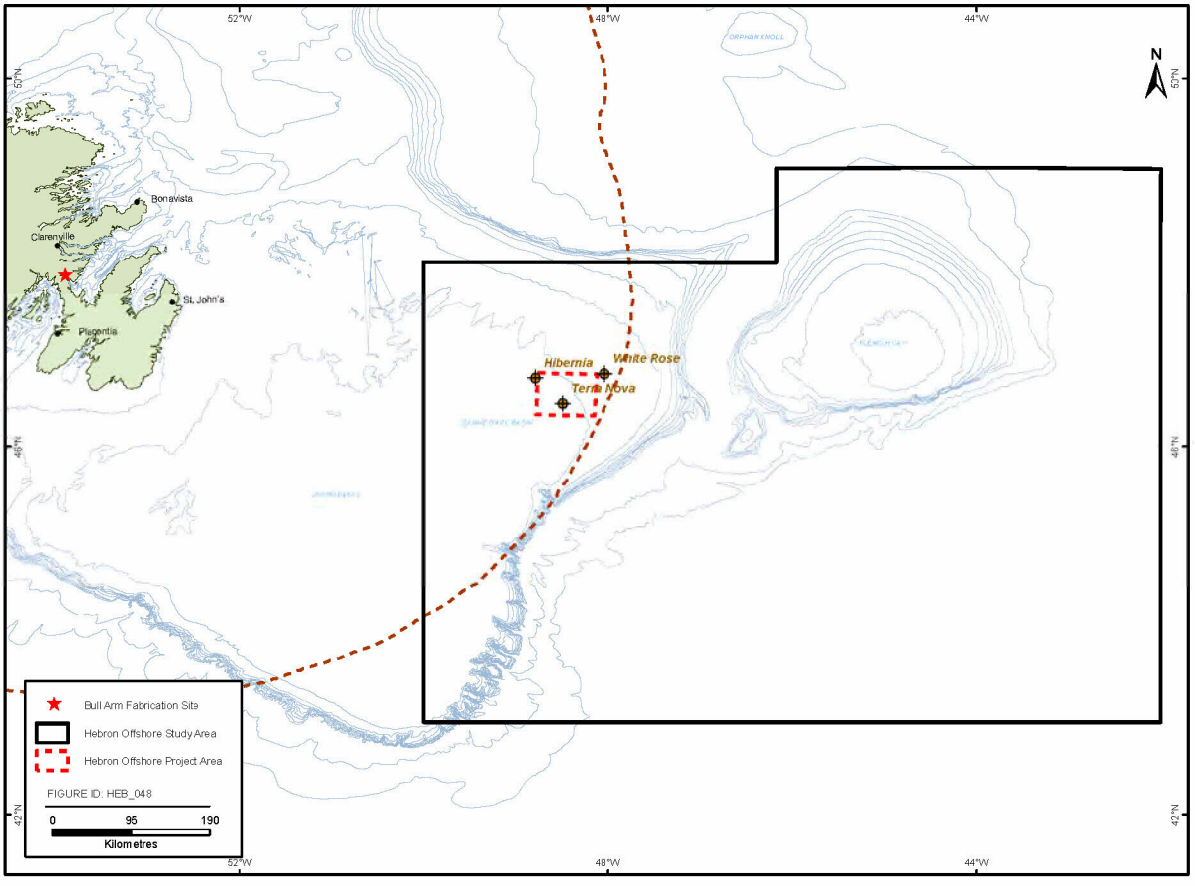

Figure 4-2 Offshore Study and Project Area

- Affected Area: The area which could potentially be affected by Project works or activities within or beyond the Project Area. The Affected Area boundary varies with the component being considered (e.g., drill cutting discharges Affected Area and air emissions Affected Area), the nature of the VEC and the sensitivity of different species within the VEC. The Affected Areas for several Project activities have been determined by modelling (AMEC 2010; ASA 2011a, 2011b; JASCO 2010; Stantec 2010b)
- Study Area: The Offshore Study Area (see Figure 4-2) has been defined by modelling Project-environment interactions, such as accidental events and emissions and discharges, and considers all Project-environment interactions. This is the area within which significance will be determined for offshore activities and it represents a compilation of the various offshore Affected Areas for all Project works and activities and VECs

4.3.2.2 Temporal Boundaries

The temporal boundaries of the environmental assessment reflect the construction period, the operating life of the Project, through to decommissioning and abandonment. The scheduling of physical works and activities associated with the Project have been considered in relation to the sensitive life cycle phases of the VECs. Chapter 2 provides a description of the activities that will occur during the Project phases.

Nearshore

Early works activities (e.g., re-establishment of bund wall, drydock construction, blasting / dredging) are scheduled to commence in the second quarter of 2011. The construction of the Gravity Base Structure (GBS) is scheduled to commence in the second quarter of 2012. GBS construction, Topsides fabrication and assembly, and commissioning activities will continue at Bull Arm until approximately the end of 2016.

Offshore

Construction activities may commence as early as 2013 to avail of potential synergies with other operations offshore. Site preparation / start-up, and drilling activities are scheduled to commence in 2016/17, but may commence as early as 2015. Production operations will continue through the approximate 30+ years of operational life for the Hebron field. Decommissioning and abandonment will take place at the end of production activities. Project activities, including field survey programs, may occur at any time of the year.

The potential timing of Project activities in the Offshore Project Area includes:

a) Offshore Surveys (geotechnical, geophysical, geohazard and environmental) from 2011 through the life of the Project
b) Offshore construction activities from 2013
c) Site preparation as early as 2015
d) Drilling and production beginning in 2016 or 2017 (or earlier) and continue through the life of the Project, estimated at 30 or more years. All production and drilling activities (either from the Hebron Platform or mobile offshore drilling unit (MODU)) and ancillary activities will occur year-round as required
e) Potential expansion opportunities - subsea tiebacks (excavated drill centres, subsea installation, MODU drilling, flow-line installation) may occur at any time of the year throughout Project life

The temporal scope is summarized in Table 4-1.

Table 4-1 Temporal Scope of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning/abandonment: after approximately 2046

4.3.2.3 Administrative Boundaries

Administrative boundaries are the boundaries associated with resource management or socio-cultural boundaries (e.g., NAFO Division and Unit

Areas designating fishing areas along Newfoundland and Labrador's coast and offshore area). Administrative boundaries are described for each VEC, as required.

4.3.3 Step 3 – Definition of Significance

Under CEAA, determining the significance of environmental effects is central to decision-making. Significance definitions are developed for each VEC to provide the threshold for the significance of residual adverse environmental effects. These definitions have been established using information obtained through issues scoping, available information on the status and characteristics of each VEC and the experience of study team members. Significance thresholds indicate at which point the VEC would experience environmental effects of sufficient geographic extent, magnitude, duration, frequency and/or reversibility to whereby its status or integrity is altered beyond an acceptable level even after application of the mitigation measures (each of these is described in more detail in Step 6 - Section 4.3.6).

Significance definitions for each of the VECs are provided below.

Air Quality: A significant adverse residual environmental effect is one that degrades the quality of the air such that the maximum Project-related ground-level concentration of the criteria air contaminants being assessed frequently exceeds stipulated air quality guidelines in the Nearshore or Offshore Study Area. Frequently is defined as once per week for 1-hour standards and once per month for 24-hour standards.

Fish and Fish Habitat: A significant adverse residual environmental effect is one that affects fish and/or fish habitat resulting in a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

For potential environmental effects on marine fish habitat, a significant adverse residual effect would be one that results in a harmful alteration, disruption or destruction of fish habitat that is so large and/or the fish and fish habitat is of such importance that it cannot be adequately compensated.

Commercial Fisheries: A significant adverse residual environmental effect has a measurable and sustained adverse effect on commercial fishing incomes.

Marine Birds: A significant adverse residual environmental effect is one that affects marine birds by causing a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

Marine Mammals and Sea Turtles: A significant adverse residual environmental effect is one that affects marine mammals or sea turtles by causing a decline in abundance or change in distribution of a population(s)

over more than one generation within the Nearshore and/or Offshore Study Area. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

Species at Risk: A significant, adverse residual environmental effect is one that, after application of feasible mitigation and consideration of reasonable Project alternatives:

- Will jeopardize the achievement of self-sustaining population objectives or recovery goals
- Is not consistent with applicable allowable harm assessments
- Will result in permanent loss of SAR critical habitat as defined in a recovery plan or an action strategy
- An incidental harm permit would not likely be issued

Sensitive or Special Areas: A significant adverse residual environmental effect is one that alters the valued habitat of the identified Sensitive or Special Areas physically, chemically or biologically, in quality or extent, to such a degree that there is a decline in abundance of key species or species at risk or a change in community structure, beyond which natural recruitment (reproduction and immigration from unaffected areas) would not return the population or community to its former level within several generations.

A population as considered above in the definitions of significance for each VEC are those individuals occurring within the Study Areas.

4.3.4 Step 4 – Description of Existing Environment

A key step in an environmental assessment is the characterization of the environmental conditions within which a project will occur. In this CSR, the existing environmental conditions for each VEC are presented, focussing on the Nearshore and Offshore Study Areas. Key data sources include results from sediment quality and fish surveys conducted by Chevron in 2002 and 2003, Environmental Effects Monitoring (EEM) programs conducted on the Grand Banks, primary literature, Newfoundland and Labrador offshore oil and gas environmental assessment reports and Environment Canada and DFO databases.

4.3.5 Step 5 – Identifying Project-VEC Interactions and Environmental Effects

To conduct an environmental assessment, it is necessary to understand how a project may affect the defined VECs by both direct and indirect means. The manner in which a project may affect the VECs is a function of the linkage, or pathway, from one to the other. The environmental effects of a project are a function of its activities, while the pathways are a function of several things, including project activities, ecological systems, and contaminant properties. Environmental effects and pathways have been identified and considered using the following criteria:

- Input from experts, stakeholders, and regulators

- Experience from previous environmental assessments, in particular environmental assessments for offshore oil development projects
- Primary scientific literature
- Results from EEM programs on the Grand Banks
- Analyses of modelling studies of discharges and accidental events

This step involved identifying VEC-specific environmental effects resulting from interactions with the Project, and a description of issues and concerns regarding key interactions. A Project activity-environmental effects interaction matrix is used for each VEC, as shown in Table 4-2. The "Effect" as presented in the table is specific to each VEC; an example of an "Effect" is "Change to Habitat Quantity".

Table 4-2 Example Potential Project-Valued Ecosystem Component Interactions Matrix

Potential Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Effect 1	Effect 2	Effect 3	Effect 4
Construction				
Nearshore Project Activities				
Presence of Safety Zones (Great Mosquito Cove Zone followed by a deepwater site Zone)				
Bund Wall Construction (e.g., sheet / pile driving, infilling)				
Inwater Blasting				
Dewater Drydock / Prep Drydock Area				
Concrete Production (floating batch plant)				
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site)				
Lighting				
Air Emissions				
Re-establish Moorings at Bull Arm deepwater site				
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)				
Removal of Bund Wall and Disposal (dredging / ocean disposal)				
Tow-out of GBS to Bull Arm deepwater site				
GBS Ballasting and De-ballasting (seawater only)				
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site				
Hook-up and Commissioning of Topsides				
Surveys (e.g., geophysical, geological, geotechnical, environmental, Remotely Operated Vehicle (ROV), diving)				
Platform Tow-out from deepwater site				
Offshore Construction / Installation				
Presence of Safety Zone				
Offshore Loading System (OLS) Installation and Testing				

Potential Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Effect 1	Effect 2	Effect 3	Effect 4
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines				
Installation of Temporary Moorings				
Platform Tow-out/Offshore Installation				
Underbase Grouting				
Possible Offshore Solid Ballasting				
Placement of Rock Scour Protection on Seafloor around Final Platform Location				
Hookup and Commissioning of Platform				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)				
Air Emissions				
Lighting				
Potential Expansion Opportunities				
Presence of Safety Zone				
Excavated Drill Centre Dredging and Spoils Disposal				
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation				
Hook-up and Commissioning of Drill Centres				
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)				
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures				
Lighting				
Maintenance Activities (e.g., diving, ROV)				
Air Emissions				
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)				
Chemical Use/Management/Storage (e.g., corrosion inhibitors, well treatment fluids)				
WBM Cuttings				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)				
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, Vertical Seismic Profile (VSP), geohazard, geological, geotechnical, environmental, ROV, diving)				
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill				

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Potential Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Effect 1	Effect 2	Effect 3	Effect 4
Centres				
Presence of Structures				
WBM and SBM Cuttings				
Chemical Use and Management (Blowout Preventer fluids, well treatment fluids, corrision inhibitors)				
Geophysical / Seismic Surveys				
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Hebron Platform and OLS Loading Points				
Lighting				
Plugging and Abandoning Wells				
Abandoning the OLS Pipeline				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / ROVs)				
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)				
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture				
Nearshore Spill (at Bull Arm Site)				
Failure or Spill from OLS				
Subsea Blowout				
Crude Oil Surface Spill				
Other Spills (fuel, chemicals, drilling muds or waste materials / debris from the drilling unit, GBS, Hebron Platform)				
Marine Vessel Incident (i.e., fuel spills)				
Collisions (involving Hebron Platform, vessel, and/or iceberg)				
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)				
Terra Nova Development (production)				
White Rose Oilfield Development and Expansions (drilling and production)				
Offshore Exploration Drilling Activity				
Offshore Exploration Seismic Activity				
Marine Transportation (nearshore and offshore)				
Commercial Fisheries (nearshore and offshore)				

Notes:

- The “Hook-up and Commissioning of Topsides” activity may result in discharges to the environment
- The “Geophysical / Seismic Surveys” may include the use of 2D, 3D, and/or 4D as required, geohazard / wellsite surveys, as well as VSP
- “OLS Offloading Lines” includes flow lines

For the purposes of the environmental assessment, the construction phase for the Project includes two sub-phases: nearshore construction (i.e., all activities at Bull Arm including removal of the bund wall); and offshore construction (i.e., Platform tow-out, installation, hook-up and commissioning). The operations and maintenance phase includes all activities occurring at the Platform. Decommissioning and abandonment will include decommissioning of the Hebron Platform at the offshore site. All activities associated with this Project will be conducted within the Project Areas. As required by CEAA and the Scoping Document (C-NLOPB 2009), the potential environmental effects of accidental events and cumulative environmental effects are also assessed. Potential accidental events, and other projects and activities that could result in potential environmental effects that act cumulatively with the Project are also identified in Table 4-2. Additional information on the assessment of cumulative environmental effects is provided in Section 4.3.7.

4.3.6 Step 6 – Environmental Effects Analysis and Mitigation

The next step in the environmental assessment process involves evaluating potential residual adverse environmental effects by Project phase. The evaluation of environmental effects, including cumulative environmental effects, included:

- The potential interaction between Project activities, for each Project phase, and their environmental effects in combination with those of other past, present and likely future projects
- The mitigation strategies applicable to each of the interactions
- Evaluation criteria for characterizing the nature and extent of the environmental effects

Environmental effects assessment matrices have been used to summarize the analysis of environmental effects, including cumulative environmental effects, by Project phase and include accidents, malfunctions and unplanned events (Table 4-3). This allows for a comprehensive analysis of all Project-VEC interactions. Supporting discussion in the accompanying text highlights particularly important relationships, data or assessment analyses results. Where appropriate (e.g., Air Quality), the effects of various Project activities have been assessed under one comprehensive Project activity (e.g., air emissions from vessels are assessed under Vessel Operations).

The concept of classifying environmental effects simply means determining whether they are adverse or positive. The following includes some of the key factors that must be considered in determining adverse environmental effects, as per the CEA Agency's guidance (1994b):

- Negative environmental effects on the health of biota
- Loss of rare or endangered species
- Reduced biological diversity
- Loss or avoidance of critical / productive habitat
- Habitat fragmentation or interruption of movement corridors and migration routes
- Transformation of natural landscapes

- Chemical discharge
- Adverse effects on human health
- Loss or detrimental change in current use of lands and resources for traditional purposes
- Foreclosure of future resource use or production
- Negative environmental effects on human health or well-being

Table 4-3 Example Environmental Effects Assessment Matrix (Construction)

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Activity 1							
Activity 2							
Activity 3							
Activity 4							
Activity 5							
Activity 6							

KEY

Magnitude:
1 = Low: <10 percent of the population or habitat in the Study Area will be affected.
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected.
3 = High: >25 percent of the population or habitat in the Study Area will be affected.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = <1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

Note: Sample key is typical for biological VECs and is provided for illustrative purposes only. The key will vary from VEC to VEC as appropriate

Mitigation includes environmental design, environmental protection strategies, environmental management systems, compensation and measures specific to the avoidance, reduction or control of potential adverse environmental effects on a particular VEC. As required by CEAA, these measures must be technically and economically feasible. In the case of positive environmental effects, enhancement opportunities need to be considered. Depending on the anticipated environmental effects, mitigation and enhancement strategies

have been optimized to reduce adverse environmental effects and enhance those that are positive. Therefore, the significance of an environmental effect is determined by taking the mitigative measures into consideration to determine the residual environmental effects.

The criteria used to characterize potential environmental effects for VECs are described below and are consistent with those outlined in CEAA guidance documents (the CEA Agency 1994a,b), in accordance with the Scoping Document. These criteria established the framework for the assessment of environmental effects.

- Nature: the ultimate long term trend of the environmental effect (e.g., positive, neutral or adverse)
- Magnitude: the amount or degree of change in a measurable parameter or variable relative to existing conditions
- Geographic Extent: the area over which the effect will occur
- Frequency: the number of times during the Project or a specific Project phase that an effect might occur (e.g., one time or multiple times)
- Duration: the period of time over which the effect will occur
- Reversibility: the likelihood that a VEC will recover from an environmental effect, including consideration of active management techniques (e.g., habitat reclamation works). This may be due to the removal of a Project component / activity or due to the ability of a VEC to recover or habituate. As well, reversibility is considered on a population level for biological VECs. Therefore, although an environmental effect like mortality is irreversible at the individual level, the environmental effect on the population may be reversible
- Ecological or Social Context: the general characteristics of the area in which the Project is located, as indicated by existing levels of human activity and associated disturbance

These criteria are defined and presented within the environmental effects analyses in Table 4-3.

- Level and Degree of Certainty of Knowledge: level of confidence in the knowledge that supports the prediction. The Level and Degree of Certainty of Knowledge is evaluated for the determination of significance, and is summarized in the Residual Environmental Effects table for each VEC (see Section 4.3.8 as an example)

4.3.7 Step 7 – Cumulative Environmental Effects

Past, present and likely future projects and activities that will be carried out and that could interact in combination with the Hebron Project are identified in Table 4-4. These projects have been characterized for consideration in the analysis of the contribution of the Hebron Project to cumulative environmental effects. Within-Project cumulative environmental effects have been assessed as part of the Project-specific environmental effects analysis. The extent that other past, present and future projects have been considered is determined based on the guidance documentation developed by the CEA Agency (Hegmann et al. 1999). The current activities (e.g., marine transportation and

commercial fisheries) and those future projects or activities that are reasonably likely to proceed (i.e., proceeding through regulatory approvals process) have been considered. The projects and activities described in Table 4-4 have been identified as having the potential to act in combination with the Hebron Project to cause cumulative environmental effects to one or more of the defined VECs.

Table 4-4 Past, Present and Likely Future Projects and Activities Considered in the Environmental Assessment

Project Name	Project/Activity Description
Projects	
Hibernia Development and the HSE Project	The Hibernia oil field is located approximately 35 km northwest of the Hebron Project location. The Hibernia platform, including a GBS with storage capacity for 1.3 million barrels of oil, has been in production since November 1997. An approximately 6 km^2 Safety Zone has been established in accordance with the Drilling and Production Guidelines and is around the Hibernia platform and the OLS, which is approximately 2 km east of the Platform. Activities associated with this field include drilling and production activities, three multi-function support and stand-by vessels, and three purpose-built shuttle tankers that transport the crude to the International-Matex Tank Terminal Transshipment Terminal at Whiffen Head or direct to market The HSE Project is located approximately 6 km from Hibernia and may include up to six drill centres that will be connected back to the existing Hibernia GBS. Each drill centre may include the drilling of up to 11 wells. The total approximate size of the Safety Zone to be established for HSE is 53 km^2, plus zones for each future flowline. Geotechnical surveys are scheduled to occur in 2010 and excavated drill centre excavation and subsea construction is scheduled from 2011 to 2012. Production is scheduled to commence in late 2012, with an anticipated Project life of 24 years
Terra Nova Development	The Terra Nova oil field is located approximately 9 km south of the Hebron Project location. Terra Nova has been in production since January 2002. The Terra Nova operation uses a floating production, storage and offloading (FPSO) facility that can store up to 960,000 barrels of oil. The Terra Nova Development includes four drill centres. Terra Nova completed the latest phase of its initial development drilling program in August 2007. A total of 34 distinct wellbores and sidetracks have been drilled to date Drilling operations resumed in 2009 for approximately six months. There have been 14 development wells drilled in the Graben area, 11 development wells in the East Flank area and one extended reach producer and an extended reach water injection well in the Far East Central area. The Terra Nova Field Safety Zone extends 9.26 km (5 nautical miles) from the FPSO and is recognized by International Maritime Organization and Transport Canada. Two shuttle tankers and two to four support vessels are associated with the Terra Nova Development
White Rose Oilfield Development and Expansions	The White Rose Development is located approximately 46 km northeast from the Hebron field. The project involves an FPSO vessel, with three drill centres (Northern, Central and Southern), and subsea flowlines tied-back to the FPSO. A total of 21 wells support the core White Rose Development. The White Rose Safety Zone (including proposed new drill centres) is approximately 95 km^2. The Safety Zone has been established in accordance with the Drilling and Production Regulations Husky is proposing to develop up to five additional drill centres, within the White Rose field and the southern North Amethyst field. The associated Safety Zone will be approximately 17 km^2. Excavated drill centre construction, including installation of sub-sea equipment, for the North Amethyst drill centre was completed in 2008. Development drilling began the fourth quarter of 2008 and first oil target is second quarter 2010. Activities associated with the White Rose and North Amethyst fields include drilling by MODU and production subsea equipment installation with tieback to the SeaRose FPSO. As of December 2009, three shuttle tankers and four to six supply vessels provide support services in the ice-free season. An additional five supply vessels may be in service during the ice season

<table>
<tr><th>Project Name</th><th>Project/Activity Description</th></tr>
<tr><td colspan="2">Activities</td></tr>
<tr><td>Offshore Oil Exploration Activities, including multi-year drilling and seismic programs</td><td>As of February 2010, there have been a total of 308 exploration, delineation and development / production wells drilled on the Grand Banks, including 104 exploration wells, 45 delineation wells and 159 development / production wells (C-NLOPB 2010a). As of April 2010, there were 46 SDLs and 24 Exploration Licenses (ELs) and eight production licenses active on the Grand Banks (C-NLOPB 2010b). According the C-NLOPB website, there are three proposed marine seismic programs and two proposed exploratory drilling programs on the Grand Banks. There is one seismic program proposed / ongoing in the Jeanne d'Arc Basis, one seismic program proposed/ongoing in the Laurentian Subbasin, and one seismic/drilling program proposed for the Sydney Basin. Off the coast of Labrador there are three seismic program proposed
The programs in the following table are proposed:
<table>
<tr><th>Proponent</th><th>Exploration Activity (e.g. drilling, seismic surveys)</th><th>Location</th><th>Timing</th><th>Comments</th></tr>
<tr><td>Statoil Canada</td><td>Maximum of 27 wells</td><td>Jeanne d'Arc basin
Flemish Pass</td><td>2008 to 2016</td><td>Single and/or dual side-track exploration and appraisal / delineation wells</td></tr>
<tr><td>Statoil Canada</td><td>2D, 3D, and potential 4D seismic program</td><td>Jeanne d'Arc Basin (in and near EL 1100 and 1101 and within the Terra Nova Field)</td><td>2008 to 2016</td><td></td></tr>
<tr><td>Suncor Energy</td><td>Maximum of 18 wells</td><td>Jeanne d'Arc Basin</td><td>2009 to 2017</td><td>Single and/or dual side-track exploration wells</td></tr>
<tr><td>Suncor Energy</td><td>Seismic Surveys</td><td>Jeanne d'Arc Basin</td><td>2007 to 2010</td><td></td></tr>
<tr><td>Husky Energy</td><td>Drilling</td><td>Jeanne d'Arc Basin</td><td>2008 to 2017</td><td>18 oil and gas targets; combination of vertical and deviated (twin) wells</td></tr>
<tr><td>ConocoPhilips</td><td>Seismic Survey</td><td>Laurentian Subbasin</td><td>2010 to 2013</td><td>2 exploration blocks 1085 / 1082</td></tr>
<tr><td>ExxonMobil</td><td>Geohazard Survey</td><td>SDL 1006, 1007, 1009, 1010</td><td>2010</td><td></td></tr>
</table></td></tr>
<tr><td>Marine Transportation and Vessel Traffic</td><td>Various marine transportation activities take place along the Atlantic coast, including tankers, cargo ships, supply vessels, cruise ships and other vessels both commercial and recreational. Marine transportation in Trinity Bay is predominantly comprised of fishing vessels</td></tr>
<tr><td>Commercial Fisheries</td><td>There is a considerable amount of commercial fishing activity on the Grand Banks and Flemish Cap. The Hebron Field does not overlap with any major fishing areas. There is a high concentration of fishing activity approximately 50 km to the southeast (within NAFO Unit Area 3L) (snow crab and scallop) and 50 km to the northeast (within NAFO Unit Area 3L) (snow crab). Snow crab fishing is also common along the proposed traffic routes between Hebron and the Avalon Peninsula. Commercial fishing is an activity in Bull Arm (and Trinity Bay). Commercial fisheries include herring, mackerel, capelin, cod, lobster and squid. A more detailed description of commercial fisheries is outlined in Chapter 8 of this CSR</td></tr>
</table>

Results of the marine environmental effects monitoring (EEM) program conducted at Bull Arm from August 1991 to November 1997 indicated that the construction activities associated with the Hibernia GBS did not affect the marine environment beyond acceptable levels (i.e., none of the null hypotheses developed for the marine EEM program were rejected) (Christian and Buchanan 1998).

Cumulative environmental effects have been assessed in an integrated manner for each VEC. In analyzing cumulative environmental effects within this integrated methodological framework, a number of key elements were essential for evaluating the contribution of Project-related environmental effects. The environmental effects analysis for the CSR included a consideration of the following questions, where they are applicable.

- Are there Project-related environmental effects that act in combination with other effects to result in cumulative environmental effects
- Do identified Project-related environmental effects overlap with (i.e., act in combination with) those of other past and/or present projects? This can be established through characterizing the existing baseline conditions of the VEC, and then reflecting the overlapping cumulative environmental effects with those of past, present and/or future projects
- What is the contribution of the Project to the overlapping cumulative environmental effects of past and/or present projects
- Do the combined Project and cumulative environmental effects of past and/or present projects overlap with those of any likely future projects and/or activities that will be carried out

Historical trends for VECs (i.e., fish and shellfish, marine birds, marine mammals and sea turtles) are described to help characterize past and current population trends. Temporal and spatial boundaries are established for the cumulative environmental effects assessment for each of the VECs. In some cases, cumulative environmental effects assessment boundaries may vary from those defined for Project-specific environmental effects. The cumulative environmental effects assessment included explicit indication of other projects and activities that may contribute to cumulative environmental effects for that VEC, and mitigation measures that EMCP proposes to reduce the Project's contribution to cumulative environmental effects. The proposed mitigation measures are outlined in the appropriate VEC analysis sections.

4.3.8 Step 8 – Determination of Significance

Analyzing and predicting the significance of environmental effects, including cumulative environmental effects, encompasses the following:

- Determining the significance of residual adverse environmental effects, for each Project phase and for the Project overall
- For any predicted significant adverse environmental effect, determining the capacity of renewable resources (e.g., fish species associated with the commercial fishery), that are likely to be significantly affected, to meet the needs of the present and those of the future and determining the probability of occurrence

- Establishing the level of confidence for predictions
- Estimating the probability of occurrence

At the completion of the environmental effects evaluation, the residual adverse environmental effects are assigned an overall rating of significance for each Project phase (e.g., construction, operation and maintenance, decommissioning and abandonment, and accidents, and malfunctions and unplanned events). The significance rating for each Project phase is presented in a residual environmental effects summary table. An example of this is provided in Table 4-5.

Table 4-5 Example Residual Environmental Effects Summary Matrix

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]			
Operation and Maintenance			
Decommissioning and Abandonment[C]			
Accidents, Malfunctions and Unplanned Events			
Cumulative Environmental Effects			

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect
P = Positive Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform
C Includes decommissioning and abandonment of the GBS and offshore site

An overall rating of “significant” or “not significant” has been assigned for adverse environmental effects within each Project phase on a VEC-by-VEC basis. The rating of significance was determined by applying the definition of significance to the aggregate of Project-related environmental effects. The significance criteria were considered and applied for each VEC. Significance definitions are provided for residual environmental effects (i.e., the environmental effect remaining after the application of mitigation or effects management measures) and are VEC-specific. Significant residual environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the VEC, whereby its status or integrity is altered beyond an acceptable level even after application of the mitigation measures. The thresholds developed for this assessment are based on guidance from the CEA Agency, applicable regulatory standards and requirements, previous environmental assessments, and the professional experience of the Hebron

Project study team. The text accompanying each section provides a summary of the cumulative environmental effects analysis, with a significance determination for adverse cumulative environmental effects.

4.3.9 Step 9 – Evaluating the Need for Follow-up

A follow-up program, as defined in CEAA, is a program that verifies the accuracy of the environmental assessment of a project, and/or determines the effectiveness of any measures taken to mitigate the adverse environmental effects of the project.

A follow-up program will be developed for the Hebron Project. The elements of the program will be developed through consideration of each VEC; where appropriate or warranted, follow-up measures will be recommended. In accordance with the requirements of a follow-up program, actions will be proposed for those cases where the accuracy of the environmental effects analysis for a VEC should be verified, and/or where the effectiveness of mitigation measures should be determined. The results of Steps 1 through 5 will help focus the Project on important interactions in the development of follow-up programs.

In addition to follow-up programs pursuant to requirements of CEAA, EMCP will also evaluate the need for monitoring pursuant to other statutes, and principles of EMCP environmental management.

4.4 Determining the Effects of the Environment on the Project

The effects of the environment on the Project have also been taken into consideration. Details of the Project description were reviewed for interactions with the natural environment, including wind, waves and ice. Project plans and activities have been designed to reflect the limitations imposed by the natural environment. An example of a table summarizing the environmental effects of the environment on the Project is presented in Table 4-6.

Table 4-6 Environmental Effects of the Environment on the Project

Marine Environmental Event	Mitigation
Nearshore Events	
Wind / Waves – ROV operations	
Wind / Waves – barge, tug or support vessel operations	
Wind / Waves – access to GBS at deepwater site	
Waves – bund wall failure	
Waves / Currents – mooring failure	
Storm surges / high water levels - flooding and damage to drydock / bund wall	
Sea Temperature - contributor to vessel and structure icing potential	
Sea Temperature - exposure to personnel	

Table 4-6 Environmental Effects of the Environment on the Project (continued)

Marine Environmental Event	Mitigation
Offshore Events	
Tsunamis – OLS / Tanker disruption (high currents)	
Wind / Waves – tug or support vessel operations (e.g., ice, spill response, Search and Rescue)	
Waves / Low water level – affecting Hebron Platform installation on seabed	
Currents – OLS / Tanker disruption	
Sea Temperature - contributor to vessel and structure icing potential	
Sea Temperature - exposure to personnel	
Seaonally-occurring Sea Ice and Icebergs	
Climate Change – Sea level rise	
Climate Change – Waves	
Climate Change - Sea Surface Temperature	
Climate Change - Sea Ice and Icebergs	

A significant effect of the environment on the Project is one that:

- Harms Project personnel or the public
- Results in a substantial delay in construction (e.g., more than one season) or shutdown of operations
- Damages infrastructure and compromises public safety
- Damages infrastructure to the extent that repair is not economically or technically feasible

While effects of the environment on the Project can in turn result in effects on the environment (e.g., an oil spill could result from weather or ice conditions), this is fully addressed in the environmental assessment for each of the VECs. For instance, in the case of an accidental event, the worst case scenario event, regardless of the cause, has been assessed for each VEC. The effects of the environment on the Project are assessed in Chapter 13.

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5 CONSULTATION

The Canadian Environmental Assessment Act (CEAA) requires that public consultation be conducted during a comprehensive study-level environmental assessment. The CEAA requires that public consultation be conducted at three points during a comprehensive study:

- During the preparation of the Scoping Document (subsection 21(1))
- During the conduct of the comprehensive study (Section 21.2)
- During a review of the completed Comprehensive Study Report (CSR) prior to the Minister's issuance of an environmental assessment decision statement (section 22)

The Scoping Document was made available by the Responsible Authorities (RAs) for public review and comment, as per subsection 21(1) of CEAA, for the period from April 22 to May 22, 2009. A public notice was placed on the Registry internet site to initiate the public comment period. The Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), on behalf of the RAs, invited the public to comment on the draft Scoping Document for the Hebron Development Project. Also, a notice was posted on the C-NLOPB web site and the draft Scoping Document and Project Description were made available electronically on the C-NLOPB website; hard copies were available from the C-NLOPB upon request.

Notices were also placed in the following local newspapers:

- The Telegram – April 25, 2009
- The Western Star – April 25, 2009
- The Advertiser – April 27, 2009
- The Gulf News – April 27, 2009
- The Labradorian – April 27, 2009
- The Packet – April 30, 2009
- The Gander Beacon – April 30, 2009

Comments were requested to be provided, either electronically or via post, by May 22, 2009. There were no comments received in response to the public notice.

A consultation program to satisfy the requirements of Section 21.2 of CEAA has been designed and carried out by ExxonMobil Canada Properties (EMCP). Questions and issues raised by stakeholders throughout the consultations and are addressed in this CSR.

ECMP recognizes the importance of communications with federal, provincial and municipal regulatory agencies, stakeholders, and the public and accordingly has conducted an extensive public and stakeholder consultation program associated with the Project. The program focused primarily on the geographic regions most likely to be affected by the Project, including the Isthmus region of Newfoundland, Marystown, and St. John's. However, a wider audience was reached through meetings in other communities such as

Corner Brook. The consultation program during the preparation of the CSR involved:

- Reviewing the environmental assessment documents prepared for previous Newfoundland and Labrador offshore oil and gas developments especially the more recent White Rose and Hibernia South Extension
- Reviewing issues raised during consultations held for the White Rose, Terra Nova and Hibernia developments
- Consulting community members, fishers, businesses and organizations, women's groups, environmental non-governmental organizations (ENGOs), youth groups and the general public (key informant workshops, open houses, meetings / presentations)
- Meetings with government departments and agencies
- Open houses
- Media tracking
- Distributing Project information through traditional and electronic media
- Establishing a Project website (www.hebronproject.com)

An important component of the consultation program was the recording of issues and comments raised at meetings and events. Meetings, events, media briefings, and presentations were recorded in an issues tracking database, along with issues or comments raised. Additionally, issues raised in the media and submitted through the website were also recorded in the issues tracking database.

A detailed report of the issues scoping and stakeholder consultation program is provided in the Hebron Project Public Consultation Report (Appendix A). This chapter provides a summary of the consultation program for the CSR and lists observations, questions, comments, issues, and concerns identified through the program.

Consultations conducted to date during the preparation of the comprehensive study are detailed below. EMCP will continue open dialogue with any stakeholders with questions or concerns. Ongoing meetings are planned with the fishing industry and non-governmental organizations.

The Hebron study area and Project area have not historically been identified as those with Aboriginal use or title. There are no land claims before the Government of Canada or the Government of Newfoundland and Labrador for these areas. Therefore, based on this assessment, EMCP did not undertake consultations with Aboriginal persons.

As per Section 22 of CEAA, the Agency will invite the public to comment on the CSR prior to the Minister of the Environment making a final environmental assessment decision. The Minister of the Environment may request additional information or require that public concerns be addressed further before issuing the environmental assessment decision statement. Once the Minister of the Environment issues the decision statement, the Project will be referred back to the RAs for appropriate action.

5.1 Public Consultation

The Hebron Project study team drafted a consultation plan to engage the public and stakeholder groups, as a mechanism for sharing Project information, answering questions, and recording all comments and issues identified by participants. During preparation of the CSR, the consultation program involved eight events, as listed in Table 5-1. A detailed description of these events, as well as other consultations undertaken by the Project study team in support of the Development Plan, Socio-economic Impact Statement and Benefits Plan is included in Appendix A.

Table 5-1 Consultation Events Held in Support of the Comprehensive Study Report

Event	Date and Location	Number of Attendees
One Ocean Workshop	February 2009, St. John's	100
Bull Arm Area Fishers Meeting Representatives from: • Local fisher community • One Ocean • Fish, Food and Allied Workers (FFAW) Union	12 August 2009, Bellevue	9
ENGO Workshop Representatives from: • Sierra Club • Natural History Society • Newfoundland and Labrador Environmental Association • Alder Institute • Canadian Parks and Wilderness Society • Northeast Avalon Atlantic Coastal Action Program (ACAP) • Whale Release and Stranding • Newfoundland and Labrador Environmental Network	11 September 2009, St. John's	6 *Note: There were attendees who represented more than one ENGO
ENGO Follow-up Meeting Representatives from: • Northeast Avalon ACAP • Canadian Parks and Wilderness Society • Natural History Society	27 January 2010	3
Offshore Fishers Workshop Representatives from: • FFAW Union • One Ocean • Offshore Fishers	03 December 2009, St. John's	12
Open Houses – Clarenville	14 September 2009, Clarenville	37
Open Houses – Marystown	15 September 2009, Marystown	29
Open Houses – St. John's	17 September 2009, St. John's	117
Open Houses – Corner Brook	21 September 2009, Corner Brook	39

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Directed stakeholder meetings were held with fishers from the Bull Arm area and the offshore sector, and with the local ENGO community (see Sections 5.2 and 5.3). At these sessions an overview of the Project was presented, followed by a general discussion where the parties asked questions, as well as raised comments and concerns.

The Open Houses included two sessions per community, one from 2 to 4 pm and the second from 7 to 9 pm. Attendance was open to all members of the public with a total of 222 people attending. The open houses provided information about the Project through a presentation and display boards, and provided an opportunity for the general public to speak directly with the senior Hebron Project Management Team to voice their interests or concerns.

Comments raised during these meetings and workshops related to matters addressed in the CSR are summarized in Table 5-2; which also indicates the section of the CSR where each issue or concern is addressed.

Table 5-2 Comments Related to the Environment

Comment	CSR Section Where Comment / Concern is Addressed
Accidental Events	
Include oil / chemical spills associated with tanker traffic	Section 2.9.5
Include chronic small oil / chemical spills in modelling and predictions	Sections 14.1.3, 14.2, 14.3
Include and specify oil spill data from Newfoundland and Labrador	Sections 14.1, 14.2, 14.3
Effects and probability of blowouts	Sections 7.5.4, 8.5.3, 9.5.4, 10.5.4, 11.4.1.4, 11.4.3, 11.5.3, 11.6.3, 12.5.1, 14.1.1
Probability of impact from icebergs and modelling scenarios used	Sections 2.9, 3.1.4, 3.2.3, 13.3, 13.4, 14.4, 14.6, 17.1
Birds	
Effects of flaring on sea birds	Section 9.5.2
Effects of chronic small oil spills on sea birds	Section 9.5.4
Monitoring programs for sea birds	Section 9.5.7
Commercial Fisheries	
Need to time blasting to prevent effects on migrating fish populations	Sections 8.4.1, 8.5.1, 8.5.4
Concerns regarding local crab populations near the deepwater mooring site if any dredging or dumping were to take place	Sections 8.4.1, 8.5.1, 8.5.4
Concern that nearshore fishers would be prohibited from fishing grounds in Bull Arm, specifically near the deepwater site	Sections 8.4.1, 8.5.1, 8.5.4
Concern that activities and additional vessel traffic asscociated with Gravity Base Structure (GBS) construction will disrupt harvesting operations	Sections 8.4.1, 8.5.1, 8.5.4
Effects of construction-related noise and lights on catchability	Sections 8.4.1, 8.5.1, 8.5.4
Concern related to loss and damage to fishing gear	Section 8.4.1
Concern that offshore fishing grounds will be lost due to additional safety zones and exclusion zones	Section 8.4.1
Effects of on-going oil and gas exploration and production on the Grand Banks on future fisheries	Section 8.4.1
Endangered or Special Status Species	
Effects of planned discharges on marine life and sea birds	Sections 11.4.2, 11.6.2

Comment	CSR Section Where Comment / Concern is Addressed
Effects of chronic small oil / chemical spills on marine life and sea birds	Sections 11.4.3, 11.6.3
Effects of blowouts on marine life and sea birds	Section 11.4.3, 11.6.3
Environmental Assessment / Development Application	
Inclusion of tanker traffic associated with the Project in the assessment	Section 2.9.5
Incorporate comments from previous offshore assessments	CSR (general)
Environmental Management	
Local fishers should be consulted in regard to monitoring programs for fish and fish habitat	Section 8.5.1
Fish and Fish Habitat	
Effects of chronic small oil / chemical spills on marine life	Section 7.5.4
Effects of dredging in Bull Arm on water quality	Section 7.5.1.2
Effects of blasting on pelagic fish species (herring, mackeral, capelin)	Section 7.5.4
Effects of oil spill on herring spawning grounds in Bull Arm	Section 7.5.4, 12.5.1.1
Marine Mammals	
Effects of blasting on marine mammals	Section 10.5.1
Monitoring	
Provide public access to 24-hour monitoring raw data for produced water and other waste streams	Chapter 15
Provide public access to EEM raw data	Chapter 15
Monitoring programs for fish and fish habitat	Section 7.5.7
Public Involvement	
Direct communication between EMCP and the public needs to be on-going	Section 5.1
Important to communicate the results of the CSR and Socio-economic Impact Statement to the public	Section 5.1
Technical / Project Description	
Will the GBS have an ice wall? Will the GBS be built to withstand impact from an iceberg?	Sections 2.6, 2.7, 2.8.2
Will there be underwater blasting for creation of the bund wall at Bull Arm?	Section 2.8.1
What is the size of the drydock in Bull Arm?	Section 2.8.1
Will the production platform be able to produce natural gas in addition to oil?	Section 2.11
Quantify amount of flaring	Sections 2.9, 2.6.2.2, 6.3.2
Does the Project include pre-drilling of wells offshore?	Section 2.8.6
What is the transportation process of oil to market?	Section 2.9.5
What are the transportation methods for drilling muds and drill cuttings to and from the offshore site?	Section 2.9
Where will oil well fillers (drill muds and cuttings) originate from?	Section 2.9.5
Waste Management	
Concern regarding floating debris/waste from the deepwater construction site	Section 16.4.3.1
Waste from the construction sites may exceed capacity of local waste management sites	Section 16.4.3.1

The main message heard throughout the Open Houses was that the majority of participants are supportive of the Project and want to see it proceed in a manner that is environmentally sound and that provides the maximum benefit, especially to those communities adjacent to existing construction sites, such as Clarenville and Marystown.

Overall, issues raised during the consultation program were primarily related to industrial benefits, employment, the development concept, and construction and operational matters. These will be addressed. A comprehensive list of all issues raised during the consultation program is available in Appendix A.

5.2 Environmental Non-Governmental Organization Consultations

This section describes and summarizes the consultations held by EMCP with the ENGO community in Newfoundland and Labrador. As described above, specific comments raised and where they are addressed in the CSR are detailed in Table 5-2.

5.2.1 Consultation Approach

A consultation workshop with the ENGO community was held at the Hebron offices in St. John's in September 2009. The purpose of this workshop was to provide Project information to the ENGO representatives, answer any questions about the Project, and to document their concerns.

Invitations were issued to nine ENGOs: the Alder Institute, Canadian Parks and Wilderness Society (CPAWS), Natural History Society, Newfoundland and Labrador Environmental Association, Newfoundland and Labrador Environmental Network, Northeast Avalon Atlantic Coastal Action Program (ACAP), Sierra Club, Whale Stranding and Release Group, and World Wildlife Fund, of which eight attended. A Project Description was provided to each participant and Project design, activities, and schedule were reviewed in a PowerPoint presentation and discussed in detail. Participants were encouraged to ask questions and voice concerns.

At the conclusion of the Workshop participants were invited to contact the Project study team with any additional questions or concerns they may have. A follow-up meeting with representatives of ACAP, CPAWS and Natural History Society was held in January 2010. This meeting was held in response to letters received by EMCP from ACAP and CPAWS posing several questions regarding details of the Project Description. EMCP provided a brief update on the status of the Project and the environmental assessment process. The meeting then proceeded to address the questions posed in the letters including transportation of oil and drilling muds, the discharge of produced water, the origin of well fillers and mud compounds, and the availability of data from Environmental Effects Monitoring (EEM) programs.

5.2.2 Issues

During the workshop, participants raised some issues and questions related to the Hebron Project. However the main focus of discussion was regarding ongoing issues related to the offshore oil and gas industry in Newfoundland and Labrador and ways the Hebron Project will address these issues for their operations.

During discussion of construction activities at Bull Arm the main concern voiced was in regard to blasting. During construction of the Hibernia Gravity Base Structure (GBS), there was an association between whale strandings in Bull Arm and blasting at the site. It was noted that standard measures such as bubble screens will help mitigate this concern during construction of the Hebron GBS, and that blasting should be timed to avoid presence of whales.

When discussing the operations phase of the Project, much of the discussion was focused on issues with the existing offshore facilities, and how the Hebron Team could avoid or minimize similar problems. This included issues related to small / chronic oil spills, access to and transparency of environmental monitoring data, impacts of flaring and spills on marine birds, and concerns related to offshore discharges (drill cuttings / muds, produced water, oil spills).

Participants also indicated that tanker traffic, and any accidental oil or fuel spills associated with shipment of product to market, be included as part of the Project for the purposes of environmental assessment.

Specific issues and concerns raised during consultations and within the scope of the Project are described below and have been included in Table 5-2. These are further discussed in Appendix A.

- Underwater blasting: Participants voiced concerns that mitigations be put in place to protect marine mammals in the event of underwater blasting in Great Mosquito Cove during construction. During construction of the Hibernia GBS, there was an association between blasting at the site and whale strandings in Bull Arm. They stated that if blasting is required, standard mitigations such as bubble screens need to be used, and any blasting should be timed to avoid the presence of marine mammals.
- Flaring: Representatives stated concerns regarding the amount of flaring observed at other offshore installations as it is an attraction for sea birds, altering their habitat, possibly resulting in mortality. Although no flaring would be their preference, participants requested that flaring be minimized, especially during the night.
- Oil spills and blowouts: There was concern that small / chronic spills and sheens around production platforms need to receive more attention during environmental assessment. It was stated that the anticipated number of spills in past assessments have not included these chronic spills and the numbers of predicted spills have been far exceeded. It was also requested that the environmental assessment include spill data from Newfoundland and Labrador and not use global statistics only. In addition to accidental oil spills, participants were concerned about the likelihood of a blowout and potential impacts on marine birds. Participants also asked

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if the pre-drilling option would increase the risk for blowouts prior to installation.

- Offshore discharges: Participants were concerned about the planned discharge of produced water and would like to see zero use of the marine environment for waste treatment and disposal. However, participants were pleased to hear that drill cuttings and muds will be re-injected.
- Iceberg impacts and ice management: Participants raised concerns regarding the environmental consequences if the GBS was impacted by an iceberg. They stated that the GBS needs to be built to withstand the impacts of icebergs and sea ice, and designed with climate change in mind.

Each of these concerns were discussed at the meetings and/or have been addressed in specific sections of the CSR (refer to Table 5-2).

5.3 Fishing Industry Consultations

This section describes and summarizes the Project consultations with the nearshore and offshore fish harvesting sectors. Chapter 8 (Commercial Fisheries) presents information about these fisheries, incorporating details about local fish harvesting practices gathered from these consultations (mainly pertaining to the Nearshore Study Area). Assessment of the effects of the Project on fisheries, including the issues raised during the consultations and the means and mechanisms identified to mitigate potential effects are presented in Chapter 8.

Prior to the start of the Hebron consultation workshops, EMCP participated in a fishers conference held by One Ocean in February 2009. One Ocean is a liaison organization to facilitate communication between the fishing and oil and gas industries in Newfoundland and Labrador. An overview of the Project was presented and some concerns were raised by attendees regarding potential effects to commercial fisheries. These have been included in Table 5-2. Additional details regarding consultation with the fishing industry is provided in Appendix A.

5.3.1 Nearshore Study Area

5.3.1.1 Consultation Approach

Consultations were conducted with fishers and Fisher Committees based in the seven homeports within the Nearshore Study Area: Sunnyside, Chance Cove, Bellevue, Thornlea, Norman's Cove, Long Cove and Chapel Arm. These communities maintain a Fisher Committee structure established by the Fish, Food and Allied Workers (FFAW) Union and fisher representatives in the 1980s. These elected, community-level committees (four in the Study Area) were established to represent fishers in a particular area or community. Committees usually have four or five members, including a chairperson.

Representatives from EMCP's consulting team met with each committee during June and July 2009. A Project Description was provided to each

group, and project activities planned for the Bull Arm area were reviewed and discussed in detail. Fishers asked questions about the Project, noted their concerns and issues, discussed potential effects on their activities, and suggested potential mitigative measures.

A joint meeting with Fisher Committee representatives was held on August 12, 2009, to introduce the EMCP Project study team, to present information about the Hebron Project, and to review and discuss specific Project activities planned for the Bull Arm construction site. Representatives of the FFAW and One Ocean, a liaison organization for the fishing and oil and gas industries in Newfoundland and Labrador, also attended the meeting. Following a presentation by EMCP representatives, there was a general discussion where fishers asked questions, raised concerns, and shared lessons learned from their experiences during the Hibernia GBS construction.

5.3.1.2 Issues

Many of the fishers, having had previous experience with the Hibernia GBS construction project, shared their knowledge and also expressed concerns regarding the Hebron GBS construction activities.

Although proposed Hebron construction activities at Bull Arm will be similar to those during the Hibernia Project (both are GBS construction projects), fisheries representatives stated that the potential economic effects on their harvesting operations might be different from those associated with the Hibernia operations. For example, they stated that fishing patterns and harvesting locations have changed greatly since construction of the Hibernia GBS in the 1990s. In the early 1990s, the Trinity Bay crab fishery was in its infancy; today, it is the most economically important species for all enterprises. Concern regarding the interference of Project activities with this particular fishery was expressed by fishers.

Another difference is the fall fisheries for two key pelagic species: mackerel and herring. These fisheries are a much more important economic component of the local fishery than they were 18 years ago. Pelagic harvesting activities occur throughout the bottom of Trinity Bay, particularly around the shoreline of Tickle Bay from Tickle Harbour Point into Bull Arm. Many of the vessels larger than 40-feet in length have come to rely on this late season income from pelagic species to top up their annual fishing income. Given these factors, fishers are very concerned about any possible effects on either of these two fisheries.

Fishers also reported that improvements in harvesting techniques, new technology, and better gear have improved their ability to identify, locate and harvest fisheries resources in their area. They stated that they have a better knowledge and understanding of their fisheries and better information about their fishing grounds. New fish-finding systems allow them to track fish and to time their harvest in order to maximize their catches. Improvements in the design of purse seines allow vessel operators to fish mackerel very close to any shoreline infrastructure (e.g., the construction wharf in Great Mosquito Cove). Today's fishers are more aware of where the best fishing grounds

are, and they have a better understanding of how those harvesting locations could potentially be affected by marine construction activities.

Fishers indicated that, owing to the structural changes that have taken place in the Nearshore Study Area fisheries since the Hibernia Project, many enterprise operators are very concerned about anything that might affect revenues and profit margins, particularly given current economic conditions, product markets and cost-price structures in the fishing industry. Adding to these concerns is the short window of opportunity in which to harvest certain species. For instance, capelin are generally only available for 9 to 10 days, and therefore must be harvested quickly, before market conditions change or before the quota is caught. Fishers stated that the same considerations apply to herring and mackerel, which may be abundant in an area for several days but then leave quickly in response to factors such as water temperatures, noise levels, or site lighting conditions.

To help reduce potential effects on their fisheries, fishers indicated their desire for a high level of involvement and participation in Project decisions that might affect their day-to-day operations and their long-term interests. The fishers felt very strongly that they should be the primary voice in any liaison and communication between the local area fishery and the Project. They clearly indicated that they do not wish to have fishing industry representatives who live outside the region speak on their behalf, and would prefer to have a committee of local representatives established, as was done during construction of the Hibernia GBS. They believe that Nearshore Study Area fishers have the best knowledge regarding the local area to inform the Project about key industry issues and concerns and to recommend the most appropriate ways to mitigate potential effects.

The specific issues and concerns raised during consultations are summarized below and have been included in Table 5-2. Biophysical issues are further addressed in Chapter 7 (Fish and Fish Habitat) and fisheries issues in Chapter 8 (Commercial Fisheries), where the relevant issues and concerns raised are evaluated in the effects assessment.

Biophysical issues raised during consultation with nearshore fishers included:

- Underwater blasting: Fishers stated concerns that blasting operations at Great Mosquito Cove might have short- and long-term effects on key species such as herring, mackerel and capelin. They stated their view that the area's herring fisheries are only just now recovering from the effects of the Hibernia Project (e.g., blasting of the seabed area in Great Mosquito Cove). The fishers want to be consulted before any blasting takes place, especially with respect to the timing of the blasting activities. Fishers expressed concern that blasting may disrupt migration of herring during the spring and fall, and could have effects on stocks if herring over-winter in Bull Arm, as they have in previous years.

  Fishers would like to see some analysis of shock waves from blasting in order to identify and assess the geographic extent of blasting activities. As a possible monitoring option, fishers suggested that a test fishery be conducted before and after any blasting operations to determine the

effects on local commercial fish stocks. Fishers suggested that Nearshore Study Area vessels should undertake some of this research.

- Effects on herring spawning: Fishers noted their concern about an accidental release of petroleum and the effects of sediments on water quality from the disposal of material at an ocean dumping site. They identified concerns regarding potential effects on herring spawning areas in the area of Bellevue known locally as "the Brood".
- Effects on water quality: There is concern that dredging operations and the disposal of seabed material from Great Mosquito Cove at an approved ocean dumping site would have negative effects on water quality.

Issues associated with commercial fisheries raised during consultation with nearshore fishers included:

- Exclusion from fishing grounds: Exclusion from pelagic species fishing grounds within Bull Arm, especially fishing areas close to the deepwater site; and exclusion from lobster and other fishing grounds in Great Mosquito Cove.
- Disruption of harvesting operations: Impacts of marine activities (vessel traffic) on fish harvesting operations, including high levels of activity that would make fishing more difficult or dangerous, and might result in de facto exclusion from busy areas, especially Project activities that might interfere with crab or other species harvesting operations within the Tickle Bay portion of the Traffic Lane.
- Gear and vessel damage: Damage to fishing gear or fishing vessels resulting from Project vessels or from Project-related debris escaping from the site.
- Effects of noise and lights on catchability: Effects of construction-related activities on fish behaviour and/or movement within Bull Arm, especially during the time when the GBS is moored at the deepwater site.

Mitigation Recommendations

Fishers offered the following recommendations and mitigation measures to reduce potential impacts on commercial fisheries in the Nearshore Study Area. These are further discussed in Chapters 7 and 8.

- Assist in the purchase of VHF radios or radar reflectors as part of a marine safety and communications plan
- Re-establish the Traffic Lane in Bull Arm
- Conduct an EEM program during Project activities to identify any effects on commercial species or habitat
- Implement a water quality sampling program in Bull Arm prior to the start of construction (local fishers and fishing vessels should be involved in any such programs, as was the case with the Hibernia Project)
- Maximize local economic benefits for fisheries participants (e.g., hiring Nearshore Study Area fishing vessels to support various Project operations) to help offset losses and extra expenses
- Implement a gear damage compensation program

- Consider a compensation program for lost income associated with loss of access to fishing grounds and lost harvesting opportunities

These recommendations and mitigation measures will be reviewed by EMCP. Further discussions with fishers will be undertaken regarding monitoring and implementation of mitigation measures.

5.3.2 Offshore Study Area

5.3.2.1 Consultation Approach

Participants in the independent offshore fleet met with representatives from EMCP and its fisheries consultant in December 2009 to discuss issues and concerns related to the Project. Representatives of One Ocean and the FFAW Union were also in attendance. This offshore fleet comprises enterprises engaged primarily in the harvest of crab and shrimp resources, but also includes other ground fish and pelagic species. The fleet has three segments based on the type of crab licence held by each enterprise:

- 44 enterprises in the "Full Time" fleet
- 78 enterprises in the "Large Supplementary" fleet
- 240 enterprises in the "Small Supplementary" fleet (vessels in this fleet do not currently operate in the Jeanne d'Arc Basin. However, they do have the potential to interact with oil industry operations in other offshore marine areas (e.g., along traffic routes used by supply / service vessels or those used for the towing of drilling rigs)

5.3.2.2 Issues

During consultations fishers raised some specific issues about the Hebron Project, but a chief focus of their concern related to the offshore petroleum sector in general and to the growing presence of that industry on the eastern Grand Banks in particular. Fishers expressed concern that the present relationship between the two industries imposes a number of pressures on their economic well-being that are not yet being addressed. Fishers feel that there is a growing level of frustration, misunderstanding, miscommunication, and - increasingly - animosity, as representatives of both industries proceed with their daily work in their shared operating environment.

One of their primary concerns is lack of set standards for the application of a number of vessel traffic management procedures and at-sea communications protocols for vessels working near offshore oil production facilities. The protocols have been developed arbitrarily without consultation with the fisheries industry, and are now being applied with little or no consideration of their potential economic impact on fish harvesting operations.

Specific examples were cited by fishers included fishing gear being ignored in the path of a vessel engaged in ice deflection, and fishing vessels being chased by standby vessels in the general vicinity of a production platform, even though they were well outside the established Safety Zones. In another case, fishers stated that an oil industry radio operator informed several

nearby fishing vessels that they should not be using a certain VHF Channel because this frequency was "reserved for the oil industry".

Fishers believe that as oil industry activities increase (e.g., including iceberg towing operations, seismic surveys, drill rig transits, and other routine oil-related activities) the need for mutually agreed communications and protocols will become even more problematic. Fishers believe this problem must be resolved at the level of specific interactions between representatives of the two industries.

The following summarizes potential issues related to the Hebron Project raised during the offshore sector consultations. These are further described in Chapter 8:

- Lost harvesting grounds: Exclusion from established construction and operational Safety Zones, as well as exclusion areas as a result of ships' activities and interventions beyond the platforms within an extended "zone of influence" identified by fishers.
- Lost or damaged gear: Fishing gear damage, and the concomitant or subsequent loss of catch and fishing time resulting from standard vessel operations, as well as damage from other activities such as iceberg towing or geophysical surveys.
- Reduced fishing opportunity: Generally reduced fishing opportunity as a result of the combined effects of ongoing development of the Jeanne d'Arc Basin oil field area (site operations, support activities, vessel hailing zones around each installation, ice deflection activities, and surveys). Fishers report that the current situation is resulting in fishing vessels steaming farther around offshore Safety Zones, to reach grounds around activities, costing fishing time and increasing expenses.
- Effects on future fisheries: Potential effects on future fishing activities, especially if further development occurs in the Jeanne d'Arc Basin. This problem could increase if DFO increases crab quotas in the area or reinstates groundfish quotas.
- Oil Spills: Effects of an oil spill and how a compensation program for an oil spill would work. Knowledge about the concrete steps that the oil industry would take following an oil spill.

Mitigation Recommendations

Fishers provided recommendations and advice about various mitigations they believe would help reduce effects on their fisheries (discussed further in Chapter 8).

- A mechanism is needed to define clearly the appropriate "rules of the road" for all users in both industries. This should include the creation of a permanent mechanism for communications and addressing future issues (This was considered the most urgent recommendation brought forward). Since the Offshore Fishers Workshop in December 2009, the One Ocean Working Group has developed a protocol document titled 'Protocols for Communications with Oil Installations on the Grand Banks'. Once the Hebron Platform is towed offshore and its Safety Zone is established, the

Protocol will be updated. The Working Group includes representatives from the fishing industry and oil and gas industry and will include representation from Hebron once the Project is operating

- Work to establish a more positive and respectful working relationship with the fishing industry
- Establish compensation mechanisms for lost income resulting from Project activities, including lost fishing opportunities and gear loss or damage
- Respond to the fishers' request for information about mechanisms for compensation in the event of an oil spill

These recommendations and mitigation measures will be reviewed by EMCP. Further discussions with offshore fishers, One Ocean and FFAW will be undertaken regarding monitoring and implementation of mitigation measures.

5.4 Meetings with Government Departments and Agencies

The Hebron Project study team have been consulting with key government officials and regulators (municipal, provincial, and federal), both formally and informally, on an ongoing basis. The objective of these consultations is to provide information and updates on the Hebron Project and the environmental assessment, and also to receive input and guidance as appropriate. The C-NLOPB and the following Regulatory Authorities have been regularly consulted both before and since filing of the Project Description:

- The Canadian Environmental Assessment Agency
- Transport Canada
- Fisheries and Oceans Canada
- Environment Canada
- Industry Canada
- Major Projects Management Office

There have also been on-going meetings with the provincial Minister of Natural Resources and the deputy ministers and assistant deputy ministers to keep them apprised of Project developments.

These consultations have involved one-on-one meetings (locally and in Ottawa), telephone conversations, and e-mail correspondence. Issues and concerns identified during these meetings were recorded in the issues tracking database.

5.5 Other Consultation Methods

EMCP also provided information to the public and tracked issues using press releases and the Project website.

5.5.1 Media Tracking

EMCP responds to media inquiries as appropriate and has provided information about the project to local, national and international media. EMCP regularly monitors the provincial media, including print, broadcast and

electronic news media. Any issues are noted and incorporated into EMCP's issues tracking database.

5.5.2 Project Website

To increase accessibility and enhance communications with the public, the Hebron Project established a Project website (http://www.hebronproject.com), which was widely advertised and promoted during presentations at workshops and open houses. The website is updated regularly and the public are able to submit questions and issues through an online questionnaire or contact email address (hebronproject@exxonmobil.com).

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6 AIR QUALITY

Air Quality is considered a Valued Ecosystem Component (VEC) as its constituents are essential to sustain life and maintain the health and well-being of humans, wildlife, vegetation and other biota. The atmosphere is also a pathway for the transport of air emissions species to marine, freshwater, terrestrial and human environments.

The health and safety of the workers is of prime importance as well, and is ensured through programs of safety training, emergency response planning, and the engineering of the offshore facilities. The air quality situation with respect to workers comprises no issues that are more complex than those of other projects. The absence of hydrogen sulphide in the produced gas reduces the potential risks that are routinely handled on many other facilities. Existing legislation for worker health and safety and the Hebron Project (the Project)-specific planning that will occur as detailed engineering proceeds will provide the requisite degree of protection for workers on the facilities.

6.1 Environmental Assessment Boundaries

6.1.1 Spatial

The Nearshore and Offshore Study and Project Areas are defined in the Environmental Assessment Methods Chapter (Chapter 4).

The Nearshore Affected Area is the area which could potentially be affected by Project activities within and surrounding the Nearshore Project Area, including associated physical works and activities at the Nalcor Energy-Bull Arm Fabrication Site. The Nearshore Affected Area for air quality is set to encompass the residences on the land adjacent to Bull Arm, recognizing that it is important to consider the potential environmental effects of the air quality that the residents experience, although professional experience indicates that the environmental effects of emissions in construction would disperse to within the range of normal background levels at this distance. The Nearshore Affected Area is presented in Figure 6-1. The Offshore Affected Area is the area within and beyond the Offshore Project Area that could potentially be affected by Project works and activities. The Offshore Affected Area for the assessment of Air Quality is defined by the air dispersion modelling extents as an area that is 100 km by 65 km and is presented in Figure 6-2. This domain is sufficient to show the reduction of the Hebron Platform emissions to near background levels. The spatial boundary for greenhouse gas (GHG) emissions is global, as the effects on climate change are through the cumulative action of global emissions.

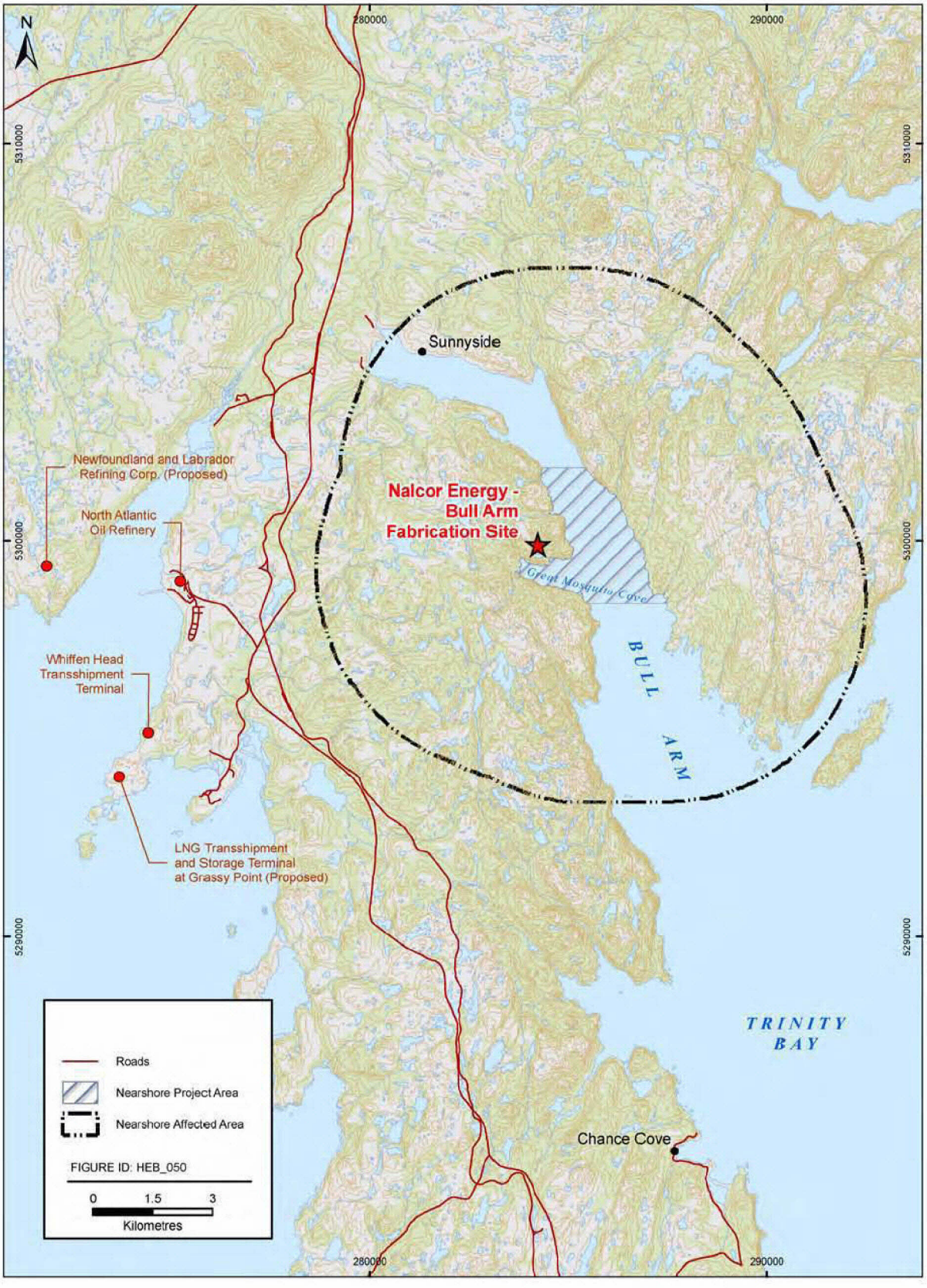

Figure 6-1 Nearshore Affected Area

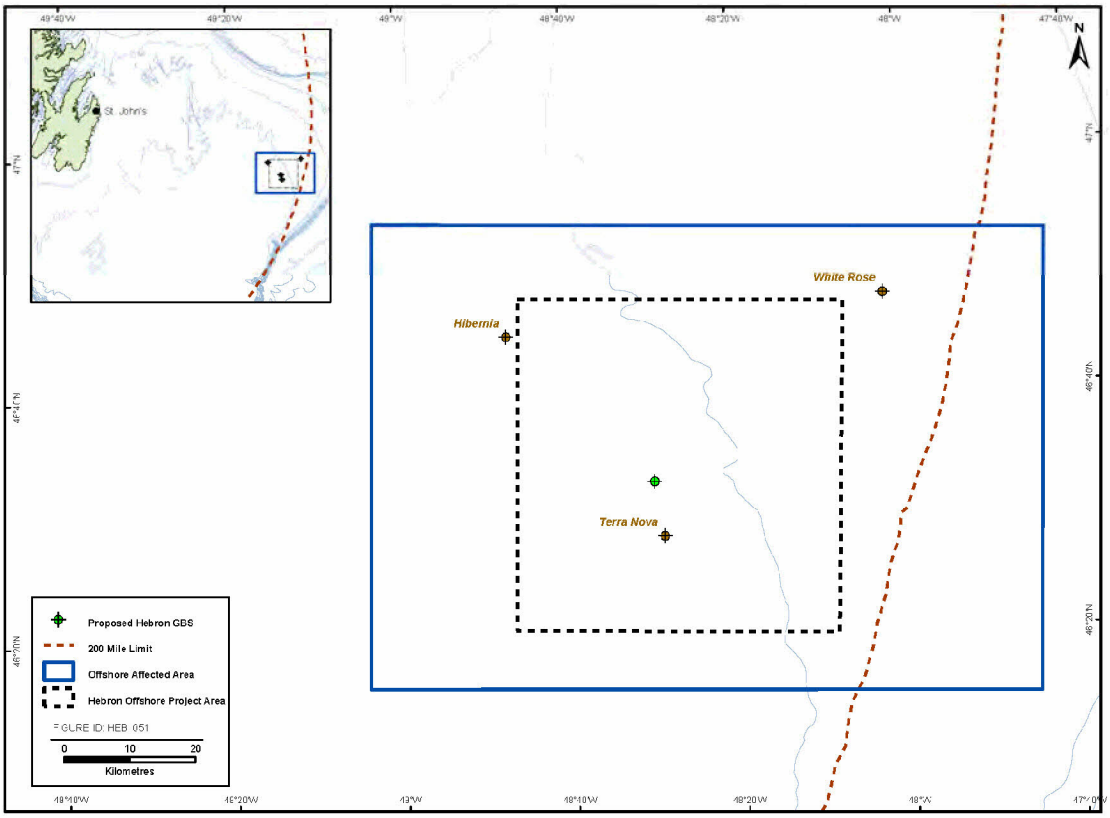

Figure 6-2 Offshore Affected Area

6.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Chapter 4). The nearshore and offshore temporal boundaries are summarized in Table 6-1.

Table 6-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential future activities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

6.1.3 Administrative

The administrative boundaries for Air Quality pertain mainly to regulatory limits and standards for the air emissions in the Nearshore and Offshore Project Areas, where such limits and standards exist. These limits are set by regulatory authorities to reflect environmental protection objectives, with the intent of being protective of air quality and human and environmental health.

Air quality will be assessed in the context of potential Project-related criteria air contaminants (CACs) and their ground-level concentrations (GLCs), as well as potential emissions of non-criteria air contaminants. For the purposes of this environmental assessment, the Project-related CACs include carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2), total suspended particulate matter (TSP) and volatile organic compounds (VOCs). The non-criteria air contaminants are GHGs, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

The federal government has set objectives for air quality which are taken into account by federal agencies in project environmental assessment reviews. These objectives also tend to form the basis for the air quality regulations of several provinces, including Newfoundland and Labrador. The Newfoundland and Labrador regulatory limits generally correspond to the upper limit of the Maximum Acceptable category of air quality, which are set under the Canadian Environmental Protection Act. These objectives may also be used as reference by provincial or federal regulators. Additional guidelines are under development by the Canadian Council of Ministers of the Environment (CCME), and ultimately this body may develop Canada-wide Standards that harmonize the regulations in all jurisdictions.

The National Ambient Air Quality (NAAQ) Objectives and the Newfoundland and Labrador Air Pollution Control Regulations for specified CACs are presented in Table 6-2 for reference. In terms of the Hebron Project, the Newfoundland and Labrador Maximum Permissible Ground Level Concentrations would be applicable to the Nearshore Project Area and the NAAQ Objectives would be applicable to the Offshore Project Area.

The federal government of Canada has recently (March 2010) published Planning for a Sustainable Future: A Federal Sustainable Development Strategy for Canada that sets out the current targets for various environmental actions. Included as the target for the first goal is: "(R)elative to 2005 emission levels, reduce Canada's total GHG emissions 17 percent by 2020". The strategy is open for comments. The second goal of the strategy is "Air Pollutants". According to the document, targets are under discussion between the federal and provincial governments, and the main implementation scheme is the Clean Air Regulatory Agenda. Within this agenda, the important activities include the National Pollutant Release Inventory (NPRI), as mandated by the Canadian Environmental Protection Act (1999), and the harmonization of vehicle emission regulations within Canada and with the United States. Additional federal initiatives include the Base Level Industrial Emission Requirements that aims to quantify the minimum facility or equipment performance standards to be applied to new and existing industrial facilities and equipment in Canada. These standards will represent a good level of environmental performance, and apply to smog-causing pollutants such as NO_x, SO_2, VOCs, and total particulate matter (TPM). Upstream oil and gas is a target sector for determination of Base Level Industrial Emission Requirements, and recommendations are expected in 2010, with enforcement expected in 2015.

Table 6-2 Newfoundland and Labrador Air Pollution Control Regulations and Canadian Environmental Protection Act Ambient Air Quality Objectives

Pollutant and Units (alternative units in brackets)	Averaging Time Period	Newfoundland and Labrador	Canada			
		Maximum Permissible Ground Level Concentration	Canada-Wide Standards	Ambient Air Quality Objectives		
				Maximum Desirable	Maximum Acceptable	Maximum Tolerable
Nitrogen Dioxide (NO_2) ($\mu g/m^3$) (ppb)	1 hour	400 (213)	-	-	400 (213)	1000 (532)
	24 hour	200 (106)	-	-	200 (106)	300 (160)
	Annual	100 (53)	-	60 (32)	100 (53)	-
Sulphur Dioxide $\mu g/m^3$ (ppb)	1 hour	900 (344)	-	450 (172)	900 (344)	-
	3 hour	600 (228)				
	24 hour	300 (115)	-	150 (57)	300 (115)	800 (306)
	Annual	60 (23)	-	30 (11)	60 (23)	-
Total Suspended Particulate Matter (TSP) ($\mu g/m^3$)	24 hour	120	-	-	120	400
	Annual	60	-	60	70	-
$PM_{2.5}$ ($\mu g/m^3$)	24 hour	25	30 (by 2010) Based on the 98th percentile ambient measurement anually, averaged over three consecutive years	-	-	-
PM_{10} ($\mu g/m^3$)	24 hour	50	-	-	-	-
Carbon monoxide (mg/m^3) (ppm)	1 hour	35 (31)	-	15 (13)	35 (31)	-
	8 hour	15 (13)	-	6 (5)	15 (13)	20 (17)
Oxidants – ozone ($\mu g/m^3$) (ppb)	1 hour	160 (82)	-	100 (51)	160 (82)	300 (153)
	8 hour	87 (45)	65 (by 2010) Based on 4th highest annual value, averaged over three consecutive years	-	-	-
	24 hour	-	-	30 (15)	50 (25)	-
	Annual	-	-	-	30 (15)	-

6.2 Existing Conditions

6.2.1 Nearshore

The air quality surrounding the Nearshore Project and Study Areas is generally good due to its remote location; however, industries surrounding the Bull Arm Site have had an effect on the local airshed over the past 100 years.

Environment Canada operates a series of ambient air monitoring stations across Canada under the National Air Pollution Surveillance Network. There

are six monitoring locations in Newfoundland and Labrador, with St. John's being the closest to the Nearshore Project and Study Areas. Due to the distance between this monitoring station and the Nearshore Project and Study Areas, the measured data would not be representative of the local air quality. Instead, background air quality data for the Nearshore Project and Study Areas were summarized using information available from nearby industrial sites and from the NPRI and from the National GHG Report.

6.2.1.1 Air Quality

The closest industrial site to the Nearshore Project and Study Areas is the Come by Chance North Atlantic Refining Limited refinery, located approximately 9 km west of the Bull Arm Site and the Newfoundland Transshipment Terminal, located approximately 10 km south-west of the Bull Arm Site (Figure 6-1). Other nearby proposed facilities include the Grassy Point Liquefied Natural Gas Transshipment and Storage Terminal, the Newfoundland and Labrador Refining Corporation's Southern Head Marine Terminal and Associated Crude Oil Refinery and the Whiffen Head Transshipment Terminal (refer to Figure 6-1).

Background ambient air quality in and surrounding the Nearshore Affected Area was summarized in Newfoundland and Labrador's 2009 Air Quality Report (Newfoundland amd Labrador Department of Environment and Conservation (NLDEC) 2010). These data are presented in Table 6-3.

Table 6-3 Ambient Air Quality in and Surrounding the Nearshore Affected Area (Maximum Annual Values for 2009)

Pollutants ($\mu g/m^3$)	Time Frame	Arnolds Cove	Come by Chance	Sunnyside
SO_2	1-hour	138	204	193
	24-hour	20	65	50
$PM_{2.5}$	24-hour	16	17	18
PM_{10}	24-hour	-	-	22
NO_x	-	NA	NA	NA

NA = Not Available
Source: NLDEC 2010

The monitoring sites located closest to the Nearshore Project Area include Come by Chance and Sunnyside. These background concentrations indicate that the area meets the air quality regulations of the province, and attains the strictest NAAQ Objectives of Canada.

The annual emissions from the existing Come by Chance North Atlantic Refining Limited refinery have also been summarized using data available from the 2008 NPRI and are presented in Table 6-4.

Table 6-4 Annual Emissions – Come By Chance North Atlantic Refinery, 2008

Facility	Criteria Air Contaminants (tonnes/yr)				
	SO_2	CO	NO_X (as NO_2)	TSP	VOCs
North Atlantic Refinery	12,549	357	1,948	306	645
Source: Environment Canada 2009a					

The Bull Arm Site is an approved construction support facility and will, therefore, have local emissions characteristic of fabrication, such as welding, grinding, and similar activities. However, on a scale that includes the local communities, the refinery is the dominant source in the airshed.

6.2.1.2 Greenhouse Gas Emissions

According to the 2008 National GHG Emissions Report, the annual emissions of GHGs from the North Atlantic Refining Limited refinery in Come by Chance were approximately 1,285,356 tonnes CO_2eq (Environment Canada 2009b). These emissions represent 24 percent of the provincial total. This source will be the major local contributor to concentrations of GHGs.

6.2.2 Offshore

Given its offshore location, air quality within the Offshore Project and Study Areas is likely to be very good, with only occasional exposure to exhaust products from existing offshore oil production facilities (i.e., Hibernia, Terra Nova and White Rose), supply ships and other vessels in the area, as each platform would generally be downwind of another less than 15 percent of the time. This region also receives long-range contaminants from the industrial mid-west and northeastern seaboard of the United States.

To assess the existing ambient air quality in the Offshore Study Area, site specific emissions data were collected from the NPRI and National GHG reports. These reports are completed and submitted annually by each of the offshore oil and gas operators located near the proposed Hebron Project and are presented in the following sub-sections.

6.2.2.1 Air Quality

The 2008 NPRI data for CACs for each of the existing offshore oil platforms located near the proposed Hebron Project are presented in Table 6-5.

Table 6-5 2008 Annual Emissions of Criteria Air Contaminants – Existing Offshore Oil Platforms

Facility	Criteria Air Contaminants (tonnes/yr)				
	SO_2	CO	NO_X (as NO_2)	TSP	VOCs
Hibernia	-	797	1,084	196	470
Terra Nova	-	731	2,313	208	6,717
White Rose	0.26	890	2,421	267	285
Source: Environment Canada 2009a					

6.2.2.2 Greenhouse Gas Emissions

The 2008 GHG data for each of the existing offshore oil platforms located near the Project and the provincial and national totals are presented in Table 6-6.

Table 6-6 2008 Annual Emissions of Greenhouse Gas – Existing Offshore Oil Platforms

Facility	Greenhouse Gases (tonnes CO_2eq per year)		
	CO_2	CH_4	N_2O
Hibernia	556,231	34,961	4,557
Terra Nova	576,456	31,274	10,597
White Rose	515,691	30,047	9,796
Provincial Total	5,140,424	97,037	35,955
National Total	247,400,881	7,983,044	4,897,951
Source: Environment Canada 2009b			

The reported GHG emissions from each of the existing oil platforms are representative and consistent with such a facility.

The national GHG emissions by sector during 2004 to 2007 are provided in Table 6-7.

Table 6-7 National Greenhouse Gas Emissions Data by Sector, 2004 to 2007

Sector	2004		2005		2006		2007	
	Emissions (kt CO_2eq)	% of Yearly Total	Emissions (kt CO_2eq)	% of Yearly Total	Emissions (kt CO_2eq)	% of Yearly Total	Emissions (kt CO_2eq)	% of Yearly Total
Mining, Quarrying and Oil and Gas Extraction	49,591	18	49,178	18	53,878	20	56,823	20
Utilities	121,459	43	123,787	44	115,868	43	121,401	44
Manufacturing	96,615	35	91,480	33	88,676	33	87,114	31
Other	11,589	4	14,148	5	13,483	5	12,755	5
Source: Environment Canada 2009b								

As presented in Table 6-7, the major contributors of GHG emissions by sector include the utilities sector, followed by the manufacturing sector, and oil and gas extraction (including other activities such as mining and quarrying). In 2007, the GHG emissions related to the mining, quarrying and oil and gas extraction sector represented approximately 20 percent of the national annual reported GHG emissions.

6.3 Project-Valued Ecosystem Components Interactions

6.3.1 Nearshore Project Activities

Project-related construction activities within the Nearshore Project Area, including the following activities, will generate air emissions from:

- Vessel traffic (supply, ferry, tow, diving support, barge, dredging) (CO, NO_x, TSP, VOCs, GHGs)
- Vehicle traffic (cars, trucks, buses, cranes, loaders) (CO, NO_x, TSP, VOCs, GHGs)
- Construction emissions from blasting, welding, concrete production and the re-establishment of the bund wall (TSP)

Therefore, potential interactions with Air Quality could result from the above-mentioned activities.

Typical air emissions from the operation of vessels during construction at the Bull Arm Site include CO, NO_x, TSP, VOCs and GHGs. Various types of vessels, including supply and ferry vessels, barges, tow vessels and diving support vessels, will be used while implementing nearshore construction activities (i.e., concrete production, re-establish moorings at Bull Arm deepwater site, dredging of Bund Wall and disposal, tow-out of GBS, complete GBS construction and mate Topsides at Bull Arm deepwater site and surveys). The potential environmental effects associated with such activities will be assessed in Section 6.5 based on the operation of vessels.

Typical air emissions from the operation of vessels during construction at the Bull Arm Site include CO, NO_x, TSP, VOCs and GHGs. Various types of vessels will be used while implementing nearshore construction activities, including supply and ferry vessels, barges, tow vessels and diving support vessels.

Air emissions related to the operation of vehicles would be similar to that of vessels. Various types of vehicles will be used to carry out nearshore Project activities and include, but not limited to, cars, trucks, buses, cranes and loaders.

Emissions of CACs and GHGs will also result from typical construction activities such as blasting, welding and concrete production. The amount and type of equipment used during construction will vary depending on the construction contractor.

Electrical power for the Bull Arm Site will be acquired from the provincial utility power grid and, therefore, was not assessed in this assessment. However, there may be times during emergency situations or when power requirements are high, when additional power supply may be required. In such instances, the use of temporary generators may be required.

6.3.2 Offshore

6.3.2.1 Offshore Construction / Installation

As with the nearshore construction of the Hebron Platform, the offshore construction and installation activities (including hook-up and commissioning) also have the potential to interact with Air Quality. Air emissions associated with offshore construction and installation activities include:

- Vessel exhaust (e.g., supply, support, tow, barge) and helicopter exhaust (CO, NO_x, TSP, VOCs, GHGs)
- Power generation exhaust (CO, NO_x, TSP, VOCs, SO_2, GHGs)
- Flaring (CO, NO_x, VOCs, TSP, GHGs)
- Fugitive and venting emissions (e.g., leaks from valves, pump seals, compressor seals, flanges, pressure relief valves and fuel and chemical storage) (VOCs, GHGs)
- Construction activities (e.g., welding, solvent use) (TSP, VOCs)

Various vessels will be required to carry out a number of activities (i.e., offshore loading system (OLS) installation and testing, concrete mattress pads / rock dumping over OLS offloading lines, installation of temporary moorings, platform tow-out / offshore installation, underbase grouting, offshore solid ballasting, placement of rock scour protection on seafloor around final Platform location and hook-up and commissioning) during offshore construction and installation of the Hebron Platform. The typical emissions associated with the operation of the vessels will be the same as those mentioned in Section 6.3.1. The potential environmental effects associated with such activities will be assessed in Section 6.5 based on the operation of vessels. Helicopters will be used to transport personnel and supplies to and from the Offshore Project Area. The typical emissions associated with the operation of helicopters are similar to those from the operation of vessels and are outlined above.

During the construction and installation of the Hebron Platform, power generation will be supplied from two dual-fuelled turbine generators operating at full capacity. These units will use distillate fuel (diesel fuel) during offshore construction and installation of the Hebron Platform and change to produced gas once the facility is operational and gas compression is online. During the early stages of the offshore construction and installation of the Hebron Platform; however, power may be supplied by temporary generators until the dual-fuelled turbines have been commissioned. The power requirements may not require the operation of both turbines at all times. For conservative purposes throughout this assessment; however, power generation for offshore construction and installation of the Hebron Platform was based on the full capacity operation of both turbines.

The primary emissions from turbine generators include NO_x, CO, TSP and VOCs.

The Project emissions will generally be the same when operating on either diesel or produced gas (during the operation phase), except that the diesel fuel may have some trace SO_2 emissions and release greater quantities of

CO_2, whereas natural gas will release lower quantities of CO_2 and TSP and greater quantities of NO_x.

Sulphur dioxide emissions could be of concern when the units are operating on distillate fuels, in which case, the sulphur emissions would be directly related to the sulphur content of the fuel.

Greenhouse gases, including CO_2, N_2O and CH_4, will also be emitted during the operation of dual-fuelled turbine generators. In terms of diesel fuel, CO_2 will be produced during the combustion process but the emissions of N_2O and CH_4 will be negligible. In terms of natural gas combustion, traces of CH_4 are present in the exhaust gas as unburned fuel and CO_2 will also be emitted via the combustion process, however at slightly lower quantities than from the burning of diesel fuel (US Environmental Protection Agency (EPA) 2000).

Flaring is an essential component of the safety system of an oil and gas production facility and it is vital to ensure safe working conditions on the platform. There will be occasions during the offshore construction and installation phase of the Hebron Platform when flaring of excess gas, test flaring and/or emergency flaring will be required. Typical emissions from a flaring event include CO, NO_x, VOCs, TSP and GHGs. The quantity of GHG emitted from flaring will be measurably higher during the construction and installation phase of the Hebron Platform, until the Hebron Platform is operational and gas compression is on-line.

Fugitive emissions of VOCs will also occur during the offshore construction and installation phase of the Hebron Platform via venting from chemical and fuel storage. However, these emissions are considered to be limited in quantity and largely controlled by, for example, using closed rather than open containers, and reventing where practicable. Limited quantities of TSP and VOC emissions will be emitted during various construction activities during the construction and installation phase of the Hebron Platform. There will be also be minor quantities of VOCs from fugitive emissions from the loading and unloading of fuels and chemicals and equipment leaks. These emissions will be similar in quantity to those released during the first year of operation and are therefore further discussed in Section 6.3.2.2.

6.3.2.2 Operation / Maintenance

Project offshore operations and maintenance activities have the potential to interact with Air Quality. Air emissions associated with offshore operation and maintenance activities include:

- Vessel (e.g., supply, support, tow, standby) and helicopter traffic (CO, NO_x, TSP, VOCs, GHGs)
- Power generation (CO, NO_x, TSP, VOCs, SO_2, GHGs)
- Gas compression (CO, NO_x, TSP, VOCs, GHGs)
- Flaring (CO, NO_x, VOCs, TSP, GHGs)

- Fugitive and venting emissions (e.g., product loading, unloading and storage, chemical and fuel storage, leaking valves, pumps seals, compressor seals, flanges / connectors, and pressure relief valves) (VOCs, GHGs)
- Maintenance activities (e.g., welding) (TSP, VOCs)

Emissions produced from the operation of vessels and helicopters during the operation and maintenance phase of the Hebron Platform will be similar to those during the construction and installation phase of the platform, as discussed in Section 6.3.2.1. Vessel operation supports a number of project activities including geophysical and seismic surveys. The potential environmental effects associated with such activities will be assessed in Section 6.5 based on the operation of vessels.

During the operation of the platform and various well activities, it is planned that power generation will be supplied from four turbine generators (two dual-fuelled, one gas, and one spare). During the first year of operation (approximately eight months), only the two dual-fuelled turbine generators will be in operation and they will use diesel fuel. Once gas compression is online the two dual-fuelled units and the gas turbine generator will be in operation and will operate on produced gas. The air emissions associated with the use of these units were discussed above in Section 6.3.2.1.

Based on current design, gas compression will be accomplished via the use of two dual-fuelled turbine-driven compressors. The turbines will normally operate on natural gas with each compressor handling up to 60 percent of the design gas capacity. The air emissions will be similar to those released during power generation, as discussed in Section 6.3.2.1.

The produced water and water injection system will be operated by electrically-driven pumps and hence, there will be no direct related emissions of CACs or GHGs, as the emissions would have been accounted for through the generation of power by the turbine generators.

During operation of the Platform, there will be times when excess gas will be flared, for example, during well clean-up and unloading after initial completion of a well, during upset conditions, and during background flaring. Background flaring represents flaring associated with normal operations and encompasses pilot and sweep gas, blowdown valve leakage, pressure safety valve leakage, and compressor seals. The emissions released during these events will be similar to those released during the construction and installation of the platform, as discussed in Section 6.3.2.1, but smaller in quantity for background flaring, is much lower in volume, than during upset conditions.

Minor amounts of TSP and VOC emissions will be emitted during various routine maintenance activities, including welding, machine oils and cleaning solvents. There will also be some fugitive emissions of VOCs and GHGs from the loading and unloading of fuels and products and from leaking valves, pumps, seals, compressor seals, flanges / connectors, open ended lines and pressure relief valves.

6.3.2.3 Decommissioning / Abandonment

Project decommissioning and abandonment activities will be similar to those associated with the construction and installation of the Hebron Platform. Air emissions associated with decommissioning and abandonment include:

- Vessel (e.g., supply, support, tow, standby) and helicopter traffic (CO, NO_x, TSP, VOCs, GHGs)
- Power generation (CO, NO_x, TSP, VOCs, GHGs)
- Emissions related to refloating and towing of the platform (CO, NO_x, TSP, VOCs, GHGs)

The air emissions emitted from vessel and helicopter operation related to various activities including removal of the Hebron Platform and OLS loading points, plugging and abandoning wells and the OLS pipeline, and power generation will be similar to those emitted during the construction and installation of the Hebron Platform and have been discussed in Section 6.3.2.1.

Some air emissions will result from work activities associated with the refloating and towing of the Hebron Platform. These emissions will be limited in quantity and temporary.

6.3.3 Summary

The interactions from nearshore and offshore construction and installation, and operation and maintenance activities with Air Quality that have the potential to result in an environmental effect include: vehicle traffic, power generation, gas compression, flaring, and vessel and helicopter operations. In summary, the Project can have potential effects on air quality that can be categorized as:

- A change in ambient air quality (CACs)
- A change in GHG emissions

A summary of the potential environmental effects resulting from Project-VEC interactions, including accidental and cumulative environmental effects is provided in Table 6-8. Most of the activities listed in Table 6-8 do contribute to air and GHG emissions because of the generation of power required to carry out the activity.

Table 6-8 Potential Project-related Interactions: Air Quality

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects	
	Ambient Air Quality	Greenhouse Gas Emissions
Construction		
Nearshore Project Activities		
Presence of Safety Zone (Great Mosquito Cove zone followed by a deepwater site Zone)		
Bund Wall Construction (e.g., sheet/pile driving, infilling)	x	x
Inwater Blasting		
Dewater Drydock / Prep Drydock Area	x	x
Concrete Production (floating batch plant)	x	x
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	x	x
Lighting		
Air Emissions	x	x
Re-establish Moorings at Bull Arm deepwater site	x	x
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	x	x
Removal of Bund Wall and Disposal (dredging / ocean disposal)	x	x
Tow-out of GBS to Bull Arm deepwater site	x	x
GBS Ballasting and De-ballasting (seawater only)		
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	x	x
Hook-up and Commissioning of Topsides		
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	x	x
Platform Tow-out from deepwater site	x	x
Offshore Construction / Installation		
Presence of Safety Zone		
OLS Installation and Testing	x	x
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	x	x
Installation of Temporary Moorings	x	x
Platform Tow-out / Offshore Installation	x	x
Underbase Grouting	x	x
Possible Offshore Solid Ballasting	x	x
Placement of Rock Scour Protection on Seafloor around Final Platform Location	x	x
Hook-up and Commissioning of Platform	x	x
Operation of Helicopters	x	x
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	x	x
Air Emissions	x	x
Lighting		
Potential Expansion Opportunities		
Presence of Safety Zone		
Excavated Drill Centre Dredging and Spoils Disposal	x	x
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insultation	x	x
Hook-up and Commissioning of Drill Centres	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects	
	Ambient Air Quality	Greenhouse Gas Emissions
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	x	x
Offshore Operations and Maintenance		
Presence of Safety Zone		
Presence of Structures		
Lighting		
Maintenance Activities (e.g., diving, ROV)	x	x
Power Generation	x	x
Gas Compression	x	x
Flaring	x	x
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)	x	
WBM Cuttings		
Operation of Helicopters	x	x
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	x	x
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	x	x
Potential Expansion Opportunities		
Presence of Safety Zone		
Drilling Operations from MODU at Future Excavated Drill Centres	x	x
Presence of Structures		
WBM and SBM Cuttings		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)	x	
Geophysical / Seismic Surveys	x	x
Offshore Decommissioning / Abandonment		
Presence of Safety Zone		
Removal of the Platform and OLS Loading Points	x	x
Lighting		
Plugging and Abandoning Wells	x	x
Abandoning the OLS Pipeline	x	x
Operation of Helicopters	x	x
Operation of Vessels (supply, support, standby and tow vessels, ROVs)	x	x
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		
Accidents, Malfunctions and Unplanned Events		
Bund Wall Rupture	x	x
Nearshore Spill (at Bull Arm Site)	x	
Failure or Spill from OLS	x	
Subsea Blowout	x	x
Crude Oil Surface Spill	x	
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS,Platform)	x	
Marine Vessel Incident (i.e., fuel spills)	x	x
Collisions (involving Platform, vessel, and/or iceberg)	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects	
	Ambient Air Quality	Greenhouse Gas Emissions
Cumulative Environmental Effects		
Hibernia Oil Development and Hibernia Southern Extension (drilling and production)	x	x
Terra Nova Development (drilling and production)	x	x
White Rose Oilfield Development and Expansions (drilling and production)	x	x
Offshore Exploration Drilling Activity	x	x
Offshore Exploration Seismic Activity	x	x
Marine Transportation (nearshore and offshore)	x	x
Commercial Fisheries (nearshore and offshore)	x	x

6.4 Definition of Significance

6.4.1 Change in Ambient Air Quality

For a change in ambient air quality a significant adverse residual environmental effect is one that degrades the quality of the air such that the maximum Project-related GLC of the CAC being assessed frequently exceeds stipulated air quality guidelines in the Nearshore or Offshore Study Area. Frequently is defined as once per week for 1-hour standards and once per month for 24-hour standards.

The air quality guidelines chosen for use in the evaluation of significance for the Hebron Project are NAAQ Objectives for the "acceptable" levels (as presented in Table 6-2). The maximum "acceptable" level is intended to provide protection against effects on soil, water, vegetation, visibility, and human wellbeing.

6.4.2 Greenhouse Gas Emissions

In determining the significance criteria for a change in GHG emissions, guidance published by the Federal-Provincial Territorial Committee on Climate Change and Environmental Assessment as per the Canadian Environmental Assessment Agency (CEA Agency 2003) was consulted. This guideline states the following:

> "…the environmental assessment process cannot consider the bulk of GHG emitted from already existing developments. Furthermore, unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured."

It is, therefore, recognized that it is not possible to assess the significance related to a measured environmental effect on climate change on a project-specific basis. Project emissions of GHGs will contribute to these cumulative environmental effects, but the contribution, although potentially important in comparison to local and provincial levels, will be small in a global context. Policies and regulations are being developed by the governments of Canada and Newfoundland and Labrador for regulating GHG emissions for specific sources or industry sectors.

Thus, instead of setting a specific significance criterion for environmental effects on greenhouse gas emissions and determining whether and how it can be met, a change in GHG emissions for this Project will be considered by conducting a preliminary scoping of GHG emissions, determining the industry profile (where possible), and by considering the magnitude, intensity and duration of Project emissions as directed by the CEA Agency guidance (CEA Agency 2003). Project-related GHG emissions will also be compared to similar projects, and to provincial and national greenhouse gas emissions.

6.5 Environmental Effects Analysis and Mitigation

The assessment of the environmental effects due to the construction / installation and decommissioning phases of the Hebron Platform at the Bull Arm Site on Air Quality have been assessed qualitatively as there is limited information available on the quantities of equipment in use at this stage of the Project design.

The assessment of the environmental effects due to the offshore construction / installation and operations / maintenance of the Hebron Platform has been conducted using an emissions inventory and modelling approach, in which the emissions inventory is used to predict the annual emissions released and the dispersion modelling is used to estimate the maximum GLCs.

6.5.1 Construction

6.5.1.1 Change in Ambient Air Quality

Nearshore

Emissions during the nearshore construction phase will result from typical construction activities, including blasting, grinding, welding, concrete production, vessel traffic, and the use of construction equipment, including for example, forklifts, cranes and trucks.

The primary air emissions associated with blasting, grinding, welding and concrete production are TSP and from construction equipment combustion gases. Such emissions however, will be temporary in nature and are considered to be localized, such as welding, or relatively minor in quantity and environmental effect.

Vessels will emit CO, NO_x, TSP and VOCs. However, these emissions are small in quantity, temporary and localized, and will be mitigated using vessels suitable for each work activity (i.e., using appropriately sized vessels for each associated work activity) and by conducting inspections of the vessels to ensure they are being properly maintained.

Offshore

During the offshore construction and installation of the Hebron Platform, activities such as vessel and helicopter traffic and power generation have the

potential to interact with Air Quality and potentially result in environment effects.

Supply and tow vessels and helicopters, will be required during the offshore construction phase of the Hebron Platform. The emissions from these sources will result from the combustion of diesel fuels (distillate fuel) in engines. Typical emissions will include CO, NO_x, TSP and small amounts of VOCs. These emissions however will be localized, small in relative quantity, temporary and mitigated by using vessels suitable for each activity and by conducting inspections of the vessels to ensure they are being properly maintained.

As described in Section 6.3.2.1, power generation during the construction and installation of the Hebron Platform will result in air emissions from the combustion of distillate fuel (diesel). The air emissions include CO_2, NO_x, TSP, VOCs and SO_2. The SO_2 would be directly related to the amount of sulphur in the fuel (anticipated to be very low).

The air emissions of the above CACs (with the exception of SO_2), based on power generation during offshore construction and installation (distillate fuel versus natural gas, for comparison) are presented in Table 6-9.

Table 6-9 Criteria Air Contaminant Emissions for Power Generation (Distillate Fuel versus Natural Gas)

Function	Criteria Air Contaminants (tonnes/year)			
	CO)	NO_x	TSP	VOC
Power Generation[A] (Distillate fuel)	95	448	25.8	0.88
Power Generation[B] (Natural Gas)	20	1,325	14.2	4.5
Notes: A Assumed two turbines operating at full capacity(conversative case) B Assumed peak operation (three turbines operating at full capacity) Source: US EPA 2000; EMCP				

The air emissions related to power generation on distillate fuel will be temporary in nature, and are small in magnitude (except for NO_x) and extent. ExxonMobil Canada Properties (EMCP) will investigate the use of efficient/reduced emission technology where appropriate and incorporate into the design if emission reduction provisions can be economically obtained.

The GLCs predicted for the offshore construction and installation phase of the Hebron Platform would be similar to those predicted for the first year of operation, prior to gas compression, and are presented in Section 6.5.2.1.

6.5.1.2 Greenhouse Gas Emissions

Nearshore

During the construction of the Project at the Bull Arm Site, GHG emissions will be associated with vessel traffic through the combustion of diesel fuel in engines. These temporary emissions will be limited in quantity and mitigated through similar measures as described above in Section 6.5.1.1.

Offshore

Emissions of GHGs during the construction and installation phases of the Hebron Platform at its offshore location will result from the operation of supply and tow vessels, helicopter traffic and power generation. The emissions from the operation of vessels and helicopters include CO_2 from the combustion of diesel fuel, and will be short term, relatively limited in quantity and mitigated using similar measures as discussed above in Section 6.5.1.1.

The estimated annual emissions of GHGs from power generation during the offshore construction and installation phases of the Hebron Platform are presented in Table 6-10. Emissions estimates based on using natural gas to fuel the turbines have also been included for comparison.

Table 6-10 Greenhouse Gas Emissions from Gas Turbines – Distillate Fuel versus Natural Gas

Function	Greenhouse Gas Emissions (tonnes CO_2eq per year)		
	CO_2	N_2O	CH_4
Power Generation[A] (Distillate fuel)	71,674	6.7	1
Power Generation[B] (Natural Gas)	269,024	19.9	5
Notes: A Assumed two turbine generators operating at full capacity (conservative case) B Assumed peak operation (assumed three turbines operating at full capacity) Source: US EPA 2000; EMCP			

A summary of the potential environmental effects on Air Quality during the construction and installation phases of the Hebron Platform is provided in Table 6-11 (only those activities that result in Project-VEC interactions are included). As indicated in Sections 6.3.1 and 6.3.2.1, several activities that indirectly affect Air Quality as a result of vessel traffic are assessed within the vessel traffic and operation of vessels activities of Table 6-11. Power Generation is included as an activity unique to the analysis of environmental effects to Air Quality.

Table 6-11 Environmental Effects Assessment Matrix (Construction and Installation)

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	3/3	R	2

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Concrete Production (floating batch)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	4/6	R	1
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	3/6	R	1
Dredging of Bund Wall and Possibly Sections of Tow-out (Route to deepwater site)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	2/1	R	1
Tow-out of GBS to Bull Arm deepwater site	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	1/1	R	1
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	1	2/2	R	1
Offshore Construction / Installation							
Platform Tow-out / Offshore Installation	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections • Ensure the use of properly maintained and functioning equipment	1	4	2/6	R	2
Power Generation	• Change in Ambient Air Quality • Greenhouse Gas Emissions		2	2	3	R	2
Operation of Helicopters	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Ensure properly maintained and efficient operation	1	4	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	4	3/6	R	2

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

6.5.2 Operations and Maintenance

6.5.2.1 Change in Ambient Air Quality

During the first year of operation and normal operations of the Hebron Platform air emissions will result from power generation, gas compression, flaring, fugitive sources and vessel and helicopter traffic. Other emissions related to well drilling and drilling production operations will be small in quantity and extent.

Power Generation and Gas Compression

During the operation of the Hebron Platform power generation will be accomplished via the use of four turbine generator units, with three units running and one spare, at peak production. Two of these units will have dual-fuelled capacity. During the first year of operation (for approximately the first eight months); however, only the two dual-fuelled units will be in operation and these units will operate on diesel fuel, similar to the offshore construction and installation of the Hebron Platform. Once gas compression is online all units will operate on produced gas, with diesel available as a back-up fuel source. Typical air emissions from the combustion of natural gas in stationary gas turbines include NO_x, CO, and to a lesser degree TSP and VOCs. There is potential for the SO_2 to be present in exhaust emissions later in field life if

the producing reservoir sours; however, it is not initially anticipated in the emissions. The formation of NO_x is dependent upon the temperature and residence time in the flame, whereas emissions of CO and VOCs are a result of incomplete combustion. Emissions of TSP from stationary gas turbines are considered negligible for natural gas combustion. A number of models of turbine have been identified as candidates; however, the final selection will be made in detailed engineering.

Nitrogen oxides formation from the burning of either natural gas or diesel fuel in turbine generators can occur three ways: thermal NO_x, prompt NO_x, and fuel NO_x. For the most part, all of the NO_x produced from the combustion of natural gas is through thermal NO_x, which results from the thermal dissociation and subsequent reaction of nitrogen and oxygen molecules (US EPA 2000). Changes in ambient humidity and temperature can also cause variations of up to approximately 30 percent in NO_x emissions (US EPA 2000).

EMCP will investigate the use of efficient/reduced emission technology where appropriate and incorporate into the design if emission reduction provisions can be economically obtained.

Gas compression will be accomplished via two dual-fuelled turbine-driven compressors.

Flaring

The flare system is an essential component of the process safety control equipment on an offshore production facility. The flare system will be designed for pressure relief to prevent over-pressurization of equipment during process upset conditions and to dispose of associated gas produced during emergency situations. The air emissions during flaring include CO, NO_x and VOCs. Excess gas will be flared until gas compression is online, at which time it will be injected to the sub-surface. A small amount of fuel gas will be continuously flared during normal operations (background flaring). This background flaring represents flaring associated with normal operations and encompasses pilot and sweep gas, blowdown valve leakage, pressure safety valve leakage and compressor seals.

Fugitive Emissions

Fugitive VOC emissions from sources such as leaking valves, pump seals, compressor seals, flanges / connectors, and pressure relief valves will occur during operation of the platform and have been considered quantitatively in this assessment. Minor amounts of TSP and VOCs will be emitted during various routine maintenance activities including welding, grinding and solvent use. Standby generators and other similar on-platform machinery are either considered minor or displacement sources (they are used in place of primary sources like main generators).

Vessel and Helicopter Traffic

Throughout the life of the Project, standby vessels, supply vessels, product vessels and helicopters will routinely navigate between the Project's offshore location and the east coast of Newfoundland. Air emissions associated with vessel and helicopter traffic include CO, NO_x, TSP and VOCs. Air emissions from the operation of these units are considered to be minor and will be mitigated by implementing, where possible, mitigation measures described in Section 6.5.1.1.

Overall Operations

Air dispersion modelling was performed to predict the maximum ambient ground level concentrations of CACs during the first year of operation and during a peak year of operation of the Hebron Platform. Dispersion modelling is used to simulate the transport of pollutants in the atmosphere based on representative weather information, and on the emission information provided by the process engineering and design team. The model algorithms are contained in a computer program that has been accepted by regulators for such use. The US EPA approved model AERMOD was used for dispersion calculations in this project. AERMOD is the current recommended model by the US EPA, and is suitable for distances up to about 35 km, beyond which the accuracy deteriorates. In this project, preliminary calculations showed that this range was more than sufficient to reveal the maximum ground-level concentrations.

Meteorological data for the surface were obtained for the five most recent calendar years from the Hibernia platform (a similar production facility, operating in the northeast Grand Banks), and they were coupled with upper air data from St. John's. Three nested receptor grids were considered in the modelling to cover the Study Area at higher resolution in the vicinity of the proposed platform location. Discrete receptors, including each of the existing platforms, were also included in the modelling study. As noted above emissions from the operation of vessels and helicopters were not included in these models. The air emissions model were re-run to include the larger generators using generic vendor data and fugitive emissions estimates.

Two scenarios were modelled for the operational phase of the Platform and included the following:

- First Year of Operation – Two dual-fuelled turbines operating on distillate fuel, fugitive releases and flaring of excess gas
- Peak Hebron Platform Operation – three turbine generators operating on natural gas, two dual-fueled turbine-driven compressors operating on natural gas, fugitive releases and background flaring

The sources used in the modelling study, their physical stack characteristics and emission factors are presented in Tables 6-12 and 6-13, respectively. The following is a list of assumptions used in both modelling scenarios:

- Two dual-fueled turbines operating on distillate fuel for power generation during the first year of operation (conservative case)

- Three turbines operating on natural gas for power generation and two additional dual-fueled turbine-driven compressors for gas compression during peak operation of the Project
- Quantities of fugitive emission sources and emission rates were provided by EMCP
- The emission rates for NO_x, SO_2 and CO for the turbines were provided by EMCP
- The emission factors for TSP and VOCs for the turbines were acquired from the US EPA's AP-42 documentation for Stationary Turbines for uncontrolled units
- The emission rates for the other Grand Bank facilities were acquired from 2008 NPRI information and the stack characteristics were assumed to be similar to the Hebron Platform
- The emission rates for NO_x, CO, TSP and VOCs for flaring were provided by EMCP
- The stack physical information and the topside configuration were provided by EMCP
- Minor amounts of sulphur in the distillate fuel
- Methane gas will initially be sweet, therefore limited quantities of sulphur
- Water injection via electrically driven pumps
- Emissions of NO_x, CO, TSP and VOCs from vessel and helicopter traffic were not included in the model runs (but were assessed in terms of GHG emissions)
- Receptors within the 500 m safety radius surrounding the platform were excluded from the model

Table 6-12 Point and Volume Source Physical Parameters

Point Sources	Source Location UTM		Stack Physical Parameters				
	Easting (m)	Northing (m)	Base Elevation (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (°C)
Power Generation - Turbine 1	692285	5157070	30.5	61.8	2	31.5	427
Power Generation - Turbine 2	692284	5157073	30.5	61.8	2	31.5	427
Power Generation - Turbine 3	692294	5157073	30.5	61.8	2	31.5	427
Gas Compression - Turbine 4	692376	5157048	30.5	43.5	2	14.4	427
Gas Compression - Turbine 5	692380	5157048	30.5	43.5	2	14.4	427
Flare	692404	5157063	30.5	136.5	1.42	20	1,000
Hibernia	669419	5179807	36	47	3	31.5	427
Terra Nova	693372	5149964	36	47	3	31.5	427
White Rose	727708	5186021	36	47	3	31.5	427

Volume Source	Source Location UTM		Base Elevation (m)	Release Height (m)	Initial Horizontal Dimension (σ_y)	Initial Vertical Dimension (σ_z)
	Easting (m)	Northing (m)				
Platform Fugitive Emissions	692319	5157063	30.5	20	30	9.3

Table 6-13 Air Dispersion Modelling Emission Rates

Sources	Emission Factors (g/s)								
	1st Year of Operation					Peak Operation			
	NO_x	CO	VOCs	TSP	SO_2	NO_x	CO	VOCs	TSP
Power Generation – Turbine 1	78.3	4.44	0.013	0.39	1.85	39.2	2.22	0.085	0.283
Power Generation – Turbine 2	78.3	4.44	0.013	0.39	1.85	39.2	2.22	0.085	0.283
Power Generation – Turbine 3	-	-	-	-	-	39.2	2.22	0.085	0.283
Gas Compression – Turbine 4	-	-	-	-	-	39.2	2.22	0.085	0.183
Gas Compression – Turbine 5	-	-	-	-	-	39.2	2.22	0.085	0.183
Fugitive Emissions[A]			15.8					23.9	
Flare	1.46	11.7	0.058	-	-	Minimal			
Hibernia	-	-	-	-	-	-	-	-	-
Terra Nova	-	-	-	-	-	-	-	-	-
White Rose	-	-	-	-	-	-	-	-	-
A Fugitive emissions were modelled as a volume source									

In summary, the air emissions related to the first year of platform operation, cumulative first year of operation, peak operation and cumulative peak operation of the Hebron Platform would meet the NAAQ Objectives. The predicted air emissions during a flaring event would also meet the NAAQ Objectives for each time period modelled. Cumulative emissions from the operation of the existing platforms are presented in Section 6.5.5.2.

The air dispersion modelling results for the first year of operation of the Hebron Platform are shown in Table 6-14.

Table 6-14 Summary of Model Predictions – Maximum Predicted Ground-level Concentrations – First Year of Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_2	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,157,572	95.7	400
		Hibernia	669,419	5,179,807	7.34	
		Terra Nova	693,371	5,149,964	19.3	
		White Rose	727,725	5,186,025	5.04	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,157,572	58.2	200
		Hibernia	669,419	5,179,807	1.05	
		Terra Nova	693,371	5,149,964	3.41	
		White Rose	727,725	5,186,025	0.73	
	Annual Average	Maximum Prediction - Gridded Receptors	691,792	5,157,572	3.16	100

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
		Hibernia	669,419	5,179,807	0.02	
		Terra Nova	693,371	5,149,964	0.09	
		White Rose	727,725	5,186,025	0.04	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	693,792	5,157,072	47.5	35,000
		Hibernia	669,419	5,179,807	3.2	
		Terra Nova	693,371	5,149,964	10.6	
		White Rose	727,725	5,186,025	2.4	
	8-hour maximum	Maximum Prediction - Gridded Receptors	695,292	5,156,822	18.5	15,000
		Hibernia	669,419	5,179,807	0.9	
		Terra Nova	693,371	5,149,964	2.5	
		White Rose	727,725	5,186,025	0.8	
CO	Annual Average	Maximum Prediction - Gridded Receptors	695,292	5,157,572	0.7	NA
		Hibernia	669,419	5,179,807	0.01	
		Terra Nova	693,371	5,149,964	0.0	
		White Rose	727,725	5,186,025	0.02	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,157,572	1.9	NA
		Hibernia	669,419	5,179,807	0.1	
		Terra Nova	693,371	5,149,964	0.4	
		White Rose	727,725	5,186,025	0.1	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	1.2	120
		Hibernia	669,419	5,179,807	0.02	
		Terra Nova	693,371	5,149,964	0.07	
		White Rose	727,725	5,186,025	0.01	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.1	70
		Hibernia	669,419	5,179,807	0.0005	
		Terra Nova	693,371	5,149,964	0.002	
		White Rose	727,725	5,186,025	0.001	
VOCs[A]	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,156,322	1.95	NA
		Hibernia	669,419	5,179,807	0.092	
		Terra Nova	693,371	5,149,964	0.315	
		White Rose	727,725	5,186,025	0.046	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,292	5,156,572	0.275	NA
		Hibernia	669,419	5,179,807	0.005	

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Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
		Terra Nova	693,371	5,149,964	0.041	
		White Rose	727,725	5,186,025	0.004	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,322	0.02	NA
		Hibernia	669,419	5,179,807	0.0001	
		Terra Nova	693,371	5,149,964	0.0007	
		White Rose	727,725	5,186,025	0.0001	
SO_2	1-hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,157,572	9.45	900
		Hibernia	669,419	5,179,807	0.694	
		Terra Nova	693,371	5,149,964	1.81	
		White Rose	727,725	5,186,025	0.476	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	5.50	300
		Hibernia	669,419	5,179,807	0.099	
		Terra Nova	693,371	5,149,964	0.320	
		White Rose	727,725	5,186,025	0.068	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.299	60
		Hibernia	669,419	5,179,807	0.002	
		Terra Nova	693,371	5,149,964	0.008	
		White Rose	727,725	5,186,025	0.003	
A VOC values are presented in mg/m^3						

The air dispersion modelling results for the peak operations of the Hebron Platform are shown in Table 6-15.

Table 6-15 Summary of Model Predictions – Maximum Predicted Ground-level Concentrations – Peak Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
NO_2	1 -hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,072	169	400
		Hibernia	669,419	5,179,807	10.4	
		Terra Nova	693,371	5,149,964	28.0	
		White Rose	727,725	5,186,025	7.17	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	94.3	200
		Hibernia	669,419	5,179,807	1.43	
		Terra Nova	693,371	5,149,964	5.17	
		White Rose	727,725	5,186,025	1.09	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	6.5	100
		Hibernia	669,419	5,179,807	0.03	
		Terra Nova	693,371	5,149,964	0.14	
		White Rose	727,725	5,186,025	0.06	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,072	38.3	35,000
		Hibernia	669,419	5,179,807	2.4	
		Terra Nova	693,371	5,149,964	6.3	
		White Rose	727,725	5,186,025	1.6	
	8-hour maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,072	33.4	15,000
		Hibernia	669,419	5,179,807	1.0	
		Terra Nova	693,371	5,149,964	1.8	
		White Rose	727,725	5,186,025	0.5	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	1.5	NA
		Hibernia	669,419	5,179,807	0.007	
		Terra Nova	693,371	5,149,964	0.0	
		White Rose	727,725	5,186,025	0.01	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	4.9	NA
		Hibernia	669,419	5,179,807	0.3	
		Terra Nova	693,371	5,149,964	0.8	
		White Rose	727,725	5,186,025	0.2	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	2.7	120
		Hibernia	669,419	5,179,807	0.04	
		Terra Nova	693,371	5,149,964	0.15	
		White Rose	727,725	5,186,025	0.03	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.2	70
		Hibernia	669,419	5,179,807	0.001	
		Terra Nova	693,371	5,149,964	0	
		White Rose	727,725	5,186,025	0.002	
VOCs[A]	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,156,322	2.94	NA
		Hibernia	669,419	5,179,807	0.14	
		Terra Nova	693,371	5,149,964	0.477	
		White Rose	727,725	5,186,025	0.069	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,072	0.416	NA
		Hibernia	669,419	5,179,807	0.008	
		Terra Nova	693,371	5,149,964	0.062	
		White Rose	727,725	5,186,025	0.005	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,322	0.03	NA
		Hibernia	669,419	5,179,807	0.0001	
		Terra Nova	693,371	5,149,964	0.001	
		White Rose	727,725	5,186,025	0.0001	
A VOCS are presented in mg/m^3						

Further details on the air dispersion modelling study, as well as the concentration contour plots, can be found in Stantec 2010b.

Results from the air dispersion modelling show that the results of emissions produced during the first year of operation and during peak operation of the Hebron Platform would meet the stipulated air quality criteria in the short-term and long-term, and in near-field and far-field locations. There were no exceedances of the NAAQ Objectives.

Greenhouse Gas Emissions

During peak operation of the Project, emissions of GHGs will be associated with power generation, gas compression, flaring and the operation of vessels and helicopters.

Power Generation and Gas Compression

Greenhouse gases, including CO_2, N_2O and CH_4, are emitted during the operation of turbine generators when operating on either distillate fuel or natural gas. Carbon dioxide and N_2O are produced during the combustion process, as is CH_4 in the case of distillate fuel oil. Greater amounts of CO_2 are released during the combustion of distillate fuel versus natural gas due to the higher carbon content. In terms of natural gas combustion, low levels of CH_4 are present in the exhaust gas as unburned fuel (US EPA 2000). It is anticipated that once the platform is fully operational the dual-fuelled turbines will operate on natural gas, therefore reducing the quantity of GHGs emitted.

Flaring

It is a common practice for existing offshore facilities to inject produced gas into the sub-surface. The injection of produced gas reduces GHG emissions to the atmosphere. Prior to the operation of the gas compression and injection system, it will be necessary to flare that portion of the gas not used to fuel the generators.

While the use of injection wells will greatly reduce the platform's GHG emissions, some flaring will still be required during upset conditions and during normal operations (background flaring), but as mentioned above, such quantities are expected to be minor. The estimated GHG emissions from flaring during the first year of operation and during peak operation are presented in Table 6-16.

Table 6-16 Greenhouse Gas Emissions from Flaring during Hebron Platform Operation

Greenhouse Gas	1st Year of Operation	Peak Operation
CO_2 (tonnes/yr)	152,884	92,849
CH_4 (tonnes/yr)	791	484
N_2O (tonnes/yr)	0.283	0.173
Total $CO_{2\ eq}$ (tonnes/yr)	261,053	103,060

Fugitive Emissions

Fugitive greenhouse gas emissions, in particular CH_4, may be released from sources such as leaking valves, pump seals, compressor seals, flanges / connectors, and pressure relief valves during the operation of the platform.

Vessel and Helicopter Traffic

Greenhouse gas emissions, including CO_2, will be emitted during the routine operation of standby vessels, supply vessels and helicopters through the combustion of diesel fuel.

Overall Operations

An emissions inventory for the GHG emissions related to the overall operation phase of the Hebron Platform was prepared and the results are presented in Table 6-17.

As presented in Table 6-17, the estimated GHG emissions for the operation of the Hebron Platform are similar to those reported for other existing oil platforms located near the Offshore Project Area.

A summary of the potential environmental effects on Air Quality during the operations and maintenance phase of the Hebron Platform is provided in Table 6-18 (only those activities that result in Project-VEC interactions are included). As indicated in Section 6.3.2.2, several activities that indirectly affect Air Quality as a result of vessel traffic are assessed within the Operations of Vessels activity in Table 6-18. Power Generation is indicated as an activity unique to the analysis of environmental effects to Air Quality.

Table 6-17 Greenhouse Gas Emissions during the Operation of the Hebron Platform

Function	Greenhouse Gas Emissions (tonnes/year)			
	CO_2	N_2O	CH_4	Total CO_2eq
Power Generation	269,024	19.9	5	275,298
Gas Compression	174,612	6.7	3.3	176,758

Function	Greenhouse Gas Emissions (tonnes/year)			
	CO_2	N_2O	CH_4	Total CO_2eq
Flaring	92,849	0.173	484	103,067
Fugitive Emissions	-	-	1346	28,266
Vessel Traffic	12,589	ND	ND	12,589
Helicopter Traffic	491	ND	ND	491
Hebron Total				596,469
Hibernia				595,749
Terra Nova				618,327
White Rose				555,534
Source: Rolls-Royoce Marine 1991; US EPA 2000; Sikorsky 2007; Environment Canada 2009a; EMCP unpublished data				

Table 6-18 Environmental Effects Assessment: Operation and Maintenance

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Power Generation[B]	• Change in Ambient Air Quality • Greenhouse Gas emissions	• Investigate the use of efficient / reduced emission technology, where appropriate, and where technologically sound and economically justifiable incorporate into the design	2	2	5/6	R	2
Maintenance Activities (e.g., diving, ROV, welding)	• Change in Ambient Air Quality		1	1	5/3	R	2
Flaring (upset conditions)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Monitor the number of flaring events • Investigate the use of efficient / reduced emission technology, where appropriate, and where technologically sound and economically justifiable incorporate into the design.	2	3	1/1	R	2
Chemical / Fuel Management / Storage (e.g., corrosion inhibitors, BOP fluids, methane leaks from valves)	• Change in Ambient Air Quality • Greenhouse Gas	• Develop and implement Standard Operaing Procedures (SOPs) for all chemical handling operations	1	1	5/6	R	2
Operation of Helicopters	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Ensure properly maintained and efficient operation	1	4	5/6	R	2

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Maintenance and inspections	1	4	5/6	R	2

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Includes Gas Compression

6.5.3 Offshore Decommissioning and Abandonment

Project activities associated with decommissioning and abandonment will be similar to those associated with construction and installation, with regard to air emissions. Particularly, emissions may result from the removal of the topside facilities, Hebron Platform and OLS loading points and from vessel and helicopter traffic. The effect of each of these activities will be temporary in nature, medium in magnitude, geographic extent and duration and the same mitigative measures will be implemented during decommissioning as were used during construction.

The summary of potential environmental effects on Air Quality from decommissioning and abandonment-related activities is provided in Table 6-19 (only those activities that result in Project-VEC interactions are included). As indicated in Section 6.3.2.3, several activities that indirectly affect Air Quality as a result of vessel and helicopter traffic are assessed within the Operation of Vessels and Operation of Helicopters in Table 6-19.

Table 6-19 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Change in Ambient Air Quality	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	2	2	2/1	R	2
Operation of Helicopters	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Maintenance and inspections	1	4	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	4	3/6	R	2

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

6.5.4 Accidents Malfunctions and Unplanned Events

6.5.4.1 Change in Air Quality

Nearshore

As nearshore activities consist of routine fabrication of large marine structures, accidental releases of air emissions could result from collisions of vessels with the GBS and/or with other vessels or from a hydrocarbon spill. Either of these events could result in a release of fugitive gases to the atmosphere; however, the release would be very small in magnitude, geographic extent, and duration, and will be prevented or mitigated by implementing the following measures:

- Risk awareness, emergency response and preventative measures training
- Routine audits on the general contractors oil spill response preparedness program
- Training staff on spill response and awareness during "Tool Box Safety" meetings
- Routine inspections of equipment
- Use of oil containment booms when necessary

The most extensive incident, however, would be if either of the above events resulted in a fire. An uncontrolled fire involving distillate fuel may result in incomplete combustion and therefore the release of air emissions. Such emissions would possibly be greater in magnitude, extent and duration than the fugitive release.

Offshore

Accidental releases of air emissions in the Offshore Project Area could result from the failure of OLS pipelines, manifolds or risers, subsea blowout, hydrocarbon spill, chemical spill and/or marine vessel incident. Each of these events would result in the release of hydrocarbons and therefore the release of fugitive air emissions to the atmosphere. These air emissions will be small in magnitude, extent and duration because of a number of preventative or mitigative measures will be implemented to either aid in minimizing the likelihood of the event taking place or to minimize the effect on Air Quality if the event took place and include:

- Develop and implement Standard Operating Procedures (SOPs) for all oil handling operations
- Good communications and sound marine practices for all vessels
- Conducting periodic inspection and maintenance checks on product storage and handling and fuel transfer systems
- The general awareness of offshore workers will be increased through training, seminars and safety meetings
- Conducting periodic maintenance and inspections on helicopters and vessels

There is also a risk of an explosion and/or fire in the case of fuel and chemical leaks or spills. Appropriate systems, resources and training will be in place to reduce the frequency and magnitude of explosions and fires on the platform and to respond to any such incidents that occur. The air emissions related to a potential explosion or fire would be greater in magnitude, extent and duration than those released from a fuel or chemical spill, but still marginally small.

Accidental releases of air emissions could also result during emergency flaring events. Emergency flaring allows for the prevention of over-pressurization of equipment and safely disposes of associated gas during process upset conditions. Air dispersion modelling was performed to predict the maximum ambient GLCs during an emergency flaring event. One event was assumed to last for fifteen minutes. The flare system physical characteristics and the emission data (Table 6-20) was used in the model.

Table 6-20 Air Dispersion Modelling Emission Rates

Sources	Flaring (g/s)			
	NO_x	CO	VOCs	TSP
Flare	1.46	11.67	0.058	-

As the gas is initially sweet, the amount of particulate matter released from the flare will be much lower than if the flare was a sour gas flare. The use of modern efficient flare technology will further reduce the particulate that would be form as unburned hydrocarbons (soot). Particulate emissions from flaring are assumed to be minimal for this analysis.

The air dispersion modelling results for an emergency flaring event of the Hebron Platform are shown in Table 6-21.

Table 6-21 Summary of Model Predictions – Maximum Predicted Ground-level Concentrations - Flaring

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_2	1 -hour Maximum	Maximum Prediction - Gridded Receptors	693,792	5,157,072	0.956	400
		Hibernia	669,419	5,179,807	0.059	
		Terra Nova	693,371	5,149,964	0.196	
		White Rose	727,725	5,186,025	0.039	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	695,292	5,156,822	0.097	200
		Hibernia	669,419	5,179,807	0.008	
		Terra Nova	693,371	5,149,964	0.022	
		White Rose	727,725	5,186,025	0.006	
	Annual Average	Maximum Prediction - Gridded Receptors	694,792	5,159,322	0.002	100
		Hibernia	669,419	5,179,807	0.000	
		Terra Nova	693,371	5,149,964	0.001	
		White Rose	727,725	5,186,025	0.000	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	693,792	5,157,072	30.6	35,000
		Hibernia	669,419	5,179,807	1.9	
		Terra Nova	693,371	5,149,964	6.3	
		White Rose	727,725	5,186,025	1.3	
	8-hour maximum	Maximum Prediction - Gridded Receptors	695,292	5,156,822	10.9	15,000
		Hibernia	669,419	5,179,807	0.5	
		Terra Nova	693,371	5,149,964	1.5	
		White Rose	727,725	5,186,025	0.4	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
	Annual Average	Maximum Prediction - Gridded Receptors	694,792	5,159,322	0.1	NA
		Hibernia	669,419	5,179,807	5.5E-03	
		Terra Nova	693,371	5,149,964	0.02	
		White Rose	727,725	5,186,025	0.01	
VOCs	1 -hour Maximum	Maximum Prediction - Gridded Receptors	693,792	5,157,072	0.2	NA
		Hibernia	669,419	5,179,807	0.01	
		Terra Nova	693,371	5,149,964	0.03	
		White Rose	727,725	5,186,025	0.01	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	695,292	5,156,822	0.02	NA
		Hibernia	669,419	5,179,807	1.3E-03	
		Terra Nova	693,371	5,149,964	3.4E-03	
		White Rose	727,725	5,186,025	9.5E-04	
	Annual Average	Maximum Prediction - Gridded Receptors	694,792	5,159,322	2.7E-04	NA
		Hibernia	669,419	5,179,807	2.7E-05	
		Terra Nova	693,371	5,149,964	1.1E-04	
		White Rose	727,725	5,186,025	4.9E-05	

Results from the air dispersion modelling for flaring show that the emissions produced from the Platform would meet the stipulated NAAQ Objectives in the short-term and long-term, and in near-field and far-field locations. The maximum grid values present the highest concentrations at any receptor.

6.5.4.2 Greenhouse Gas Emissions

Nearshore

The release of GHGs to the atmosphere from an unplanned or accidental event, including a collision or hydrocarbon spill would represent a short-term emergency situation. In the nearshore, such a release would most likely be related to a fuel spill and possibly related to a fire, and would certainly be small in magnitude, extent and duration, adding a very small amount of GHGs to the total inventory of GHG emissions for the Project.

Offshore

Accidental events that would lead to an unplanned release of GHGs in the Offshore Project Area would include an emergency depressurization to the flare, the rupture of OLS pipelines, subsea blowout or due to a fire resulting from a fuel or hydrocarbon spill. The volume of such emissions would be

small relative to the Project's total GHG inventory, and such emissions would be limited by the specific measures as outlined above in Section 6.5.4.1.

A summary of the potential environmental effects on Air Quality due to accidents, malfunctions and unplanned events attributable to the Project is provided in Table 6-22 (only those activities that result in Project-VEC interactions are included). Emergency Flaring is included as an activity unique to the environmental effects analysis to Air Quality.

Table 6-22 Environmental Effects Assessment: Accidental Events

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Spill (at Bull Arm Site)	• Change in Ambient Air Quality	• Conduct periodic maintenance and repair on vessels • Train personnel in spill prevention and awareness • Oil containment booms	1	3	2/1	R	1
Failure or Spill from OLS	• Change in Ambient Air Quality	• Conduct periodic inspections, maintenance and repair of facilities and equipment • Train personnel in spill prevention and awareness	1	5	2/1	R	2
Subsea Blowout	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Drilling design and geotechnicla surveys • Alert / Emergency Response Contingency Plan	1	5	3/1	R	2
Crude Oil Surface Spill	• Change in Ambient Air Quality	• Conduct periodic maintenance and repair on Platform and vessels • Train personnel in spill prevention • SOPs for oil handling operations	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Ambient Air Quality	• Conduct periodic inspection, maintenance and repair of facilities and equipment • Train personnel in spills management and awareness • SOPs for chemical handling and storage	1	1	2/1	R	2
Collisions (involving Platform, vessel and/or iceberg)	• Change in Ambient Air Quality	• Risk awareness, emergency response and preventative measures, training on fuel handling and storage	1	3	2/1	R	1
Emergency Flaring	• Change in Ambient Air Quality		2	2	1/2	R	2

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effect

A Where there is more than one potential enviromental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

6.5.5 Cumulative Environmental Effects

The ambient air quality in the Study Area reflects the influence of emissions from other projects and activities occurring within or outside the Project Area. Other projects for consideration of cumulative environmental effects include the following:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activities
- Offshore exploration seismic activities
- Marine transportation
- Commercial fisheries

In addition, the North Atlantic Refinery, Newfoundland Transshipment Terminal, construction of the Long Harbour Processing Plant, and proposed Liquefied Natural Gas Transshipment and Storage Terminal and Southern Head Marine Terminal and Associated Crude Oil Refinery projects were considered in the cumulative environmental effects assessment for Air Quality.

Long-range transport of airborne emissions also contributes additional loading to the local airshed from sources located on the eastern seaboard of the United States and Canada, outside of the Study Area; however, these contributions are likely to be on the margin of detection due to the distance from the eastern seaboard to the Offshore Project Area.

6.5.5.1 Nearshore

The cumulative influences of the construction of nearshore components of the GBS with other existing or proposed projects, listed above, have the potential to result in an effect on Air Quality. However, the environmental effects of the air emissions related to the nearshore construction of the GBS are small in relative quantity, small in geographic extent and short in duration.

6.5.5.2 Offshore

Change in Ambient Air Quality

Air dispersion modelling was also conducted to assess the potential environment effects on Air Quality due to the cumulative environmental effects of the existing offshore oil platforms in the area with the operational phase of the Hebron Platform. The cumulative emissions predicted for the first year of operation would be similar to those produced during the offshore construction and installation of the Platform. The same modelling program, meteorological data, receptor grids, source physical characteristics and assumptions were used to model the Project commissioning and operation cumulative scenarios as were outlined in Section 6.5.2.1. The emission rates for each source are presented in Table 6-23.

Table 6-23 Air Dispersion Modelling Emission Rates

Sources	Project - 1st Year of Operation Cumulative				Project - Peak Operation Cumulative				
	NO_x	CO	VOCs	TPM	SO_2	NO_x	CO	VOCs	TPM
Power Generation - Turbine 1	78.3	4.44	0.013	0.39	1.85	39.2	2.22	0.085	.283
Power Generation - Turbine 2	78.3	4.44	0.013	0.39	1.85	39.2	2.22	0.085	0.283
Power Generation - Turbine 3	-	-	-	-	-	39.2	2.22	0.085	0.283
Gas Compression - Turbine 4	-	-	-	-	-	39.2	2.22	0.085	0.283
Gas Compression - Turbine 5	-	-	-	-	-	39.2	2.22	0.085	0.283
Fugitive Emissions[A]	-	-	15.8	-	-	-	-	23.9	-
Flare	1.46	11.67	0.058	-	-	Background Flaring			
Hibernia	34.4	25.3	14.9	6.2	-	34.4	25.3	14.9	6.2
Terra Nova	73.3	23.2	213	6.6	-	73.3	23.2	213	6.6
White Rose	76.8	28.2	9.04	8.47	-	76.8	28.2	9.04	8.47
Fugitive emissions were modelled as a volume source									

The air dispersion modelling results for the cumulative environmental effect of the first year of operation for the Hebron Platform with the other existing oil platforms is presented in Table 6-24.

Table 6-24 Summary of Model Predictions – Maximum Predicted Ground-level Concentrations – Cumulative 1st Year of Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_2	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691, 792	5,157,572	95.7	400
		Hibernia	669,419	5,179,807	7.83	
		Terra Nova	693,371	5,149,964	19.4	
		White Rose	727,725	5,186,025	5.25	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	58.2	200
		Hibernia	669,419	5,179,807	1.38	
		Terra Nova	693,371	5,149,964	3.42	
		White Rose	727,708	5,186,021	0.83	
NO_x (assumed to be NO_2)	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	3.20	100
		Hibernia	669,419	5,179,807	0.03	
		Terra Nova	693,371	5,149,964	0.01	
		White Rose	727,708	5,186,021	0.06	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	693,792	5,157,072	48.8	35,000
		Hibernia	669,419	5,179,807	4.5	
		Terra Nova	693,371	5,149,964	10.7	
		White Rose	727,725	5,186,025	3.3	
	8-hour maximum	Maximum Prediction - Gridded Receptors	695,292	5,156,822	18.8	15,000
		Hibernia	669,419	5,179,807	2.0	
		Terra Nova	693,371	5,149,964	2.5	
		White Rose	727,725	5,186,025	1.4	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.8	NA
		Hibernia	669,419	5,179,807	0.03	
		Terra Nova	693,371	5,149,964	0.1	
		White Rose	727,725	5,186,025	0.06	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	729,292	5,187,572	12.9	NA
		Hibernia	669,419	5,179,807	0.9	
		Terra Nova	693,371	5,149,964	1.0	
		White Rose	727,725	5,186,025	0.8	

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Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
	24-hour Maximum	Maximum Prediction - Gridded Receptors	728,292	5,187,572	1.9	120
		Hibernia	669,419	5,179,807	0.15	
		Terra Nova	693,371	5,149,964	0.2	
		White Rose	727,725	5,186,025	0.1	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.1	70
		Hibernia	669,419	5,179,807	0.005	
		Terra Nova	693,371	5,149,964	0.01	
		White Rose	727,725	5,186,025	0.011	
VOCs[A]	1 -hour Maximum	Maximum Prediction - Gridded Receptors	695,292	5,150,072	1.95	NA
		Hibernia	669,419	5,179,807	0.092	
		Terra Nova	693,371	5,149,964	0.315	
		White Rose	727,725	5,186,025	0.046	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	694,292	5,152,572	0.275	NA
		Hibernia	669,419	5,179,807	0.006	
		Terra Nova	693,371	5,149,964	0.041	
		White Rose	727,725	5,186,025	0.004	
	Annual Average	Maximum Prediction - Gridded Receptors	694,792	5,151,572	0.020	NA
		Hibernia	669,419	5,179,807	0.0002	
		Terra Nova	693,371	5,149,964	0.0007	
		White Rose	727,725	5,186,025	0.0002	
SO_2	1-hour Maximum	Maximum Prediction - Gridded Receptors	691,792	5,157,572	9.05	900
		Hibernia	669,419	5,179,807	0.69	
		Terra Nova	693,371	5,149,964	1.81	
		White Rose	727,725	5,186,025	0.48	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	5.50	300
		Hibernia	669,419	5,179,807	0.099	
		Terra Nova	693,371	5,149,964	0.32	
		White Rose	727,725	5,186,025	0.068	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.299	60
		Hibernia	669,419	5,179,807	0.002	
		Terra Nova	693,371	5,149,964	0.008	
		White Rose	727,725	5,186,025	0.004	

A VOCs are presented in mg/m^3

Results from the air dispersion modelling for the cumulative environmental effect of the first year of operation of the Platform with the existing oil platforms show that the emissions would meet the stipulated NAAQ Objectives for the short-term and long-term, and in near-field and far-field locations.

The air dispersion modelling results for the cumulative environmental effect of peak operation of the Hebron Platform with the other existing oil platforms is presented in Table 6-25.

Table 6-25 Summary of Model Predictions – Maximum Predicted Ground-level Concentrations – Cumulative Peak Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
NO_2	1 -hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,072	169	400
		Hibernia	669,419	5,179,807	10.9	
		Terra Nova	693,371	5,149,964	28.1	
		White Rose	727,725	5,186,025	7.38	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	94.3	200
		Hibernia	669,419	5,179,807	1.76	
		Terra Nova	693,371	5,149,964	5.17	
		White Rose	727,725	5,186,025	1.20	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	6.56	100
		Hibernia	669,419	5,179,807	0.04	
		Terra Nova	693,371	5,149,964	0.15	
		White Rose	727,725	5,186,025	0.08	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	729,292	5,186,072	43.2	35,000
		Hibernia	669,419	5,179,807	3.8	
		Terra Nova	693,371	5,149,964	6.4	
		White Rose	727,725	5,186,025	3.6	
	8-hour maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,072	33.4	15,000
		Hibernia	669,419	5,179,807	2.2	
		Terra Nova	693,371	5,149,964	1.8	
		White Rose	727,725	5,186,025	1.2	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	1.5	NA
		Hibernia	669,419	5,179,807	0.02	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
		Terra Nova	693,371	5,149,964	0.1	
		White Rose	727,725	5,186,025	0.05	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	729,292	5,157,572	12.9	NA
		Hibernia	669,419	5,179,807	224	
		Terra Nova	693,371	5,149,964	764	
		White Rose	729,292	5,157,572	12.9	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,792	5,157,572	2.7	120
		Hibernia	669,419	5,179,807	12.9	
		Terra Nova	693,371	5,149,964	99.4	
		White Rose	727,725	5,186,025	9.0	
	Annual Average	Maximum Prediction - Gridded Receptors	692,792	5,157,572	0.2	70
		Hibernia	669,419	5,179,807	0.006	
		Terra Nova	693,371	5,149,964	0.01	
		White Rose	727,725	5,186,025	0.01	
VOCs[A]	1 -hour Maximum	Maximum Prediction - Gridded Receptors	695,292	5,150,072	2.94	NA
		Hibernia	669,419	5,179,807	0.14	
		Terra Nova	693,371	5,149,964	0.477	
		White Rose	727,725	5,186,025	0.069	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	694,292	5,152,572	0.416	NA
		Hibernia	669,419	5,179,807	0.008	
		Terra Nova	693,371	5,149,964	0.062	
		White Rose	727,725	5,186,025	0.006	
	Annual Average	Maximum Prediction - Gridded Receptors	694,792	5,151,572	0.031	NA
		Hibernia	669,419	5,179,807	0.0002	
		Terra Nova	693,371	5,149,964	0.001	
		White Rose	727,725	5,186,025	0.0003	

A VOCs are presented in mg/m^3

Results from the air dispersion modelling for the cumulative environmental effect of peak operation of the Platform with the existing oil platforms, show that the emissions would meet the stipulated NAAQ Objectives for the short-term and long-term, and in near-field and far-field locations.

Greenhouse Gases

The cumulative environmental effect of the release of GHGs during the operational phase of the platform with the operation of the existing production platforms was assessed in terms of preparing an emissions inventory of GHGs and comparing that to the national total.

The Project will emit GHGs (including CO_2, N_2O, and CH_4) from power generation, gas combustion, non-routine flaring and vessel and helicopter traffic. The individual contributions of GHGs from each of the existing platforms in the area and the Hebron Platform, as well as their combined contribution, and the national total are presented in Table 6-26.

Table 6-26 Cumulative Greenhouse Gas Emissions

Facility	Greenhouse Gas Emissions (tonnes CO_2eq per year)		
	CO_2	N_2O	CH_4
Hibernia	556,231	4,557	34,960
Terra Nova	576,456	10,597	31,274
White Rose	515,691	9,796	30,047
Hebron	549565	8300	38,604
Provincial Total	5,140,424	35,955	97,037
National Total	247,400,881	4,897,951	7,983,044
Percent Contribution of the Hebron Project to National Total	0.22%	0.17%	0.48%
Source: Rolls-Royce Marine 1991; US EPA 2000; Sikorsky 2007; Environment Canada 2009b; EMCP unpublished data			

As displayed in Table 6-26, the percent contribution of GHGs from the operation of the Hebron Platform to the overall national total is substantially small in magnitude.

Once in operation, the Project will report annual emissions of CACs and greenhouse gases to Environment Canada under the NPRI and the National GHG Reporting schemes, as well as meet the reporting requirements pursuant to the Offshore Waste Treatment Guidelines.

6.6 Determination of Significance

The determination of significance is based on the definition provided in Section 6.4. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect, and their interactions, as presented in the preceding analysis.

6.6.1 Change in Air Quality

Overall, as demonstrated by the preceding analysis, the change in air quality attributable to the Project is expected to be low to medium in magnitude, local in extent, and short term in duration. Components associated with all phases of the Project, including power generation, compression equipment, fugitive releases and non-routine flaring, as well as accidental releases and

cumulative environmental effects, will result in emissions that will not frequently exceed applicable ground-level NAAQ Objectives. Adverse effects on air quality that could occur as a result of an accidental release of large amounts of raw gas through a blowout or pipe break could only occur in an event that is considered extremely unlikely.

Therefore, by implementing appropriate mitigation measures, the environmental effects on Air Quality during the construction, operations and decommissioning phases of the Project, including accidental and cumulative environmental effects, is predicted to be not significant. A summary of the environmental effects for a change in air quality is provided in Table 6-27.

Table 6-27 Residual Environmental Effects Summary: Change in Ambient Air Quality

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Effects	NS	3	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
N/A = Not Applicable

A As determined in consideration of established residual environmental effects rating criteria.
B Includes all Bull Arm activities, engineering, construction, removal of the bund well, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

6.6.2 Greenhouse Gas Emissions

With respect to a change in GHG emissions, the magnitude is ranked as medium for both the construction and operations phases; however, the emissions are consistent with those currently being reported for other similar facilities in the same locale. The geographic extent is provincial, national and ultimately, global. The duration is short-term during construction and continues for the full period of operations. Nevertheless, it is not yet possible to determine the effect of these emissions on climate change. In the unlikely event of a large-scale accident or malfunction, the Project's GHG emissions will be temporarily increased.

Therefore, the Project-related change in GHG emissions, including accidental events, and the potential cumulative change in GHG emissions is rated as not

significant. There is moderate level of confidence in this significance prediction due to the evolving nature of climate change science and the contributions of anthropogenic greenhouse gases to climate change. A summary of the environmental effects for a change in GHG is provided in Table 6-28.

Table 6-28 Residual Environmental Effects Summary: Greenhouse Gas Emissions

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	2	N/A[1]
Operation and Maintenance	NS	2	N/A
Decommissioning and Abandonment[C]	NS	2	N/A
Accidents, Malfunctions and Unplanned Events	NS	2	N/A
Cumulative Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
N/A = Not Applicable

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund well, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
1 Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

6.7 Follow-up and Monitoring

In the Operations and Maintenance Phase, there is no suggested follow-up or monitoring required for Air Quality. The Project will adhere to proactive maintenance scheduling and procedures to monitor and reduce factors such as corrosion, vibration, mechanical wear and fatigue. During the operation of the facility, compliance with environmental regulatory requirements and standards and emissions of CACs and GHGs will be documented annually and submitted as required by federal government reporting program.

Emission estimates are based on vendor specifications and EPA guidance. The values estimated will be validated against vendor guaranteed emissions performance data, which can only be obtained once the equipment is purchased. Once in operations, the Hebron Project will be required to report annually to the NPRI, and will do so using industry standard reporting procedures (i.e., CAPP guidance on NPRI reporting; CAPP 2007-0009). This will also serve to validate the emission estimates used in the CSR.

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7 FISH AND FISH HABITAT

The Fish and Fish Habitat Valued Ecosystem Component (VEC) includes fish, shellfish, benthos, plankton, water and sediment. These components are intrinsically related to one another and together they allow a holistic approach to the assessment of potential environmental effects of the Project on the marine environment. As well as its ecological significance, the Fish and Fish Habitat VEC is directly linked to the commercial fishery and, therefore, is of social, economic and cultural significance.

7.1 Environmental Assessment Boundaries

7.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Chapter 4). The Study areas and Project areas are illustrated in Figures 7-1 and 7-2, for the nearshore and offshore, respectively. The Affected Areas for relevant Project activities have been determined by modelling (see AMEC 2010, ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

7.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are summarized in Table 7-1.

Table 7-1 Temporal Boundaries of Nearshore and Hebron Offshore Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

7.1.3 Administrative

Marine fish and fish habitat are protected in Canada primarily through the Fisheries Act. Fisheries and Oceans Canada (DFO) has overall responsibility for the administration of the Fisheries Act. Fish habitat is protected under the Fisheries Act and by the Policy for the Management of Fish Habitat (DFO 1986). This policy applies to all projects and activities in or near water that could “alter, disrupt or destroy fish habitat by chemical, physical, or biological means.” The guiding principal of this policy is to achieve no net loss of the productive capacity of fish habitats. Environment Canada administers

Section 36 of the *Fisheries Act*, which prohibits the deposit of a deleterious substance in waters frequented by fish.

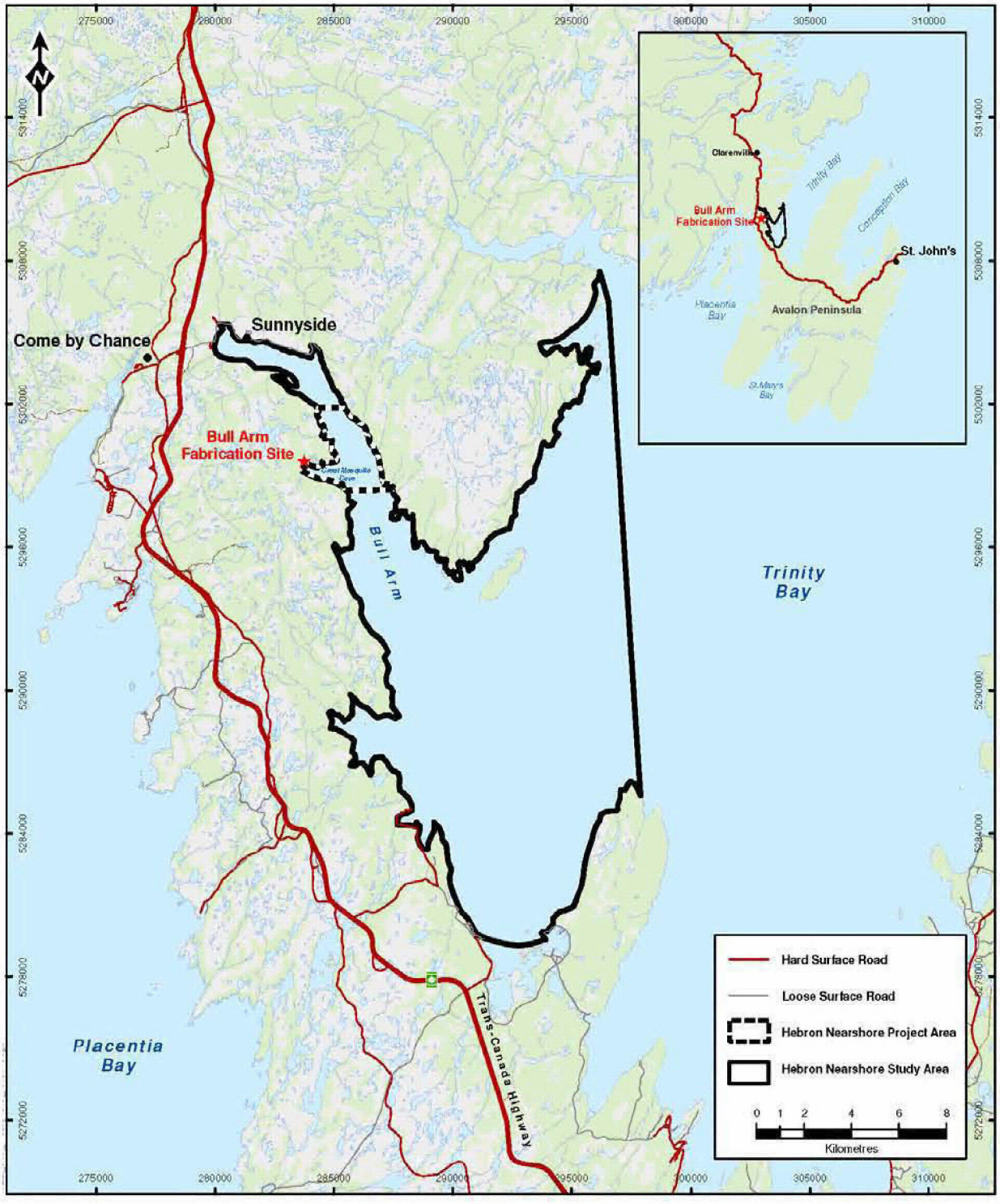

Figure 7-1 Hebron Nearshore Study and Project Areas

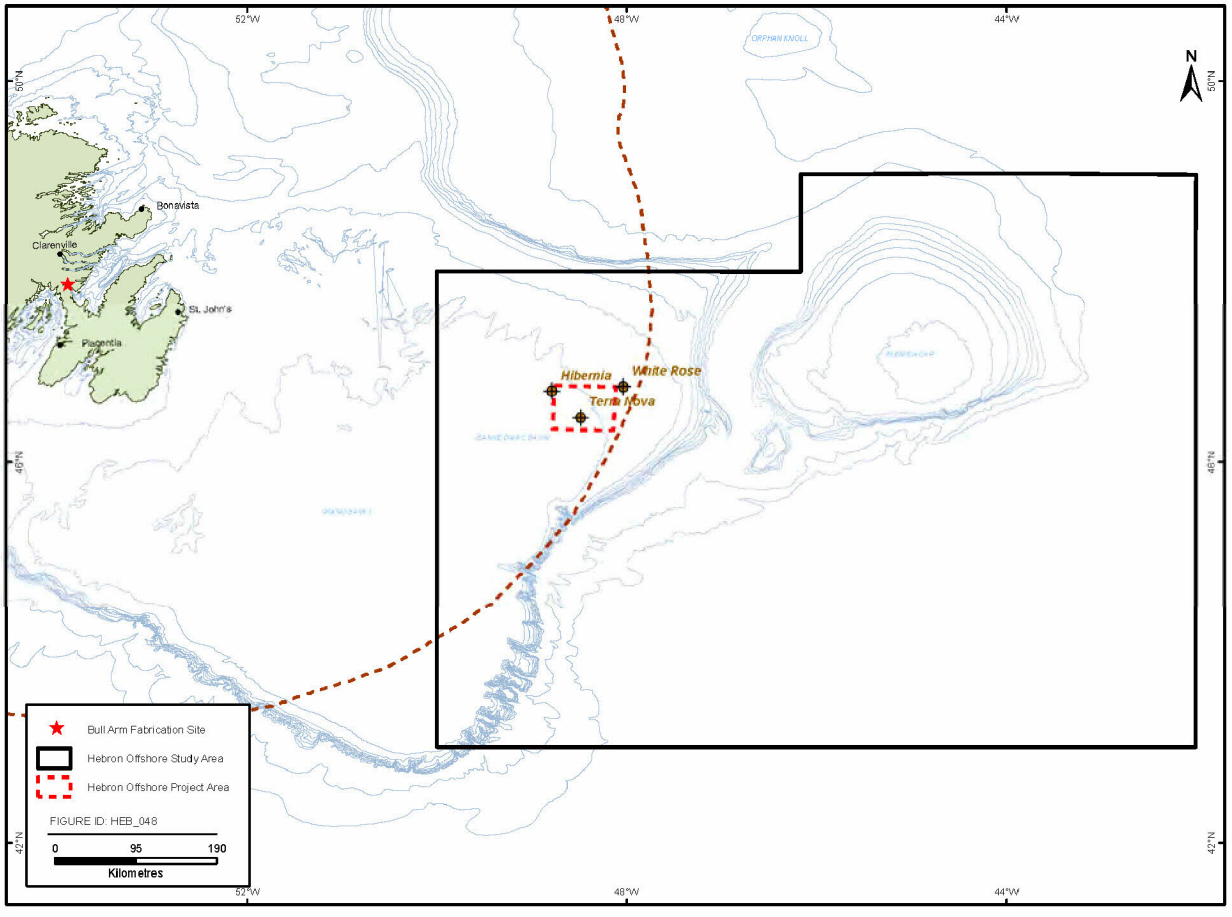

Figure 7-2 Hebron Offshore Study and Project Areas

7.2 Definition of Significance

A significant adverse residual environmental effect is one that affects fish and/or fish habitat resulting in a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

For potential environmental effects on marine fish habitat, a significant adverse residual effect would be one that results in a harmful alteration or disruption or destruction of fish habitat that is so large and/or the fish and fish habitat is of such importance that it cannot be adequately compensated.

An adverse environmental effect that does not meet the above criteria is evaluated as not significant.

7.3 Existing Conditions

Within the Nearshore Study Area, several fish and fish habitat baseline and EEM surveys from 1991 were conducted as part of the Hibernia Gravity Base Structure (GBS) construction project. Since then, an ocean disposal

monitoring survey was conducted in Great Mosquito Cove (Lee 2005) and an extensive fish and fish habitat survey of Great Mosquito Cove was conducted for the Hebron Project in August 2009. Several researchers from Memorial University and DFO have conducted studies on fish and fish habitat within the Nearshore Study Area and those primary scientific papers were also used to compile existing information.

Site-specific fish and fish habitat data were collected from the Hebron Offshore Study Area during surveys in 2001 (Chevron 2002, 2003). These data are complemented by Environmental Effects Monitoring (EEM) survey data collected by operators of adjacent offshore oil and gas projects since 1994, and by several descriptions of existing conditions for marine fish and fish habitat for other environmental assessments overlapping with the Hebron Offshore Study Area. DFO Research Vessel (RV) data from 3Lt have also been reviewed along with relevant fish and fish habitat primary literature for the Hebron Offshore Study Area.

While reviewing information on fish and fish habitat, it is important to note that stock assessment surveys are snapshots in time and space since fish tend to continually move in and out of certain areas.

7.3.1 Nearshore

The primary components of the marine ecosystem in nearshore coastal environment are phytoplankton, zooplankton (including ichthyoplankton), benthos, macroinvertebrates (e.g., scallop, crab), fish, marine birds and waterfowl and marine mammals. A description of the physical environment within the Nearshore Study Areas is provided in Section 3.1.

The following description of the fish and fish habitat within the Nearshore Study Area makes preferential use of site-specific information when the information is available; otherwise, a summary of information available for fish and fish habitat in the Newfoundland coastal environment as a whole is provided.

7.3.1.1 Nearshore Physical Environment Overview

Trinity Bay, on the northern Avalon Peninsula of Newfoundland, is a deep embayment with water depths greater than 200 m (Figure 7-1). Relatively stable thermal stratification of the water is expected during the summer. Lear and Pitt (1971) determined that the influence of the Labrador Current was indicated in the Bay by the presence of bottom waters with low temperatures (below 0°C) equivalent to those found along the Continental Slope. Bull Arm is an inlet approximately 6 km long and 0.3 km wide running north-south from the body of Trinity Bay. The town of Sunnyside lies at the head of Bull Arm. Bull Arm is relatively deep with water depths of up to 100 m in the middle and 150 to 180 m near the mouth. The nearshore of Bull Arm slopes fairly gradually along the shoreline to depths ranging from 9 to 27 m. The coastline approaching Great Mosquito Cove drops sharply to depths of 30 to 88 m. The coastline of the Bull Arm area is predominantly steep bedrock, with many jagged outcrops, and shore line energies range from low to moderate wave

energy environment. The seabed in Bull Arm tends to be rocky in the outer portions, with mud and sand predominating in the inner harbour (Department of Development 1981). There are no major rivers draining into Bull Arm and no scheduled salmon rivers running into Bull Arm.

There is considerable annual variation in sea ice cover in Trinity Bay. Ice conditions are dependent on the supply of ice and icebergs from the north, winter and spring air temperatures in the northwestern Atlantic region and the direction of prevailing winds during the ice season. Easterly winds frequently cause Trinity Bay to be filled with offshore pack-ice, with subsequent intrusions into Bull Arm (Davidson 1985). A season of heavy ice in Trinity Bay can delay the warming of the surface waters and scour intertidal habitat and clear an area of perennial kelp and invertebrate species.

The maximum tidal variation is approximately 1 m at the entrance to Bull Arm and a probable variation of 1.5 m at the head of the Arm. MacDonald and Thompson (1985a, 1985b) documented yearly temperature cycles in Bull Arm, near Sunnyside, and noted thermal stratification may occur at shallow depths (10 to 30 m) during spring and summer. In winter, the water column is fairly homogenous at -1.5°C to -1.0°C. In the summer months, surface water temperatures may rise to 15°C. The outer portion of Bull Arm is subject to 1.5 m waves generated by southeasterly to easterly winds. Exposure is reduced proceeding inward up the arm towards Sunnyside, resulting in a low to moderate exposure.

7.3.1.2 Habitat

A more recent remotely operated vehicle (ROV) survey in August 2009 (EMCP 2011) revealed that fine material was a frequent surficial substrate observed in the cove, switching to gravel and cobble towards the outer section of the cove (see Figure 7-3). The fine material was generally found in the central areas of the cove in deeper water, which is approximately 50 to 60 m in the inner area of the cove and 100 to 110 m in the middle area of the cove. The deepest areas in the outer cove reach a water depth of approximately 200 m, but on average is approximately 110 m. Benthic habitat with solid substrate was generally observed more towards the shore and may be comprised of boulder and rubble and/or mixed with gravel and cobbles. Habitat with bedrock substrate was most common in the outer section of the cove towards the north shore and covered approximately 15 percent of the seafloor.

The benthic macroflora were relatively sparse overall and ranged in cover from approximately 2 to 11 percent of the seafloor (Stantec 2010c). Sour weed (Dictyosiphon sp.) was the predominate species but decreased towards the outside area of Great Mosquito Cove where it was observed in equal proportion with sea colander (Agarum cribrosum) and to some extent the brown seaweed Laminaria longicruris. The sessile benthic macrofauna observed in the ROV transects included sea urchins (Stronglyocentrotus droebachiensis), which were the most common, followed by seastars, sea anemones and scallops. Species diversity was more pronounced on hard substrate such as boulder, rubble, cobble and gravel.

Winter flounder (Pseudopleuronectes americanus) and cunner (Tautogolabrus adspersus) were the principle fish encountered during the benthic habitat ROV survey in August 2009. The cunner was the most frequently observed fish and was equally observed among all types of substrate. Winter flounder were observed mostly on fine substrate, but were also observed on hard substrate towards the outer area of the cove. Atlantic wolffish, a federally listed Species at Risk (Schedule 1, special concern), was identified in Great Mosquito Cove during the ROV habitat surveys in August 2009. They were observed at a depth of approximately 35 m, in areas of 80 to 90 percent boulder habitat, which has been identified as potential spawning habitat (Barsukov 1959; Keats et al. 1985; Kulka et al. 2007).

A fish habitat assessment conducted in Great Mosquito Cove in November 1989 (LeDrew, Fudge and Associates 1990) noted that there were three fish habitats type identified by SCUBA surveys and one from camera photographs (based on Moyle and Cech 1982) within Great Mosquito Cove: nearshore rocky bottom; nearshore soft bottom; kelp beds; and deep-water rocky bottom. Three fish habitat types were identified in Great Mosquito Cove during marine baseline surveys (Mobil Oil 1990). The communities were described as:

- A shallow water (≤10 m depth), rocky bottom community dominated by polychaetes (fringed worms (Dodecaceria concharum) and paddle worms (Eulalia viridis)), chiton (Tonicella rubra), gastropods (limpets (Acmaea testudinalis) and Puncturella noachina), aeolidoid nudibranchs, and echinoderms (green sea urchin, daisy brittle star (Ophiopholus aculeata) and boreal sea star (Asterias vulgaris))
- A nearshore midwater (10 to 12 m depth) community characteristic of mixed substrates and dominated by nematodes, polychaetes (scale worms (Pholoe minuta), Microphthalmus sczelkowii and Harmothoe imbricate) and thread worms (Mediomastus ambizeta and Lumbrineris sp.)), cockles (Cerastoderma pinnulatum), harpacticoid copepods (Laophonte horrid, Ectinosoma sp., and Arthropsyllus serratus), unidentified cytherid ostracods, cumacean (Diastylis rathkei), and gammarid amphipods (Orchomenella minuta and Corophiium bonelli)
- A deepwater (>40 m depth) community characterized by a silty substrate and dominated by polychaetes (Gyptis vittata, Prionospio steenstrupi, Aglaopphamus neotenus, Cossura longocirrata, syllid species and unattached serpulids), pelecypods (Crenella glandula and Thyasira gouldi), cytherid ostracods, and cumacean (Leucon sp.)

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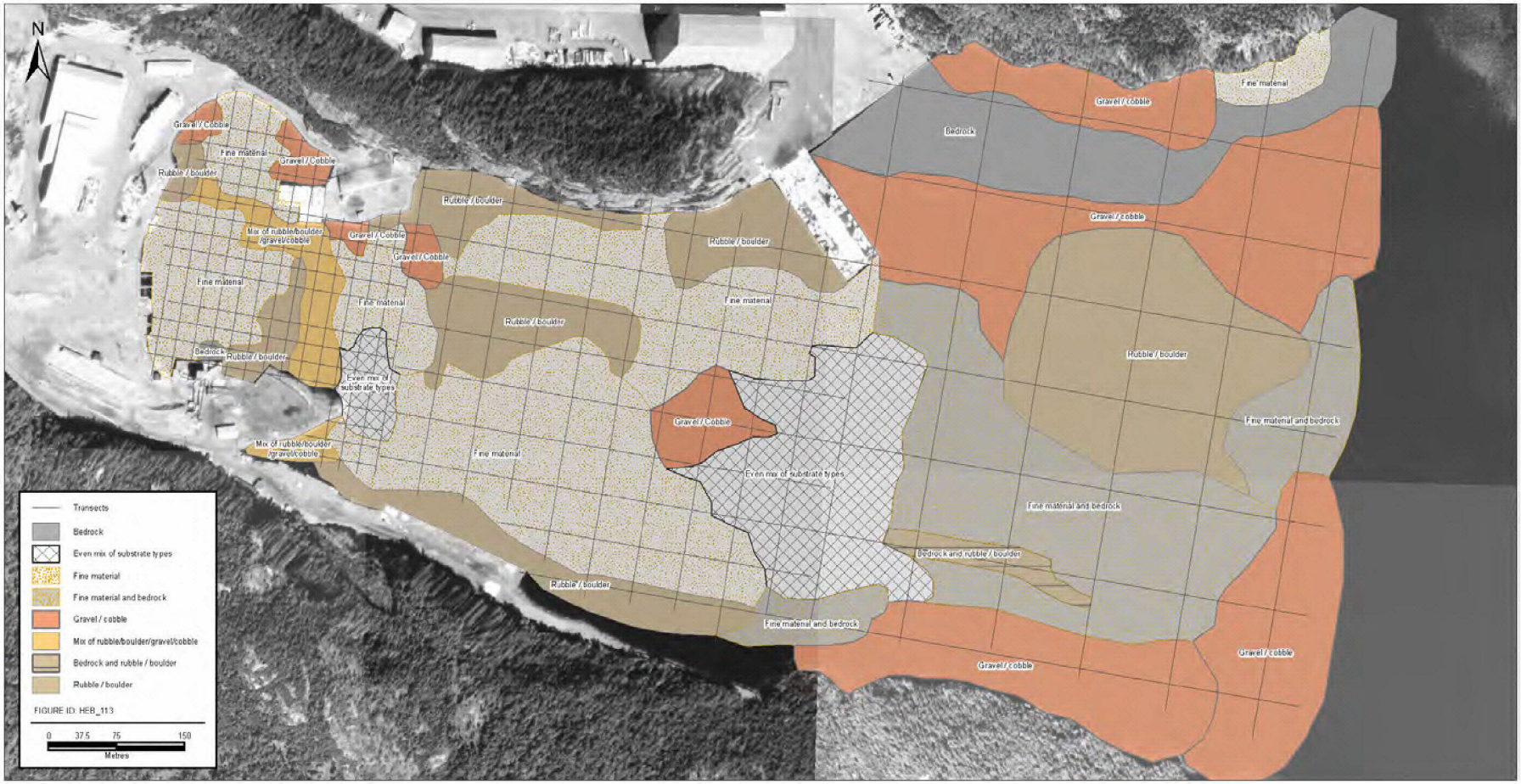


Figure 7-3 Marine Habitat Survey, Great Mosquito Cove, Trinity Bay - Location Of Hebron GBS Construction

The nearshore rocky habitat (or shallow water rocky bottom community as described in Mobil Oil 1990) was described as comprised of shallow waters generally less than 10 m in depth with steep slopes of loosely associated boulder and gravel with bedrock outcrops. This habitat type was found bordering the north and south shoreline of great Mosquito Cove (LeDrew, Fudge and Associates 1990). The 2009 fish habitat survey (EMCP 2011) concurred with this assessment having found benthic habitat with solid substrate was generally observed more towards the shore, which may be comprised of boulder and rubble and/or mixed with gravel and cobbles. Bedrock substrate was most common in the Outer Area of the cove towards the north shore, which covered approximately 15 percent of the seafloor (EMCP 2011). The shoreline in Great Mosquito Cove is primarily comprised of hard substrate, the majority of which is anthropogenic (fill, concrete dock, and rip rap shoreline units) in the Inner and Middle Areas of the cove (EMCP 2009). Bedrock cliffs are dominant and mainly present along the north shore of the cove. The width of the shore and intertidal zone is relatively narrow because of the steep ramping of the shoreline and generally ranges from 2 to 5 m. The predominant macroflora observed along the shoreline is rockweed when present in the intertidal zone; with periwinkles the most common macrofauna observed along the shoreline followed by sea urchins, mussels and anemones (EMCP 2011).

Nearshore rocky habitats in Trinity Bay are typically covered with kelp and coralline algae. Mussels, periwinkles (Littorina spp.), whelks (Colus spp.), urchins, brittle stars, hermit crabs (Pagurus spp.), rock crabs and sea stars are the most common macro-invertebrate species. Vegetation decreases with increasing depth, but patches of kelp and filamentous algae occur. The most common macro-invertebrates nearshore are sea urchins, sand dollars (Echinarachnius parma) and rock crabs.

Coralline algae play an important role in nearshore ecology as habitat for invertebrates, as a food source for a variety of gastropods (Mandeveldt et al. 2006) and by limiting the re-colonization of kelp species that have been harvested by urchins (Bulleri et al. 2002; Bulleri and Benedetti-Cecchi 2006). The attraction of invertebrates to coralline algae beds results in the attraction of fish to feed in these areas. There has been little study of the role of coralline algae as fish habitat in the western North Atlantic.

In nearshore rocky habitats, the common finfish species are gunnels (Pholis nebulosa), shannies (Ulavaria subbifurcata) and cunners (Tautogolabrus adspersus). American lobster (Homarus americanus) are commercially fished from these habitats.

The nearshore soft bottom habitat (most likely corresponds to the deepwater community described in Mobil Oil 1990) observed in Great Mosquito Cove in 1989 (LeDrew, Fudge and Associates 1990) was described as level bottomed, barren with gravel, sand and silt substrate at depths greater than 10 m. It was noted that this habitat was relatively featureless with scattered small patches of kelp and included observations of sculpins and winter founder (Pseudopleuronectes americanus). The 2009 fish habitat survey found that cunner and winter flounder were the principle fish encountered

during the benthic habitat survey (EMCP 2011) and were equally observed among all types of substrate. Winter flounder were observed mostly on fine substrate in the Inner and Middle Areas of the cove, but were also observed on hard substrate in the Outer Area of the cove.

At water depths beyond 10 m on soft substrates, winter flounder and various sculpin species are common; sea scallops occur in patches. Commercial fisheries in these habitats may include capelin (Mallotus villosus), herring (Clupea harengus), mackerel (Scomber scombrus), winter flounder, lumpfish (Cyclopterus lumpus) and lobster.

The kelp beds noted in LeDrew, Fudge and Associates (1990) was described as level-bottom dense kelp stands at depth greater than 10 m. They noted the areal extent of the kelp stands in Great Mosquito Cove is unknown. The 2009 fish habitat survey noted that benthic macroflora were relatively sparse covering two, 11 and 9 percent of the seafloor in the Inner, Middle, and Outer Areas of Great Mosquito Cove (EMCP 2011). Sea colander accounted for 39 percent of the macroflora in the Middle Area and was the dominant species at 66 percent in the Outer Area. Laminaria longicruris was mainly observed in the Middle Area of the cove and comprised 22 percent of the macroflora present in this area (EMCP 2011).

In addition to macroflora species that can be considered to be associated with "kelp beds," sour weed was the predominate species and comprised 98 percent of the macroflora in the Inner Area of the cove and was commonly observed on fine material, but also less common on hard substrate. The percentage of sour weed in the Middle and Outer Areas of the cove was 39 and 33 percent, respectively.

Based on information from deep-sea camera photographs and grab samples (LeDrew, Fudge and Associates 1990), the fourth bottom type described is for a deep-water rocky bottom at depths greater than 15 m. They noted that the extent of this habitat is unknown.

The fish habitat survey conducted in 2009 noted that sessile benthic macrofauna observed in Great Mosquito Cove included sea urchins, which were the most common macrofauna, followed by starfish, sea anemones and scallops, and were generally observed on hard substrate, but were also observed on fine substrate. Species diversity was more pronounced on hard substrate such as boulder, rubble, cobble and gravel (EMCP 2011). Much of the substrate associated with the above species would fall into the deep water rocky bottom or the deeper depths of the nearshore rocky bottom habitat.

Sea scallop (Placopecten magellanicus) and blue mussel (Mytilus edulis) beds have been recorded for the inner portions of Bull Arm (Osborne and Roberts 1983). An October 1989 survey of shellfish habitat in Great Mosquito Cove revealed no large beds of blue mussels (Newfoundland Geosciences Limited 1990). Adult sea scallops occurred sporadically in Great Mosquito Cove, but were more common along the southern shoreline.

In Bull Arm, the following species of finfish are commonly found and commercially fished (DFO Coastal Resource Inventory website (DFO 2009c), accessed October 2009): cod (Gadus morhua) (described in detail in

Section 11.3.1.1), capelin, herring and mackerel. Greenland halibut (Reinhardardtius hippoglossoides) may be present in deeper water (200 to 300 m) outside Bull Arm. Other species include wolffish (described in detail in Section 11.3.1.4), eelpout (Lycodes sp.), lumpfish, skate (Raja sp.) and cunners. As reported by fishers in the area, Great Mosquito Cove and "The Brood" in Bellevue are locally known as spawning grounds for herring.

Of particular interest and note is that the Atlantic wolffish, a federally listed Species at Risk (Schedule 1, Special Concern; see Section 11.3.1.4), was identified in Great Mosquito Cove to the south of the Outer Area during the ROV habitat surveys in August 2009. They were observed at a water depth of approximately 35 m, in 80 to 90 percent boulder habitat, which has been identified as potential spawning habitat (Barsukov 1959; Keats et al. 1985; Kulka et al. 2007).

7.3.1.3 Plankton

Profiles of chlorophyll pigments in the water column are good indicators of phytoplankton biomass. Coastal bay areas of Newfoundland typically undergo phytoplankton blooms in the spring and during September and October, resulting in high levels of pigments in surface waters. In September and October of 1981, MacDonald (1984) noted an increase in surface water chlorophyll levels to a value 2.5 µg/L, characteristic of similar values for spring bloom conditions for the Sunnyside area.

Chlorophyll values for October at 20 m water depth ranged from 0.75 to 1.3 µg/L. The lower chlorophyll a values in November may reflect a downward transport of phytoplankton over time by current or wind mixing, hence the lower levels of phytoplankton in surface waters. Surface chlorophyll a values (0 to 5 m) for the deepwater stations are relatively high, with markedly lower values of 0.012 to 0.037 µg/L at depths of 118 to 172 m. These lower values at increased depth suggest that phytoplankton productivity in the surface layers has not been transported to the deeper water layers in Bull Arm.

During a fall survey in Great Mosquito Cove, chlorophyll values ranged from 0.105 to 0.809 µg/L at surface, mid-water and near-bottom depths (Newfoundland Geosciences Limited 1990). These chlorophyll values correspond well to samples from water 7 to 10 m deep near Sunnyside in November (MacDonald 1984). Total photosynthetic pigment did not increase markedly with depth, suggesting a lack of stratification in the water column and vertical mixing of nutrients in the fall months. As summer progress, it is likely that the water column does become stratified and chlorophyll concentrations increase with depth.

A distinct spring bloom has been observed near Sunnyside during April and May, with chlorophyll a values as high as 5.5 µg/L at 10 m. Chlorophyll a concentrations were generally higher in shallow water sites (MacDonald and Thompson 1985a, 1985b).

7.3.1.4 Fish and Shellfish

The following species profiles have been provided for those fish and shellfish expected to occur within the Nearshore Study Area and are considered ecologically and/or commercially important. These species are widely distributed and are not unique to the Study Area. Fish species considered at-risk are described in Section 11.3.1.

Cunner

Cunners (a.k.a., conner) range from Newfoundland to New Jersey and can occur from intertidal to 100 m water depths (Scott and Scott 1988). Multiple age classes of cunners congregate in shallow nearshore outcrop and boulder habitats, in areas of up to 20 m deep.

Cunners tend to become docile at night and move into nearby crevices. During the winter they are dormant for five or six months and retreat to deep crevices or under rocks until the spring (Green and Farwell 1971). Curran (1992) found that cunner stop feeding for up to six months when water temperature reaches levels that induce torpor and hibernation (approximately 5°C).

Spawning occurs in late July and August in Nova Scotia and eggs are pelagic for approximately three weeks (Tupper and Boutilier 1997). Spawning in Bull Arm likely occurs several weeks later than Nova Scotia. Newly settled cunners are more abundant on shallow, rocky or shell fragment substrates, with or without eelgrass (Tupper 1994). There is no evidence of active habitat selection by newly settled cunner (Auster 1989). Differences in population density between habitats are attributed to post-settlement mortality, rather than emigration. Recruitment success was found to be highest from juveniles settling on rocky reefs, followed by cobble habitats and eelgrass. Recruitment from sand substrates was reportedly zero (Auster 1989). Juvenile cunners feed on amphipods, isopods, zooplankton and small benthic epifauna (Levin 1994). After settlement, cunners have limited home ranges for the first one or two years (Tupper 1994). Juveniles even remain near their nursery area over winter, as opposed to the adults who migrate to deeper offshore waters.

As with the juveniles, adult cunner (age one year and older) are most abundant on reefs, cobble and within eelgrass, respectively, but absent from sand substrates (Auster 1989). The adult cunner's home range is limited to several hundred metres (Green 1975). Adult cunner feed on benthic invertebrates like mussels, barnacles, clams, amphipods and juvenile lobsters. They likely compete directly with lobster, crabs and starfish for mussels as prey (see Auster 1989). Various sculpin species are the primary predators of cunner (Auster 1989).

Capelin

Offshore Newfoundland, capelin generally occur in water depths between 30 and 100 m during the winter until they undergo their spawning migration. In spring or summer, capelin migrate in surface water into bays to spawn on

beaches or in deeper waters of up to 125 m offshore. Beach spawning of capelin occurs when water temperatures are in the range of 6°C to 10°C, on gravel substrates ranging from 5 to 25 mm in diameter. Beach spawning is more prevalent at night. Capelin are able to spawn at the age of two; males usually die following spawning.

Spawning may occur in particular areas each year or appear sporadic. The exact time of spawning may be a function of annual water temperature. Spawning lasts four to six weeks, and usually occurs between May and July. Females produce as many as 50,000 eggs at one time. Males tend to spawn more than once during their reproductive season. Eggs attach to the substrate and remain in the sediment between 14 and 52 days, depending on temperature, but last approximately 15 days at 10°C (Scott and Scott 1988).

Upon hatching, capelin larvae remain in the sediment until the right conditions occur (i.e., onshore wind). If these conditions do not occur within five days, the yolk sac is depleted and the chance of survival is poor. If there is an onshore wind during this period, emergence of the larvae occurs and capelin leave the beach. It is a very critical period for the capelin larvae because they can fall prey to any organism that feeds on plankton. Capelin larvae are passive drifters nearshore during the summer months, but become more active swimmers and make their way to deeper water offshore by autumn (see Scott and Scott 1988).

Capelin feed on zooplankton, especially copepods and euphausiids, in the pre- and post-spawning season and eat very little near spawning time (Scott and Scott 1988). Adult capelin are an integral link in the marine food web between plankton and many vertebrates. They are prey for a wide variety of species of fish, marine birds, and baleen whales. Capelin spawning habitat is delineated in Section 12.3.1.2.

Winter Flounder

Winter flounder or “blackback” occurs from central Labrador to Georgia (Scott and Scott 1988). They are an inshore shallow-water species preferring soft to moderately hard substrates (Scott and Scott 1988). Juveniles and young adults inhabit shallower water. Most winter flounder undergo a season migration to deeper waters in the fall and return to nearshore shallow waters in May and June to spawn (Scott and Scott 1988), although the seasonal migration may not be triggered by temperature alone (see Pereira et al.1999). Feeding migrations have also been reported from Newfoundland (Keats 1990). Mass movements of winter flounder have been reported due to habitat disturbance. Van Guelpen and Davis (1979) found that winter flounder move from the shallow nearshore waters to deeper water during storm events, possibly to avoid the interference of suspended sediments with feeding (Pereira et al.1999).

Flounder eggs are demersal and adhesive, so inshore, the eggs settle in clumps on sand substrates in less than 5 m of water (Pereira et al. 1999). Their eggs appear to have a wide salinity and temperature tolerance, with optimal hatching success in waters ranging in salinity from 10 to 30 ppt and in

temperature from 3°C to 15°C (see Pereira et al. 1999). Hatching can occur within two to three weeks, depending on temperature, and the pelagic larvae settle out approximately eight weeks after hatching (Fahay 1983). Spawning tends to occur in areas where egg and larval dispersal by currents is limited. It has been concluded by several researchers that spawning adults choose to spawn in habitat suitable for larval settlement (see Pereira et al. 1999). In other words, spawning and nursery habitats overlap or are adjacent. Several studies have reported that highest densities of newly settled winter flounder occurred on muddy substrates (see Pereira et al. 1999).

Winter flounder are considered opportunistic feeders, cued visually by moving benthic invertebrates. Winter flounder are attracted by the most abundant and active epibenthic species (Carlson et al. 1997). Flounder feed primarily on benthic invertebrates (Keats 1990), especially polychaetes and amphipods (Carlson et al. 1997), but they also eat molluscs, capelin eggs and fish (Scott and Scott 1988).

Greenland Halibut

Greenland halibut (a.k.a., turbot) thrive in the cold, northern waters. In the northwestern Atlantic, they are especially abundant in the deep coastal bays or fjords of West Greenland, off the Continental Shelf of Baffin Island and in the Ungava Bay area of Hudson Strait. They are also found at greater depths along the Continental Slope of Labrador, and in the deepwater bays of northeastern Newfoundland. Upon approaching maturity, there appears to be a general migration to Davis Strait. They are fished commercially within the Nearshore Study Area (DFO Coastal Resource Inventory website (DFO 2009c), accessed October 2009).

Small fish (less than 20 cm in length) feed on plankton and shrimp-like crustaceans, while larger fish (up to 80 cm) in the southern Labrador and Newfoundland areas eat mainly capelin. Those that swim in the deep channels of northern Labrador and West Greenland live mainly on shrimp. Very large halibut feed heavily on larger fish such as squid, cod, redfish (Sebastes spp.) and even other Greenland halibut.

Greenland Halibut can be found at depths ranging from less than 100 m to deeper than 1,500 m. While most are caught near the sea bottom at depths of between 200 to 600 m, they can be found at all depths.

See Section 7.3.3.5 for more details on the life history of Greenland Halibut.

Herring

In the northwest Atlantic, herring occur from southern Labrador to Cape Hatteras (Scott and Scott 1988). Herring are commercially fished in Trinity Bay in the spring and the fall (see Section 8.1.5). Herring move into the bays in the spring to spawn and feed and move to deep water to over-winter, possibly within Trinity Bay (see Chapter 5).

Great Mosquito Cove and an area known as The Brood near Bellevue, are locally known as spawning areas for herring. Herring are demersal spawners,

depositing their eggs on stable substrates in high energy environments with strong tidal currents (Iles and Sinclair 1982, in Stevenson and Scott 2005). Spawning can occur on offshore banks at depths of 40 to 80 m; however, most herring stocks spawn in shallow coastal waters at depths of less than 20 m. Masses of herring eggs attach to the hard bottom substrate nearshore or to kelp leaves. Larvae hatch after approximately 30 days at 5°C and after 10 days at 15°C (Scott and Scott 1988). Duration of the pelagic larval stage is temperature-dependent and therefore depends on the time of spawning. Spring recruits will remain in the water column during spring and summer, but the fall recruits may be pelagic until the following spring. Eggs and larvae can be contained near the spawning grounds by tidally induced retention areas, or may passively drift with the dominant currents (DFO 1984).

Herring primarily feed on euphausiids (DFO 2005a) and they are an important prey item for other fish, marine birds and marine mammals.

Atlantic Mackerel

This pelagic fish undertakes long annual migrations, often travelling in dense schools in spring and fall. Most mackerel spawning occurs in the southern Gulf of St. Lawrence in June and July. These fish migrate from the Gulf in July and August through the Strait of Belle Isle, to the east coast of Newfoundland, where they are fished until November or December.

It is estimated that approximately 20 percent of adult mackerel die each year due to causes other than fishing. Sudden drops in temperature may kill even adult mackerel. Mass mortalities have been observed along the northeast coast of Newfoundland in the late fall.

Mackerel are preyed upon by large sea animals such as whales, seals, tunas, and sharks, and also by sea birds such as gannets. Cod and squid also feed upon small mackerel. Mackerel feed on plankton and on small fish, notably capelin, juvenile herring and mackerel. They engage in both "selective" feeding (the active pursuit of larger plankton and fish) and "filter" feeding, where the gill rakers filter small food items from the water.

Lumpfish

Mature lumpfish migrate inshore in the spring or early summer to spawn and return to deeper waters in the fall (Scott and Scott 1988). Males arrive on the spawning grounds several weeks in advance of the females to establish their territories. The females lay two to three egg masses on rocks in shallow water at intervals ranging from 8 to 14 days. The eggs are guarded and fanned by the male until hatching occurs after six to eight weeks, while the female returns to deeper water. Egg masses may contain more than 100,000 to 130,000 eggs measuring 2 mm in diameter and light green to yellowish in colour.

Larvae are approximately 5 mm at release and are considered semi-pelagic, remaining in the upper metres of the water column for their first year, during which time they are often associated with floating algae. After settlement, juveniles are often found in shallow water among eelgrass and kelp leaves,

especially Laminaria sp. (Moring 1989). During their early life stages, lumpfish attach to rocks, lobster traps and other solid objects with their pelvic adhesive disc.

Juveniles eat mostly copepods and amphipods during the summer (Moring 1998). The adult lumpfish tends to feed during the winter and their diet primarily consists of coelenterates, ctenophores, chaetognaths, amphipods, euphausiids, copepods, some molluscs polychaetes and small fish, such as herring and sand lance (Scott and Scott 1988; Moring 1989).

Thorny Skate

Thorny skate (Amblyraja radiata) are a temperate to Arctic species, widely distributed in the North Atlantic, ranging from Greenland to South Carolina (Kulka et al. 2006). Thorny skate have been observed over a wide range of depths, from nearshore to 1,700 m, with most of their biomass noted to occur between 50 to 150 m (Kulka and Miri 2003). Thorny skate are observed on both hard and soft substrates (Kulka et al. 1996), but are primarily associated with muddy, sandy and pebble substrates (Kulka and Miri 2003). The most common temperature where skate are found is in the 3°C to 4°C range (Colbourne and Kulka 2004). Thorny skate deposit between 6 and 40 egg cases per year (DFO 2003).

Thorny skate feed on a variety of invertebrates and fish including polychaetes, crabs and whelks (Kulka and Miri 2003). The diets of larger skates include fish prey such as sculpins, redfish, sand lance and small haddock (Melanogrammus aeglefinus). Considerable amounts of fish offal have been found in skate stomach and this, coupled with the ventral mouth location, suggests that thorny skate are opportunistic bottom feeders. There is limited information on the predators of thorny skate, but they are likely prey for large predators such as seals, sharks and Atlantic halibut (Hippoglossus hippoglossus).

Thorny skate abundance has increased from the early 1970s through the mid-1980s, followed by a decline to its lowest levels in the mid-1990s, where it has remained stable (DFO 2003). Thorny skate have become concentrated in approximately 20 percent of their former range, primarily the edge of southwest Grand Banks.

Shellfish

Shellfish species in the area include American lobster, sea scallop, horse (Modiolus modiolus) and blue mussels, rock crab (Cancer irroratus) and toad crab (Hyas coarctatus). The northern shortfin squid (Illex illecebrosus) is an important but infrequent commercial species that can occur in abundance within Trinity Bay. The focus of the following descriptions is the biology of these commercial species.

Lobster

Lobsters range throughout the western North Atlantic from Cape Hatteras north to the Strait of Belle Isle and are commercially fished in the Nearshore

Study Area. Populations tend to be localized in less than 50 m of water. Adult lobsters inhabit coastal waters during the summer, but migrate to warmer, deeper waters in the winter. Young lobsters generally stay close to the coast in depths of 10 m or less, and do not migrate during the winter.

Mating can occur between July and September, depending on water temperature. If water temperature remains below 5°C, spawning will be later than usual, or may not occur at all (Aiken and Waddy 1986). Embryo development is also regulated by temperature and proceeds slowly when temperatures are below 6°C. On the east coast of Newfoundland, lobster larvae begin hatching (emergence of stage 1 larvae) during the first half of July, when bottom temperatures are between 10.0°C and 13.8°C (Ennis 1995), but may be delayed if the water temperature is lower. Upon hatching, larvae are planktonic and the larvae moult through three stages to the fourth stage, the bottom-dwelling stage, between 42 days (15°C) to 94 days (10°C) (Harding 1992). Larval development cannot be completed at low temperatures, thus it is important that hatching occurs before water temperatures decline; this is particularly important in the northern part of the lobster's range. The post-larvae move down through the water column and settle on the bottom, where they grow through juvenile stages and into adult form. Post-larvae may delay settlement if faced with unsuitable habitat and may undergo a succession of "touchdowns and liftoffs" until suitable substratum is encountered (Aiken and Waddy 1986). During the pelagic stage, larvae are primarily drifters (i.e., wind and currents in the upper water column largely determine their distribution) (Katz et al. 1994), but they can exhibit some control over distance travelled by vertical migration (Ennis 1995).

Juveniles for the first couple of years occupy self-dug tunnels or natural crevices under cobble to avoid predation by coastal predators, such as cunner (Harding 1992). Where predators are present, time is crucial during settlement and many lobsters are likely to succumb if pre-existing shelters are not found (Wahle and Steneck 1992). According to Harding (1992), juveniles stay in their burrows, feeding on passing plankton and detritus until they reach a size corresponding to a carapace length of greater than 30 mm, when they leave the tunnels at night to feed. Wahle and Steneck (1992) report that juveniles are generally found occupying crevices and holes near small boulders or burrowing under rocks and eelgrass. Juvenile lobsters usually remain within a few kilometres of where they settle and migrate over several kilometres only after becoming mature.

In Newfoundland, it takes 8 to 10 years for a lobster to reach commercial size (DFO 2006). Adult American lobsters are known to be solitary and appear to conform to the general pattern of diminishing predator avoidance with greater body size; however, lobsters do continue to shelter as adults but are more transient than smaller lobsters. Shelter availability is a critical feature of adult lobster habitat, leading adults to select habitats where burrows can be dug or where they pre-exist under rocks or boulders.

Lobster diet consists mainly of benthic invertebrates including rock crab, polychaetes, molluscs, echinoderms and fish (DFO 2006). Adult lobsters

have few natural predators, with the commercial fishery accounting for most adult mortality.

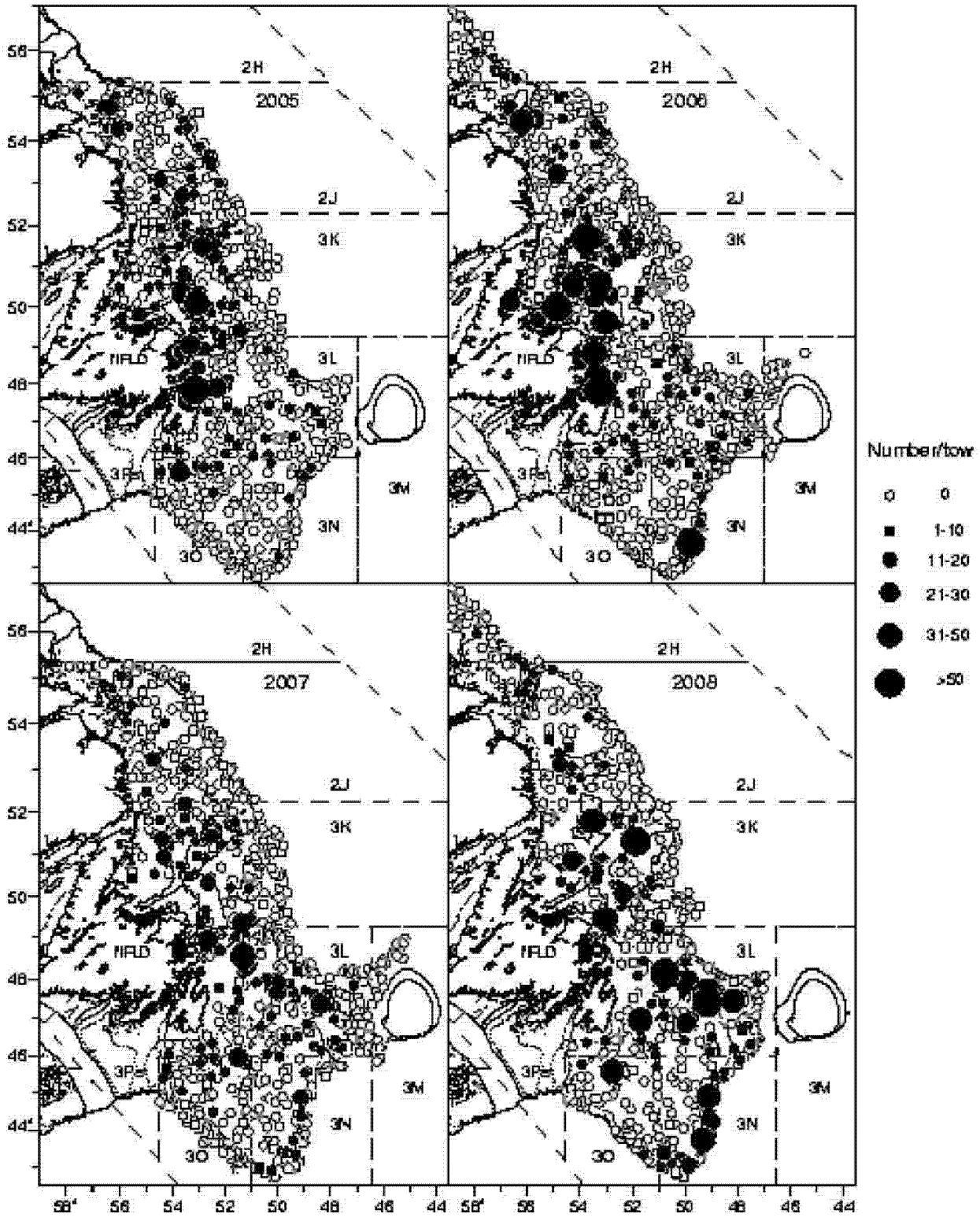
Snow Crab

In the nearshore environment, snow crab are common in the estuary and the Gulf of St. Lawrence, around Cape Breton Island and in all major bays surrounding Newfoundland and Labrador. Snow crabs feed on fish, clams, polychaete worms, brittlestars, shrimp, snow craps and other crustaceans (DFO 2009d).

Snow crabs live most commonly on muddy or sand-mud bottoms at temperatures ranging from -0.5°C to 4.5°C, at depths 20 m to 2,000 m along slope edges off Newfoundland and the Eastern Scotia Shelf (Dawe and Colbourne 2002; Fisheries Resources Conservation Council (FRCC) 2005; DFO 2005b). The distribution of small (pre-recruit) male crabs (Figure 7-4) and large (exploitable) male crabs (Figure 7-5) was analyzed based on the spatial distribution of catches from fall multispecies surveys (Dawe et al. 2010). The spatial distribution trends indicated that there have been gradual spatial shifts of densities for most size groups, as well as annual and area-specific changes in survey catch rates (Dawe et al. 2010). The following figures illustrate that there is significant overlap in the spatial distribution of large and small crabs with small crabs potentially covering slightly more area than the large crabs.

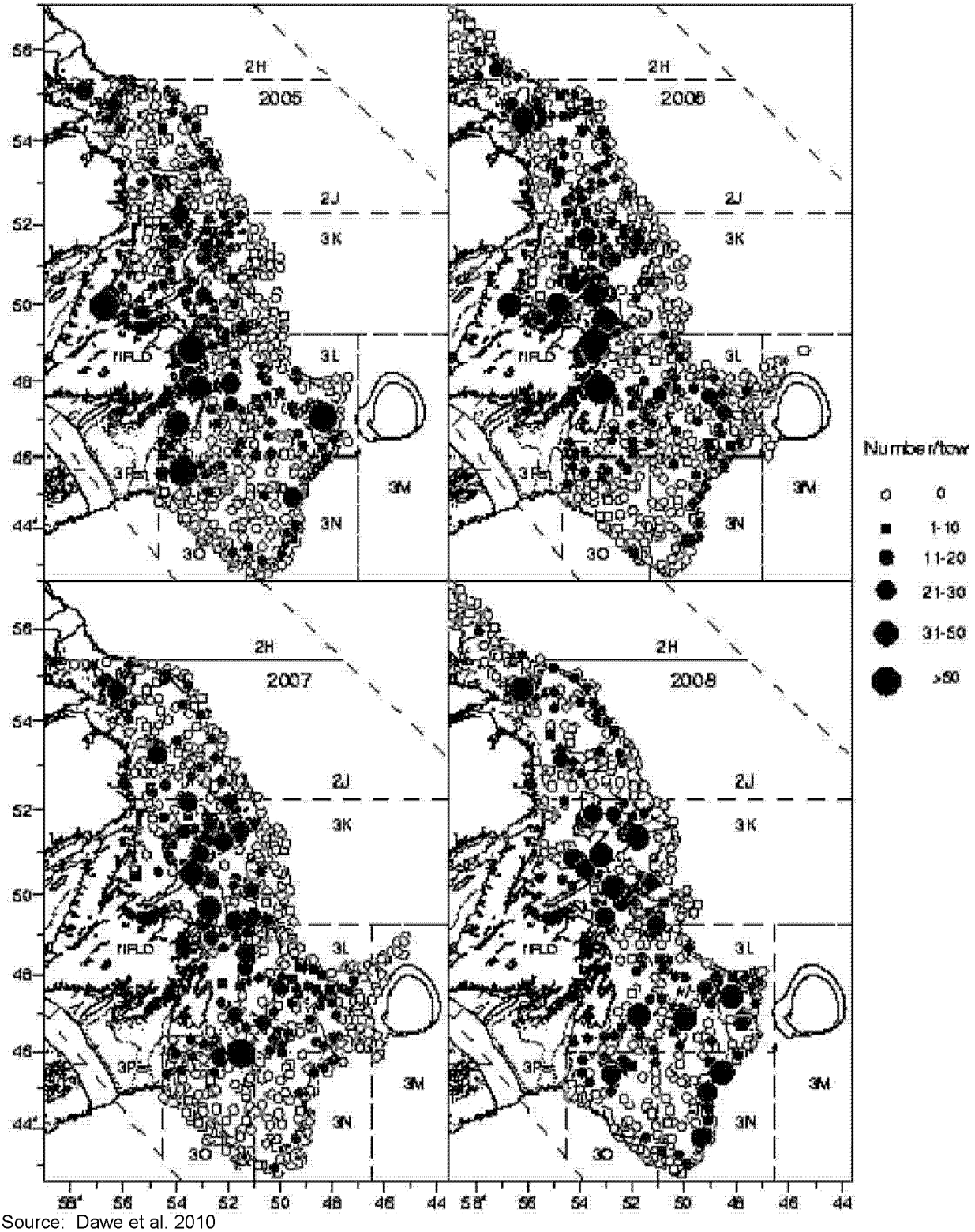
Mating is thought to occur at the end of the winter or in the spring. Females carry the fertilized eggs for one to two years, which is likely influenced by temperature (Sainte-Marie 1993; Moriyasu and Lanteigne 1998; Comeau et al. 1999). The eggs are carried until the following year. Newly hatched larvae are approximately 3 mm long. They immediately rise to the surface, where they are carried by the currents before they settle back on the bottom, most probably at a different place than where they hatched. During this period, they go through three different larval stages before adopting the regular shape of crabs and settle to the sea floor at 3 mm wide across the shell.

See Section 7.3.3.5 for more details on the life history of snow crab.



Source: Dawe et al. 2010

Figure 7-4 Distribution of Small Male Crab from Fall Division 2J3KLNO Bottom Trawl Survey (2005 to 2008)



Source: Dawe et al. 2010

Figure 7-5 Distribution of Large Male Crab from Fall Division 2J3KLNO Bottom Trawl Survey (2005 to 2008)

Sea Scallops

Sea scallops are benthic bivalve molluscs found in the Northwest Atlantic, from the Strait of Belle Isle to Cape Hatteras. They occur on sand or gravel substrates at depths of 35 to 120 m in large aggregations (beds), but also occur within shallow water nearshore. Sea scallops occur in the Bull Arm area in low densities. Sea scallops do not migrate, but are capable of limited 'swimming' by clapping their shells together.

The primary spawning event for sea scallops in Newfoundland waters generally occurs in late September / early October and lasts between two to four weeks. The first two larval stages of the scallop are pelagic, remaining planktonic for over a month after hatching and usually settling to the seabed by December (Hart and Chute 2004). Settlement is dependent on the larvae detecting a suitable substrate (Pearce et al. 2004). Larvae preferentially settle on hard surfaces, preferring substrates with shell fragments and small pebbles including existing scallop beds (Hart and Chute 2004). Scallops are filter feeders, extracting plankton and nutrients from sea water.

Blue Mussel

Blue mussels are found throughout the Nearshore Study Area, moored to any firm support available. This common smooth-shelled mussel with pointed terminal beaks has a circumpolar range, south in western Atlantic Ocean to South Carolina, from slightly brackish estuaries to depths of 100 m offshore (Gosner 1978).

Mussels moor themselves with tough threads and compete with barnacles and seaweeds to cover intertidal rocks and pilings. Given a foothold of scattered stones or shells, they form shoals, even on muddy tidal flats (Gosner 1978).

Horse Mussel

Horse mussels are also found throughout the Nearshore Study Area. Horse mussels have a circumpolar range, south in western Atlantic Ocean to Long Island or Staten Island, NY. They extend up into the lower intertidal zone in eastern Maine, but are chiefly subtidal in deeper water to 80 m. This species is mainly seen as a beach shell, often cast ashore in the grip of laminarian seaweed holdfasts.

Northern Shortfin Squid

The northern shortfin squid is a highly migratory ommastrephid that inhabits the Continental Shelf and Slope waters of the Northwest Atlantic Ocean, between Iceland and the east coast of Florida, and is considered to constitute a single stock throughout its range (Dawe and Hendrickson 1998).

The onset and duration of the squid fisheries reflect the timing of squid availability on the fishing grounds. Bottom-trawl fisheries occur on the US Continental Shelf, primarily in the Mid-Atlantic Bight, and have historically occurred on the Scotian Shelf off Canada during June through late autumn

(Hendrickson et al. 2002). In Newfoundland waters, an inshore jig fishery exists later in the year, generally during August through late autumn.

Migration patterns between US and Canadian fishing grounds are unknown. Recruitment occurs throughout the fishing season and monthly cohorts are replaced every two to three months by younger squid. Squid caught during July to November were predominantly hatched during spring (March to May) rather than winter.

Squid eat voraciously, consuming a variety of crustacean and fish, but juvenile cod and capelin are a common food for squid in Newfoundland waters (Dawe et al. 1997). Squid are preyed upon by several species of fish, marine birds and whales.

Short-finned squid are believed to live no more than 12 to 18 months, migrating southwestward from the adult feeding areas to an imprecisely known spawning area where, after spawning, they die.

7.3.2 Offshore

The primary components of the marine ecosystem on the Grand Banks, where the Offshore Study Area is located, are phytoplankton, zooplankton (including ichthyoplankton), benthos, macroinvertebrates (scallop, crab, shrimp), fish, marine birds and waterfowl and marine mammals. These components of the Grand Bank ecosystem have been described extensively in various documents (Mobil Oil 1985; Petro-Canada 1995; Husky Oil 2000).

Site-specific fish and fish habitat data were collected from the Hebron Offshore Study Area during surveys in 2001 (Chevron 2002, 2003). These data are complemented by EEM survey data collected by operators of adjacent offshore oil and gas projects since 1994, and by several descriptions of existing conditions for marine fish and fish habitat for other environmental assessments overlapping with the Hebron Offshore Study Area. DFO RV data from 3Lt have also been reviewed along with relevant fish and fish habitat primary literature for the Hebron Offshore Study Area.

The following description of the fish and fish habitat within the Hebron Offshore Study Area makes preferential use of site-specific information when this information is available; otherwise, a summary of information available for fish and fish habitat as a whole is provided.

7.3.2.1 Offshore Physical Environment Overview

The Offshore Project Area is located on the northeastern margin of the Grand Bank with water depths ranging from 93 to 100 m. Tidal range in the area is from 0.8 to 0.9 m. The chief water mass for the area originates with the nutrient-rich Labrador Current, but the Gulf Stream also has an important influence on the biology of this area of the Grand Bank. The mixing of the Labrador Current and the warm Gulf Stream creates a productive ecosystem. The offshore branch of the Labrador Current is 50 to 60 km to the east of the Offshore Project Area. Seasonal water temperatures can vary considerably from the surface to the substrate. Maximum surface water temperature

recorded is 15.4°C and only 3.0°C near the sea bottom. The minimum surface water temperature has been recorded at -1.7°C and the minimum bottom temperature is also -1.7°C (Chevron 2001a). Current speed in the area varies from surface waters to the substrate. Annual averages of near-surface waters (at 20 m depth) are 0.77 m/s; near bottom (at 70 m), currents average 0.63 m/s annually. The maximum difference between the two depths occurs from July to September, when the average surface currents are 0.80 m/s, compared to 0.41 m/s near the bottom (Chevron 2001a). A detailed summary of oceanographic conditions in the area is provided in Section 3.2.2.

7.3.2.2 Habitat

Substrate within the Offshore Project Area is predominately fine / medium sand, with a mix of coarse cobble gravels in some areas and less than 4 percent fines (Chevron 2001b). Gravel content is lower in the southern half of the Hebron site (1.4 percent gravel) than in the northern portion (6.2 percent gravel). See Section 3.2 for more detail.

There are sedimentary bedforms throughout the Offshore Project Area that are up to 1 m thick (Chevron 2001b). The western portion of the Offshore Project Area is dominated by large sand ridges that are orientated north to south, sand ripples and sand waves (Chevron 2001b). The eastern half of the Offshore Project Area is predominantly gravel, with sand and cobbles (Chevron 2001b). Sand ridges and ripples are also present in this area. Trawls during the reconnaissance survey recovered boulders ranging from 15 to 60 cm in diameter over the western portion of the Offshore Project Area (Chevron 2003). Boulders of 1 to 2 m diameter are reported to be occasionally present over the site (Chevron 2001b).

Site-specific information on sediment particle size and benthic communities is available for the Offshore Project Area. A total of 20 stations were sampled for sediment particle size, benthic community structure analysis, sediment chemistry (metals and hydrocarbon) analyses and sediment toxicity testing in 2001. The sediment chemistry in the area appears to have been influenced by exploration drilling. Sediments near the location of an abandoned well show elevated levels of barium (3,300 ppm), lead (15 ppm), manganese (87 ppm), strontium (250 ppm), ammonia (22.7 ppm) and sulphur (0.21 percent) (Chevron 2003); the highest levels of vanadium (8 ppm) and zinc (8 ppm) were reported adjacent to another abandoned well location. Median concentrations for each of these elements were well within baseline and year one of the Terra Nova EEM program results (Chevron 2003). The Microtox™ test is known to be sensitive in substrates with more than 20 percent fines (Environment Canada 2002), which may be the case in the Hebron Project Area (Chevron 2003). None of the sediment samples were declared toxic by the amphipod survival test.

7.3.2.3 Plankton

Phytoplankton are the most important primary producers on the Grand Banks, converting water and carbon dioxide into organic matter through

photosynthesis. The resulting biomass supports the entire marine food web. Peak abundance of phytoplankton on the Grand Bank usually occurs in late April to early May, within the top 30 to 50 m of the water column (Pepin and Paranjape 1996). The spring bloom is dominated by diatoms. An autumn phytoplankton peak is also characteristic of the northern Grand Bank but an obvious peak may not occur on the southern Grand Bank (Myers et al. 1994). Dinoflagellates and other microflagellates dominate the fall bloom.

Zooplankton are a crucial link between primary production and higher trophic levels (e.g., fish, crustaceans); many harvested species, including crab, shrimp and a number of fish species, have planktonic eggs and larvae. Herbivorous zooplankton such as copepods feed on phytoplankton, and are then in turn consumed by invertebrates, fish, birds and marine mammals. Zooplankton are also a major source of detritus for the benthic community, which serves as a critical pathway for nutrient generation.

Despite the general trend in ocean warming observed over the whole of the North Atlantic since the late 1990s, the seasonal cycles of most phyto- and zooplankton species on the Grand Bank have remained relatively stable (Malliet and Pepin 2006).

Zooplankton in the Northwest Atlantic are dominated by copepods (Myers et al. 1994), whose abundance rises sharply in spring and, to a lesser degree, in fall in response to phytoplankton abundance. Ichthyoplankton, or fish eggs and larvae, constitute a portion of the zooplankton community. In the 1990s, fish larvae have been found to be most abundant to the north of the Grand Banks on the northeast Newfoundland Shelf, while the lowest densities were reported on the eastern part of the Grand Banks (Dalley et al. 2000). More recent ichthyoplankton surveys on the northeast Grand Banks, during late summer and early fall, indicate the ichthyoplankton may include Atlantic cod (see Section 11.3.1.1), American plaice (Hippoglossoides platessoides) (see Section 11.3.1.2), sand lance, redfish, lanternfish (Myctophum spp.), alligator fish (Aspidophoroides monopterygius), sculpins (unidentified), blennies, seasnails, white hake (Urophycis tenuis), haddock, wolffish (unidentified) (see Section 11.3.1.4), witch flounder (Glyptocephalus cynoglossus), yellowtail flounder (Limanda ferruginea) and Greenland halibut (Dalley et al. 2000). Capelin, sand lance and redfish are the most abundant ichthyoplankton species in the area during August and September (Anderson et al. 1999). The temporal distribution of species potentially contributing to the ichthyoplankton within the Offshore Project Area is summarized in Table 7-2.

7.3.2.4 Benthos

Benthos refers to the community of plants and animals living in or on the seafloor. These organisms range in size from microscopic to tens of centimetres in length. The benthic fauna on the Grand Bank is mostly suspension and surface-deposit feeding (Mobil Oil 1985). A typical epibenthic community on the Grand Banks would be dominated by sand dollars, starfish and amphipods.

A primary food source for some benthos, like the sand dollar and sea urchin, is detritus. Other benthic organisms such as scallops will filter-feed on live plankton as it passes by in the current, while American plaice, for example, are predators, and actively hunt for benthic and epibenthic fauna.

The community living several centimetres within the sediment is called infauna and dominated by a variety of marine worms (polychaetes). Other common infaunal organisms include clams, amphipods and cumaceans.

Table 7-2 Spawning Time and Location of Fish Potentially near the Offshore Project Area

Fish Species	Spawning Period	Spawning Location	Timing of Pelagic Eggs/Larvae	Reference
American Plaice[A]	April to June	Throughout the Grand Banks; most intensive in Northern Grand Banks	American plaice eggs float near the surface and hatch within 11 to 14 days at temperatures of 3.9°C. Larvae are concentrated near the thermocline at approximately 20 m until they reach a length of approximately 25 mm, the average length for settlement). Larvae, therefore, may settle to substrate far removed from where the eggs were fertilized. However, plaice larvae are retained on the eastern edge of the Grand Banks by the Labrador Current.	Scott and Scott 1988; Frank et al. 1992; Morgan 2001; Ollerhead et al. 2004
Yellowtail Flounder	April to June	Central and southern Grand Banks	Not known	Ollerhead et al. 2004
Witch Flounder	March to June	Southern Grand Banks (3O) during peak spawning; northern 3L and in 3N later in summer	Not known	Ollerhead et al. 2004
Thorny Skate	Fall to Winter	Edge of Grand Banks, especially in 3Ps	Not known	Kulka et al. 2004a
Redfish	June	Northeastern edge of Grand Banks in >200 m of water	Larval extrusion typically occurs in late spring / summer months	Ollerhead et al. 2004
Capelin	June and July	Coastal beaches of Newfoundland	Not known	Carscadden et al. 2001
Snow Crab		Developing fertilized eggs are carried by the female	Larval hatch generally occurs in late spring / summer. Larvae remain planktonic for three to four months.	
Northern Shrimp	June and early July	Flemish Cap, eastern and northern edges of Grand Banks in 3LN, and near the south coast in 3P	Eggs remain attached to females from late summer / fall until larval hatch the following spring / summer. Larvae remain planktonic in upper water column for a few months	Ollerhead et al. 2004
Stimpson's Surf Clam	Summer / early fall and another smaller one in October	Eastern edge of the Grand Banks in 3N	Not known	Ollerhead et al. 2004
Greenland Cockle	Not known	Not known	Not known	

A American plaice are a Species at Risk and are described in detail in Section 11.3.1.2

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Spatial variability within the epifaunal and infaunal benthic community structure can be expected within metres on the Grand Banks (Schneider et al. 1987; Schneider and Haedrich 1991). When disturbance to the habitat occurs by a storm event or fishing gear, for example, epifaunal and infaunal benthos are exposed (e.g., polychaetes) and vulnerable to heavy predation (e.g., snow crab). The community in an affected area will undergo a succession of rebuilding and maturation over several generations. The dynamic physical environment of the Grand Banks seafloor coupled with the temporal variability in abundance of some macrofaunal species (Kenchington et al. 2001), results in highly variable benthic communities, even within a small area. On a larger scale, benthic community structure is not only influenced by grain size, but also by water depth and composition of the water mass (Bundy et al. 2000). Grain size and several benthic community indices (e.g., species abundance, richness, diversity) are strongly correlated within the Terra Nova field (DeBlois et al. 2005).

In areas of less fines (i.e., grain size of <500 µm) in the substrate, there are fewer short-lived polychaetes, amphipods and cumaceans, in particular, but fewer brittle star and the soft-shell coral were also noted (Kenchington et al. 2001). There are even fewer sessile species on sandy substrate because the environment is very dynamic and unstable. Most species are free-living or burrowing, with some tube-building species present as well.

The estimated benthic biomass for Northwest Atlantic Fisheries Organization (NAFO) Division 3LNO is 230.6 tonnes/km^2, compared to the less productive northern Divisions of 2J and 3K at 98.5 tonnes/km^2 total biomass (Bundy et al. 2000). These estimates do not include bivalve shell weight (Table 7-3).

Table 7-3 Estimates of Mean Benthic Biomass in Northwest Atlantic Fisheries Organization Units 2J3KLNO

Benthic Group	2J or 3K Biomass (t/km^2)	3LNO Biomass (t/km^2)	2J3KLNO Biomass (t/km^2)
Echinoderms	70.6	144.8	112.3
Molluscs	16.4	62.2	42.1
Polychaetes	8.8	11.9	10.5
Other	2.7	11.8	7.8
Total Biomass	98.5	230.7	172.7
Source: Bundy et al. (2000)			

An otter trawl survey of the Offshore Project Area during late June and early July of 2001 found that shrimp was the most abundant benthic invertebrate group, followed by sea urchins and sand dollars. Also present, but less common, were soft shelled clams, snow crab, toad crab, Iceland scallop (Chlamys islandica) and sea stars (Chevron 2002).

Relative abundance of dominant species in benthic samples collected within the Offshore Project Area is provided in Table 7-4. Mean relative abundance is expressed as a percent of the total. These data indicate minor differences in species composition between predominantly sand and gravel areas for the less abundant taxa. Amphipoda and Echinodermata diversity and abundance

were higher in the sand dominated substrate, whereas Tunaidacea were absent in sand dominated substrate.

Table 7-4 Hebron Taxa with Mean Relative Abundances ≥1%

Taxon		Abundance (number)		Percent of Total	
		Sand	Gravel	Sand	Gravel
Polychaeta	Spionidae	705	632	28	34
Polychaeta	Syllidae	374	232	15	13
Polychaeta	Cirratulidae	316	345	13	19
Polychaeta	Paraonidae	191	103	8	6
Polychaeta	Sigalionidae	136	87	5	5
Polychaeta	Orbiniidae	68	84	3	5
Polychaeta	Phyllodocidae	60	40	2	2
Polychaeta	Opheliidae	26	0	1	0
Polychaeta	Sabellidae	0	18	0	1
Echinodermata	Echinarachnidae	43	24	2	1
Echinodermata	Ophiuridae	35	0	1	0
Bivalvia	Hiatellidae	45	38	2	2
Amphipoda	Haustoriidae	31	0	1	0
Amphipoda	Phoxocephalidae	28	0	1	0
Amphipoda	Oedicerotidae	0	27	0	1
Tanaidacea	Tanaidacea (unspecified)	0	62	0	3
Source: Chevron (2003)					

Polychaetes are the most abundant group of benthic invertebrates on the Grand Banks. Many of the most common polychaete species are selective deposit feeders, like members of the Spionidae and Cirratulidae families, who sort the organic material from the sediment prior to ingestion (Brusca and Brusca 1990). However, the most abundant polychaete species is Exogene hebes, an active predator.

The Opheliidae family occurred only in the sandy substrate of the Offshore Project Area (Chevron 2003). These are mostly direct deposit feeders, ingesting the substratum and digesting the organic matter contained on the particles (Brusca and Brusca 1990). As is the case within the Terra Nova Field, the most abundant species in this family was Ophelia sp. This is a burrowing species in soft substrata (Brusca and Brusca 1990).

Sabellid polychaetes were found exclusively within the more gravelly substrates of the Offshore Project Area (Chevron 2003). These tube-dwelling polychaetes use their feathery tentacles for suspension feeding (Brusca and Brusca 1990). Their tubes can extend 3 to 8 cm into the substrate and 5 to 7 cm above the seafloor. Another abundant polychaete in the more gravelly substrate is the Tanaidacea family. This family includes burrowers or tube suspension feeders, as well as active predators (Brusca and Brusca 1990).

The most common echinoderm found was the sand dollar (Chevron 2003). Sand dollars can occur in densities as high as hundreds per square metre by

layering in loosely packed sediment (Cabanac and Himmelman 1996). It is usually the smaller juvenile sand dollars that are buried several centimetres into the substrate. Adult sand dollars may bury themselves to avoid heavy predation (Cabanac and Himmelman 1996). Sand dollars prefer areas of relatively high turbulence and current and sediment grain size of less than 230 µm (Ellers and Telford 1984). They feed by ingesting sediment particles, removing the organic material and excreting the inorganic particles. This physical shuffling of substrate by feeding and burrowing adds complexity to an often homogeneous sandy habitat. This complexity is crucial to maintaining species diversity in fine sediments (Kenchington et al. 2001). Sand dollar bioturbation is second only to storm events in reworking surface sediments (Stanley and James 1971). The primary predators of sand dollars are yellowtail flounder and American plaice. Other common detritivores in the area are the green sea urchin and the brittle star.

The most common bivalve molluscs were the propeller clam (Cyrtodaria siliqua) and a clam called the chalky macoma (Macoma calcarea) (Chevron 2003). Macoma is a deposit or detrital feeder. Gammarid amphipods, cumacea and isopods are also detritivores. The Priscillina armata amphipod was found exclusively in the sandy substrate within the Offshore Project Area. It is characteristic of clean offshore sandy substrates (Kenchington et al. 2001). These amphipods feed on suspended detritus (Brusca and Brusca 1990).

Deep-water corals are found primarily below the 200 m depth contour along the edge of the Continental Slope, in canyons or in channels between banks (Edinger et al. 2007; Campbell and Simms 2009). Some soft corals are known to occur in shallower areas on the Continental Shelf and some were found during the DFO RV surveys between 2003 and 2008 (Table 7-5; Figures 7-6 and 7-7). During this period (2003 to 2008), there were 83 trawls conducted, with 64 of these trawls recording data on the corals species ranging from 0 to 132 corals per trawl. Six of the sixty-four had the number of corals species caught per trawl greater than three. The sea strawberry (Gersemia rubiformis) and sea broccoli (Capnella flordia) corals were the most commonly encountered species, landed in eight and six trawls, respectively. Nepheid corals were collected in a single trawl sample.

Table 7-5 Mean Catch Depth, and Minimum and Maximum Catch Depth during DFO Research Vessel Surveys in the Offshore Project Area from 2003 to 2008 (Corals)

Group / Family	Scientific Name	Common Name	Number of Trawls	Mean Depth (m)	Minimum Depth (m)	Maximum Depth (m)
Aylcocacean	Capnella flordia	sea broccoli	6	94.5	70.0	110.0
	Gersemia rubiformis	sea strawberry	8	94.8	70.0	105.0
	Unknown	unknown	3	94.0	81.0	104.0
Nepheid	Unknown	unknown	1	79.0	78.0	80.0

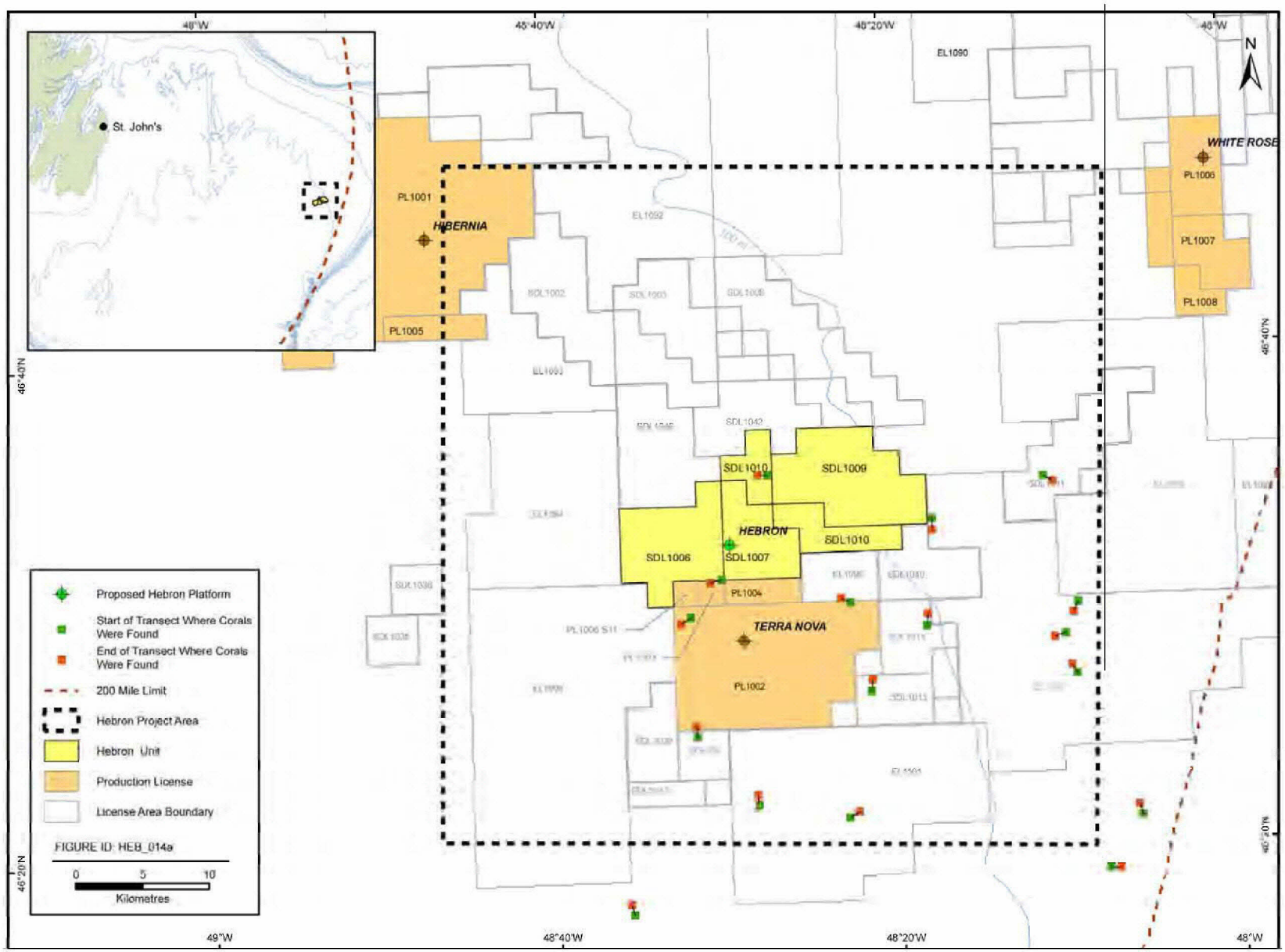

Figure 7-6 Corals Collected from the Offshore Project Area between 2003 and 2008

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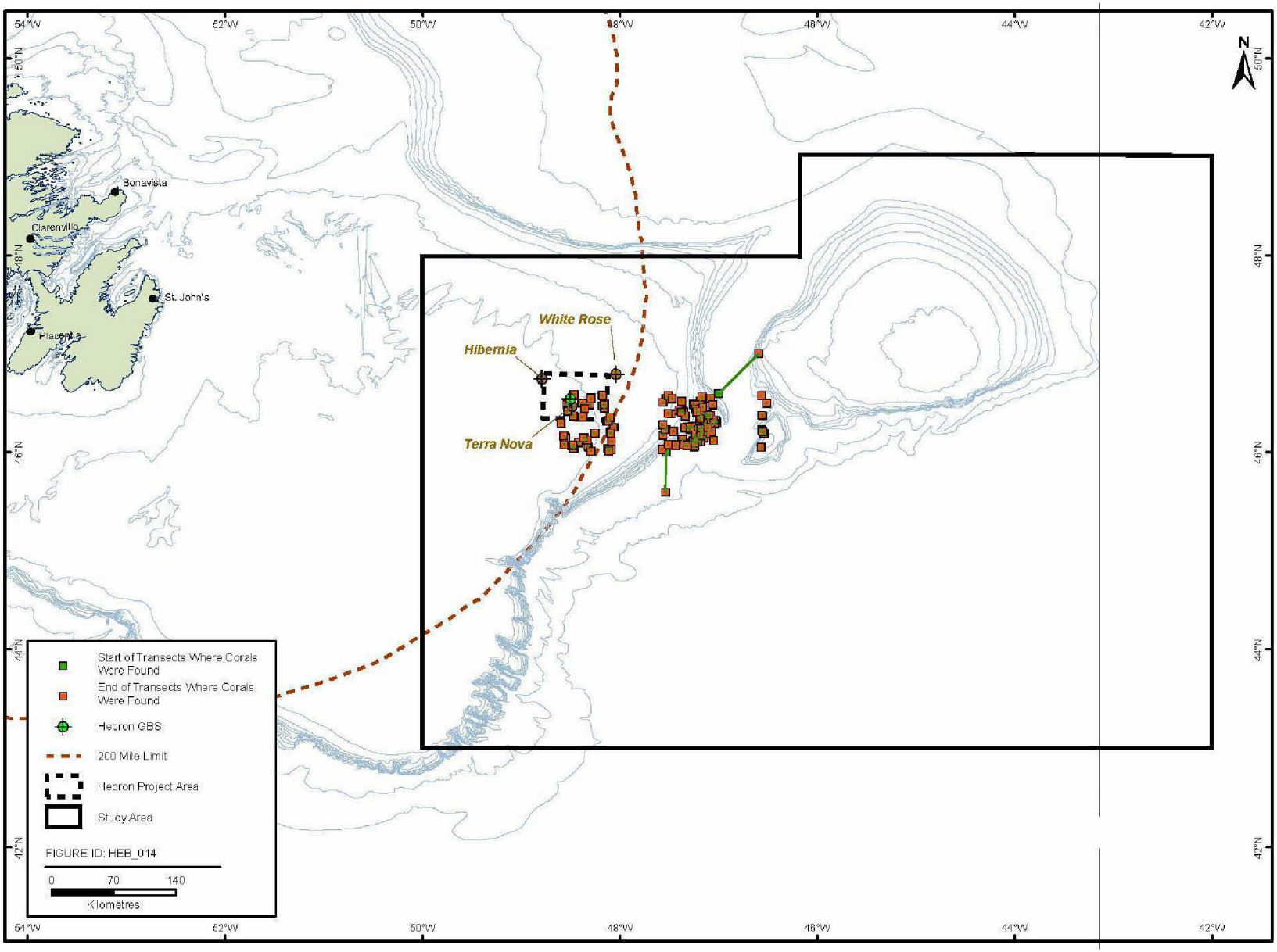

Figure 7-7 Corals Collected from the Hebron Offshore Study Area between 2003 and 2008

Within the Hebron Offshore Study Area, coral were more commonly collected in deeper water, along the edge and slope of the Continental Shelf. Strawberry and sea broccoli corals were collected in 40 and 47 RV sampling trawls, respectively. Additional species collected in more than two trawls included mushroom coral (Anthomastus grandiflorus), sea pen and bubblegum coral (Paragorgia arborea). The complete list of corals collected in RV trawls from 2003 to 2008 is provided in Table 7-6.

Table 7-6 Mean Catch Depth, and Minimum and Maximum Catch Depth during DFO Research Vessel Surveys in the Hebron Offshore Study Area from 2003 to 2008 (Corals)

Group / Family	Scientific Name	Common Name	Number of Trawls	Mean Depth (m)	Minimum Depth (m)	Maximum Depth (m)
Alyconacean	Anthomastus grandiflorus	mushroom coral	8	1,030.4	818.0	1,247.0
	Capnella flordia	sea broccoli	47	335.8	61.0	680.0
	Gersemia rubiformis	sea strawberry	40	276.0	60.0	688.0
	Unknown	unknown	4	1,032.3	818.0	1,247.0
Neptheid	Unknown	unknown	29	604.1	64.0	1,318.0
Pennatulidacea	Pennatulidae Genus	sea pen	6	1,063.5	795.0	1,214.0
Unknown Coral	Unknown	unknown	2	427.0	173.0	684.0
Gorgonia	Acanella arbuscula	bonsai coral	2	1,201.5	1,189.0	1,214.0
	Acanthogorgia armata	-	3	1,094.3	818.0	1,247.0
	Paragorgia arborea	bubblegum coral	5	320.4	121.0	583.0
	Keratoisis ornata	bamboo coral	2	1,228.0	1,208.0	1,247.0
	Paramuricae Genus	black coral	1	827.0	818.0	834.0
	Radicipes gracilis	sea whip	2	932.0	840.0	1,022.0

Deep-water corals are recognized as an important component of deep-water ecosystems providing habitat for a variety of fish species, including commercially-important species (Gilkinson and Edinger 2009). Their longevity and slow growth rates may result in recovery times from a disturbance in the tens to hundreds of years. While life histories and basic biological knowledge remains largely unresolved, thereby limiting the understanding of their ecological relationships, ongoing research by the DFO-Memorial University deep-water corals research group is working to resolve some of these data gaps (Gilkinson and Edinger 2009).

Campbell and Simms (2009) would be added to some of the citations as they confirm information cited in this report.

7.3.2.5 Fish and Shellfish

Fish species most likely to occur within the Offshore Project Area are those historically widespread over the Grand Banks. These species are yellowtail flounder, American plaice (described in Section 11.3.1.2), Atlantic cod (described in Section 11.3.1.1) and thorny skate. In more recent years, these species have been concentrated on the southern part of the Grand Banks. Monkfish (Lophius americanus), white hake, Atlantic halibut, haddock and pollock (Pollachius virens) are mostly found in the warm waters of the Southwest Slope. Whereas roundnose (Coryphaenoides rupestris) and roughhead (Macrourus berglax) grenadiers (both described in Section 11.3.1.6), Greenland halibut and redfish (described in Section 11.3.1.12) are commonly found in deeper water on the slope of the Grand Banks. Common epibenthic species in deeper areas include pink shrimp (Pandalus borealis), snow crab (Chionoecetes opilio), witch flounder and redfish.

Pelagic, schooling species common to the Offshore Project Area are capelin, Arctic cod (Boreogadus saida) and sand lance. These species are all an important food supply for larger pelagic fish species, whales, seals and marine birds.

The brittlestars, macoma bivalves, sea urchins, propeller clams and sand dollars are important components of the diet for several groundfish (Methven 1999). Smaller flatfish like yellowtail, American plaice and witch and winter flounders feed primarily on amphipods, enchinoderms and polychaetes, and may supplement their diet with sand lance (Link et al. 2002). Species such as sand lance and capelin may be a larger component of the turbot and halibut diet (Methven 1999).

In general, the Offshore Project Area does not support a higher biomass of demersal fish relative to other areas of the Grand Banks (Kulka et al. 2003). Historically, the most abundant species in the area, and over the entire Grand Banks, were Atlantic cod and American plaice. In more recent years, Atlantic cod have become uncommon on the northern portion of the Grand Banks (NAFO 3L); however, while there are fewer American plaice than were present in the 1980s, this species is still not uncommon. Commercial fishing effort on the Grand Banks is currently focused on shellfish species, such as snow crab and shrimp.

Offshore Project Area Sampling

There were 17 finfish species collected by otter trawl during the Hebron biological survey in late June to early July 2001 (Chevron 2002). Sand lance were the most abundant species as indicated by catch rate, followed by capelin, mailed sculpin (Triglops mybelini) and American plaice. Other common species collected during this survey include alligator fish, hookear sculpin (Artediellus uncinatus), and spatulate sculpin (Icelus spatula) (Figure 7-8). Species occurring infrequently during the survey were Arctic cod, Arctic eelpout (Lycodes reticulatus), Atlantic cod, seasnail, snakeblenny (Lumpenus lumpretaeformis) and thorny skate.

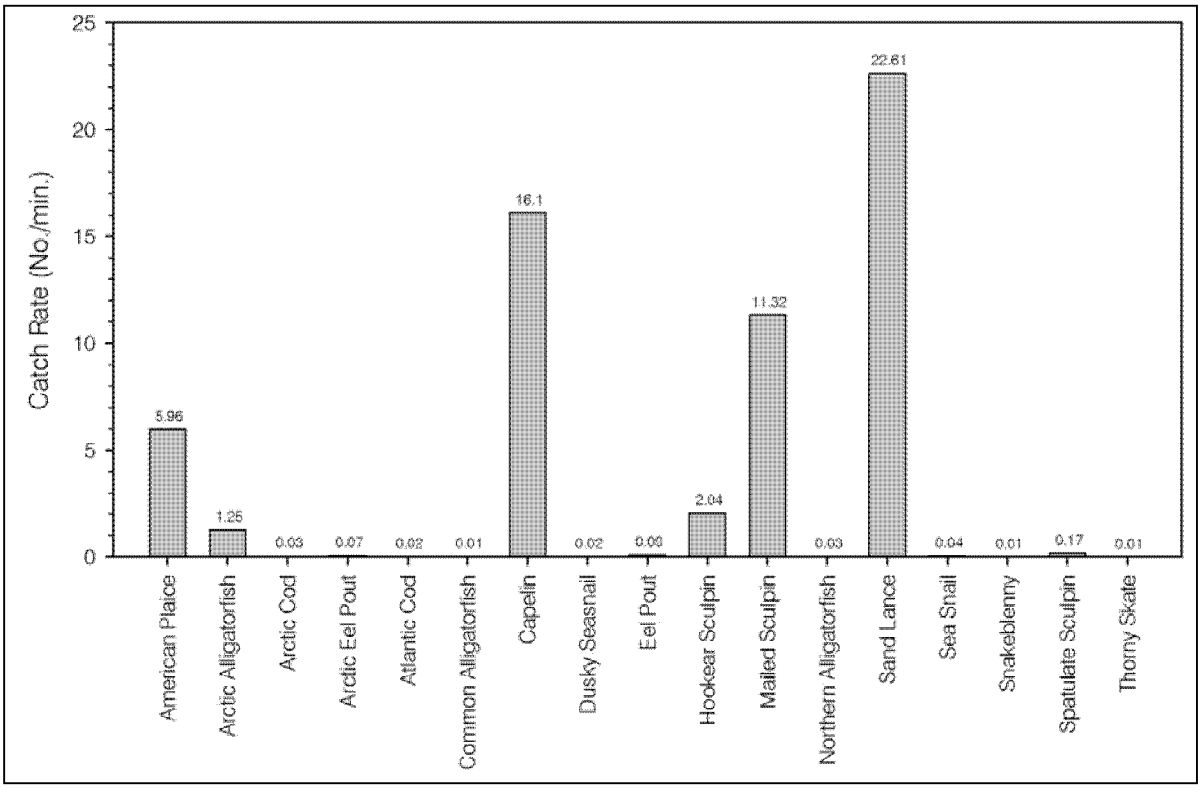

Figure 7-8 Mean Catch Rates of Fish from all Otter Trawls during the Hebron Biological Survey

The survey revealed a clear preference for the sand substrate by American plaice, mailed sculpin, hookear sculpin, sand dollar and soft-shelled clam. Species preferring the more gravelly substrate were sand lance, shrimp, capelin, sea urchin, Arctic alligator fish (Aspidophoroides olriki), spatulate sculpin and Iceland scallop.

Data collected during the 2007, 2008, 2009 and 2010 DFO RV surveys (Table 7-7) were analyzed to determine the potential for underused species and the most abundant species by catch weight in the Hebron Offshore Project and Study Areas. Overall, the abundance and diversity of species was much lower in the Offshore Project Area, compared to the larger Hebron Offshore Study Area. During 2007, sand lance accounted for approximately 88 percent of the total catch within the Offshore Project Area. In 2008, snow crab and American plaice were the dominant species landed, comprising approximately 38 and 23 percent of the total landings by weight, respectively. In 2009, the dominant species landed were brittle starts (25 percent) and American plaice (24 percent). In 2010, sand lance accounted for approximately 87 percent of the landings.

Within the Hebron Offshore Study Area, deepwater redfish was the most abundant species collected between 2007 and 2010, accounting for 38 to 64 percent of the catch by weight. Yellowtail flounder was the second most abundant species based on catch, accounting for 8 to 14.3 percent of the catch (Table 7-7). Among the least abundant species between 2007 and 2010 was snow crab, which only accounted for approximately 0.6 to 1.4 percent of the catch.

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Table 7-7 Species / Groups with Highest Catch Weights during DFO Research Vessel Surveys in the Hebron Offshore Project and Study Areas between 2007 and 2008 (Fish and Invertebrates)

Year	Hebron Offshore Project Area				Hebron Offshore Study Area				Hebron Offshore Project Area				Hebron Offshore Study Area			
	2007		2008		2007		2008		2009		2010		2009		2010	
Gear	Campelen 1800 Shrimp Trawl - Lined				Campelen 1800 Shrimp Trawl - Lined				Campelen 1800 Shrimp Trawl - Lined				Campelen 1800 Shrimp Trawl - Lined			
Total Weight Landed (kg)	113,221		20,523		6,964,725		5,012,326		23,296		87,239		6,017,415		7,200,084	
	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)	Weight Caught (kg)	Percent of total (%)
Sand lance	125,963	88.3	1,984	8	345,319	4.96	226,324	4.52	2,104	9.03	75,640	86.70	222,811	3.70	247,906	3.44
Shrimp	1,958	1.4	980	4	361,865	5.20	292,169	5.83	776	3.33	100	0.11	217,572	3.62	168,993	2.35
American plaice	6,768	4.7	5,650	22.9	594,539	8.54	454,287	9.06	5,503	23.62	4,866	5.58	450,822	7.49	341,125	4.74
Snow crab	1,125	0.8	9,349	37.9	41,251	0.59	71,566	1.43	1,356	5.82	2,844	3.26	61.656	1.02	64,520	0.90
Unspecified invertebrate	2,658	1.9	NA	-	60,756	0.69	675	0.01	NA	-	NA	-	4,097	0.07	1,345	0.02
Capelin	1,614	1.1	2,517	10.2	91.867	1.32	345,733	6.90	22	0.09	NA	-	36,301	0.60	329,537	4.58
Sea urchin	1,218	0.9	364	1.5	9,324	0.13	4,896	0.10	4,170	17.90	676	0.77	34,086	0.57	14,963	0.21
Mailed sculpin	1,097	0.8	555	2.2	30,359	0.44	12,481	0.25	120	0.52	56	0.06	3,130	0.05	3,342	0.05
Toad crab	216	0.2	21	0.1	2,871	0.04	40,178	0.80	240	1.03	141	0.16	8,668	0.14	4,694	0.07
Comb-jelly	NA	-	2,520	10.2	1,183	0.02	104,389	2.08	30	0.13	NA	-	18,267	0.30	NA	0.46
Thorny skate	NA	-	400	1.6	370,889	5.33	580,587	11.58	57	0.24	1,172	1.34	167,215	2.78	172,992	2.40
Brittle star	NA	-	332	1.3	2,282	0.03	2,649	0.05	5,855	25.13	NA	-	13,087	0.22	500	0.01
Deepwater redfish	NA	-	NA	-	3,359,966	48.24	1,928,688	38.48	NA	-	23	0.03	2,803,850	46.60	4,601,830	63.91
Sea sponge	NA	-	NA	-	486,956	3.70	26,849	0.54	NA	-	26	0.03	1,237,708[A]	20.57	179,913	2.50
Greenland shark	NA	-	NA	-	100,000	1.44	NA	-	NA	-	NA	-	NA	-	NA	-
Roughhead grenadier	NA	-	NA	-	202,972	2.91	139,755	2.779	NA	-	NA	-	158,533	2.63	148,187	2.06
Greenland halibut	NA	-	NA	-	141,049	2.17	74,132	1.48	3	0.01	NA	-	99,026	1.65	86,411	1.20
Yellowtail flounder	33	< 0.1	NA	-	1,019,225	14.26	706,968	14.10	3,060	13.14	1,695	1.94	480,586	7.99	800,652	11.21

A There are two sets of large catches associated with this number

022156

The depths at which the various species / groups were caught during the 2007 to 2010 RV surveys varied greatly. The mean depth of capture for 2007 to 2010 and the depth range (minimum and maximum) of capture for the species with the highest catch weight is presented in Table 7-8.

Table 7-8 Mean, Minimum and Maximum Catch Depth during DFO Research Vessel Surveys in the Project and Study Areas between 2007 and 2010 (Fish and Invertebrates)

Species / Group	2007		2008		2009		2010	
	Mean Catch Depth (m)	Range (m)	Mean Catch Depth (m)	Range (m)	Mean Catch Depth (m)	Range (m)	Mean Catch Depth (m)	Range (m)
Sand lance	86	12 to 223	129	61 to 301	99	40 to 716	96	40 to 440
Shrimp	363	61 to 1,372	204	61 to 656	200	50 to 716	257	48 to 1453
American plaice	144	26 to 686	235	40 to 671	243	40 to 859	189	38 to 806
Snow crab	159	49 to 660	181	38 to 693	225	50 to 859	170	56 to 728
Unspecified invertebrate	520	23 to 1,454	200	47 to 656	332	62 to 1,454	266	44 to 623
Capelin	139	26 to 643	154	68 to 301	183	43 - 435	158	38 to 656
Sea urchin	247	31 to 1407	233	68 to 196	393	40 to 1351	214	38 to 1453
Mailed sculpin	117	26 to 395	118	61 to 196	131	50 to 215	114	48 to 377
Toad crab	100	41 to 432	182	44 to 693	130	40 to 716	108	38 to 387
Comb- jelly	40	30 to 61	180	12 to 653	112	43 to 685	59	38 to 79
Thorny skate	287	26 to 1,318	296	85 to 656	280	40 to 801	224	38 to 666
Brittle star	160	103 to 301	245	105 to 460	279	50 to 1155	366	40 to 1,344
Deepwater redfish	555	68 to 1,247	386	162 to 684	382	118 to 859	356	58 to 859
Sea sponge	746	60 to 1,407	357	101 to 684	537	43 to 1365	705	38 to 1453
Greenland shark	424	387 to 461	NA	NA	NA	NA	NA	NA
Roughhead grenadier	744	176 to 1,454	443	216 to 684	718	61 to 1,454	509	63 to 1,453
Greenland halibut	675	113 to 1,454	343	124 to 684	588	81 to 1,454	455	66 to 1,453
Yellowtail flounder	67	26 to 219	221	39 to 693	65	40 to 152	64	38 to 136

NA - Species was not caught this year
Source: DFO RV database accessed 2011

Species that were caught at shallow depths included yellowtail flounder, sand lance and capelin. Species caught in deeper water included roughhead grenadier, Greenland shark (Somniosus microcephalus), deepwater redfish (Sebastes mentella), shrimp and Greenland halibut. Species that were caught over the widest range of depths included thorny skate, shrimp, deepwater redfish, sea sponge and roughhead grenadier.

The environmental effects of the Hebron Project are assessed for the principal fish species that occur within the Hebron Offshore Study Area. Some of the species considered in this assessment are less common than others in the Offshore Study Area for various reasons (e.g., fluctuations in abundance, differences in habitat preference). Species at risk, including American plaice, are addressed in Section 11.3.1.

Uncommon Species

White hake may occur from southern Labrador to Cape Hatteras, but is most abundant in the Gulf of St. Lawrence, on the Scotian Shelf and in the Gulf of Maine. On the Grand Banks, white hake occur infrequently except along the southwest slope (Kulka et al. 2004b).

Atlantic halibut occur sporadically throughout the Grand Banks, Flemish Cap and northeast Newfoundland Shelf. They are most abundant along the southwest slope of the Grand Banks and along the Laurentian Channel slope during spring. Historically, they have congregated on the centre of the Grand Banks west of the Southeast Shoal (Kulka et al. 2003). Halibut population estimates declined for many years, but industry / DFO surveys have more recently demonstrated relative population stability (Trzcinski et al. 2009).

For the most part, monkfish are restricted to the warmer waters of the southwest slope of the Grand Banks, but may occur in the deep trenches to the north or on the slope edge (Kulka and Miri 2003).

Winter skate (Leucoraja ocellata) are not expected within the Offshore Project Area. Only occasional occurrences have been reported north of the southern Grand Banks. The species is most abundant on Georges Bank and the eastern Scotian Shelf (Simon et al. 2003).

Common Species

Commonly occurring fish and shellfish species within the Hebron Offshore Study Area include shrimp, snow crab, Greenland halibut, yellowtail flounder, witch flounder, thorny skate, lumpfish, redfish, grenadier, sculpin, capelin, sand lance and Arctic cod.

Shrimp

Several species of penaeid and caridean shrimp can occur within the Hebron Offshore Study Area, but northern shrimp is by far the most abundant. The northern shrimp extend south from Labrador into the northern half of the Grand Banks. Northern shrimp on the northeast Newfoundland Shelf occur in areas greater than 200 m deep and prefer muddy substrates. Shrimp tend to congregate in the winter and spring, and are most widely distributed during the summer and early fall. Preferred temperatures in the spring are 2°C to 4°C and 1°C to 3°C during the fall, with very few shrimp found below 0°C or above 4°C during either survey (Colbourne and Orr 2004). Shrimp are most abundant along the slope of the Grand Banks during the spring and move to the shallower waters of the Grand Banks and northeast Newfoundland Shelf during the fall.

Shrimp spawn during late summer and fall, but the fertilized eggs are not released until the spring of the following year. Shrimp larvae remain pelagic for a few months, before becoming benthic.

Shrimp feed in both benthic and pelagic environments. During the day, shrimp are benthic and feed on detritus, phytoplankton, worms and small

crustaceans. At night, shrimp move up into the water column and feed on detritus and zooplankton (Bundy et al. 2000). Shrimp are common prey for Greenland halibut and Atlantic cod.

Snow Crab

Snow crab are relatively sedentary and are known to undergo seasonal or breeding migrations throughout the Gulf of St. Lawrence and Newfoundland (Ennis et. al 1988). The spatial distribution of snow crab appears to be a function of physical habitat and time of year. Research has correlated densities of both adults and juveniles with depth, temperature and bottom substrate. Adult snow crab are present within the Hebron Offshore Study Area but are most common along the slope of the Grand Bank on muddy substrates (Dawe and Taylor 2003).

Even within the juvenile stage (i.e., <70 mm carapace width), preferred habitat varies with age. Early benthic juveniles prefer different habitat types and water depths than older juveniles. Large male crabs are most common on mud or mud / sand substrates, while smaller crabs are common on harder substrates (DFO 2009e).

Snow crab mating occurs during the spring but fertilized eggs may not be released for a year or two. Once released by the female, larvae are present in the water column for three months from late spring to early fall (Dawe and Taylor 2003). Snow crab eggs and larvae may occur within the Offshore Project Area.

The snow crab diet includes polychaetes, brittlestars, clams, shrimp, snow crab and other crustaceans (DFO 2005b). Common predators of snow crab are thorny skate, Atlantic cod, adult snow crab and seals.

The exploitable biomass of snow crab (Dawe et al. 2010) in NAFO Division 3L (northern half of the Grand Banks) is uncertain, with the exploitable biomass declining sharply in post-season trawls (3L Offshore). The 3L offshore exploitable biomass has remained low in the trap survey but has increased in the trawl surveys since 2006 (Dawe et al. 2010). The exploitable biomass in 3L Inshore has recently increased. The pre-recruit index has recently increased since 2006, with the 2008 index the highest since 1996 for 3L offshore, with recruitment prospects uncertain for 3L inshore (Dawe et al. 2010). The snow crab fishery occurs almost exclusively in water depths greater than 100 m (see Section 8.2.6.1).

Greenland Halibut

Greenland halibut is a deep-water flatfish most common in waters from northern Labrador to the Grand Banks at temperatures between -0.5°C to 3°C. They are concentrated mainly along the northeast edge of the Grand Banks and on the northeast Newfoundland Shelf, but occur infrequently along the southeast and southwest Grand Banks slopes and into the Laurentian Channel (Bowering 2000; Kulka et al. 2003). Greenland halibut are relatively abundant within the Offshore Project Area during the fall, but are found more toward the edge of the Grand Banks in the spring

(Figure 7-9). The most recent assessment of Greenland halibut, using the age-based population model for the subarea 2+ division 3KLMNO Stock Area, indicates the exploitable biomass has shown decreases over 2008 to 2010, as weaker year classes have recruited to the biomass (Healey et al. 2010).

They are a semi-pelagic flatfish, spending much of their time in the water column (Scott and Scott 1988). There is indication Greenland halibut undergo a spawning migration beginning in September (Scott and Scott 1988). Spawning occurs from December to April in the north and August in the south with some evidence of year round spawning (Morgan et al. 2003a). Eggs and larvae are pelagic over deep water, off the edge of the Continental Shelf (Scott and Scott 1988).

On the northeast Newfoundland Shelf, Greenland halibut feed on small crustaceans and squid when they are less than 20 cm in length. From 20 to 69 cm, their diet is primarily capelin, and at lengths over 69 cm, their diet is a variety of demersal fish (Bowering and Lilly 1992).

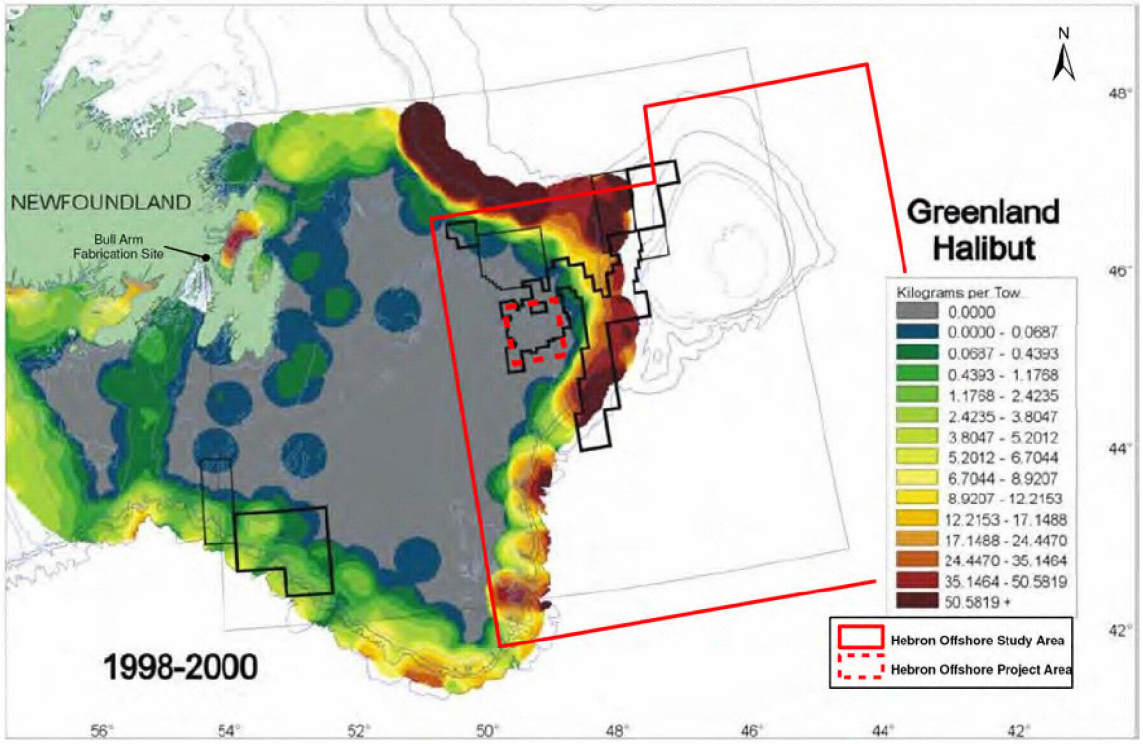
Yellowtail Flounder

Yellowtail flounder range from Labrador to Chesapeake Bay, preferring sandy substrates and water depths less than 100 m (Walsh 1992). After a decreasing trend in population in the late 1980s to early 1990s, yellowtail populations appear to be increasing more recently (Walsh et al. 2000; Kulka et al. 2003). Historically, their distribution has included the northern portion of the Grand Banks (Walsh et al. 2000); however, a more recent study shows increases in biomass in Division 3L, which is thought to be the result of an extension of the range of yellowtail flounder with increasing stock size (Walsh et al. 2006).The species is considered sedentary and does not undergo seasonal or spawning migrations.

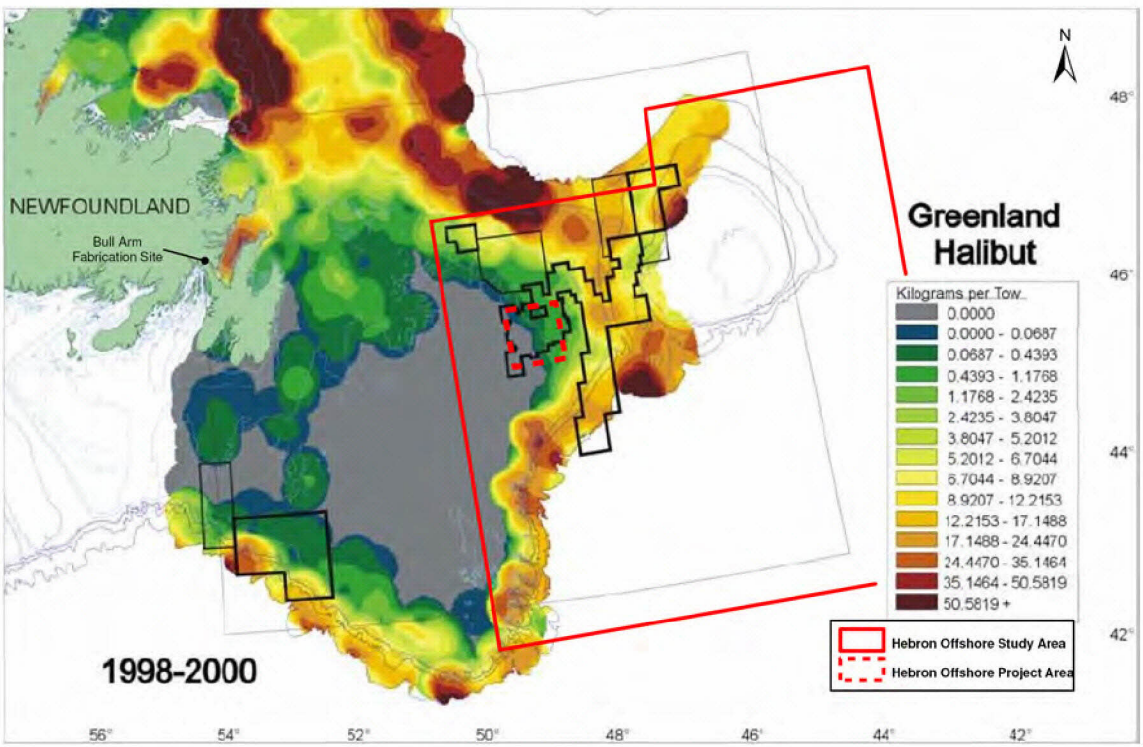
Yellowtail flounder are most concentrated in the warmer waters of the Tail of the Grand Banks and along the slope of the Laurentian Channel (Kulka et al. 2003). The Southeast Shoal of the Grand Banks is considered a nursery area for yellowtail flounder (Walsh 1992). The newly settled juveniles prefer sand or mud-sand substrate. The Offshore Project Area is not considered a nursery area for yellowtail flounder.

Yellowtail flounder spawn primarily on the central and southern portion of the Grand Banks, likely between April and June (Ollerhead et al. 2004). Spawning yellowtail have been captured near the Offshore Project Area in May and June (Figure 7-10). Yellowtail eggs are deposited on the bottom, and float to near the surface once fertilized (Scott and Scott 1988). The yellowtail diet on the Grand Bank is composed mainly of polychaetes and amphipods (Walsh 1992; Methven 1999; Link et al. 2002).

Greenland Halibut distribution based on spring research surveys from 1998-2000



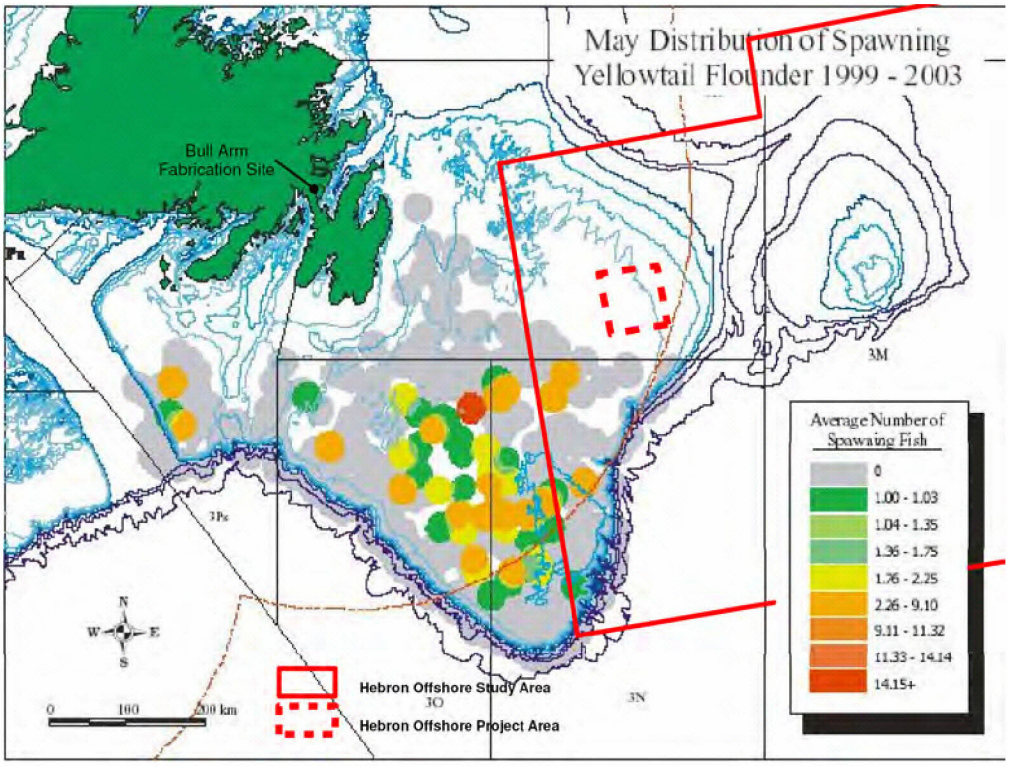
Greenland Halibut distribution based on fall research surveys from 1998-2000



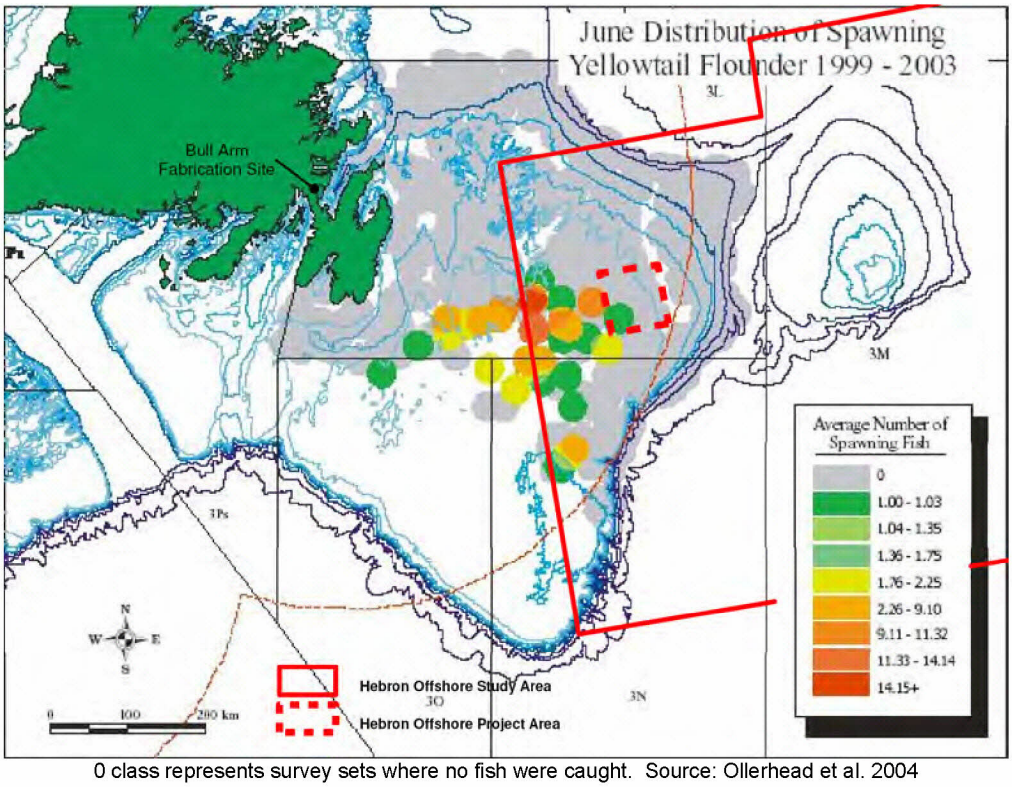
Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003.

Figure 7-9 Greenland Halibut Distribution

May distribution of spawning yellowtail flounder, 1999-2003.



June distribution of spawning yellowtail flounder, 1999-2003.



0 class represents survey sets where no fish were caught. Source: Ollerhead et al. 2004

Figure 7-10 Yellowtail Flounder Distribution

Witch Flounder

Witch flounder prefer the deeper waters off the edge of the Grand Bank, but also occur on the southwestern Grand Bank (Kulka et al. 2003). They occur at low densities within the Offshore Project Area during the spring and fall (Figure 7-11). They are not known to undergo extensive migrations (Scott and Scott 1988), so are likely in the area year-round. The stock has recently been assessed at 5 percent of the average size of the early 1980s (Maddock-Parsons 2005a, 2005b).

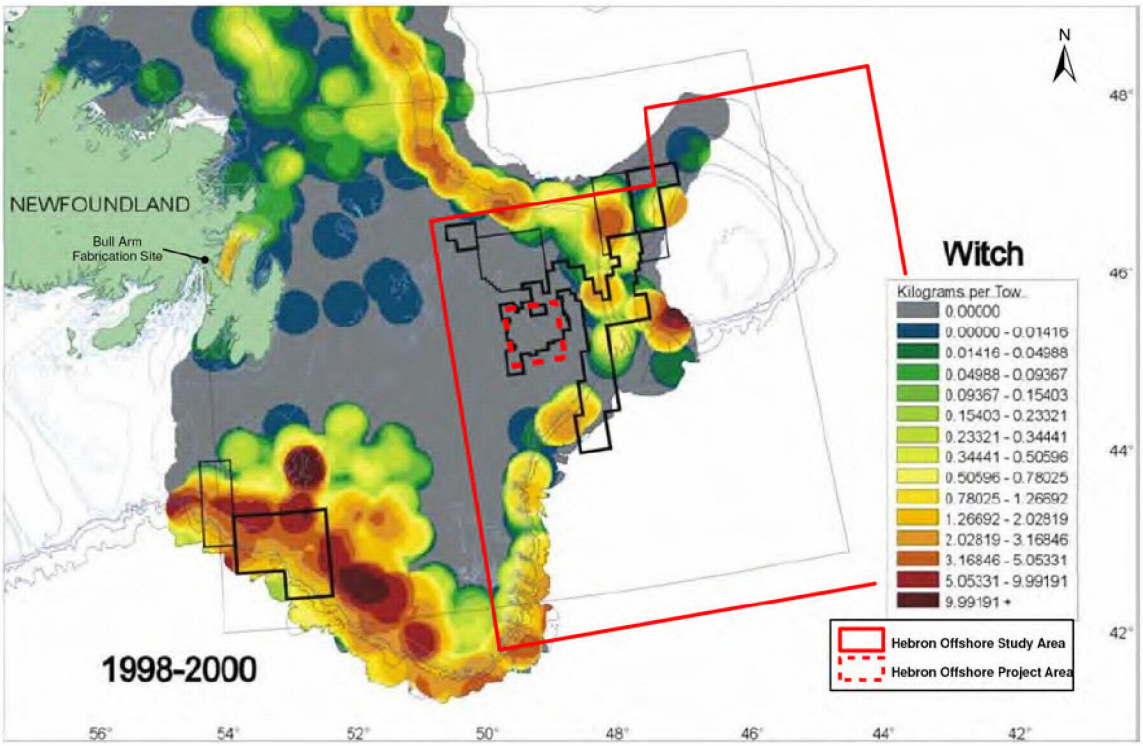
Witch flounder spawn on the Grand Bank between March and June (Bowering 1990). Spawning has been reported near the Offshore Project Area in June (Ollerhead et al. 2004). Eggs are pelagic and hatch in seven to eight days at 8°C. Witch flounder larvae may be pelagic for up to a year, before settling to the seafloor (Scott and Scott 1988). The primary prey for witch flounder are decapod crustaceans and polychaetes (Methven 1999; Link et al. 2002).

Thorny Skate

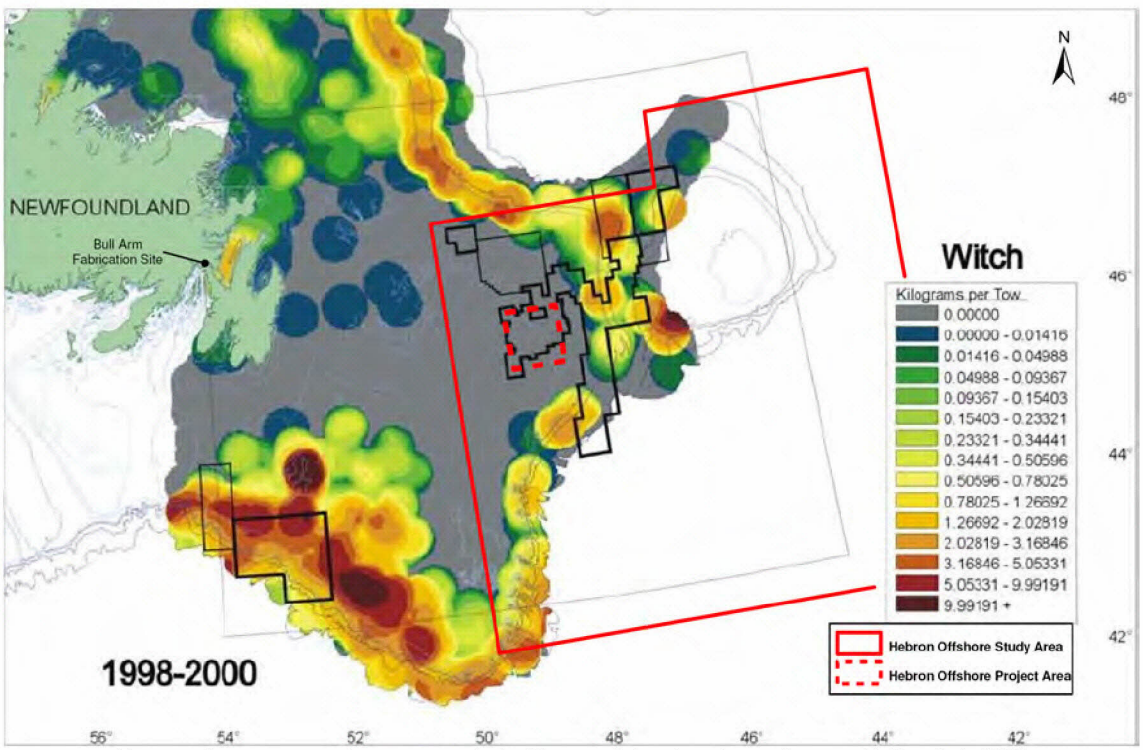
There may be up to 10 species of skates from the family Rajidae occurring in the Hebron Offshore Study Area. The most abundant, by far, is the thorny skate, followed by the smooth skate (Raja senta), winter skate, spinytail skate (Raja spinicauda) and barndoor skate (Raja laevis) (Kulka et al. 1996). Other skate species are less frequent. Thorny skate is a boreal / Arctic species occurring from Greenland to South Carolina in the western Atlantic. They are at their greatest densities on the southwestern Grand Banks and the Laurentian Channel in late fall and winter (Kulka et al. 2004a). In recent years, skate have been concentrating along the southwest slope and edges of the Grand Banks during the spring. During the fall, concentrations occur throughout the Tail of the Grand Banks, especially over the Southeast Shoal (Kulka et al. 2003). Thorny skate occur throughout the Offshore Project Area, particularly in the fall (Figure 7-12).

The abundance of thorny skate on the Grand Banks has been described as low but stable since the early 1900s (Kulka and Miri 2003). It is currently estimated that approximately 80 percent of the biomass is concentrated within 20 percent of the area on the southwest edge of the Grand Banks (Kulka et al. 2004a). There has been no genetic work conducted on skate to determine if there is a single or several populations within the Newfoundland region (includes both inshore and offshore areas), but the population dynamics of those skate sampled within, on, and in the vicinity of the Grand Banks (3LNO and 3PS) indicate the group is a single population (Kulka et al. 2004a). There are indications that thorny skate undergo a seasonal migration from the plateau of the Grand Banks in early winter to the edge and slope, returning in early summer (Kulka et al. 2004a), but are otherwise thought to be relatively sedentary (Kulka et al. 1996).

Witch flounder distribution based on spring research surveys from 1998-2000



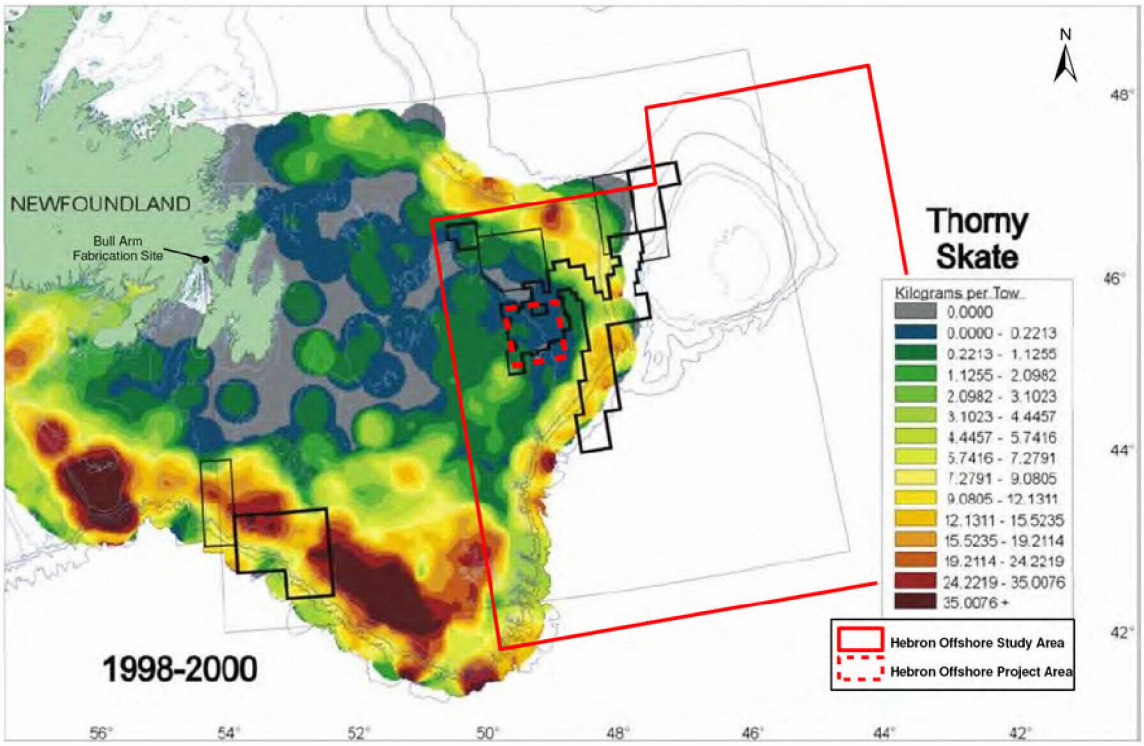
Witch flounder distribution based on fall research surveys from 1998-2000



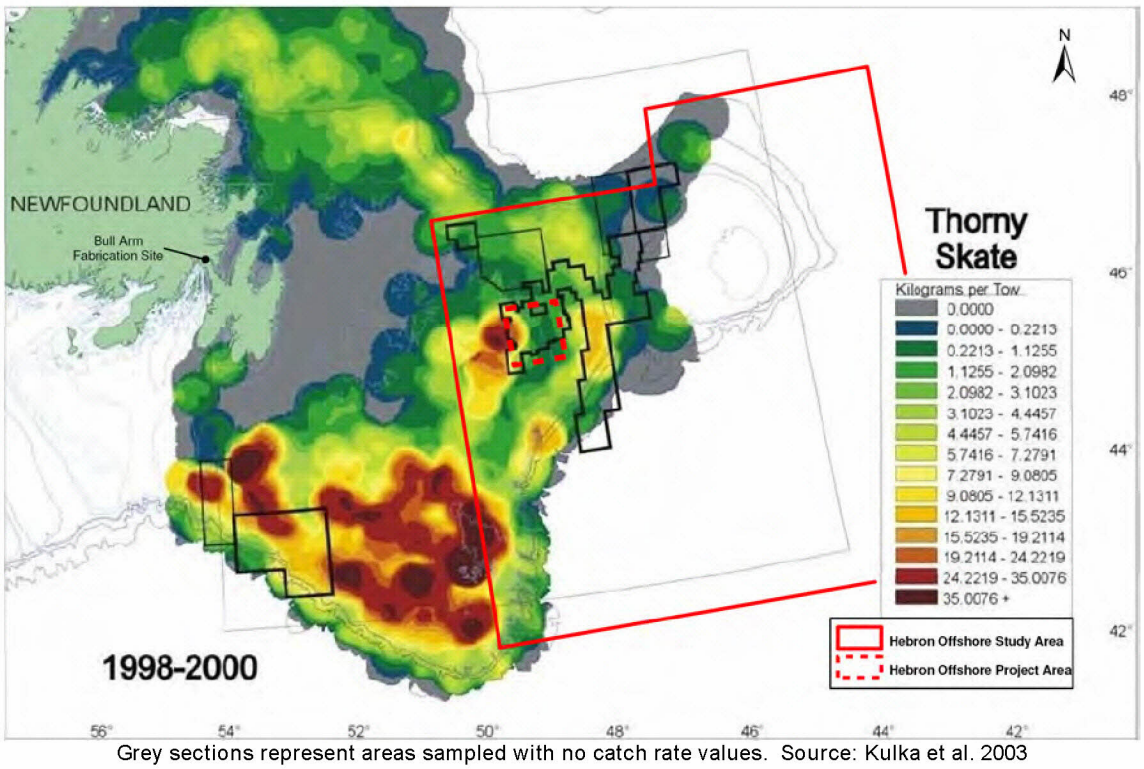
Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003

Figure 7-11 Witch Flounder Distribution

Thorny skate distribution based on spring research surveys from 1998-2000



Thorny skate distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003

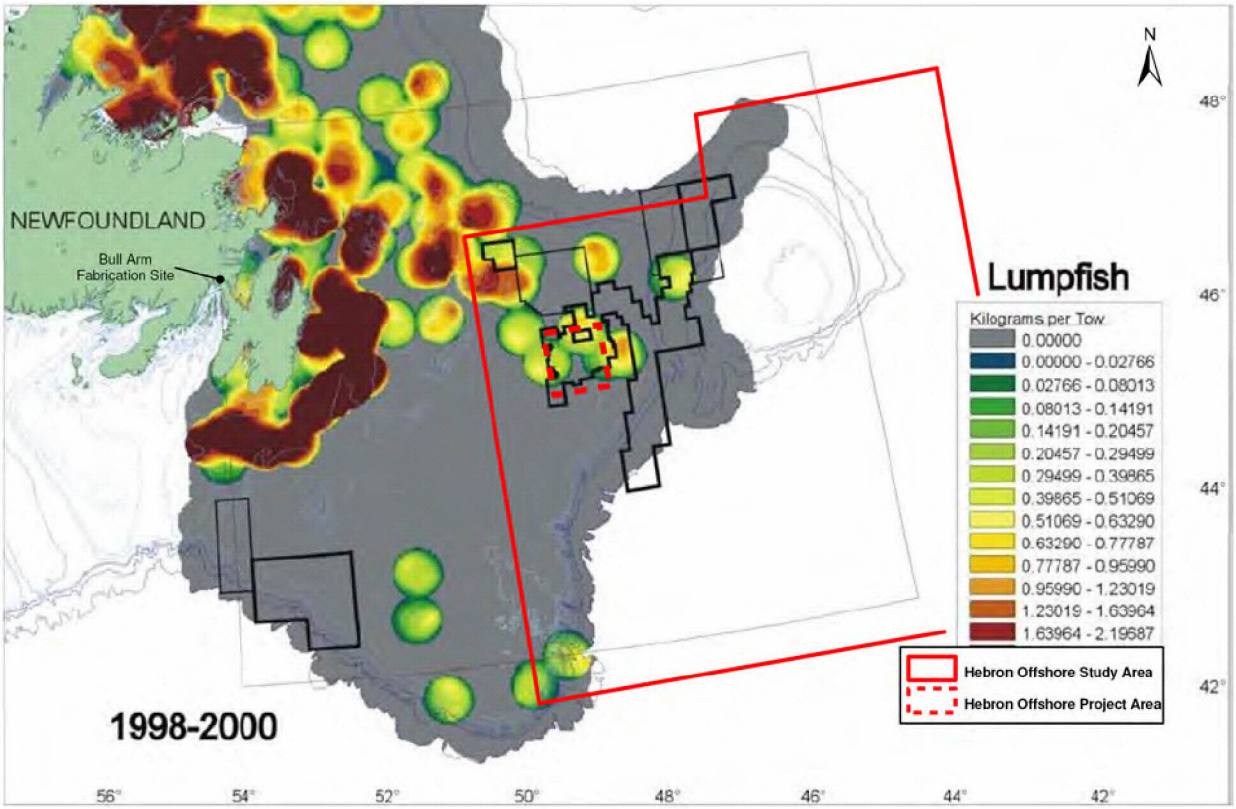
Figure 7-12 Thorny Skate Distribution

Thorny skate appear to spawn in the fall and winter. Young of the year skate are distributed around the edge of the Grand Banks, especially to the southwest of the Banks (Kulka et al. 2004a). Thorny skate consume whatever is available, preferring polychaetes and decapods (Methven 1999). Thorny skate can live up to 20 years and may lay from six to 40 egg cases per year.

Lumpfish

Lumpfish are congregated on the St. Pierre Bank in the spring, and on the northwest Grand Banks in the fall, suggesting a north-south migration (Kulka et al. 2003). They generally occur in low abundance throughout the northern and southern portions of the Grand Banks (Kulka et al. 2003). Lumpfish have not been observed near the Offshore Project Area during DFO spring surveys, but are present in the fall (Figure 7-13). Recently, lumpfish populations are showing an increasing trend (Kulka et al. 2003). A summary of the life history of the lumpfish is provided in Section 7.3.3.5.

Lumpfish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003

Figure 7-13 Lumpfish Distribution

Sculpin

There are several sculpin species common within the Offshore Project Area. The most abundant species collected during a reconnaissance survey was the mailed sculpin, but hookear and spatulate sculpins were also quite

common (Chevron 2002). Spatulate sculpin were common only in gravel substrate during the survey, whereas the mailed and hookear showed no clear preference for either substrate type. These three species are small sculpins, with maximum lengths of approximately 10 cm. They prefer cold Arctic and subarctic waters (Scott and Scott 1988). Their diet is believed to be primarily benthic and pelagic crustaceans and possibly polychaetes and small molluscs (Scott and Scott 1988). These species are not known to be a primary food source, but given their abundance and size, they may be preyed upon by benthic feeding fish. Spawning times are not known for the Grand Banks.

Capelin

There are four stocks of capelin in the Newfoundland region that are managed and referred to by NAFO Divisions 2SA+3KL, 3NO, 3PS and 4RST (Nakashima 1992, in Carscadden et al. 2001). Capelin may occur within the Offshore Project Area during spring or fall (Lilly and Simpson 2000).

Capelin spend most of their time offshore, but the 3KL stock of capelin migrates to the coastal beaches of Newfoundland to spawn in June and July. This stock is centred on the northern Grand Banks, straddling the boundary between Division 3L and 3K (Carscadden et al. 2001) and in the centre of 3K in the fall (Lilly and Simpson 2000). The 3NO stock usually spawns in June and July as well, but they tend to spawn offshore (Carscadden et al. 1989, in Carscadden et al. 2001). Juveniles live offshore and spawn at three or four years of age. Capelin are preyed upon by harp seals, cod, halibut, American plaice, Atlantic salmon (Salmo salar), marine birds and whales.

Capelin feed on plankton, especially copepods, when they are smaller and euphausiids once they are mature. Amphipods can also be a large part of their diet (Methven 1999). A summary of the life history of the capelin is provided in Section 7.3.3.5.

Sand Lance

Despite the importance of sand lance within the diets of several species on the Grand Banks, very little is known about the biology of the species. The range of the northern sand lance extends from West Greenland to Cape Hatteras, but they are most abundant on the plateau of the Grand Banks. Sand lance was one of the most abundant species found within the Offshore Project Area during the Chevron reconnaissance survey, notably in gravel substrates (Chevron 2002).

Sand lance spawn during the winter on the Scotian Shelf. Eggs are demersal and adhesive to the substrate. Sand lance larvae were abundant during pelagic surveys on the northern Grand Banks in August and September (Anderson et al. 1999).

Sand lance are semi-demersal, in that they feed pelagically at night on copepods, but prefer substrates of sand and fine gravel during the day (Scott and Scott 1988). Their most important predators are capelin, cod and sand

lance themselves (Bundy et al. 2000). They also can form a substantial portion of the American plaice diet in autumn and winter (Pitt 1973). Whales and harp seals also feed on sand lance (Bundy et al. 2000).

Arctic Cod

Arctic cod occur in the northwest Atlantic from the Arctic to the Gulf of St. Lawrence. They are semi-demersal from the age of one year and feed on zooplankton, primarily. Arctic cod feed on calanoid copepods as juveniles and hyperiid amphipods and juvenile capelin when they are older (Bundy et al. 2000). They are an important forage species for several species of fish, mammals and marine birds. Atlantic cod have been reported feeding on large numbers of Arctic cod off northeastern Newfoundland during the early spring. Arctic char (Salvelinus alpinus), Greenland halibut and Atlantic salmon also feed on Arctic cod at various times.

The distribution of Arctic cod has retreated north of the Grand Banks since the warming trend of the 1990s (Dalley et al. 2000). In northern Canadian waters, spawning is thought to occur in late autumn and winter.

7.4 Project-Valued Ecosystem Component Interactions

The environmental effects analysis focuses on those Project activities that potentially will result in environmental effects on Fish and Fish Habitat, as summarized in Sections 7.4.1 and 7.4.2.

Project activities with similar interactions on Fish and Fish Habitat have been grouped into four categories to provide a complete and comprehensive environmental effect analysis. Instead of assessing each Project activity separately, the grouping of activities with similar potential effects on Fish and Fish Habitat, allows for a cumulative assessment of within-Project activities.

The interactions summary categories are:

- Change in Habitat Quantity: Project activities that may result in harmful alteration or disruption of fish habitat, and may be declared a harmful alteration, disruption or destruction (HADD) of fish habitat by DFO and require a Section 35(2) Fisheries Act Authorization
- Change in Habitat Quality: Project activities may result in the harmful, alteration or disruption of fish habitat, and may be declared a HADD of fish habitat by DFO and require a Section 35(2) Fisheries Act Authorization. For example, Project activities creating suspended sediment in the water column, creating contamination, affecting a potential food source, or otherwise potentially causing sub lethal physiological effects on fish or shellfish are assessed as potential changes in fish habitat quality
- Change in Habitat Use: Project activities that may result in fish or shellfish changing their behaviour. Some activities may cause avoidance behaviour in fish or shellfish, whereas other activates may attract some species
- Potential Fish Mortality: Project activities that may result in fish or shellfish mortality

7.4.1 Nearshore

The primary nearshore Project activities during routine construction that could potentially interact directly or indirectly with marine fish and fish habitat include:

- Construction of the bund wall for the drydock at Great Mosquito Cove
- Subsequent removal of the bund wall and possible at-sea disposal of bund wall material
- Possible dredging along sections of the tow-out route to allow the GBS to transit to the Bull Arm deepwater site
- Upgrades to piers and wharfs in Bull Arm
- Potential temporary moorings at Topsides Pier
- Dredge spoils disposal
- Underwater noise from sheet pile installation during bund wall construction, blasting and vessel traffic
- Watering and dewatering of the drydock
- Concrete production discharges at Great Mosquito Cove and the deepwater site in Bull Arm
- Construction of the GBS at the deepwater site
- Hook-up and commissioning activities

7.4.2 Offshore

7.4.2.1 Offshore Construction / Installation

The primary offshore Project activities during construction and installation that could potentially interact directly or indirectly with marine fish and fish habitat include:

- Site preparation activities for offshore loading system (OLS) / Platform installation
- Installation of Hebron Platform, OLS and flowlines, and rock cover and/or concrete mattresses
- For potential expansion opportunities - construction of excavated drill centre(s) and dredged spoil disposal, installation of subsea equipment and flowlines, including placement of flowline protection measures (rock cover, concrete mattresses)
- Geophysical, geological, environmental and geotechnical surveys, as required

7.4.2.2 Operations / Maintenance

The primary offshore Project activities / components during operations and maintenance that could potentially interact directly or indirectly with marine fish and fish habitat include (but are not limited to):

- Operational discharges (e.g., cooling water, storage displacement water, firewater, produced water, grey/black water (refer to Chapter 2 for all operational discharges))

- Drill cuttings and muds discharges (water-based mud (WBM) from the Hebron Platform, WBM and synthetic-based mud (SBM) from mobile offshore drilling unit (MODU)-drilling associated with potential expansion opportunities) (potential siltation of the water column and mortality and/or change in habitat quality of marine species by smothering)
- Geophysical (2D / 3D / 4D seismic, vertical seismic profiles (VSPs)), geological, environmental and geotechnical surveys, as required
- Presence of Structures (e.g., subsea equipment in drill centres, Hebron Platform, OLS, flowlines)

7.4.2.3 Decommissioning / Abandonment

The primary decommissioning and abandonment activities that could potentially affect fish and fish habitat are removal of structures above the seafloor (e.g., Hebron Platform, OLS, flowlines, subsea infrastructure in drill centres). All exposed hard surfaces are expected to be colonized during the life of the Project. Removal of such structures will in effect remove the artificial reef effect created during the life of the Project, reducing localized productivity. The act of removal of the structures is expected to create temporary localized turbidity as well.

7.4.3 Accidents, Malfunctions, and Unplanned Events

During the construction and operation phases of the Hebron project, there are several hydrocarbon products carried and used onboard vessels, barges, drill rigs and platforms. These include crude oil, diesel oil, synthetic drilling mud, synthetic drill (base) fluid, lubricating oils and hydraulic oils. Hydrocarbon spills may occur as a result of human error, equipment failure or loss of well control (blowout). An oil spill, although highly unlikely, could affect fish and fish habitat and potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. A description of the probability of an oil spill as well as results of the nearshore and offshore oil spill trajectory modelling are provided in Sections 14.2 and 14.3, respectively. Other accidental events such as a rupture in the bund wall, chemical spills and collisions, are also assessed.

7.4.4 Summary

A comprehensive summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present and likely future projects and accidents, malfunctions, and unplanned events, is provided in Table 7-9.

Table 7-9 Potential Project-related Interactions: Fish and Fish Habitat

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Fish Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosquito Cove followed by a deepwater site zone)				+
Bund Wall Construction (e.g., sheet / pile driving, infilling)	x	x	x	x
Inwater Blasting	x	x	x	x
Dewater Drydock / Prep Drydock Area	x	x	x	x
Upgrades to Ferry Terminal in Back Cove	x	x	x	
Concrete Production (floating batch plant)		x	x	
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passender ferry to/from deepwater site)			x	
Lighting			x	
Air Emissions				
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	x	x	x	x
Removal of Bund Wall and Disposal (dredging / ocean disposal)	x	x	x	x
Tow-out of GBS to Bull Arm deepwater site			x	
GBS Ballasting and De-ballasting (seawater only)			x	x
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site		x	x	
Hook-up and Commissioning of Topsides			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Potential Dredging for Tow-out from the Deepwater Site to the Offshore Location	x		x	
Platform Tow-out from deepwater site		x	x	
Offshore Construction / Installation				
Presence of Safety Zone				+
OLS Installation and testing	x	x	x	x
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	x	x	x	x
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation	x	x	x	x
Underbase Grouting		x		
Possible Offshore Solid Ballasting		x		
Placement of Rock Scour Protection on Seafloor around Final Hebron Platform Location	x	x	x	x
Hook-up and Commissioning of Hebron Platform				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	
Air Emissions				
Lighting			x	
Potential Expansion Opportunities				
Presence of Safety Zone				+

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Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Fish Mortality
Excavated Drill Centre Dredging and Spoils Disposal	x	x	x	x
Installation of Pipeline(s) / Flowline(s) and testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	x	x	x	x
Hook-up, Production Testing and Commissioning of Excavated Drill Centres			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Offshore Operations and Maintenance				
Presence of Safety Zone				+
Presence of Structures	x		x	
Lighting			x	
Maintenance Activities (e.g., diving, ROV)			x	
Air Emissions				
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		x		
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)		x		
WBM Cuttings		x		x
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)			x	
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				+
Drilling Operations from MODU at Future Excavated Drill Centres	x	x	x	
Presence of Structures	x	x	x	
WBM and SBM Cuttings		x		x
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				x
Removal of the Hebron Platform and OLS Loading Points	x	x	x	x
Lighting			x	
Plugging and Abandoning Wells		x	x	
Abandoning the OLS Pipeline	x	x	x	
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture		x	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Fish Mortality
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blowout		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)		x	x	x
Marine Vessel Incident (i.e., fuel spills)		x	x	x
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)	x	x	x	
Terra Nova Development (production)	x	x	x	
White Rose Oilfield Development and Expansions (drilling and production)	x	x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (Nearshore and Offshore)		x	x	
Commercial Fisheries (Nearshore and Offshore)	x	x	x	x
+ indicates a positive interaction and possible decrease in mortality				

7.5 Environmental Effects Analysis and Mitigation

Potential environmental effects on marine fish and fish habitat during all phases of the Project are discussed by Project phase and summarized at the end of this chapter.

7.5.1 Construction and Installation

7.5.1.1 Change in Habitat Quantity

Nearshore

Construction of the bund wall, drydock, dredged areas and any in-water dredge spoil disposal areas may be declared a HADD of fish habitat by DFO and likely require a Section 35(2) Fisheries Act Authorization, requiring any loss of fish habitat to be compensated with the objective to achieve no net loss of productive capacity of fish habitat.

The GBS will be towed out and moored at the deepwater site where construction will continue. As described in Section 2.8.3, it is anticipated that existing deepwater moorings will be used; however, additional moorings may be required. The requirement for additional moorings will be determined at the FEED stage. If additional moorings are required at the deepwater site, they will be constructed on land (mooring chains will be hooked from the mooring point to a tension barge and from the barge to the GBS at the

deepwater site; there is no interaction of the mooring chains with fish habitat (quantity, quality, use, or mortality). In addition, temporary underwater moorings (or anchors) may be required at the Topsides pier to position the heavy lift vessel for Topsides tow-out. Details regarding the requirement for moorings, or the type of moorings that may be required are unknown at this time, as the Project is in the early stages of Project design. The footprint of the bund wall, the area of drydock, potential topsides pier moorings, the area to be dredged and the footprint of any at-sea disposal will be quantified and detailed within the "Hebron Project HADD Quantification Report" (EMCP 2011). The development and implementation of the Strategy and subsequent Habitat Compensation Plan will prevent significant adverse residual environmental effects to habitat quantity.

Upgrades to the Back Cove ferry terminal may be required. Based on current project design it is not anticipated that these upgrades will include a change in the overall the footprint of the pier. However, as project design evolves and work begins at the deepwater site, there may be requirements to alter the footprint of the ferry pier. Upgrades to the ferry pier will be designed to avoid potential impacts to the adjacent stream. If changes are made to the footprint of the ferry pier, the quantity of fish habitat available for use may be affected by the covering and/or smothering of existing habitat. Mitigation measures outlined in DFO's Marine Wharf Repair / Reconstruction Operational Statement (http://www.dfo-mpo.gc.ca/habitat/what-quoi/os-eo/nl/pdf/mwharf-eng.pdf) will be implemented.

The bund wall footprint and the area to be drained for the drydock in Great Mosquito Cove may temporarily affect the quantity of available habitat for fish and shellfish for an estimated 24 months. During this time, the submerged surface area of the bund wall will provide new habitat for some species. Species associated with boulder habitats like periwinkles, barnacles and blue mussels may increase in abundance where boulders replace fine grained substrates. The addition of boulders to a relatively flat sand / gravel habitat may attract fish and shellfish. Adult lobster will be attracted from marginal habitats in the immediate area by newly created habitat that the armour stone crevices may provide. Areas vacated by these individuals may become available for new recruit lobsters. Other fish species that may colonize the bund wall area are rock gunnel (Pholis gunnellus), eelpout, radiated shanny (Ulvaria subbifurcata) and longhorn sculpin (Myoxocephalus octodecemspinosus). The bund wall may not only provide shelter for these species, but also create a feeding ground for several additional fish and shellfish species. Invertebrate species may inhabit the rocky subtidal portions of the bund wall, include rock crab, mussels, polychaetes, starfish, brittlestars, periwinkles, barnacles, urchins and fan worms.

The drydock area will be drained and unavailable for use by fish or shellfish for an estimated 24 months, until the bund wall is removed for the tow-out of the GBS to the deepwater site in Bull Arm.

If dredging is required prior to GBS tow-out, there will be an alteration of habitat within the dredged area(s). Macrobenthic species diversity may decrease briefly, but overall abundance and biomass of the benthic

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community in most habitats will likely not decrease as opportunistic invertebrate and fish species move into and thrive in the dredged area. Depending on the depth of the overburden in the area to be dredged, a very similar habitat to the existing substrate may be exposed and the dredged area will be re-colonized from neighbouring communities within one (e.g., polychaetes and amphipods) to several (e.g., scallop) years. This habitat disturbance within the dredged area is therefore temporary and highly reversible. Existing benthic habitat within the disposal area will be altered by the placement of dredged material. The magnitude of the alteration will depend on the similarity of the dredged material to the existing substrate within the disposal area. For example, if the dredged material is a mix of cobble and boulder and the material is placed over existing rocky substrate, less alteration of the habitat is expected compared to disposal of fine grained sediments in an area of rocky substrate.

With respect to the Nearshore Project Area, a HADD compensation plan will be required, since installation of a bund wall and de-watering of the proposed drydock area to allow for construction of the GBS, potential dredging (and blasting) of native sediments in selected locations within Great Mosquito Cove, temporary moorings at the topsides pier, and potential upgrades to the ferry pier will likely be considered a HADD by DFO. As its preferred option for HADD compensation, EMCP is proposing to enhance fish habitat in Great Mosquito Cove by re-locating bund wall material[1] to featureless sedimentary areas of the sea floor, which currently have low commercial fish productivity. The re-located rock material will be deposited in closely-spaced piles (to maximize 'edge' effects) with the intention of creating 'artificial reefs'. In addition, local fishers have recommended that the rock 'reefs' be placed in shallow, sub-tidal areas of Great Mosquito Cove (<20 m water depth), which are adjacent to areas with bedrock, boulder and medium to coarse gravel substrates, which will provide access corridors to allow for development of juvenile lobsters into later life stages and ultimately into mature, commercial-size adult lobsters and facilitate the growth of kelp species that provide food and/or cover for a variety of fish and invertebrate species.

Offshore

Activities affecting habitat quantity during offshore construction include Hebron Platform and OLS installation, construction of excavated drill centres, installation / protection of flowlines (OLS and tie-back from drill centres to Platform), and disposal of excavated materials.

There is currently no plan to trench the OLS, but to protect the line with rock cover and or concrete mattresses. The footprint of the OLS on the seafloor will restrict access by fish and shellfish to some habitat and may be declared

[1] According to DFO guidelines, the re-located rock material should be clean and free of sediment and a combination of equal portions of boulder (250 to 750 mm), rock (130 to 225 mm) and cobble (65 to 130 mm). In addition to the bund wall material, there is also the possibility that some dredged native sediments would be available for incorporation into the proposed rock reefs if not taken to an onshore site for disposal / reuse.

a HADD of fish habitat by DFO and likely require a Section 35(2) Fisheries Act Authorization, requiring any loss of fish habitat to be compensated with the objective to achieve no net loss of productive capacity of fish habitat. However, the presence of unburied material over the OLS (i.e., concrete mattresses and rock cover) is expected to create habitat by increasing the amount of available hard substrate habitat that could be colonized by local flora and fauna, creating a reef effect for fish populations in otherwise barren sandy or soft bottom areas. Where flowlines and equipment are buried, the overlying sediments will provide habitat upon which benthic communities will recover.

Installation of the GBS will have a similar effect in that access to habitat under the GBS, and that covered by rock scour, will be lost to fish and shellfish and may be declared a HADD of fish habitat by DFO and likely require a Section 35(2) Fisheries Act Authorization, requiring any loss of fish habitat to be compensated with the objective to achieve no net loss of productive capacity of fish habitat. However, colonization by invertebrates on the concrete GBS is expected.

The Hebron Platform, the rock scour protection, and the rock mattress and/or concrete mattress cover over the flowline and OLS will provide new hard substrate habitat to be colonized and perform as an artificial reef. The presence of these structures over an unstable sand and gravel substrate enhances the habitat complexity of the surrounding area and increases localized productivity. The new surfaces will become colonized by sponges, anemones, brittlestars and seastars, which themselves provide habitat for smaller epifaunal and epifloral species. Studies in the North Sea indicate most of the fouling biomass in the upper 50 m is composed of seaweeds, hydroids, soft corals, anemones and mussels. Hydroids, soft corals, anemones and tubeworms are the most common animals below 50 m (Welaptega 1993, in Husky Oil 2000). An artificial reef effect is created shortly after the installation and the structures become a source of food and shelter for several species of fish and shellfish, especially juveniles.

With respect to the Offshore Project area, it is predicted that the increased hard surface area afforded by structures (not including the Hebron Platform itself) and associated rock cover in the Hebron offshore production field will likely offset any footprint losses (including the base area of the Hebron Platform). Therefore, EMCP submits that additional compensation will not be required for the offshore Project Area based on preliminary design of these elements[2]. EMCP will provide DFO with a habitat quantification report for the offshore Project Area once final design details of these structures are available in order to make a final determination of whether HADD compensation may be required.

[2] While the rock cover over the flowlines and the armouring around the Platform has the potential to constitute fish compensation, it would be contingent upon the size of the rock material and its likely benefits to species within the area.

If excavated drill centres and flowlines are installed as part of the Hebron Project in the future, associated dredging may be completed by a suction hopper dredge or alternate technology (e.g., clam shell). The potential environmental effects of each technology are similar, but they may differ in extent. The clam shell dredge will side cast the material during drill centre excavation, which will confine sediment dispersion and the disposal pile footprint to near the excavation site. The suction hopper dredge vessel would cut the substrate and vacuum the material up to the vessel for disposal at a pre-approved disposal site.

The areas to be dredged will result in a temporary loss of productivity within the footprint of the excavated drill centre or flowline. Several studies indicate that dredging causes an initial reduction in the abundance, species diversity and biomass of the benthic community and that substantial progress towards full restoration of the fauna and sediments can be expected within a period of approximately two to four years following cessation (Kenny et al. 1998; Sardá et al. 2000; Van Dalfsen et al. 2000). It has been suggested that recolonization of a dredged area by polychaetes occurred within five to 10 months after the cessation of dredging in a site located within the North Sea, with restoration of biomass to pre-dredge levels anticipated within two to four years (Van Dalfsen et al. 2000).

Productivity within the footprint of the dredge spoils disposal area is decreased due to smothering under several centimetres of sand and gravel dredged from the excavated drill centre. However, on the surface of the disposal pile, the emergence of infauna from the excavation will create a newly available food source for snow crab, skate and any flatfish or benthic feeder in the area.

On the periphery of the disposal pile, sessile epifauna such as bryozoans, barnacles, brittlestars and urchins will be smothered, whereas infauna such as most polychaetes, amphipods and clams are burrowing species and can be expected to resurface from a covering of several centimetres.

The installation of pipelines / flowline to the Hebron Platform will require protection to be in place, such as concrete mattresses, rock cover or other flowline insulation.

As with the nearshore, any offshore activities including construction of excavated drill centre(s) and spoils disposal, installations of pipeline(s) / flowline(s) (including related infrastructure such as concrete mattresses, rock cover or other flowline insulation) and tie-back from excavated drill centre(s) to the Hebron Platform may be declared a HADD of fish habitat by DFO and likely require a Section 35(2) Fisheries Act Authorization, requiring any loss of fish habitat to be compensated with the objective to achieve no net loss of productive capacity of fish habitat. Concrete mattresses, rock cover or other flowline insulation have the potential to provide new hard substrate habitat to be colonized and function as an artificial reef and would likely be colonized by sponges, anemones, brittlestars and seastars.

Offshore Project design has not progressed to the stage of being able to accurately quantify the footprint of possible excavated drill centre(s), the OLS

or installation of pipeline(s) / flowline (including related infrastructure such as concrete mattresses, rock cover or other flowline insulation) and testing from excavated drill centre(s) to the Hebron Platform, nor the area of the dredge spoil disposal footprint. However, potentially affected areas can be estimated from previous similar projects on the Grand Banks. The nominal areal extent of the activities with the potential to affect habitat quantity is provided in Table 7-10.

Table 7-10 Nominal Seafloor Disturbance Area for Offshore Project Components

Project Component	Quantity	Typical Dimensions on the Seafloor	Typical Seafloor Area
Hebron Platform	1	133 m	13,892 m^2
OLS	2	0.6 x 2,400 m	1,440 m^2
Potential Expansion Opportunities			
Excavated Drill Centre (70 m x 70 m)	Up to 4	130 x 130 m	16,900 m^2
Excavated Drill Centre dredge spoils disposal	Up to 4	1 km x 1 km	1 km^2
Flowline bundle	Up to 4	0.5 x 4,000 m	2,000 m^2

In accordance with the DFO policy of no net loss of fish habitat, a habitat compensation program will be developed in conjunction with DFO as a mitigation measure for the net loss of fish habitat resulting from nearshore and offshore Hebron Project activities.

7.5.1.2 Change in Habitat Quality

Project activities may affect water and sediment quality and the sound environment, as described in this section. To mitigate these environmental effects, measures have been included within the Project design so that significant residual adverse environmental effects will likely not occur.

Nearshore

Bund wall construction and removal, drydock dewatering, upgrades and/or repairs to the Back Cove ferry terminal, concrete washwater discharge, dredging, blasting and sheet pile driving are the primary nearshore construction activities that could affect the quality of fish habitat in the Nearshore Project Area. The potential environmental effects of these activities are discussed separately below, but considered together in the effects analysis and significance determination of the Hebron Project on fish and fish habitat.

Suspended Sediment

Fine-grained sediment can be suspended in the water column during the following nearshore Project activities:

- Bund wall construction
- Dredging of bund wall and possibly sections of tow-out route
- Disposal of dredged material at sea

- Drydock dewatering
- Mooring replacement / upgrades
- Blasting in areas of fine-grained sediment
- Upgrades and / or repairs to the Back Cove ferry terminal

One effect of increased levels of suspended sediment is a reduction in the amount of light that is able to transmit through the water column. If elevated levels of suspended solids are sustained before or during a plankton bloom, a decrease in primary productivity may result. In turn, the food supply for young fish and shellfish may be diminished during that period. Zooplankton may be affected as well. Copepods show negative effects and reduced numbers when there is moderate loading of suspended solids (Robinson and Cuthbert 1996, and references therein). This may have localized effect on prey selection for some fish species.

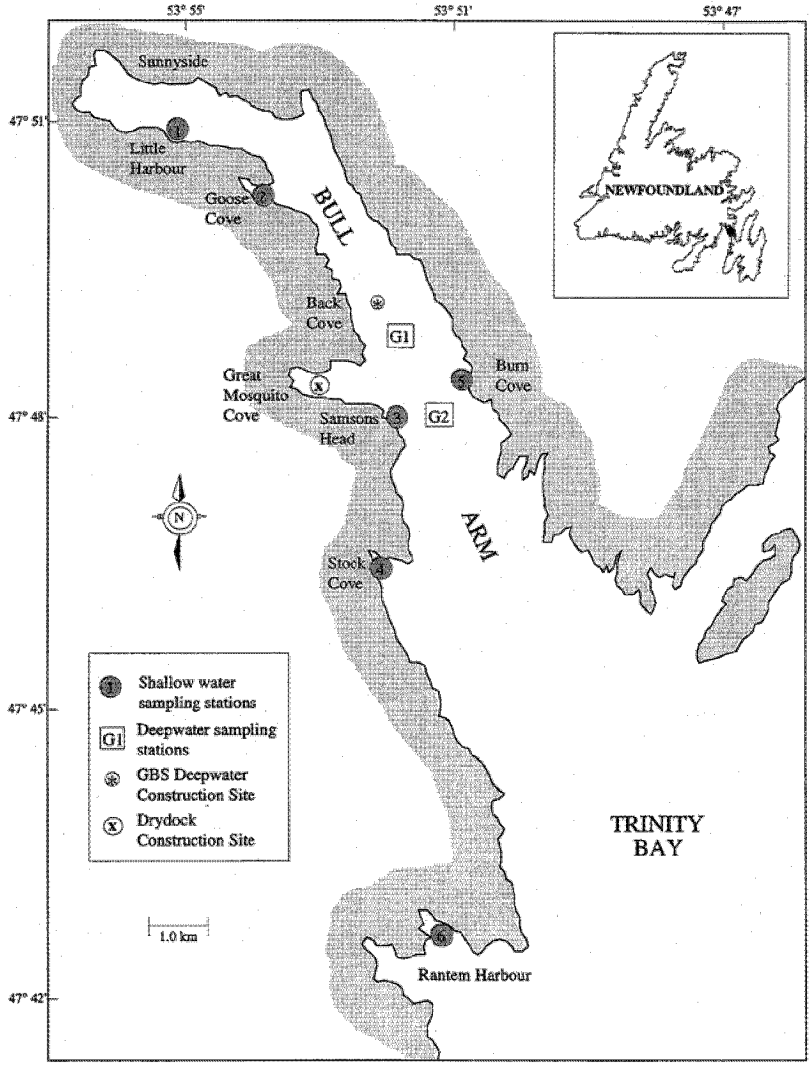
Eggs and larvae of finfish and shellfish are generally more prone to physical damage from increased levels of suspended sediment because they are passive drifters and cannot avoid the affected area like the post-settlement life stages. Total suspended solid (TSS) levels of 1,000 mg/L have caused mechanical damage to herring larvae (Boehlert and Yoklavich 1984). Suspended sediment may cause respiratory and feeding problems for finfish species in the area or they may simply avoid the area of construction activity (Robinson and Cuthbert 1996, and references therein). The severity of effects of suspended sediments increases as a function of sediment concentration and duration of exposure (Newcombe and Jensen 1996). Sublethal effects in several fish species have been reported after several days of exposure to suspended sediment concentrations of approximately 650 mg/L or greater (Appleby and Scarratt 1989). Concentrations of this magnitude would likely be localized to the immediate site of seabed disturbance and within the area fish are expected to avoid due to construction activity (see Section 7.5.1.3).

Shellfish are generally more susceptible to the effects of increased sediment load than finfish because they are filter feeders (Peddicord 1980). If the levels of suspended solids are sufficient, non-organic sediment loading can cause macroinvertebrates to ingest sediment particles that may inhibit digestion. Under extreme sediment loading, shellfish tend to stop feeding for as long as required.

Suspended sediments will resettle on the seabed after disturbance. The rate and location of this process is dependent upon the sediment grain size and the water currents in the area. Fines (silt / mud) will drift longer distances in the water column. Observed sediments within the Great Mosquito Cove area are comprised predominantly of sands, often with gravels. The frequent outcrops of consolidated sediments suggest a very thin layer of unconsolidated sediments on top of the bedrock (Lee 2005). Given this substrate composition, any re-suspended sediments would be expected to settle through the water column relatively quickly. Hitchcock et al. (1999) monitored the settlement of sediment from a number of dredging operations. The results indicated that in general, the majority of sediments settled within

10 to 15 minutes of release, and coarse sands (>2 mm) and gravels settled out virtually instantaneously.

An EEM program was conducted within Bull Arm from 1991 to 1997 (Christian and Buchanan 1998) during the Hibernia GBS construction phase. In an effort to monitor the potential environmental effects on the quality of fish and fish habitat, six shallow water (<20 m) sampling stations were established throughout Bull Arm from the innermost site at Little Harbour near Sunnyside to the outermost one at Rantem Harbour. In addition, deepwater (>120 m) grab samples for surficial sediments were collected at two stations; one just north of, and one immediately south of the entrance to Great Mosquito Cove (Figure 7-14). A total of 43 field trips were conducted at Bull Arm during the Hibernia EEM Program.



Source : Christian and Buchanan (1998)

Figure 7-14 Environmental Effects Monitoring Study Area, Hibernia Project, Bull Arm

Nearshore sedimentation was measured as total deposited solids (TDS) and volatile deposited solids (VDS) during the Hibernia EEM program (Christian

and Buchanan 1998). Generally, the highest values of TDS and VDS occurred in the fall, followed by a decrease in the winter and a slight increase in the spring. Those areas with the most freshwater influence (i.e., Stock Cove and Goose Cove) displayed the highest absolute levels compared to the other stations. The most marked inter-annual difference occurred at Station 3, the station nearest the construction site, during the time of breaching the drydock bund wall (Figure 7-12). At this time, the TDS increased and the VDS / TDS decreased markedly. TDS amounts also increased at adjacent stations but to a lesser degree.

The following is a list of mitigation measures designed to reduce sediment loading during construction. These will be implemented, where applicable, to reduce potential effects. Additional mitigation measures will be investigated during Front-end Engineering Design (FEED) and detail design and engineering:

- Investigate the use of washed rock or in-water sediment control measures for fill material in the construction of the bund wall (different measures will be investigated, and a proven method will be implemented)
- Chemistry of rock and till material will be tested prior to placement
- Efficient installation with minimal seabed disturbance
- Investigate technologies to reduce sedimentation during dredging operations (different measures will be investigated, and a proven method will be implemented)
- Minimal movement of barge anchors to reduce resuspension of sediments
- Releasing water for hydrostatic testing only when it meets criteria set out in the Fisheries Act or Canadian Environmental Protection Act (or the Newfoundland and Labrador Environmental Control Water and Sewer Regulations, 2003, of discharged from a land-based settling pond), prior to discharge
- Where applicable, adherence to Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines for the protection of aquatic life when considered in conjunction with existing ambient water quality and site-specific factors
- Where applicable, adherence to mitigation measures outlined in DFO's Marine Wharf Repair / Reconstruction Operational Statement (http://www.dfo-mpo.gc.ca/habitat/what-quoi/os-eo/nl/pdf/mwharf-eng.pdf)
- Use of settlement basins and/or containment areas for concrete washwater
- Use of best practices, continuous improvement programs and best available technology

Contamination

If the dredge spoils or material used for bund wall construction have levels of metals, hydrocarbons or other compounds above background level, there is increased risk of introducing or spreading contaminated soils. Concrete washwater or uncured concrete can be very alkaline and affect the quality of fish habitat if exposed to the marine environment.

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The EEM results within Bull Arm during the Hibernia GBS construction phase (Christian and Buchanan 1998) tested for the effects of contamination and indicated no detectable effect on fish heath as measured by Mixed Function Oxygenase activity, histopathology, bile metabolites or gill parasitism. During the EEM program, iron and manganese were the only elements recorded above the Maximum Allowable Effects Levels, the concentration level in sediments above which the frequency of associated biological effects are unacceptable. At Station 3, 10 of the 21 trace metal analytes were distinctly more concentrated in the "breach" composite sample (Figure 7-12). Most PAHs and total petrogenic hydrocarbons in sediments collected throughout the EEM were below their respective Maximum Allowable Effects Levels.

Blue mussels were also monitored during the Hibernia EEM program to test for indications of contamination. There were no obvious differences in condition index of blue mussels sampled outside of the bund wall breach time and those sampled during and immediately following breach time. Concentrations of 13 trace metal analytes in mussels were essentially unchanged throughout the EEM program regardless of location, exposure time duration, sampling season and period of exposure relative to bund wall breaching. Concentrations of the remaining eight trace metal analytes appeared most affected by sampling season. Arsenic, copper, nickel, selenium and tin consistently appeared most concentrated in mussel soft tissue sampled in May. Barium, chromium and vanadium appeared most concentrated in mussels sampled in the fall. Almost all polycyclic aromatic hydrocarbon (PAH) concentrations in muscle tissue were below the analytical detection limit. Those that did exceed limits of quantitation were considered to be minimal (Christian and Buchanan 1998).

The potential environmental effect from concrete production is the effects of washwater released to the environment. Liquid wastes may contain hazardous materials such as cement, concrete additives and oil.

Cement is very alkaline and washwater from spoiled concrete or from the cleaning of the batch plant mixers and mixer trucks, conveyors and pipe delivery systems can be expected to have very high pH, which may exceed regulatory limits. Similarly, spoiled concrete or washwater would contain concrete additives and agents, some of which are toxic to aquatic species. Aggregates, particularly the finer sand fractions can be expected to be washed from spoiled concrete or discharged in washwater. Uncontrolled release of such washwater will be prevented.

Mitigation measures to reduce the risk of contamination during nearshore construction may include:

- Concrete washwater containment and testing to meet applicable regulations (e.g., Canadian Environmental Protection Act, Fisheries Act and provincial Water Resources Act) prior to discharge
- Investigate use of washed-rock for bund wall construction
- EPP to address discharge of all chemicals to the marine environment
- Treatment of washwater from batch plants prior to discharge / disposal

Noise and Blasting

Nearshore fish habitat quality may also be affected by noise. Underwater noise created by blasting, sheet piling and vessel traffic (including vessel traffic associated with the tow-out of the GBS to the deepwater site, completion of GBS construction and Topsides mating at the deepwater site, hook up and commissioning of Topsides and Hebron Platform tow-out from the deepwater site) can affect the physiology of fish and invertebrates. Background noise in the ocean can originate from a range of natural and anthropogenic sources, including oceanic turbulence, thermal noise, surface wave action, animal communications and vessel traffic. Large tankers, at full steam, may have a source noise level of 170 dB re 1 µPa at 1 m and average fishing vessels emit noise between 127 and 146 dB at 100 m. Typical peak levels of ambient noise range from 110 to 120 dB re 1 µPa in shallow water (Richardson et al. 1995), depending on oceanographic conditions, shipping and other human activity. Therefore, typical peak background values of 110 dB re 1 µPa are a reasonable assumption for shallow nearshore waters. However, noise level is very much dependent upon frequency, in that levels at higher frequencies are typically lower.

Fish with swim bladders and specialized auditory couplings to the inner ear (e.g., herring) are considered to be most sensitive to sound pressure. Fish with a swim bladder but without a specialized auditory coupling (e.g., cod and redfish) are moderately sensitive, while fish with a reduced or absent swim bladder (e.g., mackerel and flounder) have low sensitivity (Fay 1988). The swim bladder is the most likely site of damage in finfish, but the kidney, liver and spleen may also be ruptured. In comparison to finfish, benthic invertebrates and shellfish are likely less affected by sudden pressure changes underwater because they do not have contained airspaces.

Acoustic modelling of pile driving activity into bedrock at Great Mosquito Cove was conducted. The model estimated a source level of 216 dB re 1 µPa @ 1 m and that a sound pressure of >190 dB re 1 µPa (rms) will extend to approximately 300 to 400 m from the bottom of Great Mosquito Cove, depending on distance of the bund wall from the shoreline (JASCO 2010). If pile driving is required at the deepwater site in Bull Arm, the model estimates that a sound pressure of >190 dB re 1 µPa (rms) will occur less than 100 m from the source. At sound pressures of 192 dB re 1 µPa, fish may be stunned temporarily and internal injuries may result at levels of 200 dB re 1 µPa (Turnpenny and Nedwell 1994). There is limited risk of these interactions occurring given that fish are expected to avoid the area near in-water construction activity. The mitigation measures outlined below will further reduce the risk of damage to fish.

Underwater noise levels from a tug vessel were estimated at 185 dB re µPa at 1 m during transit and as 193 dB re µPa @ 1 m when the vessel is doing an anchor pull. These are conservative assumptions used for modelling (JASCO 2010). The sound pressure level emitted by the tug is not expected to cause any physical injury to fish since the 193 dB is the maximum sound pressure expected within 1 m of the tug's propeller (see JASCO 2010).

Blasting may be required at Great Mosquito Cove to provide adequate draft or channel width for the GBS tow-out to the deepwater site. Because the details of the potential blasting have not yet been determined, a sample scenario was developed using the simple case of a single explosive charge with size and burial depth as prescribed by current DFO guidelines (Wright and Hopky 1998). If blasting were required in Great Mosquito Cove, results of acoustic modelling for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998) indicate that greater than 200 dB re 1 uPa (rms) sound exposure levels would occur for approximately 50 m from the blast source and that sound pressures of between 190 and 199 dB re 1 uPa (rms) sound levels would occur from the mouth of Great Mosquito Cove to the eastern side of Bull Arm (JASCO 2010). Sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario and therefore injury to egg and larval stages is not expected (Turnpenny and Nedwell 1994).

In-water blasting, if required, will be limited in duration and frequency and will be governed by a series of mitigation measures designed to reduce potential effects on fish. Any blasting that may be required near the shoreline will adhere to DFO's Guidelines for Use of Explosives in Canadian Fisheries Waters (Wright and Hopky 1998). The following are a selection of mitigations rather than the exhaustive list of mitigations contained within these guidelines. The following mitigations plus others noted in Wright and Hopky (1998) will be implemented to reduce environmental effects associated blasting:

- Backfilling a loaded charge hole
- No detonation of explosive in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (i.e., overpressure) greater than 100 kPa (14.5 psi) in the swim bladder of a fish
- No detonation of explosive that produces, or is likely to produce, a peak particle velocity greater that 13 mm/s in a spawning bed during the period of egg production
- Mitigation to help further reduce the potential for physiological effects of noise on fish and fish habitat during construction may include:
- Use of acoustic harassment devices or a ramp-up of detonation pressures to encourage fish to move away from the blasting area
- Use of bubble curtains and other acoustic absorbents, where feasible; to contain shock waves
- Consultation with DFO on blasting plans prior to use
- Compliance with section 32 of the Fisheries Act as detailed in Section 35(2) Fisheries Act Authorization

Light Attraction

Light attraction's primary environmental effects is related to habitat use (Section 7.5.1.3) but it can also affect habitat quality in that the light / dark cycle may be interrupted and fish and invertebrates in the area may not react in their normal manner. This has the potential to result in physiological stress, as light resulting in 24-hour light regime affects their normal circadian rhythm. The response of fish to changes in their circadian rhythm varies among

species. Examples of the effects of a 24-hour light regime on fish species are provided to demonstrate the potential for physiological stresses.

Nighttime rest deprivation in zebra fish was found to result in a significant decline in daytime locomotor activity and in a heightened arousal threshold, compared to basal recordings (Zhdanova and Reebs 2006). Leonardi and Klempau (2003) demonstrated that the application of 24-hour light period for 60 days induced an increase of cortisol in trout that lasted up to two months after return to normal light regimes. The changes observed in fish towards the end of the two-month illumination period (increased haematocrit values and erythrocyte numbers) can be explained as a consequence of acute stress or, alternatively, as a stimulation of erythropoiesis by increased light exposure. Hemre et al. (2002) found that a 24-hour light regime for Atlantic cod resulted in a delay in gonadal maturation and evident anaemia.

Offshore

There are several construction and installation activities in the Offshore Project Area that could affect the quality of fish habitat. Installation of the OLS, flowlines, concrete mattress pads (rock dumping over OLS offloading lines), installation of temporary moorings, underbase grouting, possible offshore solid ballasting, placement of rock scour protection on seafloor around final Hebron Platform location, Hebron Platform and surveys (geophysical, seismic, geohazard and/or geotechnical surveys) and potential future excavated drill centre construction, are the primary offshore construction activities which could affect the quality of fish habitat.

It is very early in the design to determine if temporary mooring will be required for the installation of the Hebron Platform at its offshore location. If temporary moorings are required, up to four lines (two in one direction, (e.g., south), and one to each side (e.g., east and west) will be installed prior to the arrival of the Hebron Platform. During the final Hebron Platform installation phase, these lines would be connected to the bow of towing tugs and when system is tightened up, the final positioning will be achieved by use of the tugs winches.

The mooring lines may consist of a conventional drag embedded anchor (10 to 15 tonnes), short piece of chain and approximately 400 m of 64 mm steel wire rope buoyed at the surface. The anchors will be set approximately 1,000 m away from the final Hebron Platform location.

It is assumed that the lines will be installed a couple of weeks prior to the final Hebron Platform installation and removed immediately after completion of Hebron Platform installation. Both installation and retrieval may be done by one or two towing tugs using conventional anchor handling methods.

Suspended Sediment

The above discussion regarding sedimentation and potential effects on fish and shellfish in the nearshore also applies to the assessment of potential offshore effects. The primary difference between the nearshore and offshore sites is the role that the contrasting physical environment will have on the dispersion of suspended sediments.

Dispersion of sediment during dredging and dredge spoils disposal, installing concrete pad / rock dumping over OLS offloading lines, installation of temporary mooring, placement of rock scour protection on seabed floor around final Hebron Platform location, and placement of Hebron Platform is dependent upon the excavated or disturbed sediment grain size, water depth and currents in the area in which they are disposed or disturbed. Surficial sediments in the offshore are much coarser than those in Great Mosquito Cove and are therefore expected to settle more quickly. Observed sediments within the Hebron Project Area are comprised predominantly of sands and gravels with limited fine material (see Section 3.1.6).

Contamination

As summarized in Section 7.3.3.2, there are indications of previous drilling activities in the surficial sediments of the Offshore Project Area. Several metals were found to have concentrations above the median for the Offshore Project Area (Chevron 2003). The areal and temporal extent of discharged drill wastes (as measured by barium and total petroleum hydrocarbon (TPH) concentrations in sediments) tend to be related to differences in the number of wells and associated volume of discharges, mud types, current speed and direction, water depth and/or sediment mobility at the drilling location (Hurley and Ellis 2004). Hurley and Ellis (2004) also concluded that changes in the diversity and abundance of benthic organisms were detected within 1,000 m of drill sites, most commonly within the 50 to 500 m range of drill sites. The results were consistent for both literature (international) review case studies and for east coast offshore petroleum project EEM data. This scale of effects apply to wells discharging SBM or WBM and for multiple or single wells drilled at the same site. Beyond the bottom area covered by the cuttings pile, benthic communities generally returned to baseline conditions within one year after cessation of drilling discharges.

The Terra Nova EEM program has conducted a baseline characterization in 1997 and has conducted six operational EEM programs to date. A review of the first five operational EEM programs for Terra Nova conducted in 2000, 2001, 2002, 2004 and 2006 found that total petroleum hydrocarbons were detected at 35 (2000) to 52 (2002) of the 53 stations (Petro-Canada 2001, 2002, 2003, 2005, 2007). Elevated hydrocarbon levels were detected above 4 mg/kg within 2 km (2000, 2002) to 3.5 km (2002) from the various Terra Nova drill centres. The maximum $>C_{10}$-C_{21} levels were 13.3 mg/kg at station 750 m from Northwest (NW) drill centre (2000); 28.6 near Northeast (NE) drill centre (2001); 925 mg/kg at 150 m from Far East (FE) drill centre (2002); 6.550 mg/kg at 150 m from FE drill centre (2004); and 980 mg/kg at 150 m from FE drill centre (2006).

Barium levels at Terra Nova were slightly elevated compared to baseline conditions in 2000, with a maximum barium level of 230 mg/kg at 250 m from Southwest (SW) drill centre and the median barium level of 130 mg/kg (Petro-Canada 2001). Barium levels in 2001 (Petro-Canada 2002) were comparable to baseline conditions (1997 levels). Elevated barium levels were observed within 1 to 2 km of drill centres for 2002, 2004 and 2006

(Petro-Canada 2003, 2005, 2007). During these years the maximum barium concentrations were observed at 150 km from far east drill centre and were 2,200, 2,100 and 16,000 mg/kg respectively (Petro-Canada 2003, 2005, 2007).

The Petro-Canada baseline amphipod survival had 1 of 54 samples that was considered to be toxic (Petro-Canada 1997). There were no toxic amphipod results for 2000, 2001 and 2002. In 2004 and 2006 (Petro-Canada 2005; 2007) amphipod survival had a toxic response within 150 m from the FE drill centre (station 30FE). In 2006 (Petro-Canada 2007), in addition to the toxic response within 150 m from the FE drill centre, there were two other toxic amphipod survival responses located at 1.08 and 1.28 kms from a drill centre (W14). The hydrocarbon levels ($>C_{10}$-C_{21}) for the within 150 m from the FE drill centre (station 30FE) were 6,550 mg/kg in 2004 and 925 mg/kg in 2006.

The benthic community structure in 1997 at Terra Nova was dominated by polychaetes, with good abundances of amphipods, bivalves, gastropods, echinoderms and anthrozoa and a similar relationship was observed in 2000 (Petro-Canada 1998, 2001). Potential enrichment of polychaetes (primarily of spionidae family) was observed from 2001 through 2006 (Petro-Canada 2002, 2003, 2005, 2007). An inhibitory response on abundance and richness was observed within 150 m from FE drill centre (30 FE station) in 2002, 2004 with an inhibitory response in richness observed in 2006 for the 30FE station (Petro-Canada 2003, 2005, 2007). Inhibitory responses on amphipods were observed within 150 m from FE drill centre (30 FE station) in 2004 and 2006 (Petro-Canada 2005, 2007).

The highest levels of barium, lead, manganese and strontium within the Offshore Project Area were found less than 750 m southeast of an abandoned oil well. These metals in other samples from the Offshore Project Area were well within the range from baseline and Year One of EEM programs at Terra Nova (Chevron 2003). The metal concentration for sediment samples collected at the Hebron site (Chevron 2003) were not above the ISQGs and Probable Effects Levels as listed in the CCME interim marine sediment quality guidelines provided in CCME (1999).Low-level fuel and lube range hydrocarbons were detected in 16 and 11 of 20 samples, respectively, during the sediment quality survey at Hebron (Chevron 2003). The median concentration of fuel range hydrocarbons was 0.81 mg/kg, while the median for lube range hydrocarbons was 0.75 mg/kg. Hydrocarbon concentrations were below 2 mg/kg in all samples. PAHs were not detected above an estimated quantification limits of 0.05 mg/kg in any sediment samples from Hebron. These are not concentrations that are expected to cause hydrocarbon contamination should they become suspended in the water column during offshore construction activities.

Hebron plans to re-inject SBMs for drilling completed from the GBS and only release SBMs associated with satellite wells drilling from MODU in potential future well developments. The EEM programs from Hibernia have demonstrated that reinjection of SBMs reduces the contaminant footprint associated with the release of SBMs. Hibernia commenced cuttings

reinjection in March 2001, with greater than 95 percent cuttings reinjection achieved by second quarter 2002. Since the installation of the cuttings reinjection systems, hydrocarbon and barium concentrations around the Hibernia platform have returned to near baseline conditions for most contaminants beyond 250 m from the Platform.

Underbase grouting has the potential to cause localized contamination immediately to the bottom of the Hebron Platform. The footprint of this contamination would be contained within the footprint associated with the release of WBMs.

Noise

There are several potential sources of noise during offshore construction activities. Surveys geophysical, seismic and/or geohazard surveys), and possible pile driving for OLS installation are the primary potential sources. Other sources of noise from construction include geotechnical surveys vessels, and in water construction activities such as dredging of excavated drill centres, installation of the OLS, flowlines and Hebron Platform structures included related activities such as placement of concrete mattress pads (rock dumping over OLS offloading lines), installation of temporary moorings, possible offshore solid ballasting and placement of rock scour protection on seafloor around the final Hebron Platform location. It is not certain whether these activities will be required during the construction phase of the Project or whether they may be spread out over the entire life of the Project.

The focus of this analysis is on the effects of seismic sound sources on fish habitat quality, given that seismic surveys potentially produce the highest levels of sound pressure of all the geophysical surveys proposed for this Project. Seismic airguns release most of the acoustic energy focused in a vertically downward direction. The noise associated with airguns can range between approximately 215 and 235 dB re 1 µPa-m for a single airgun and approximately 235 to 260 dB re 1 µPa-m for arrays (Richardson et al. 1995). Source levels off to the sides of the array in the horizontal are generally lower. In general, the frequency output of an airgun depends on its volume: larger airguns generate lower-frequency impulses. However, due to the pulsive nature of the source, airguns inevitably generate sound energy at higher frequencies, above 200 Hz, although the energy output at these frequencies is substantially less than at low frequencies.

Sub-lethal injury has only been observed as a result of repeated exposure to very high received levels of sound, at a higher cumulative level than would be expected in the field under normal seismic operating conditions (LGL 2008a). Depending on source noise level, water depth and distance of the fish relative to the source, injuries (such as eyes and internal organs) would only occur within a few tens of metres with lesser symptoms such as hearing damage possible out to several hundred metres (Turnpenny and Nedwell 1994).

Snow crab eggs have shown delayed embryonic development after exposure to seismic energy (Payne 2004). Christian et al. (2004) exposed snow crab eggs to 221 dB at 2 m and demonstrated possible signs of retarded

development. However, eggs in nature are unlikely to be exposed to noise levels of range or intensity as they are carried by the female on the seafloor (the same is true for shrimp). Results from a DFO (2004a) study on the effects of seismic activity on adult snow crab indicated no changes to embryo mobility of hatched larvae affected.

Sub-lethal physiological effects on lobsters exposed to seismic energy were observed by Payne et al. (2007) during preliminary exploratory studies. The observed serum biochemical effects included reduced levels of serum protein, specific serum enzymes, and serum calcium. In some cases, the reduced levels persisted for a period of weeks.

In conclusion, invertebrates without gas-filled organs appear less vulnerable to the effects of airguns than fish with gas-filled organs. Benthic invertebrates in water deeper than about 20 m (i.e., at the Hebron Offshore Project Area) are likely far enough away from the seismic source near the surface so that particle velocity effects become negligible.

Seismic activities associated with the Project will adhere to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) 2011).

Potential Expansion Opportunities: Construction and Installation

The hook-up and commissioning of drill centres has the potential to cause contamination related to possible releases of limited amounts of chemicals that maybe involved with these activities. These activities are of limited duration occur primarily from the Platform, and the amount of potential chemical releases would be small. The implementation of the chemical selection management system for overall Platform operations, and adherence to regulatory limits with respect to discharges to marine waters are mitigation measures that would be implemented to limit the potential for environmental effects associated the hook-up commissioning of drill centres.

7.5.1.3 Change in Habitat Use

There are Project activities that have the potential to affect the behaviour of fish and shellfish. In-water activities in the Nearshore and Offshore Project Areas may affect habitat use by fish and shellfish by causing avoidance or attraction behaviours. To mitigate these environmental effects, measures have been included within the Project design so that significant residual adverse environmental effects will likely not occur. These measures include noise control measures, and application of standard seismic mitigation measures. These are described in more detail in this section.

Nearshore

Increased noise levels associated with dredging, bund wall construction and removal, potential upgrades/repairs to Back Cove Pier, vessel traffic (including vessel traffic associated with the tow-out of the GBS to the deepwater site and offshore, GBS ballasting and de-ballasting, completion of GBS construction and topside mating and hook-up at deepwater site),

potential blasting and surveys (e.g., geophysical, geohazard, geotechnical, environmental) may affect habitat use by causing an avoidance of fish and invertebrates. Lights and related structures with light sources (including the floating batch plant for concrete production) may affect habitat use by providing an attraction of fish and invertebrates. Drydock dewatering may affect habitat use as there will be a loss of habitat quantity in this area. The habitat use environmental effects associated with noise and lights (see Section 7.5.1.2 for a discussion of potential effects on lighting) are discussed below. The environmental effects of drydock dewatering on habitat use is directly related to the loss of habitat, which triggers a HADD and are discussed in Section 7.5.1.1.

A comparison of moderately-sensitive species, such as cod, haddock, pollock and redfish, determined a measurable behavioural response in the range of 160 to 188 dB re 1 µPa (Turnpenny and Nedwell 1994; Richardson et al. 1995). If blasting were required in Great Mosquito Cove, results of acoustic modelling for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998), indicate that 180 and 190 dB re 1 uPa (rms) sound levels occur at 2.7 km and 0.99 km, respectively, from the blast site (JASCO 2010). The noise from nearshore blasting is therefore expected to cause a startle response and temporary avoidance of the area by some species. Behavioural effects of noise on benthic invertebrates, such as lobster and crab, are not well documented. Few invertebrates have gas-filled spaces, and therefore, are less likely to be behaviourally affected by underwater noise, as are fish.

Most available literature indicates that the environmental effects of noise on fish are transitory, and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible effects on individuals and populations.

The mitigation measures presented above for noise and blasting (Section 7.5.1.1), in addition to procedures in place specifying speed for vessels within the traffic lane in Bull Arm and limiting survey equipment and vessels to using only the power required to attain data (thereby minimizing noise), may also reduce the potential effects from noise on habitat use. Operational lights used in or near the marine environment may affect pelagic migratory fish species. Studies from the Pacific coast report changes in juvenile herring and sand lance distribution at night, in artificially lighted areas (Nightingale and Simenstad 2002). Predators may also have been attracted by the increase in juvenile herring and sandlance under the lights (Nightingale and Simenstad 2002). Lights are also known to attract squid, if they are present in the area. Many planktonic species and life stages are phototaxic; floating to near surface during the day and settling to deeper water at night. Any lights on the water at night may attract nekton that have active swimming ability.

Offshore

The footprint of the OLS on the seafloor, concrete mattress pads / rocking dumping over flowlines, installation of temporary moorings (see Section 7.5.1.2), Platform tow-out / offshore installation, placement of rock scour protection on seabed around the final Hebron Platform location, the operation of vessels (construction, supply, support, standby, tow, diving, ROV), and barges, geophysical, seismic, and/or geohazard and/or geotechnical surveys and potential future excavated drill centre construction are the primary offshore construction activities that could affect the behaviour of fish and invertebrates, and therefore, habitat use. These activities could affect the behaviour of fish and invertebrates by causing avoidance or attraction. In addition to avoidance or attraction behaviours, some of these construction activities could also have an effect on habitat use directly related to the temporary loss of habitat, which would trigger a HADD; these have been discussed in Section 7.5.1.1.

The focus is on the environmental effects of seismic sound sources on fish habitat use, given that seismic surveys potentially produce the highest levels of sound pressure of all the geophysical surveys proposed for this Project.

Source levels during seismic surveys are usually in excess of the noise levels that elicit a response in fish, so the area in which fish react to the noise may extend several kilometres in the open ocean. There are several well documented observations of fish and invertebrates exhibiting behaviours that appeared to be in response to exposure to seismic activity like a startle response, a change in swimming direction and speed, or a change in vertical distribution (Blaxter et al. 1981; Schwarz and Greer 1984; Pearson et al. 1992; McCauley et al. 2000; Wardle et al. 2001; Hassel et al. 2003), although the importance of these behaviours is unclear. Some studies indicate that such behavioural changes are temporary (i.e., within minutes (Pearson et al. 1992, in Skalski et al. 1992)), while others imply that marine animals might not resume pre-seismic behaviours and/or distributions for a number of days (Løkkeborg 1991; Engås et al. 1996). Conversely, pollock on a shallow coastal reef were observed during a signal of 230 dB re1 µPa (Wardle et al. 2001). Direct visual observations determined that only minor changes in fish behaviour patterns were detectable around the reef. When smaller pollock passed within a few metres of the array and were exposed to approximately 229 dB, they showed a typical “C-start” response and moved away only a few metres.

The expected distance for fish to react to a typical peak source level of 250 to 255 dB re 1 µPa is from 3 to 10 km (Engås et al. 1996). A reaction may simply mean a change in swimming speed or direction (Løkkeborg et al. 2010). The spatial range of response in fish will vary greatly with changes in the physical environment in which the sounds are emitted. In one environment, fish distribution has been shown to change in an area of 74 km x 74 km (40 x 40 nautical miles (nm)) and 250 to 280 m deep for more than five days after shooting ended, with fish larger than 60 cm being affected to a greater extent than smaller fish (Engås et al. 1996). The potential effect of a spatial response in fish during sensitive times is unknown, in part due to data

constraints associated with life histories of many species and overall lack of knowledge of seismic effects during sensitive periods for most, if not all species. Behavioural effects on lobsters exposed to seismic energy were observed by Payne et al. (2007) during preliminary exploratory studies. Four of the five exposure trials resulted in observed increases in food consumption, and these feeding differences were often apparent several weeks post-exposure. Behavioural effects of exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20-inch airgun have been reported (McCauley et al. 2000). The behavioural responses included squid firing their ink sacs and moving away from the airgun, startle responses and increased swimming speeds.

Christian et al. (2004) conducted a behavioural investigation during which caged snow crabs were positioned 50 m below a seven-gun array. No obvious startle behaviours were observed. Results from a DFO (2004a) study on the effects of seismic activity on adult snow crab, indicated no changes in feeding activity.

Seismic activities associated with the Project will adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment, as referenced in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011). Potential environmental effects of lighting on fish are addressed in the nearshore discussion above.

Potential Expansion Opportunities: Construction and Installation

Excavated drill centre dredging and spoil disposal, installation of pipelines / flowlines, and tie-back to the Hebron Platform, and flowline protection (concrete mattresses, rock cover or other flowline installation), subsea equipment may affect habitat use by fish and shellfish by causing avoidance or attraction behaviours. The primary avoidance of habitat would be related to noise disturbances, which has been discussed in detail under the offshore portion of Section 7.5.1.2.

7.5.1.4 Potential Mortality

Project activities may result in lethal effects to fish and shellfish, as described in this section. To mitigate these environmental effects, measures have been included within the Project design so that significant adverse residual environmental effects likely will not occur. These measures include standard blasting control measures, and the application of standard seismic mitigation measures. These are described in more detail in this section.

Nearshore

Mortality of fish and shellfish during nearshore construction could result from dewatering the dry-dock area, dredging, spoils disposal, GBS ballasting and deballasting, bund wall construction and blasting.

Dredging and dredge spoils disposal increase the levels of suspended sediment. In conditions of extreme sediment load, mortality of finfish and shellfish results from extreme oxygen deficient water or respiratory

obstruction. Levels of 100,000 mg/L kaolin resulted in an average mussel mortality of 10 percent after 5 and 11 days (Peddicord 1980). However, the highest suspended sediment levels reported during concurrent activities of till placement, dredging, drilling and underwater blasting for the Hibernia project at the mouth of Great Mosquito Cove were less than 40 mg/L (LeDrew, Fudge & Associates 1991). Dredging may cause mortality of some sessile invertebrates, like mussels and scallops, by crushing if a clam dredge is used. Sessile epifaunal species may be smothered during dredge spoils disposal. GBS ballasting and deballasting could potentially cause mortalilty of some fish species (including larval and eggs) if they are sucked into the ballast system during ballasting and deballasting procedures.

The blasting program, if required, in the nearshore will be designed to minimize the risk of mortality to fish. Nearshore and in-water blasting will adhere to DFO's Guidelines for Use of Explosives in Canadian Fisheries Waters (Wright and Hopky 1998), which is designed to mitigate fish mortality. In-water sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario and therefore, fish mortality is not expected (Turnpenny and Nedwell 1994). Nevertheless, mortality of sessile invertebrates in the immediate area of blasting is likely due to compression waves and flying debris.

During the dewatering of the drydock, a fish recovery and relocation program (to be included as part of the Environment Protection Plan) will be initiated. The goal of the program is to remove fish that would be stranded as a result of the drydock dewatering and relocate them to the nearby marine environment. It is acknowledged that while every reasonable effort will be made to recover and relocate the stranded fish, a certain degree of fish mortality may occur. With regard to potential entrainment of fish during the dewatering of the drydock, EMCP will consult with DFO regarding the sizing of fish screens. Note: during the construction of the Hibernia GBS, fish were not present within the drydock when it was dewatered. With regard to potential fish entrainment during ballasting, the GBS ballast water intake will include fish screens.

Bund wall construction may result in fish mortality due to the smothering of bottom-dwelling fish and invertebrates during the placement of the rock fill for the bund wall.

Mitigation measures to reduce the risk of mortality to fish during nearshore construction activities are provided in Section 7.5.1.2.

Offshore

Platform tow-out and offshore installation, placement of rock scour, installation of the OLS and placement of concrete mattress pads has the potential to cause mortality of benthic invertebrate species. However, the relative number of individuals potentially within the footprints of these sub-sea structures is negligible when compared to the population numbers in adjacent habitat.

Potential for future dredging of excavated drill centre, spoils disposal and flowlines installation have the potential to cause mortality of shellfish and potentially to eggs and larvae of fish.

Dredging and spoils disposal will be required for excavated drill centre construction, but also may be required for OLS and flowline installation. Regardless of the dredging method chosen, some mortality of sessile invertebrates (e.g., clams and scallops) may be expected from crushing and smothering. Smothering of sessile invertebrates is also expected from installation of the Hebron Platform, concrete and/or rock mattress placement over the flowlines and OLS and placement of rock scour protection on the seafloor around the Hebron Platform location. Anchoring of construction and support vessels or drill rigs will have similar, highly localized effects. These effects are considered highly reversible on a population level, as disturbed areas will soon recolonize, including colonization of the subsea structures themselves.

Studies considering the effects of marine aggregate extraction have concentrated on establishing the rates and processes of macrobenthic recolonization upon cessation of dredging (Kenny et al. 1998; Desprez 2000; Sardá et al. 2000; Van Dalfsen et al. 2000). These studies indicate that dredging causes an initial reduction in the abundance, species diversity, and biomass of the benthic community and that substantial progress towards full restoration of the fauna and sediments can be expected within a period of approximately two to four years following cessation (Kenny et al. 1998; Sardá et al. 2000; Van Dalfsen et al. 2000). It is recognized that long-lived species such as corals, while unlikely to be present in the dredged area, may take longer to recover.

The risk of direct mortality to fish and shellfish from seismic surveys is limited to pelagic eggs and larvae. Acute mortality of eggs and larvae has been demonstrated in experimental exposures, but only when the eggs and larvae were exposed very close to the seismic sound sources and the received pressure levels were very high (see Dalen et al. 2007 for a review).

Recent collaborative research was conducted by the Fish Food and Allied Workers (FFAW) Union and DFO on the potential effects of sound on developing monkfish eggs (Payne et al. 2009). This study found that there were no significant differences observed between control and exposed larvae examined 48 to 72 hours post-esposure. This study recognizes the potential difficulty in collection of monkfish veils, so it was decided that research should also be conducted on capelin eggs. Although artificial fertilization was poor, no significant differences in mortality were observed between control and capelin eggs exposed to seismic energy and examined three days post-exposure to 20 airgun discharges (Payne et al. 2009). Payne et al. (2009) concluded it is unlikely that seismic surveys pose any real risk to either monkfish eggs or near-hatch larvae that may float in veils on the sea surface during monkfish spawning.

There have been no reports of mass fish kills from seismic surveys (Payne 2004). Since fish are likely to be driven away by approaching seismic shots, fish mortality is not expected (Turnpenny and Nedwell 1994).

Mortality in shrimp was not observed after exposure to an airgun array with a peak pressure of 196 dB (re 1µPa at 1 m) (Andriguetto-Filho et al. 2005). Caged shrimp were also exposed to the airguns at very close range; there were no reported mortalities (Andriguetto-Filho et al. 2005). Webb and Kempf (1998) subjected shrimp to a 15-gun array (volume 480 cubic inches with source levels of 190 dB re 1µPa at 1 m depth) and reported no evidence of mortality or reduced catch rates for the shrimp.

Data on the effects of seismic surveys on macroinvertebrates (e.g., crab and scallops) are limited, but the available data suggest that mortality through physical harm is unlikely below sound levels of 220 dB re 1 µPa @ 1 m (Royal Society of Canada 2004). There are no indications of acute or mid-term mortality in adult snow crab due to seismic activity, nor does there appear to be any effect on the survival of embryos carried on the female or on the locomotion of the larvae after hatch (DFO 2004a). The Royal Society of Canada (2004) suggests that seismic surveys will have no effect on the marine benthos, provided the water depth is greater than 20 m, as will be the case for this Project.

Seismic activities associated with the Project will adhere to the Seismic activities associated with the Project will adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment, as referenced in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011). The risk of mortality to sessile invertebrates from dredging will be reduced by having dredging contained to the smallest area possible and restricting dredge spoils disposal to a designated disposal area. EMCP will consult with relevant federal departments regarding the location of the disposal area.

The environmental effects of the Project during the construction and installation phase and the mitigations to be implemented are summarized in Table 7-11.

Significant adverse environmental effects on fish and fish habitat from construction and installation activities nearshore and offshore are not likely to occur. Environmental effects are generally low in magnitude, of limited geographic extent and reversible.

7.5.2 Operations and Maintenance

7.5.2.1 Change in Habitat Quantity

The majority of Project environmental effects on habitat quantity occur in the construction phase. As presented in Section 7.5.1.1, a Project-specific Habitat Compensation Strategy and Plan will be developed and implemented to mitigate adverse environmental effects and prevent significant adverse residual environmental effects on marine fish habitat. As part of potential future activities, drilling operations from a MODU at future excavated drill

centres have the potential to have environmental effects on habitat quantity, primarily as a result of the excavated drill centres and related seafloor infrastructures. Any offshore activities, including future excavated drill centres and seafloor infrastructures contained within, may be declared to cause a HADD by DFO and will require a Section 35(2) Fisheries Act Authorization; any loss of fish habitat will be fully compensated with the objective to achieve no net loss of productive capacity of fish habitat.

7.5.2.2 Change in Habitat Quality

Operational discharges (e.g., WBM and cuttings, seawater discharges, storage displacement water, produced water, grey and black water, drains) could affect fish habitat quality. Potential expansion opportunities could include drilling from a MODU at excavated drill centres. The effects of excavated drill centre construction have been discussed in Section 7.5.1.2, but the effects of MODU drilling on fish habitat quality are addressed here.

To mitigate potential environmental effects on water and sediment quality, measures have been included within the Project design so that significant adverse residual environmental effects will likely not occur. Use of best practices, continuous improvement programs and best available technology will be applied if technically and economically feasible and reliable. Results from the EEM programs at Hibernia, White Rose and Terra Nova have confirmed their respective assessment predictions of no significant environmental effect on the marine environment as a result of discharges. These are described in more detail in this section.

Table 7-11 Environmental Effects Assessment: Construction and Installation

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Presence of Safety Zone	• Potential Decrease in Fish Mortality	• None required	1	2	3/6	R	2
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains, if feasible • HADD authorization and compensation • Chemistry of rock and till material will be tested prior to placement • Investigate use of washed-rock or in-water sediment control measures in bund wall construction	1	1	3/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
In-water Blasting	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters • Bubble curtains, if required • Compliance with terms of Section 32 Fisheries Act Authorization	1	2	2/1	R	2
Dewater Drydock / Prep of Drydock Area	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Fish Recovery and Relocation Program • Compliance with terms of Section 35(2) Fisheries Act Authorization • Fish habitat compensation	1	1	3/1	R	2
Upgrades to Ferry Terminal in Back Cove	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Bubble curtains, if feasible • Sediment control measures • Mitigation measures outlined in DFO's Marine Wharf Repair / Reconstruction Operational Statement • HADD authorization and compensation	1	1	2/1	R	2
Concrete Production (floating batch plant)	• Change in Habitat Quality • Change in Habitat Use	• Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be treated prior to discharge or directed to a settling basin • Concrete wash water containment and testing to meet applicable regulations	1	1	3/3	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	• Change in Habitat Use	• Procedures will be in place specifying speed for vessels within the traffic lane and in Bull Arm	1	1	3/6	R	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Dredging of Bund Wall and Possibly Sections of Tow-out Route (may require at-sea disposal)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Investigate use in-water sediment control measures • Fish habitat compensation • Proper disposal site selection • Compliance with terms of Section 35(2) Fisheries Act Authorization	1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Investigate use in-water sediment control measures • Compliance with terms of Section 35(2) Fisheries Act Authorization (if required) • Proper disposal site selection • Removal of construction debris	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use • Potential Mortality	• Use of fish screens	1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use	• Use of best practices, continuous improvement programs and best available technology	1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use	• Comply with appropriate regulatory limits with respect to discharges into marine waters	1	1	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental)	• Change in Habitat Use	• Survey equipment and vessels will only use the power required to attain the data , therby minimizing noise.	1	1	2/1	R	2
Potential Dredging for Tow-out from the Deepwater Site to the Offshore Location	• Change in Habitat Quantity • Change in Habitat Use	• Investigate use in-water sediment control measures • Fish habitat compensation • Proper disposal site selection	1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Offshore Construction / Installation							
Presence of Safety Zone	• Potential decrease in Mortality	• None required	1	2	3/6	R	2
OLS Installation and Testing	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Efficient installation with minimal seabed disturbance • Fish habitat compensation • Chemical selection management system • Adherence to regulations • Compliance with terms of Section 35(2) Fisheries Act Authorization	1	2	5/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Efficient installation with minimal seabed disturbance • Fish habitat compensation • Compliance with terms of Section 35(2) Fisheries Act Authorization	1	2	5/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs and best available technology	1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Fish habitat compensation • Compliance with terms of Section 35(2) Fisheries Act Authorization	1	4	5/6	R	2
Underbase Grouting	• Change in Habitat Quality	• Use of best practices, continuous improvement programs and best available technology	1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Quality	• None required	1	1	2/1	R	2

022199

C0814-366

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Placement of Rock Scour Protection on Seafloor around Final Hebron Platform Location	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortaility	• Use of best practices, continuous improvement programs and best available technology • Compliance with terms of Section 35(2) Fisheries Act Authorization • Fish habitat compensation	1	1	5/1	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Habitat Use		1	2	3/6	R	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Potential Expansion Opportunities							
Presence of Safety Zone	• Potential Decrease in Mortality	• None required	1	2	3/6	R	2
Excavated Drill Centre Dredging and Spoils Disposal	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Fish habitat compensation	1	2	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Efficient installation with minimal seabed disturbance • Fish habitat compensation • Compliance with terms of Section 35(2) Fisheries Act Authorization	1	2	5/1	R	2
Hook-up, and Commissioning of Drill Centres	• Change in Habitat Quality • Change in Habitat Use	• Implement chemical selection management system • Adherence to regulatory limits with respect to discharges in to marine waters	1	2	2/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use	• Survey equipment and vessels will only use the power required to attain the data, thereby minimizing noise • Adherence to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (OWTG, 2010)	1	3	2/1	R	2

KEY

Magnitude:
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Drilling Discharges

Discharge of WBMs and associated cuttings is regulated by the C-NLOPB. WBMs and cuttings do not require treatment prior to discharge (in accordance with the Offshore Waste Treatment Guidelines (OWTG) (National Energy Board (NEB) et al. 2010)). The discharge of WBMs may increase metals such as barium, arsenic, cadmium, copper, lead and zinc in sediments, but these metals are not bioavailable, and thus unlikely to accumulate in benthic species. Elevated levels of metals have been found to occur within 250 to 500 m of the drill site, but sometimes occur further, depending on environmental conditions and the number of wells drilled (see Hurley and Ellis 2004). Signals of drill muds (i.e., barite) have been detected 5,000 m from Terra Nova (18 production wells) and 8,000 m from Hibernia (32 production wells) (Hurley and Ellis 2004), but not at levels likely to have any biological effect.

From modelling of WBM cutting discharge from 52 wells at the Hebron Platform, thicknesses of 1 to 2 m is estimated within 10 m distance and 10 to 20 cm within 25 m distance. These estimates are based on preliminary analyses which will be updated during FEED and detailed engineering phases. Thicknesses of at least 1 cm are generally confined to within about 50 to 60 m of the GBS. These cuttings near the GBS are almost exclusively the fast-settling pebbles and sand (a very small percentage of the fines will drift for a time and ultimately settle near the GBS) whereas at distances greater than about 50 to 200 m, the deposits will be exclusively fines (see AMEC 2010).

WBMs are expected to remain in suspension in a thin layer area above the seafloor. Since drill mud will remain in suspension, the most likely species to be affected by drill mud release are filter feeders. Contamination associated with the use of WBMs is of minimal concern to the environment, since it is virtually free of hydrocarbons and the metals present are in a form that is not readily bioavailable (Canadian Association of Petroleum Producers (CAPP 2001a). Although changes in benthic density and diversity from drilling muds have been detected within 1,000 m of drill sites, most of these effects are found within the 50 to 500 m range and are of short duration (Hurley and Ellis 2004). Additives to WBMs are selected for use in accordance with the Offshore Chemical Selection Guidelines (NEB et al. 2009), which ensures that the additives selected have an acceptable risk to the environment. Metals from WBMs and cuttings have not been demonstrated to cause biological effects (CAPP 2001a; Hurley and Ellis 2004). There will be no discharge of SBMs from the Hebron Platform during normal operations.

SBM cutting reinjection will be undertaken for Platform drilling as a means of waste reduction. SBM cutting reinjection is not technically feasible for MODU drilling and SBM cuttings will be discharged overboard after treatment in accordance with the OWTG. These estimates are based on preliminary analyses which will be updated during FEED and detailed engineering phases. Thicknesses of at least 1 cm are generally confined to within about 50 to 60 m of the GBS. The cuttings near the GBS are almost exclusively the fast-settling pebbles and sand (a very small percentage of the fines will drift for a time and ultimately settle near the GBS), whereas at distances greater than about 50 to 200 m, the deposits will be exclusively fines (see AMEC 2010).

Liquid Discharges

Operational discharges from an offshore oil production facility include, but not limited to: produced water, storage displacement water, deck drainage, well completion fluids, cooling water, grey and black water. These waste streams are treated in accordance with the OWTG (NEB et al. 2010) prior to discharge. In addition, chemicals used in during well activities will be screened in accordance with an approved chemical screening process

Produced water (see Section 2.6.4.3) discharges may induce flocculation that could concentrate and transport metal and organic compounds contained in formation water to the benthos. The temperature of the produced water

discharge will be approximately 70°C and below the summer thermocline, which occurs between 20 and 30 m from the surface (see Chapter 3).

Based on preliminary analyses to be updated during FEED and detailed engineering phases, at a modelled produced water discharge elevation of 35 m, the plume reaches the bottom. At a discharge rate of 56,000 m^3/day, a dilution factor of 300 is reached within a horizontal distance of 379 m in February under average current conditions, and within a distance of 676 m under low ambient current conditions. In August, the dilution factor of 300 is reached at distances of 74 m under average current speeds and out to 352 m under low current speeds (AMEC 2010).

For storage displacement water (Table 2-2; Section 2.6.3), the modelling shows that under all ambient conditions that can typically be expected in the Project Area, an oil concentration criteria of 0.1 ppm can be achieved within a distance of 200 m, but will be unlikely to rise near the ocean surface (AMEC 2010).

Sensitivity analyses indicate that increasing the discharge elevation has little effect on dilution, and reducing the discharge temperature has only limited effect on dilution.

Effects resulting from the discharge of produced water are expected to be undetectable further than 500 m from the Hebron Platform. Within 500 m, Querbach et al. (2005) quantified these potential effects of chronic and acute exposure to produced water from an offshore oil production facility on some commonly found marine organisms. They concluded that survival, growth and fertilization success of the species in question (haddock, lobster and sea scallop) were all reduced. The assessed levels of exposure were also shown to have negative effects on the physical condition of a species of diatom, Thalassiosira pseudonana. The early planktonic life stages of fish, as well as phytoplankton and zooplankton, are particularly sensitive to contaminants due to the inability of these organisms to move from areas of contamination. However, the proportion of the total population that is exposed to these routine discharges is very small and indistinguishable from the high rate of natural mortality.

Operational discharges will be dispersed rapidly and planktonic organisms will be exposed to continuously diminishing concentrations of produced water as they drift away from the source. Experiments on the toxicity of produced water on snow crab larvae indicate that produced water has a very low toxicity potential (J. Payne, pers. comm., in HMDC 2005). Somerville et al. (1987) found that cod and herring larvae and phytoplankton appear to be unaffected by produced water. Both PAHs and phenols have been detected at very low concentrations in marine bivalves attached to legs of offshore Gulf of Mexico platforms; all concentrations were well below the marine acute criteria and there appears to be little net bioaccumulation in fish species that may prey on biofouling organisms (Neff 2002).

The two primary components of produced water that are of environmental concern are the aromatic hydrocarbons (or the benzene, toluene, ethylbenzene and xylene (BTEX) fraction of TPH analyses) and PAHs. BTEX

is soluble in seawater and highly toxic to marine organisms. However, there is minimal exposure risk to marine organisms given the rapid loss due to evaporation, adsorption and sedimentation, biodegradation and photolysis (Johnsen et al. 2004). PAHs are less soluble but more persistent in the environment (Holdway and Heggie 2000) and the associated toxicity to marine organisms are primarily related to benzene and naphthalene fractions (Brand et al. 1989, in Holdway and Heggie 2000).

Naphthalene fractions are rapidly degraded in the water column (Johnsen et al. 2004). Low-molecular weight PAHs are the dominant fraction of produced water; these fractions degrade more readily than the high-molecular PAH fractions, which generally have a more specific toxicological nature, potentially interacting with cellular protein and DNA (Neff 2002; Johnsen et al. 2004). However, their concentrations in a produced water plume are very low due to the rapid dilution following discharge, and are rarely at levels high enough to cause toxic effects in marine plants and animals (Neff 2002; Johnsen et al. 2004).

Concentrations of phenols (and alkylated phenols) in produced water declines rapidly due to dilution, evaporation and bio- and photo-degradation with distance from a discharge point (Neff 2002). The solubility of phenols is very low in sea water, with concentrations often below detection limits; however, concern remains about their potential to disrupt reproduction when the degree of alkylation is increased (Johnsen et al. 2004). Laboratory-based studies on uptake of alkylated phenols in fish species have indicated that there is uptake in fish within 100 to 1,000 m of a discharge point, located primarily in the gastro-intestinal tract; and that the fish excreted the alkylated phenols (and all other associated compounds) via bile to background levels within 24 to 48 hours (Sundt and Baussant 2003).

The expected amount of toxic and/or carcinogenic forms of PAHs and alkylated phenols in a produced water plume are generally below detection limits or at very low concentrations (Neff 2002). Produced water discharge will be treated to meet the oil in water limits stipulated in the OWTG (NEB et al. 2010). The feasibility of produced water re-injection is being investigated during FEED studies.

Grey and black water (see Table 2-10) produced on the Hebron Platform will be treated as per the OWTG (NEB et al. 2010). Black water or sewage (Table 2-2; Section 2.6.3) will be macerated to 6 mm particle size or less prior to discharge. Organic matter associated with discharges will disperse quickly in an open ocean environment and degraded by bacteria. Any biocides (Sections 2.6.4.1 and 2.6.4.2; Tables 2-9 and 2-10) used will be screened in accordance with an approved and established chemical management system.

All liquid waste discharges from the Hebron Project drilling and production operations will be discharged in accordance with the OWTG. Discharges limits are based on best available technologies and are the focus of continuous improvement programs. Where practicable, use of technology to reduce discharge limits below those in the OWTG will be implemented.

7.5.2.3 Change in Habitat Use

During the Hebron Project operations and maintenance phase, there is potential for noise generated by geophysical surveys, dredging, vessel traffic, drilling and maintenance activities (diving , ROV), all of which could affect fish habitat use. The environmental effect of noise from geophysical surveys and vessel traffic was discussed in Section 7.5.1.2 as a construction phase activity. To mitigate these environmental effects, measures have been included within the Project design so that significant residual significant environmental effects will likely not occur. These mitigation measures include noise control and application of standard seismic mitigation measures, more specifically those mitigation measures referenced within the Seismic activities associated with the Project will adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment, as referenced in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011).

A semi-submersible drill rig produces a broad band noise level at approximately 154 dB re 1 µPa (Richardson et al. 1995), which would be reflective of the MODU drilling for potential development of excavated drill centres in the future. Drilling noise from the Hebron Platform is expected to be less, given that the drill rig is inside the Hebron Platform. For comparison, noise from a drillship is emitted at a range between 174 and 185 dB re 1 µPa, a dredge vessel at 187 dB re 1 µPa and a large tanker can emit noise at approximately 186 dB re 1 µPa (Richardson et al. 1995).

Most available literature indicates that the effects of noise on fish are transitory, and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible environmental effects on individuals and populations. Behavioural effects of noise on benthic invertebrates, such as crab, are not well documented. Few invertebrates have gas-filled spaces, and therefore, are less likely to be affected by underwater noise, as are fish.

There is some evidence that lights on the water may attract some fish species. Operational lights used in or near the marine environment may affect pelagic migratory fish species. Studies from the Pacific Coast report changes in juvenile herring and sand lance distribution at night, in artificially lighted areas (Nightingale and Simenstad 2002). Predators of these species may also have been attracted by the increase in juveniles under the lights (Nightingale and Simenstad 2002). Lights are also known to attract squid, if they are present in the area. Many planktonic species and life stages are phototaxic; floating to near surface during the day and settling to deeper water at night. Any lights on the water at night may attract nekton that have active swimming ability.

The artificial reef effect created by subsea structures may attract nearby fish and shellfish to feed or for shelter. The rock mattress used to cover the OLS is not expected to pose an obstacle to the movement of snow crab.

7.5.2.4 Potential Mortality

Operational discharges of WBMs may result in mortality of shellfish, whereas the presence of a Safety Zone may actually decrease the mortality rate. To mitigate adverse environmental effects, measures have been included within the Project design so that significant adverse residual environmental effects will likely not occur. These measures include standard blasting control measures and the application of standard seismic mitigation measures. These are described in more detail in Section 7.5.1.2 and in this section.

Shellfish such as scallops will be smothered within a 50 m radius of the WBM discharge, whereas infauna such as clams are burrowing species and can be expected to resurface from a covering of several centimetres (Husky and Norsk Hydro 2006; Fredette and French 2004; Maurer et al. 1980). Based upon the published literature (reviewed in Husky 2000, 2001; LGL 2005a, 2006a; US MMS 2000; CAPP 2001b; Hurley and Ellis 2004; Neff 2005), the benthos can be expected to recover over a period of several months to several years, but most likely within one year after cessation of drilling. Sessile organisms are likely to be smothered in areas where cuttings are greater than 1 cm thick (Bakke et al. 1989).

In the case of potential MODU drilling, WBMs and treated SBMs will be released. Due to a larger average size and discharge rate, SBM cuttings stay closer to the well site and do not disperse as widely as WBMs and cuttings (CAPP 2001a). SBM cuttings do not tend to disperse like WBM cuttings unless the fluid retention values are below five percent (Getliff et al. 1997; CAPP 2001a). Due to the fact that SBM-related particles are not water miscible, they tend to aggregate, resulting in rapid fall velocities (CAPP 2001a). Due to the rapid fall velocity, SBMs tend to fall through the water column faster, be deposited in smaller areas, and to accumulate in higher concentrations near the discharge point than would WBM cuttings (CAPP 2001a; Sayle et al. 2001; CSA International 2004; Jacques Whitford Stantec Limited 2009). Fine suspended solids associated with WBMs are not trapped in agglomerations like fines associated with SBMs (CAPP 2001a). This allows these WBMs fines to disperse in the marine environment and travel farther than fines in SBMs before contacting the seabed (CAPP 2001a; Sayle et al. 2001; JWSL 2009). For MODU-based drilling, the discharge of SBM cuttings will be in accordance with the OWTG (NEB et al. 2010). No additional smothering of sessile benthic invertebrates is expected to occur as a result of SBM discharge as the area will have been subjected to smothering from previous WBM deposition.

Implementation of a Safety Zone around the Hebron Platform, OLS and flowlines could have a minor positive effect by creating an artificial reef and provide food and shelter to benthic species. The Safety Zone may act as refuge for some species and decrease mortality rates.

The potential effects on mortality associated with geophysical, seismic, geohazard and geotechnical surveys have been assessed as a construction activity.

The environmental effect of the Project during the operations and maintenance phase and the mitigation to be implemented are summarized in Table 7-12.

Table 7-12 Environmental Effects Assessment: Operations and Maintenance

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Safety Zone	• Potential Decrease in Mortality	• None required	1	2	5/6	R	2
Presence of Structures	• Change in Habitat Use	• Minor positive reef effect, no mitigation required	1	1	5/6	R	2
Lighting	• Change in Habitat Use		1	1	5/6	R	2
Maintenance Activities (e.g., diving, ROV)	• Change in Habitat Use	• Use of best practices, continous improvement programs	1	1	5/3	R	2
Wastewater (e.g., produced water, cooling water, storage displacement water, grey water, deck drainage)	• Change in Habitat Quality	• Use of best practices, continuous improvement programs • Adherence to discharge limits as per OWTG	1	2	5/6	R	2
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality	• Use of best practices, continuous improvement programs • chemical management system for screening of chemicals	1	2	5/6	R	2
WBM Cuttings	• Change in Habitat Quality • Potential Mortality	• Re-use of drill mud	1	2	5/2	R	2
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers / barges / ROVs)	• Change in Habitat Use		1	1	5/6	R	2
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (OWTG, 2010)	1	3	3/2	R	2
Potential Expansion Opportunities							
Presence of Safety Zone	• Potential decrease in Mortality	• None required	1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Use	• Minor positive reef effect, no mitigation required	1	1	5/6	R	2
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quanity • Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality • Potential Mortality	• Use of best practices, continuous improvement programs • Adherence to OWTG	1	2	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality	• Use of best practices, continuous improvement programs • Chemical management system for screening of chemicals	1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	3	3/2	R	2

KEY

Magnitude:

1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:

1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:

1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:

1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:

R = Reversible
I = Irreversible

Ecological / Socio-economic Context:

1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Operations and maintenance activities are not likely to result in any significant adverse environmental effects on Fish and Fish Habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible. The presence of Safety Zones will create refuge effects. Results from the EEM programs at Hibernia, White Rose and Terra Nova have

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confirmed the respective assessment predictions of no significant environmental effect on the marine environment for those production projects.

7.5.3 Offshore Decommissioning and Abandonment

The Operator will decommission and abandon the Hebron production facility according to regulatory requirements in place at the time of end of Project life. The GBS infrastructure will be decommissioned and the wells will be plugged and abandoned. The GBS structure will be designed for removal at the end of its useful life, although the decision as to whether this will be required will be made at that time. The decision to remove or abandon in place the pipeline and other subsea equipment will be made after a thorough analysis and in compliance with all applicable regulations. The use of best practices and continuous improvement programs will be implemented at that time as mitigation measures for removal of Hebron Platform and OLS loading points, plugging and abandoning wells, and abandoning the OLS pipeline.

7.5.3.1 Change in Habitat Quantity

The possible removal of offshore subsea infrastructure during Project decommissioning and abandonment may affect the quantity of fish habitat in the Offshore Project Area; however, the effects of habitat quantity will be of less magnitude and geographic extent than during Project construction (see Section 7.5.1.1). The possible removal of the Hebron Platform, rock and/or concrete mattress cover over the OLS and or flowlines, will remove the reef and refuge effect that these structures had created.

7.5.3.2 Change in Habitat Quality

Project decommissioning and abandonment activities may affect fish habitat quality during the possible removal of subsea structures through vessel noise (associated with the operations of vessels including supply, support, tow vessels, barges) and suspended sediments. In addition, noise maybe associated with surveys that may be required or undertaken as apart of the decommissioning and abandonment activities. Such surveys may likely include environmental, ROV and diving surveys; however geophysical, geohazard and/or geological surveys may be undertaken if required. The environmental effects of these activities are expected to be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and suspended sediments on fish habitat quality are discussed in Section 7.5.1.2.

7.5.3.3 Change in Habitat Use

Project decommissioning and abandonment activities could affect the behaviour of fish and invertebrates and therefore habitat use. The noise and underwater activity required during possible removal of subsea structures (e.g., OLS, flowlines and wellhead, operation of vessels, diving programs, surveys (as outlined in 7.5.3.2)) and lighting will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential

effects of noise, underwater activity and lighting on fish habitat use are discussed in Section 7.5.1.3.

7.5.3.4 Potential Mortality

Project decommissioning and abandonment activities have the potential to cause mortality of fish and shellfish during the possible removal of subsea structures (including the Hebron Platform and OLS loading points, if they are removed), and during survey activities, as described above. Activities will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential for underwater construction activity to cause mortality of fish and shellfish is discussed in Section 7.5.1.4.

A minor negative environmental effect could result from the removal of a Safety Zone around the Hebron Platform, OLS and flowlines. The refuge effect created by the Safety Zone for some species will be removed upon Project decommissioning and abandonment.

The environmental effect of the Project during the decommissioning and abandonment Phase and the mitigation to be implemented are summarized in Table 7-13. Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm.

Table 7-13 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Safety Zone	• Potential Mortality		1	2	3/6	R	2
Removal of the Hebron Platform and OLS Loading Points	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Use of best practices, continous improvement programs	1	2	2/1	R	2
Lighting	• Change in Habitat Use		1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs	1	1	3/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Abandoning the OLS Pipeline	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs	1	2	3/1	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Use		1	3	3/6	R	2
Surveys (e.g., Geophysical, Geological, Geotechnical, Environmental, ROV, Diving)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality		1	2	3/2	R	2

KEY

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Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Decommissioning and abandonment activities are not likely to result in any significant adverse environmental effects on fish and fish habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible.

7.5.4 Accidents Malfunctions and Unplanned Events

The potential environmental effects from accidental events on fish and fish habitat in the Nearshore and Offshore Study Areas are assessed together under each environmental effect category.

The type and probability of various types of accidental events involving hydrocarbons in the offshore is discussed in Chapter 14, as well as modelling results (without the implementation of control measures) for oil spill trajectory in the nearshore and offshore. The complete modelling reports are provided as ASA 2011a, 2011b.

Spill prevention will be incorporated into the design and operations of the Hebron Project. All systems and structures, procedures and programs will be designed with consideration of preventing the loss of any hydrocarbons or chemicals. Examples of measures to reduce the likelihood of an accidental event involving a hydrocarbon release include equipment and facility design, routine maintenance and testing for all aspects of the production program, the use of good communications and sound marine practices, regular inspections and audits of the facilities and equipment, and employee awareness training. EMCP will also undertake all of the necessary planning, training, and exercising to ensure that the appropriate spill response capability is in place for all phases of the Project, in the unlikely event of an accidental event resulting in a hydrocarbon release. Oil spill response is included as part of the contingency planning undertaken for the Project and additional information regarding spill response planning is found is Section 14.4. Chapter 16 describes the Hebron Project's overall environmental management process. Additional mitigation measures to reduce the potential occurrence of an accidental event include, but not limited to:

- Ship operations will adhere to Annex I of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)
- Ice management plan
- Adherence with all standard navigation procedures, Transport Canada requirements, Canadian Coast Guard requirements and navigation systems

7.5.4.1 Change in Habitat Quantity

There is potential for fish habitat quantity to be affected by an accidental event (e.g., nearshore spill, bund wall rupture, spill from the OLS, subsea blowout, crude oil surface spill, marine vessel incident, or collision) resulting in hydrocarbon releases associated with the Hebron Project.

In the nearshore, an accidental event resulting in the release of diesel from a collision or grounding of a construction vessel or barge is the most credible scenario. An accidental event resulting in diesel releases on the surface of the water could potentially affect the quantity of habitat, if shorelines were to be oiled (see ASA 2011a). In the absence of spill countermeasures, the nearshore modelling report (ASA 2011a), and as discussed in Section 14.2.2.1, indicates spills of 100 m^3 of marine diesel has a 60 percent chance of making contact with the Bull Arm shoreline in summer, and a 30 percent probability in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of contacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season. If the bund wall were to break or

rupture, fish habitat quantity could be affected by an increase in sedimentation or a smothering of fish habitat by bund wall material.

In the offshore, a spill of crude oil (e.g., spill from OLS, subsea blowout, or crude oil surface spill) would dissipate through a variety of different processes, including evaporation, and would likely form tar balls (Iliffe and Knap 1979; Ramamurthy 1991; NRC 2003). Tar balls may be transported long distances from source and concentrating in convergence zones or shorelines (NRC 2003). The actual fate of the tar balls will be dependent upon their specific gravities, which are influenced by the amount of sediment and other extraneous materials incorporated into the tar balls. Tar balls and the PAHs associated with them have low bioavailability (Gustafsson et al. 1997; Baumard et al. 1999). Based on modelling of an offshore blow-out (ASA 2011b), and as discussed in Section 7.5.4.2, there is less than 10 percent probability of oil reaching the shoreline of Newfoundland if oil remains on the surface for an extended period of time.

Therefore, for nearshore and offshore areas, it is predicted that fish habitat quantity could be affected by an accidental event. The quantity of fish habitat that may be affected by an accidental event would be examined as part of an post-spill environmental effects monitoring program in the event of an accidental event.

An accidental event (other spills) resulting in the release of cuttings and muds (WBMs and/or SBMs) would form a small component and would be contained within of the cuttings footprint discussed in Section 7.5.1.2.

7.5.4.2 Change in Habitat Quality

The quality of fish habitat could potentially be affected by an accidental event resulting in the release of hydrocarbons (nearshore spill, failure or spill from OLS, subsea blowout, crude oil surface spill, marine vessel incident, or collisions),or chemicals (other spills) or a bund wall rupture in the Nearshore or Offshore Study Areas.

Environmental effects of an accidental event involving the release of hydrocarbons (from nearshore spill, failure or spill from OLS, subsea blowout, crude oil surface spill, marine vessel incident, or collisions)on plankton would be short-lived, although zooplankton are more sensitive than phytoplankton. Phytoplankton production may be inhibited by oil concentrations under a slick, but standing crop and species composition of the phytoplankton may be unaffected. Johansson et al. (1980) found that zooplankton densities declined near an accidental event that resulted in a release of hydrocarbons but rebounded within five days. Data from the Prestige oil spill did not reveal any significant shifts in zooplankton biomass during the spring bloom after the spill (Varela et al. 2006). Calanoid copepods were the dominant group of zooplankton in 2003, as they were in previous years (Varela et al. 2006). The capability of both phytoplankton and zooplankton to metabolize hydrocarbons would reduce the environmental effects on the pelagic ecosystem. Fish would accumulate hydrocarbons if they eat contaminated zooplankton, but

they are also able to metabolize hydrocarbons, so there is no potential for biomagnification.

The environmental effects of an accidental event resulting in the release of hydrocarbons on invertebrates and invertebrate habitat (from nearshore spill, failure or spill from OLS, subsea blowout, crude oil surface spill, marine vessel incident, or collisions) are determined by factors such as species and life history stage, type of habitat, weather and time of year. Hydrocarbons can be detectable in sediments for several years if they are not physically or biologically disturbed (Sanders et al. 1980). Low levels of hydrocarbons in the substrate can have sublethal effects on nearby invertebrates, resulting in possible histopathological damage. When small spills of diesel are stranded on shorelines, the diesel will penetrate porous sediments, but are quickly washed by wave action and tidal flushing.

The benthic community could be at risk from an accidental event involving the release of hydrocarbons as a result of a blowout (subsea or crude oil surface spill). Oil from a blowout can reach the seafloor (thereby affecting the benthic invertebrate community) through weathering, losing buoyancy and eventually sinking or by associating with particulate matter suspended in the water and eventually sinking (Elmgren et al. 1983). Crustaceans appear to be the most sensitive organisms in benthic communities. Most accidental events resulting from a release of hydrocarbons have resulted in major environmental effects on crustacean fauna (Elmgren et al. 1980; Sanders et al. 1980; Dauvin and Gentil 1990; Jewett et al. 1999).

When compared to an accidental event involving the release of crude (e.g., spill from OLS, subsea blowout, or crude oil surface spill), the nature of diesel fuel (marine vessel incident or collision) is such that it evaporates from the surface relatively quickly and does not persist in the environment for any length of time (National Oceanic and Atmospheric Administration 2006). Diesel has a low viscosity and is readily dispersed within the water column when winds reach approximately 9 to 13 km/h (5 to 7 knots) or with breaking waves. It is possible for diesel to be dispersed by wave action and may form droplets that are kept in suspension and move with currents. Diesel may also be restricted from dispersion and evaporation by sea ice and therefore maintain its toxic potential. An accidental event resulting in a hydrocarbon release in Bull Arm (marine vessel incident) during the ice season would have a localized effect on productivity. Microalgae grow on the undersurface of sea ice and can account for up to 30 percent of the annual productivity in the water column (Clark and Finley 1982).

Egg and larval stages would be more subject to physiological effects from an accidental event involving a release of hydrocarbons (nearshore spill, failure or spill from OLS, subsea blowout, crude oil surface spill, marine vessel incident, or collisions), as they cannot actively avoid the spill nor have they developed any detoxification mechanisms. Environmental effects to eggs and larvae can include morphological malfunctions, genetic damage, reduced growth or localized mortality (see Section 7.5.4.4).

The offshore oil spill model (ASA 2011b) predicted, that without the implementation of spill countermeasures, there is <10 percent probability of oil small amounts of weathered oil reaching Newfoundland shores from a Platform spill if the oil remains on the surface for an extended period of time. The summer and winter with ice simulations indicated that no shoreline would be oiled, and approximately 143 km (428,100 m^2) of shoreline would be oiled in the winter without ice, with oil first reaching the shoreline in 41 days. No Newfoundland shoreline would be oiled from a batch transfer or subsurface oil spill. The model predictions are based on no oil spill countermeasures being implemented. EMCP will implement an oil spill response plan and will take measures to protect shorelines. Modelling was also run for an extended period of time after flow from the well stopped flowing (in order to determine the fate of any oil remaining on the sea surface) and verified that there was a <10 percent probability of oil reaching the Newfoundland shoreline. Refer to Section 14.3 for a summary of the results of the offshore oil spill model and ASA 2011b for the complete modelling report).

Tracker buoy data collected during the 2004 Terra Nova spill indicated that it took five weeks for the buoy to reach 40.00.0W and approximately 48.00.00N in November / December (and basically confirmed the oil spill trajectory modelling results conducted to date for the Grand Banks oil developments). If an uncontrolled spill (i.e., no spill countermeasures implemented) lasted more than 120 days, the modelling predicts that oil from a surface or sub-surface blowout at the Hebron Platform will extend beyond the model domain area and, therefore, could potentially (less than 10 percent probability) reach an international coastline with a thickness greater than 0.01 mm. However, any oil that did reach an international shoreline would be patchy, weathered oil.

In the unlikely event of an accidental event resulting in a release of diesel from a vessel or barge accident in the nearshore, marine diesel (Figure 7-15) and IFO-180 (a heavier form of diesel) could reach the shoreline of the Nearshore Study Area. The nearshore oil spill model predicts that at the end of 30 days, a spill of 100 m^3 of marine diesel will result in 10.1 and 19.8 km oiled shoreline (>0.01 mm) in summer and winter, respectively, with oil ashore ranging from 10 m^3 during winter with no ice and 42 m^3 during winter with ice. Spills of 100 m^3 of marine diesel oil representing the 95th percentile for shoreline oiling are predicted to impact up to 75 percent of the Bull Arm shoreline and isolated segments of the Trinity Bay shoreline in both the summer and winter seasons.

The nearshore oil spill model predicts that at the end of 30 days, a spill of 1,000 m^3 of IFO-180 will result in 137.5 and 144.3 km oiled shoreline (>0.01 mm) in winter and summer, respectively, with oil ashore ranging from 610 m^3 during summer and winter no ice and 690 m^3 during winter with ice. Spills of 1,000 m^3 of IFO-180 representing the 95th percentile for shoreline oiling are predicted to impact much of the Bull Arm shoreline and segments of the Trinity Bay shoreline in both the summer and winter seasons. The summer shoreline oiling is restricted to the east and west shorelines in the

southern half of Trinity Bay. Winter season shoreline oiling is predicted to affect primarily the east coast of Trinity Bay.

Therefore, a limited amount of shoreline would be affected by a spill of marine diesel. More shoreline would be affected during a spill of the heavier IFO-180. Diesel has been found to have an immediate toxic effect on many intertidal organisms, including periwinkles, limpets, gastropods, amphipods and other potential prey of fish and shellfish (Wormald 1976; Stirling 1977; Pople et al. 1990; Kennicutt et al. 1991; Cripps and Shears 1997).

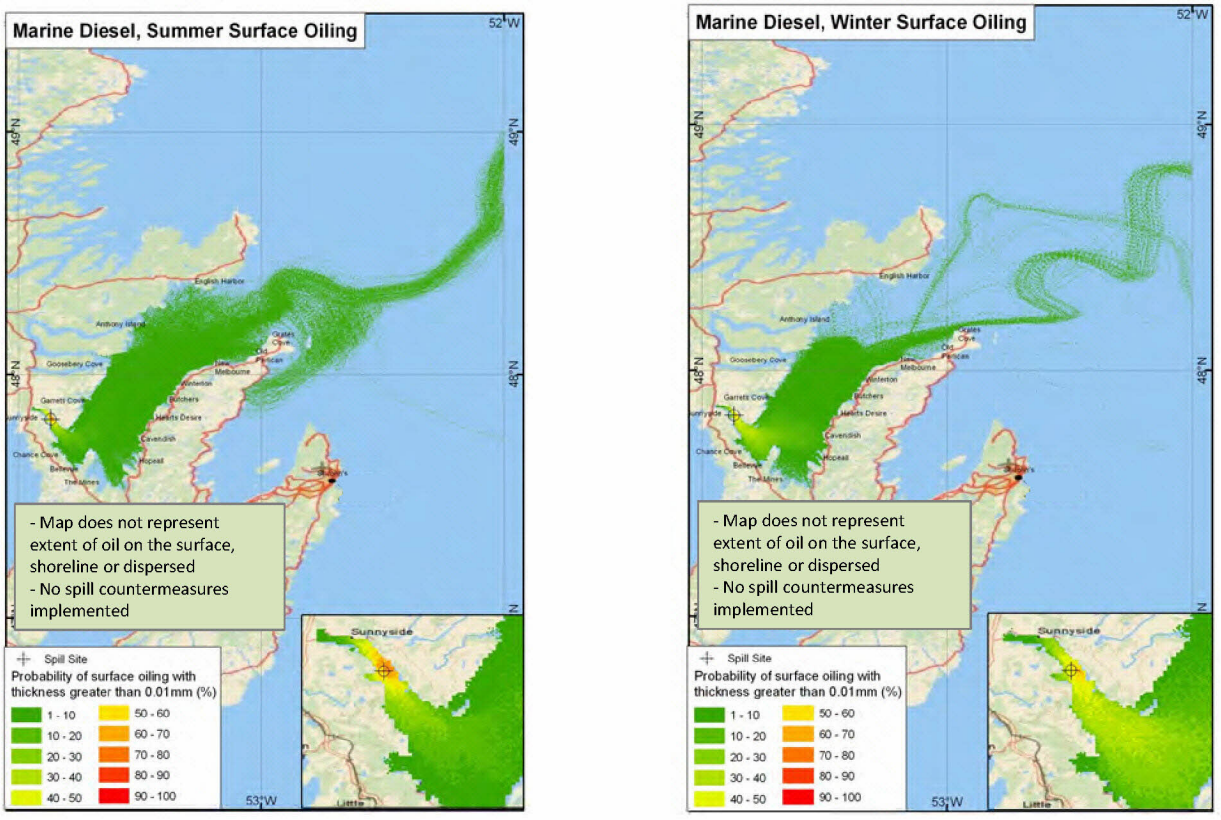

Figure 7-15 Probability of Surface Contact from a Release of 100 m^3 of Marine Diesel in the Nearshore Study Area in Summer (left) and Winter (right)

Another potential accidental event scenario is the failure of the SBM handling system during potential future MODU drilling resulting in the release of SBMs (other spills). There are few studies that focus on the fate and effects of an accidental event resulting in the release of drilling muds and fluids (US Minerals Management Service 2004b; Canada-Nova Scotia Offshore Petroleum Board 2005). Drilling fluids and muds are known for their degradation under certain environmental conditions. The rate of biodegradation is dictated by temperature, hydrostatic pressure and oxygen levels. Smothering of potential food sources for fish and shellfish may occur due to the weight of the barite where the SBM collects in a layer of 1 cm or more (Bakke et al. 1989), in particular in areas where sediment unevenness may permit pooling of the SBM. The SBM would likely be confined to the sediment-water interface and would not likely be incorporated into the

sediment as would be the case with cuttings. Marine fauna that depend on this interface for food or that are non-tolerant to the SBM would be most affected. Another potential environmental effect would be reduced recruitment caused by habitat selection in settling invertebrate larvae.

Biological effects are usually not detectable outside 500 m (Hurley and Ellis 2004), but may occur to a distance of 1,000 m (Olsgård and Gray 1995). At concentrations of 1.5 mg/L, ParaDrill IA appears to have caused weight loss in sea scallop somatic and reproductive tissues; however, the effects were reversed after exposure ceased (Armsworthy et al. 2005). Bioaccumulation of PAHs from ParaDrill IA particulate can occur in scallop, depending on the concentration, suspended particulate matter and feeding rate of the scallop. The sea scallop is one of the most sensitive species to drilling waste in that low PAH levels of 0.05 to 2.0 mg/L have been shown to affect growth and reproduction (Cranford et al. 2005). These effects likely result from physical effects, since SBMs are non-toxic. These effects are caused by the physical properties of the SBMs and WBMs, as fine particles of bentonite and barite interfere with digestion and feeding of scallops (Armsworthy et al. 2005) and possibly other bivalve species (Barlow and Kingston 2001).

A bund wall rupture that has the potential to result in change in habitat quality as a result of increased suspended sediment and contamination. A variety of construction activities will be ongoing behind the bund wall such that a bund wall rupture could result in a immediate release of suspended solids, chemicals and hydrocarbons carried into Bull Arm as the water breaches the bund wall. The environmental effects of suspended solids and contamination have been discussed in Section 7.5.1.2 and would also apply to this accidental event scenario.

7.5.4.3 Change in Habitat Use

An accidental event (including bund wall rupture, nearshore spill, failure or spill from OLS, subsea blowout, crude oil spill, other spills, marine vessel incident or collisions) in the Nearshore or Offshore Study areas could cause a change in fish behaviour and thus affect use of a particular habitat. Juvenile and adult finfish have been known to avoid areas of oiled sediment (Irwin1997). Less mobile invertebrates could not so easily avoid the oil. The ability of fish to avoid an oiled area must be considered within the context of their habitat requirements. Presumably, if fish were avoiding an area, they would seek the next clean area of similar habitat. The habitat seeking behaviour may have consequences on the mortality rates of juvenile fish and shellfish through predation and on the success of foraging of all life stages, if alternate habitats are not readily available. However, alternate habitats are available for both the Nearshore and Offshore Study areas and changes in behaviour not likely to have further consequences.

An accidental release of drill muds (most likely accidental event scenario) and other related production chemicals from the MODU or Hebron Platform could result in a change in habitat use primarily as a result of potential reduced recruitment caused by habitat selection in settling invertebrate larvae or other physical-related effects, as SBMs are non-toxic. The footprint of such an

accidental event would be limited to near the Hebron Platform (where the accidental event would occur) and would be contained within the footprint of the WBMs and most likely limited to 500 m. Additional information on the environmental effects of SBMs are discussed in Sections 7.5.2.2, 7.5.2.4 and 7.5.4.2.

7.5.4.4 Potential Mortality

In the unlikely event of a rupture in the bund wall, mortality of fish and shellfish in the immediate area could result. Depending on the rate of collapse of the bund wall, some fish and shellfish near the rupture point could be entrained in the surge of water into the drydock area. Fish and mobile shellfish outside the immediate entrainment area would likely avoid the risk.

In the unlikely event of an accidental event involving a release of hydrocarbons or chemicals, lethal effects on eggs and larvae are more likely to occur than adult fish mortality. Eggs and larvae tend to congregate in the upper water column where they could be directly exposed if they occur at the same time and in the same space as an accidental event resulting in a release of hydrocarbons or chemicals (other spills). Fish eggs and larvae are more vulnerable to hydrocarbons since they have not yet developed any detoxification mechanisms, and cannot actively avoid the area of the accidental event. Fish eggs generally appear to be highly sensitive to hydrocarbon contamination at certain stages and then become less sensitive just prior to larval hatching (Kühnhold 1978; Rice 1985). Rice et al. (1987) reported that larval sensitivity varies with yolk sac stage and feeding conditions, with eggs and larvae exposed to high concentrations of hydrocarbon exhibiting morphological malformations, genetic damage and reduced growth. Embryo damage may not be apparent until the larvae hatch (Kühnhold 1974).

Given the high rate of natural mortality of eggs and larvae, the environmental effects of a localized spill would be undetectable, and recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of a spawning area were lost (Rice 1985). No effect was detected at the population level when herring larvae survival was reduced by 58 percent due to the Exxon Valdez spill (Hose et al. 1996).

The accidental release of SBMs would result in smothering of benthic organisms where the SBM collects in a layer of 1 cm or more (Bakke et al. 1989), in particular, in areas where sediment unevenness may permit pooling of the SBM.

The spatial extent of an accidental event resulting in the release of hydrocarbons or chemicals (other spills) in the nearshore and offshore is highly variable depending on the nature of the accidental event and the weather conditions immediately after the accidental event. A summary of those scenarios is presented in Sections 14.2 and 14.3, and complete spill modelling reports are provided in ASA (2011a, 2011b).

The environmental effect of the potential accidental events and the mitigation to further reduce the likelihood of occurrence and potential effects is summarized in Table 7-14.

Table 7-14 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Fish Mortality	• Prevention through design standards and maintenance	1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	3	4	2/1	R	2
Failure or Spill from OLS	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	1	5	2/1	R	2
Subsea Blowout	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	2	5	3/1	R	2
Crude Oil Surface Spill	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	1	5	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	1	1	2/1	R	2
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Ship operations will adhere to Annex I of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	1	5	2/1	R	2
Collisions (involving Hebron Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Ice Management Plan • Adherence with all standard navigation procedures,Coast Guard requirements and navigation systems	1	3	2/1	R	2

KEY

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Ecological / Socio-economic Context:
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2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Due to the reversibility and limited duration of an accidental event, potential environmental effects of an accidental event resulting in the release of hydrocarbons or chemicals, blowout or bund wall rupture on marine fish and fish habitat is considered adverse but not significant and not likely to occur. Natural recruitment is expected to re-establish the population to its original level and avoidance of the area is expected to be temporary should an accidental event occur.

7.5.5 Cumulative Environmental Effects

7.5.5.1 Nearshore

Cumulative environmental effects on marine Fish and Fish Habitat in the Nearshore Study Area could occur as a result of the proposed Project in combination with commercial fisheries, which can contribute to physical disturbance during trawling and noise effects, and marine transportation, which can contribute to contamination and noise effects.

It is unlikely that nearshore routine activities associated with marine transportation would have much adverse direct environmental effects on marine Fish and Fish Habitat within the Nearshore Study Area. There is some recreational marine transportation, but other than commercial fisheries-related transportation, there is little commercial vessel traffic within the Nearshore Study Area. While commercial fisheries have an environmental effect on marine invertebrates and fish through resource exploitation, the current level of commercial fishing activity within the Project Area is limited. The commercial fishery is managed by DFO to maintain fish populations at sustainable levels.

7.5.5.2 Offshore

In the Hebron Offshore Study Area, cumulative environmental effects on marine fish and fish habitat could occur as a result of the proposed Project in combination with the following activities:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activity
- Offshore seismic activity
- Marine Transportation and
- Commercial fisheries

Cumulative environmental effects on marine Fish and Fish Habitat in the Hebron Offshore Study Area could occur as a result of the proposed Project in combination with past, present and future oil and gas activities, which can contribute to physical disturbance, contamination, smothering of benthic organisms and noise effects. Commercial fisheries contribute to physical disturbance during trawling and noise effects, while chronic oil spills by marine transportation contributes to contamination as well as noise effects within the Hebron Offshore Study Area. These industries can interact cumulatively with the Hebron Project to have adverse environmental effects on Fish and Fish Habitat.

As of February 2010, there have been a total of 308 exploration, delineation and development / production wells drilled on the Grand Banks, including 104 exploration wells, 45 delineation wells and 159 development / production wells (C-NLOPB 2010a). As of April 2010, there were 46 SDLs,

24 Exploration Licenses (ELs) and eight Production Licenses active on the Grand Banks (C-NLOPB 2010b). According to the C-NLOPB website, there are two proposed exploratory drilling programs on the Grand Banks. The currently proposed drilling activities are summarized in Table 7-15.

Table 7-15 Proposed Drilling Activity on the Grand Banks

Proponent	Exploration Activity (*e.g.*, wells, seismic surveys)	Location	Timing	Comments
Statoil Canada	Maximum of 27 wells	Jeanne d'Arc Basin Flemish Pass	2008 to 2016	Single and/or dual side-track exploration and appraisal / delineation wells
Suncor	Maximum of 18 wells	Jeanne d'Arc Basin	2009 to 2017	Single and/or dual side-track exploration wells
Husky	Wells	Jeanne d'Arc Basin	2008 to 2017	Eighteen oil and gas targets; combination of vertical and deviated (twin) wells

EEM programs for production facilities in the Newfoundland offshore have demonstrated that the mitigation measures being implemented with respect to marine fish and fish habitat have been effective. It is generally accepted that the biological zone of influence from cuttings deposition is confined to within 500 m of the well (Hurley and Ellis 2004; Neff 2005). The changes to marine fish habitat as measured by benthic community changes have been primarily attributed to physical alterations in sediment texture, including smothering as opposed to toxic effects (Hurley and Ellis 2004). The data from current Canadian EEM programs suggest that benthic community change can be detected within 1,000 m of the drill site, with some habitat types and more sensitive species affected over greater distances, particularly along the axis of predominant current (Hurley and Ellis 2004).

The effects of drill mud and cuttings deposition in the area immediately adjacent to a well lessen considerably one to two years after drilling cessation (Kingston 1987; Gray et al. 1990). Fish habitat, as measured by changes in benthic community structure around single exploration wells, returned to baseline conditions within one year after cessation of drilling (Hurley and Ellis 2004). At Hibernia, partial re-injection of SBM drill cuttings commenced in March 2000; full re-injection capacity began in September 2002. In the 2002 EEM field study, a substantial reduction in hydrocarbon concentrations in sediment was already observed. The concentration of hydrocarbons was comparable to levels found in 1998 after one year of drilling and concentrations of barium were comparable to 1999 levels, after two years of drilling. The biological effects of drilling are considered reversible.

For the assessment of StatoilHydro Canada Ltd.'s proposed drilling program, LGL (2008b) calculated that for the drilling of up to 45 wells between 2008 and 2017, the total area of seabed potentially covered by at least 1 cm of drill

cuttings would be approximately 45 x 0.8 km^2 or 36 km^2 (approximately 0.034 percent of the StatoilHydro Canada project area). The Husky White Rose New Excavated Drill Centre Construction and Operations Program, is proposing up to 54 wells; the total area potentially affected by drill cuttings deposition (without consideration of the potential for overlap) would be 54 x 0.8 km^2 or 43.2 km^2. These two areas combined represent approximately 0.07 percent of their cumulative project areas (LGL 2008b). The Hibernia South Project proposed a maximum of six excavated drill centres each supporting up to 11 wells, resulting in the worst case scenario (i.e., no overlap of cuttings) of 8.8 km^2 of seabed covered by a minimum of 1 cm of drill mud and cuttings (Jacques Whitford 2009). Such is most likely not to be the case and as the cumulative affected area of 8.8 km^2 is an over-estimation. This cumulative area represents less than 1 percent of the Hibernia South project area.

The proposed Hebron Project could have up to 52 wells drilled from the Hebron Platform, with an additional 15 wells that may be drilled from MODUs within the Project Area. As a worst case, if it is assumed that all wells outside the Hebron Platform are separated such that drill cuttings are not re-injected and deposits around each well do not overlap, the result would be 12 km^2 of cuttings deposition around the MODU wells (0.8 km^2 x 15), plus 0.8 km^2 around the Hebron Platform. A total of 12.8 km^2 equals less than 0.5 percent of the Offshore Project Area of approximately 2,560 km^2.

There is a potential cumulative environmental effect from the WBM discharge when considered together with other drilling projects. While it is acknowledged that each production or exploration well is contributing to a cumulative environmental effect on marine fish habitat, each of these projects is affecting a localized area and the environmental effects are reversible. Each of these projects is also required to adhere to the OWTG (NEB et al. 2010) and related monitoring requirements.

It is unlikely that routine activities associated with marine transportation have much adverse direct environmental effect on marine Fish and Fish Habitat. However, although commercial fisheries can have an environmental effect on marine Fish and Fish Habitat, the current level of commercial exploitation within the Project Area is very limited and DFO manages the fishery to keep populations at sustainable levels.

All discharges from the Hebron Project will be in accordance with the OWTG (NEB et al. 2010). As general marine vessel discharges are also regulated, it is not predicted that any significant cumulative environmental effects on marine fish habitat would result. Produced water potentially affects the chemistry of the receiving environment within 50 to 500 m from each operating facility (Hibernia Management and Development Company (HMDC) 2005; Querbach et al. 2005), so there will be no additive environmental effect between projects. Pelagic organisms are not likely to be exposed to more than one plume. If fish do move between operation platforms, the ability of fish to metabolize low level hydrocarbons will reduce the potential for chronic effects.

The timing of seismic surveys within and between projects within the Hebron Offshore Study Area are unlikely to overlap. The only known project to coincide with the timing of the Hebron surveys is the Statoil Canada seismic survey of the Jeanne d'Arc Basin (in and near Exploration License (EL) 1100 and EL 1101), and within the Terra Nova Field), which may continue up to 2016. Both the Suncor seismic survey in the Jeanne d'Arc Basin and the EMCP geohazard survey are scheduled for 2010.

The Hibernia South Project anticipated up to six drill centres may be required, and possibly two, 1-km^2 dredge spoil disposal areas, although more may be required. The Hebron Project may require up to four excavated drill centres as part of potential expansion opportunity plans. As a conservative assumption, the excavation of each excavated drill centre may require its own dredge spoil area, each approximately 1 km^2. However, it is possible that a dredge spoils disposal area may be used more than once. The total area of the potential HADD has yet to be determined, but EMCP will adhere to the DFO policy of no net loss of the productive capacity of fish habitat from this Project. The spatial and temporal scales of potential environmental effects from dredging, compared to the amount of existing similar habitat on the Grand Banks, the high potential for reversibility and the commitment for habitat compensation, will reduce the cumulative environmental effects from dredging and disposal.

Given that the predicted environmental effect of the proposed Project is not significant, and that other oil and gas activities in the Offshore Project Area are likely to have similar environmental effects on Fish and Fish Habitat, and given the limited nature of commercial fishing in the area, and the temporal and spatial overlap with other projects is limited, the cumulative environmental effects of the Project on Fish and Fish Habitat are predicted to be not significant.

7.5.6 Determination of Significance

The determination of significance is based on the definition provided in Section 7.2. It considers the magnitude, geographic extent, duration, frequency, reversibility, and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Fish and Fish Habitat, after taking into account any proposed mitigation, is summarized in Table 7-16.

The potential residual adverse environmental effects of the Project on Fish and Fish Habitat are not considered of sufficient geographic extent, magnitude, duration, frequency and/or reversibility to result in a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Any potential residual adverse environmental effects of the Project on marine fish

habitat will be mitigated. The potential residual adverse environmental effects of the Hebron Project on Fish and Fish Habitat are therefore predicted to be not significant.

Table 7-16 Residual Environmental Effects Summary: Fish and Fish Habitat

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	2	N/A
Cumulative Environmental Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria.
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site.
C Includes decommissioning and abandonment of the GBS and offshore site.
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

As required by the Canadian Environmental Assessment Act (CEAA), an analysis of potential environmental effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on Fish and Fish Habitat are predicted that could affect renewable resource use.

7.5.7 Follow-up and Monitoring

The CEAA definition of "follow-up program" is "a program for (a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project". Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. Compliance monitoring on its own, does not satisfy the requirements for a follow-up program. Compliance monitoring is conducted to ensure that a project and its activities are meeting the relevant environmental standards, guidelines and regulations. Compliance monitoring will be conducted for the Project in accordance with regulatory requirements.

An environmental protection program may require effects monitoring at Bull Arm during construction. Similarly, if ocean disposal permits are required, EMCP will implement a monitoring program in accordance with the provisions of the Ocean Disposal Permit.

The offshore and nearshore EEM programs that will be designed and implemented for this Project are both considered as follow-up monitoring as defined by CEAA.

EMCP will implement an offshore EEM program that will be designed to determine if activities associated with the Hebron Project, as predicted in this environmental assessment, are affecting the receiving environment. The parameters of the EEM program may include those being monitored by other offshore oil and gas operations (i.e., sediment chemistry, sediment toxicity, water chemistry, fish taint, fish health and body burden). However, the details of the EEM design program will be determined in consultation with regulatory, scientific authorities and other interested stakeholders. An overview of the process that will be followed in the design of the EEM program is provided in Section 15.2.

A fish habitat compensation monitoring program will also be implemented as a follow-up monitoring program once the habitat compensation measures implemented. Details of the compensation monitoring program will be outlined in the Hebron Habitat Compensation Strategy report.

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8 COMMERCIAL FISHERIES

8.1 Environmental Assessment Boundaries

8.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Chapter 4). The Study Areas and Project Areas are illustrated in Figures 8.1 and 8.5, for the nearshore and offshore, respectively.

8.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are provided in Table 8-1.

Table 8-1 Temporal Boundaries of Nearshore and Hebron Offshore Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

8.1.3 Administrative

Administrative boundaries for commercial fisheries are determined by DFO, which manages the fisheries resources in the area and is primarily responsible for scientific surveys within the area. These boundaries generally follow Northwest Atlantic Fisheries Organization (NAFO) Division and Unit Areas. The Nearshore Study Area falls entirely within NAFO sub-division 3Lb, which includes all of Trinity Bay. The Offshore Study Area encompasses several sub-divisions within NAFO Division 3LMN. The Offshore Project Area is located entirely within sub-division 3Lt. DFO manages the fisheries in both the Nearshore and Offshore Study Areas. The Provincial Department of Fisheries and Aquaculture manages aquaculture, emerging fisheries and developing fishery projects within the territorial seas (12 nm).

8.2 Definition of Significance

The following definition of significance is used for the Commercial Fisheries assessment:

- Not Significant: does not have a measurable effect on commercial fishing incomes
- Significant: has a measurable and sustained adverse environmental effect on commercial fishing incomes

8.3 Existing Conditions

This section describes the existing and recent commercial fisheries in the Nearshore and Offshore Study and Project Areas.

8.3.1 Nearshore Project Area

8.3.1.1 Study Area Homeports

The boundaries of the Nearshore Study Area (Figure 8-1) include all of Bull Arm and Tickle Bay, bounded on the east by a line from Tickle Harbour Point to the southern headland of Deer Harbour, as described in Chapter 4.

While other Trinity Bay-based fishing enterprises may occasionally operate on established fishing grounds in this part of the bay, most of the harvesting activities are conducted by fishers from seven fishing homeports in the southernmost part of the bay: Sunnyside; Chance Cove; Bellevue; Thornlea; Norman's Cove; Long Cove; and Chapel Arm. Discussion and analysis of harvesting activities in this section focus on the fishing activities of enterprises from these seven homeports.

8.3.1.2 Data Sources and Use

Analysis of fish harvesting activities examined in this section relies on data from the Statistics Division of the Fisheries and Oceans Canada (DFO) and from the department's Regional Licensing Office. In addition to using relevant information from the DFO catch and effort database (e.g., for the overview of fisheries activities in Unit Area 3Lb discussed above), a special data run was requested from the Statistics Division that focused specifically on the activities of enterprises in the seven homeports. This was the smallest geographic area for which DFO was able to provide information without infringing on its data confidentiality guidelines.

Additional information on fishing enterprises and harvesting was obtained during consultations with Study Area fishers based in the seven relevant communities. These consultations are described in Section 5.3.

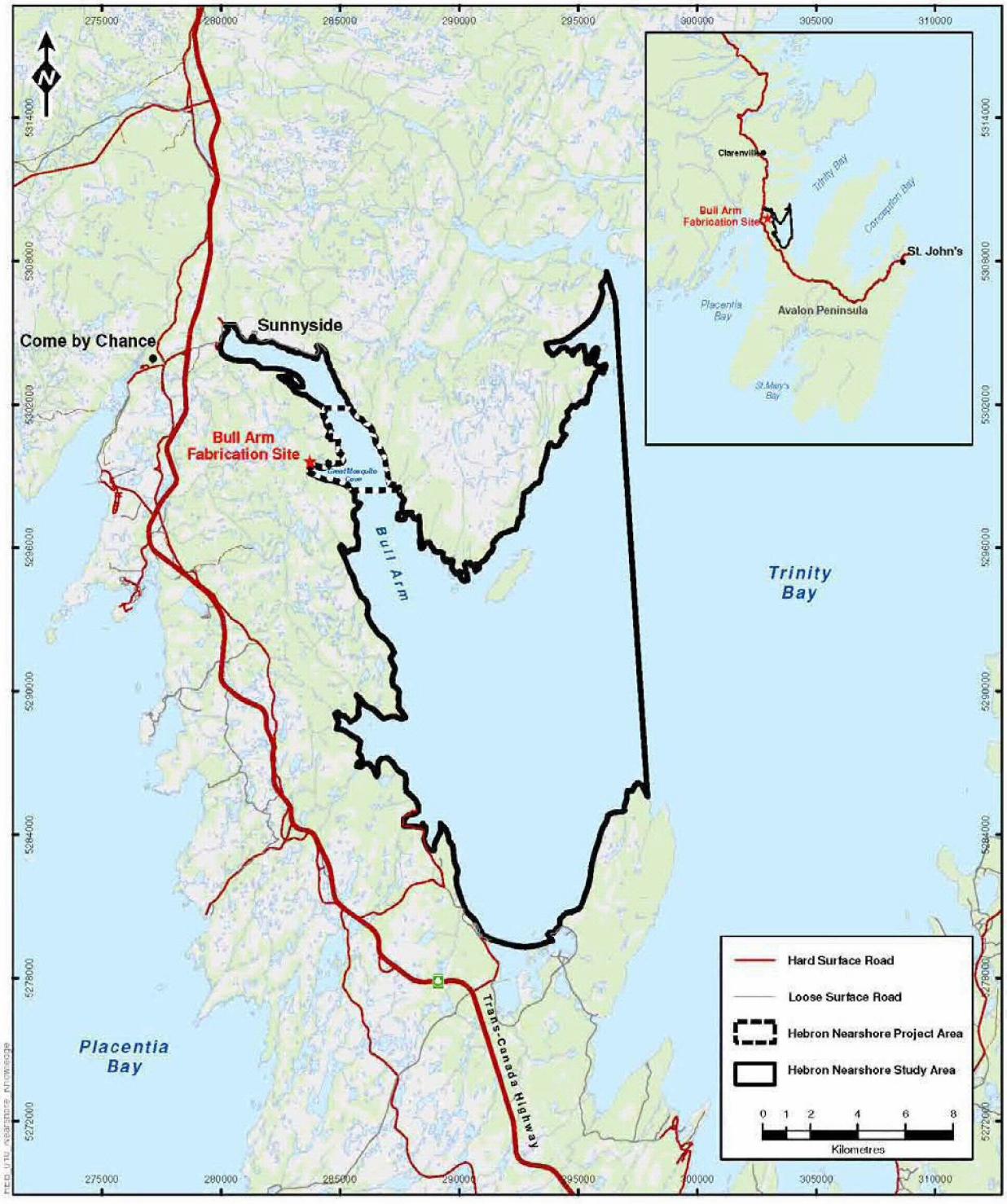

Figure 8-1 Nearshore Project and Study Areas

8.3.1.3 Enterprises, Vessels and Species Licenses

There are a total of 35 Core[1] and non-Core fishing enterprises in the Nearshore Study Area (Table 8-2), 23 of them operating vessels in the less

[1] "Core" enterprises are those which are headed by a Core fisher. A Core fisher must be the head of an enterprise, hold key species licences (i.e., for Newfoundland, groundfish, capelin, lobster, snow crab, scallop, shrimp, and all

than 40-foot class size, and 12 using vessels in the greater than 40-foot class size. The two non-Core enterprises in the Study Area are in Bellevue and in Chapel Arm. These 35 enterprises employ 70 to 80 individuals.

Table 8-2 Total Number of Core and Non-Core Enterprises by Fleet, Nearshore Study Area Homeports, 2009

Homeport	<40'	40' and greater	Total
Sunnyside	3	1	4
Chance Cove	6		6
Bellevue	4	2	6
Thornlea	1	2	3
Long Cove	4	2	6
Norman's Cove	3	3	6
Chapel Arm	2	2	4
Total	23	12	35
Source: DFO 2009f (Licensing Branch)			

The distribution of species licenses by vessel size is shown in Tables 8-3 and 8-4. Core fishing enterprises collectively hold a total of 288 species licences. Additionally, the two non-Core enterprises hold nine licences in total.

Table 8-3 Licenses held by Core Enterprises by Fleet, Nearshore Study Area Homeports, 2009

Species / Gear Type	Vessels <40'	Vessels >40'	Total
Bait	19	4	23
Capelin FG[A]	21	5	26
Capelin PS[B]	-	6	6
Groundfish FG[A]	21	12	33
Herring FG[A]	20	3	23
Herring PS[B]	-	7	7
Mackerel FG[A]	21	7	28
Mackerel PS[B]	-	8	8
Lobster	18	3	21
Scallop	-	2	2
Shrimp	-	3	3
Squid	21	10	31
Snow Crab	21	12	33
Sea Urchin	4	-	4
Whelk	11	4	15
Seal	17	7	24
Eel	1	-	1
Totals	195	93	288
Source: DFO 2009f (Licensing Branch) A FG = Fixed gear B PS = Purse seine			

species using purse seine), have a demonstrated attachment to the fishery, and be dependent on the fishery. See http://www.dfo-mpo.gc.ca/communic/lic_pol/ch3_e.htm

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Table 8-4 Licenses held by Non-Core Enterprises by Fleet, Nearshore Study Area Homeports, 2009

Species / Gear Type	Vessels <40'	Vessels >40'	Total
Bait	1		1
Capelin FG[A]	1		1
Capelin PS[B]	-		-
Groundfish FG[A]	2		2
Herring FG[A]	1		1
Herring PS[B]	-		-
Mackerel FG[A]	-		-
Mackerel PS[B]	-		-
Lobster	1		1
Scallop	-		-
Shrimp	-		-
Squid	2		2
Snow Crab	-		-
Sea Urchin	-		-
Whelk	-		-
Seal	1		1
Eel	-		-
Totals	9		9

Source: DFO 2009f (Licensing Branch)
A FG = Fixed gear
B PS = Purse seine

Only the larger vessels (greater than 40-foot) are licensed to fish certain species such as shrimp and scallop, or to participate in fisheries where quotas are allocated to mobile gear sectors. All of the 33 Core enterprises are licensed to fish crab. The 21 smaller boats harvest their crab entirely within Trinity Bay (within UA 3Lb; see Figure 8-2), while the 12 larger vessels take this species in quota zones well beyond Trinity Bay (the two non-Core enterprises are not permitted to harvest snow crab).

8.3.1.4 Historical Overview of Regional Fisheries (Trinity Bay)

The fisheries in Trinity Bay have changed significantly since the mid to late 1980s, as shown in Figure 8-3. This is largely the result of the collapse of several commercially important groundfish species stocks in the early 1990s and the subsequent declaration of a harvesting moratorium in 1992, virtually ending the directed fisheries for cod and some other species in most waters off Newfoundland and Labrador. From 1990 to its low point in 1996, the Trinity Bay (Unit Area 3Lb) cod harvest fell from 11,475 tonnes to under 75 tonnes, a drop of more than 99 percent. Similar relative levels of decline occurred in the Trinity Bay greysole flounder and turbot fisheries.

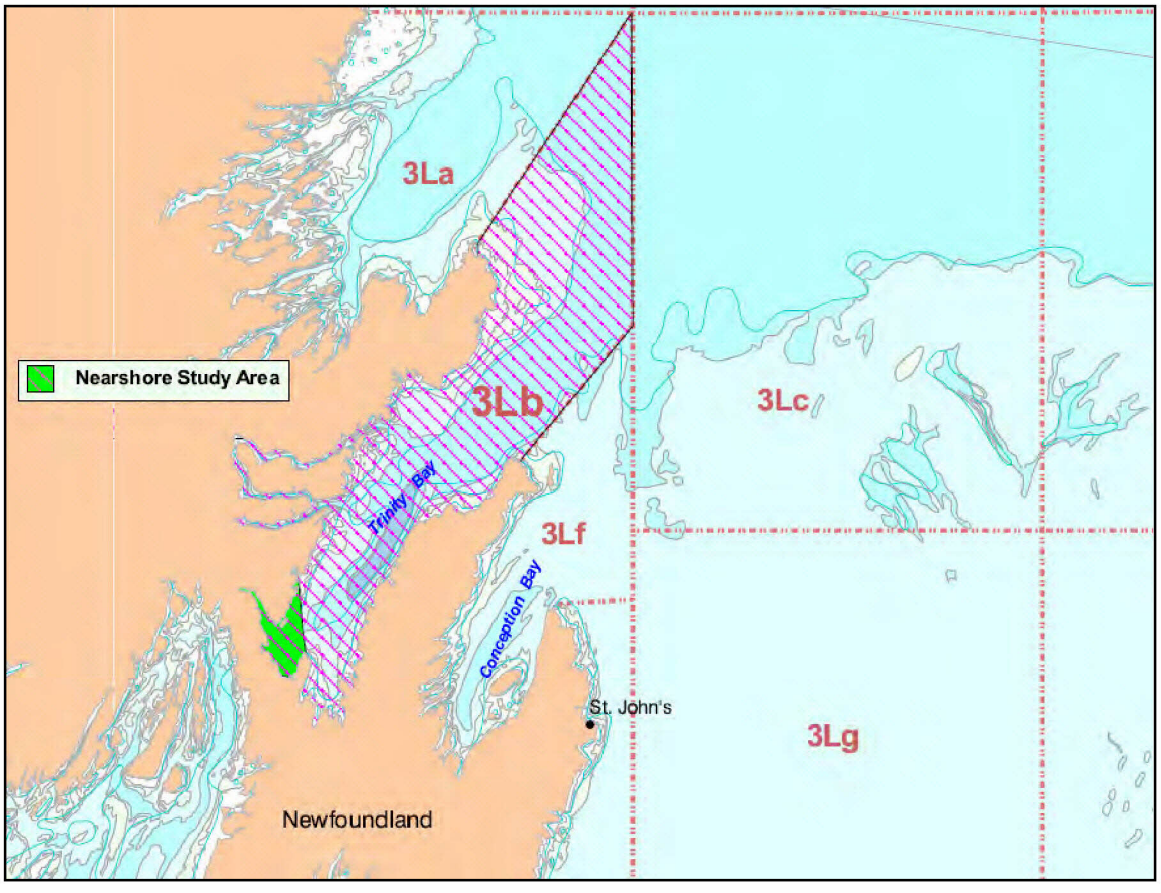


Figure 8-2 Trinity Bay, Unit Area 3Lb

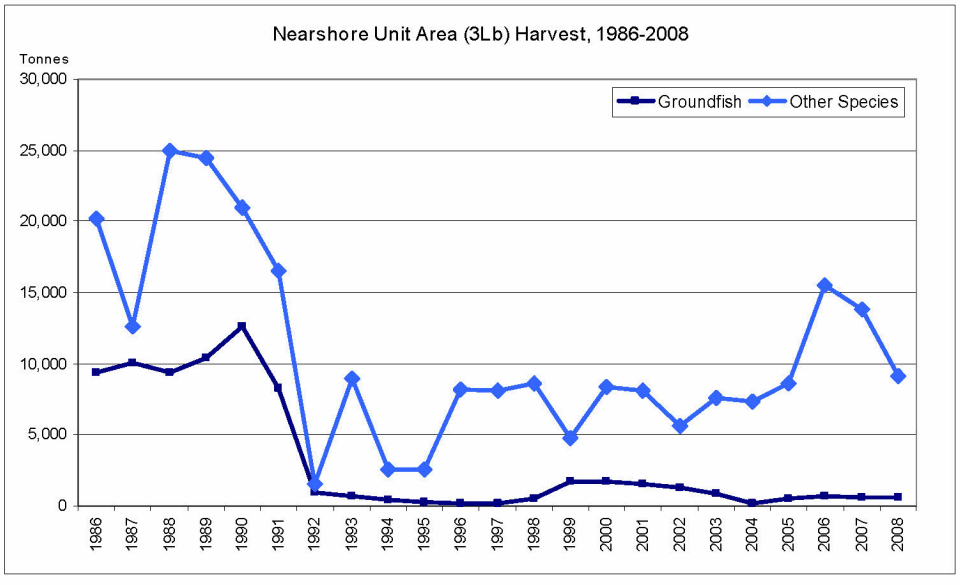


Figure 8-3 Nearshore Unit Area (3Lb) Harvest, 1986 to 2008

The virtual disappearance of groundfish fisheries generated an increasing interest in and reliance on other species, mainly snow crab in this area. Between 1990 and its high point in 1995, the snow crab harvest in Trinity Bay increased by more than 200 percent, from 535 tonnes to 1,635 tonnes. Squid, capelin, herring and mackerel have continued to be the other principal fisheries (in terms of quantity) through this period, though landings have varied considerably from year to year depending on markets and resource availability.

Landings for individual species of significance in Trinity Bay for the 20-year period from 1989 to 2008 are illustrated in Figures 8-4 to 8-8.

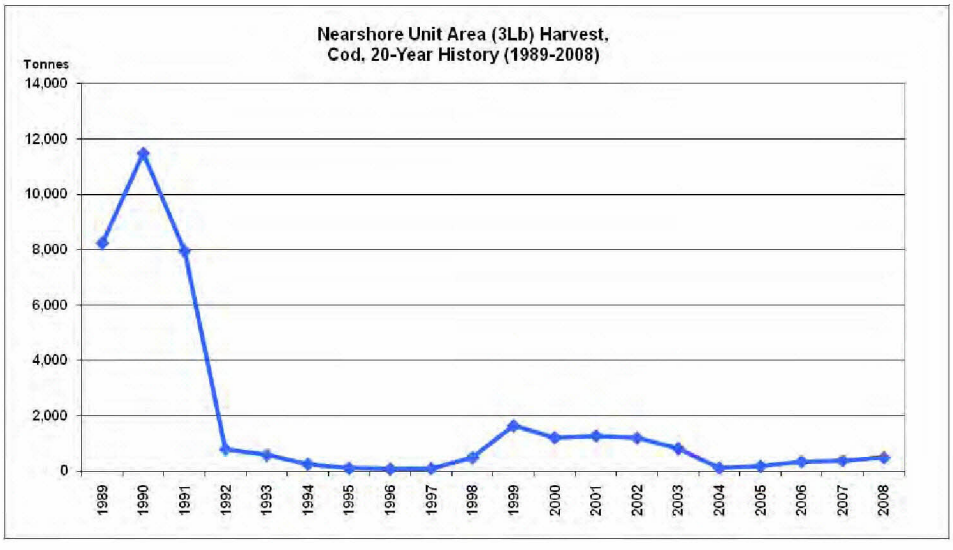


Figure 8-4 Nearshore Unit Area (3Lb) Harvest, Cod, 20-year History (1989 to 2008)

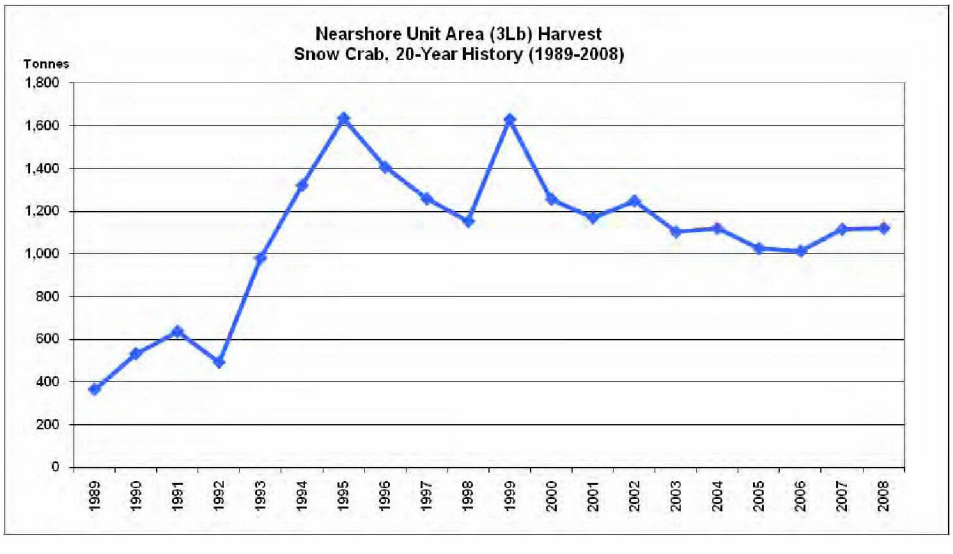


Figure 8-5 Nearshore Unit Area (3Lb) Harvest, Snow Crab, 20-year History (1989 to 2008)

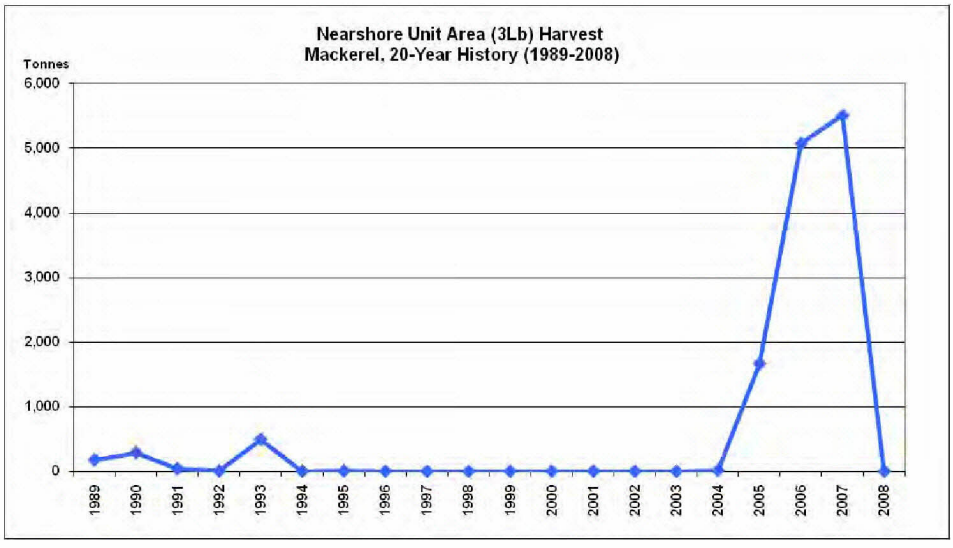


Figure 8-6 Nearshore Unit Area (3Lb) Harvest, Mackerel, 20-year History (1989 to 2008)

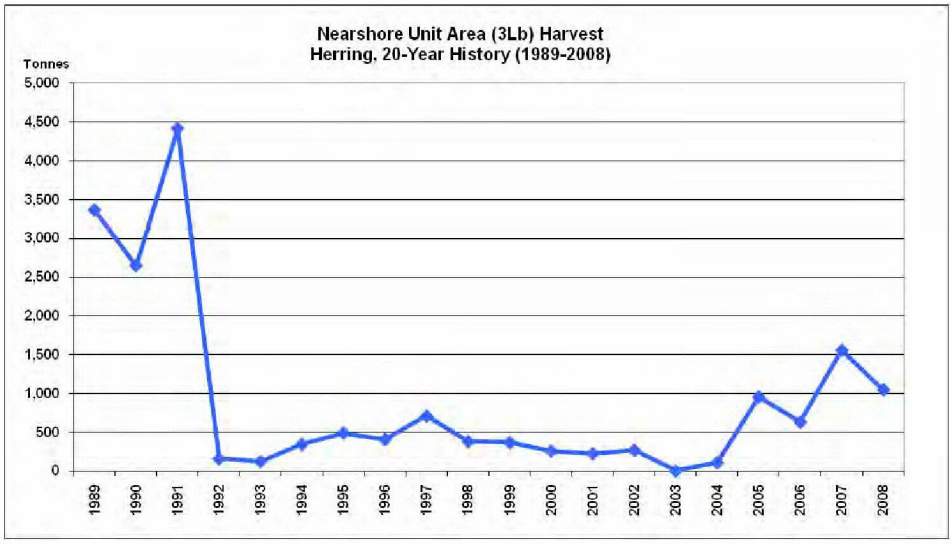


Figure 8-7 Nearshore Unit Area (3Lb) Harvest, Herring, 20-year History (1989 to 2008)

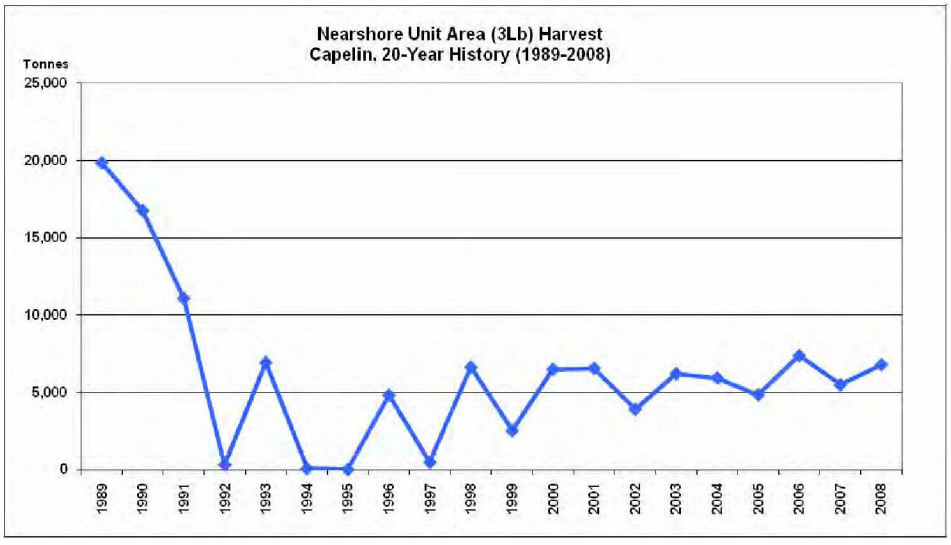


Figure 8-8 Nearshore Unit Area (3Lb) Harvest, Capelin, 20-year History (1989 to 2008)

8.3.1.5 Key Species Catches – Trinity Bay Fishing Grounds (Nearshore Study Area Homeports)

Overall landings have fluctuated from year to year during the past 10 years, ranging from a peak of about 3,200 tonnes in 2000 to a low of 1,500 tonnes in 2002. Despite these ups and downs, the general trend has been relatively stable.[2]

As indicated in Tables 8-5 and 8-6, the annual average catch 2004 to 2008 was just over 2,100 tonnes, and the average annual fishing income just over $1 million.

As indicated in Tables 8-5 and 8-6, capelin, mackerel and herring accounted for almost 90 percent by weight of the total catch with crab and squid making up a further 8.5 percent. Capelin, mackerel and herring also made up almost 50 percent of the average annual value of landings. Crab and lobster contributed a further 44 percent of the area's annual fishing income. Together, these five species have generated over 90 percent of all fishing income from species caught in Trinity Bay. Cod, sea urchin, squid and lumpfish make up most of the remaining portion of their annual earnings.

These catch and value figures pertain only to the species caught by Nearshore Study Area enterprises within Trinity Bay. The total average income for nine all enterprises is actually higher than the $1.056 million shown in Table 8-6. The 12 vessels in the "greater than 40-foot fleet" harvest considerable quantities of other species, such as crab and shrimp, and occasionally some pelagics, on grounds well beyond Trinity Bay / 3Lb. In 2008, for example, the total value of crab caught by all Nearshore Study Area enterprises on all fishing grounds was just under $2.5 million, but $425,000 (17 percent) was taken from crab grounds in Trinity Bay. In the same year,

[2] Unless otherwise indicated, all landings in this section refer to species catches harvested from UA 3Lb by vessels based in the seven Nearshore Study Area homeports.

the "greater than 40-foot fleet" harvested $455,000 worth of shrimp from grounds beyond Trinity Bay.

Table 8-5 Average Harvest by Quantity, 2004 to 2008

Species	Tonnes	% of Total
Cod, Atlantic	27.00	1.3
Redfish	0.08	0.0
American plaice	0.00	0.0
Yellowtail flounder	0.01	0.0
Winter flounder	7.23	0.3
Turbot / Greenland halibut	0.01	0.0
Skate	1.34	0.1
Herring, Atlantic	247.08	11.5
Mackerel	346.87	16.2
Eels	0.12	0.0
Capelin	1,315.86	61.4
Shark, blue	0.02	0.0
Squid, Illex	56.47	2.6
Whelks	0.06	0.0
Sea Urchins	8.55	0.4
Lobster	2.16	0.1
Crab, Queen / Snow	124.21	5.8
Seal fat	1.05	0.0
Roe, lumpfish	4.00	0.2
Total	2,142.12	100.0

Table 8-6 Average Harvest by Value, 2004 to 2008

Species	Value	% of Total
Cod, Atlantic	$36,579	3.5
Redfish	$44	0.0
American plaice	$1	0.0
Yellowtail flounder	$4	0.0
Winter flounder	$3,393	0.3
Turbot / Greenland halibut	$9	0.0
Skate	$316	0.0
Herring, Atlantic	$47,493	4.5
Mackerel	$106,193	10.0
Eels	$649	0.1
Capelin	$339,115	32.1
Shark, blue	$27	0.0
Squid, Illex	$20,253	1.9
Whelks	$59	0.0
Sea Urchins	$18,467	1.7
Lobster	$25,122	2.4
Crab, Queen / Snow	$442,393	41.9
Roe, lumpfish	$16,640	1.6
Total	$1,056,755	100.0

Based on historical catch data and consultations with nearshore fishers, most of the annual catch by Study Area enterprises operating "less than 40-foot vessels" is harvested from grounds within Trinity Bay. It is also reasonable to conclude that, with the exception of a portion of the crab, most of the all-species catch by "vessels less than 40-foot" comes from grounds within the Study Area. Enterprises in the "greater than 40-foot fleet" harvest a large portion of their annual catch of several key species within the Study Area.

8.3.1.6 Key Species Seasons

The seasons for various key Study Area species are shown in Table 8-7.

Table 8-7 Fishing Season by Species

Species	Fishing Season
Lobster	April 27 to July 8
Crab	Usually late April to the end of June; the opening date depends on winter ice conditions. In the past five or six years, crab has generally been harvested in May and June
Cod	Usually opens in the first week of September and continues for about four weeks
Herring	The mobile gear fishery usually takes place in October-November but can last into December depending on available quota. A fixed-gear fishery (usually with nets) in spring supplies bait for the lobster and crab fisheries
Capelin	Mobile and fixed-gear fisheries usually take place within a 10 to 12 day window in late July-early August. (The opening date depends on capelin arrival and on DFO regulations.) In the period 2006 to 2008, the capelin fishery within the study area took place entirely in July
Mackerel.	Usually opens August 15 and continues into December (Harvesting period is unpredictable, depending on mackerel arrival). During the period 2006 to 2008, the only mackerel fishery was in 2007, when all of the catch was made in October
Sea Urchin	Generally harvested in late fall and in winter months when the roe content and quality is most suited to market demand

8.3.1.7 Key Species Fisheries

This section provides a brief overview of trends in several key Nearshore Study Area species over the past decade. The discussion focuses on species which might be affected by Project activities, as identified by Nearshore Study Area fishers.

Harvesting locations identified in this section are based on the following information: fishers' previous experience with, and knowledge of, fish harvesting activities in the Bull Arm-Tickle Bay area; information obtained from fishers during recent consultations; and, analysis of a limited amount of geo-referenced catch data (for 35-foot to 65-foot vessels only)[3]. Fishing areas for key pelagic species (capelin, mackerel and herring) are shown in Figure 8-9.

[3] DFO's catch and effort database for less than 35-foot enterprises usually has a very low portion of geo-referenced information, because these fishers are not required to record the longitude / latitude location of their catches, except for snow crab. A higher portion of the catch taken by larger vessels is geo-referenced. The discussion in this section is based on available geo-referenced catch data indicating the harvesting locations for capelin, mackerel and herring that fall within the geographic boundaries of the Nearshore Study Area. All of these data are for vessels between 35-foot and 65-foot for the past three years only (2006 to 2008).

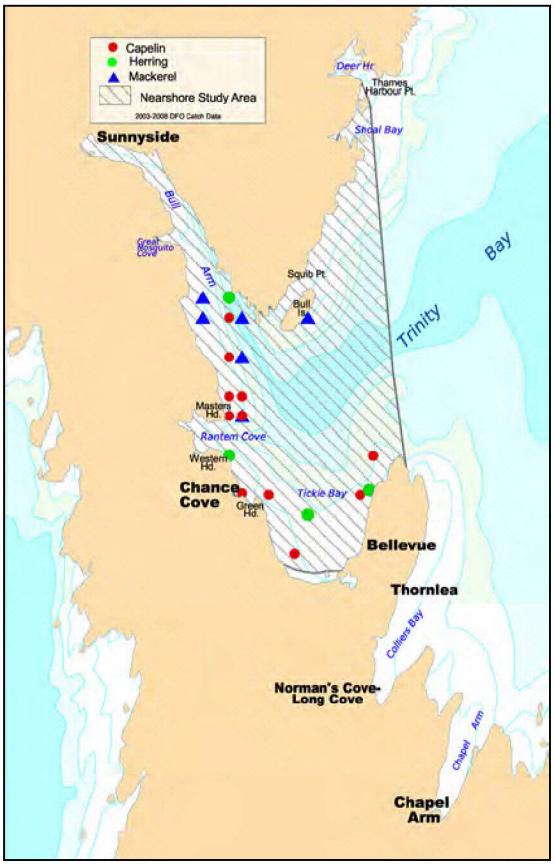


Figure 8-9 Nearshore Study Area Harvesting Locations for Key Pelagic Species, 2006 to 2008

Capelin

Annual capelin catches over the past 10 years have ranged from 1,260 to 3,500 tonnes. In nearly all years, the majority of the capelin caught by Study Area enterprises has been taken within Trinity Bay (3Lb). Fixed-gear fisheries account for most of the capelin harvested in the area; in 2007 and 2008, fixed-gear vessels took 77 percent and 82 percent, respectively. In addition, the majority of the catch, approximately 64 percent, is typically harvested by the smaller vessels. All of the 2008 catch came from 3Lb, with a landed value of $336,000.

In 2006, capelin were harvested during July in several locations along the western shore of Tickle Bay between Green Head and Ram Head and in other Tickle Bay locations (e.g., on grounds just to the west of Tickle Harbour Point). In the same year, one enterprise in the 35-foot to 44-foot fleet harvested 17.5 tonnes of capelin just below Green Head using fixed gear (see Figure 8-9).

In 2008, larger (35-foot to 44-foot and 45-foot to 54-foot) vessels, using fixed and mobile gear, harvested 273 tonnes of capelin in nearshore grounds between Chance Cove and the entrance to Bull Arm. In that year, Study Area vessels less than 35-foot caught 824 tonnes of capelin valued at $210,000. Though no data are available to indicate the locations where these capelin were harvested, it is likely that a substantial portion of the 824-tonne catch

was taken within the Study Area (i.e., on some of the same capelin grounds fished by the larger vessels discussed above).

Herring

Herring catches were generally poor in the first six years of this decade. There were no landings in 2000, 2001 or 2003, and only 3.6 tonnes were landed in 2005. However, the fishery has been improving since 2006, with 333 tonnes harvested in that year and 534 tonnes harvested in 2007. Herring is not a high-value species; the annual average value of the Nearshore Study Area catch over the three years (2006 to 2008) was only $78,000. However, it provides a good income boost. Like most pelagic species, herring can be harvested very efficiently and relatively cheaply, close to the fisher's homeport. Over the past 10 years, 90 percent to 100 percent of the catch has come from 3Lb, and in the past three years, approximately 72 percent of the catch has been taken by the larger vessels using mobile gear.

In 2006, according to DFO geo-referenced catch data, purse seiners caught 35 tonnes of herring in October. There were no landings in 2007. The largest harvest of herring was in November 2008, with over 125 tonnes of herring harvested, all by larger vessels. Herring were taken by tuck seine and by purse seine on grounds just off Western Head. This species was also harvested in the outer part of Bull Arm and in the middle portion of Tickle Bay (see Figure 8-9).

Mackerel

Mackerel is a relatively new species for Study Area fishers. There were no landings in the period 1999 to 2003, and only 36 tonnes were taken in 2004. However, almost 500 tonnes were landed in 2005, and catches in 2006 and 2007 were 884 and 974 tonnes, respectively. In 2007, almost 97 percent of the catch came from 3Lb, up from 70 percent in the previous year. However, mackerel landings dropped to 180 tonnes in 2008, with all of the fish caught outside Trinity Bay. In general, most of this species is harvested by the "greater than 40-foot vessels" using mobile gear. Smaller vessels, however, landed almost 40 percent (385 tonnes) of the total catch in 2007. In that year, this fishery was worth $265,000 to Study Area enterprises.

Study Area enterprises have been harvesting large quantities of mackerel within 3Lb since 2004. However, according to DFO geo-referenced catch data, 2007 was the only year that mackerel was harvested on grounds within the Study Area. In October of that year, the "greater than 40-foot vessels" using fixed and mobile gear harvested 253 tonnes in the Study Area. Harvesting locations included: within Great Mosquito Cove, grounds close to shore near the entrance to Rantem, off Ram Head, at various locations along the west side of Bull Arm between Ram Head and Great Mosquito Cove, and on grounds off the south shore of Bull Island (see Figure 8-9).

Snow Crab

All of the 33 Core enterprises hold crab licenses, but only vessels less than 35-foot who hold "Inshore" crab licences may fish crab in Trinity Bay, designated as Crab Fishing Area 6A. The remaining 12 enterprises operating vessels greater than 40-foot hold either "Large Supplementary" or "Small Supplementary" crab licenses and harvest their quota on grounds well beyond Trinity Bay.

The crab fishery is the most economically important fishery in the Nearshore Study Area. During the past 10 years, it has generated an annual average income of $2.88 million for all Study Area enterprises combined (including catches made by larger Nearshore Study Area vessels on grounds beyond 3Lb [e.g., on quota areas outside 200 miles]).

The average annual landed value of crab of these enterprises from Trinity Bay (Crab Fishing Area 6A) is just under $465,000, based on annual average landings of 130 tonnes from this area. Over the past decade, snow crab harvesting in Trinity Bay have generated approximately 16 percent of the average annual value of the total crab ($2.88 million) catch by all Nearshore Study Area enterprises.

Nearshore Study Area enterprises operating vessels less than 35-foot harvest crab on grounds within Trinity Bay, including those located in the deeper water within Tickle Bay and Bull Arm. Crab gear is set in water depths between 200 and 300 m. Crab harvesting locations within the Study Area are indicated in Figure 8-10. There are approximately 15 well established harvesting locations, most of which are located in the deeper water within Tickle Bay. The relative importance of each site as a harvesting location is also indicated on Figure 8-10. For example, crab fishing area with number 26 indicates that this area has 26 "data hits" stacked on top of one another. In other words, it is likely a very abundant crab harvesting location, a potential "hot spot" where a particular fisher (or several fishers) will fish throughout the season or from year to year. Detailed analysis of the DFO geo-referenced data shows that this location yielded 10.3 tonnes of crab catch between 2005 and 2007. Another "hot spot" with 13 data points yielded 2.5 tonnes during one season.

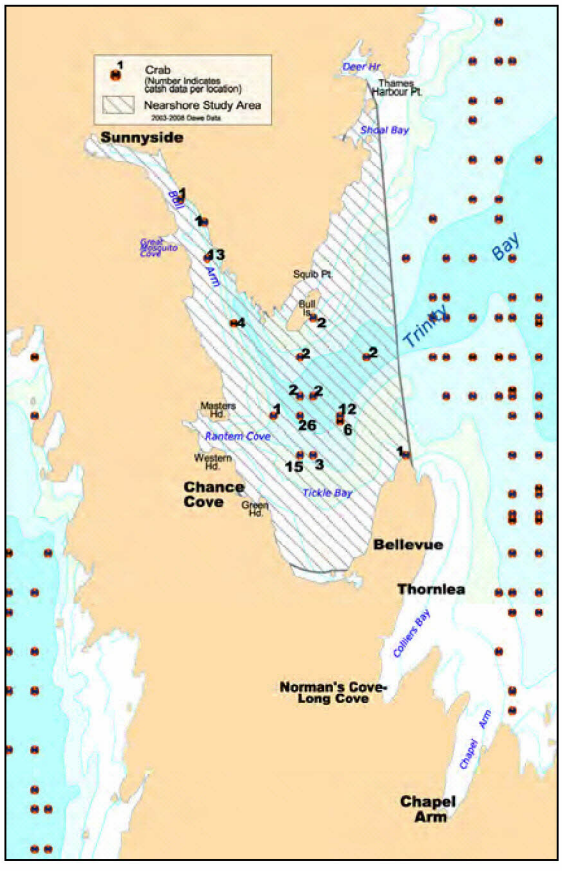


Figure 8-10 Nearshore Study Area Snow Crab Harvesting Locations, 2003 to 2008

Lobster

Lobster catches have been in decline since the late 1990s, when the annual catch was about five tonnes. In the past five years, landings have ranged between 1.3 and 2.9 tonnes. In 2003, the catch was worth just under $50,000. Most of the lobster is harvested by vessels less than 35-foot; three of the 22 license holders are enterprises operating vessels greater than 40-foot.

Lobster are fished on grounds close to a homeport. Pots are set close to shore, generally in water depths of less than 20 m. Chance Cove lobster fishers set some of their gear on the west side of Bull Arm between Ram Head and Great Mosquito Cove. Sunnyside fishers set their lobster gear in various shoreline locations within Bull Arm, including grounds directly within Great Mosquito Cove.

Sea Urchin

Sea urchins have been harvested in the Study Area since 1998; however, there have not been any landings since 2006, primarily because of poor market conditions. Landings peaked at 43 tonnes in 2003, when the catch was worth just over $100,000. Urchins are fished by vessels less than 35-foot and, with the exception of 1999 and 2003, when small quantities were taken in 3La, all of the landings have been from Trinity Bay.

This species is taken by divers on kelp beds in water depths between 3 and 12 m. Within the Study Area, urchins have been harvested in several nearshore locations within Bull Arm, including in Great Mosquito Cove, on grounds close to Chance Cove, and in Bellevue Bight. This species has not been harvested since 2006. Fishers note that urchin harvesting could resume if market conditions improve.

8.3.1.8 Potential Commercial Fisheries

The greatest potential for commercial fisheries in the future is a return of groundfish harvesting to levels approaching those of the past (for example, in the late 1980s cod harvesting in Trinity Bay (i.e., Unit Area 3Lb) was an average of 7,774 tonnes a year (1986 to 1990), compared to the recent average (2004 to 2008) of 303 tonnes). However, a return of these quotas to such levels, or any significant increase in quota, is not likely during the timeframe of the nearshore project activities. The following is a summary of potential commercial fisheries in the Bull Arm area as determined through consultation with the FFAW, DFO, and local area harvesters.

In terms of other future commercial species, the Fish, Food and Allied Workers (FFAW) marketing analyst was not aware of any new species with the potential to develop into a commercially harvested fishery. It was noted that currently known species such as sea cucumber and whelk might be harvested in Trinity Bay in future (K. Sullivan, pers. comm.). The FFAW's Petroleum Industry Liaison was not aware of any DFO or industry research designed to identify future commercially harvested species, and noted that the FFAW has not undertaken any research of this nature (R. Saunders, pers. comm.).

DFO's Area Chief, Resource Management - Eastern Newfoundland, was not aware of any new potential species in the area that might qualify as an "emerging" commercial species, though, as noted above, whelk is one possibility for an increase in Trinity Bay. It was noted that billfish (also called Atlantic saury) are known to inhabit nearshore coastal areas and there have been incidental catches of this species in capelin and herring traps in Trinity Bay, and other inshore areas (L. Knight, pers. comm.).

Similarly, the Resource Management Officer of DFO's Fisheries and Aquaculture Management Branch was not aware of any emerging species or any fishery with the potential to be developed on a commercial basis (L. Yetman, pers. comm.).

Nearshore Project Area fish harvesters and community-based industry experts were also contacted. The Newfoundland and Labrador Energy Corporation (Nalcor) Fisheries Consultant (formerly a full-time Project Area fisher) did not know of any underutilized species in the area other than whelk and sea urchins (B. Warren, pers. comm.). Some Project Area fishers hold whelk licences but this species has not yet been fished extensively. Sea urchins have been harvested in the past but not for the last several years due to unfavourable market conditions and low prices. He noted that one Project Area fisher has been harvesting eels in the fall for the past few years.

The Chair of the Sunnyside Fisher Committee notes that there are some signs of whelk, sea cucumbers and billfish in the areas in which he fishes, but none of these species are of commercial interest at the present (D. Temple, pers. comm.). The Chair of the Norman's Cove – Chapel Arm Fisher Committee notes that, in the past, whelk have been harvested in parts of Trinity Bay, mostly in water depths greater than 100 fathoms (approximately 200 m). He noted that some of Project Area fishers hold whelk licences but so far this species has not been fished to any significant extent because fishers have not had to pursue this fishery in order to make their annual fishing income. Billfish have been fished in the past using traps, but price and market conditions were not sufficient to sustain this effort and it did not "take off". In the past, kelp laden with herring roe has been harvested after the annual herring spawn on grounds near Long Cove and Bellevue. Another species – known locally as "sea cats" – was harvested some years ago. This species was apparently harvested for research purposes because it was said to contain a chemical similar to antifreeze (C. Warren, pers. comm.)).

8.3.1.9 Recreational and Subsistence Fisheries

Nearshore Project Area fish harvesters and other local area industry experts stated that, other than the annual food fishery for cod, there are no other known or known potential recreational or subsistence fisheries in the Nearshore Project Area. This cod fishery has been limited to a few days a year, as determined by DFO and this is not expected to change during the life of the nearshore project components.

8.3.2 Offshore Fisheries

This section describes commercial fisheries in the Offshore Study Area and, in particular, the Offshore Project Area. It focuses primarily on domestic Canadian fisheries from 2004 to 2008, but also provides a historical overview of the general region. This general overview includes data analysis that characterizes international fisheries in the Offshore Study Area beyond Canada's 200 nautical mile (nm) Exclusive Economic Zone (EEZ).

The Offshore Study Area, the Offshore Project Area and proposed Hebron Platform site are shown in relation to the 200 nm EEZ and NAFO fisheries management Unit Areas in Figure 8-11. The Offshore Project Area is located within NAFO unit area 3LT. The Offshore Study Area includes portions or all of NAFO unit areas 3LMN.

8.3.2.1 Data Sources and Use

The commercial fisheries descriptions of the domestic harvest for the Offshore Study Area are based in part on data derived from the DFO Newfoundland and Labrador Region and Maritimes Region catch and effort datasets for the period 1986 to 2008[4]. Maritimes Region data are included

[4] The data represent all catch landed within the Scotia-Fundy section of DFO Maritimes Region and for all Newfoundland and Labrador landed catch. Foreign catches landed outside these areas are not captured by the data. The data are still classified by DFO as preliminary, though the species data shown in this report are not likely

because a portion of the harvest (7 to 8 percent by quantity, mainly shrimp) is typically landed in Nova Scotia. Foreign catches landed outside these areas are not included in the DFO data.

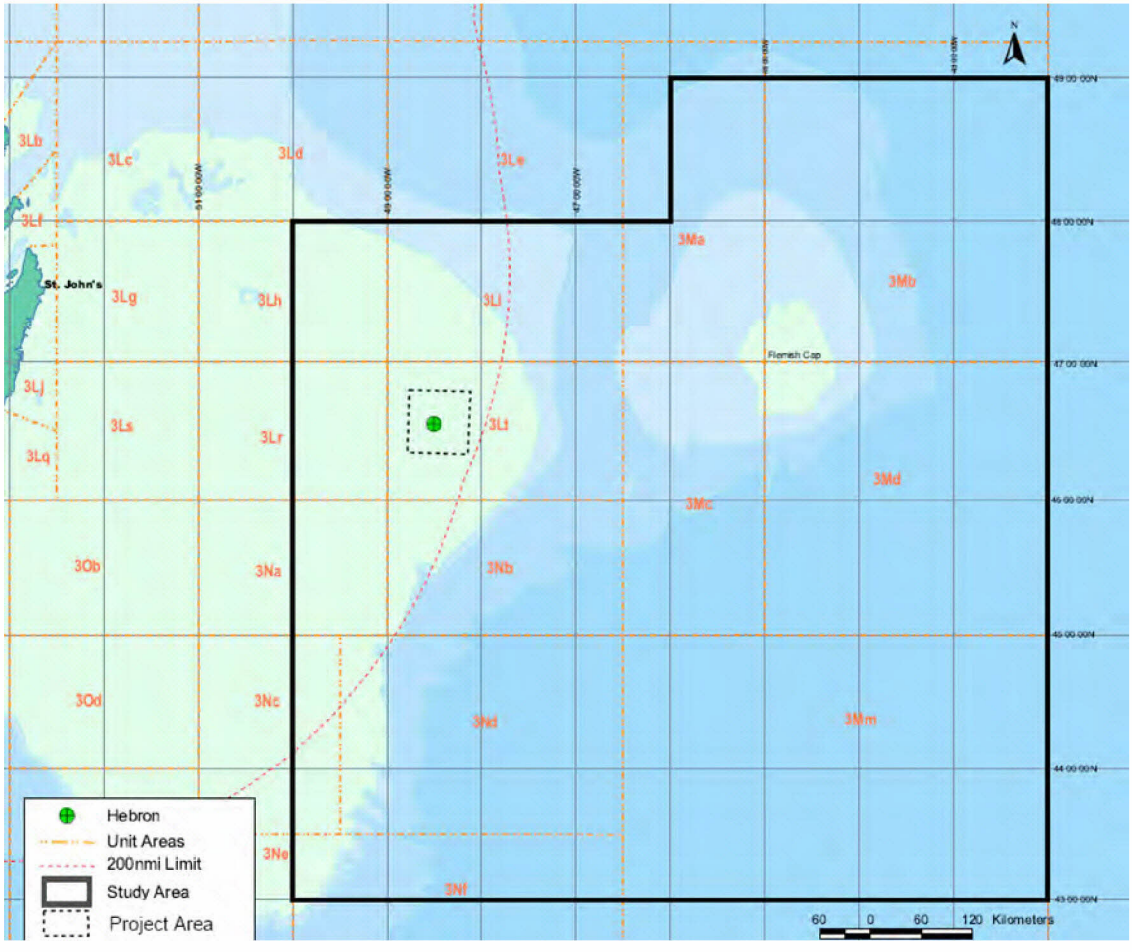


Figure 8-11 Offshore Study Area, Project Area and Other Zones

Most of the catch data for the Offshore Study Area are geo-referenced (e.g., an average of 98 percent by quantity of the harvest from Unit Area 3Lt over the past five years), which allows plotting of past harvesting locations[5]. The fish harvesting maps in the following sections show harvesting locations as dark points. The points are not "weighted" by quantity of harvest, but show where fishing effort was recorded.

to change to any significant extent when the data are finalized. Initial data for 2009 were also received (April 2010) and these indicate that fishing activities in 2009 (in terms of quantities and harvesting locations) were quite consistent with those in recent years (i.e., 2004 to 2008)

[5] The location given is that recorded in the vessel's fishing log, and is reported in the database by degree and minute of latitude and longitude; thus the position is accurate within approximately 0.5 nm of the reported coordinates. It should be noted that for some gear, such as mobile gear towed over an extensive area, or for extended gear, such as longlines, the reference point does not represent the full distribution of the gear or activity on the water. However, over many data entries, the reported locations create a fairly accurate indication of where such fishing activities occur.

For foreign fisheries, primarily outside the EEZ, NAFO datasets (STATLANT 21A data) for 2004 to 2008 are used (NAFO 2009). These datasets capture NAFO-managed harvests by Canadian fishers and non-Canadian NAFO states at the fisheries management Division level within the NAFO Convention Area[6]. The location of these divisions and the relevant Convention Area boundary are shown in Figure 8-12.

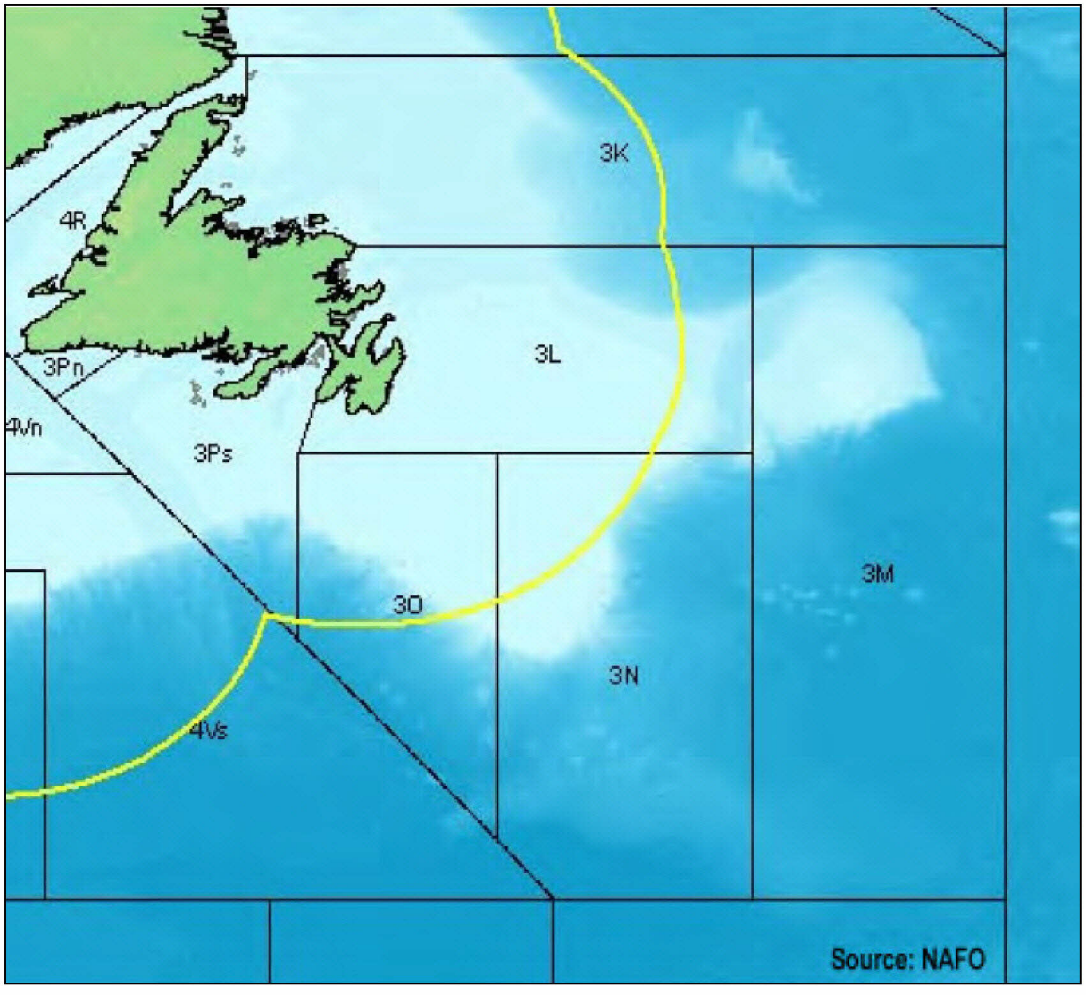


Figure 8-12 Northwest Atlantic Fisheries Organization Divisions

In most of the following data tables, the weight of the harvest (in tonnes) is given rather than value, since these quantities are directly comparable from year to year. Values (for the same quantity of harvest) may vary annually with species, negotiated prices, changes in exchange rates and fluctuating market conditions.

Where values are used in this section, they are taken directly from the DFO datasets and are not corrected to current dollars. Other sources consulted include DFO species management plans, quota reports, other research reports and studies, and consultations with scientists, managers and fishing

[6] The Hebron Offshore Study Area includes parts of NAFO Divisions 3N, 3L and 3M; the Hebron Platform is within 3L.

interests. Additional information was obtained during consultations with offshore fishers, described in Chapter 5.

8.3.2.2 Historical Overview of Regional Fisheries

Until the early 1990s, most of the harvesting in the offshore areas of the eastern Grand Bank was groundfish (i.e., demersal species) taken by large stern otter trawlers. Groundfish harvested included Atlantic cod, redfish, American plaice and several other species. In 1992, with the acknowledgement of the collapse of several of these stocks, a harvesting moratorium was declared and directed fisheries for cod virtually ended in the area. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Atlantic cod (Newfoundland and Labrador population) as endangered in 2003.

Shrimp and crab, formerly underused species, have come to replace most of the groundfish harvested since the collapse in 1992. These two species are now the principal catches by most harvesters in the Study Area, as they are in many other areas offshore Newfoundland and Labrador. Other economically important fisheries in the offshore Study Area are the deep sea clams (propeller and Stimpson's surf) and Greenland cockles. In Newfoundland and Labrador waters, this fishery is localized primarily near eastern and southeastern edges of the Bank. It has grown to become a key part of the region's harvest since its start in 1989. Fish landings from 1986 to 2008 from NAFO Unit Areas 3LMN are illustrated in Figures 8-13 and 8-14.

The historical landings in Unit Area 3Lt are similar, except that the impact of the closures on groundfish harvesting has been even more pronounced, as indicated in Figure 8-15. It should be noted; however, that even before the moratorium (e.g., 1984 to 1990), Unit Area 3Lt usually accounted for just over 2 percent of the NAFO 3L groundfish harvest.

8.3.2.3 Domestic Fisheries

In general, the Offshore Study Area fisheries have changed little over the past decade or so, as the preceding graphs show. Although fishers express hopes that the groundfish fisheries (especially cod) will return to previous levels in these areas, there is not yet sufficient reliable indication of when and if this might occur. Since 1992 through 2009 there has been virtually no change in the groundfish fisheries in Unit Area 3Lt, which has consistently recorded harvests of less than 2 percent of its pre-1992 levels.

The following table (Table 8-8) shows the average domestic harvest in more recent years (2004 to 2008) by quantity and value recorded specifically within the Study Area. The principal fisheries (by quantity of harvest) within the Study Area are snow crab (approximately 40 percent by quantity of the overall harvest / 64 percent by value), northern shrimp (36 percent quantity / 25 percent value) and a variety of deep sea clams and cockles (21 percent quantity / 10 percent value). The remaining fisheries are for groundfish (mainly yellowtail flounder, with lesser quantities of halibut and American

plaice); together these species make up less than 3 percent by quantity or value.

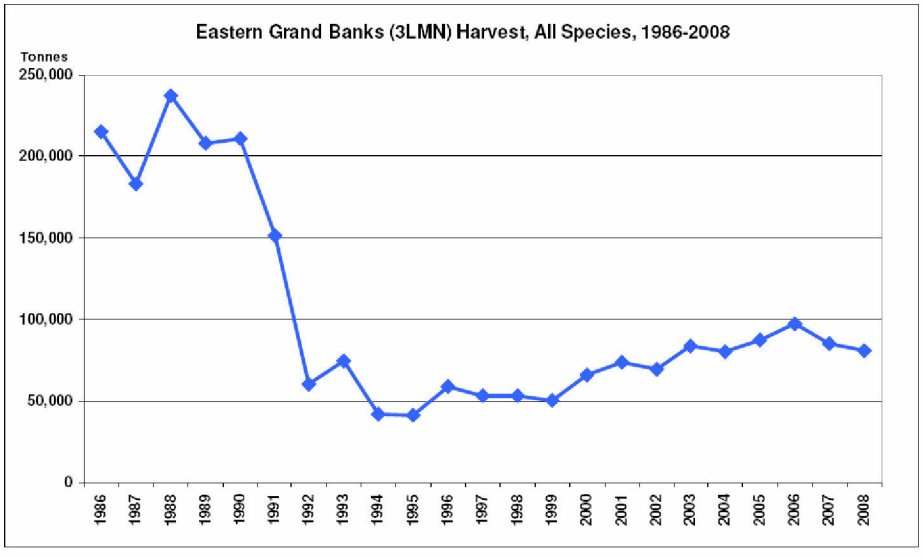


Figure 8-13 Eastern Grand Bank Harvest, All Species, 1986 to 2008

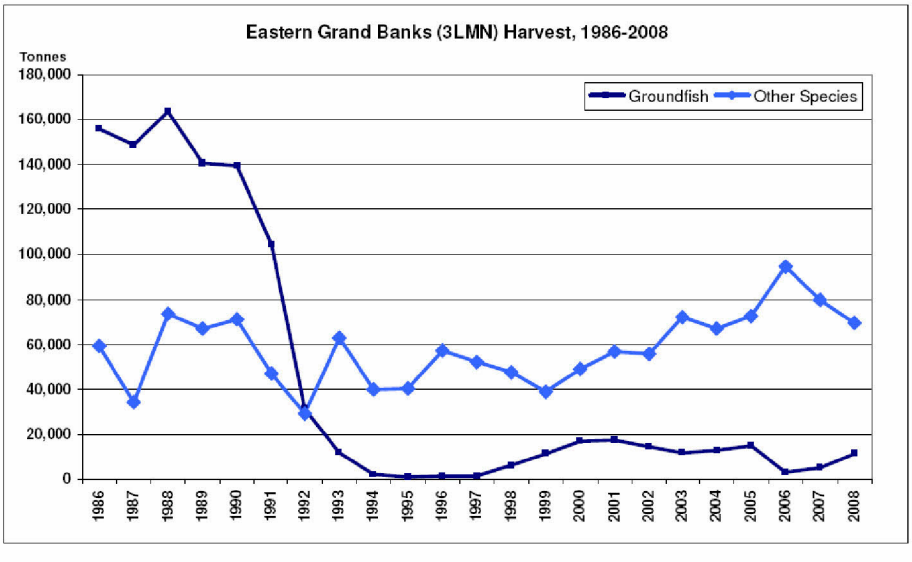


Figure 8-14 Eastern Grand Bank Harvest, Groundfish versus Other Species, 1986 to 2008

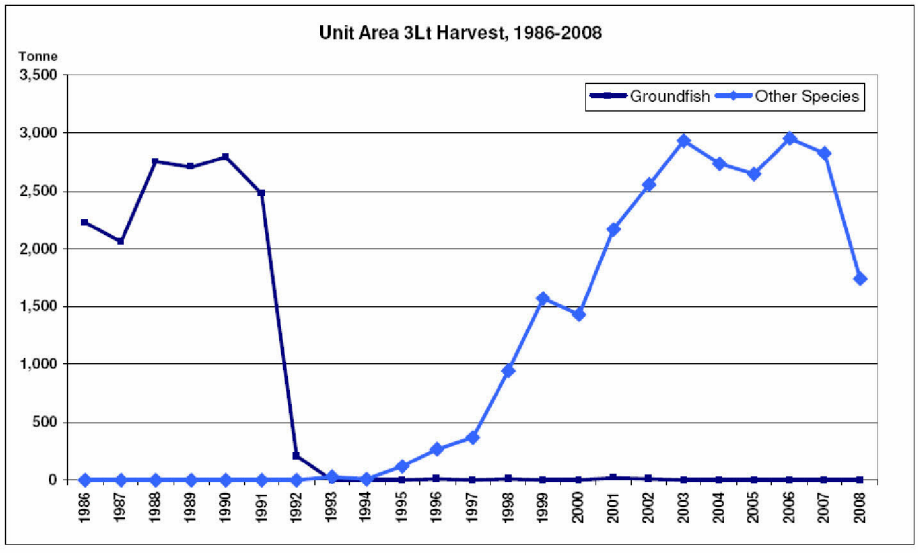


Figure 8-15 Unit Area 3Lt Harvest, Groundfish versus Other Species, 1986 to 2008

Table 8-8 Offshore Study Area Quantity and Value of Harvest by Species, all Months, 2004 to 2008

Species	Quantity (t)	% of Total	Value ($)	% of Total
Cod	4.2	0.0	4,999	0.0
Halibut	19.7	0.1	226,008	0.5
American plaice	31.5	0.1	15,592	0.0
Yellowtail flounder	592.6	2.4	327,744	0.8
Turbot	2.2	0.0	4,032	0.0
White hake	1.0	0.0	733	0.0
Roundnose grenadier	1.6	0.0	1,454	0.0
Total groundfish	652.8	2.7	580,562	1.4
Swordfish	15.2	0.1	37,199	0.1
Tunas	4.4	0.0	27,171	0.1
Sharks	1.9	0.0	768	0.0
Deepsea bivalves (clams / cockles)	4,993.8	20.5	4,078,278	9.7
Scallops	30.3	0.1	40,288	0.1
Shrimp	8,828.3	36.3	10,372,915	24.7
Snow crab	9,796.9	40.3	26,817,261	63.9
All other	3.1	0.0	784	0.0
Total, all species	24,326.6	100.0	41,955,224	100.0

Source: DFO 2009g (Maritimes and Newfoundland and Labrador and Maritimes Regions 2005-2009)
All data tables and graphs include both Newfoundland and Labrador and Maritimes Region DFO catch and effort data

8.3.2.4 Offshore Project Area

Since the early 1990s there has been very little fish harvesting activity within the vicinity (i.e., 30 to 50 km) of the proposed Hebron production site and the associated leases. What little harvesting there has been has been almost exclusively for snow crab over the last five years (2004 to 2008).

The harvesting data from within the Offshore Project Area by year for 2004 to 2008 are shown in Table 8-9.

Table 8-9 Species Harvest by Year from Offshore Project Area, 2004 to 2008

Year	Species	Quantity (t)	Value ($)
2004	Snow crab	6.5	35,369
2005	Snow crab	9.2	29,289
2006	Snow crab	6.0	13,009
2007	Snow crab	0.7	2,076
2008	Snow crab	2.5	8,396
Average		5.0	17,628

Harvesting Locations

Geo-referenced harvesting locations (DFO 2009g) in relation to the Offshore Study Area and the Project Area (aggregated for all species during all months) for 2004 to 2008 are shown in Figures 8-16 to 8-20.

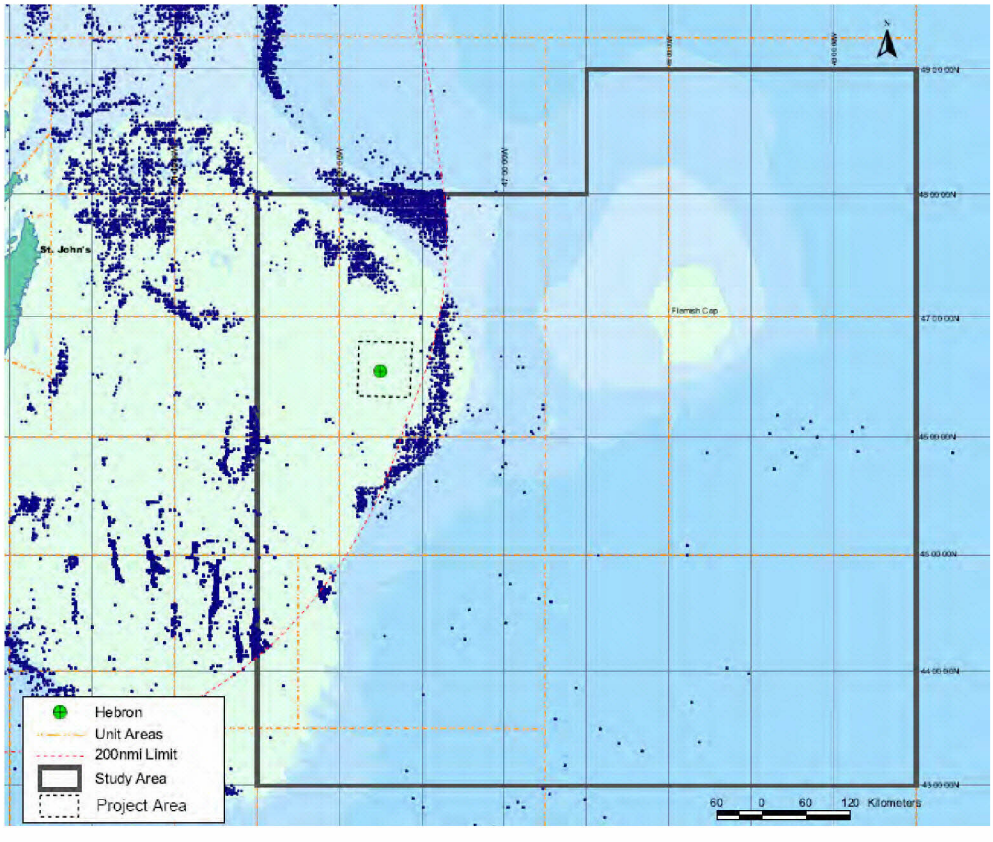


Figure 8-16 Domestic Harvesting Locations, 2004

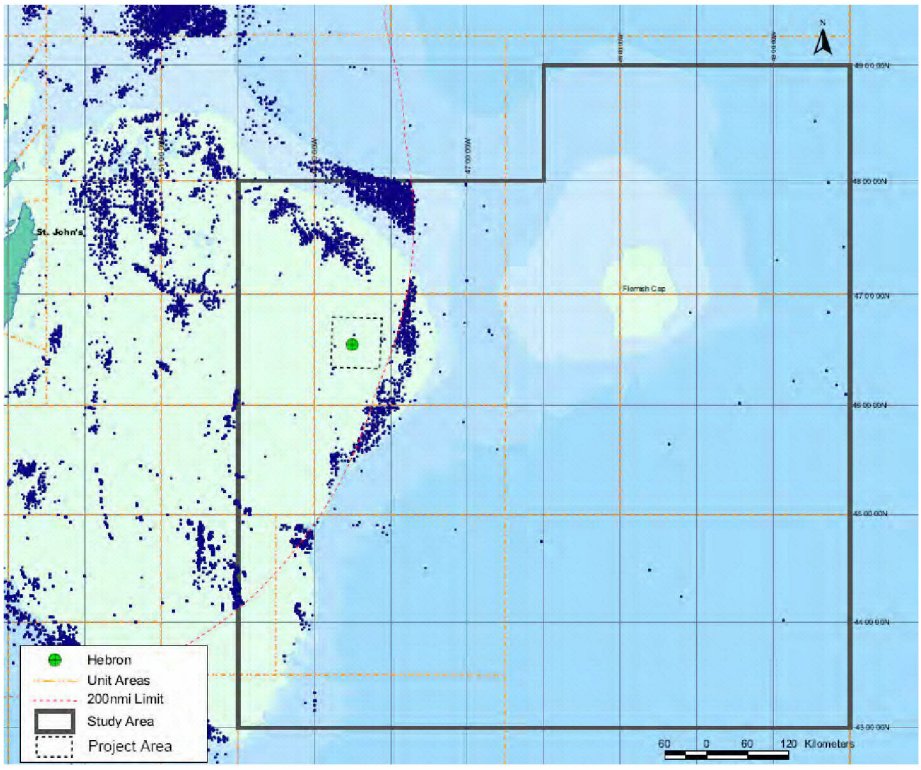


Figure 8-17 Domestic Harvesting Locations, 2005

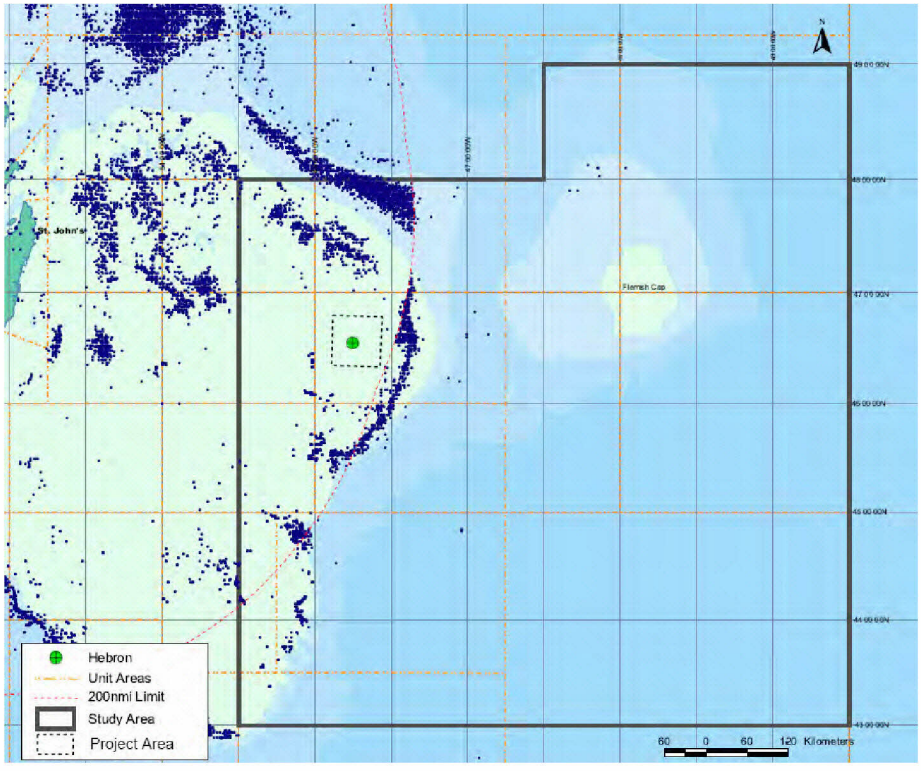


Figure 8-18 Domestic Harvesting Locations, 2006

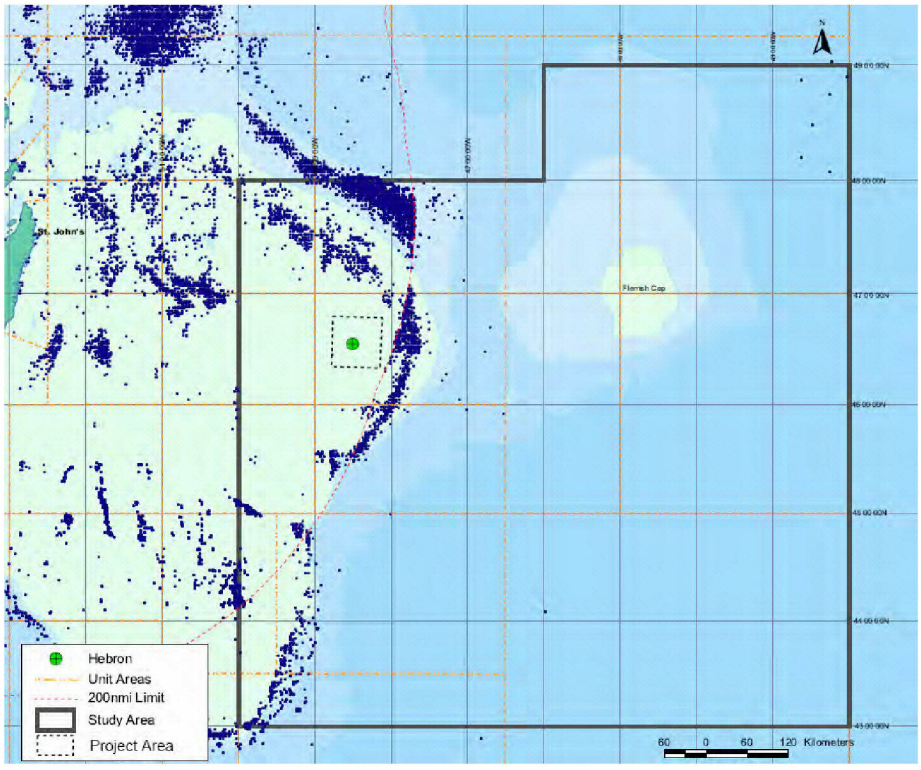


Figure 8-19 Domestic Harvesting Locations, 2007

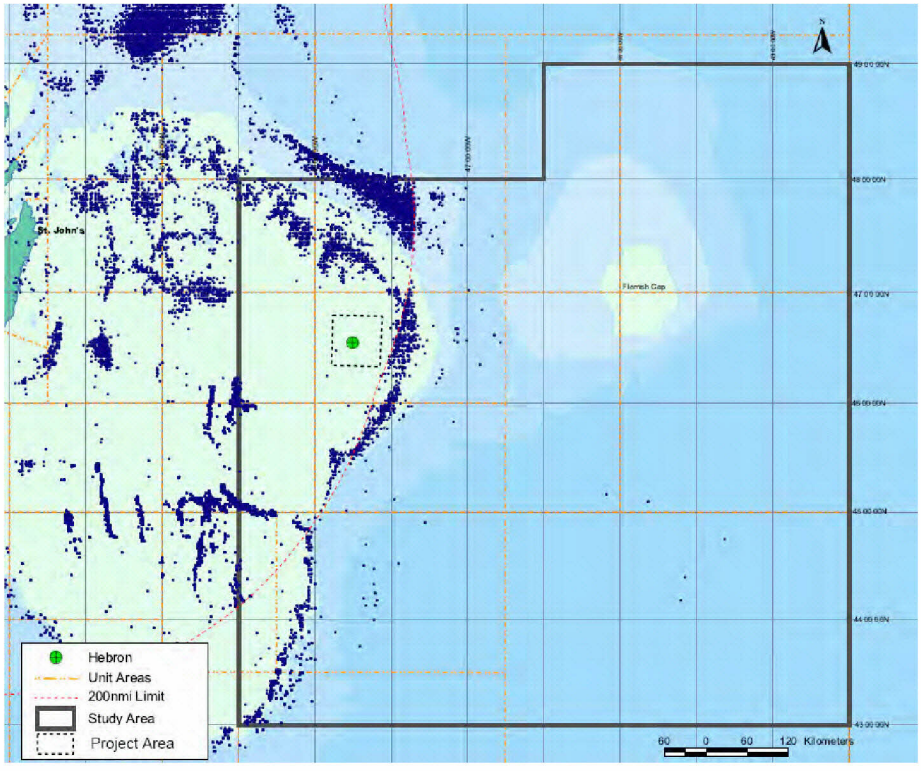


Figure 8-20 Domestic Harvesting Locations, 2008

As indicated in these figures, the harvesting locations are quite consistent from year to year. Most of the fish harvesting within and near the Offshore Study Area is concentrated on or near the shelf edge and slope. Much of this is at depths between 200 m and 500 m.

8.3.2.5 Timing of the Harvest

The quantity and value of fish harvested by month, averaged over the past five years, for the Offshore Study Area and the Offshore Project Area are shown in Figures 8-21 to 8-23. In both areas, overall harvesting effort and income have been highest May to July and lowest during the fall. However, the timing of the harvests can vary to some degree from year to year with resource availability, fisheries management plans and enterprise harvesting strategies. There was no recorded harvest before May and none after July in the Offshore Project Area.

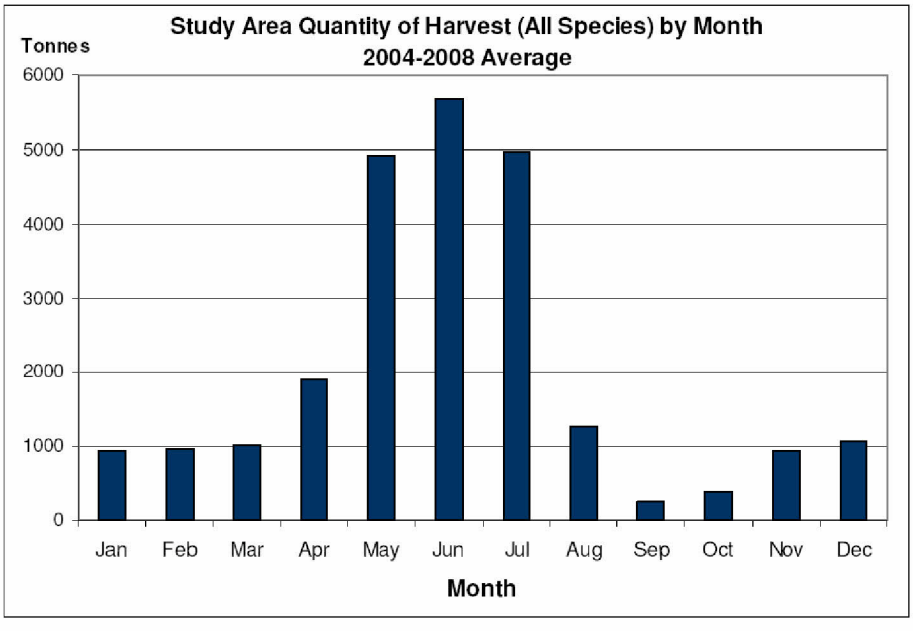


Figure 8-21 Offshore Study Area Quantity of Harvest by Month, 2004 to 2008, Averaged

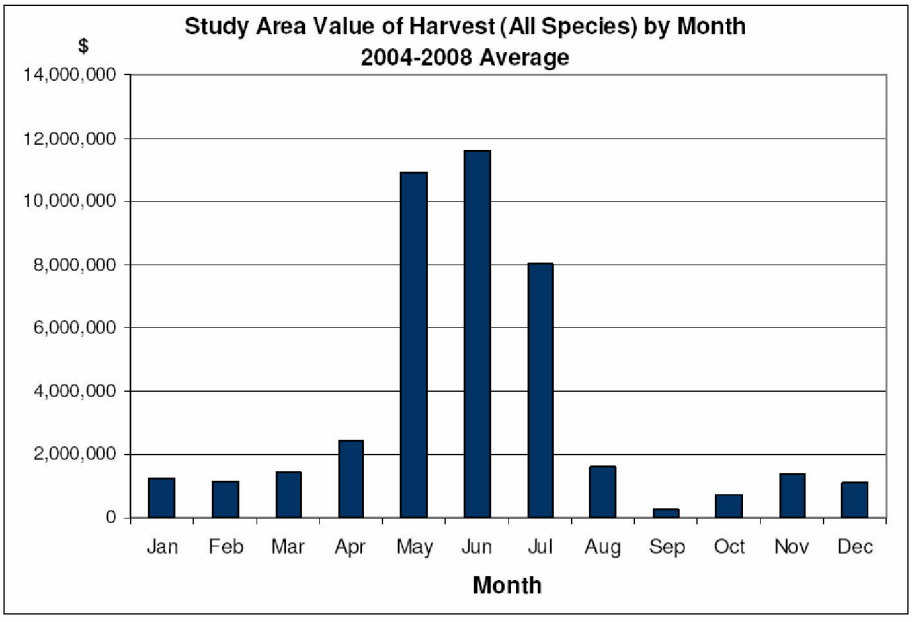


Figure 8-22 Offshore Study Area Value by Month, 2004 to 2008, Averaged

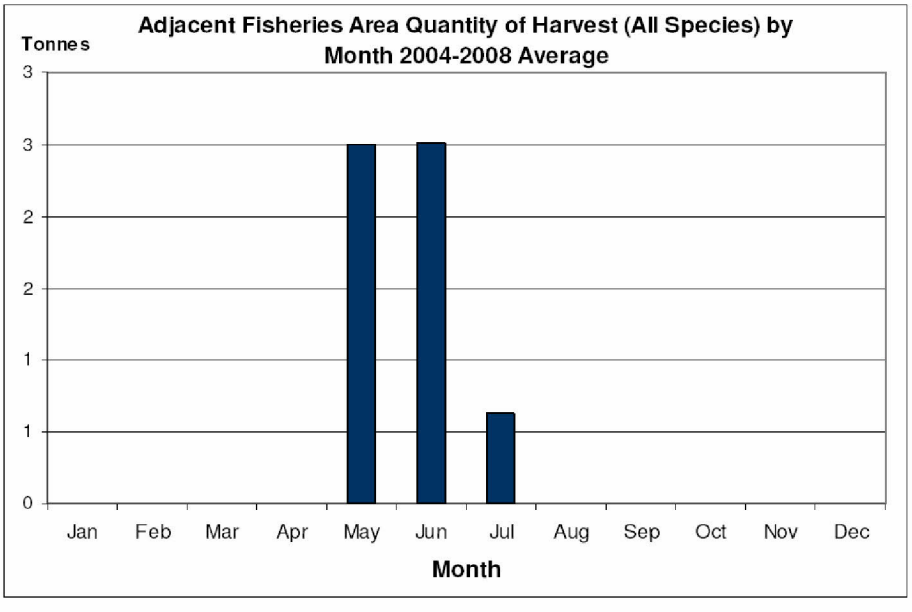


Figure 8-23 Offshore Project Area Quantity of Harvest by Month, 2004 to 2008, Averaged

The locations of domestic harvesting for all species by month (data aggregated) for 2004 to 2008 from Offshore Project Area fishing grounds are shown in Figures 8-24 to 8-35.

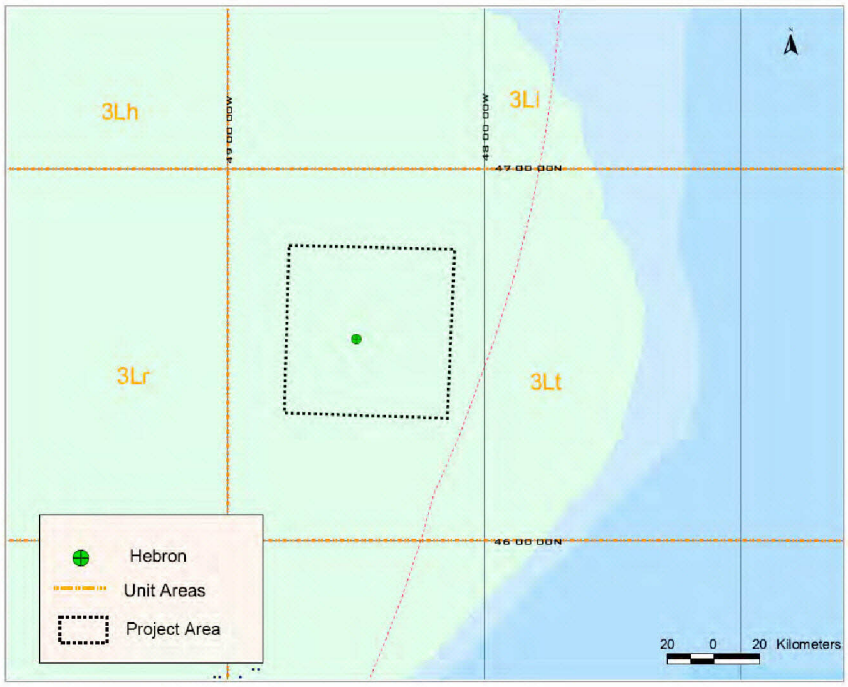


Figure 8-24 Location of Domestic Harvest, All Species, January 2004 to 2008, Aggregated

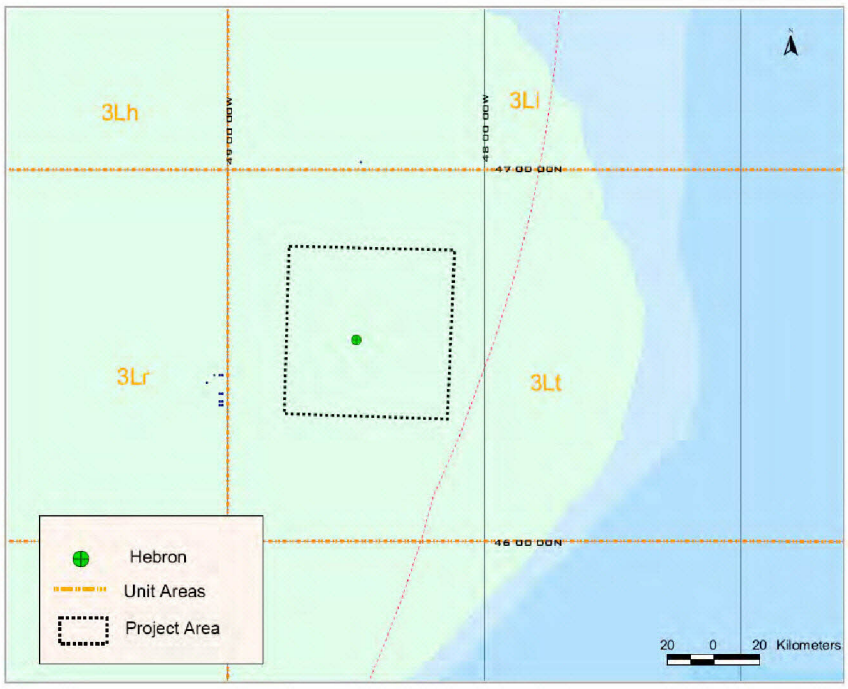


Figure 8-25 Location of Domestic Harvest, All Species, February 2004 to 2008, Aggregated

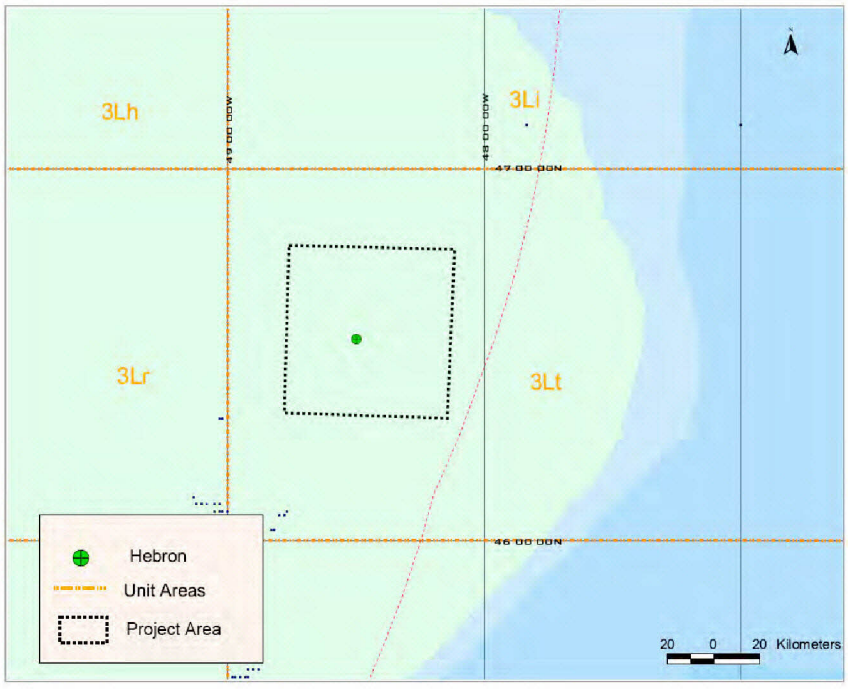


Figure 8-26 Location of Domestic Harvest, All Species, March 2004 to 2008, Aggregated

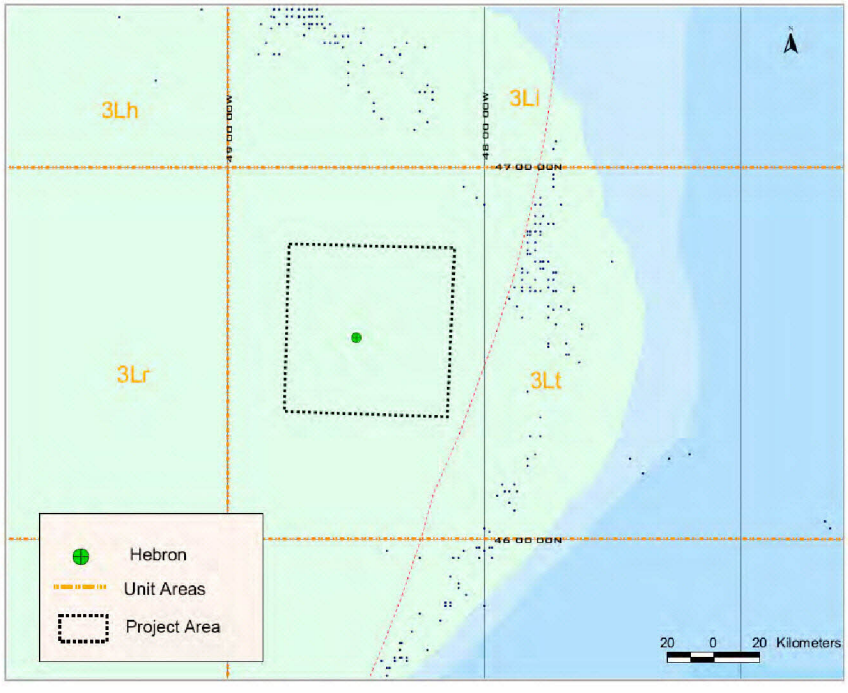


Figure 8-27 Location of Domestic Harvest, All Species, April 2004 to 2008, Aggregated

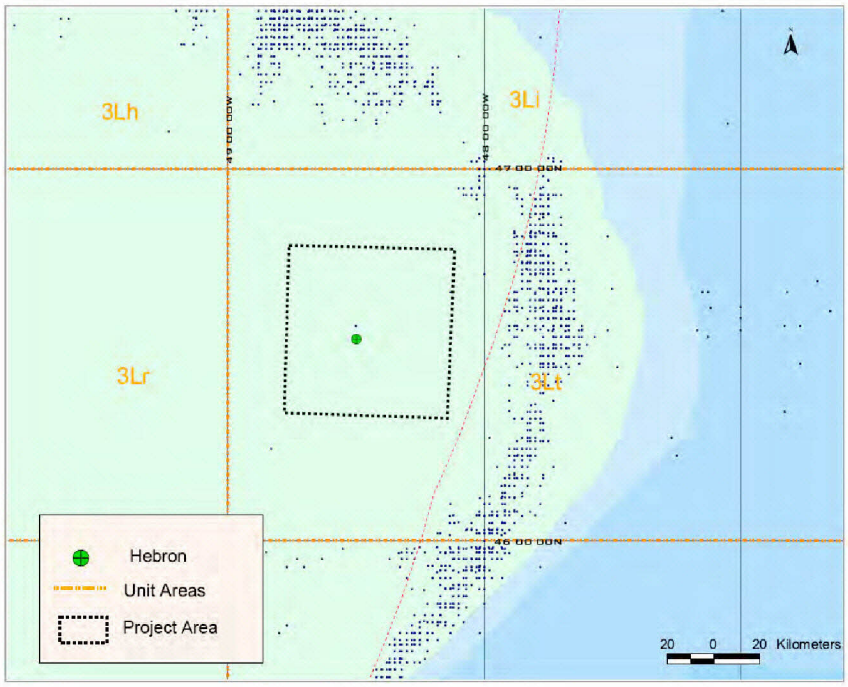


Figure 8-28 Location of Domestic Harvest, All Species, May 2004 to 2008, Aggregated

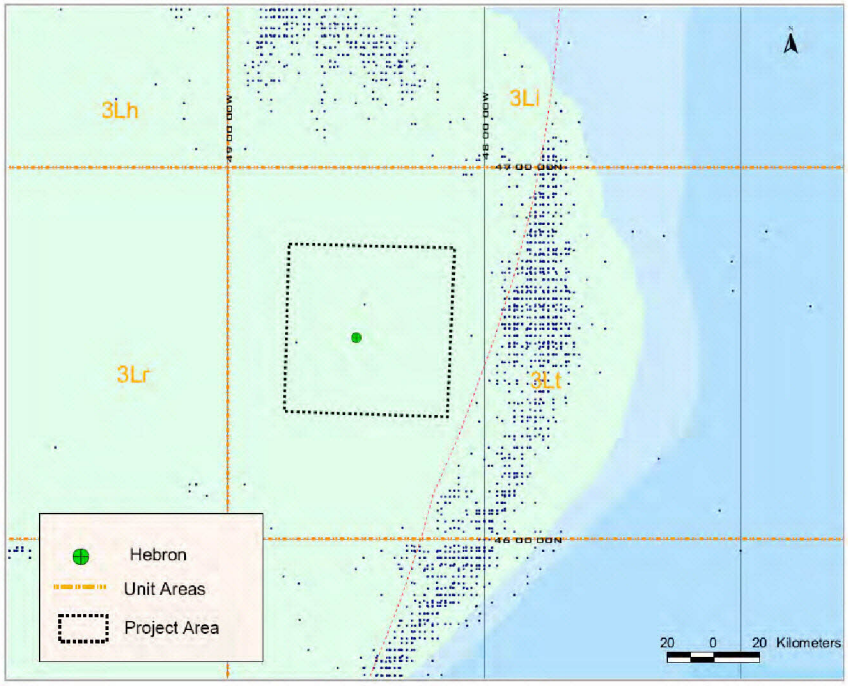


Figure 8-29 Location of Domestic Harvest, All Species, June 2004 to 2008, Aggregated

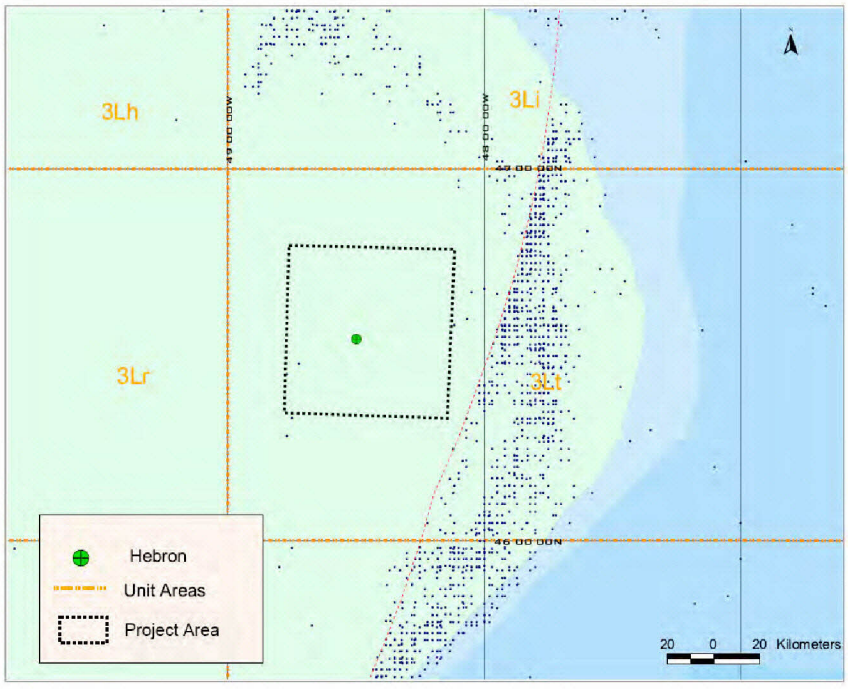


Figure 8-30 Location of Domestic Harvest, All Species, July 2004 to 2008, Aggregated

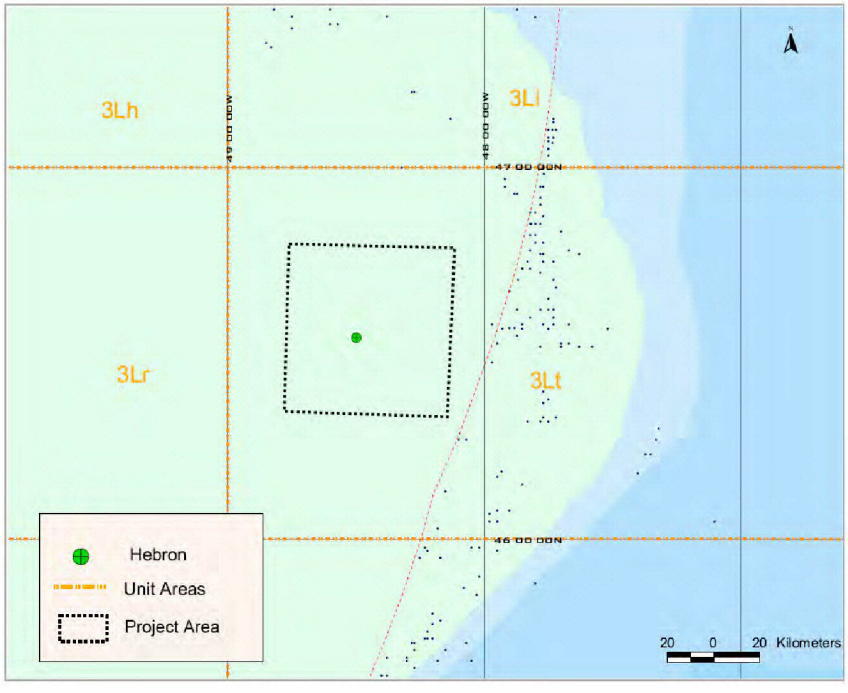


Figure 8-31 Location of Domestic Harvest, All Species, August 2004 to 2008, Aggregated

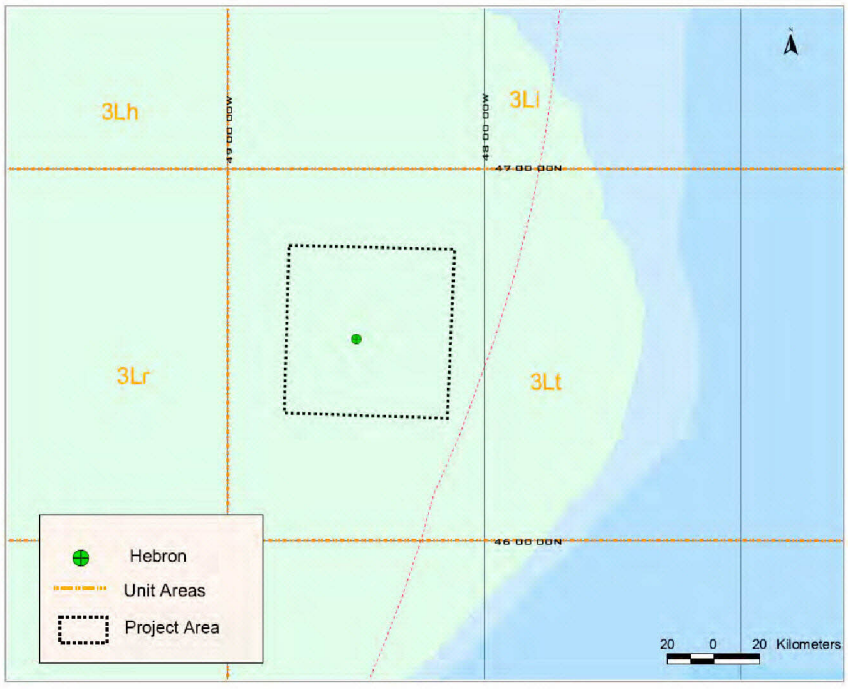


Figure 8-32 Location of Domestic Harvest, All Species, September 2004 to 2008, Aggregated

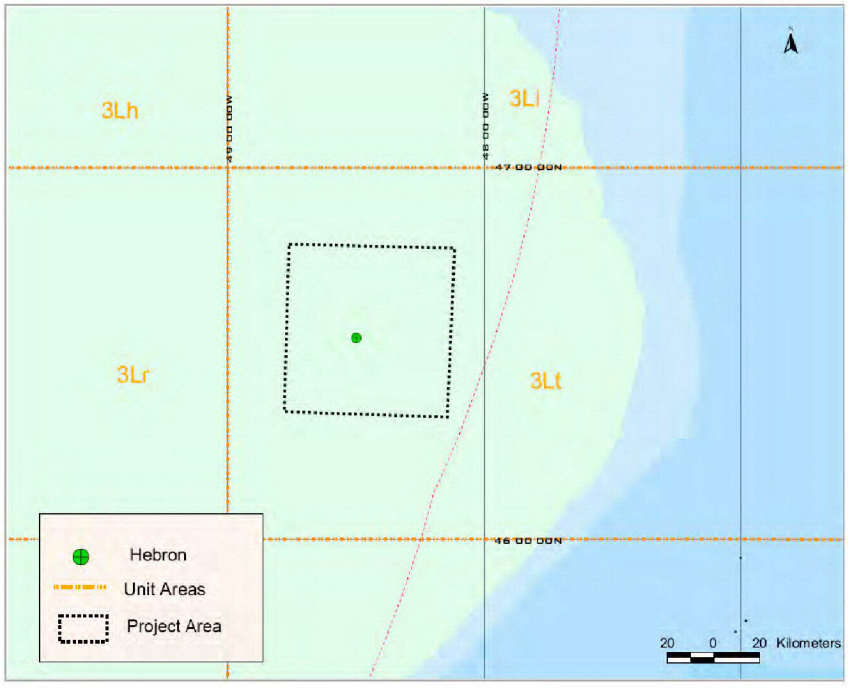


Figure 8-33 Location of Domestic Harvest, All Species, October 2004 to 2008, Aggregated

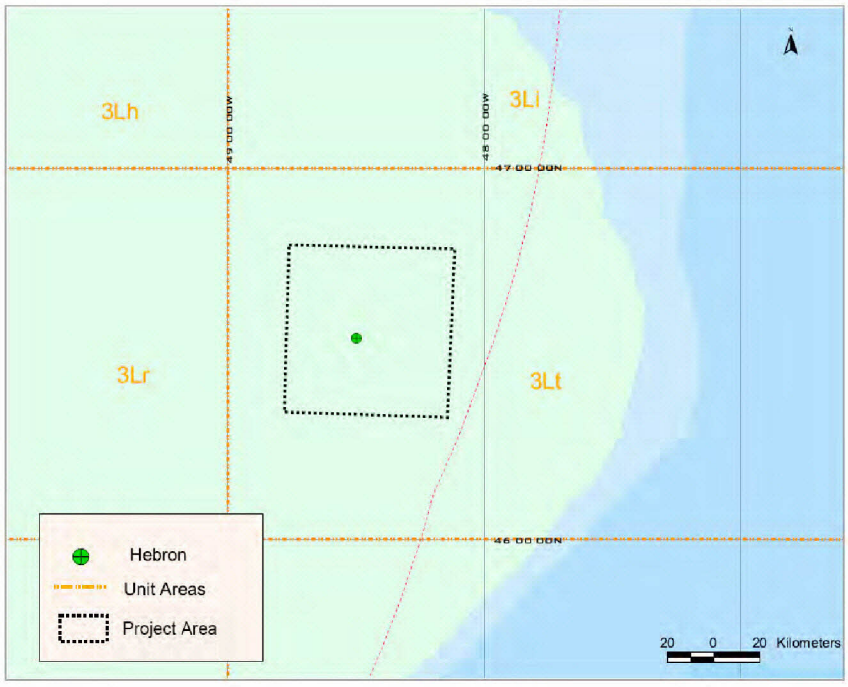


Figure 8-34 Location of Domestic Harvest, All Species, November 2004 to 2008, Aggregated

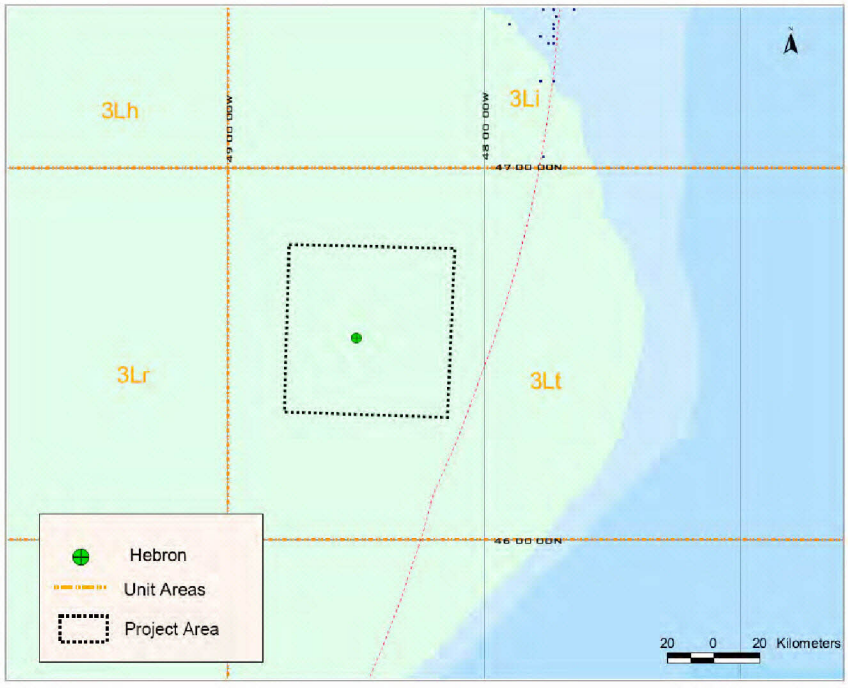


Figure 8-35 Location of Domestic Harvest, All Species, December 2004 to 2008, Aggregated

8.3.2.6 Fishing Gear

Except for groundfish, the gear types used in the Offshore Study Area and the Offshore Project Area are almost exclusively specific to the species harvested

– crab pots for snow crab, shrimp trawls for northern shrimp and hydraulic dredges for deep sea clams (Table 8-10). Groundfish is harvested primarily with stern otter trawls (approximately 96 percent) and the remainder with longlines. Longlines are also used for the small quantity of large pelagics (tunas, swordfish) caught in the eastern reaches of the Study Area.

Table 8-10 Offshore Study Area Landings by Gear Type, 2004 to 2008, Averaged

Gear	Quantity (t)	% of Total	Value ($)	% of Total
Otter trawl, bottom	624.1	2.6	342,694	0.8
Shrimp trawl	8,829.6	36.3	10,373,933	24.7
Longlines[A]	50.3	0.2	314,147	0.7
Trap / Pot*	9,798.4	40.3	26,817,356	63.9
Hydraulic Dredge	5,024.2	20.7	4,118,565	9.8
Total	24,326.5	100.0	41,966,696	100.0
A Fixed gear				

The locations of fixed and mobile gear harvesting locations during 2004 to 2008, aggregated, are shown on Figures 8-36 and 8-37.

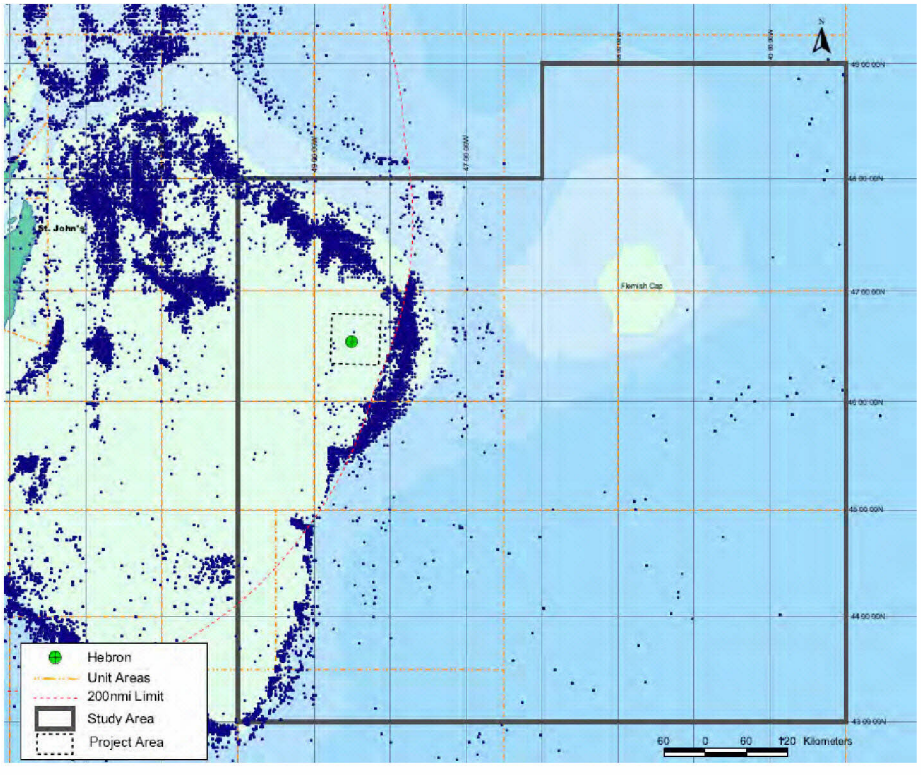


Figure 8-36 Fixed Gear Harvesting Locations, 2004 to 2008, Aggregated

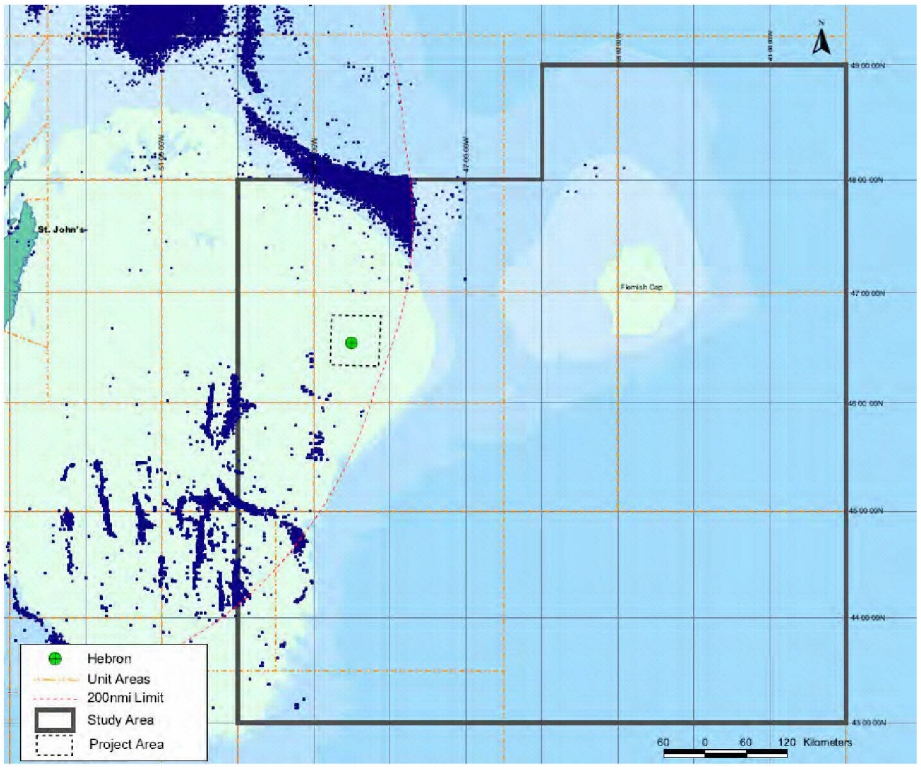


Figure 8-37 Mobile Gear Harvesting Locations, 2004 to 2008, Aggregated

Crab Pots

The amount of gear fishers are permitted to use varies by license category, and also by the area in which a license holder may be fishing. Crab pots are set on the seabed in strings buoyed at the surface. Crab gear generally has a highflyer (radar reflector) at one end and a large buoy at the other. Some fishers use highflyers at both ends. Depending on weather, they may be left unattended several days at a time. Fishers typically try to leave approximately 20 fathoms (36.5 m) on the seabed between each pot. Thus, allowing slack for the anchor ropes on either end of the string to extend upwards at an angle, the distance between the typical highflyer and end-buoy of, for example, a 50 to 60 pot string of crab gear would be approximately 1.8 to 2.3 km.

Shrimp Trawls

Shrimp harvesting uses mobile shrimp trawls. These are modified stern otter trawls, for both inshore and offshore vessels, though some use beam trawls.

Hydraulic Dredges

Used for deep sea clams, these boat-based dredges are dragged along the sea bottom by the ship. Sea water is pumped through a large hose in front of the dredge as it is pulled along the sea floor. The jets of water temporarily fluidize the sand and allow the dredge to go through, picking up the clams.

Stern Otter Trawls

These are large bottom-tending nets towed behind vessels, most of which are 150 to 200 feet in length. After filling with fish, the net is winched aboard, emptied and re-deployed.

8.3.2.7 Principal Fisheries

The following sections provide information on the principal fisheries in the offshore Study Area.

Snow Crab

In terms of both quantity of catch and value, the crab fishery has been the most significant fishery in the Study Area (40 percent by quantity and 64 percent by value) and the only one recorded in the Project Area in the last several years. The crab quota areas are shown on Figure 8-38 and the quotas for the snow crab fishery in relevant portions of 3LMN are listed in Table 8-11.

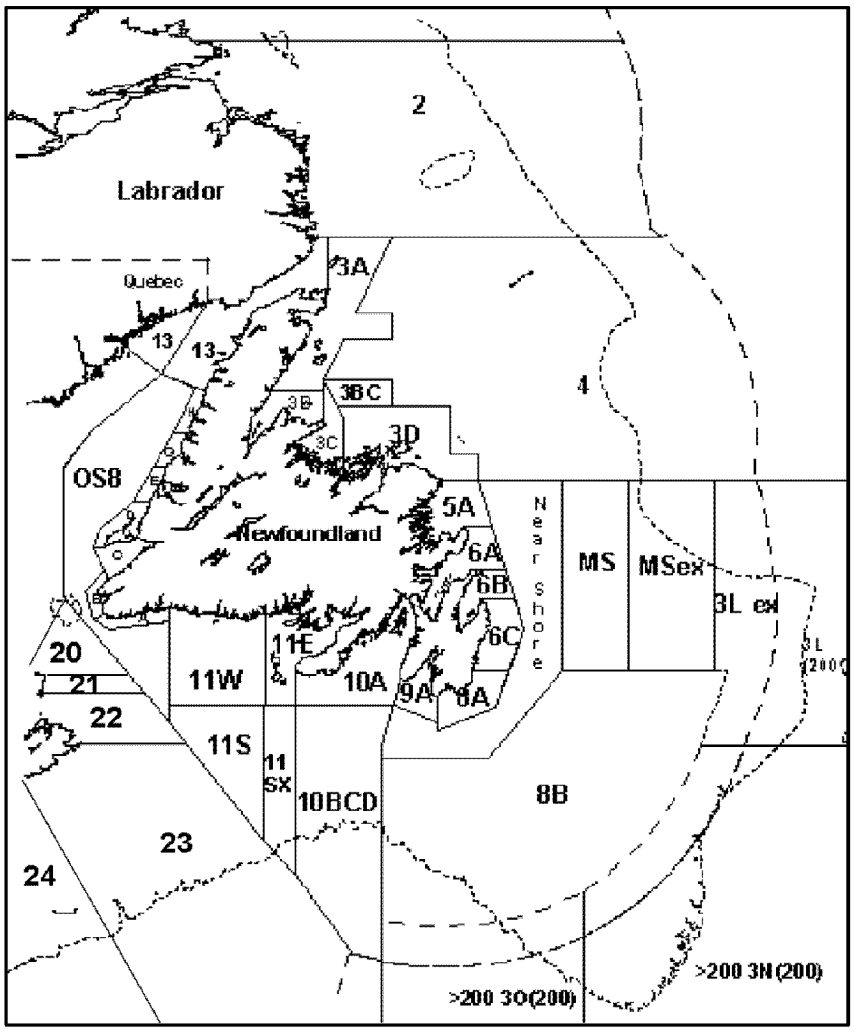


Figure 8-38 Newfoundland and Labrador Snow Crab Fishing Areas

Table 8-11 Relevant 2009 Snow Crab Quotas

Licenced Category / Quota Definition	Quota (t)
3L Full Time Midshore	668
3L Full Time Midshore Extended (MSX)	1,386
3L Full Time Outside 170 and Inside 200 nm (3LX)	999
3L Full Time Outside 200 nm (3L200)	533
3L Supplementary Large Midshore	602
3L Supplementary Large Midshore Extended (MSX)	1,427
3L Supplementary Large Outside 170 Inside 200 nm (3LX)	1,426
3L Supplementary Large Outside 200 nm (3L200)	1,112
3L Supplementary Small Midshore (MS)	2,580
3L Supplementary Small Outside 50 nm (8B)	680
3L Supplementary Small 8B Exploratory (8BX)	2,720
3N Full Time Outside 200 nm (3N200)	512
3N Supplementary Large Outside 200 nm (3N200)	1,048
3N Offshore (3NEX / 3NO)	401

Snow crab harvesting locations recorded for 2004 to 2008, aggregated for all years, during all months, are shown in Figure 8-39. As illustrated in this figure, snow crab effort (placement of fixed gear crab pots) is consistently focused on key grounds, based on both license restrictions and resource availability. Within the Study Area, the main focus is along and near the shelf break, either just inside or outside the 200 nm EEZ boundary, which also matches license conditions.

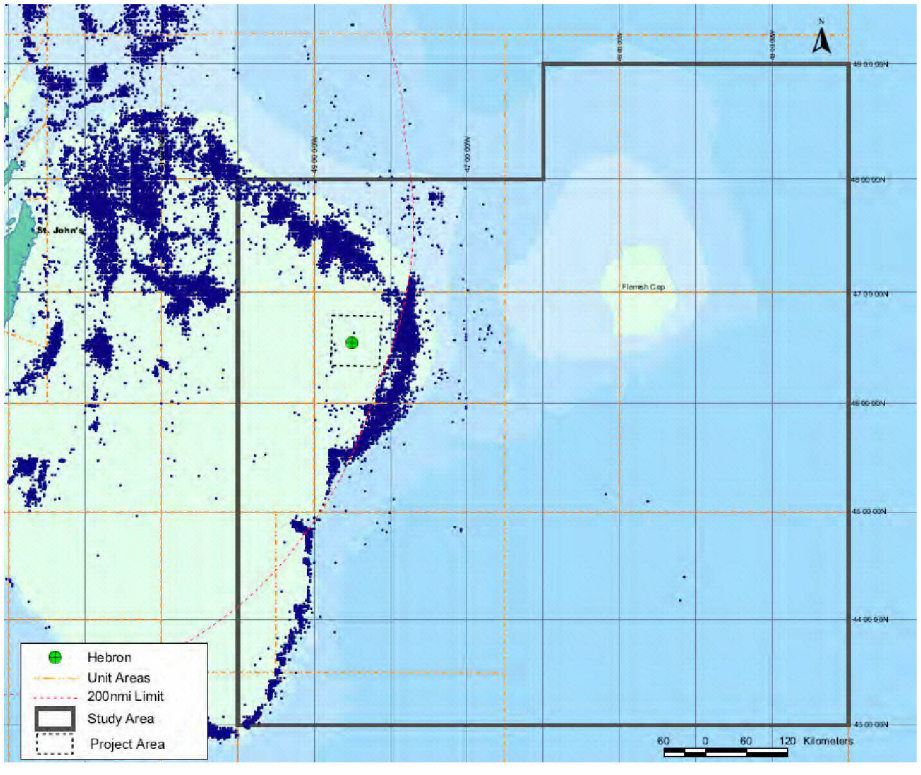


Figure 8-39 Snow Crab Harvesting Locations, 2004 to 2008, Aggregated

Snow crab seasons may vary somewhat each year by quota / license category, depending on when quotas are taken, or if other factors intervene, such as the presence of too much soft shell crab. However, it usually occurs within the April to July period. The average harvest by month for the 2004 to 2008 for the Offshore Study Area is shown in Figure 8-40.

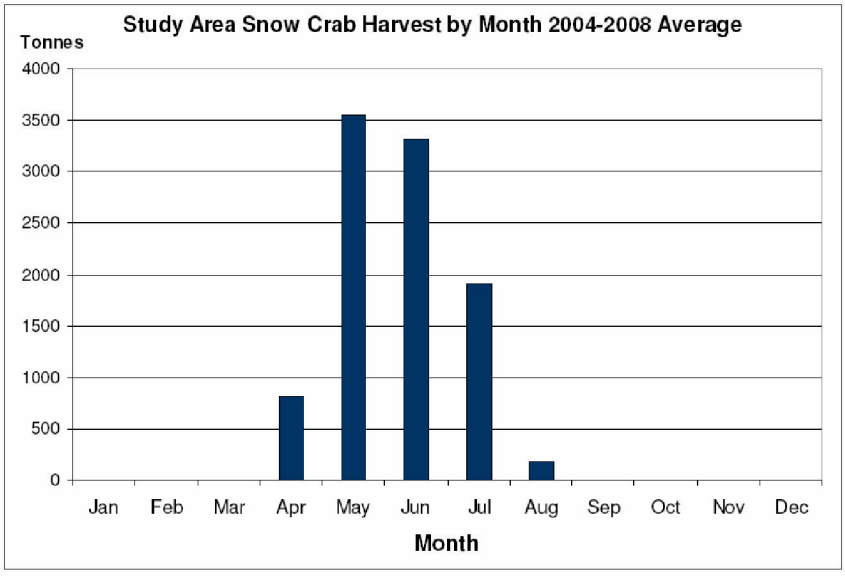


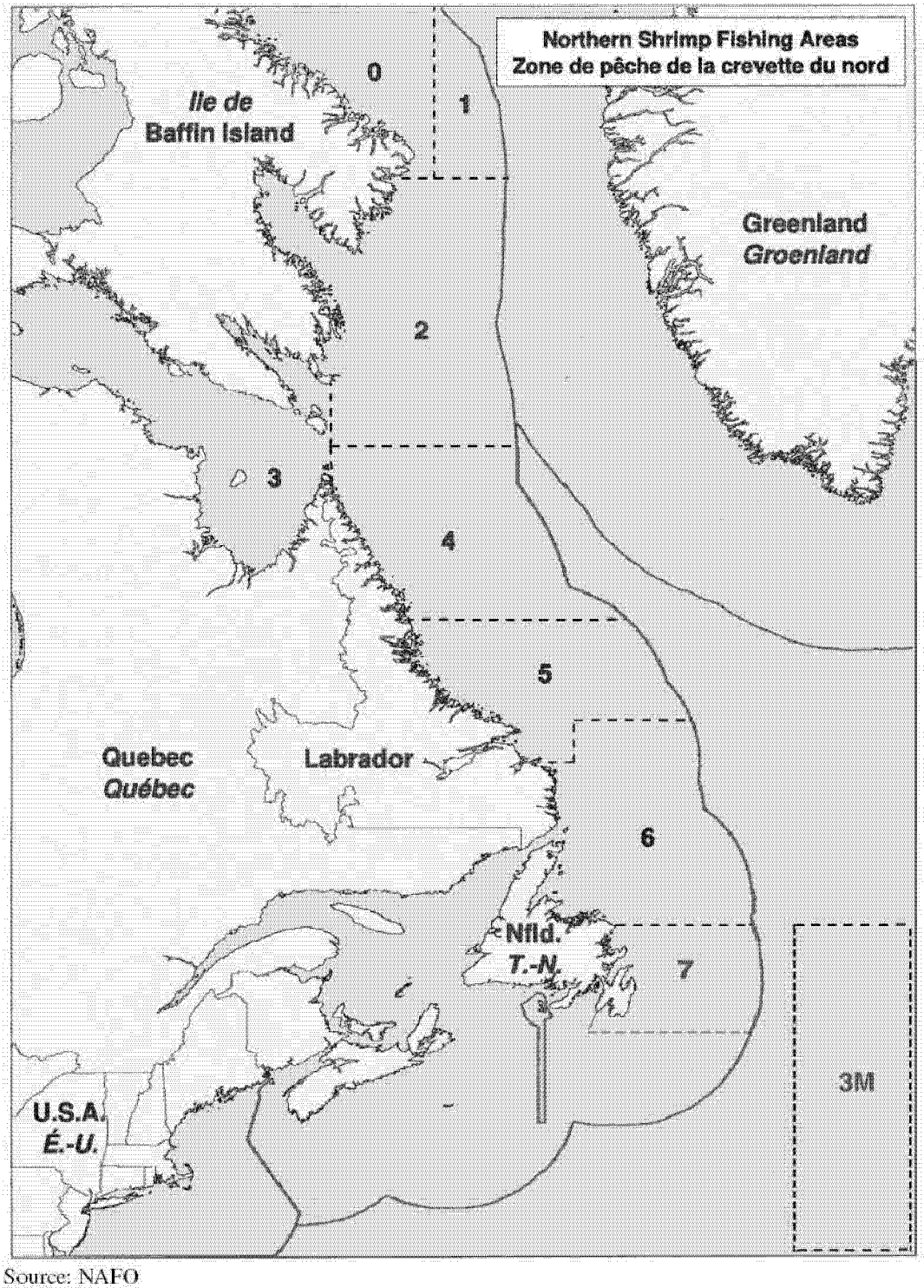
Figure 8-40 Offshore Study Area Quantity of Snow Crab Harvest by Month, 2004 to 2008, Averaged

Northern Shrimp

Shrimp has also been a major fishery in the Offshore Study Area (36 percent by quantity and 25 percent by value). The Offshore Study Area overlaps shrimp fishing area 7, which has domestic quotas. The relevant quotas for 2009 are listed in Table 8-12. The shrimp fishing areas are shown in Figure 8-41.

Table 8-12 Area 7 2009 Northern Shrimp Quotas

Licence Category / Quota Definition	Quota (t)
Area 7 - Offshore > 100-foot and Special Allocations	5,344
Area 7 - 2J Fishers	739
Area 7 - 3K Fishers North of 50'30	739
Area 7 - 3K Fishers South of 50'30	4,562
Area 7 - 3L Fishers	11,353
Area 3M (International waters)	Not designated



Source: NAFO

Figure 8-41 Shrimp Fishing Areas

The harvesting locations recorded for 2004, 2005 and 2006, all months, are shown in Figure 8-42.

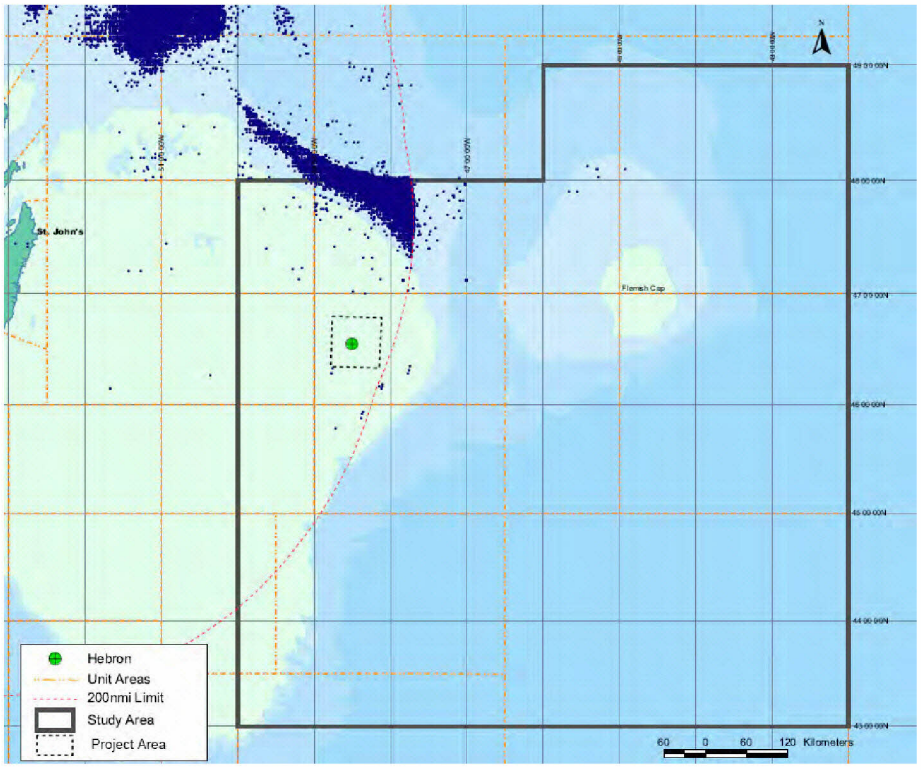


Figure 8-42 Northern Shrimp Domestic Harvesting Locations, 2004 to 2008, Aggregated

The shrimp harvest, pursued in the Offshore Study Area by larger trawlers from Newfoundland and Nova Scotia, can occur year-round, though the summer months (June and July) have been the most important time. The average northern shrimp harvest by month for 2004 to 2008 for the Offshore Study Area is shown in Figure 8-43.

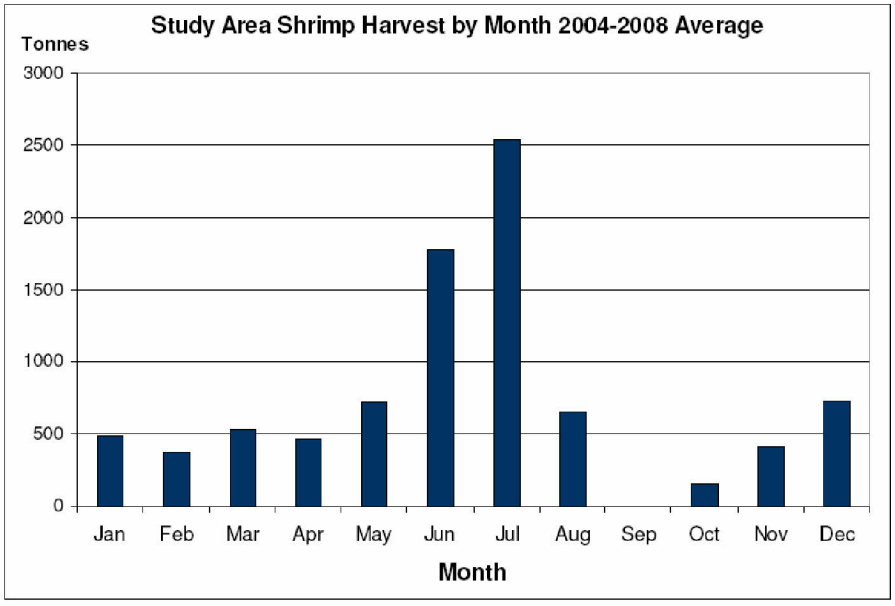


Figure 8-43 Offshore Study Area Quantity of Northern Shrimp Harvested by Month, 2004 to 2008, Averaged

Offshore Bivalves

This fishery in the Study Area is primarily Greenland cockles, Stimpson's (Arctic) surf clams and a small quantity of propeller clams.

Offshore deepwater clams and cockles were the third most significant fishery in the Study Area (21 percent by quantity and 10 percent by value) for 2004 to 2008. It would have had a higher average value except that in 2008, owing to ship logistics and mechanical issues, the harvesting company involved focused on the western deep sea clam grounds on the eastern Scotian Shelf, rather than the Newfoundland grounds. Consequently, in 2008 only 10 tonnes were harvested, compared to the previous four-year average of 2,360 tonnes (C. Boyd, pers. comm.).

According to the latest management plan (DFO 1998), the three vessels in the fishery are specialized large factory freezer vessels, equipped to operate year round. Each vessel has equal allocations for each commercial fishing area (Banquereau and Grand Banks), and each vessel lands product for further processing at separate plants. Recorded locations for 2004 to 2008 are shown in Figure 8-44. Because these bivalves are slow-growing species, the harvesting usually occurs on different beds from one year to the next to allow time for the grounds to recover.

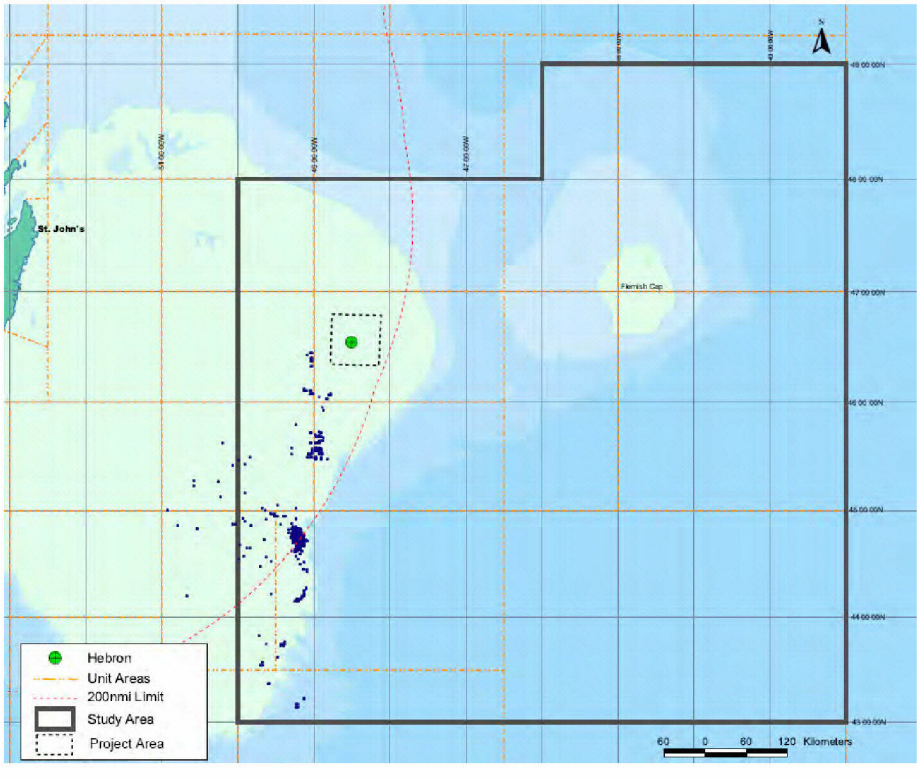


Figure 8-44 Deep Sea Clams / Cockles Harvesting Locations, 2004 to 2008, Aggregated

Over the past several years, the Grand Banks portion of this fishery has been largely confined to localized areas within NAFO Division 3N, mainly within Unit Area 3Nd, but in 2006 the harvest expanded northward into 3Lr and 3Lt

(see Figure 8-44). Another recent change in this fishery is an increase in the Greenland cockle harvest, which accounted for 65 percent of the Grand Banks deep sea clams harvested in 2006. In contrast, before 2004, no cockles were reported, and during 2004 and 2005 the species made up approximately 20 percent of the harvest. As a result of the increase in cockle harvesting, the overall deep sea clam fishery increased by more than 50 percent in 2006, compared to the average recorded harvest from 2000 to 2005.

In recent years, the majority of this fishery in the area has been harvested by a Newfoundland-based vessel (from Grand Bank) operated by Clearwater Ltd. Partnership, which holds all three of the Atlantic Canadian licences for this species. The quota is divided between grounds on Banquereau Bank and the eastern Newfoundland Grand Banks. The fishery may be conducted year-round, commencing January 1 of each year. Clearwater Ltd. Partnership usually fishes Banquereau first and then the Grand Banks, as indicated in Figure 8-45. The average timing of the harvest over the 2004 to 2008 period for the Study Area is also shown in Figure 8-45; harvesting effort is distributed throughout the year.

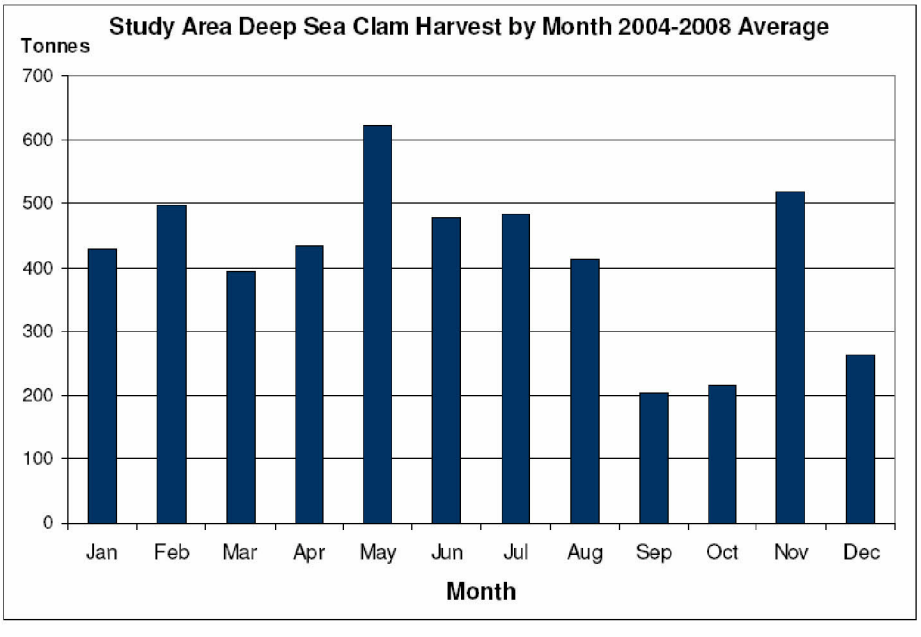


Figure 8-45 Offshore Study Area Quantity of Deep Sea Clam Harvest by Month, 2004 to 2008, Averaged

Groundfish

Overall, groundfish harvests made up just 2.7 percent of the Offshore Study Area harvest by quantity and 1.4 percent by value in 2004 to 2008. Many groundfish species are harvested together, either as directed or by-catch fisheries. The main fisheries in recent years in the Offshore Study Area has been for yellowtail flounder, although halibut has also been important because of its high relative value. The domestic harvesting locations for all groundfish species for 2004 to 2008 are shown in Figure 8-46. As indicated in this

figure, most fishing occurs in the northern and west parts of the Offshore Study Area, and very little in the Offshore Project Area.

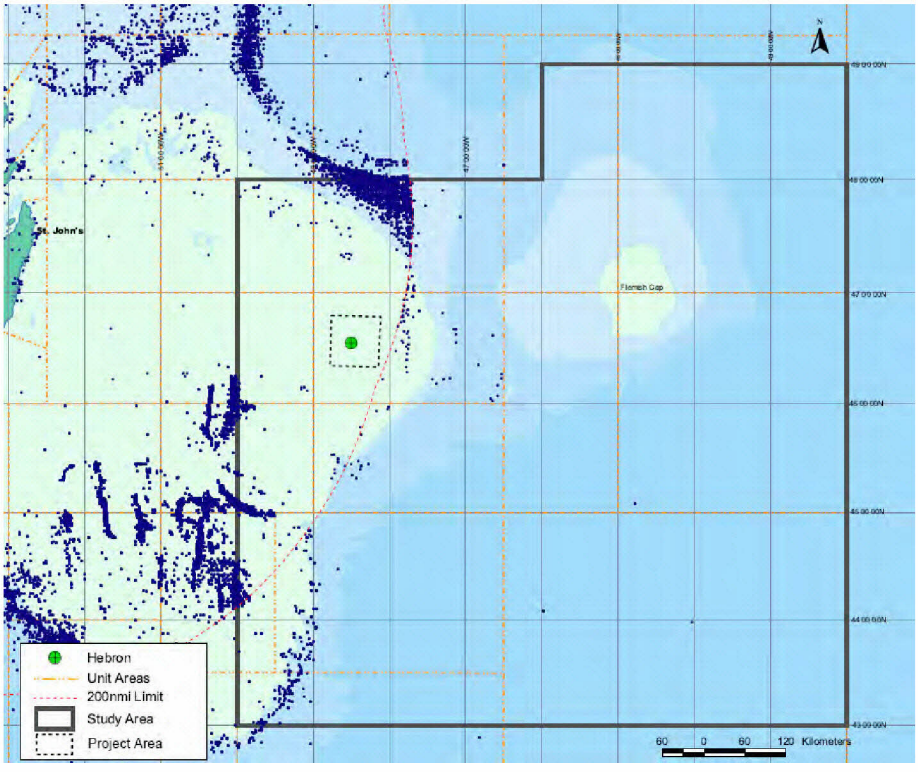


Figure 8-46 Groundfish Harvesting Locations, 2004 to 2008, Aggregated

The average timing of groundfish harvesting for 2004 to 2008 in the Offshore Study Area is shown in Figure 8-47.

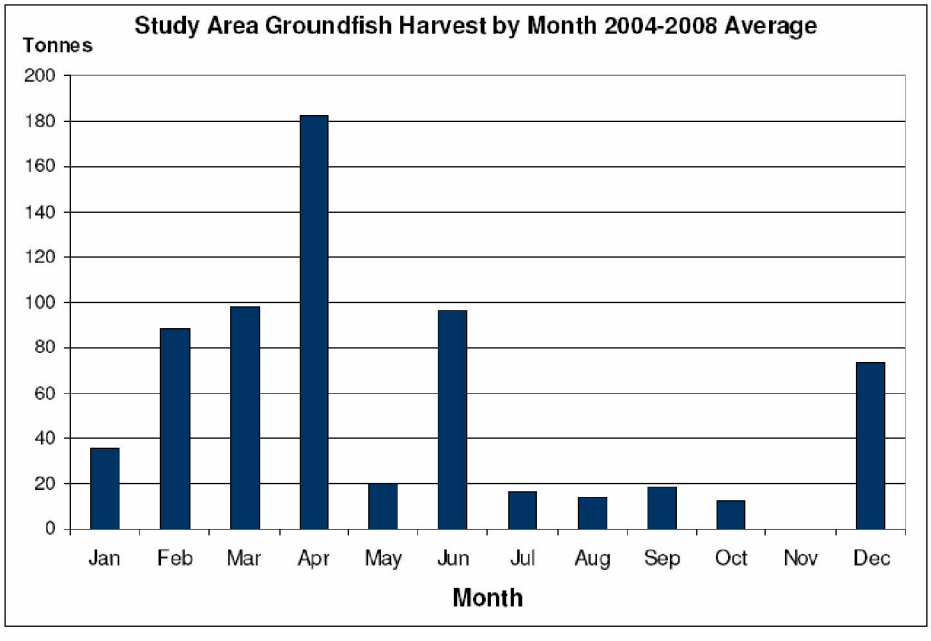


Figure 8-47 Offshore Study Area Quantity of Groundfish Harvest by Month, 2004 to 2008, Averaged

8.3.2.1 International Fisheries

Several Convention nations have harvested a variety of fish stocks in the NAFO areas to the north and west of the Study Area. This is primarily in the area of the NAFO Divisions 3LMN from the waters outside Canada's EEZ.

The landings by foreign fisheries from 1985 to 2004 are illustrated in Figure 8-48. They show harvests by foreign and (for comparison) domestic harvesters from these Divisions, most of which are within the Study Area.

The principal species harvested during this period were northern shrimp, capelin, cod and turbot (snow crab is not managed by NAFO). Other than Canadian ships, those fishing in these areas during this time included fishing vessels from Denmark, Iceland, Cuba, Japan, South Korea, Russia, the US and various European Union nations.

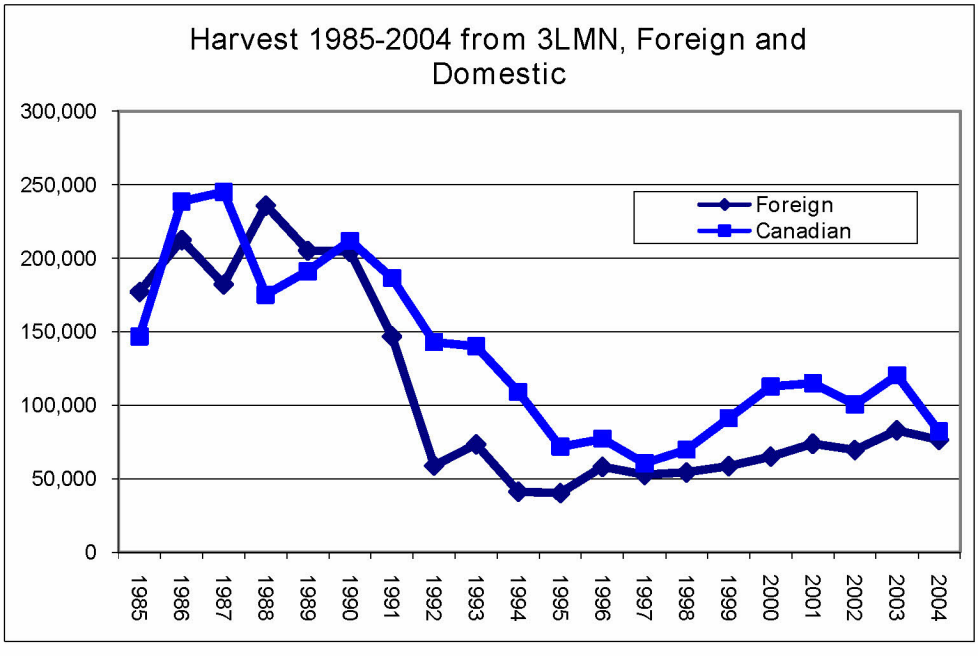


Figure 8-48 Harvest (1985 to 2004) from Divisions 3LMN, Foreign and Domestic, NAFO-managed Stocks

8.3.2.2 Recreational and Subsistence Fisheries

There has been no subsistence or recreational fisheries in the Offshore Project Area.

8.3.2.3 Potential Commercial Fisheries

As with the Nearshore Project Area, the most likely new future fishery, from the perspective of current harvesting, is a return of groundfish harvesting, particularly cod and American plaice, though when this might happen is not known. DFO managers consulted noted that plaice stocks still have a long way to go before they were at a level where they could be harvested on a commercial basis.

For other potential future fisheries there is very little information available. DFO conducts annual stratified random multi-species trawl surveys during the spring and autumn in the Newfoundland and Labrador Region (Brodie 2005; DFO 2009h). One of the main objectives of these surveys is to determine the distribution and abundance of various groundfish and shellfish species.

A recent study dealing with the potential effects of various types of fishing gears on sub-sea installations (Husky Energy 2010) identified an abundance of sand lance in the 3Lt region. These findings, based on an analysis of DFO research survey data from 2002 to 2008, might indicate some future commercial potential for this species. The same study indicated the presence of eelpout which, given the relatively large individual body sizes of this species, might make it attractive to commercial harvesters at some point in the future.

Commenting on the potential for the commercial exploitation of eelpout, DFO managers agreed that this might be a possibility in the long term, but pointed out that other sources of marine protein would likely be explored before this species was used.

8.3.3 Fisheries Research Surveys

DFO research surveys in 3L and/or 3N overlap with parts of the Offshore Study Area. The preliminary schedule for any year is usually available in the early spring, and the spring survey is typically conducted within NAFO Division 3LNO in May to June. The fall survey usually operates in these areas from early October to about mid-December. Often, the R/V Templeman will be used during the spring surveys (and the Teleost), and either the R/V Templeman or the R/V Needler, in the fall. More specific plans are typically available as the season moves forward in the year, and may be modified as circumstances change (W. Brodie, pers. comm.).

A typical schedule from recent years is provided in Table 8-13. In any year of activity, contact will need to be maintained to understand the current season's schedule.

Industry-DFO collaborative post-season research surveys of snow crab also have been undertaken in 3L and other NAFO Divisions since 2003. These research activities are conducted by snow crab harvesters in the fall between September and November. Surveys take place on established crab fishing grounds at fixed "stations" that generally follow a grid pattern (R. Saunders, pers comm.).

Table 8-13 Typical Fisheries Research Schedules

Scientist / Ship	Survey	Start Date	End Date
R/V Templeman or R/V Needler			
Brodie	Multi-species 3LNO	06-May	20-May
Brodie	Multi-species 3LNO	21-May	03-Jun
Brodie	Multi-species 3LNO	04-Jun	17-Jun
Brodie	Multi-species 3LNO	18-Jun	28-Jun
Brodie	Multi-species - 3KLNO	01-Oct	07-Oct
Brodie	Multi-species - 3KLNO	08-Oct	21-Oct
Brodie	Multi-species - 3KLNO	22-Oct	04-Nov
Brodie	Multi-species - 3KLNO	05-Nov	18-Nov
Brodie	Multi-species - 3KLNO	19-Nov	02-Dec
Brodie	Multi-species - 3KLNO	03-Dec	16-Dec
R/V Teleost			
Brodie	Multi-species 3KLMNO	03-Dec	16-Dec

8.4 Project-Valued Ecosystem Component Interactions

This section considers potential interactions through all Project phases between the Project and commercial fish harvesting activities conducted in order to generate fishing income. These activities include accessing and setting gear on established fishing grounds, retrieving/hauling the gear to harvest the fish and getting the catch back to port. Interactions resulting in impacts which might interrupt or prevent any part of that process (such as having grounds closed to fishing, impediments en route to or from fishing grounds, lost fishing gear, or lost or reduced catch) are the focus of the assessment in Section 8.5.

Economic impacts could also result from physical effects on commercial fish species and their habitats. Potential Project effects on Fish and Fish Habitat are considered to be not significant with the appropriate mitigations in place (see Chapter 7).

8.4.1 Issues

The potential effects considered in this section reflect the issues raised by both inshore and offshore fishers during the consultations for this CSR, which are summarized in Sections 5.3.1 and 5.3.2, respectively. These issues are also typical of those raised and assessed for similar offshore development projects in these areas in the past. Potential interactions with, and effects on, fisheries science / research surveys (industry-led and DFO) are also considered in this section. These issues are addressed in the mitigation subsections of Section 8.5.

8.4.1.1 Nearshore

Exclusion from fishing grounds. Fishers expressed concern that marine construction operations would result in their being excluded from pelagic

species fishing areas within Bull Arm such as grounds close to the deepwater site. They wanted to know what the "rules of the road" would be with respect to where and when they would be allowed to fish. Sunnyside fishers who fish lobster and other species in Great Mosquito Cove wanted to know if they would be allowed to continue fishing these grounds, at least in the initial stages of the Project.

Disruption of harvesting operations. Fishers expressed concern about general Project activities on the water (vessel traffic) and the effects these might have on their fish harvesting operations. This included high levels of activity that would make fishing more difficult or dangerous, and might result in de facto exclusion from busy areas. Fishers were concerned that Project-related vessel traffic could interfere with crab fishing activities or other species harvesting operations within the Tickle Bay portion of the Traffic Lane.

Effects of noise and lights on catchability. Fishers stated concern about effects of construction-related noise and light on fish behaviour and/or movement within Bull Arm, especially during the time when the Gravity Base Structure (GBS) is moored at the deepwater site. Fishers stated, for example, that a purse seiner might miss a catch of mackerel if lights associated with platform construction activities in the middle of Bull Arm deflected a school of fish away from the grounds, resulting in an economic loss for the vessel operator. The effects of construction-related noise and light on fish behaviour in the nearshore are described in the Section 7.5.1.3 (Fish and Fish Habitat).

Gear and vessel damage. Fishers were concerned about potential damage to fishing gear or fishing vessels resulting from Project-related vessels or debris escaping from the site.

8.4.1.2 Offshore

Lost or damaged gear. Fishing gear damage, and the concomitant or subsequent loss of catch, may result from regular support vessel operations, as well as from other activities such as iceberg towing or geophysical surveys. Most gear damage incidents involve fixed gear (e.g., crab pots); mobile gear (e.g., shrimp trawls) is rarely affected. In most cases, the owner of gear damaged by an oil-related vessel activity is identified and compensated, after submitting a claim to the responsible operator through gear compensation programs currently in place. However, fishers say that an increase in the number of "un-attributable" damage incidents, for which no claim is provable because it cannot be linked to petroleum industry operations, even though fishers are convinced that project vessels are responsible. Many of these cases involve the loss of small items (e.g., a 90-inch balloon buoy). Fishers say that while each such incident can be viewed as a nuisance - a regular component of the "cost of doing business" offshore - the rising number of these incidents contributes to the overall sense of unease and distrust among fishers.

Fishers stressed that gear replacement is often not the biggest part of their resulting economic loss. It may not be possible for the enterprise to make up the lost fishing time associated with a gear damage incident. The entire trip may be lost, or the enterprise may fail to make its quota for the season. Fishers indicated in such cases there should be some mechanism in place to compensate for the lost catch, as well as for the damaged gear.

Fishers noted that, as fishing seasons become more confined, the potential economic consequences of lost fishing time will increase. Fishers believe that certain routine oil industry activities already compound this situation. For example, the busiest months for the offshore crab fishery are generally April to July; iceberg deflection operations are undertaken during the same months and in many of the same areas fishers set their crab gear.

Lost fishing grounds. In addition to the Safety Zones that are established around production platforms, fishers expressed concern regarding the lack of protocols and standards for establishment of Closest Point of Approach (CPA) zones around oil and gas activities. Although fishers reported that the three existing oil production installations occupy a relatively small total area, they feel that the operational "zone of influence" extends well beyond the boundaries of the official Safety Zone of each installation. Fishers repeatedly stated that the combined restraints of existing DFO quota areas and existing oil operations already force them to operate within a relatively narrow band of fishing grounds. Fishers are of the view that the Hebron development and operations will exacerbate this situation.

As discussed above, fishers feel that there is an inadequate level of understanding and communication between the two industries at sea. For their part, fishers admit they are not always informed about the "rules of the road", why particular rules or protocols were developed, or what their rights and responsibilities are when operating in the general vicinity of an offshore production facility. For example, fishers are not sure what their CPA should be when they are transiting waters adjacent to an operator's Safety Zone. Some operators apparently require fishing vessel to maintain a CPA of 9.2 km (5 nm), while others ask them to maintain a CPA of 18.5 lm (10 nm). Without a common understanding, agreement on compliance and enforcement is difficult.

Reduced fishing opportunity. Fishers stated a growing concern that the ongoing development of the Jeanne d'Arc Basin oil field area is beginning to have a negative effect on their ability to harvest fisheries resources in adjacent areas of the Grand Banks. It appears to fishers that the size of the area in which they can safely and efficiently fish is shrinking, resulting in reduced fishing opportunity.

The lack of well-understood protocols are perceived as having a measurable negative economic impact on their operations, according to fishers. Fishers stated that this is occurring because fishing vessels are forced to steam around an oil field area to get from one quota area to the next, rather than being able to transit through that area while maintaining a reasonably safe distance (i.e., CPA) from the installation, resulting in lost fishing time and

increased fuel costs. Fishers frequently cited the need to maximize fishing time as the most critical issue they face. They noted that preventing any such loss of opportunity in the first case is preferable to financial compensation for that loss after the fact.

Effects on future fisheries. Fishers noted that if further development occurs in the Jeanne d'Arc Basin, effects on future fishing activities could increase substantially. The situation is not yet overly problematic, for several reasons, according to fishers. To begin with, the three existing production facilities are not situated on important fishing grounds. At present, two species dominate the Grand Banks fishery: shrimp and snow crab. Neither of these species is fished extensively in the immediate vicinity of Hibernia or Terra Nova; however, there are well-established crab grounds near the White Rose installation (e.g., to the east of this oilfield area, both inside and outside and the 200 nm limit line).

Fishers point out that if DFO changes current quota area allocation boundaries (as fishers have been requesting), there would be more crab fishing within the Jeanne d'Arc Basin. Likewise, there would be much more fishing vessel activity in and around the Hibernia / Terra Nova / White Rose zone if offshore groundfish quotas were reinstated. Changes in the current quota zone boundaries, or the resumption of offshore groundfish fisheries, would alter the existing distribution of harvesting locations and fishing vessel activity patterns. Fishers expressed concern that with these potential changes, the presence of the existing three oil field installations, combined with the effects of Hebron development activities during the next several years, could result in future lost fishing opportunities.

Oil Spills. Fishers stated concern about the commitment of oil companies to compensate the fishing industry in the event of an oil spill. They stated that the oil industry does not "have a good reputation about cleaning up its messes". They would like to see more information made available about how a compensation program for an oil spill would actually work. They wanted to know more about what concrete steps would be taken following an oil spill, how claims would be submitted and assessed.

8.4.2 Potential Interactions (and Impact Pathways)

Each of the commercial fisheries issues identified by fishers and potential impacts relate to possible reductions in fishing income, and specifically to net fishing income losses. Losses might occur because of decreased revenues (reduced catches, prices or marketability) or because of increased expenses (higher fuel costs, replacing damaged gear), or both. As the previous discussion indicates, these losses might arise from a variety of different impact pathways. For the purpose of the assessment these pathways are considered under four specific categories:

- Access to Fishing. Those activities that prevent access to former or potential fishing grounds (loss of access to areas such as the Safety Zones)

- Fishing Vessel Operations. Those activities that might result in temporary or ongoing interference with fishing activities (vessel traffic or other Project marine activities beyond the Safety Zones that impede or otherwise interfere with fishing)
- Fishing Gear. Those activities which could damage, foul or cause the loss of fishing gear, including consequent catch losses (vessel traffic beyond Safety Zones, or escaped debris)
- Catchability. Those activities which might affect the catchability of commercial fish species (issues related to scaring fish from the harvesting area or away from fishing gear)

The Project activities that have the potential to interact with each of the preceding categories (Effects), organized by location (nearshore and offshore) and phase (construction, operations) are provided in Table 8-14. It should be noted that most of the construction related activities and operations will be wholly contained within the Safety Zones and therefore most of the specific construction activities, such as bund wall construction and drydock preparation, will not interact with commercial fisheries.

Table 8-14 Potential Project-related Interactions: Commercial Fisheries

Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Access to Fishing Grounds	Fishing Vessel Operations	Fishing Gear	Catchability
Construction				
Nearshore Project Activities				
Presence of Safety Zones (Great Mosquito Cove zone followed by a deepwater site zone)	x			
Bund Wall Construction (e.g., sheet / pile driving, infilling)				
Inwater Blasting				x
Dewater Drydock / Prep Drydock Area				
Upgrades to Ferry Terminal				
Concrete Production (floating batch plant)				
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)		x	x	
Lighting				
Air Emissions				
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)		x	x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)				
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site				
Hook-up and Commissioning of Topsides				

Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Access to Fishing Grounds	Fishing Vessel Operations	Fishing Gear	Catchability
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Platform Tow-out from deepwater site	x	x	x	
Offshore Construction / Installation				
Presence of Safety Zone	x			
OLS Installation and Testing				
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines				
Installation of Temporary Moorings		x		
Platform Tow-out / Offshore Installation	x	x	x	x
Underbase Grouting				
Possible Offshore Solid Ballasting				
Placement of Rock Scour Protection on Seafloor around Final Platform Location				
Hook-up and Commissioning of Platform				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs, ice management)		x	x	
Air Emissions				
Lighting				
Potential Expansion Opportunities				
Presence of Safety Zone	x			
Excavated Drill Centre Dredging and Spoils Disposal		x	x	
Installation of Pipeline(s) / Flowline(s) and Tie-back from Drill Centre(s) to Platform; Concrete Mattresses, Rock Cover, or Other Flowline Insulation				
Hook-up and Commissioning of Excavated Drill Centres				
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, Diving)		x	x	x
Offshore Operations and Maintenance				
Presence of Safety Zone	x			
Presence of Structures				
Lighting				
Maintenance Activities (e.g., diving, ROV)				
Air Emissions				
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)				
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)				
WBM Cuttings				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)		x	x	

Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Access to Fishing Grounds	Fishing Vessel Operations	Fishing Gear	Catchability
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	x
Potential Expansion Opportunities				
Presence of Safety Zone	x			
Drilling Operations from MODU at Future Excavated Drill Centres				
Presence of Structures				
WBM and SBM Cuttings				
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)				
Geophysical / Seismic Surveys		x	x	x
Offshore Decommissioning / Abandonment				
Presence of Safety Zone	x			
Removal of the Hebron Platform and OLS Loading Points				
Lighting				
Plugging and Abandoning Wells				
Abandoning the OLS Pipeline				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / ROVs,)		x	x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture				
Nearshore Spill (at Bull Arm Site)	x	x	x	
Failure or Spill from OLS	x	x	x	
Subsea Blowout	x	x	x	
Crude Oil Surface Spill	x	x	x	
Other Spills (fuel, chemicals, drilling muds or waste materials/debris from the drilling unit, GBS, Hebron Platform)		x	x	
Marine Vessel Incident (i.e., fuel spills)	x	x	x	
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x		
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)		X		
Terra Nova Development (production)		X		
White Rose Oilfield Development and Expansions (drilling and production)		X		
Offshore Exploration Drilling Activity				
Offshore Exploration Seismic Activity				
Marine Transportation (Nearshore and Offshore)		x		
Commercial Fisheries (Nearshore and Offshore)	--	--	--	--

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Accidental events (such as spills) and associated potential effects on the fisheries are discussed and assessed in Section 8.5.3. Cumulative environmental effects are discussed in Section 8.5.4.

8.5 Environmental Effects Analysis and Mitigation

This section presents the assessment of effects on the commercial fisheries, based on the potential interactions identified, including a determination of the significance of the effects after the identified mitigations are applied. In terms of mitigations, it should be noted that many elements and procedures to avoid, reduce or eliminate effects on the commercial fisheries have already been designed into the Project plans. These include the use of environmentally-sound construction and operational methods and materials, best practices, and location and timing considerations.

8.5.1 Construction / Installation and Operations / Maintenance

The categories of potential impacts (those affecting access to fishing grounds, fishing vessel operations, fishing gear and catchability) are the same during both the construction and operations phases of the Project, as are many of the effects pathways (e.g., exclusion from Safety Zones). Consequently, many of the mitigations are also the same. Thus the effects and mitigations for both these phases are discussed together. For the Nearshore Project Area, there will be no operations and maintenance phase activities.

8.5.1.1 Nearshore

Access to Fishing Grounds

Before the start of marine activities in Great Mosquito Cove, a Safety Zone will be established. The size of the zone will be dependent upon the mooring arrangement within Bull Arm at the deepwater site. ExxonMobil Canada Properties (EMCP) will consult with fishers regarding the establishment of the Safety Zone. All fisheries activities will be excluded from this Safety Zone area, between 2011 and 2016, for safety reasons and to allow platform construction activities to take place in an efficient and timely manner.

When the partially-completed GBS is ready to be towed to the deepwater site within Bull Arm, another Safety Zone will be established around that marine construction site. This Safety Zone will extend out 500 m from the centre of the deepwater site. During construction activities at the deepwater site, estimated to be 2+ years, fishers will be temporarily prohibited from fishing within the Safety Zone, and will have to access alternate fishing grounds. EMCP will actively engage fishers throughout all phases of project activities to keep them informed as to the timing of and locations of these Safety Zones. In addition, EMCP, in consultation with local fishers, will implement mitigations to reduce disruption to their traditional fish harvesting activities.

During the tow-out of the completed platform from the Nearshore Area, there will also be a temporary exclusion/Safety Zone around the Hebron Platform

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and the ships tending it. However, this will be of short duration and will be continually moving.

While the establishment of the construction Safety Zones will create a temporary loss of access to fishing grounds first at the Great Mosquito Cove site and later at the deepwater site, they will, in fact, serve as key mitigations to avoid or prevent impacts from many other activities and to help ensure the safety of workers, fishers and other marine users.

Fishing Vessel Operations

Some Project activities will take place outside the designated Safety Zones (e.g., vessel transits). This would include service and supply ships, tugs, towing operations, barge, and a shift change ferry to / from the deepwater site. Other activities that might occur outside the Safety Zone in Bull Arm would be re-establishing moorings near the deepwater site, possible dredging of sections of the tow-out route within Trinity Bay, ocean disposal operations, activities related to the GBS tow-out to the deepwater site and the final platform tow-out from the bay. There may also be a need for localized surveys outside the Safety Zones.

Each of these activities has the potential to affect the efficiency of fishing vessel operations (more time reaching alternative grounds, delays for traffic) within the Nearshore Study Area, and/or to contribute to increased expenses (additional fuel costs).

As noted, the confinement of most activities within the Safety Zones will reduce the potential for interference with day-to-day fishing operations. For those activities that do occur outside these areas, several further mitigations will be established to minimize impacts on fishing vessel operations (see below). For instance, fisheries representatives have frequently noted that good communications at sea are effective ways to minimize interference between offshore oil and gas exploration projects and fishing activities.

Fishing Gear

Project construction-related ships operating outside the Safety Zones (e.g., tow out, routine vessel traffic, dredging) could make contact with and damage fishing gear or cause its loss. Such conflicts are more likely to involve fixed fishing gear (e.g., crab pots) than mobile gear since those vessels can actively avoid conflicts.

As noted, the establishment of the construction Safety Zones will reduce the likelihood of conflicts with gear because, with the exception of vessels delivering materials by sea via the Traffic Lane, and a limited number of other operations, most construction-related activities will be confined to these two areas.

Catchability

As addressed in Chapter 7, Project activities might result in the scaring of fish causing them to avoid an area, thereby affecting the "catchability" of commercial species. Noise will be created by sheet/pile driving, dredging and underwater blasting activities associated with re-establishing the bund wall for the drydock and widening of the tow-out channel for the partially completed platform.

Depending on the placement of fishing gear in relation to the noise source, the effects on a particular harvesting opportunity might be either positive or negative. Finfish species, such as groundfish or pelagics might be either driven away from or towards waiting fishing gear.

Similar effects are not usually documented for benthic invertebrates such as lobster and crab (see Christian et al. (2004); Parry and Gason (2006)). Biophysical and behavioural effects of sound on biota, including commercial and prey species, are considered in Chapter 7 where effects are assessed as not significant with mitigations in place.

Lighting may also have an effect on the cathcability of fish. Effects of lighting are addressed in Section 7.5.1.3.

As described, construction Safety Zones will be established in consultation with Project Area fishers. This will reduce the impacts of pile / sheet driving or dredging activities on fish harvesting operations since there will be none in the immediate area of these operations. As such, there will likely be a sound attenuation buffer between construction activities and fisheries operations beyond the boundary of the Safety Zone. Prior to the start of marine construction activities, EMCP will undertake a detailed analysis and assessment of shock waves from blasting in order to identify and assess their geographic extent beyond the Safety Zones and the potential effect on fish.

EMCP will consult with fishers in the area regarding the timing of blasting activities and the implementation of monitoring programs. To the extent possible, blasting will be planned to avoid interference with finfish harvesting activities.

Mitigations

The following are proposed mitigations to address the issues discussed above and in Section 8.4.1.1.

- Fisheries Liaison Committee. A fisheries liaison committee can facilitate communications between Project construction at Bull Arm and local fisheries activities. Such a committee could include representation of local fishers, Project personnel and the FFAW, and may be similar to the liaison committee established during construction of the Hibernia GBS. EMDC, in consultation with local fishers, will establish a liaison committee before the start of construction activities.
- Fisheries Compensation Plan. EMCP will establish a fisheries compensation plan associated with construction activities at Bull Arm.

The compensation plan will be developed based on existing practice and industry-based guidance.

EMCP is in the early stages of developing a Bull Arm fisheries agreement, which will be similar to the agreement in place during the construction of the Hibernia GBS. Elements of the Agreement may include communication protocols, vessel traffic management procedures and compensation to fishers directly affected by Project Activities during the construction of the GBS.

Compensation for any accidental releases at Bull Arm will be captured in the oil spill response plan, which is under development. Project Area fishers sustaining gear or vessel damage as a result of contact with Project Activities will be compensated for any such demonstrated economic loss where it is directly attributable to Project activities. The principles and procedures for calculating and paying Project-related gear and vessel damage claims will be similar to those contained in existing programs such as those used by operators involved in offshore exploration activities (e.g., seismic surveys).

- Nearshore Project Fisheries Liaison Officer. EMCP will employ the services of a dedicated local area Project Fisheries Liaison Officer (FLO). The role of this position is to maintain continuous communication between fishers and Project personnel and contractors at Bull Arm regarding the daily construction and fisheries activities in the Project Area.
- Designated Vessel Traffic Lane. EMCP will re-establish the vessel traffic lane for the approach to Bull Arm, Trinity Bay. All vessels will be required to travel within this lane, and therefore should minimize interference with fish harvesting activities and minimize the opportunity for gear conflicts in other areas.
- Vessel Traffic Management Plan. EMCP in consultation with local fishers will implement a traffic management plan for Bull Arm. This plan should facilitate marine communications between fishers, Project vessels and other users in the area. It may include such provisions as communications protocols, speed of vessel in designated areas. The Vessel Traffic Management Plan will include, for example
  - All vessel traffic to be made aware of the provisions of the Eastern Canada Traffic Zone Regulations and inshore High Level Traffic Zone practices and procedures
  - All parties provide Canadian Coast Guard with required information for issuance of Notices to Shipping and Notices to Mariners in a timely manner
  - Private floating and fixed Aids to Navigation be established in Trinity Bay approaches to Bull Arm.
- Communications and Notification. Communications will be maintained via marine radio to facilitate information exchange between Project personnel and fishers. EMCP will establish a marine communication protocol that will include provisions for notification of activities outside the established Safety Zone and other Project information that may be

warranted. Such information will be exchanged via established mechanisms such as Notice to Mariners and the FLO.

- On-Board Fisheries Liaison Officer. The requirement for a Fisheries Liaison Officer will be determined based on Project activity and in consideration of Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) guidance (i.e., Geophysical, Geological, Environmental and Geotechnical Guidelines, (C-NLOPB 2011)) and in consultation with the FFAW and fishers in the area in accordance with a protocol being developed by One Ocean.
- Single Point of Contact. As required, a single point of contact may be engaged to facilitate communications regarding gear loss/damage or other compensation claims pursuant to a fisheries compensation program.

8.5.1.2 Offshore

Access to Fishing Grounds

During construction, EMCP will establish a Safety Zone around the offshore site. The Safety Zone will extend 500 m from the perimeter of construction vessels in the area and will be of short duration. All fisheries activities will be excluded from this area during construction and installation. However, analysis of past fishing activities indicates no harvesting has occurred within the zone in the past two decades indicating that the area is not currently used by the industry as fishing grounds (see Section 8.3).

During the tow-out of the Hebron Platform there will also be a temporary exclusion/Safety Zone around the platform and the ships tending it. However, this will be of short duration and will be continually moving.

For the operations phase, EMCP will establish a permanent Hebron Platform Safety Zone that extends 500 m from the perimeter of the platform, OLS and pipeline system. A recent initiative by One Ocean involved the creation of a factsheet highlighting the Safety Zones for each offshore production facility. EMCP will work with One Ocean to update these factsheets to include the Safety Zone for the Hebron Project.

As discussed above (under Nearshore mitigations), the offshore construction and operations phase Safety Zones function as key mitigations to avoid or prevent effects from many other activities and to help ensure the safety of workers, fishers and other marine users since they will contain most of the specific construction and operations activities.

Even in the years before the moratorium, Unit Area 3Lt was one of the least productive / harvested of all the Division 3L fishing areas (though geographically one of the largest), accounting for just 1.7 percent of the harvest by quantity in those years (see Table 8-15).

The requirement for a FLO during tow-out of the Hebron Platform to the offshore location will be determined in consultation with the FFAW.

Fishing Vessel Operations

Most construction- and operations-related activities that could affect fishing vessel operations will occur within the Safety Zone. Therefore there will be no interaction with fishing operations. Activities that have a potential to interfere with fishing activities include supply ships, as well as the initial Hebron Platform tow-out to the offshore site. There may also be a need for localized surveys some of which might extend outside the Safety Zone in both phases.

Table 8-15 Pre-Moratorium Landings in Unit Area 3L

3L Unit Area	Tonnes (1984 to 1990 average)	% of total
3Lc	2,691	1.5%
3Lt	3,057	1.7%
3Lg	3,221	1.8%
3Le	3,308	1.9%
3Li	4,494	2.5%
3Lh	5,774	3.3%
3Ls	9,265	5.2%
3Lq	12,091	6.8%
3Lj	15,799	8.9%
3Ld	19,209	10.8%
3La	20,098	11.3%
3Lf	23,302	13.1%
3Lr	25,839	14.6%
3Lb	29,294	16.5%
3L Total	177,442	100.0%

Fishing Gear

Ships and other vessels traversing marine areas outside the Safety Zone (including some geophysical, geological and geotechnical operations) and the Hebron Platform during tow-out have the potential to make contact with and damage fishing gear or cause its loss. As discussed, typically such conflicts involve fixed fishing gear such as crab pots. Considering the relatively low level of fish harvesting in the Offshore Project Area in recent decades (see Section 8.3), gear conflicts are more likely to occur enroute between seaports and the offshore work area than near the Offshore Project Area.

Catchability

As discussed in more detail in the Nearshore section, above, fish may move from an area because of loud noises underwater. During offshore construction, this could be the result of noise associated with certain platform installation activities or with geophysical, geological and geotechnical surveys. Noise does not appear to affect invertebrate harvests (such as snow crab; see Section 7.5.2), which is the only recorded harvest in the Project Area for many years.

Because most activities producing sound will be limited to the Safety Zone during construction and operations, effects of sound will be minimal.

Mitigations

The restriction of most activities within the Safety Zone will avoid most of the potential for interference with fishing vessel operations. For those activities that do occur outside the Safety Zone, mitigation measures will be established to minimize impacts on fishing vessel operations. For geophysical, geological and geotechnical activities specifically, the Geophysical, Geological, Environmental and Geotechnical Guidelines (C-NLOPB 2011) provide guidance aimed at minimizing, specifically, any impacts of well-site seismic surveys on commercial fish harvesting.

The relevant Guidelines state (Section II, Interaction with Other Ocean Users of Appendix 2, Environmental Mitigative Measures):

- Well Site Surveys

  1. The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and the local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained.
  2. Relevant information about marine operations outside Safety Zones will also be publicized, when appropriate, using established communications mechanisms, such as the Notices to Shipping (Continuous Marine Broadcast and NavTex) and CBC Radio's (Newfoundland and Labrador) Fisheries Broadcast.
  3. Operators should implement a gear and/or vessel damage compensation program, to promptly settle claims for loss and/or damage that may be caused by survey operations. The scope of the compensation program should include replacement costs for lost or damaged gear and any additional financial loss that is demonstrated to be associated with the incident. The operator should report on the details of any compensation awarded under such a program.
  4. Procedures must be in place on the survey vessel(s) to ensure that any incidents of contact with fishing gear are clearly detected and documented (e.g., time, location of contact, loss of contact, and description of any identifying markings observed on affected gear). As per Section 4.2 of these Guidelines, any incident should be reported immediately to the 24-hour answering service at (709) 778-1400 or to the C-NLOPB Duty Officer.

- Seismic Programs

  In addition to the measures indicated in Section 1 above, the following mitigation measures should also be implemented

  a) Surveys should be scheduled, to the extent possible, to reduce potential for impact or interference with DFO science surveys. Spatial and temporal logistics should be determined with DFO to reduce overlap of seismic operations with research survey areas, and to allow an adequate temporal buffer between seismic survey operations and DFO research activities.

b) Seismic activities should be scheduled to avoid heavy fished areas, to the extent possible. The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained. The use of a FLO onboard the seismic vessel is considered best practice in this respect.

c) Where more than one survey operation is active in a region, the operator(s) should arrange for a 'Single Point of Contact' for marine users that may be used to facilitate communication.

The following describe how the Project will implement these guidelines, as appropriate, as well as other measures designed to mitigate potential effects:

- Vessel Traffic Route. In the offshore areas, traffic associated with Project construction and operations will transit within traffic routes used by existing operators. This will also greatly reduce the potential for gear conflicts.
- Operational Protocols. One Ocean is exploring concerns raised by fishers regarding such operational issues as restrictions on fishing vessel transits in the vicinity of offshore installations. EMCP will work cooperatively with One Ocean and the fishing industry in this initiative.
- Communications and Notification. Communications will be maintained directly at sea by Project Vessels via Marine Radio to facilitate information exchange with fishers. Relevant information regarding Project activities occurring outside the establish Safety Zone will be publicized, when appropriate, using established communication mechanisms such as the Notice to Mariners.
- On-Board Fisheries Liaison Officer. The requirement for a FLO during certain offshore Project activities will be determined based on Project activity, and in consideration of C-NLOPB guidance (i.e., Geophysical, Geological, Environmental, and Geotechnical Guidelines (C-NLOPB 2011)) in consultation with the FFAW and fishers in the area, in accordance with a protocol being developed by One Ocean.
- Single Point of Contact. As required, a single point of contact may be engaged to facilitate communications regarding gear loss/damage or other compensation claims pursuant to an offshore fisheries compensation program.
- Fishing Gear Compensation Program. EMCP will establish a Fishing Gear Compensation Program (FGCP) to cover loss of or damage to fishing gear resulting from Project activities. The compensation program will be developed based on C-NLOPB and Canadian Association of Petroleum Producers guidance.

For accidental events in the offshore area, a compensation plan will adhere to the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (C-NLOPB and CNSOPB 2002) and CAPP guidance "Canadian East Coast Offshore Operators Non-attributable Fisheries Damage Compensation Program" (2007).

In addition, under the Atlantic Accord Acts, Section 160, "actual loss or damage" is defined as including “loss of income, including future income, and, with respect to any aboriginal peoples of Canada, includes loss of hunting, fishing and gathering opportunities.” Section 162 states that claims can be made for “all actual loss or damage incurred by any person as a result of the spill or the authorized discharge, emission or escape of petroleum” as well as for actual loss or damage and all such costs or expenses resulting from the escape of debris.

8.5.2 Decommissioning / Abandonment

During decommissioning operations the effects and the mitigations will be similar to those during construction, with whatever additional measures the situation (considering the then-current fisheries) requires.

8.5.3 Accidents, Malfunctions and Unplanned Events

Accidental events that might affect commercial fisheries in both the Nearshore and Offshore areas are almost exclusively related to the unplanned release of hydrocarbons, whether refined or crude product. One exception is the accidental release of construction debris, which might damage fishing gear beyond the Safety Zones.

8.5.3.1 Spills

Chapter 7 concludes that biophysical effects on fish from a spill will be not significant. However, economic impacts might still occur if a spill prevented or impeded a harvester’s ability to access fishing grounds (because of areas temporarily excluded during the spill or spill clean-up), caused damage to fishing gear (through oiling) or resulted in a negative effect on the marketability of fish products (because of market perception resulting in lower prices).

While there is little fish harvesting in the Offshore Project Area, in the case of an uncontrolled release from the Hebron Platform, a slick could reach an active fishing area (e.g., to the east of the Platform in summer). In that case, it is likely that fishing would be halted, owing to the possibility of fouling gear. If the release site is some distance from snow crab fishing grounds, there would be time to notify fishers of the occurrence and prevent the setting or hauling of gear and thus prevent or minimize gear damage.

Exclusion from the spill area would be expected to be short-term, as typical sea and wind conditions in the Project Area would promote fairly rapid evaporation and weathering of the slick, and fishing vessels would likely be able to return within several days. Nevertheless, if fishers were required to cease fishing, harvesting might be disrupted (though, depending on the extent of the slick, alternative fishing grounds might be available in a nearby area). An interruption could result in reduced catches, or extra costs associated with having to relocate crab harvesting effort.

Effects due to market perceptions of poor product quality (no buyers or reduced prices) are more difficult to predict, since the actual (physical)

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impacts of the spill might have little to do with these perceptions. It would only be possible to quantify these effects by monitoring the situation if a spill were to occur and if it were to reach snow crab harvesting areas.

Effective responses to mitigate market perceptions (publicizing the results of testing fish flesh for hydrocarbon presence or establishing taste panels to determine organoleptic effects) require that they be tailored to the specific circumstances of any actual release and should consider such factors as the size and duration of the release, the areas affected, the species affected, the time of year and clean-up or rehabilitation methods, as well as the type and characteristics of the markets (local or international, competing products). These factors are considered at the contingency planning stage.

EMCP will establish a fisheries compensation plan for the Project.

8.5.3.2 Control and Containment of Debris

The accidental release or escape of construction debris from the Safety Zones could damage fishing gear if it became caught or entangled.

Appropriate precautions will be taken during construction to prevent the escape of debris from onshore and marine construction sites. If debris did escape and damage gear, fishers will be entitled to make a claim under the FGCP, described above.

The environmental effects of the Project on Commercial Fisheries and the mitigations to be implemented are summarized in Table 8-16.

Table 8-16 Environmental Effects Assessment: Commercial Fisheries

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Construction							
Nearshore Project Activities							
Presence of Safety Zones (Great Mosquito Cove zone follwed by a deepwater site)	• Access to Fishing Ground	• Fisheries Compensation Plan	1	2	2/6	R	2
Inwater Blasting	• Catchability	• Safety Zone, Fisheries Liaison Committee (Nearshore), Timing	1	2	2/1	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, VTMP, Fisheries Compensation Plan, N&C	1	1	3/6	R	2

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Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Re-establish Moorings at Bull Arm deepwater site	• Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, N&C, VTMP	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, Fisheries Compensation Plan, VTMP	1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, Fisheries Compensation Plan, N&C, Timing	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, FLO, SPOC, N&C	1	1	1/1	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FLO, Fisheries Compensation Plan, SPOC, N&C, Timing	1	1	2/1	R	2
Platform Tow-out from Deepwater SIte	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, FLO, SPOC, N&C	1	1	3/6	R	2
Offshore Construction / Installation							
Presence of Safety Zone	• Access to Fishing Ground	• One Ocean Working Group	1	2	3/6	R	2
Installation of Temporary Moorings	• Fishing Vessel Operations	• Safety Zone, FGCP, N&C	1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear • Catchability	• FGCP, FLO, SPOC, Safety Zone, N&C	1	4	2/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, One Ocean Working Group, FGCP, Traffic Route	1	2	3/6	R	2
Potential Expansion Opportunities							
Presence of Safety Zone	• Access to Fishing Ground (A)		1	2	3/6	R	2

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Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Excavated Drill Centre Dredging and Spoils Disposal	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, FGCP, N&C	1	2	2/1	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FGCP, SPOC, N&C	1	3	2/1	R	2
Offshore Operations and Maintenance							
Presence of Safety Zone	• Access to Fishing Ground		1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, One Ocean Working Group, FGCP, Traffic Route	1	1	5/6	R	2
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FLO, FGCP, SPOC, N&C	1	3	3/2	R	2
Potential Expansion Opportunities							
Presence of Safety Zone	• Access to Fishing Ground		1	2	5/6	R	2
Geophysical / Seismic Surveys	• Fishing Vessel Operations • Fishing Gear • Catchability	• FGCP, FLO, SPOC, N&C	1	3	3/2	R	2
Offshore Decommissioning / Abandonment							
Presence of Safety Zone	• Access to Fishing Ground (+)		1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / ROVs)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, FGCP, Traffic Route	1	3	3/6	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FLO, FGCP, SPOC, N&C	1	2	2/2	R	2

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Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Accidents, Malfunctions and Unplanned Events							
Nearshore Spill (at Bull Arm Site)	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	3	2/1	R	2
Failure or Spill from OLS	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	2/1	R	2
Subsea Blowout	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	3/1	R	2
Crude Oil Surface Spill	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials / debris from the drilling unit, GBS, Hebron Platform)	• Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, control and containment of debris	1	1	2/1	R	2
Marine Vessel Incident (i.e., fuel spills)	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	2/1	R	2
Collisions (involving Hebron Platform, vessel and/or iceberg)	• Fishing Vessel Operations	• Fisheries Compensation Plan, N&C	1	3	2/1	R	2

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Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
1 =Low: does not have a measurable effect on commercial fishery net incomes
2 =Medium: has a measurable effect on commercial fishery net incomes, but is temporary and/or is highly localized
3 =High: has a measurable and sustained effect on commercial fishery net incomes

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 =< 1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/ year
4 = 101 to 200 events/ year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

Acronyms:
FGCP = Fishing Gear Compensation Program (Offshore)
FLO = Fisheries Liaison Officer (in consultation with FFAW)
VTMP = Vessel Traffic Management Plan
SPOC = Single Point of Contact
N&C = Notification and Communications

8.5.4 Cumulative Environmental Effects

During consultations (reported in Section 5.3), offshore fish harvesters indicated concerns about the Hebron Development Project related to the combined effects of Hebron with other petroleum industry activities in the Jeanne d'Arc Basin oil field area. They cited concerns about reduced fishing opportunity resulting from general activities, such as extensive vessel hailing zones around each installation, ice deflection activities, and surveys. Fishers report that the current situation is forcing fishing vessels to steam farther in order to get around activities and installations to reach grounds, costing fishing time and increasing expenses, and that additional activities will exacerbate conditions. In particular, fishers cited growing levels of frustration, misunderstanding and miscommunication between fishing industry and petroleum industry operations, as described in Chapter 5.

EMCP is committed to work with the One Ocean Working Group, relevant offshore fishers, FFAW representatives and other agencies to ensure good

relations, cooperation and partnering between all offshore marine user groups.

With the described mitigations in place, the effects of Project-related construction / installation and operations / maintenance activities on access to fishing grounds, fishing vessel operations (movements and harvesting), fishing gear, and catachability of commercial species within the Nearshore Project Area will be not significant.

The offshore construction Safety Zone is not an area typically used as harvesting grounds in recent years, and thus there should be no impact on fish harvesting operations. Considering the relatively low level of fish harvesting in the Project Area, and the type of fisheries in recent decades, few gear conflicts or catchability effects are likely to occur. The most likely occurrence of interactions and impacts is along the route from ports servicing the Project and the Project Area. With the mitigations identified above in place, the effects of Project-related construction / installation and operations / maintenance activities on access to fishing grounds, fishing vessel operations (movements and harvesting), fishing gear, and catachability of commercial species within the Offshore Project Area during construction and installation will be not significant. This also applies to potential expansion opportunities which would be accorded the similar mitigations.

Like the construction Safety Zone, the permanent platform Safety Zone will not occupy an area typically used as harvesting grounds so there should be no reduction in fishing income as a result of its presence. For issues related to traffic along the route from ports servicing the platform, and for any surveys, the mitigations identified above will be in place. Consequently the effects of Project-related activities on access to fishing grounds, fishing vessel operations, fishing gear and catachability of commercial species within the Offshore Project Area during operations and maintenance (including potential expansion opportunities) will be not significant.

Economic effects from accidental events, including hydrocarbon spills (caused by loss of access, gear damage or changes in market value) could be considered significant to the commercial fisheries. However, the application of appropriate mitigative measures (e.g., compensation plan) would reduce the potential impact to not significant. The same is true for gear damage sustained because of debris release, with the FGCP in place.

The cooperative development of appropriate and mutually agreed protocols and procedures through the One Ocean Working Group will minimize future economic impacts, and cumulative environmental effects would be not significant.

8.5.5 Determination of Significance

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Commercial Fisheries, after taking into account any proposed mitigation, is summarized in Table 8-17.

Table 8-17 Residual Environmental Effects Summary: Commercial Fisheries

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Environmental Effects	NS	3	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

The potential environmental effects of the Project on Fish and Fish Habitat are not considered of sufficient geographic extent, magnitude, duration, frequency and/or reversibility to have a measurable effect on commercial fishing incomes. Therefore, the potential environmental effects of the Hebron Project on Commercial Fisheries are predicted to be not significant.

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9 MARINE BIRDS

The Marine Birds Valued Ecosystem component (VEC) includes species of birds that typically use the nearshore / coastal marine and offshore environments. The groups considered under the Marine Birds VEC are waterfowl (geese and ducks), cormorants, fulmars and other shearwaters, storm-petrels, gannets, phalaropes and other shorebirds, larids (jaegers, skuas, gulls, and terns), stercorariids (jaegers, skuas), and alcids (e.g., Dovekie (Alle alle), murres, and Atlantic puffin (Fratercula arctica)).

9.1 Environmental Assessment Boundaries

9.1.1 Spatial and Temporal

9.1.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Section 4.3.2). The Study Areas and Project Areas are illustrated in Figures 9-1 and 9-2, for the nearshore and offshore, respectively. The Affected Areas for several Project activities have been determined by modelling (see AMEC 2010; ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

9.1.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Chapter 4). The nearshore and offshore temporal boundaries are summarized in Table 9-1.

Table 9-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

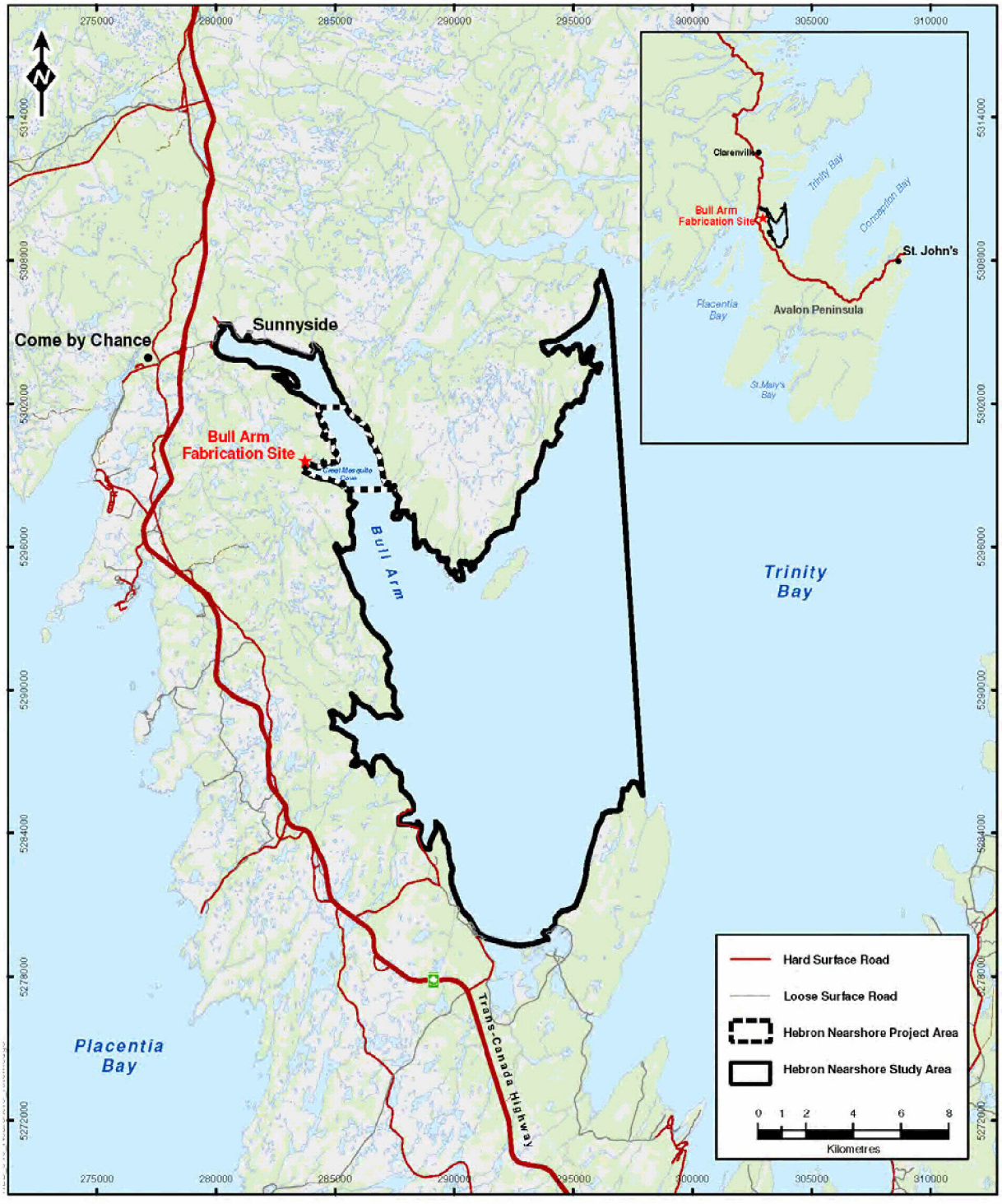

Figure 9-1 Hebron Nearshore Study and Project Areas

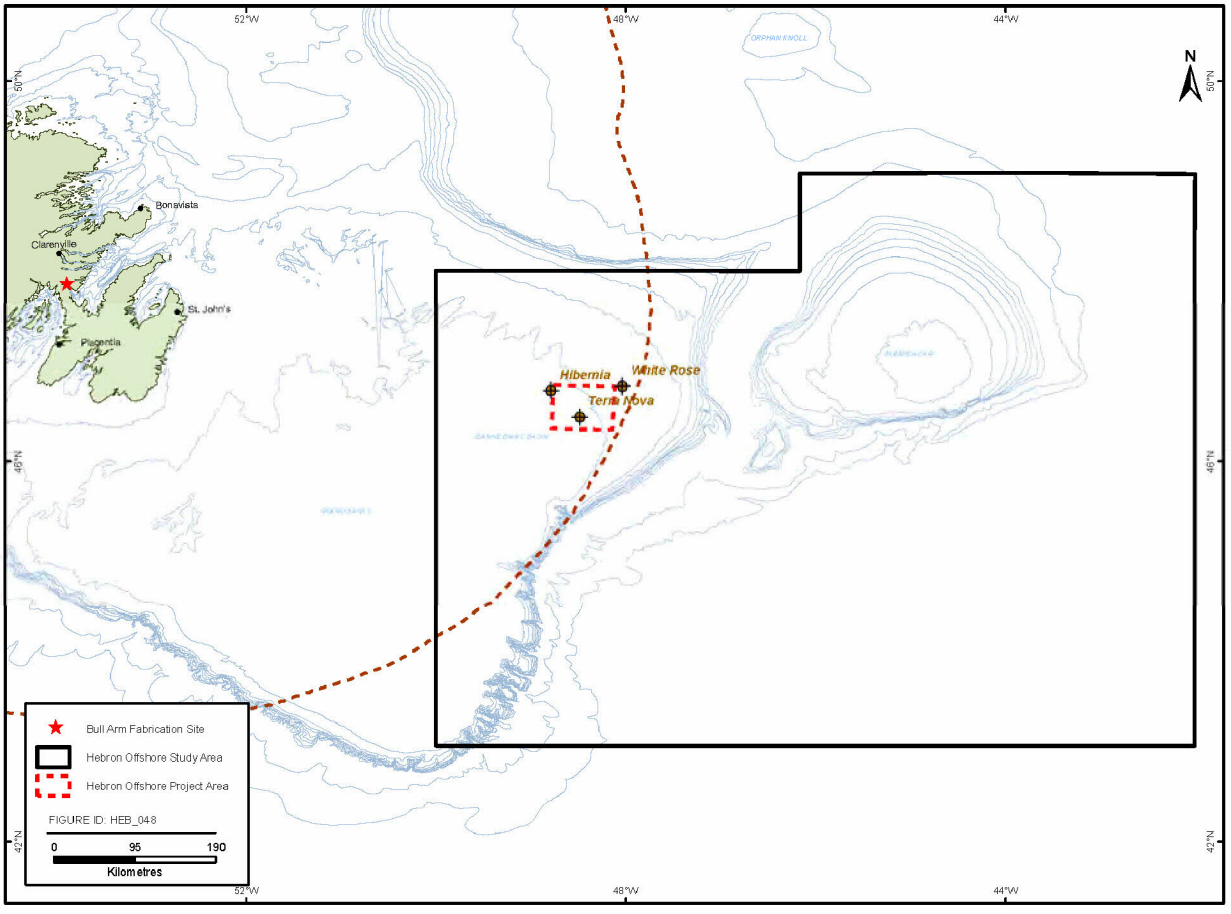

Figure 9-2 Offshore Study and Project Areas

9.1.2 Administrative

Most migratory and many non-migratory bird species are protected under the federal Migratory Birds Convention Act, 1994. The Act states, in part, that "No person or vessel shall deposit a substance that is harmful to migratory birds, or permit such a substance to be deposited, in waters or an area frequented by migratory birds or in a place from which the substance may enter such waters or such an area." Bird species at risk are protected under the Species at Risk Act (SARA) (refer to Section 11.6).

9.2 Definition of Significance

A significant adverse residual environmental effect is one that affects marine birds by causing a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

An adverse environmental effect that does not meet one of the above criteria is evaluated as not significant.

9.3 Existing Conditions

9.3.1 Nearshore

Bull Arm is a steep-sided narrow arm near the bottom of Trinity Bay. Most of the shoreline is rocky and treed to the high tide mark before dropping off into relatively deep water. The tidal zone is mostly narrow and rocky. Habitat for shorebirds (Charadriiformes), such as shoreline deposits of fine sediments and tidal flats, is limited in the Nearshore Study Area. The rocky cliffs could provide nesting habitat for Black Guillemot (Cepphus grylle). Bald Eagles (Haliaeetus leucocephalus) nest in Trinity Bay and may nest in trees near the shoreline of Bull Arm. Gull and tern species (i.e., Common Tern (Sterna hirundo), Arctic Tern (Sterna paradisaea), Herring Gull (Larus argentatus) and Great Black-backed Gull (Larus marinus)) are common throughout coastal Newfoundland, probably include Bull Arm as part of a feeding area and may also nest in small numbers. There are no known concentrations of seaducks (Anatidae) in the winter, summer or during migration in the Nearshore Study Area. Bull Arm is sheltered from the open waters of Trinity Bay, where Dovekie and Thick-billed Murre (Uria lomvia) are known to occur in considerable numbers during the winter months (Lock et al. 1994).

Bellevue Beach, located at the southern boundary of the Nearshore Study Area, provides important habitat for marine birds. A strong tidal current flowing over a mud flat at the south end of Bellevue Beach creates a rich marine habitat. Gulls, terns, shorebirds and Ospreys (Pandion haliaetus) are common here in season. Great Black-backed, Herring and Ring-billed Gulls (Larus delawarensis) feed in the tidal currents and on the tidal flats at low tide. There is a nesting colony of gulls and terns on Bellevue Island, 0.5 km from the tidal flats. In 1989, 1,100 nests of Ring-billed Gull were recorded on Bellevue Island (Cairns et al. 1989). Smaller numbers of Great Black-backed and Herring Gulls, and Common and Arctic Terns also nest on this island (Cairns et al. 1989). Significant numbers of Osprey hunt for fish in the tidal currents; up to 20 Osprey have been observed hovering in the air above the rip tide at one time (B. Mactavish, LGL Ltd., unpublished observations, August 26, 2009). Approximately 15 species of migrating shorebirds, including the Red Knot (Calidris canutus), occur regularly on the Bellevue Beach tidal flats during south bound migration (July to October; Table 9-2). The rufa subspecies of Red Knot is currently listed as Endangered by the Committee on the Status of Endagered Wildlife in Canada (COSEWIC). This species is described in more detail in Section 11.3.3.1.

Table 9-2 Shorebirds Regularly using Bellevue Beach in the Nearshore Study Area

Species	Scientific Name	Season of Occurrence	Status in Nearshore Study Area
Black-bellied Plover	(Pluvialis squatarola)	Aug-Nov	migrant
American Golden-Plover	(Pluvialis dominica)	Aug-Oct	migrant
Semipalmated Plover	(Charadrius semipalmatus)	Jun-Oct	migrant and summer visitor
Spotted Sandpiper	(Actitis macularius)	May-Sep	migrant and local breeder
Greater Yellowlegs	(Tringa melanoleuca)	May-Oct	migrant and may breed locally

Species	Scientific Name	Season of Occurrence	Status in Nearshore Study Area
Lesser Yellowlegs	(Tringa flavipes)	Aug-Oct	migrant
Hudsonian Godwit	(Limosa haemastica)	Aug-Oct	migrant
Ruddy Turnstone	(Arenaria interpres)	Jul-Oct	migrant
Red Knot	(Calidris canutus rufa)	Aug-Oct	migrant
Sanderling	(Caldris alba)	Jul-Oct	migrant
Semipalmated Sandpiper	(Caldris pusilla)	Jul-Oct	migrant
Least Sandpiper	(Caldris minutilla)	Jun-Sep	migrant
White-rumped Sandpiper	(Caldris fuscicollis)	Jul-Nov	migrant
Pectoral Sandpiper	(Caldris melanotos)	Aug-Oct	migrant
Short-billed Dowitcher	(Limnodromus griseus)	Jul-Sep	migrant

9.3.2 Offshore

The Hebron Offshore Study Area includes portions of the Grand Banks, Flemish Pass and Flemish Cap; however, much of the Study Area is off the Grand Banks. Those features include shelf, slope and deep-water habitats, as well as cold Labrador Current and warm Gulf Stream waters, all of which influence the distribution and abundance of marine birds. Marine birds are not spread evenly over the ocean but tend to be concentrated over anomalies such as shelf edges and areas where currents mix. Mixing in the water column at these edges creates a productive environment for plankton, which is the base of marine food webs.

The Grand Banks Shelf and Slope are rich in abundance and diversity of marine birds (Brown 1986; Lock et al. 1994) throughout the year. The food resources of the Grand Banks support many locally breeding birds. Several million marine birds nest along the coasts of the Avalon Peninsula and elsewhere along southeastern Newfoundland, and forage on the Grand Banks during and following the nesting season. In addition to local breeding birds, there are many non-breeding marine birds on the Grand Banks during the summer months. Most of the world's population of Greater Shearwater (Puffinus gravis) is thought to migrate to the Grand Banks and eastern Newfoundland to moult and feed during summer months after completion of nesting in the Southern Hemisphere. During the winter months, marine birds from the Arctic and subarctic of eastern Canada, and from Greenland, gather on the Grand Banks. All species of marine birds require more than a single year to become sexually mature. Many of those non-breeding sub-adult marine birds, especially Northern Fulmars (Fulmarus glacialis) and Black-legged Kittiwakes (Rissa tridactyla), are present on the Grand Banks year-round.

Little is known about the occurrence of birds in the deeper waters of the southeastern portions of the Offshore Study Area, away from the shelf and slope. However, such habitats typically are less productive and thus support far fewer numbers and variety of marine birds than the shelf and slope.

9.3.2.1 Data Sources and Survey Effort for Marine Birds in the Study Area

Most data on the occurrence of marine birds in the Offshore Study Area from the Grand Banks Shelf and Slope and Orphan Basin include the June through September period. Marine bird surveys conducted by environmental observers on offshore installations in the Terra Nova field during 1999 to 2009 fill in some of the data gaps for the October to May period. There are data gaps for all seasons for the Flemish Cap, the deep waters east of the Flemish Cap and southeast of the Grand Banks (see below). The principal sources of data in the Offshore Study Area are surveys conducted by the Canadian Wildlife Service (CWS), and by biologists onboard seismic vessels as part of a marine mammal and marine bird monitoring program required by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB).

Most of the information available up to 2000 was collected by the CWS through PIROP (Programme intégré de recherches sur les oiseaux pélagiques). Those data have been published for 1969 to 1983 (Brown 1986), and up to the early 1990s (Lock et al. 1994). The PIROP survey coverage within and around the Offshore Study Area is presented in Figure 9-3, which is derived from maps in Lock et al. (1994). PIROP marine bird data are of birds per linear kilometre. In 2006, the CWS resumed surveying marine bird abundance and distribution and those recent data have become available for the years 2006 to 2009 (Fifield 2009). New survey protocols (see Wilhelm et al. in prep.) based on the Tasker survey method (Tasker et al. 1984) were used to collect these recent data, which allow for the derivation of density estimates.

Systematic marine bird observations (Tasker surveys; Tasker et al. 1984) were conducted on the northern Grand Banks and the adjacent Orphan Basin from 2004 to 2008. The results of those surveys have greatly increased the knowledge base regarding marine bird distribution and diversity in those areas, at least during the warmer months of June through September (Moulton et al. 2005, 2006a; Lang and Moulton 2008; Abgrall et al. 2008a, 2008b, in prep.). Marine bird data from other sources have been summarized for the period 1999 to 2002 by Baillie et al. (2005) and Burke et al. (2005). Tasker surveys provide marine bird data as densities (numbers per km^2). The offshore research and seismic-related cruises on which Tasker surveys and other marine bird observations were conducted are listed in Table 9-3. The geographic distribution of Tasker surveys in and around the Offshore Study Area is illustrated in Figure 9-4.

Marine bird surveys conducted from the drill platform in the Terra Nova field from 1999 to 2009 used variable survey methods from 2-minute to 10-minute counts of all birds within a 300 m radius of the drill platform. Relative abundances, as well as spatial and temporal distribution of marine birds were derived from these data (Suncor unpublished data 2009).

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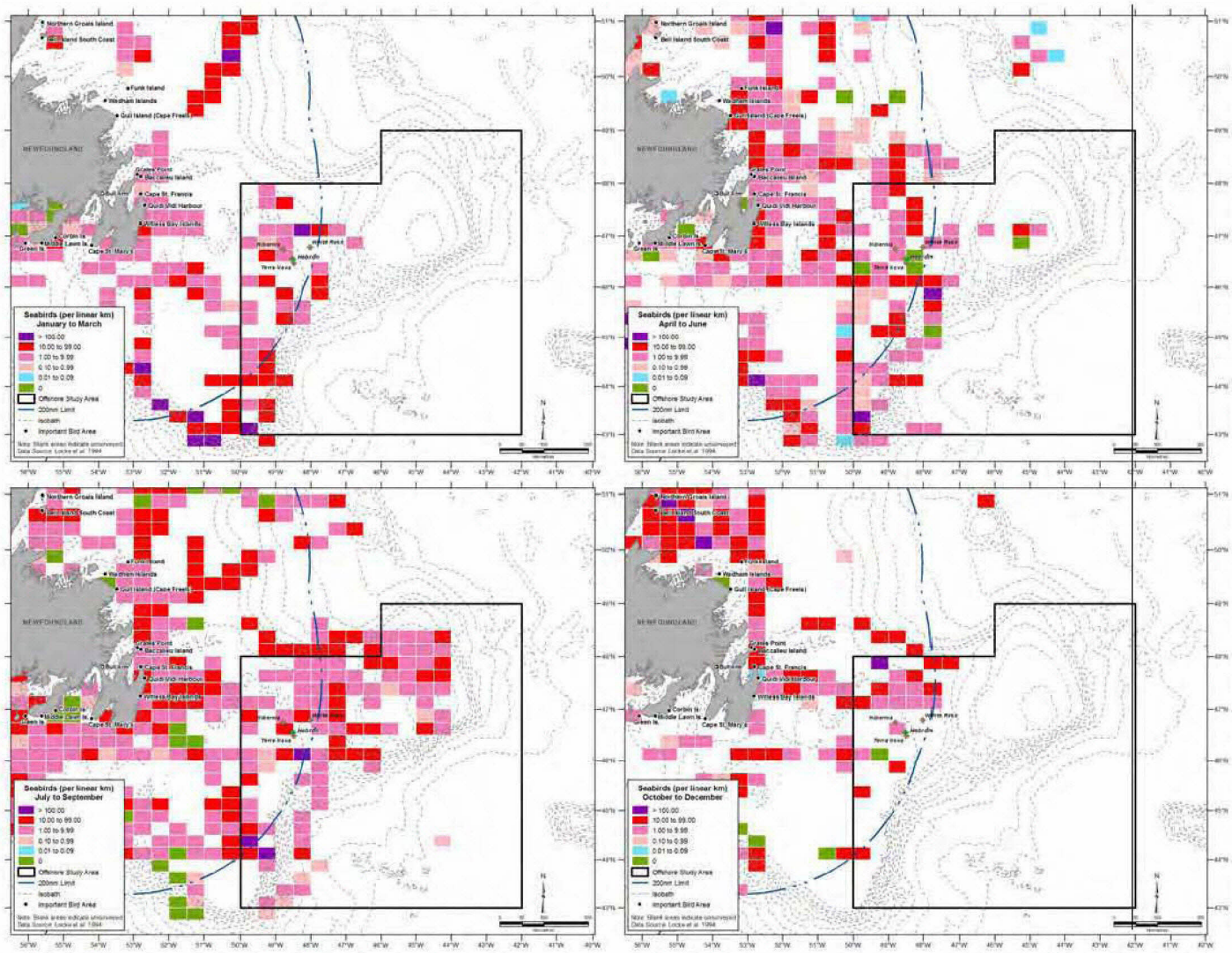

Figure 9-3 Geographic and Seasonal Distribution of Canadian Wildlife Service PIROP Survey Effort and Results in and around the Offshore Study Area

Table 9-3 Recent Seismic, Controlled-source Electromagnetic and Research Cruises in and around the Offshore Study Area during which Marine Bird Observations were Conducted by Biologists (2004 to 2008)

Project	Time Period	Location (Relative to Project Area and/or Study Area)	Approximate Water Depth (m)	Species with Highest Relative Abundances during Observations
CCGS Hudson Research Expedition	June 2004	South Grand Banks (southwestern Study Area)	< 100	Greater Shearwater
CCGS Hudson Research Expedition	June 2004	Salar Basin (southwestern Study Area)	> 1,000	Greater Shearwater Northern Fulmar
CCGS Hudson Research Expedition	June 2004	Western Slope of Southern Flemish Pass (north-central Study Area)	~ 500	Northern Fulmar Greater Shearwater Sooty Shearwater
CCGS Hudson Research Expedition	June 2004	Sackville Spur (northeast of Study Area)	~ 1,000	Northern Fulmar Greater Shearwater Great Black-backed Gull
CCGS Hudson Research Expedition	June-July 2004	Orphan Basin (north of Study Area)	> 2,000	Northern Fulmar Greater Shearwater Great Black-backed Gull Leach's Storm-Petrel
CCGS Hudson Research Expedition	July 2004	North Grand Banks (northwestern Study Area)	200-1,000	Greater Shearwater Manx Shearwater
Seismic Program for Chevron Canada Resources and ExxonMobil Canada Limited	June-September 2004	Orphan Basin (north of Study Area)	1,850-2,500	Northern Fulmar Greater Shearwater Leach's Storm-Petrel Sooty Shearwater Black-legged Kittiwake (Aug-Sept)
Seismic Program for Chevron Canada Resources and ExxonMobil Canada Limited	May-September 2005	Orphan Basin (north of Study Area)	1,108-2,747	Northern Fulmar Leach's Storm-Petrel Greater Shearwater Black-legged Kittiwake, Dovekie, and Thick-billed Murre (May-June) Great Black-backed Gull (Aug-Sept)
Seismic Program for Husky Energy Inc.	October-November 2005	Approximately 75 km northwest of Terra Nova FPSO (northwestern Study Area)	68-376	Northern Fulmar Dovekie Black-legged Kittiwake Thick-billed Murre
Petro-Canada`s Terra Nova Hull Cleaning	May-June 2006	46 km radius around Terra Nova FPSO	65-190	Leach's Storm-Petrel
Seismic Program for Husky Energy Inc.	July-August 2006	1) 95 km north and 2) 15 km east of Terra Nova FPSO	86-387	Greater Shearwater Leach's Storm-Petrel
CSEM Program for ExxonMobil Canada Limited	August-September 2006	Orphan Basin (north of Study Area)	2,076-2,603	Greater Shearwater Leach's Storm-Petrel Black-legged Kittiwake Northern Fulmar
Seismic Program for Petro-Canada	June-July 2007	Approximately 17 km northwest of Terra Nova FPSO (northwestern Study Area)	61-171	Greater Shearwater Northern Fulmar Leach's Storm-Petrel
CSEM Program for ExxonMobil Canada Limited	July-September 2007	Orphan Basin (north of Study Area)	1,122-2,789	Leach's Storm-Petrel Greater Shearwater Northern Fulmar
Seismic Program for Petro-Canada, StatOil Hydro, and Husky Energy Inc.	May-September 2008	Jeanne d'Arc Basin	66-119	Greater Shearwater Northern Fulmar Leach's Storm-Petrel
Sources: Lang and Moulton (2004, 2008); Moulton et al. (2005, 2006a); Lang et al. (2006); Lang (2007); Abgrall et al. (2008a, 2008b, in prep.)				

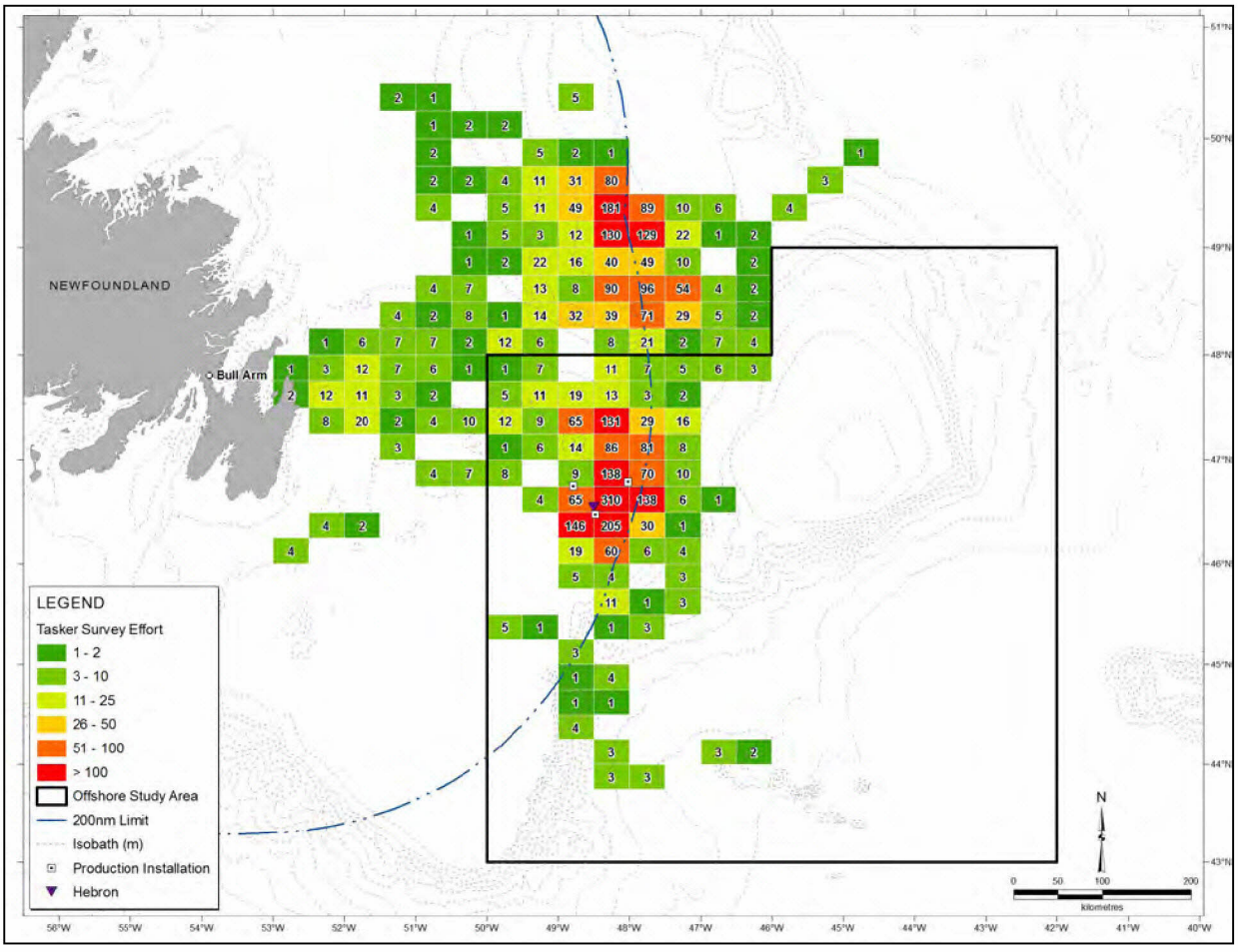

Figure 9-4 Geographic Distribution of Tasker Surveys (number of 10-minute counts) Conducted during 2004 through 2008 in and around the Offshore Study Area

9.3.2.2 General Patterns of Marine Bird Occurrence in the Offshore Study Area

The following description of marine bird occurrence in the Offshore Study Area pertains primarily to the Grand Banks (shelf and slope) and the Orphan Basin. Those are the areas where sufficient survey effort has been conducted to describe patterns of marine bird occurrence with reasonable confidence. Little is known about the distribution and abundance of marine birds in other parts of the Offshore Study Area.

The Grand Banks (shelf and slope) are known to support large numbers and diversity of marine birds at all seasons (Brown 1986; Lock et al. 1994). This is likely true of the Flemish Cap and its slopes as well, given that the same factors promoting increased productivity (upwelling and mixing) are present. In all seasons, densities of birds generally are higher along the shelf break. Approximately 27 species of marine birds occur annually on the Grand Banks in at least small numbers. The species and general monthly abundance expected on the Continental Shelf and slope waters of the Offshore Study Area are listed in Table 9-4.

The highest densities and diversity occur during the July to September period (Brown 1986; Lock et al. 1994). This is the period when there is the combination of non-breeding summering species (e.g., Greater Shearwater), plus post-breeding local nesters that have moved to the offshore from coastal colonies (e.g., Leach's Storm-petrel (Oceanodroma leucorhoa), Black-legged Kittiwake). The lowest densities occur during the winter months, December through March. Nevertheless, the Grand Banks support hundreds of thousands of birds even during winter. Large numbers of Arctic-breeding Thick-billed Murre, Dovekie, Northern Fulmar and Black-legged Kittiwake migrate to eastern Newfoundland, including the Grand Banks, for the winter. During migration periods (April-May; September-November), other marine birds (e.g., jaegers, terns, phalaropes) migrate north in spring and south in autumn over the Grand Banks between breeding sites in the Arctic (Canada and Greenland) and wintering areas in more southern latitudes.

The only species of eastern offshore marine bird that is listed under SARA is the Ivory Gull (Pagophila eburnea). This species is currently listed as "Endangered" on Schedule 1. It is likely rare and of less than annual occurrence in the Offshore Study Area (see Section 11.3.3.2 for more details).

9.3.2.3 Marine Bird Nesting Colonies Along Southeastern Newfoundland

Enormous numbers of marine birds nest on the Avalon Peninsula. The marine bird breeding colonies on Baccalieu Island, the Witless Bay Islands and Cape St. Mary's are among the largest in Atlantic Canada. More than 4.6 million pairs nest at these three locations (Table 9-5 and Figure 9-5). That includes the largest Atlantic Canada colonies of Leach's Storm-Petrel (3,336,000 pairs on Baccalieu Island), Black-legged Kittiwake (43,927 pairs on Witless Bay Islands), Thick-billed Murre (1,000 pairs at Cape St. Mary's) and Atlantic Puffin (216,000 pairs Witless Bay Islands). No marine bird nesting colonies are located within either the Nearshore or Offshore Study Areas, so these sites are not discussed within the Sensitive or Special Areas VEC. They are included here as part of the life histories of the species and populations that may occur with the Study Areas.

All these birds feed on the Grand Banks during the nesting and/or post-nesting seasons (May to September). In addition, Funk Island, located 150 km northwest of the Grand Banks, supports the largest colony of Common Murre in Atlantic Canada. Many of these birds would reach the northern Grand Banks during the breeding season.

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Table 9-4 Monthly Abundance of Bird Species Occurring on Continental Shelf Waters within and around the Offshore Study Area

Common Name	Scientific Name	Monthly Abundance											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Procellariidae													
Northern Fulmar	Fulmarus glacialis	C	C	C	C	C	C	U-C	U-C	C	C	C	C
Greater Shearwater	Puffinus gravis					U	C	C	C	C	C	S	
Sooty Shearwater	Puffinus griseus					S	S-U	S-U	S-U	S-U	S-U	S	
Manx Shearwater	Puffinus puffinus				S	S	S	S	S	S	S		
Hydrobatidae													
Leach's Storm-Petrel	Oceanodroma leucorhoa				U-C	U-C	U-C	U-C	U-C	U-C	U-C	S	
Wilson's Storm-Petrel	Oceanites oceanicus						S	S	S	S			
Sulidae													
Northern Gannet	Morus bassanus				S	S	S	S	S	S	S		
Phalaropodinae (Scolopacidae)													
Red Phalarope	Phalaropus fulicarius					S	S	S	S	S	S		
Red-necked Phalarope	Phalaropus lobatus					S	S	S	S	S			
Laridae													
Herring Gull	Larus argentatus	S	S	VS	VS	VS	VS	VS	VS	S	S	S	S
Iceland Gull	Larus glaucoides	S	S	S	S							S	S
Lesser Black-backed Gull	Larus fuscus					VS	VS	VS	VS	VS	VS	VS	VS
Glaucous Gull	Larus hyperboreus	S	S	S	S						S	S	S
Great Black-backed Gull	Larus marinus	U	U	VS	VS	VS	VS	VS	U	U	U	U	U
Ivory Gull	Pagophila eburnea	VS VS?	VS	VS	VS								
Black-legged Kittiwake	Rissa tridactyla	C	C	C	C	S	S	S	S	S	C	C	C
Arctic Tern	Sterna paradisaea					S	S	S	S	S			
Stercorariidae													
Great Skua	Stercorarius skua					S	S	S	S	S	S		
South Polar Skua	Stercorarius maccormicki					S	S	S	S	S	S		
Pomarine Jaeger	Stercorarius pomarinus					S	S	S	S	S	S		
Parasitic Jaeger	Stercorarius parasiticus					S	S	S	S	S	S		
Long-tailed Jaeger	Stercorarius longicaudus					S	S	S	S	S			

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Common Name	Scientific Name	Monthly Abundance											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alcidae													
Dovekie	Alle alle	U-C	U-C	U-C	U-C	S	VS	VS	VS	S	C	C	U-C
Murre spp.	Uria spp.	U-C	U-C	U-C	U-C	S-U	S-U	S-U	S-U	U-C	U-C	U-C	U-C
Razorbill	Alca torda				S	S	S	S	S	S	S	S	
Atlantic Puffin	Fratercula arctica				S-U	S	S	S	S	S-U	S-U	S-U	

Notes: C = Common, present daily in moderate to high numbers; U = Uncommon, present daily in small numbers; S = Scarce, present, regular in very small numbers; VS = Very Scarce, very few individuals or absent. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from 2004, 2005, 2006 and 2007 monitoring studies in the Orphan Basin and Jeanne d'Arc Basin and extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986) and Lock et al. (1994)
Sources: Brown (1986); Lock et al. (1994); Baillie et al. (2005); Moulton et al. (2005, 2006a); Lang et al. (2006); Lang (2007); Lang and Moulton (2008); Abgrall et al. (2008a, 2008b, in prep.); Fifield 2009

Table 9-5 Numbers of Pairs of Marine Birds Nesting at Marine Bird Colonies in Eastern Newfoundland

Species	Wadham Islands	Funk Island	Cape Freels and Cabot Island	Baccalieu Island	Witless Bay Islands	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island
Procellariidae									
Northern Fulmar	-	46[A]	-	12[A]	22[A,F]	Present[A]	-	-	-
Manx Shearwater	-	-	-	-	-	-	13[K]	-	-
Hydrobatidae									
Leach's Storm-Petrel	1,038[D]	-	250[J]	3,336,000[J]	667,086[H,I,J]	-	13,879[H]	100,000[J]	103,833[M]
Sulidae									
Northern Gannet		9,987[L]		2,254[L]	-	14,789[L]	-	-	-
Laridae									
Herring Gull	-	500[J]	-	Present[A]	4,638[e,j]	Present[J]	20[J]	50[L]	Present[M]
Great Black-backed Gull	Present[D]	100[J]	-	Present[A]	166[E,J]	Present[J]	6[J]	25[J]	-
Black-legged Kittiwake	-	100[N]	-	12,975[J]	23,606[F,J]	10,000[J]	-	50[J]	-
Arctic and Common Terns	184[L]	-	250[J]	-	-	-	-	-	-
Alcidae									
Common Murre	-	412,524[C]	10,000[L]	1,697[L]	83,001[F,J]	15,484[J]	-	-	-
Thick-billed Murre		250[J]	-	216[L]	600[J]	1,000[J]	-	-	-
Razorbill	273[D]	200[J]	25[J]	352[L]	676[F,J]	100[J]	-	-	-
Black Guillemot	25[J]	1[J]	-	100[J]	20+[J]	Present[J]	-	-	-
Atlantic Puffin	6,190[D]	2,000[J]	20[J]	30,000[J]	272,729[F,G,J]	-	-	-	-
TOTALS	7,902	426,268	3,145	3,385,080	1,052,546	32,256	13,918	105,075	65,280

Sources: [A] Stenhouse and Montevecchi (1999a); [B] Chardine (2000); [C] Chardine et al. (2003); [D] Robertson and Elliot (2002); [E] Robertson et al. (2001); [F] Robertson et al. (2004); [G] Rodway et al. (2003); [H] Robertson et al. (2002); [I] Stenhouse et al. (2000); [J] Cairns et al. (1989); [K] Robertson (2002); [L] CWS (unpublished Data); [M] Russell (2008); [N] Nettleship (1980)

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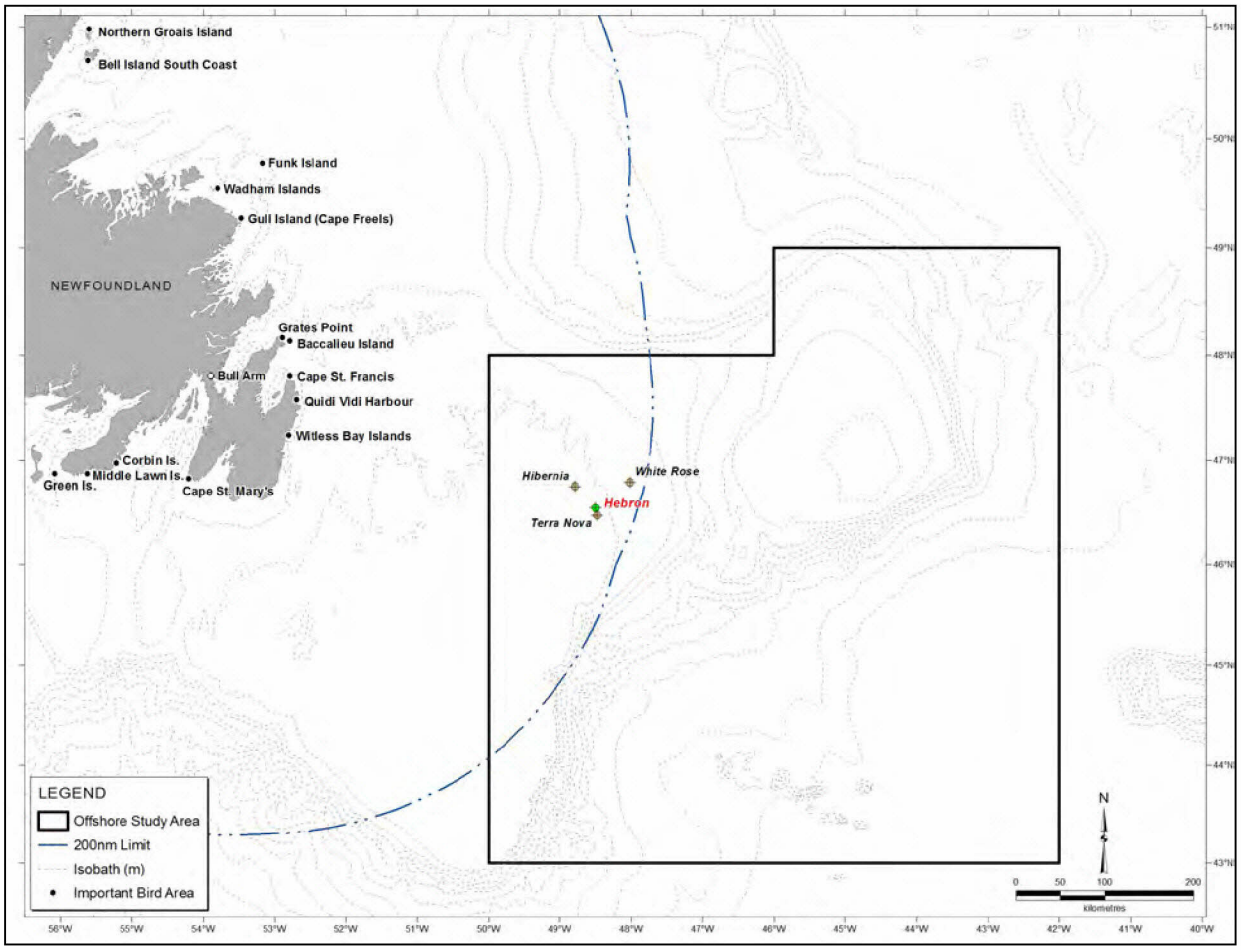

Figure 9-5 Map of Important Bird Areas including Marine Bird Colonies along Southeastern Newfoundland

There are nine marine bird nesting sites on the southeast coast of Newfoundland from Cape Freels to the Burin Peninsula meeting the criteria for an Important Bird Area (IBA) (an IBA is a site that provides essential habitat for one or more species of breeding or non-breeding birds) (Figure 9-5). In addition, Grates Point, Mistaken Point and Placentia Bay qualify as IBAs because of important wintering populations of Common Eider (Somateria mollissima). A total of 5.2 million pairs of birds breed at these sites. The Study Area is well beyond the foraging range of breeding birds during the breeding season, approximately May to August. At Witless Bay, Common Murres forage up to 200 km from the breeding site but usually only 50 to 100 km (Cairns et al. 1990, in Gaston and Jones 1998). However, during post-breeding dispersal, the Study Area is within range of all marine birds breeding in eastern Newfoundland and Labrador.

9.3.2.4 Species Profiles

The world range, and seasonal occurrence and abundance of marine birds in the Study Area are described in this section. The monthly abundance status for each species is summarized in Table 9-4. Information was derived primarily from Brown (1986), Lock et al. (1994), Baillie et al. (2005), and Abgrall et al. (2008a, 2008b, in prep.).

Procellariidae (Fulmars and Shearwaters)

Northern Fulmar and the four species of shearwaters that are expected to occur in the area feed on a variety of invertebrates, fish and zooplankton at or very near the surface. Capelin is an important food source for shearwaters. Shearwaters secure their prey by swimming on the surface and picking at items on the surface, or dipping their heads under the water. They are also capable of diving a short distance under the surface, probably no more than 1 m or so. They may do this by flying low over the water and then plunging into the water with enough force to get them below the surface for a few seconds, or dive from a sitting position.

Northern Fulmar

Northern Fulmar is common in the Offshore Study Area all year. The Northern Fulmar breeds in the North Atlantic, North Pacific and Arctic oceans. In the Atlantic Ocean, it winters south to North Carolina and southern Europe (Brown 1986; Lock et al. 1994). Through band recoveries, it is known that most individuals in Newfoundland waters are from Arctic breeding colonies. Adults and sub-adult birds are present in the winter with sub-adults remaining through the summer. Fewer than 100 pairs breed in eastern Newfoundland (Cairns et al. 1989). Fulmars were found to be most numerous during spring and autumn 1999 to 2002 on the northeast Grand Banks, based on observations from drill rigs (Baillie et al. 2005).

Results from seismic monitoring programs indicate that Northern Fulmar is much less common on the Jeanne d'Arc Basin during spring and summer than during fall and winter, or in deep water areas such as Orphan Basin at all times of the year (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.; Suncor unpublished data).

Cory's Shearwater

Cory's Shearwater (Calonectris diomedea) is rare in the Offshore Study Area and is present during the July to September period. Cory's Shearwater is a subtropical species breeding in the eastern Atlantic Ocean on Azores Island and the Cape Verdes Islands, the Mediterranean and western Indian Ocean. In late summer, small numbers reach the waters off southern Nova Scotia. A few occur in southern Newfoundland waters, including the Grand Banks. Cory's Shearwater was recorded from drill platforms on the northeast Grand Banks, but because of the Cory's similarity in appearance to the abundant Greater Shearwater, the actual numbers of Cory's observed is unclear (Baillie et al. 2005; Suncor unpublished data).

Cory's Shearwater was not identified during seismic or controlled-source electromagnetic (CSEM) monitoring programs in the Jeanne d'Arc Basin or Orphan Basin.

Table 9-6 Average Densities of Marine Birds by Week Recorded during 10-minute Marine Bird Counts

Species	Average Density (number of individuals per km²) per 10-minute Observation Period						
	1-7 Oct.	8-14 Oct.	15-21 Oct.	22-28 Oct.	29 Oct. - 4 Nov.	5-8 Nov.	All weeks combined
Northern Fulmar	3.07	25.57	4.35	34.17	10.00	10.77	14.72
Dovekie	1.53	5.07	10.14	13.58	7.07	4.16	7.09
Black-legged Kittiwake	1.16	8.38	11.76	8.97	4.29	5.78	6.57
Thick-billed Murre	0	1.86	5.01	4.16	7.41	9.58	4.11
Greater Shearwater	11.82	1.71	0.45	0	0	0	2.87
Atlantic Puffin	0.86	1.73	2.37	1.34	1.65	0.51	1.46
Common Murre	1.05	0.88	1.52	0.83	0.05	0.20	0.81
Great Black-backed Gull	0.25	1.59	0.65	0.67	0.51	0.46	0.68
Leach's Storm-Petrel	1.02	0.39	0.46	0.54	0.04	0	0.47
Sooty Shearwater	0.19	1.03	0.50	0.61	0	0	0.40
Glaucous Gull	0	0	0.06	0.50	0.04	0.48	0.16
Herring Gull	0.04	0.05	0.00	0.06	0.20	0.76	0.13
Pomarine Jaeger	0.21	0	0	0	0	0	0.04
Jaeger sp.	0.08	0	0	0.07	0	0	0.03
Murre sp.	0	0.05	0.04	0.08	0	0	0.03
Northern Gannet	0.07	0	0	0	0.09	0	0.03
Razorbill	0.14	0	0	0	0	0	0.03
Iceland Gull	0	0	0	0	0.05	0.09	0.02
Lesser Black-backed Gull	0	0.12	0	0	0	0	0.02
Parasitic Jaeger	0	0.05	0	0.04	0	0	0.02
Red Phalarope	0.07	0	0	0.04	0	0	0.02
Skua sp.	0	0.05	0.05	0	0	0	0.02
Great Skua	0	0	0.05	0	0	0	0.01
Manx Shearwater	0	0	0	0.04	0	0	0.01
South Polar Skua	0.03	0	0	0	0	0	0.01
All species	21.7	48.6	37.4	65.7	31.4	32.8	39.8

Source: Abgrall et al. (2008a)
Note: Recorded in the Seismic Analysis Area and adjacent areas where the Western Neptune sailed, October 1 to November 8, 2005, arranged in order of decreasing density

Table 9-7 Average Densities of Marine Birds by Week Recorded during 10-minute Marine Bird Counts

Species	Average Density (number of individuals per km²) per 10-minute Observation Period						
	9-16 July	17-23 July	24-30 July	31 July - 6 Aug.	7-13 Aug.	14-16 Aug.	All Weeks Combined
Greater Shearwater	2.54	7.04	4.33	8.90	1.57	0.62	5.06
Leach's Storm-Petrel	1.15	0.17	0.24	0.41	0.42	0.10	0.60
Northern Fulmar	0.15	0.05	0.05	0	0	0.05	0.07
Sooty Shearwater	0.07	0	0.05	0.02	0.03	0	0.04
Atlantic Puffin	0.12	0	0	0	0	0	0.03
South Polar Skua	0	0	0.05	0.05	0	0	0.02
Common Murre	0.08	0	0	0	0	0	0.02
Skua sp.	0	0	0.05	0	0	0	0.01
Red Phalarope	0	0	0.10	0	0	0	0.01
Pomarine Jaeger	0	0	0.05	0	0.03	0	0.01
Northern Gannet	0	0	0	0.02	0	0	0.01
Murre sp.	0	0.05	0	0.03	0	0	0.01
Manx Shearwater	0.02	0	0	0.03	0	0	0.01
Great Black-backed Gull	0	0	0	0	0	0.03	0.01
Dovekie	0	0	0	0.03	0	0	0.01
Black-legged Kittiwake	0	0	0	0	0	0.05	0.01
All Species	4.14	7.32	4.91	9.49	2.03	0.85	5.93

Source: Abgrall et al. (2008a)
Note: Recorded in the Seismic Analysis Area and adjacent areas where the Western Regent sailed, July 9 to August 16, 2006, arranged in order of decreasing density

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Table 9-8 Average Densities of Marine Birds Bi-monthly Recorded during 10-minute Marine Bird Counts

Species	Average Density (number of individuals per km²) per 10-minute Observation Period									
	21-31 May	1-15 June	16-20 June	1-15 July	16-31 July	1-15 Aug.	16-31 Aug.	1-15 Sept.	16-29 Sept.	Grand Total
Greater Shearwater	0.05	2.11	15.07	26.65	19.93	24.27	9.81	9.04	3.18	11.92
Sooty Shearwater	0	0.33	1.04	0.25	0.1	0.07	0.53	6.06	3.98	1.65
Northern Fulmar	0.08	0.18	3.54	0.15	0.26	0.57	1.02	1.41	3.03	1.24
All murres	1.1	0.25	0.46	0.31	0.29	0.02	0.88	1.61	3.57	1.02
Leach's Storm-Petrel	0.22	0.13	0.21	0.21	0.97	0.57	0.49	1.49	2.92	0.9
Common Murre	0.72	0.09	0.28	0.31	0.24	0	0	1.51	3.42	0.84
Unidentified Murre	0.38	0.12	0.18	0	0.03	0.02	0.88	0.08	0.15	0.18
Great Black-backed Gull	0	0	0	0	0	0	0.03	0.55	0.52	0.15
Atlantic Puffin	0	0.02	0.13	0.14	0.02	0	0	0.02	0.59	0.11
Manx Shearwater	0	0	0.06	0.14	0.21	0.07	0	0	0	0.05
Pomarine Jaeger	0	0	0	0	0	0.02	0.06	0.12	0.14	0.04
South Polar Skua	0	0	0	0.14	0.03	0.03	0.06	0.04	0	0.03
Great Skua	0	0	0	0.03	0	0	0.03	0.06	0.04	0.02
Northern Gannet	0	0	0	0	0	0	0.16	0.03	0	0.02
Dovekie	0.03	0	0.02	0	0	0	0	0	0.07	0.02
Black-legged Kittiwake	0	0.02	0.07	0	0	0	0.03	0.03	0.02	0.02
Thick-billed Murre	0	0.04	0	0	0.03	0	0	0.02	0	0.01
Red Phalarope	0	0	0	0	0	0	0	0.05	0	0.01
Long-tailed Jaeger	0	0	0	0	0	0	0	0.03	0.02	0.01
Unidentified phalarope	0	0	0	0	0	0	0	0.03	0	0.005
Parasitic Jaeger	0	0	0	0	0	0	0	0.005	0.02	0.003
Wilson's Storm-Petrel	0	0	0	0	0	0	0	0.02	0	0.003
Herring Gull	0	0	0	0	0	0	0	0.02	0	0.002
Unidentified Skua	0	0	0	0	0	0	0.03	0	0	0.002
Unidentified Jaeger	0.03	0	0	0	0	0	0	0	0.02	0.002
Lesser Black-backed Gull	0	0	0	0	0	0	0	0	0.02	0.002
Arctic Tern	0	0	0	0	0	0	0	0	0.02	0.002
All Birds	1.51	3.03	20.6	31.03	21.82	25.63	13.14	20.59	18.12	17.23

Note: Recorded in the Seismic Analysis Area and adjacent areas where the Veritas Vantage sailed, May 21 to September 29, 2008, arranged in order of decreasing density

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Greater Shearwater

The Greater Shearwater breeds on the Tristan de Cunha Islands in the South Atlantic Ocean from October to March. It spends its non-breeding season on the North Atlantic. Greater Shearwater has an important presence on the Grand Banks. A considerable portion of the entire population of approximately 5,000,000 migrate from the Southern Hemisphere breeding sites to feed and moult on the Grand Banks and offshore eastern Newfoundland in June and July (Lock et al. 1994). After moulting, birds remain in the area until early November. Greater Shearwater was the most numerous species observed from drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie et al. 2005). Numbers increased through the summer to a peak in September then decreased rapidly with stragglers into November. Median flock size was usually less than 50 but occasionally up to 1,200.

Results from seismic monitoring programs in the Jeanne d'Arc Basin also indicate that Greater Shearwater is quite abundant during the summer period, with numbers declining in early fall (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep). It was among the most numerous species observed by environmental observers on offshore installations on the Terra Nova oil field during June to September from 1999 to 2009 (Suncor unpublished data).

Sooty Shearwater

Sooty Shearwater (Puffinus griseus) is predicted to be present in the Study Area from May to early November. It is expected to be scarce in May, uncommon from June to October and scarce in early November.

Sooty Shearwater breeds in the south Atlantic and south Pacific Oceans. It spends most of the non-breeding season in the Northern Hemisphere. Some Sooty Shearwaters follow the same migration pattern as Greater Shearwater by migrating north to Canadian waters in spring. Sooty Shearwater is usually outnumbered by Greater Shearwater in eastern Canada (Brown 1986). Numbers peaked at 2.5 birds/day at one drill platform on the northeast Grand Banks 2000 and 2001 (Baillie et al. 2005).

Sooty Shearwater was the second most abundant marine bird species over the course of the 2008 seismic monitoring program in the Jeanne d'Arc Basin; increased densities in September may reflect staging prior to southward migration (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep).

Manx Shearwater

Manx Shearwater (Puffinus puffinus) is scarce in the Offshore Study Area during the April to October period. Manx Shearwater breeds in northeast Atlantic Ocean. It is uncommon in the northwest Atlantic, and has only recently begun nesting in North America. The only known established breeding colony in North America is at Middle Lawn Island off the Burin

Peninsula, Newfoundland, where less than 100 pairs breed (Cairns et al. 1989). Other nest sites in Newfoundland have not been confirmed. Most Manx Shearwater observed in North American waters are probably non-breeding sub-adults and post-breeding birds from European breeding colonies. Manx Shearwater winters in middle latitudes of the Atlantic Ocean. A total of 39 were observed on drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie et al. 2005); this represents <0.1 percent of all the birds recorded.

Manx Shearwater densities averaged <0.1 birds/km^2 per month from May to October during seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b in prep).

Hydrobatidae (Storm-Petrels)

Leach's and Wilson's (Oceanites oceanicus) Storm-Petrels feed on small crustaceans, various small invertebrates, and zooplankton. These storm-petrels usually feed while on the wing, picking small food items from the surface.

Leach's Storm-Petrel

Leach's Storm-Petrel is common in the Offshore Study Area between April and early November. Leach's Storm-Petrel breeds in the north Pacific and North Atlantic Oceans. It winters at the middle latitudes and south of the equator in both oceans. It is a very abundant breeder in eastern Newfoundland, with more than 4,000,000 pairs nesting on islands off the eastern Avalon Peninsula. The largest breeding colony in the world is at Baccalieu Island on the northeast Avalon Peninsula, where over 3.3 million pairs nest (Lock et al. 1994). They range far from breeding colonies to feed. Many non-breeding sub-adults remain at sea through the breeding season. An average of less than one Leach's Storm-Petrel per day was recorded from the drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie et al. 2005). This number is low compared to the numbers of Leach's Storm-Petrels seen from ships in the same area, and may have been a result of the tall height of observers off the water and the lack of persistent use of binoculars for scanning (Ballie et al. 2005). Storm-Petrels are difficult to see because they are dark and fly very low over the water (Ballie et al. 2005).

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 densities ranged from 0.1 to 1.1 birds/km^2 (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep).

Wilson's Storm-Petrel

Wilson's Storm-Petrel is scarce in the Offshore Study Area between June and September. The Wilson's Storm-Petrel breeds in the south Atlantic Ocean and Antarctic. In their non-breeding season (May to October), they migrate north to waters off southern Nova Scotia and Newfoundland. This species is uncommon in Newfoundland waters June to September (Brown 1986).

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 very few were detected (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep).

Sulidae (Gannets)

Northern Gannets (Morus bassanus) feed on cephalopods and small fish including capelin, mackerel, herring and Atlantic saury. They secure prey in spectacular fashion by plunging from a height of up to 30 m above the water and reaching depths of up to 10 m. They pop back to the surface within a few seconds of entering the water.

Northern Gannet is scarce in the Offshore Study Area between April and October, and generally absent from the Offshore Study Area outside that period. The Northern Gannet breeds in the North Atlantic from Canada to Iceland and the British Isles. The species winters at sea south of their breeding range but north of the equator. Approximately 12,000 pairs nest on three colonies in the eastern Newfoundland. Gannets are common near shore and scarce beyond 100 km from shore. The Offshore Project Area is farther off shore than the range of most Northern Gannets.

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 very few were detected (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep).

Phalaropodinae (Phalaropes)

Red-necked (Phalaropus lobatus) and Red (Phalaropus fulicarius) Phalaropes eat zooplankton at the surface of the water. They secure food by swimming and rapidly picking at the surface of the water. These phalarope species are scarce in the Offshore Study Area during the May to October period, and generally absent outside that period.

Both species breed in the Arctic and subarctic of North America and Eurasia. They winter at sea mostly in the Southern Hemisphere. They migrate and feed offshore, including Newfoundland offshore waters during spring and autumn migrations. The two phalaropes are often difficult to distinguish at sea. Red Phalarope usually outnumbers Red-necked Phalarope in Newfoundland waters (Brown 1986). Phalaropes seek out areas of upwelling and convergence where rich sources of zooplankton are found. They are locally numerous along the shelf edges off Newfoundland and Labrador.

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 very few phalaropes were detected (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.).

Laridae (Skuas, Jaegers, Gulls and Terns)

Skuas and jaegers feed by chasing other species of birds until they either drop food or disgorge the contents of their stomachs. This method of securing food is called kleptoparasitism. The Long-tailed Jaeger (Stercorarius longicaudus), the smallest member of this group, also feeds on

small invertebrates and fish that it catches by dipping to the surface of the water while remaining on the wing.

Great Skua and South Polar Skua

These two skua species occur in the Offshore Study Area during the May to October period; they are usually scarce during this period.

The Great Skua (Stercorarius skua) breeds in the North Hemisphere, in Iceland and northwestern Europe. The South Polar Skua (Stercorarius maccormicki) breeds in the Southern Hemisphere from November to March and migrates to the Northern Hemisphere where it is present May to October. Both species occur in Newfoundland waters from May to October. Identifying skuas to species is very difficult at sea. Skuas usually occur where other marine birds are numerous, particularly along shelf edges.

Skuas occurred in such low densities that they were infrequently recorded during systematic surveys on the Jeanne d'Arc Basin in 2005, 2006 and 2008 (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.).

Pomarine Jaeger, Parasitic Jaeger and Long-tailed Jaeger

These three jaeger species are scarce in the Offshore Study Area during the May to October period. All three species of jaeger nest in the subarctic and Arctic in North America and Eurasia. They winter at sea in the Pacific Ocean and Atlantic Ocean. Pomarine (Stercorarius pomarinus) and Parasitic (Stercorarius parasiticus) Jaegers winter mainly south of 35°N, and Long-tailed Jaegers winter mainly south of the equator. The three species of jaeger are relatively easy to identify in adult plumage but very difficult in sub-adult plumages. As a group, their habits are very similar. Adults migrate through Newfoundland waters in spring and fall, while sub-adults often migrate only part way to the breeding grounds and are often present in Newfoundland waters all summer. Like skuas, they are kleptoparasites, primarily targeting the prey of Black-legged Kittiwakes and Arctic Terns. Densities of jaegers, like most predators, are relatively low. Peak numbers occur during migration in May and early June, and September to October.

All three jaeger species were observed in low densities during seismic monitoring programs in the Jeanne d'Arc Basin in 2005, 2006 and 2008 (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.).

Herring, Great Black-backed, Lesser Black-backed, Iceland, and Glaucous Gull

The predicted status in the Offshore Study Area for Herring Gull is scarce throughout the year; Great Black-backed Gull is uncommon from August to February and very scarce from March to July; Glaucous Gull (Larus hyperboreus) is scarce from late October to April; Iceland Gull (Larus glaucoides) is scarce from November to April; and Lesser Black-backed Gull (Larus fuscus) is considered very scarce from May to December.

Herring Gull breeds in northern North America, Europe and northeast Russia and winters in the southern part of its breeding range. The breeding range of the Great Black-backed Gull is restricted to areas surrounding the North Atlantic Ocean. It winters in coastal Canada and Europe. Iceland Gull breeds in northeast Canadian Arctic and Greenland and winters on open coastal waters south to the New England states. Glaucous Gull breeds in the subarctic and Arctic of North America, Greenland and Eurasia and winters within its breeding range and south of it. With the exception of the Great Black-backed Gull, these large gulls are generally rare to scarce far from shore on the Grand Banks.

On drill platforms on the northeast Grand Banks during 1999 to 2002, Great Black-backed Gull was common from September to February and nearly absent from March to August (Baillie et al. 2005). A similar pattern was observed by environmental observers on offshore installations on the Terra Nova oil field from 1999 to 2009 (Suncor, unpublished data). Herring Gulls were present in consistent numbers throughout the year but in lower numbers than Great Black-backed Gulls. Results from seismic monitoring programs in Jeanne d'Arc Basin in 2005, 2006 and 2008 indicate that large gulls were most numerous from mid August to October (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.).

Black-legged Kittiwake

The predicted status of Black-legged Kittiwake in the Offshore Study Area is common from October to May and scarce from June to August and uncommon in September. The Black-legged Kittiwake has a circumpolar breeding range. In Canada, it breeds from the Arctic south to Nova Scotia, and it winters at sea in the northern Pacific Ocean and northern Atlantic Ocean. Black-legged Kittiwake is an abundant marine bird off the Newfoundland coast. Breeding colonies on the Avalon Peninsula and northeast coast of Newfoundland total approximately 77,400 pairs (Cairns et al. 1989). Many of the 4,000,000 pairs that breed in the North Atlantic Ocean spend some time off the east coast of Newfoundland (Brown 1986; Lock et al. 1994). Black-legged Kittiwake is present in all months of the year on the Grand Banks. Observations from the drill platforms on the northeast Grand Banks during 1999 to 2002 showed Black-legged Kittiwakes were present in October to May, but were most prevalent during November to December (Baillie et al. 2005). It was among the most numerous species observed by environmental observers on offshore installations on the Terra Nova oil field during the winter months (Suncor, unpublished data).

During marine bird monitoring programs conducted between May and October, Black-legged Kittiwake was found to be most numerous in October (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.).

Arctic Tern

Arctic Tern is a scarce spring and autumn migrant in the Offshore Study Area, occurring between May and September. The Arctic Tern breeds in subarctic and Arctic regions of North America and Eurasia. In the western Atlantic, its

breeding range includes Newfoundland and extends south to Nova Scotia. The Arctic Tern winters at sea in the Southern Hemisphere. Arctic Terns are migrants at sea through Newfoundland and Labrador waters in spring and autumn. Small numbers of Arctic Terns have been recorded during 2005, 2006 and 2008 seismic monitoring programs in Jeanne d'Arc Basin (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.).

Alcidae (Dovekie, Murres, Black Guillemot, Razorbill and Atlantic Puffin)

Alcids feed by diving and pursuing prey underwater. They eat fish, copepods, amphipods, cephalopods, molluscs, crustaceans and other invertebrates.

Dovekie

The predicted status in the Offshore Study Area is common from October to November and uncommon to common from December to May. Dovekies breed in the North Atlantic, primarily in Greenland and east Nova Zemlya, Jan Mayen and Franz Josef Land in northern Russia. This species winters at sea south to 35°N. The Dovekie is a very abundant bird, with a world population estimated at 30 million (Brown 1986). A large percentage of the Greenland breeding Dovekies winters in the western Atlantic, mainly off Newfoundland (Brown 1986). The low numbers of Dovekies observed from the drill platforms on the northeast Grand Banks 1999 to 2002 was attributed to the difficulty in seeing the small birds from the observation posts (Baillie et al. 2005).

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008, Dovekies were most numerous in May and October (Tables 9-6 to 9-8) (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.). Dovekies were found to be fairly common during marine bird monitoring of Husky's 2005 seismic program (Abgrall et al. 2008a). Densities within the Study Area ranged from 1.0 to 9.9 birds per km² in areas where the majority of 10-minute counts were conducted. Dovekies were first observed on October 3, when 500 individuals were counted. This species was observed daily during October in numbers typically ranging from 100 to 300. Maximum daily totals from incidental sightings were 2,000 on October 13, 1,500 on October 28 and 2,500 on November 4 (Abgrall et al. 2008a, in prep.).

Common Murre

The predicted status for Common Murre in the Study Area is scarce to uncommon throughout the year. The Common Murre breeds in the North Pacific Ocean and North Atlantic Ocean. In the western Atlantic, it winters from southern Newfoundland to Massachusetts. It is an abundant breeder in eastern Newfoundland, with nearly half a million pairs, 80 percent of those on Funk Island (Table 9-5). During breeding season, the Offshore Study Area is probably too far from breeding sites to be used regularly for foraging. In the non-breeding season between August and March, Common Murres are likely to occur on the northern Grand Banks. Due to low density and high difficulty in detecting murres at sea, surveys generally underestimate their numbers.

Common Murre was seen in small numbers almost daily throughout the May to September 2008 seismic monitoring program in Jeanne d'Arc Basin except during the first half of August (Abgrall et al. in prep.). The first adult-chick pair was seen on August 29 and these pairs were common after September 13, with up to 75 individuals (adults and flightless chicks) per day. In October and November 2005, an average density of 0.81 birds/km^2 was observed for Common Murre in Jeanne d'Arc Basin (Abgrall et al. 2008a). Weekly densities derived from 10-minute Tasker counts peaked at 7.5 birds/km² in the third week of October.

Thick-billed Murre

The predicted status of Thick-billed Murre in the Offshore Study Area is uncommon to common from October to April and very scarce to scarce from May to September. Thick-billed Murres breed in subarctic and Arctic areas in North America and Eurasia. In Atlantic Canada, they breed as far south as Newfoundland, and winters in open water within the breeding range and in the western Atlantic south to New Jersey.

The Thick-billed Murre is the winter murre in eastern Newfoundland. Many of the more than 2,000,000 Arctic Canada and Greenland breeders winter in Newfoundland and Labrador waters. The Grand Banks has been identified as an important wintering area for Thick-billed Murres (Brown 1986; Lock et al. 1994). Relatively small numbers (approximately 2,000) breed in eastern Newfoundland (Table 9-5). It is likely that Jeanne d'Arc Basin is part of the main wintering area for Thick-billed Murres in eastern North America.

As expected, only small numbers of Thick-billed Murres were seen on Jeanne d'Arc Basin during the May to September 2008 seismic monitoring program; the birds were primarily seen during May and June (Abgrall et al. in prep.). An average density of 0.01 birds/km^2 was derived from quantitative counts over the course of the seismic monitoring program. The authors report that visible northward migration was apparent on May 7 and 21, 2008 (Abgrall et al. in prep.). Thick-billed Murre was observed almost daily during the October and November 2005 seismic monitoring program in Jeanne d'Arc Basin (Table 9.6) (Abgrall et al. 2008a). The average density was 4.11 birds/km^2 with a peak density of 9.58 birds/km^2 observed during November 5 to 8 (Table 9.6).

Razorbill

The predicted status of Razorbill (Alca torda) in the Offshore Study Area is very scarce from April to November, and likely absent in other months. Razorbills breed in the North Atlantic Ocean in Maine, eastern Canada, Greenland, Iceland and Great Britain. They typically winter south to North Carolina and France. Razorbills are relatively scarce compared to the murres. Most of the 20,000 pairs of breeding in Atlantic Canada are in southeast Labrador (Brown 1986). Approximately 710 pairs breed in eastern Newfoundland (Table 9-5).

Razorbills, for the most part, winter south of Newfoundland from Nova Scotia to North Carolina. They are probably rare or uncommon on the northeastern Grand Banks as a migrant. Observations of Razorbills at sea are often obscured because of the difficulty in differentiating them from the murres.

Atlantic Puffin

The predicted status of Atlantic Puffins in the Offshore Study Area is scarce to uncommon from April to November. The Atlantic Puffin breeds in the North Atlantic in Maine, Nova Scotia, Newfoundland and Labrador, Greenland, Iceland and northwest Europe. Atlantic Puffins are abundant in the North Atlantic with approximately 12,000,000 pairs (Brown 1986). Approximately 320,000 pairs nest in Atlantic Canada, mostly in southeast Newfoundland (Brown 1986). In North America, Atlantic Puffins are thought to winter from southern Newfoundland to southern Nova Scotia.

The Offshore Study Area is probably east of the breeding sites used as foraging areas in the summer. Migrants and post-breeders may use the northern Grand Banks in late summer and early autumn. Only one was observed from the drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie et al. 2005). This was at least partly due to difficulty in detecting them at sea.

During the October to November 2005 seismic monitoring program in Jeanne d'Arc Basin, Atlantic Puffin was observed on 32 of the 39 days with survey effort, daily counts typically ranged from 20 to 50 individuals, and the average density was 1.46 birds/km^2 (Table 9-6) (Abgrall et al. 2008a). Relatively few Atlantic Puffins were reported during summer seismic monitoring programs in Jeanne d'Arc Basin (Tables 9-7 and 9-8) (Abgrall 2008a in prep.).

9.4 Project-Valued Ecosystem Component Interactions

Project activities with similar interactions on Marine Birds have been grouped into four categories to provide a complete and comprehensive environmental effect analysis. Instead of assessing each Project activity separately, the grouping of activities with similar potential effects on Marine Birds, allows for a cumulative assessment of within-Project activities.

The interactions summary categories are:

- Change in Habitat Quantity: Project activities that may result in physical alteration of habitat available to marine birds
- Change in Habitat Quality: Project activities that may result in a change in the biological or physical properties of marine bird habitat
- Change in Habitat Use: Project activities that may result in marine birds changing their behaviour. Some activities may cause avoidance behaviour in birds, whereas other activates may attract some species
- Potential Bird Mortality: Project activities that may result in marine bird mortality

9.4.1 Nearshore

9.4.1.1 Nearshore Project Activities

Nearshore Project activities have the potential to have effects on habitat quantity, habitat quality, and habitat use for marine birds. Bund wall construction can create a limited reduction in habitat quantity by obstructing use. Project emissions including noise and lights can result in reduced habitat quality. Activities with the greatest potential for disturbance (i.e., change in habitat use) include pile driving (bund wall construction), blasting, vessel traffic and dredging. Lighting during periods of darkness may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or infrastructure leading to injury or strandings. Several activities (e.g., blasting, dredging, pile driving and vessel traffic) may also lead to temporary disturbance of marine birds in a localized area. Mortality of marine birds is not expected to be an environmental effect of most routine activities in the Nearshore Study Area, except perhaps from collisions with vessels / infrastructure.

9.4.2 Offshore

9.4.2.1 Offshore Construction / Installation

Offshore construction / installation activities have the potential to result in effects on habitat use, and, to a lesser extent, habitat quality and habitat quantity (e.g., placement of the Hebron Platform structure will obstruct use of a limited area of habitat). Activities with the greatest potential for disturbance (e.g., effects on habitat use) include the operation of helicopters, the operation of vessels, seismic surveys and dredging activities. Lighting at night throughout the Project may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality. It is unknown if there is hearing impairment to marine birds spending considerable amounts of time below the surface of the water and in close proximity to airgun pulses during seismic surveys. Few of the species that occur in the Offshore Study Area spend considerable time below the surface of the water.

In addition, several activities may also lead to temporary disturbance of marine birds in a localized area. With the exception of collisions with infrastructure, mortality of marine birds is not expected to be an environmental effect of activities in the Offshore Study Area during the construction / installation phase.

9.4.2.2 Operations / Maintenance

Operations / maintenance activities have the potential to result in changes to habitat quality and habitat use. Interactions are summarized here:

- Lighting and flaring at night and periods of low visibility for the duration of the Project may attract marine birds, particularly the Leach's Storm-Petrel,

which may strike vessels or platform infrastructure leading to injury, strandings, and mortality

- The operation of helicopters, the operation of vessels, and seismic surveys have potential for disturbance
- The discharges of fluids or solids have the potential to foul the feathers of marine birds and possibly lead to ingestion of non-biological substances, which may lead to mortality
- Hearing impairment to marine birds spending considerable amounts of time below the surface of the water and in close proximity to airgun pulses during seismic surveys may be a possibility. However, as mentioned above, there is no evidence to support this

9.4.2.3 Decommissioning / Abandonment

Effects of Project decommissioning / abandonment activities have the potential to affect habitat use by marine birds, similarly to those effects experienced during the construction and operations phases. Lighting during darkness periods may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or platform infrastructure leading to injury, strandings, or mortality. In addition, the operation of helicopters and vessels may also lead to temporary disturbance of marine birds in a localized area.

9.4.2.4 Accidents, Malfunctions and Unplanned Events

The primary accidental event associated with the proposed Project having environmental consequences of concern is the unintentional release of hydrocarbons either during development drilling or production operations. The hydrocarbon products subject to accidental release include crude oil, diesel oil, synthetic drilling muds and/or fluids, synthetic drill (base) fluid, lubricating oils, and hydraulic oils. The main event of concern that can result in a hydrocarbon spill is a loss of well control (blowout). Hydrocarbon spills may also occur as a result of human error or equipment failure during loading / unloading, storage tank overflows, hydraulic system failures, drains system failures and others. An oil spill could potentially occur during the construction, operation and maintenance and/or decommissioning phases of the Project (see Section 14.1.4 for a summary of blowout and spill frequencies). Several accidents, malfunctions and unplanned events could result in mortality for marine birds within the Affected Area (see Section 9.5.4).

Other effects include a change in habitat quality (i.e., effects on habitat that could result in physical and/or physiological effects on marine birds).

9.4.3 Summary

A summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present, and likely future projects, and accidents, malfunctions and unplanned events is provided in Table 9-9.

Table 9-9 Potential Project-related Interactions: Marine Birds

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosquito Cove zone followed by a deepwater zone)				
Bund Wall Construction (e.g., sheet / pile driving, infilling)	x		x	
Inwater Blasting		x	x	x
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passender ferry to / from deepwater site)			x	x
Lighting		x	x	x
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site			x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)			x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site			x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Platform Tow-out from deepwater site			x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and Testing			x	
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines			x	
Installation of Temporary Moorings			x	
Platform Tow-out / Offshore Installation			x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location			x	
Hookup and commissioning of Platform			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)			x	x
Air Emissions		x		
Lighting		x	x	x
Potential Expansion Opportunities				
Presence of Safety Zone				
Excavated Drill Centre Dredging and Spoils Disposal			x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation			x	
Hook-up and Commissioning of Drill Centres			x	

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Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures			x	x
Lighting		x	x	x
Maintenance Activities (e.g., diving, ROV)			x	
Air Emissions		x		
Flaring		x	x	x
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		x		x
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)		x		
WBM Cuttings		x		
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)			x	x
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres			x	
Presence of Structures			x	x
WBM and SBM Cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Hebron Platform and OLS Loading Points			x	
Lighting		x	x	x
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)			x	x
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Accidents, Malfunctions, and Unplanned Events				
Bund Wall Rupture		x	x	
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blowout		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials/debris on the drilling unit, GBS, Hebron Platform)		x	x	x
Marine Vessel Incident (i.e., fuel spills)		x	x	x
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)	x	x	x	x
Terra Nova Development (production)	x	x	x	x
White Rose Oilfield Development and Expansions (drilling and production)	x	x	x	x
Offshore Exploration Drilling Activity	x	x	x	x
Offshore Exploration Seismic Activity			x	
Marine Transportation (nearshore and offshore)			x	x
Commercial Fisheries (nearshore and offshore)			x	x

9.5 Environmental Effects Analysis and Mitigation

There is limited information and few detailed studies regarding the environmental effects of construction and offshore industrial activities on marine birds. However, noise and routine discharges have the greatest potential to affect the habitat quality of marine birds, while lighting, vessel traffic and helicopter overflights likely have the greatest potential to affect marine birds by changing habitat use. Blasting and flaring, as well as collisions with infrastructure, may also lead to mortality of marine birds and are discussed at the end of the review.

9.5.1 Construction and Installation

9.5.1.1 Change in Habitat Quantity

Nearshore

In the Nearshore Project Area, construction of the bund wall will result in a limited reduction of available habitat. However, it should be noted that this will represent a relatively small footprint within an area that has previously been disturbed during construction activities of other projects (i.e., does not represent a loss of important marine bird habitat).

Offshore

The placement of the Hebron Platform at the offshore site location will result in minimal habitat loss for pelagic and migratory marine bird species. Given the relatively small footprint of the Hebron Platform within total available habitat and reversibility of the effect once the Platform is removed, this effect is not considered to be significant.

9.5.1.2 Change in Habitat Quality

Nearshore

Blasting

The key nearshore Project activity that could have an effect on habitat quality is inwater blasting. Underwater shock waves resulting from blasts in the Nearshore Study Area during construction activities have the potential to injure (or kill) marine birds that are nearby at the time of the blast. Most species of marine birds that occur off eastern Newfoundland spend little time below the water's surface and, thus, are unlikely to experience injury if they do not occur in very close proximity to the blast.

Stemp (1985) did not mention damage to birds on the water surface when 25 to 125 kg charges were detonated underwater. Marine birds hovering over the explosion sites, apparently attracted to floats, were often stunned by water blasted up into the air. Most recovered and flew away but a small number of these were killed. Blasts at the construction site will likely be sufficiently buried and small that there will be no upward blast of water into the air.

Yelverton et al. (1973) conducted controlled tests to quantify the effects of high explosives on ducks 0.6 m underwater (exposed to 0.45 kg charges at slant ranges of 7 to 33.5 m) and at the surface (exposed to 0.45 to 3.63 kg charges at ranges of 3 to 6.4 m). No deaths occurred at 11+ m for ducks exposed to detonations while underwater, but those just beyond the lethal zone (see Section 9.5.1.5) had extensive lung haemorrhage and liver and kidney damage. Those that were 25.3 to 33.5 m away had no eardrum ruptures or other detectable injuries. Ducks that survived the blasts showed no delayed mortality over a 14-day post-blast period. Ducks at the surface were less prone to blast damage. No deaths were observed at distances of 4.6 to 6.4 m from detonations. Based on the Yelverton et al. (1973) data, Yelverton (1981) estimated safe ranges for birds on the surface as 8 m, birds at 1 m below the surface as 119 m, and birds at 15 m depth as 262 m.

Most species of marine birds that occur off eastern Newfoundland spend little time below the water's surface and, thus, are unlikely to experience injury if they do not occur in very close proximity to the blast. However, some species of the family Alcidae are known to spend considerable time submerged during foraging. Of the alcids, most species primarily occur nearshore when attending nesting colonies; however, no known major nesting colonies of alcids occur within the Nearshore Study Area. The Black Guillemot is known to forage in nearshore areas throughout eastern Newfoundland and could potentially occur in the Nearshore Study Area. Attraction of birds to blasting operations due to the presence of fish killed during blasts is not expected since the blasting program will be designed to not kill fish (see Chapter 7). It is unlikely that fish will be killed by blasting during the construction activities.

An observer will be placed nearby the blasting site to monitor if diving marine birds occur within a Safety Zone of the blast location. Blasts may cause fish

mortality which could attract diving and plunge feeding birds. Blasts should be delayed until birds move outside the designated Safety Zone. The designated Safety Zone will be determined in conjunction with the CWS.

Lighting

In Newfoundland waters, marine birds, mainly Leach's Storm-Petrels, are often attracted to lights at night and/or during darkness-like conditions (e.g., foggy conditions), including coastal lighthouses and ships at sea. Birds may become injured by flying directly into the source of light or associated infrastructure. Alternatively, light-attracted Storm-Petrels may strike infrastructure (including vessels) and strand (or experience mortality). Storm-Petrels have short and weak legs that limit their ability to become airborne from solid, flat surfaces. Furthermore, Storm-Petrels will remain stranded until found and released; thus, without proper release, animals will remain stranded until they starve or die. Stranded marine birds also risk becoming oiled by landing or moving through catchment basins.

Foggy nights seem to attract more birds (Williams and Chardine 1999). Leach's Storm-Petrels breed in large numbers in eastern Newfoundland, with Baccalieu Island at the northeastern tip of Trinity Bay representing the largest breeding colony in the world. Lighting is potentially an issue during Project activities that provide continuous use of lights during darkness or periods of poor visibility.

ExxonMobil Canada Properties (EMCP) will develop protocols for regular searches of birds that may become stranded on all vessels and facilities. Recovered birds will be released in accordance with standard protocols (Williams and Chardine 1999; Husky Energy 2008). A marine bird salvage and release permit under the authority of the Federal Migratory Bird Permit must be applied for and obtained from the CWS. EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected.

Air Emissions

Although air emissions could, in theory, affect the health of some resident marine birds, the effects would likely be minimal because emissions of potentially harmful materials will be small and rapidly disperse to undetectable levels. Air emissions are expected to have a negligible effect on the habitat quality of the Marine Bird VEC.

Offshore

Seismic Surveys

The key potential future Project activity during construction in the offshore that is predicted to have an effect on habitat quality is seismic surveys. Birds have good hearing abilities in air (Fay 1988), but their hearing underwater is not well known. The hearing systems of marine birds are most likely best

adapted for hearing in air, but likely have some sensitivity in water. Diving birds within a large but unknown radius of an underwater sound source could hear a sound pulse if the birds are underwater at the time the pulse arrives. Potentially, marine birds that are diving in close proximity to a loud underwater sound could be injured.

Seismic sound energy is predominantly directed downward and below the surface of the water. Received sound above the water is significantly reduced from that underwater and is likely to have little or no effect on birds that have their heads above water or are in flight. It is possible that birds on the water at close range would be startled by the sound; however, the presence of the ship and associated gear should have already warned any birds of unnatural visual and auditory stimuli. Received sound levels of airgun pulses in the upper few metres of the water column are also considerably diminished from those at depth due to pressure-release effects and interference phenomena that occur at and near the surface (Richardson et al. 1995).

Most species of marine birds that are expected to occur in the Offshore Study Area (see Table 9-4) feed at less than one metre from the surface of the ocean. This includes members of Procellariidae, Hydrobatidae, Phalaropodinae, and Laridae. Northern Gannet plunge dive to a depth of 10 m, but animals remain submerged for only a few seconds in total, so would have minimal chance to receive underwater seismic sound. The only group of marine birds that spends considerable time submerged underwater is the Alcidae (Dovekie, Common Murre, Thick-billed Murre, Razorbill, Black Guillemot (Cepphus grylle) and Atlantic Puffin). Alcids secure food by diving under the water and propelling their bodies rapidly through the water with their wings. All are capable of reaching considerable depths and spending prolonged periods of time submerged (Gaston and Jones 1998). Murres regularly dive to a maximum depth of 100 m and have been recorded underwater for up to 202 seconds (Gaston and Jones 1998).

The effects of seismic sounds on Alcidae are unknown. Sounds are probably not important to Alcidae in securing food. However, all six species are quite vocal at breeding sites indicating auditory capabilities are important in that part of the life cycle of Alcidae.

It is thought that the presence of an on-coming seismic vessel may potentially alert alcids (and other marine birds on the water), thereby flushing animals from the area (see assessment of the effect of seismic surveys on habitat use below) prior to being exposed to any airgun sounds or occurring in close proximity to operating airguns. Of the Alcidae found in the Offshore Study Area, the Dovekie is likely common in the fall, the Common Murre is uncommon from fall to spring, the Thick-billed Murre is likely uncommon from fall to spring, the Black Guillemot is scarce year-round, the Razorbill is scarce from Spring to late fall, and the Atlantic Puffin is likely uncommon from spring to late fall.

Seismic surveys should be planned, to the extent possible, to avoid periods of known concentration in the Offshore Study Area for members of the Alcidae.

Thus, it is predicted that there is not likely to be a significant environmental effect on habitat quality in the Offshore Study Area during construction / installation.

Lighting

As described previously in Nearshore, Habitat Quality, marine birds (particularly Leach's Storm-Petrels) and potentially some migrating land birds may be attracted to lights during periods of darkness or poor visibility. Attraction can cause birds to strike lights and associated infrastructure, potentially leading to injury, stranding, and mortality. Foggy nights seem to attract more birds, and Leach's Storm-Petrels are more common in the Offshore Study Area during late summer to early fall. Leach's Storm-Petrels have also been observed in densities ranging from 0.1 to 4.9 birds/km^2 during monitoring from May to September aboard seismic vessels operating in the Jeanne d'Arc Basin (Lang 2007; Abgrall et al. 2008a, 2008b, in prep.). Stranded Leach's Storm-Petrels have been recorded during monitoring aboard seismic vessels in the Jeanne d'Arc Basin each summer and/or fall period from 2005 to 2008; June and July / August have the lowest number of birds recovered (2 and 11, respectively) while a total of 130 birds have been recovered over a week-long period in late September and 107 birds have been recovered during a 10-day period in early October (Lang et al. 2006; Abgrall et al. 2008; Lang and Moulton 2008; Abgrall et al. in prep.). The largest Leach's Storm-petrel stranding events that have been recorded from seismic vessels in and near the Study Area have occurred at the time of year when the young have recently fledged (T. Lang, pers. comm., 2010), but the extent of Storm-Petrel susceptibility is unclear. Other marine bird species, as well as migrating land birds, are also known to be attracted to lights on offshore oil and gas platforms at night, especially during foggy or overcast conditions. Birds could potentially injure themselves by flying into structures on the platform (Avery et al. 1978). Some accounts also describe birds becoming disoriented and flying aimlessly about the lights for hours, consuming energy and being delayed in their foraging or migration.

On one occasion Dovekies were observed to circle the lighted Hibernia platform for hours (in Wiese et al. (2001)), but EMCP is not aware of any large-scale strandings or mortalities related to such events on the Grand Banks. There have been reports in other regions of strandings involving related species. For example, Dick and Donaldson (1978) interviewed the crew of an Alaskan crab fishing boat that experienced a collision with Crested Auklets (Aethia cristatella), a related species. It was estimated that about 1.5 tons of birds collided and landed on the brightly lit boat. The birds appeared to be disoriented by the bright overhead work deck lights although they only ran into the lower running lights because the birds were all flying close to the water. Poot et al. (2008) examined the use of green spectrum lighting on offshore platforms in the North Sea to reduce or eliminate the disorientation to nocturnally migrating birds normally caused by white and red lights. EMCP will develop protocols for regular searches of birds that may become stranded on all vessels and facilities. Recovered birds will be released in accordance with standard protocols (Williams and Chardine 1999;

Husky Energy 2008). EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected.

Air Emissions

Although air emissions could, in theory, affect the health of some resident marine birds, the effects would likely be minimal because emissions of potentially harmful materials will be small and rapidly disperse to undetectable levels. Air emissions are expected to have a negligible effect on the habitat quality of the Marine Bird VEC.

9.5.1.3 Change in Habitat Use

Nearshore

Temporary and localized disturbances are the most likely effects of Project construction activities on marine birds. In coastal regions, varying levels of human disturbance (from human presence to physical substrate disturbance and construction activities) are known to cause minor disturbance of several species. Such disturbance could have important environmental effects on birds if opportunities to forage or breed become limited as a result of the activities.

Burger et al. (2007) described the effects of human presence, cars or planes and dog presence on the average number of Herring Gulls, Laughing Gulls (Leucophaeus atricilla) and shorebirds that included Red Knot. The responses of gulls and shorebirds differed considerably, with gulls generally returning to pre-disturbance levels within five minutes of a disturbance. All shorebirds responded most strongly to the presence of dogs and did not return to the beach within the 10 minute post-disturbance monitoring period. Red Knots also appeared to be more responsive to humans than to cars or planes, showing moderate signs of recovery to pre-disturbance within 30 seconds of car or plane disturbance relative to periods greater than 10 minutes for human disturbance.

Burger (1988) monitored the abundance of shorebirds (species not provided) and Laughing Gulls and Herring Gulls during pre- and post-activities associated with demolition, beach clean-up and construction for development on a coastal mudflat in New Jersey. Activities included the use of chainsaws, humans picking up and/or piling debris from the mudflat and crane loading from the beach. The overall number of birds using the mudflat was higher during the period prior to coastal activities. Birds also moved away when activity began and returned when activity ceased. Gulls that moved farther out on the mudflat had measurably lower foraging efficiencies, and foraging efficiencies of gulls did not return to previous levels until 60 to 90 minutes after work began. Mitigation measures that restricted human activity to a 100 m stretch of beach at a time succeeded in significantly reducing adverse environmental effects and in allowing birds to rest and feed.

It should be noted that the Nearshore Study Area does not contain important bird habitat and is already an area that has been subjected to disturbance from human activity. Nonetheless, Project activities that have the potential to result in behavioural disturbances, in turn resulting in potential changes in habitat use, are evaluated below.

Pile Driving

Pile driving involved in the construction of the bund wall, produces impulsive sound levels high enough to temporarily disturb marine birds occurring in close proximity at a localized scale. The environmental effects of pile driving on Marine Birds in the Nearshore Study Area are not well known, but these activities will occur in a small area that has been previously disturbed by construction activities associated with other projects. There are no known marine bird nesting colonies located within Bull Arm, Trinity Bay, nor are there any known concentrations of foraging marine birds that could potentially be affected by pile driving activities.

Blasting

Blasting operations may cause temporary and localized behavioural disturbance, potentially resulting in a change in habitat use. However, there are no specific sound levels for blasting activities that are linked with behavioural effects on marine birds. The environmental effects of blasting in the Nearshore Study Area are not well known, but these activities will occur in an area that has been previously disturbed by construction activities associated with other projects. There are no known marine bird nesting colonies located within Bull Arm, Trinity Bay, nor are there any known concentrations of foraging marine birds that could potentially be affected by blasting activities. Therefore any effects would most likely be on individuals that may occur in the area. Blasts that are closely spaced relative to the dive duration of birds could have greater impacts. Widely spaced blasts will likely result in no more than one pulse (if any) being received during a given dive. In general, birds may interrupt their foraging dives and return to the surface. It is possible that some might leave the area, but available evidence suggests that disturbance would be temporary. In contrast, some marine birds, such as gulls or other scavengers, may be attracted to blasting activities if fish are killed as a result of detonation (see Section 7). Blasting activities will be required to adhere to Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998). Monitoring of a safety zone, as described above, will also mitigate potential disturbance of Marine Birds.

Lighting

Lighting is an issue during Project activities that provide continuous use of lights during darkness periods in the Nearshore Study Area. Mitigation measures to address the impacts of lighting on marine birds were described previously in Section 9.5.1.2.

Vessel Traffic

Marine birds may be temporarily disturbed by passing vessels associated with Project activities, including construction and survey vessels. Some species are also attracted to vessels and follow them for extended periods. There is concern for vessels passing known concentrations of foraging or nesting marine birds, but no known concentrations are likely to occur within Bull Arm or Trinity Bay that potentially may be affected. Vessels of large size, which are fast-moving, or move with an erratic course, though unlikely to occur, are more likely to disturb birds. However, vessels operating within the Nearshore Study Area will typically be moving at slow speed or will remain stationary for extended periods, and will, therefore, be less likely to affect nearby marine birds. Whenever possible, vessels associated with the Project should maintain a steady course and speed. Concentrations of marine birds, if any occur, should be avoided.

Other Activities

Several other activities associated with the construction phase in the Nearshore Study Area may induce temporary and localized disturbance of marine birds (Table 9-9). However, no nesting or feeding concentrations of marine birds are expected to occur within the small areas associated with these activities, and bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

Offshore

Temporary and localized disturbances to marine birds in the Offshore Study Area may result in similar behavioural changes and affect bird habitat use. Project activities creating noise, such as vessel traffic, helicopter operations, and seismic surveys, and light emissions are most likely to potentially result in a change in habitat use.

Vessel Traffic

Marine birds may potentially be temporarily disturbed by passing vessels associated with Project activities. However, many bird species are known to have adapted to ship traffic throughout the world. Some species, such as Northern Fulmar and gulls, are attracted to ships and often follow them for extended periods (Wahl and Heinemann 1979; Brown 1986).

While vessels which pass in close proximity to bird colonies may create concern for disturbance, the routing of Project vessels will not take them within 2 km of any nesting marine bird colonies.

Operation of Helicopters

Most marine birds flush or dive in response to low-flying aircraft (e.g., Polar Gas Project 1977; Husky Oil 2000; LGL Ltd. unpublished data). The magnitude of these disturbances is likely low, given infrequent flights at low levels. Of greater concern are flights over large colonies of nesting marine birds. An aircraft flying low near a marine bird colony is capable of causing a

panic response by the birds, which can result in eggs and flightless young being accidentally pushed off cliff ledges when the adults suddenly flush, or being unguarded and thus exposed to harsh weather and predators.

As with current regular helicopter servicing of offshore platforms in the Jeanne d'Arc Basin, helicopters used for the Project will likely be based at St. John's Airport and will generally fly "straight" to the Offshore Study Area. Helicopters will be directed to avoid the closest marine bird colonies (e.g., Witless Bay Ecological Reserve) and any known concentrations. The Wilderness and Ecological Reserves Act states that no aircraft will fly lower than 300 m or take off or land within the reserve during the period 1 April to 1 September.

Seismic Surveys

Seismic surveys have the potential to affect the habitat quality of marine birds, particularly members of the Alcidae (described above), but seismic surveys also have the potential to disturb marine birds. The main environmental effect of seismic surveys on habitat use by marine birds is that of the operation of vessels, as described above. In general, limited information is available on the behavioural effects of seismic surveys on marine birds.

A study on the effects of underwater seismic surveys on moulting Long-tailed Ducks (Clangula hyemalis) in the Beaufort Sea showed no effects on movement or diving behaviour (Lacroix et al. 2003). The authors suggested caution in interpretation of these data, however, because they were limited in their ability to detect subtle disturbance effects and recommended studies on other species to fully understand the effects of seismic sounds.

Other Activities

Various other activities associated with the Construction Phase in the Offshore Study Area may induce temporary and localized disturbance of marine birds (refer to Table 9-9). These activities are not expected to occur near any known nesting colonies, so they should not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common during summer periods (particularly Greater Shearwater, Sooty Shearwater and Leach's Storm-Petrel), winter periods (particularly Black-legged Kittiwake and Thick-billed Murre), fall (particularly Dovekie), or year-round (particularly Northern Fulmar) in the Offshore Study Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

9.5.1.4 Potential Mortality

One routine Project construction / installation activity that is predicted to potentially result in mortality of marine birds is blasting in the nearshore. Collision with infrastructure is another potential source of mortality. This issue is mostly relevant to offshore operations and is discussed in Section 9.5.2.

Marine birds occurring in close proximity to an explosion can be injured or killed. At a given distance, death is more likely for birds that are below the surface than for those at the surface. For birds at the surface, available information suggests that there is little or no risk of injury or death unless the birds are very close to the explosion. As noted above, most of the marine bird species occurring in the Nearshore Study Area spend very little time submerged; only members of the Alcidae are known to dive to considerable depth and spend substantial periods below water. However, most alcid species will occur farther offshore or near nesting colonies that do not occur within the Nearshore Study Area.

Fitch and Young (1948) described the effects of 73 kg high explosive charges on marine birds occurring nearby. Cormorants (Phalacrocoraciidae) that dove beneath the surface to feed on fish attracted to the blasts were killed consistently; distances of birds to the detonations were not reported. Pelicans were also frequently killed, but only when their heads were below water. A few gulls sustained broken wings when they were struck by a column of water rising into the air.

As evaluated above under effects on Habitat Use (Section 9.5.1.3), Yelverton et al. (1973) conducted controlled tests to quantify the effects of high explosives on ducks. Based on the Yelverton et al. (1973) data, Yelverton (1981) estimated safe ranges for birds on the surface as 8 m, birds at 1 m below the surface as 119 m, and birds at 15 m depth as 262 m.

Environment Canada cannot authorize by permit or exempt the inadvertent mortality ("incidental take") caused by construction (or other) activities of bird species protected by the Migratory Birds Convention Act (Environment Canada 2007). Instead, Environment Canada recommends that proponents adopt migratory bird protection measures and monitor for the presence of migratory birds based on scientifically credible methods before and during the period in which activities are carried out. An observer experienced in marine bird identification and behaviour will be placed nearby the blasting site to monitor if diving marine birds occur within a specified safety zone of the blast location. Blasts should be delayed until birds move outside the designated safety zone. The safety zone will be determined in consultation with the CWS. EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected.

The environmental effects of Project construction / installation activities on Marine Birds are summarized in Table 9-10.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse environmental effects on Marine Birds from construction or installation activities associated with the Project.

Table 9-10 Environmental Effects Assessment: Construction and Installation

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Use	• Equipment design • Potential use of bubble curtains • Safety zone • monitoring	1	1	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters • Monitor appropriate safety zone for diving birds	1	2	2/1	R	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use	• Discharge area and depth designed to reduce suspended sediment	1	1	2/1	R	2
Concrete Production (floating batch)	• Change in Habitat Use	• Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be directed to a settling basin • The settling basin will be cleaned on an as required basis to ensure that the retention capacity is maintained at all times	1	1	3/3	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge)	• Change in Habitat Use • Potential Mortality	• Maintain steady course and speed • Avoid concentrations of marine birds	1	2	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Proper release of stranded birds per CWS protocol • EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Use	• Restrict disturbance to mooring sites	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Use		1	1	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Monitor appropriate safety zone for diving and plunge-feeding birds	1	1	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (e.g., geophysical, geological geotechnical, environmental)	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Use		1	1	3/6	R	2
Offshore Construction / Installation							
OLS Installation and Testing	• Change in Habitat Use		1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Use		1	1	2/6	R	2
Underbase Grouting	• Change in Habitat Use		1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Platform Location	• Change in Habitat Use		1	1	2/1	R	2
Hook-up and Commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes, where possible	1	1	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Habitat Use • Potential Mortality	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed • Avoid concentrations of marine birds	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	5	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Proper release of stranded birds • EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected	1	2	3/6	R	2
Potential Expansion Opportunities							
Excavated Drill Centre Dredging and Spoils Disposal	• Change in Habitat Use		1	1	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental)	• Change in Habitat Use		1	3	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

9.5.2 Operations and Maintenance

9.5.2.1 Change in Habitat Quantity

None of the Project activities in the Offshore Study Area during the Operations and Maintenance Phase are predicted to result in changes in habitat quantity for marine birds.

9.5.2.2 Change in Habitat Quality

Primary Project activities that could potentially result in changes in habitat quality for marine birds include lighting and flaring, operational discharges and seismic surveys.

Lighting

As described previously for lighting in the Offshore Study Area during the construction / installation phase (Section 9.5.1.2), lighting of infrastructure in the Offshore Study Area will likely attract marine birds (especially Leach's Storm-Petrels) during darkness and low visibility periods. Mitigation measures described in Section 9.5.1.2 will also be applied during operation to limit the potential environmental effects on marine birds.

Flaring

During steady-state operations, it is estimated that the Hebron facility will have reduced flare emissions compared with existing operations. Flaring during platform start-up and early year operations will be greater than steady-state operations. Flare operating practices will be developed for the Operations Authorization and a flaring allowance established in consultation with the C-NLOPB.

Night-migrating or night-active marine birds might be attracted by gas flaring in the Offshore Study Area, similar to the effect described for lighting (above). The Leach's Storm-Petrel is the species most likely to be affected, particularly on foggy nights in late summer to early fall. However, the heat and noise generated by the flare may deter marine birds from the immediate area under most night-time conditions. When attracted to the flare, marine birds may strike infrastructure and become injured or stranded.

As in the case of lighting (described above), EMCP will develop protocols for regular searches of birds that may become stranded on all vessels and facilities. Recovered birds will be released in accordance with standard protocols (Williams and Chardine 1999; Husky Energy 2008). Stranded bird reports will be provided to the CWS.

Operational Discharges

Routine Platform discharges are not expected to produce sheens. Nonetheless, there has been a number of small petroleum spills on the Grand Banks (see Section 14.1.4 of the CSR).

Activities that involve the storage and discharge of fluids and solids that occur during the operations and maintenance phase in the Offshore Study Area have the potential to foul marine birds. Fouling the feathers of marine birds may affect their ability to fly and possibly lead to ingestion of toxic substances. The discharge of some fluids like water-based muds (WBMs) and cuttings could potentially leave a sheen on the water surface, although this effect will be mitigated by discharge at depth and is unlikely to occur. The discharge of any blowout preventer fluid is likely to have minimal environmental effects on marine birds because low-toxicity glycol-water mixes will be used; these fluids are also typically released on a periodic basis near the seafloor. Produced water has the potential to affect birds if sheening occurs on the sea. This effect is considered below in Section 9.5.4.2. Sanitary waste and wastewater generated by the platform and support vessels will be macerated before subsurface discharge. Cooling water will be chlorinated and discharged overboard at an approximate temperature of 30°C, with a residual chlorine level <0.5 ppm. Thus, the volume of entrainment will be low and the area of thermal effects will be small. O'Hara and Morandin (2010) demonstrated that it only requires a small amount of oil (e.g., 10 ml) to affect the feather structure of Common Murre and Dovekie. Such modifications to feather structure cause a loss of insulation, which in turn can result in mortality in the cold Northwest Atlantic environment.

Some marine birds, such as the Leach's Storm-Petrel, are known to feed on naturally-produced oily slicks on the water of biological origin and could possibly be attracted to a slick. However, Leach's Storm-Petrels do not spend much time on the water and would remain on the wing during an investigation of a slick, reducing the chances that feathers will contact the fluid. Some species such as shearwaters, Northern Fulmars and gulls may be attracted to vessels and the platform (discussed below in Presence of Structures); these birds may rest on the water, making them more likely to come in contact with discharges. Some marine birds, particularly gulls, may be attracted to sewage particles, but the small amount discharged below the surface is unlikely to increase the abundance of marine birds in the Offshore Study Area.

To minimize the possibility of fouling marine bird feathers, fluids will be discharged below the water's surface whenever possible. It is predicted that the residual environmental effect of fluid / solid storage or discharge on the habitat quality of marine birds in the Offshore Study Area will affect a limited area and be of low magnitude.

Seismic Surveys

As described above for seismic surveys in the Offshore Study Area during the construction / installation phase, most species of marine birds that are expected to occur in the Offshore Study Area have limited potential to be exposed to underwater sounds produced by airguns during seismic surveys. These species are not expected to experience any hearing impairment as a result of seismic surveys. However, members of the family Alcidae forage under the water's surface to maximum depths of 100 m for up to 202 seconds. It is possible that alcids may experience an unknown level of hearing impairment if exposed at a close proximity to underwater airgun pulses. The environmental effects of seismic sounds on alcids are completely unknown. It is thought that the presence of an on-coming seismic vessel may potentially alert alcids (and other marine birds on the water), thereby flushing animals from the area (see Section 9.5.2.3) prior to being exposed to any airgun sounds or occurring in close proximity to operating airguns. Seismic surveys should be planned, to the extent possible, to avoid periods of known concentration in the Offshore Study Area for members of the Alcidae.

9.5.2.3 Change in Habitat Use

Potential changes in habitat use during Hebron Project operations relate primarily to the presence of the structures (and associated lighting), vessel and helicopter traffic, seismic surveys, and other activities that generate noise / light that could potentially induce temporary and localized disturbance of marine birds.

The physical structure of the platform and support vessels could affect marine birds by attracting them. Additionally, it is possible that the artificial reef affected, created by stationary structures will affect marine bird prey. Shearwaters, Northern Fulmars, and gulls are the species most likely to be attracted to the platform and may rest on the water nearby.

Effects and mitigation associated with lighting, vessel traffic, helicopter traffic and seismic surveys have been discussed under the construction / installation phase (Section 9.5.1.3) and are applicable to the operations and maintenance phase.

Various other activities associated with the operations and maintenance phase (e.g., lighting, flaring) in the Offshore Study Area may induce temporary and localized disturbance of marine birds. These activities are not expected to occur near any known nesting colonies, so will not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common during summer periods (particularly Greater Shearwater, Sooty Shearwater and Leach's Storm-Petrel), winter periods (particularly Black-legged Kittiwake and Thick-billed Murre), fall (particularly Dovekie), or year-round (particularly Northern Fulmar) in the Offshore Study Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

9.5.2.4 Potential Mortality

It is possible that marine birds attracted by gas flaring at night might become incinerated, collide with platform structures, or strand on the platform, thereby causing mortality (Russell 2005; Montevecchi 2006). However the heat and noise generated by the flare may deter marine birds from the immediate area under most night-time conditions. Marine birds may also be attracted to the Platform lights. As described above, the Leach's Storm-Petrel is the most likely marine bird species to be affected, particularly on foggy nights in late summer to early fall (Williams and Chardine 1999). It is unknown which seabird species, if any, are susceptible to mortality from flaring. There is currently no known mitigation for the potential environmental effects from flaring, but flaring is expected to have minimal effect on marine birds over the duration of the Project.

Although free oil is usually removed from produced water before discharge, oil sheens are sometimes associated with produced water discharges (e.g., ERIN Consulting Ltd. and OCL Services Ltd. 2003). These sheens are thought to be derived from the dispersed oil or soluble medium- to high-molecular weight hydrocarbons components of produced water (Veil et al. 2004). Data on the relationship between sheen thickness and lethality to marine birds are lacking (Hartung 1995). The geographic extent of produced water is usually thought to be 1 km^2 or less (Fraser et al. 2006). Fraser et al. (2006) modelled the potential effect of produced water on the Grand Banks on alcids. They used published estimates of alcid density and also assumed a daily occurrence of sheens (210 days) and that any contact between birds and sheens causes mortality - these assumptions are considered a worst case scenario. Their modelling suggests a potential negative impact ranging in magnitude from low to high within 1 km^2. The Environmental Studies Research Find (ESRF) commissioned a study on the effects of sheens on marine birds. This laboratory study by O'Hara and Morandin (2010) demonstrated that it only requires a small amount of oil (e.g., 10 ml) to affect

the feather structure of Common Murre and Dovekie. However, "there are no data on threshold number of affected feathers before an individual bird would begin to be affected by exposure to oil sheen. Further research quantifying amounts of oil that cause negative impacts in relation to sheen thickness and exposure levels are crucial" (O'Hara and Morandin, 2010). See Section 9.5.4 for a more detailed discussion of the environmental effects of oil exposure on marine birds.

The environmental effects of Project operation / maintenance activities on Marine Birds are summarized in Table 9-11.

Given that project activities are mostly localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse environmental effects on Marine Birds from the operation and maintenance activities associated with the Project.

Table 9-11 Environmental Effects Assessment: Operations and Maintenance

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Use • Potential Mortality		1	1	5/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Proper release of stranded birds • EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected	1	2	5/6	R	2
Maintenance Activities (e.g., diving, ROV)	• Change in Habitat Use	• Use of best practices	1	1	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Flaring	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality		1	1	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Wastewater (e.g., produced water, storage displacement water, deck drainage)	• Change in Habitat Quality • Potential Mortality	• Subsurface discharge	1	2	5/6	R	2
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes where possible	1	4	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Use • Potential Mortality	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed • Avoid concentrations of marine birds	1	4	5/6	R	2
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use	• Maintain steady course & speed • Avoid concentrations of marine birds	1	3	3/2	R	2
Potential Expansion Opportunities							
Drilling operations from MODU at Future Excavated Drill Centres	• Change in Habitat Use		1	1	3/6	R	2
Presence of Structures	• Change in Habitat Use • Potential Mortality		1	1	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrosion inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	2	5/6	R	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use	• Plan surveys to avoid concentrations of members of Alcidae	1	3	3/2	R	2

KEY

Magnitude:

N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:

1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:

1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
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Frequency:

1 = <11 events/year
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5 = >200 events/year
6 = continuous

Reversibility:

R = Reversible
I = Irreversible

Ecological / Socio-economic Context:

1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

9.5.3 Offshore Decommissioning and Abandonment

None of the Project activities in the Offshore Study Area during the decommissioning and abandonment phase are predicted to result in changes in habitat quantity, or mortality for marine birds. Lighting and surveys may affect habitat quality as discussed previously during the construction and operations phases. Changes in habitat use are described below.

Activities associated with the removal of the Hebron Platform and offshore loading system (OLS) loading points may induce temporary and localized disturbance of marine birds. These activities are not expected to occur near any known nesting colonies, so will not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common in the Offshore Study Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

Effects and mitigation associated with lighting, vessel traffic, helicopter traffic and surveys, have been discussed under the construction (Section 9.5.1.3) and are applicable to the decommissioning / abandonment phase.

The potential environmental effects of decommissioning activities are expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

The environmental effects of Project decommissioning / abandonment activities on Marine Birds are summarized in Table 9-12.

Table 9-12 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Hebron Platform and OLS Loading Points	• Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Proper release of stranded birds • EMCP will evaluate use of shielding and deflectors with directional lighting to minimize attraction by lighting, and may incorporate such features where safety of operations and navigation are not affected	1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies • Avoid flying at low altitudes where possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / ROVs)	• Change in Habitat Use • Potential Mortality	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed • Avoid concentrations of marine birds	1	3	3/6	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use	• Maintain steady course and speed • Avoid concentrations of marine birds	1	2	3/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

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Reversibility:
- R = Reversible
- I = Irreversible

Ecological / Socio-economic Context:
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9.5.4 Accidents, Malfunctions and Unplanned Events

Marine birds are the marine biota most at risk from oil spills. Shorebirds (plovers (Charadriidae), and sandpipers (Scolopacidae)), sea ducks and other coastal water birds (e.g., loons (Gaviidae), grebes (Podicipedidae) and cormorants) are also at risk, as they use the marine environment to varying degrees. Reported effects vary with species, type of oil, weather conditions, time of year, and duration of the spill (Gorsline et al. 1981). Natural inter-annual variation in other factors that affect populations (e.g., prey availability and weather) reduces the ability of scientists to assess the full effect of oil spills on bird populations (Eppley 1992; White et al. 1995; Votier et al. 2005).

The following sections assess the effect of an accidental release of hydrocarbons in the nearshore and offshore. Spills in the nearshore would be attributable to vessel malfunctions and similar effects and mitigation discussed for the offshore is applicable to the nearshore scenarios; therefore, nearshore and offshore effects are assessed together. The type and probability of spills (blow-out (surface and subsea) and batch) are discussed in Section 14.1 and spill trajectories on water in the Nearshore Study Area and Offshore Study Area are described in Sections 14.2 and 14.3, respectively. A detailed analysis is included in ASA (2011a, 2011b).

Oil spill response is included as part of the contingency planning undertaken for the Project and additional information regarding spill response planning is

found is Section 14.4. Chapter 16 describes the Hebron Project's overall environmental management process.

9.5.4.1 Change in Habitat Quality

Nearshore

Hydrocarbon spills or collisions resulting in hydrocarbon spills may affect habitat quality as described for the Offshore Study Area below.

Offshore

It is possible that birds exposed to oil in the Offshore Study Area may return to nesting sites. Nesting marine birds that have survived oil contamination generally exhibit decreased reproductive success. Nesting marine birds transfer oil from their plumage and feet to their eggs (Albers and Szaro 1978). Very small quantities (1 to 20 µL) of oil on eggs have produced developmental defects and mortality in avian embryos of many species (Albers 1977; Albers and Szaro 1978; Hoffmann 1978, 1979a; Macko and King 1980; Parnell et al. 1984; Harfenist et al. 1990). The resultant hatching and fledging success of young appears to be related to the type of oil (Hoffman 1979b; Albers and Gay 1982; Stubblefield et al. 1995) and the timing of exposure during incubation. Embryos are most sensitive to oil during the first half of incubation (Albers 1978; Leighton et al. 1985). Breeding birds that ingest oil generally exhibit a decrease in fertilization (Holmes et al. 1978), egg laying and hatching (Hartung 1965; Ainley et al. 1981), chick growth (Szaro et al. 1978), and survival (Vangilder and Peterle 1980; Trivelpiece et al. 1984), as well as a reduction in mean eggshell thickness and strength (Stubblefield et al. 1995). Growth was retarded in Herring Gull chicks, Black Guillemot chicks, and Mallard (Anas platyrhynchos) ducklings after they ingested oil directly (Peakall et al. 1981; Szaro et al. 1981).

Oil spills that affect prey availability of a species with low seasonal dietary variation could have a greater effect on that species through an indirect reduction in reproduction and poorer chick condition (Velando et al. 2005). Eppley and Rubega (1990) suggested that exposure to an Antarctic oil spill causes changes in the normal parental behaviour of South Polar Skua, thus exposing young to increased predation and contributing to reproductive failure in that population. In another case, abandonment of nesting burrows by oiled adult Leach's Storm-Petrels may contribute to reproductive failure in that population (Butler et al. 1988). Therefore, a spill that occurs during the reproductive period could cause mortality of young even if the adults survived the exposure to oil.

Other sublethal effects of oil contamination include reduced feeding rates (Sanderling (Calidris alba); Burger and Tsipoura 1998).

9.5.4.2 Change in Habitat Use

Nearshore

Hydrocarbon spills or collisions resulting in hydrocarbon spills will affect habitat use as described for the Offshore Study Area below. A rupture in the bund wall may result in increased sedimentation in the water column. After sediment released by a bund wall rupture settles out of the water column, siltation of fish habitat and benthos may result in lower numbers of prey available to marine birds. Marine birds will learn to avoid silted areas because of low prey densities until benthic fish habitat recovers.

Offshore

There are possible changes in habitat use of oiled areas by both oiled and un-oiled birds. After a large oil spill off the coast of Washington by the Nestucca in December 1988, a study of oiled shorebirds suggested that within 10 days of the oil spill they could be found at beach roosting sites, but that after 10 days they tended to remain in the harbour rather than complete their usual return flight to beach roosting sites at high tide (Larsen and Richardson 1990). In June 1979, an oil blow-out occurred from the Ixtoc I in the Gulf of Mexico off Mexico, causing shorebirds there to avoid oil-affected foreshores and instead use poorer backshore feeding habitats and freshwater pools (Chapman 1981). Three months after the oil spill, storms cleaned the beaches, but shorebirds failed to return to the foreshore feeding habitats at their pre-spill levels (Chapman 1981).

The greatest decrease in use of contaminated habitats immediately following a spill occurs in species that feed on or close to shore and either breed along the coast or are full-year residents (Wiens et al. 1996). Day et al. (1995) showed that species lacking clear evidence of recovery tended to be intertidal feeders and residents. However, they also found that other ecologically similar species did not show signs of initial impact or showed rapid recovery.

9.5.4.3 Potential Mortality

Nearshore

Hydrocarbon spills or collisions resulting in hydrocarbon spills can cause mortality as described for the Offshore Study Area below. Within the Nearshore Study Area, Bellevue Beach provides important habitat for marine birds (see Section 9.3.1). Spill modelling at the Bull Arm site shows that there is a 1 to 10 percent probability of a diesel fuel spill reaching Bellevue Beach. This probability increases to 10 to 30 percent for IFO-180 fuel released in summer. These probabilities were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b). The spill modelling suggests that there is reduced probability (<1 percent or 1 to 10 percent) of a spill affecting marine bird concentration areas such as nesting colonies outside the Nearshore Study Area (e.g., off the Bonavista and Bay de Verde Peninsulas). Once again, these probabilities were based on modelling results in the

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absence of any spill intervention (ASA 2011a, 2011b). Mitigation measures will likely reduce effects of potential hydrocarbon spills on marine birds in the Nearshore Study Area.

Offshore

Exposure to oil causes thermal and buoyancy deficiencies that typically lead to the deaths of affected marine birds. Although some may survive these immediate effects, long-term physiological changes may eventually result in death (Ainley et al. 1981; Williams 1985; Frink and White 1990; Fry 1990). Reported effects vary with bird species, type of oil (Gorsline et al. 1981), weather conditions, time of year, and duration of the spill or blowout. Although oil spills at sea have the potential to kill tens of thousands of marine birds (Clark 1984; Piatt et al. 1990), some studies suggest that even very large spills may not have long-term effects on marine bird populations (Clark 1984; Wiens 1995).

External exposure to oil occurs when flying birds land in oil slicks, diving birds surface from beneath oil slicks, and swimming birds swim into slicks. The external exposure results in matting of the feathers, which effectively destroys the thermal insulation and buoyancy provided by the air trapped by the feathers. Consequently, oiled birds may suffer from hypothermia and/or drown (Clark 1984; Hartung 1995). Birds living in coldwater environments, such as the Study Area, are most likely to succumb to hypothermia (Hartung 1995; Wiese and Ryan 2003). Most mortalities occur during the initial phase of oil spills when large numbers of birds are exposed to floating oil (Hartung 1995).

Oil spills at sea have the potential to kill tens of thousands of birds (Clark 1984; Piatt et al. 1990). However, it is difficult to estimate how many marine birds are oiled during any particular oil-spill, because some birds may not reach shore (dead or alive), and beached carcasses may be scavenged or washed out to sea before being counted (Ford et al. 1987). There is also no clear correlation between the size of an oil spill and numbers of marine birds killed, because the density of birds in a spill area, wind velocity and direction, wave action, and distance to shore can have a greater bearing on mortality than the size of the spill (Burger 1993). Accordingly, even small spills can cause cumulative mass mortality of marine birds (Joensen 1972; Carter et al. 2003; Hampton et al. 2003). In contrast, relatively low mortalities have been recorded from some huge spills. For example, the Amoco Cadiz spilled 230,000 tonnes of crude oil along the French coast, causing the recorded deaths of 4,572 birds (Clark 1984). A major spill that persists for several days near a nesting colony could kill a high proportion of pursuit-diving birds (e.g., murres) within the colony (Cairns and Elliot 1987).

Oiled birds that escape death from hypothermia and/or drowning often seek refuge ashore, where they engage in abnormally excessive preening in an attempt to remove the oil (Hunt 1957, in Hartung 1995). The preening leads to the ingestion of significant quantities of oil that, although apparently only partially absorbed (McEwan and Whitehead 1980) can cause lethal effects. Noted effects on Common Murres and Thick-billed Murres oiled off

Newfoundland's south coast include emaciation, renal tubular degeneration, necrosis of the duodenum and liver, anemia, and electrolytic imbalance (Khan and Ryan 1991). Glaucous-winged Gulls (Larus glaucescens) experienced similar effects after they ingested bunker fuel oil during preening (Hughes et al. 1990).

Another commonly observed effect is adrenal hypertrophy. This condition tends to make birds more vulnerable to adrenocortical exhaustion (e.g., Mallards (Hartung and Hunt 1966; Holmes et al. 1979), Black Guillemots (Peakall et al. 1980), and Herring Gulls (Peakall et al. 1982)). The adrenal gland maintains water and electrolyte balance that is essential for the survival of birds living in the marine environment. Hartung and Hunt (1966) found that ingested oils can cause lipid pneumonia, gastrointestinal irritation, and fatty livers in several species of ducks. Aromatic hydrocarbons have been detected in the brains of Mallards (Lawler et al. 1978) and are probably associated with observed symptoms (e.g., lack of coordination, ataxia, tremors and constricted pupils) of nervous disorders (Hartung and Hunt 1966). Polycyclic aromatic hydrocarbons (PAH) can also be detected in plasma samples of oiled Common Murres (Troisi and Borjesson 2005). The availability of an immunoassay for the determination of PAH concentrations in plasma samples of oiled birds potentially can serve in the exposure assessment during oil spill response and rehabilitation (Troisi and Borjesson 2005).

Other toxicological effects, however, do not appear to differ between oiled and unoiled birds (Kammerer et al. 2004; Pérez-López et al. 2006). Levels of zinc, copper, arsenic, chromium, lead and cadmium were all similar in the liver of three species (Common Murre, Atlantic Puffin and Razorbill Murre) affected by the Prestige oil spill of September 2002 on the northwest Spanish Galician coast; only mercury showed increased levels in the liver of oiled birds (Pérez-López et al. 2006). Vanadium hepatic and renal concentrations did not prove to be appropriate biomarkers for recent exposure to oil spills following analyses of samples from Common Murres, Black Scoters (Melanitta nigra), and Common Eiders exposed to the Erika wreck off coastal France (Kammerer et al. 2004).

Birds exposed to oil are also at risk of starvation (Hartung 1995). For example, oiled Common Eiders generally deplete all of their fat reserves and much of their muscle protein (Gorman and Milne 1970). In addition, energy demands are higher because the metabolic rate of oiled birds increases to compensate for the heat loss caused by the reduced insulating capacity of their plumage. This can expedite starvation (Hartung 1967; McEwan and Koelink 1973). For birds living under harsh environmental conditions (e.g., winters in colder climates), even a seemingly insignificant amount of oiling can have fatal consequences (Levy 1980).

Oiled birds that are cleaned and released might not have high survival rates. Pooling across the three species with the most band recovery data between 1969 and 1994 (Western Grebe (Aechmophorus occidentalis), White-winged Scoter (Melanitta fusca) and Common Murre), the median days that cleaned birds survived were 4 to 11 days, or a mean of four days (Sharp 1996). Birds

that survived longer were those that typically had a low degree of oiling and spent less time in captivity; initial or release weights did not seem to matter (Sharp 1996). Birds cleaned after 1990 using more modern methods do not have a higher survival rate than those cleaned before 1990 (Sharp 1996).

Birds are particularly vulnerable to oil spills during nesting, moulting, and the period of time before young marine birds gain the ability to fly. Because newly fledged murres and Northern Gannets are unable to fly for the first two to three weeks at sea, they are less likely to be able to avoid contact with oil during that time (Lock et al. 1994). Before and during moult, the risks of hypothermia and drowning are increased (Erasmus and Wessels 1985), because feather wear and loss reduce the ability to repel water by about 50 percent (Stephenson 1997).

It is clear that truly aquatic and marine species of birds are most vulnerable and most often affected by exposure to marine oil spills. Diving species such as Black Guillemot, murres, Atlantic Puffin, Dovekie, eiders, Long-tailed Duck, scoters, Red-breasted Merganser (Mergus serrator), and loons are considered to be the most susceptible to the immediate effects of surface slicks (Leighton et al. 1985; Chardine 1995; Wiese and Ryan 1999; Irons et al. 2000). Alcids, especially Common and Thick-billed Murres, often have the highest oiling rate of marine birds recovered from beaches along the south and east coasts of the Avalon Peninsula, Newfoundland (Wiese and Ryan 2003). Those were the only group of marine birds to show an annual increase over a 13-year period (2.7 percent) in the proportion of oiled to stranded birds (Wiese and Ryan 1999). There also appears to be a strong seasonal effect, as significantly higher proportions of alcids (along with other marine bird groups) are oiled in winter versus summer (Wiese and Ryan 1999).

Other species such as Northern Fulmar, shearwaters, storm-petrels, gulls, and terns are vulnerable to contact with oil because they feed over wide areas and make frequent contact with the water's surface. They are also vulnerable to the disturbance and habitat damage associated with oil spill cleanup (Lock et al. 1994).

Shorebirds may be more affected by oil spills than has been suggested by carcass counts. A total of 7,800 collected bird carcasses were identified after the Nestucca oil spill off Washington State in 1988, but only six shorebird carcasses were present out of 3574 oiled shorebirds observed by Larsen and Richardson (1990). The authors suggested that this reveals a historic difficulty in finding shorebird carcasses, which may be explained by the higher mobility of oiled shorebirds (Larsen and Richardson 1990).

The extent of bioaccumulation of the chemical components of oil in birds is limited because vertebrate species are capable of metabolizing them at rates that minimize bioaccumulation (Neff 1985, in Hartung 1995). Birds generally excrete much of the hydrocarbons within a short time period (McEwan and Whitehead 1980).

Some studies have suggested that oil pollution is unlikely to have major long-term effects on bird productivity or population dynamics (Clark 1984; Butler

et al. 1988; Boersma et al. 1995; Erikson 1995; Stubblefield et al. 1995; White et al. 1995; Wiens 1995, 1996; Seiser et al. 2000) while others suggest the opposite (Piatt et al. 1990; Walton et al. 1997; Votier et al. 2005). Natural inter-annual variation in other factors that affect populations (e.g., prey availability and weather) reduces the ability of scientists to assess the full effect of oil spills on bird populations (Eppley 1992; White et al. 1995; Votier et al. 2005).

Individual seabirds that come into contact with oil could suffer a variety of effects ranging from sublethal to lethal. If effects on individuals were extensive enough to cause large numbers of mortalities and/or severe sublethal effects on growth and reproduction, then effects could be measured at the level of populations. The duration of sublethal effects would likely vary by species, life stage, type and degree of exposure, and many other factors. The maximum duration of any effect at the individual level would be the life span of that individual. It is impossible to predict with any level of realistic precision how a range of sublethal effects might affect a particular population and thus, the conservative prediction was made that a large oil spill could significantly affect seabird populations. It also can be predicted that given the relatively large abundance and distribution of the seabird species in the Northwest Atlantic, no population would be extirpated and the affected colonies would likely rebound within several generations if environmental conditions were favourable. Bernanke and Kohler (2009) consider the effects of oil spills on seabird populations as “transient”, with recovery times of 10 years, or possibly longer. Some sublethal effects reported in recent literature from two very large tanker spills include those briefly discussed below.

Large numbers of seabirds suffered mortality after the Exxon Valdez spill in Cook Inlet, Alaska and the Prestige spill in northwest Spain. Some reported sublethal effects of Prestige oil on birds included potential liver and kidney damage to Yellow-legged Gulls 17 months after the spill (Alonzo-Alvarez et al. 2007). Common Guillemots and razorbills (but not Atlantic Puffins) displayed brain acetylcholinesterase inhibition (Oropesa et al. 2007). Decreased breeding success at oiled colonies of European Shag (Phalacrocorax aristotelis) was reported by Velando et al. (2005).

Elevated hydrocarbon-inducible cytochrome P4501A in Harlequin Duck (Histrionicus histrionicus) livers up to 20 years after the Exxon Valdez spill was reported by Esler et al. (2010). It should be noted that this measurement is a biomarker for exposure and not necessarily a deleterious effect per se. Iverson and Esler (2010), based on modelling, suggested a recovery time of 24 years for Harlequin Duck after the spill.

In summary, it is possible that sublethal effects could persist for a number of years, depending upon generation times and the persistence of any spilled oil. Most seabirds are relatively long-lived. On the other hand, oil spilled on the Grand Banks, even if it made to the exposed coast, would likely not persist very long on Newfoundland’s high energy rocky coastline.

Studies conducted following the Exxon Valdez oil spill in 1989 have tried to ascertain whether marine bird populations have recovered in the Prince William Sound area in Alaska. Esler et al. (2002) noted that as of 1998, the Harlequin Duck (Histrionicus histrionicus) population that winters in Prince William Sound has not yet recovered, based on initial high mortalities, the decrease in population size only in oiled areas during 1995 to 1997, and the fact that fewer female adults survived winters in oiled areas possibly because of continued oil exposure through at least 1998 (likely still from the Exxon Valdez spill). For other populations, it is not as clear whether they have or have not yet recovered. Irons et al. (2000) conducted a study of marine bird densities and found that as of 1998, five taxa (mostly those that dive for their food) were still negatively affected by the oil spill, including cormorants, goldeneyes (Bucephala spp.), mergansers, Pigeon Guillemot (Cepphus columba), and murres. Furthermore, as of July 2000, goldeneyes, mergansers (Mergus spp.), Pigeon Guillemot, and Black-legged Kittiwake had decreased significantly in oiled areas, and only one species, the Black Oystercatcher (Haematopus bachmani), had shown signs of recovery (Irons et al. 2001). Wiens et al. (2001) disagreed with the study design and interpretation of data by Irons et al. (2000), maintaining that most populations are no longer affected by the oil spill. However, Esler et al. (2002) pointed out that the studies that have found rapid recovery of bird populations are either based on presence / absence data (Wiens et al. 1996), which are not informative about the status of populations, on a short time period and inappropriate geographic scale for some species (Day et al. 1997), or on summer data (Murphy et al. 1997) when some populations mainly overwinter in Prince William Sound. All authors do agree; however, that bird populations responded differently to the Exxon Valdez oil spill. Some populations showed little signs of being affected, other populations recovered quickly, and some populations took as much as a decade to fully recover (e.g., Pigeon Guillemot; Golet et al. 2002, in Esler et al. 2002). Populations of bird species with little genetic differentiation among breeding colonies are less likely to be affected severely by an oil spill because they have a greater potential for population recovery through dispersal (Riffaut et al. 2005).

Several small spills have occurred in or near the Study Area, and “small” oil releases (most likely from bilge pumping and de-ballasting by trans-Atlantic vessel traffic) occur frequently, killing thousands of marine birds (Brown et al. 1973; Brander-Smith et al. 1990; Chardine and Pelly 1994; Wiese and Ryan 2003). These discharges total more metric tons of oil on a world-wide basis than the total spillage from more well-known catastrophic spills, such as the Exxon Valdez and others (Brander-Smith et al. 1990, in Wiese and Ryan 2003). Between 1984 and 1999, the southeast coast of Newfoundland had the highest recorded rates in the world of oiled dead birds per kilometre of beach (0.77 versus 0.02 to 0.33 elsewhere; Wiese and Ryan 2003). Some researchers suggest that chronic oil pollution, acting in combination with other mortality factors, may affect seabirds at the population level (Piatt et al. 1990).

In February 1970, the Irving Whale spilled between 11,356 to 26,497 L (3,000 and 7,000 gallons) of Bunker C oil near St. Pierre and Miquelon, which subsequently spread along Newfoundland’s southeast coast. It was

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estimated that 7,000 birds, primarily Common Eiders, were killed (Brown et al. 1973). During the same month, the Arrow ran aground in Chedabucto Bay, Nova Scotia. Approximately 9,463,265 L (2,500,000 gallons) of Bunker C fuel oil were spilled, and at least 2,300 birds were killed in the bay itself (Brown et al. 1973). Primarily diving birds were affected, most notably Long-tailed Duck, Red-breasted Merganser, murres, Dovekie, and grebes (Brown et al. 1973). The spill spread offshore to Sable Island where mostly murres, Dovekie, and Northern Fulmar were killed. The lowest estimate of marine bird mortality from that part of the slick was 4,800 birds (Brown et al. 1973). In November 2004, a spill of crude oil occurred from the FPSO on the Terra Nova oil field. Based on the total area of the spill and on marine bird densities derived from marine bird surveys conducted in the spill area after the release, CWS has estimated that mortality to marine birds in the area may have been in the order of 10,000 (Wilhelm et al. 2007). This estimate depends on a number of assumptions, including: the marine bird surveys conducted seven and eight days following the incident were representative, the proportion of those birds flying during those surveys that made contact with the oil is known, and that the oil covered the entire surface area within the slick's perimeter. In fact, the high sea state during and after the spill resulted in areas of slick-free water within the slick (Wilhelm et al. 2007). Using a different method, a Memorial University scientist arrived at a mortality estimate for the Terra Nova spill that was of similar order of magnitude as the CWS estimate. He did this by inserting the Terra Nova spill volume into Burger's (1993) regression of mortality estimates on spill volumes, which was derived from historical spills occurring in a wide range of locations (Wilhelm et al. 2007).

On a broader geographical scale, estimates of the number of birds that die annually from spills range from 21,000 on the Atlantic coast of Canada, and 72,000 in all of Canada (Thomson et al. 1991), to 315,000 ±65,000 Common Murres, Thick-billed Murres and Dovekies annually in southeastern Newfoundland alone due to illegal oil discharges from ships (Wiese and Robertson 2004). Clark (1984) estimated that 150,000 to 450,000 birds die annually in the North Sea and North Atlantic from oil pollution from all sources.

Spill modelling at the site of the Hebron Platform shows that the majority of spills are predicted to travel eastward (ASA 2011b). Modelling was conducted for well blow-outs of crude oil, with oil released at either the seafloor or from the top of the drilling platform and durations of 30 to 120 days. Short duration (less than 24 hours) small volume batch transfer spills of crude oil and diesel fuel were also modelled. Additional extended duration spill simulations were completed for platform blow-out scenarios to track oil remaining on the sea surface 200 days beyond termination of the oil flow. Blow-out simulations >30 days duration are predicted to have a 0 to 3 percent probability of reaching segments of the Newfoundland shoreline (primarily the southern Avalon Peninsula). However, this probability increases to a maximum of 8 percent based on modelling of oil remaining 200 days beyond termination of a blowout. If oil reaches the shoreline during summer (1 percent probability), it is predicted that about 5 km of shoreline

may be oiled (at >0.01 mm thickness). If oil reaches the shoreline during winter (1 to 8 percent probability), it is predicted that up to 785 km of shoreline may be oiled (at >0.01 mm thickness). These probabilities were based on modelling results in the absence of any spill intervention (ASA 2011b). Based on spill modelling, there is little chance that seabird colonies on the Avalon Peninsula will experience shoreline oiling during the breeding season. There is some chance that oil may reach the southern Avalon Peninsula, including Cape St. Mary's during winter. This could put Harlequin Ducks and other winter seabirds (e.g., eiders) at risk to be exposed to weathered oil (three weeks to nine months old). Oil removal from the exposed and rocky shoreline of the Avalon Peninsula will be faster than removal from protected areas with softer substrate because of increased water penetration and flushing and wave erosion (ASA 2011b). Weathering processes will have reduced the amount of oil potentially reaching shorelines (ASA 2011b). Mitigation measures will likely reduce effects of potential hydrocarbon spills on marine birds in the Offshore Study Area.

Tracker buoy data collected during the 2004 Terra Nova spill indicated that it took five weeks for the buoy to reach 40.00.0W and approximately 48.00.00N in November / December (and basically confirmed the oil spill trajectory modelling results conducted to date for the Grand Banks oil developments). If an uncontrolled spill (i.e., no spill countermeasures implemented) lasted more than 120 days, the modelling predicts that oil from a surface or sub-surface blowout at the Hebron Platform will extend beyond the model domain area and, therefore, could potentially (less than 10 percent probability) reach an international coastline with a thickness greater than 0.01 mm. However, any oil that did reach an international shoreline would be patchy, weathered oil.

Mitigation for accidental hydrocarbon spills will consist of following the protocols detailed in the spill response plan. The oil spill response plan is under development; however, Section 14.6 provides an outline of the proposed spill response plan for offshore operations. Depending on the nature and tiered response required, mitigations include the provision for spill response equipment and the rescue and rehabilitation of oiled marine birds. Marine bird rehabilitation will be facilitated through ExxonMobil's North American support network. These procedures will minimize the potential mortality from such accidental events.

The environmental effects of Project accidental events activities on Marine Birds are summarized in Table 9-13. The geographic extents provided in Table 9-13 were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b).

Table 9-13 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Change in Habitat Use	• Prevention through design standards and maintenance • Emergency Response Contingency Plan	1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	4	2/1	R/I [B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2
Subsea Blowout	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	3/1	R/I[B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	1	2/1	R/I[B]	2
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Collisions (involving Hebron Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	3	2/1	R/I [B]	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential Mortality effects reversible at the population level and irreversible at the individual level

The potential environmental effects from some of the assessed accidental event scenarios could be high in magnitude, high in geographical extent and moderate in duration. However, a Project-related accidental event is considered unlikely.

9.5.5 Cumulative Environmental Effects

Marine oil and gas exploration, commercial fishery activity, marine transportation and existing production activity (e.g., White Rose, Hibernia, and Terra Nova) all have the potential to interact with marine birds (see Table 9-9). Hunting of marine birds occurs in the Nearshore Study Area. It is unlikely that routine activities associated with other marine exploration, existing production areas, marine transportation, and commercial fisheries have substantive environmental effects on marine birds. The one exception would be an accidental hydrocarbon spill or blowout in the Offshore Study Area.

9.5.5.1 Nearshore

With the exception of marine bird hunting, cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area, as fewer activities have the potential to interact with the current Project (see Section 9.5.5.2 for cumulative environmental effects assessment of the Offshore Study Area).

Most hunting of marine birds in Newfoundland and Labrador waters occurs inshore. The harvested populations are primarily sea ducks (especially Common Eider) and murres (mostly Thick-billed Murre). Sea ducks occur primarily inshore, but Thick-billed Murre occurs both inshore and offshore (autumn to spring). The last harvest survey was run in 2001 and estimated that approximately 300,000 murres were harvested in Newfoundland and Labrador (Wiese et al. 2004). Since then, based on permit purchases, there has been a general decline in hunter participation (CWS, unpublished data). Wiese et al. (2004) modelled the effects of hunting and oil pollution on the population growth of Thick-billed Murres and found that hunting decreased the population growth at the same rate as chronic oil pollution, arising primarily from illegal discharges of oily water from ships. Hunting of sea ducks and murres may therefore have a cumulative environmental effect with effects of accidental hydrocarbon spills and produced water (Wiese et al. 2004).

9.5.5.2 Offshore

The effects of illumination on structures and vessels, air emissions, discharges, underwater sound, accidental hydrocarbon spills from exploration vessels, existing production drilling platforms and vessels, other exploratory drilling structures and platforms may have cumulative environmental effects with Project activities and Project accidental events.

Marine birds, particularly Leach's Storm-Petrels, may be attracted to the lights of offshore structures and vessels at night and during periods of poor visibility. As a result, Leach's Storm-Petrels may strand on offshore platforms, as discussed in Section 9.5.1.2. The stranding of birds at offshore platforms is largely mitigated by bird handling and release protocols so that any cumulative environmental effects, if they occur, would be low and not significant.

The Project will create additional emissions to the atmosphere, but air emissions from one drilling operation will be relatively small in scale and within the range of other offshore marine activities such as marine shipping. Emissions will very rapidly dissipate in the windy offshore environment and will not endanger the health of marine birds since any exposures will be of very low concentrations and durations. Any cumulative environmental effects are considered negligible.

Drill mud and other discharges are regulated by the Offshore Waste Treatment Guidelines (National Energy Board et al. 2010), and the quantities involved, geographic extents and magnitudes are small. There are few pathways for drill mud / cuttings discharges to affect marine birds, other than

the potential exception of a sheen of synthetic-based mud (SBM) under flat calm conditions. As described for the effects of discharges on marine birds, any cumulative environmental effect is considered not significant.

The bycatch of marine birds in commercial fisheries has historically been a known source of at-sea mortality. However, bycatch of marine birds in commercial fisheries (e.g., inshore gill netting) has declined sharply since 1992 (Piatt and Nettleship 1987; Benjamins et al. 2008). This has probably had a positive effect on marine bird populations, both those nesting in Newfoundland and those nesting in the Arctic. Consequently, the environmental effects of commercial fisheries probably no longer pose any significant cumulative environmental effects on marine birds.

As described in the assessment above, underwater sound has the potential to disturb marine birds that spend prolonged periods submerged near a loud sound source. Alcids are the only family of marine birds found in Newfoundland offshore waters that are known to dive underwater for extended periods and are, thus, more likely to be affected by underwater sound than other species. Avoidance or behavioural disturbance is the most likely effect of underwater sound produced by offshore operations associated with the Project or other nearby operations, but these effects are expected to be low in magnitude and only affect a small area. Thus, it is predicted that cumulative environmental effects of underwater sound on marine birds are not significant.

A major spill or blowout on the Grand Banks could affect marine birds, depending on the type, size, location, timing, species, and life stages involved. A major spill is statistically very unlikely to coincide among various operations on the Grand Banks. Nevertheless, cumulative environmental effects could occur from chronic discharges of oil bilges at sea by ships transiting the area or from other activities that could affect marine birds. A major oil spill could significantly affect marine birds on the Grand Banks and thus result in a significant cumulative environmental effect when considered in addition to other stressors on bird populations (e.g., hunting, bycatch in commercial fishing, or oiling from bilge dumping). However, petroleum hydrocarbons from a deepwater blowout may be considerably reduced when it reaches the surface, and the wind and wave conditions typical of the Grand Banks will further aid in the dispersal of petroleum hydrocarbons. Spill countermeasures and marine bird rehabilitation would additionally reduce potential cumulative environmental effects.

9.5.6 Determination of Significance

The determination of significance is based on the definition provided in Section 9.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect with the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

Adverse environmental effects of attraction to illumination on structures and vessels on Marine Birds during the construction / installation phase of the Project are predicted to be low in magnitude, geographic extent, duration and frequency when mitigation measures are practiced. Although significant at the individual level, these environmental effects are predicted to be reversible at the population level. These environmental effects are therefore predicted to be not significant.

Adverse environmental effects of attraction to illumination on structures and vessels on Marine Birds during the operation and maintenance phase are predicted to be low in magnitude, geographic extent, duration and frequency when mitigation measures are practiced. Adverse environmental effects of produced water on Marine Birds during the operation and maintenance phase are predicted to be low in magnitude, geographic extent, duration and frequency when mitigation measures are practiced. Although potentially significant at the individual level, these environmental effects are predicted to be reversible at the population level. Therefore, these environmental effects are predicted to be not significant.

Adverse environmental effects of attraction to illumination on structures and vessels on Marine Birds during the decommissioning and abandonment phase of the project are predicted to be low in magnitude, geographic extent, duration and frequency when mitigation measures are practiced. Although significant at the individual level, these environmental effects are predicted to be reversible at the population level. These environmental effects are therefore predicted to be not significant.

Adverse environmental effects of accidents, malfunctions and unplanned events (i.e., hydrocarbon and other chemical spills due to collisions, failure of OLS manifolds or risers, subsea blowouts, batch spills or marine vessel incidents) are predicted to be low to high in magnitude, low to high in geographic extent, low to moderate in duration and low in frequency. Although significant at the individual level, these environmental effects are predicted to be reversible at the population level. Nevertheless, these environmental effects are predicted to be significant. Smaller scale spills and blowouts in calm conditions may be mitigated via oil spill response measures and marine bird rehabilitation; however, these mitigations are recognized to be limited. ExxonMobil's philosophy is focused on prevention using safety and risk management systems, management of change procedures, and global standards. There will be an emphasis on accident prevention at all phases of the Project.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Marine Birds, after taking into account any proposed mitigation, is summarized in Table 9-14.

Because the adverse environmental effects of each Project phase are predicted to be not significant, the adverse environmental effects of the Project overall is predicted to be not significant.

Table 9-14 Residual Environmental Effects Summary: Marine Birds

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	S	1	1
Cumulative Environmental Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria.
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site.
C Includes decommissioning and abandonment of the GBS and offshore site.
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

9.5.7 Follow-up and Monitoring

The CEAA definition of "follow-up program" is "a program for (a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project". Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. Compliance monitoring on its own, does not satisfy the requirements for a follow-up program. Compliance monitoring is conducted to ensure that a project and its activities are meeting the relevant environmental standards, guidelines and regulations. Compliance monitoring will be conducted for the Project in accordance with regulatory requirements.

Environmental effects monitoring (EEM) programs, for the nearshore and offshore components of the Project, are at the very early stages of development. Chapter 15 of the CSR outlines a proposed process to develop the EEM program. Based on the environmental effects assessment for marine birds, a marine bird EEM component is not contemplated at this stage. The EEM will be developed in consultation with stakeholders, including the public, regulatory agencies and scientific community. The final EEM design may include marine bird monitoring; however, that will be determined as the EEM design process progresses.

In light of current knowledge of bird strikes associated with lighting on offshore platforms, EMCP commits to the development and implementation of a research monitoring program at the Hebron field location. This program will

be designed to provide information regarding potential interactions between pelagic seabirds (significant concentrations hosted on the Grand Banks) and the Hebron platform. Information from the Hebron Platform site would provide additional data to allow assessment of risk and mortality regarding potential seabird attraction to offshore structures. The program design would be developed in consultation with Environment Canada's Canadian Wildlife Service and would be completed prior to platform start-up in 2017. It is anticipated that field testing would begin upon completion of platform start-up and commissioning activities offshore.

In the event of a spill, and depending on the nature and size of the spill, marine bird monitoring will be implemented. The details regarding monitoring requirements and protocols will be outlined in the oil spill response plan and will be determined in consultation with the C-NLOPB and Environment Canada.

Mobile offshore drilling unit drilling programs typically engage a weather observer on staff to undertake dedicated marine bird and marine mammal observations. This position is not currently envisaged for the Hebron Platform, as all weather observations will be automated.

EMCP supports initiatives such as the recent ESRF marine bird monitoring program and will investigate the development of a marine bird observation program from Hebron Project supply vessels, where space is available. Marine bird monitoring protocols will be based on those provided by CWS (Wilhelm et al. n.d.) as per Appendix 2 in the C-NLOPB Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2010).

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10 MARINE MAMMALS AND SEA TURTLES

The Marine Mammal and Sea Turtle Valued Ecosystem Component (VEC) includes cetaceans (whales, dolphins, and porpoises), pinnipeds (seals) and sea turtles that are not considered at-risk species by the Species at Risk Act (SARA) or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Marine mammal and sea turtle species at risk are described and assessed in Chapter 11.

10.1 Environmental Assessment Boundaries

10.1.1 Spatial and Temporal

10.1.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Section 4.3.2). The Nearshore and Offshore Study Areas and Project Areas are illustrated in Figures 10-1 and 10-2, for the nearshore and offshore, respectively. The Affected Areas for several Project activities have been determined by modelling (see ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

10.1.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are summarized in Table 10-1.

Table 10-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

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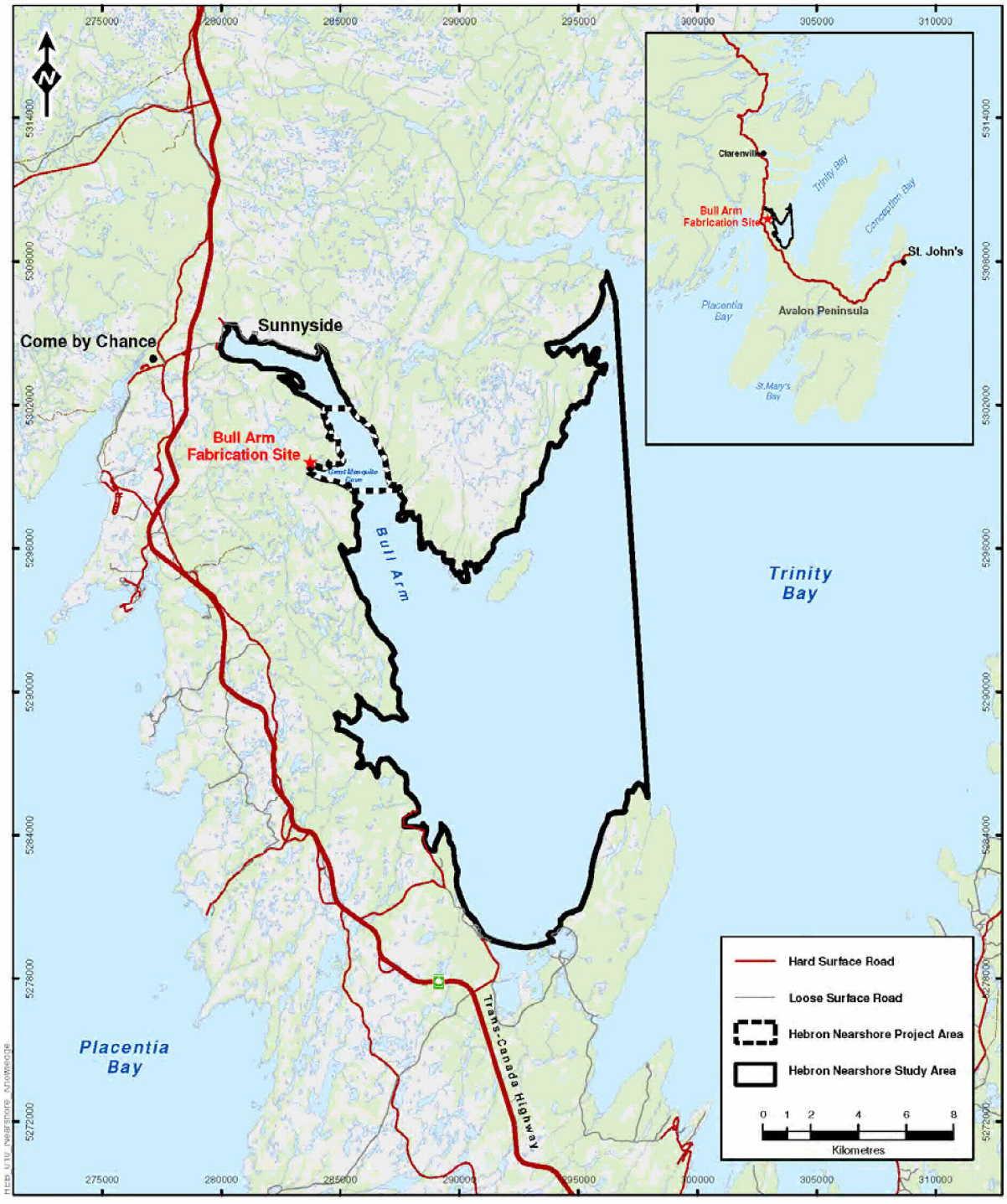

Figure 10-1 Nearshore Study and Project Areas

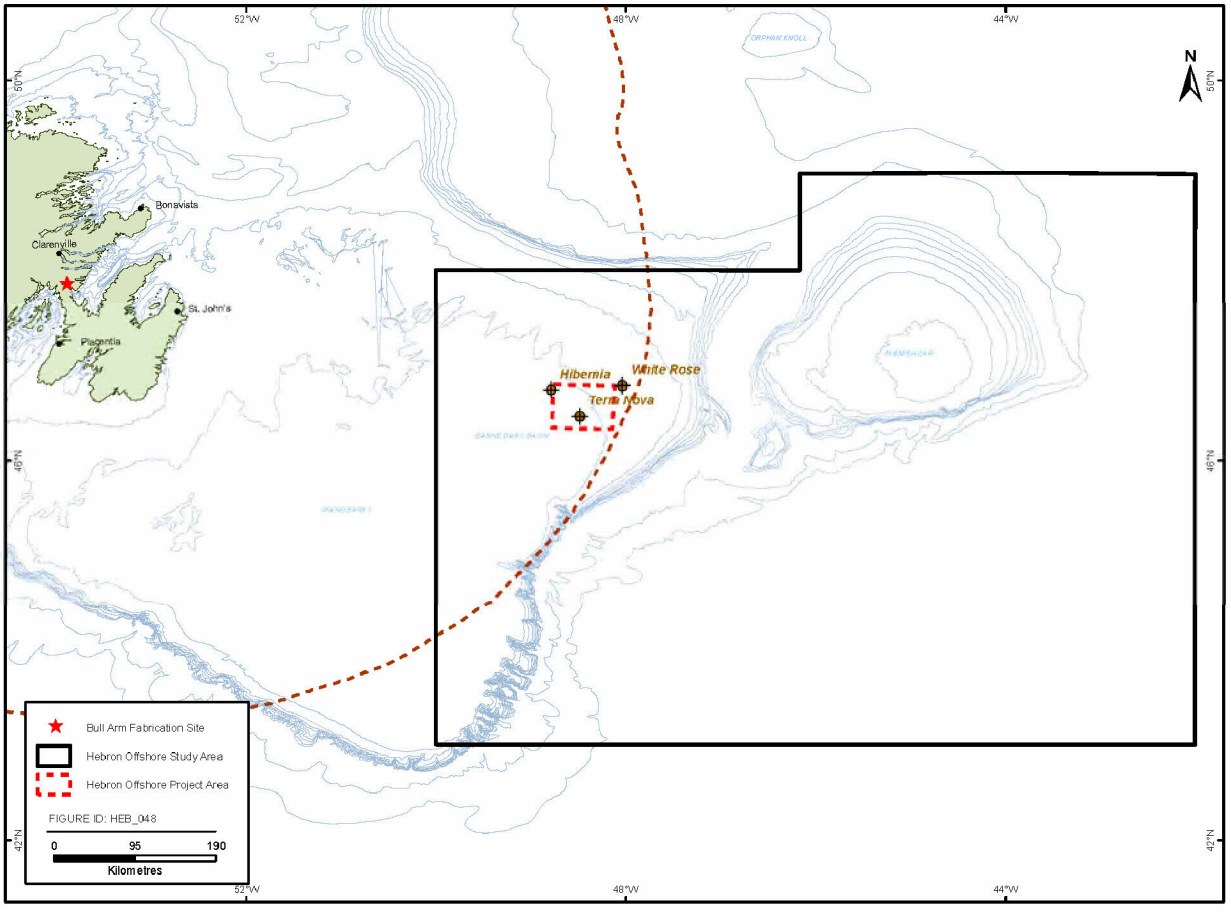

Figure 10-2 Offshore Study and Project Areas

10.1.2 Administrative

Marine mammals and sea turtles are protected under the federal Fisheries Act. Marine mammal and sea turtle species at risk are protected under SARA (refer to Chapter 11).

10.2 Definition of Significance

A significant adverse residual environmental effect is one that affects marine mammals or sea turtles by causing a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Area. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

An adverse environmental effect that does not meet the above criteria is evaluated as not significant.

10.3 Existing Conditions

10.3.1 Marine Mammals

A total of 21 marine mammals, including five baleen whales (mysticetes), 12 toothed whales (odontocetes), and four true seals (phocids), are known to occur in the Nearshore and/or Offshore Study Areas (Table 10-2). The temporal and spatial distribution, habitat, and relevant SARA listings and COSEWIC designations for each species are presented in Table 10-2. At-risk species are described in greater detail in Chapter 11. Most marine mammals are seasonal inhabitants of the Study Areas, with both regions representing important foraging grounds for many species. The best available abundance estimates for each of the marine mammal species in the Northwest Atlantic, as well as for eastern Newfoundland, are provided in Table 10-3.

Table 10-2 Marine Mammals Known or Expected to Occur within the Nearshore and Offshore Study Areas

Species (Scientific Name)	Bull Arm Study Area		Hebron Study Area		Habitat	SARA Status[A]	COSEWIC Status[B]
	Occurrence	Season	Occurrence	Season			
Baleen Whales (Mysticetes)							
Humpback whale (Megaptera novaeangliae)	Common	Year-round, but mostly June-Sept	Common	Year-round, but mostly May-Oct	Coastal & banks	NS	NAR
Blue whale (Balaenoptera musculus)	Uncommon	Year-round, but mostly July-Sept	Uncommon	Year-round, but mostly June-Oct	Coastal & pelagic	Schedule 1: Endangered	E
Fin whale (Balaenoptera physalus)	Common?	June-Oct	Common	Year-round, but mostly June-Oct	Slope & pelagic	Schedule 1: Special Concern	SC
Sei whale (Balaenoptera borealis)	Rare	Summer	Uncommon	May-Sept	Offshore & pelagic	NS	DD
Minke whale (Balaenoptera acutorostrata)	Common	Year-round, but mostly June-Oct	Common	Year-round, but mostly May-Oct	Shelf, banks, & coastal	NS	NAR
Toothed Whales (Odontocetes)							
Sperm whale (Physeter macrocephalus)	Uncommon	Summer	Uncommon	Year-round, but mostly summer	Pelagic, slope, canyons	NS	NAR; LPC
Northern bottlenose whale (Hyperoodon ampullatus)[D]	Very Rare	Year-round?	Rare	Year-round?	Pelagic, canyons, slope	NS	NAR
Sowerby's beaked whale (Mesoplodon bidens)	Very Rare	Year-round?	Rare	Year-round?	Pelagic, deep, slope, canyon	Schedule 3: Special Concern	SC

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Species (Scientific Name)	Bull Arm Study Area		Hebron Study Area		Habitat	SARA Status[A]	COSEWIC Status[B]
	Occurrence	Season	Occurrence	Season			
Killer whale (Orcinus orca)	Uncommon?	Year-round, but mostly June-Oct	Uncommon	Year-round, but mostly June-Oct	Widely distributed	NS	SC
Long-finned pilot whale (Globicephala melas)	Common	Year-round, but mostly July-Oct	Common	Year-round	Mostly pelagic	NS	NAR
Risso's dolphin (Grampus griseus)	Very Rare	Year-round?	Rare	Year-round?	Slope	NS	NAR
Common bottlenose dolphin (Tursiops truncatus)	Very Rare	Summer	Rare	Summer	Shelf & pelagic	NS	NAR
Short-beaked common dolphin (Delphinus delphis)	Uncommon	Summer	Common	June-Oct	Shelf & pelagic	NS	NAR
Striped dolphin (Stenella coeruleoalba)	Rare	Summer	Uncommon	July-Oct	Slope & pelagic	NS	NAR
Atlantic white-sided dolphin (Lagenorhynchus acutus)	Common	Year-round, but mostly June-Sept	Common	Year-round, but mostly June-Oct	Shelf & slope	NS	NAR
White-beaked dolphin (Lagenorhynchus albirostris)	Common	Year-round, but spring & fall	Common	Year-round, but mostly June-Sept	Shelf	NS	NAR
Harbour porpoise (Phocoena phocoena)	Common	Year-round?, but mostly summer	Uncommon	Year-round, but mostly May-Oct	Shelf	Schedule 2: Threatened	SC
True Seals (Phocids)							
Harbour seal (Phoca vitulina)	Uncommon?	Year-round	Rare	Year-round	Coastal	NS	NAR
Harp seal (Phoca groenlandica)	Uncommon?	Feb-May	Common	Dec-June	Ice & pelagic	NS	NC; LPC
Hooded seal (Cystophora cristata)	Uncommon?	Mostly late winter	Uncommon	Mostly late winter	Ice & pelagic	NS	NAR; LPC
Grey seal (Halichoerus grypus)	Rare	Year-round	Uncommon	Year-round	Coastal	NS	NAR

Notes:
Note additional information on Species at Risk is provided in Chapter 11
? Indicates uncertainty
A Species designation under SARA (Government of Canada 2009); NS = No Status
B Species designation under COSEWIC (COSEWIC 2010a); E = Endangered, T = Threatened, SC = Special Concern, DD = Data Deficient, NAR = Not At Risk, NC = Not Considered, LPC = Low-priority Candidate, MPC = Mid-priority Candidate, HPC = High-priority Candidate
C Refers to the Davis Strait population. The Scotian Shelf population is considered Endangered on Schedule 1 of SARA and Endangered by COSEWIC. It is unknown to which population individuals observed in the Study Areas would belong

Table 10-3 Population Estimates of Marine Mammals that Occur off Eastern Newfoundland

Species	NW Atlantic	Population Occurring off Eastern Newfoundland		
	Estimated Abundance[A]	Stock	Estimated Abundance	Source
Baleen Whales				
Humpback whale	11,570[B]	NL	1,700-3,200	Whitehead (1982); Katona and Beard (1990); Baird (2003)
Sei whale	Unknown	Nova Scotia	207	Waring et al. (2009)
Minke whale	188,000[D]	Can. E. Coast	3,312	Dufault (2005); Waring et al. (2009)
Toothed Whales				
Sperm whale	4,804[E]	NW Atlantic	Unknown	Reeves and Whitehead (1997); Waring et al. (2009)
Northern bottlenose whale	Unknown	North Atlantic	Unknown	Reeves et al. (1993)
Long-finned pilot whale	31,139[G]	NL	Tens of thousands	Hay (1982); Nelson and Lien (1996)
Risso's dolphin	20,479	Can. E. Coast	Rare	Baird and Stacey (1991)
Common bottlenose dolphin	81,588[H]	Can. E. Coast	Unknown	Waring et al. (2009)
Short-beaked common dolphin	120,743	NL	Seasonally abundant	Gaskin (1992)
Striped dolphin	94,462	Can. E. Coast	Unknown	Baird et al. (1993a)
Atlantic white-sided dolphin	63,368	Can. E. Coast	Unknown	Palka et al. (1997); Waring et al. (2009)
White-beaked dolphin	2,003	Can. E. Coast	Unknown	Waring et al. (2009)
True Seals				
Harbour seal	99,340	NL	Thousands (at least 1,000)	Hammill and Stenson (2000); Sjare et al. (2005a); COSEWIC (2007a)
Harp seal	5.9 million[I]	NL	Abundant	DFO (2007b)
Hooded seal	593,500[J]	NE NL	535,800	Hammill and Stenson (2006a)
Grey seal	304,000[K]	NL	Unknown	

Notes:
A "Best" estimates from the Northwest Atlantic (Waring et al. 2009), unless otherwise noted
B Estimate for North Atlantic (Stevick et al. 2003)
C Estimate for North Atlantic (US National Marine Fisheries Service (NMFS) 1998)
D Estimate for North Atlantic (IWC 2007; Waring et al. 2009)
E Estimate for North Atlantic (Waring et al. 2009)
F Estimate for all Mesoplodon spp. and Ziphius cavirostris combined in the Northwest Atlantic (Waring et al. 2009)
G Estimate may include both long- and short-finned pilot whales (Waring et al. 2009)
H Estimate for the Northwest Atlantic offshore stock, but may include coastal forms (Waring et al. 2009)
I Estimate for the Northwest Atlantic (DFO 2007b)
J Estimate for the Canadian Northwest Atlantic (Hammill and Stenson 2006a)
K Estimate for Sable Island, eastern Nova Scotia, and the Gulf of St. Lawrence breeding populations (Thomas et al. 2007)

In addition to the species listed in Table 10-2, four species may be rare visitors in one or both of the Study Areas: the beluga whale (Delphinapterus leucas), North Atlantic right whale (Eubalaena glacialis), ringed seal (Pusa hispida), and bearded seal (Erignathus barbatus). There have been occasional reports of beluga whales at the head of Trinity Bay and adjacent Newfoundland waters, mostly during summer months (Curren and Lien 1998; Ledwell and Huntington 2006). However, these records are considered extralimital. The distributions of both ringed and bearded seals are centred in the Arctic and pack ice of the sub-Arctic (Jefferson et al. 2008). Occasionally, small numbers of either species may stray into the Offshore Study Area, particularly in heavy ice years. While it is possible that these four species

could occur in the Study Areas, their presence is highly unlikely and they are not considered further in this document.

Marine mammal surveys of the Grand Banks, including the Offshore Study Area, were conducted over 25 years ago in support of the Hibernia EIS (Parsons and Brownlie 1981). These surveys represented the primary source of information on marine mammal distribution and abundance within the Jeanne d'Arc Basin for several years, but are not repeated for this report. However, marine mammal sightings from recent monitoring programs in and near the Offshore Study Area (including data from 2005 to 2008) as well as cetacean observations from Newfoundland waters compiled by Fisheries and Oceans Canada (DFO) and the Whale Release and Stranding Group are summarized and incorporated into the following species profiles, updating a previous summary in LGL (2006b). Marine mammals were also recorded during supply vessel transits in August and early September 1999 from St. John's to oil platforms in the Jeanne d'Arc Basin (Wiese and Montevecchi 1999). Marine mammal observations are also available from the Terra Nova Floating, Production, Storage and Offloading (FPSO) monitoring facility for 2007 and 2008, but these are limited in terms of observational effort and detail. Waring et al. (2009) provide additional information on the distribution, abundance, seasonality, and conservation status of marine mammals in the Northwest Atlantic. It should be noted that the "best estimates" of marine mammal population size in Waring et al. (2009) are largely based on aerial survey data that are typically uncorrected for dive times.

10.3.1.1 Recent Marine Mammal Monitoring in the Jeanne d'Arc Basin

There have been several recent marine mammal monitoring programs (from 2005 to 2008) conducted during seismic surveys in Jeanne d'Arc Basin and adjacent areas, which provide new information on the spatial and temporal distribution of marine mammals in the area. Relevant programs include: Husky Energy's seismic programs during October and November 2005 (Lang et al. 2006) and July and August 2006 (Abgrall et al. 2008a); Petro-Canada's seismic survey during June and July 2007 (Lang and Moulton 2008): and StatoilHydro and Husky Energy's seismic program from June to September 2008 (Abgrall et al. in prep.). However, the data represent only the late spring, summer and fall seasons (and typically only portions of the summer), and the number and types of marine mammals observed may be biased by potential responses to noise from the airgun arrays. Additional marine mammal sightings were recorded by Wiese and Montevecchi (1999) during supply vessel transits between St. John's and oil platforms in Jeanne d'Arc Basin during August and September 1999 (three roundtrips in both August and September). Marine mammals were also recorded during a research expedition from the southern Grand Banks, along the eastern slope, through the Flemish Pass, around the Orphan Basin, and through the northern Grand Banks on a return to St. John's in June and July 2004 (Lang and Moulton 2004).

A summary of marine mammal sightings during the 2005 to 2008 seismic monitoring programs in the Jeanne d'Arc Basin is provided in Table 10-4.

Table 10-4 Effort and Number of Marine Mammal Sightings in the Jeanne d'Arc Basin during Monitoring Programs Conducted as a Component of Seismic Surveys, 2005 to 2008

Species	Oct-Nov 2005[A]	July-Aug 2006[B]	June-July 2007[C]	May-Sept 2008[D]	Total
Effort (km)[E]	1,895	2,731	2,511	6,734	13,871
Humpback whale	27	178	5	138	348
Sei whale	0	0	0	1	1
Fin or sei whale	0	0	0	1	1
Minke whale	4	12	1	31	48
Unidentified baleen whale	14	21	1	84	120
Total baleen whales	45	211	7	255	518
Unidentified beaked whale	1	0	0	1	2
Unidentified toothed whale	0	1	0	0	1
Total large toothed whales	1	1	0	1	3
Long-finned pilot whale	0	2	1	2	5
Common dolphin	1	7	0	0	8
Atlantic white-sided dolphin	2	7	0	24	33
White-beaked dolphin	1	0	5	4	10
Unidentified dolphin	2	28	5	41	76
Total dolphins & porpoises	6	44	11	71	132
Unidentified Whale	4	33	1	9	47
Total Cetaceans	56	289	19	336	700
Harp seal	0	0	0	14	14
Unidentified seal	0	2	0	22	24
Total seals	0	2	0	36	38

Notes:
A Husky Energy's seismic program from 1 October to 8 November 2005 (Lang et al. 2006)
B Husky Energy's seismic program from 9 July to 17 August 2006 (Abgrall et al. 2008a)
C Petro-Canada's seismic program from 18 June to 14 July 2007 (Lang and Moulton 2008)
D StatoilHydro and Husky Energy's seismic program from 25 May to 28 September 2008 (Abgrall et al. in Prep.)
E Effort and sightings include those made in the designated "Seismic Analysis Area" or "Study Area" of each seismic program (i.e., the areas where seismic data were actually acquired plus a zone around this area where the seismic vessel made the majority of its turns at the end of seismic lines; effort and sightings during transit to and from the Jeanne d'Arc basin were excluded). See text of each report for specific coordinates, but all encompass Jeanne d'Arc Basin and immediately adjacent areas

There were a total of 700 non-Species At Risk (SAR) cetacean sightings (including 518 baleen whale, three large toothed whale, 132 dolphin and porpoise, and 47 unidentified whale sightings) and 38 seal sightings within the Jeanne d'Arc Basin during seismic monitoring programs from 2005 to 2008. The majority of non-SAR baleen whale sightings identified to species consisted of humpback whales (91.3 percent of identified baleen whale sightings) followed by minke whales (12.6 percent). There were no confirmed identifications of sperm whales, Sowerby's beaked whales, or northern bottlenose whales. Perhaps with the exception of sperm whales, this was not unexpected, given that the seismic programs occurred in relatively shallow shelf waters. Most of the non-SAR dolphin and porpoise sightings in the

Jeanne d'Arc Basin were of unidentified species (57.6 percent of dolphin and porpoise sightings), but Atlantic white-sided dolphins were the most frequently identified species (58.9 percent of identified dolphin and porpoise sightings). The harp seal was the only identified seal in Jeanne d'Arc Basin during these monitoring programs (14 of 38 seal sightings). The distribution of marine mammal sightings observed during these surveys, relative to the proposed Offshore Study Area, are shown in Figure 10-3.

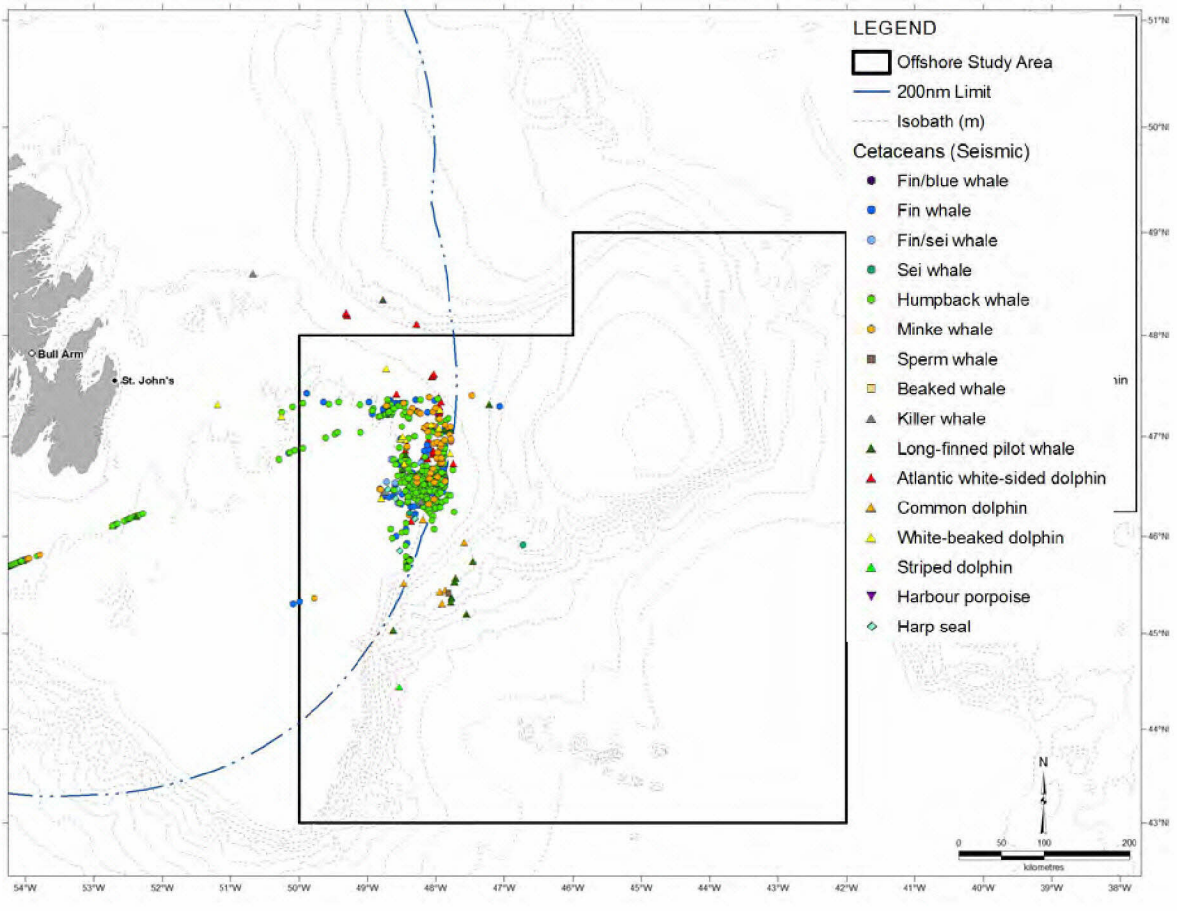

Figure 10-3 Locations of Marine Mammal Sightings Observed during Jeanne d'Arc Basin Seismic Surveys (2005 to 2008), Relative to the Offshore Study Area

Wiese and Montevecchi (1999) recorded 34 sightings of 282 individuals during the six round-trip surveys aboard a supply vessel travelling from St. John's to Jeanne d'Arc Basin. The majority of sightings were of humpback whales (11 sightings totalling 13 individuals). There were also sightings of minke and fin whales (eight and seven sightings, respectively). Most dolphin sightings were of Atlantic white-sided dolphins (seven sightings totalling 250 individuals). There was also a sighting of three killer whales recorded on August 24, 1999.

Lang and Moulton (2004) reported 20 sightings of marine mammals during a June to July 2004 research cruise from the southern Grand Banks, around Orphan Basin, and across the northern Grand Banks; long-finned pilot whales were the most frequently sighted species (six sightings), although there were

also several sightings of unidentified baleen whales and dolphins. Atlantic white-sided dolphins and fin whales were also identified.

In the adjacent Orphan Basin, several years of monitoring during seismic and controlled source electromagnetic (CSEM) surveys have also yielded hundreds of sightings of marine mammals. Orphan Basin has much greater water depths than Jeanne d'Arc Basin and different species were more frequently encountered in the Orphan Basin. For example, deep-diving sperm whales, northern bottlenose whales, and Sowerby's beaked whales were identified on several occasions in the Orphan Basin, and there have also been sightings of blue whales, bottlenose dolphins, and striped dolphins in the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b).

10.3.1.2 Fisheries and Oceans Canada Cetacean Sighting Database

DFO in St. John's (J. Lawson 2007, pers. comm.) is compiling a database of cetacean sightings in waters around Newfoundland and Labrador. These data provide some indication of what species can be expected to occur in the area, but they cannot, at this point in the development of the database, provide any fine-scale quantitative information as the database typically does not include observation effort. The coarse summary data pertaining to sightings within the Nearshore and Offshore Study Areas are provided in Tables 10-5 and 10-6; caveats associated with the DFO data are also presented.

Table 10-5 DFO Database Cetacean Sightings within the Nearshore Study Area, 1945 to 2007

Species	No. of Sightings	No. of Individuals	Month(s) Sighted
Humpback Whale	62	81	May-Aug
Minke Whale	57	64	May-Sept
White-beaked Dolphin	1	10	August

Source: DFO (2007c)
*Note the following caveats associated with the tabulated data:

- The sighting data have not yet been completely error-checked
- The quality of some of the sighting data is unknown
- Most data have been gathered from platforms of opportunity that were vessel-based. The inherent problems with negative or positive reactions by cetaceans to the approach of such vessels have not yet been factored into the data
- Sighting effort has not been quantified (i.e., the numbers cannot be used to estimate true species density or real abundance)
- Both older and some more recent survey data have yet to be entered into this database. These other data will represent only a very small portion of the total data
- Numbers sighted have not been verified (especially in light of the significant differences in detectability among species)
- For completeness, these data represent an amalgamation of sightings from a variety of years (e.g., since 1945) and seasons. Hence, they may obscure temporal or real patterns in distribution (e.g., the number of pilot whales sighted in nearshore Newfoundland appears to have declined since the 1980s but the total number sighted in the database included here suggest they are relatively common)

Table 10-6 DFO Database Cetacean Sightings within the Offshore Study Area, 1945 to 2007

Species	No. of Sightings	No. of Individuals	Month(s) Sighted
Sei Whale	11	20	Feb, June, Aug, Sept
Humpback Whale	465	1,423	Jan, Mar-Dec
Minke Whale	42	63	April-Dec
Sperm Whale	45	125	Feb-Dec
Northern Bottlenose Whale	6	41	Mar, May, June, Sept
Long-finned Pilot Whale	76	1,187	Jan-Mar, May-Nov
Atlantic White-sided Dolphin	20	154	June-Oct
Common Dolphin	46	1,115	Mar, April, June-Oct, Dec
White-beaked Dolphin	21	89	Feb, Mar, June-Aug
Striped Dolphin	1	Not recorded	Aug

Source: DFO (2007c)
*Note the following caveats associated with the tabulated data:

- The sighting data have not yet been completely error-checked
- The quality of some of the sighting data is unknown
- Most data have been gathered from platforms of opportunity that were vessel-based. The inherent problems with negative or positive reactions by cetaceans to the approach of such vessels have not yet been factored into the data
- Sighting effort has not been quantified (i.e., the numbers cannot be used to estimate true species density or real abundance)
- Both older and some more recent survey data have yet to be entered into this database. These other data will represent only a very small portion of the total data
- Numbers sighted have not been verified (especially in light of the significant differences in detectability among species)
- For completeness, these data represent an amalgamation of sightings from a variety of years (e.g., since 1945) and seasons. Hence, they may obscure temporal or real patterns in distribution (e.g., the number of pilot whales sighted in nearshore Newfoundland appears to have declined since the 1980s but the total number sighted in the database included here suggest they are relatively common)

Humpback whales and minke whales accounted for most non-SAR sightings in the DFO sightings database within the Nearshore Study Area (Table 10-5; Figure 10-4). There was also a single sighting of 10 white-beaked dolphins reported in the DFO database (Table 10-5; Figure 10-4).

By far, humpback whales accounted for most sightings in the Offshore Study Area. There were also several sightings of long-finned pilot whales (Table 10-6; Figure 10-5). Other commonly sighted marine mammals included minke whales and sperm whales. Common dolphins, white-beaked dolphins, and Atlantic white-sided dolphins were also frequently observed in the Offshore Study Area (Table 10-6; Figure 10-5).

Lawson and Gosselin (2009) provide preliminary abundance estimates of three mysticete and four small odontocete species based on aerial survey data collected off the south and northeast coasts of Newfoundland. It is difficult to comment on the distribution and relative abundance of cetacean species near the Hebron Study Area versus adjacent areas given the nature of the report. Overall densities (uncorrected for availability and perception biases) off the south coast of Newfoundland (0.002 cetacean sightings/km^2) were much higher than those (0.0005 cetacean sightings/km^2) off the northeast coast (Table 3 in Lawson and Gosselin (2009)). The south coast

survey stratum is adjacent to the western portion of the offshore Hebron Study Area. Overall, preliminary abundance estimates (uncorrected) for cetaceans off the south and northeast coasts of Newfoundland including 95 percent confidence intervals in parentheses are as follows:

- humpback whale - 1,427 (952 to 2,140)
- minke whale -1,315 (855 to 2,046)
- fin whale - 890 (551 to 1,435)
- white-beaked dolphin - 1,842 (1,188 to 2,854)
- white-sided dolphin - 1,507 (968 to 2,347)
- common dolphin - 576 (314 to 1,056)
- harbour porpoise - 1,195 (639 to 2,235)

10.3.1.3 Whale Entrapment Records

The Whale Release and Stranding Group produced yearly reports of whale entrapments and stranding from 2000 to 2008 (Ledwell et al. 2000, 2001, 2002; Ledwell and Huntington 2003, 2004, 2006, 2007, 2008, 2009). These reports include animals caught in fishing gear, stranded on land, observed dead at sea, and free-swimming on rare occurrences. In Trinity Bay, several reports were made for 2000 to 2008 (Table 10-7).

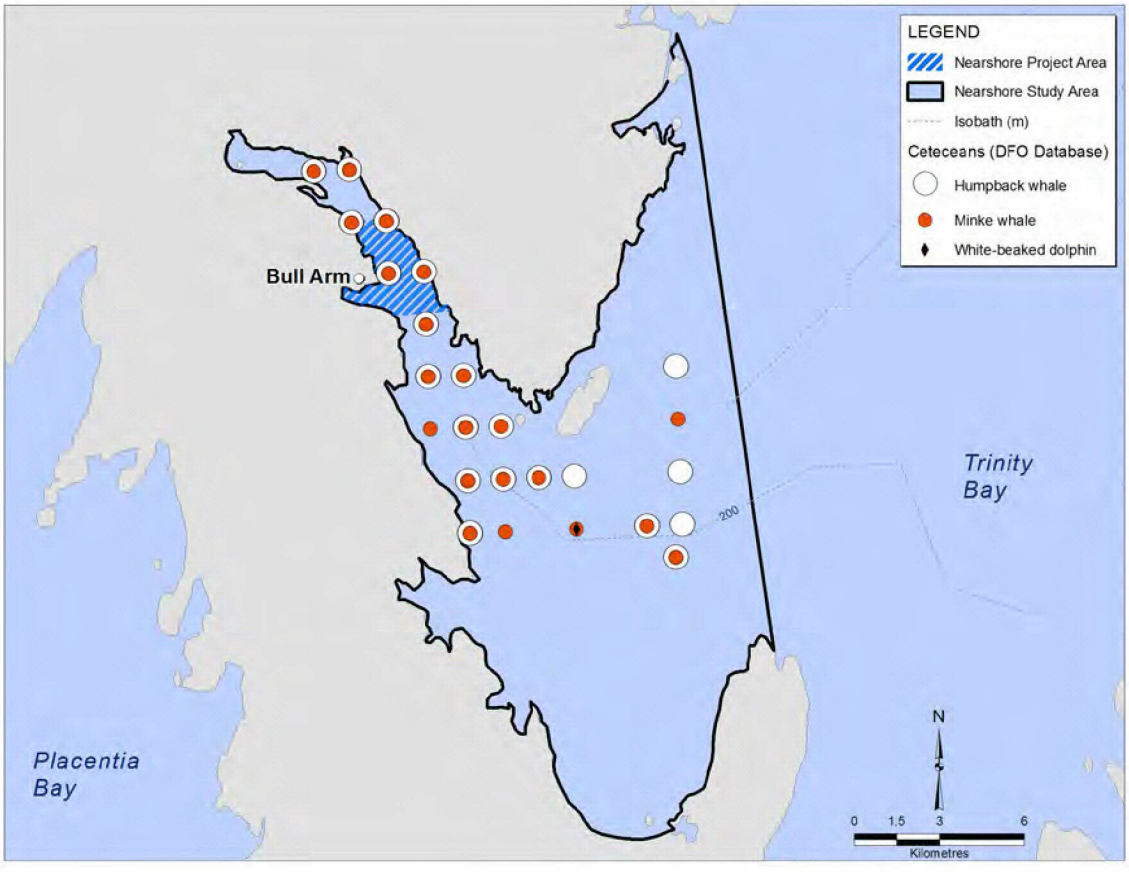

Figure 10-4 Sightings of Cetaceans within the Nearshore Study Area, Based on DFO Cetacean Sighting Database (1945 to 2007)

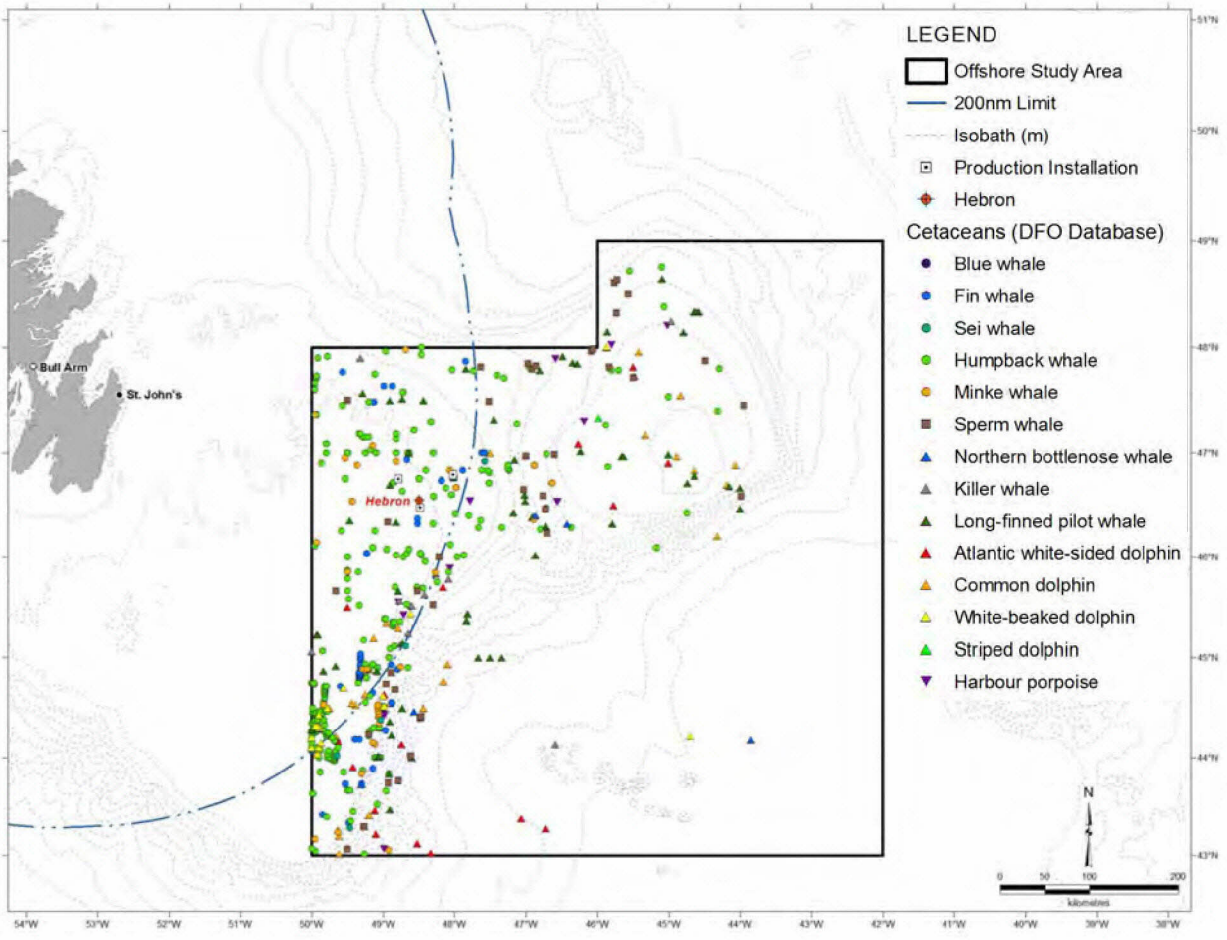

Figure 10-5 Sightings of Cetaceans within the Offshore Study Area, based on DFO Cetacean Sighting Database (1945 to 2007)

Table 10-7 Cetacean Entrapments and Strandings from 2000 to 2008

Species	Year(s)	Comments
Humpback whale	2001, 2002, 2006, 2007	Entrapped in fishing gear on 9 occasions
Minke whale	2005, 2007, 2008 (twice)	Entrapped in fishing gear
Minke whale	2008	Dead, drifting in Trinity Bay
Sei whale	2008	Stranded on shore and died
Sowerby's beaked whale	2008	Stranded dead on shore
Beluga whale	2005	Free-swimming, August
White-beaked dolphin	2005	Trapped by pack ice, March
Unkown Large whale	2002	Entrapped in fishing gear
Source: Ledwell et al. (2000, 2001, 2002); Ledwell and Huntington (2003, 2004, 2006, 2007, 2008, 2009)		

10.3.2 Species Profiles

10.3.2.1 Baleen Whales (Mysticetes)

Five species of baleen whales may occur in the Study Areas, two of which have garnered special status under SARA (see Section 11.3.2). Nearly all species of baleen whales became depleted due to commercial whaling, but it appears that some, including North Atlantic humpback whales, are showing signs of recovery (Best 1993). All of the species occurring in eastern Newfoundland presumably migrate to lower latitudes during winter months, although a small number of animals appear to remain in Newfoundland waters year-round.

An aerial survey of cetaceans was conducted in the Northwest Atlantic during the summer of 2007 (Lawson and Gosselin 2009). The most common species sighted during the Newfoundland portion of this survey was the humpback whale, followed by minke and fin whales (Lawson and Gosselin 2009). It was noted that few small cetaceans were sighted in the Newfoundland and Labrador Strata despite good conditions and significant effort. This may have resulted from the late arrival of cetaceans in the Newfoundland and Labrador region in 2007, as borne out by reports from fisheries officers, fishers, and tour operators, and the fact that more marine mammal sightings were recorded late in the survey (Lawson and Gosselin 2009).

Humpback Whale

Humpback whales have a cosmopolitan distribution, but typically occur in coastal regions or over the continental shelf (Jefferson et al. 2008). There are an estimated 11,570 individuals in the North Atlantic (Stevick et al. 2003), but Whitehead (1982) estimated a total of 1,700 to 3,200 animals in the Newfoundland and Labrador population. On the Southeast Shoal of the Grand Banks, approximately 900 individuals were estimated to use the area for summer foraging on capelin, their primary prey in Newfoundland waters (Whitehead and Glass 1985). The North Atlantic population is thought to be increasing (Stevick et al. 2003) and is no longer listed under SARA (COSEWIC 2003).

Humpback whales undergo annual migrations from summer foraging grounds in high latitudes to tropical breeding grounds during the winter. Four distinct summer foraging concentration areas in the North Atlantic have been described, based on genetic and individual identification studies: the Gulf of Maine, eastern Canada, western Greenland, and the eastern North Atlantic (Stevick et al. 2006). Winter breeding occurs in the West Indies in three primary areas: the Virgin Bank, Puerto Rico, and the Dominican Republic (Katona and Beard 1990). Additionally, not all individuals migrate to the tropics each year, with some presumably remaining near their foraging grounds in mid- and high-latitudes during winter (Clapham et al. 1993).

Humpback whales often occur singly or in small groups of two to three, but large aggregations can occur in feeding or breeding areas (Clapham 2000).

Hay (1982) reported an average group size of 2.87 animals (ranging from one to eight) for an August 1980 aerial survey off Newfoundland and Labrador, similar to group sizes of 1 to 10 observed on the Southeast Shoal of the Grand Banks during June and July of 1982 and 1983 (Whitehead and Glass 1985). During summer feeding periods, humpbacks generally dive for less than five minutes, and dives that last greater than 10 minutes are atypical (Clapham and Mead 1999).

The humpback whale is common in Newfoundland waters, especially during summer. Humpbacks begin arriving in offshore areas by April and remain until October; they occur in inshore areas primarily from June to September. Some humpbacks likely stay in Newfoundland waters year-round. In the Jeanne d'Arc Basin, humpback whales were the most commonly sighted baleen whale during each seismic survey from 2005 to 2008, making up approximately 91 percent of the identified non-SAR baleen whale sightings (Table 10-4). They were also the most frequently sighted baleen whale species in the Orphan Basin during seismic monitoring programs in 2004 and 2005 (Moulton et al. 2005, 2006b) and the second most frequently sighted baleen whale species during CSEM monitoring programs in 2006 and 2007 (Abgrall et al. 2008b). The humpback whale was the most frequently reported species in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6).

Humpback whales also frequently occur during the summer period in Trinity Bay. Hay (1982) reported a density of approximately 0.09 humpbacks per square nautical mile in Trinity Bay during an August 1980 aerial survey, a higher density than in any other nearshore region of Newfoundland that was surveyed (St. Mary's Bay to White Bay). Lien (1994) reported several humpback entrapments in fishing gear throughout Trinity Bay from 1979 to 1990, and Whitehead et al. (1980) estimated that approximately 255 animals moved north past the Bay de Verde Peninsula during June and July in 1978. The inshore abundance of humpback whales (and other baleen whale species) is related to the relative abundance of prey species, primarily capelin (Piatt et al. 1989), and several major capelin spawning beaches are found in Trinity Bay. In coastal areas of northern Newfoundland, humpback whales were most frequently observed feeding in waters less than one nautical mile from shore, although they also occurred in areas greater than 5 nm from shore (Perkins and Whitehead 1977). Over 19 days in June 1992, at least 71 individuals were uniquely identified in southern Trinity Bay, with 57 percent of sightings occurring approximately 3 to 9 km from Mosquito Cove in Bull Arm (Todd et al. 1996). The humpback whale was the most frequently reported species in the DFO cetacean sightings database in the Nearshore Study Area; there were 62 sightings of 81 individuals reported (Table 10-5). Thus, humpback whales are common in both Study Areas during early summer to fall, and a smaller number of animals may be present year-round.

Sei Whale

The distribution of sei whales is not well understood, but they are found in all oceans and appear to prefer mid-latitude temperate waters (Jefferson et al.

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2008). There are two stocks of sei whales recognized in the Northwest Atlantic: a more well-known Nova Scotia stock whose distribution extends from the northeast United States to southern Newfoundland, and a Labrador Sea stock (Waring et al. 2009). The Nova Scotia stock is estimated to contain 207 individuals, but there is no current population estimate for the Labrador Sea stock (Waring et al. 2009). It is unclear to which population animals occurring off eastern Newfoundland belong.

Sei whales tend to be found in pelagic regions, most often in areas with steep bathymetric relief like continental shelf breaks, seamounts, canyons, or basins near banks and ledges (Kenney and Winn 1987; Gregr and Trites 2001). Sei whales typically occur alone or in groups of two to five, and females are larger than males (Jefferson et al. 2008). Although they sometimes consume small fish, primary prey consists of euphausiids and copepods (Flinn et al. 2002).

Mitchell and Chapman (1977) hypothesized that sei whales in the Northwest Atlantic are migratory, moving from spring feeding areas on or near Georges Bank to the Scotian Shelf in June and July, eastward to Newfoundland and the Grand Banks in late summer, back to the Scotian Shelf in fall, and offshore and south during winter. These authors estimated a minimum stock size of 870 individuals, based on mark-recapture data from the 1960s to 1970s. In the Jeanne d'Arc Basin, there has been one confirmed sei whale sighting and one possible sighting (either a sei or fin whale) (Table 10-4). However, sei whales were encountered several times in the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b).There were 11 sei whale sightings reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available information suggests that sei whales are present during summer and fall months, but are likely uncommon, in the Offshore Study Area.

There is little information on the presence of sei whales in Trinity Bay, but the sei whale tends to be a more pelagic species and is not typically reported in coastal Newfoundland. In addition, it is often difficult to differentiate between sei whales and fin whales in the field. It is possible that some reports of fin whales could actually be sei whales. A live sei whale was reported stranded off Catalina on August 11, 2008 and subsequently died (Ledwell and Huntington 2009). There were no sightings of sei whales reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). Given the information available, sei whales are expected to be rare in the Nearshore Study Area throughout the year.

Minke Whale

The smallest of the baleen whales, minke whales are cosmopolitan in distribution and can be found in polar, temperate, and tropical waters (Jefferson et al. 2008). Four populations are recognized in the North Atlantic: the Canadian east coast, west Greenland, central North Atlantic, and northeastern North Atlantic stocks (Waring et al. 2009). An estimated 3,312 individuals occur in the Canadian east coast stock, which ranges from

the continental shelf of the northeast United States to the eastern half of Davis Strait (Waring et al. 2009).

Minke whales often occur singly or in small groups of two or three, although large aggregations can form in areas where prey concentrates (Jefferson et al. 2008). Off coastal portions of northern Newfoundland, Perkins and Whitehead (1977) most frequently observed single minke whales, but groups of up to five animals were occasionally observed. Occasionally minke whales approach vessels, but their small size, inconspicuous blows, and brief surface durations can make them otherwise challenging to detect at sea (Stewart and Leatherwood 1985). Foraging typically occurs over the continental shelf on small schooling fish, and minke whales appear to make short duration dives (Stewart and Leatherwood 1985). Seasonal movements in many parts of the world have been noted and generally mirror the abundance and distribution of their primary prey species (Macleod et al. 2004). Their presence in the Gulf of St. Lawrence has also been linked to thermal fronts that presumably function to concentrate prey (Doniol-Valcroze et al. 2007).

Minke whales regularly occur in coastal areas and the offshore banks of eastern Newfoundland. In the Jeanne d'Arc Basin, minke whales were the second most frequently observed non-SAR baleen whale (after humpback whales) during seismic monitoring programs, representing approximately 13 percent of all identified non-SAR baleen whale sightings (Table 10-4). There were also multiple minke whale sightings each year during monitoring programs in the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). Minke whales were commonly reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). Thus, minke whales can be considered common in the Offshore Study Area, particularly from late spring to early fall.

The coastal presence of minke whales in eastern Newfoundland is linked to the presence and abundance of capelin (Sergeant 1963), with minke whales the second most frequently observed species (after humpback whales) in nearshore areas (Piatt et al. 1989). Minke whales were also the second most common cetacean to be entrapped in commercial fishing gear, with entanglements occurring throughout Trinity Bay from 1979 to 1990 (Lien 1994). In Trinity Bay, minke whales were once commercially harvested and landed at the South Dildo whaling station. Catches of minke whales were concentrated throughout the southwestern portion of Trinity Bay and primarily exploited juvenile males, females, and pregnant females (over 85 percent of mature females sampled were pregnant); catches were highest from May to July (Mitchell and Kozicki 1975), but continued until late October (Sergeant 1963). The minke whale was the second most commonly reported species in the DFO cetacean sightings database in the Nearshore Study Area; there were 57 sightings of minke whales (Table 10-5). Given the available information, minke whales are expected to be common in Trinity Bay during summer and are likely present at lower densities in early spring and winter.

10.3.2.2 Toothed Whales (Odontocetes)

Twelve species of toothed whales may occur in the two Study Areas (see Table 10-2). These species include the sperm whale, the largest living toothed whale (approximately 18 m for an adult male (Reeves and Whitehead 1997)), as well as one of the smallest odontocetes, the harbour porpoise (approximately 1.6 m for an average adult (COSEWIC 2006a)). Many of these species occur seasonally in the Study Areas, but little is known about their distribution and population sizes.

Sperm Whale

Sperm whales are widely distributed, occurring from the edge of polar pack ice to the equator, but are most common in tropical and temperate waters (Jefferson et al. 2008). Whitehead (2002) estimated a total of 13,190 sperm whales for the Iceland-Faroes area, the area northeast of it, and the east coast of North America combined, but Waring et al. (2009) only estimated a total of 4,804 sperm whales in the North Atlantic.

Sperm whale abundance and distribution in an area can vary in response to prey availability, particularly mesopelagic and benthic squid (Jaquet and Gendron 2002; Jaquet et al. 2003). Sperm whales tend to occur in deep waters off the continental shelf, particularly areas with high secondary productivity and steep slopes (Jaquet and Whitehead 1996; Waring et al. 2001). Distribution has also been linked to warm core rings of the Gulf Stream off the United States continental shelf, with sightings occurring in water depths from 1,539 to 4,740 m deep (Griffin 1999). Sperm whales routinely dive to hundreds of metres, with maximum depths up to 3,000 m; foraging dives may last up to an hour and occur at depths below 1,000 m (Whitehead and Weilgart 2000).

Males tend to range farther north than females, making sperm whales encountered in eastern Newfoundland more likely to be males. Adult females and juveniles form large aggregations in warm tropical and sub-tropical regions, but males typically occur singly or in small same-sex groups and occur at higher latitudes (Whitehead et al. 1992; Whitehead and Weilgart 2000; Whitehead 2003). However, males can also sometimes form large aggregations of 20 to 30 individuals (Whitehead 2003), and mixed groups containing females and juveniles have occasionally been observed in higher latitudes (e.g., Whitehead and Weilgart 2000).

No sperm whales were observed within the Jeanne d'Arc Basin during seismic monitoring programs (Table 10-4), but were regularly sighted in deeper waters of Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). Sperm whales were commonly reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). Sperm whales may periodically occur in the Offshore Study Area, but are relatively uncommon; they would most likely be found in deeper portions of the Study Area and during summer months. It has been noted that sperm whales have been attracted to fishing operations on the Grand Banks and, therefore, may approach other vessels as well (DFO, pers. comm.).

Sperm whales have rarely been observed in coastal Newfoundland, and would be most likely in areas with deep water and steep slopes. There were no sightings of sperm whales reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). Thus, sperm whale occurrences are expected to be uncommon in the Nearshore Study Area.

Northern Bottlenose Whale

Northern bottlenose whales occur only in the North Atlantic, predominantly in deep offshore areas, and have two (known) primary areas of concentration: The Gully and adjacent canyons of the eastern Scotian Shelf, and Davis Strait off northern Labrador (Reeves et al. 1993). The abundance of northern bottlenose whales in the Northwest Atlantic is unknown (Waring et al. 2009), but there are an estimated approximately 163 individuals in the Scotian Shelf population (Whitehead and Wimmer 2005). The Scotian Shelf population is considered to be of Special Concern by COSEWIC and Endangered on Schedule 1 of SARA, but the Davis Strait population has no status under SARA and is considered not at risk by COSEWIC (COSEWIC 2002a).

It appears that the Scotian Shelf population has a relatively restricted distribution. This population spends the majority of its time in The Gully (with a third of the population present there at any time), but nearby Shortland and Haldimand canyons are also extensively used; their home range is thought to be a few hundred kilometres or less (Wimmer and Whitehead 2004). On the Scotian Shelf, tagged northern bottlenose whales routinely dove to depths over 800 m and remained submerged for over an hour; the maximum recorded depth was 1,453 m (Hooker and Baird 1999a). Foraging appears to occur at depth, primarily for large and medium-bodied squid. Group sizes on the Scotian Shelf average around three individuals, and are rarely more than 10 individuals, with males forming long-term bonds while females do not seem to have preferred associates (Gowans et al. 2001).

For the purposes of this assessment, it is assumed that northern bottlenose whales which occur in the Hebron Offshore Study Area would belong to the Davis Strait population. There have been two sightings of beaked whales in the Jeanne d'Arc Basin during summer and fall seismic surveys (Table 10-4), one of which was confirmed as a species other than the northern bottlenose whale (Lang et al. 2006). However, there have been several confirmed sightings of northern bottlenose whales in the deeper Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). There were six sightings of northern bottlenose whales reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available evidence suggests that northern bottlenose whales likely occur at low densities, possibly year-round, in the deeper waters of the Offshore Study Area.

Northern bottlenose whales have occasionally been observed in coastal eastern Newfoundland, although most records are based on carcasses that have washed ashore. Lien (1994) reported that northern bottlenose whales were entrapped in inshore fishing gear on two occasions from 1979 to 1990, and Sergeant et al. (1970) described a single northern bottlenose whale taken at the South Dildo, Trinity Bay, whaling station in July 1953. Apparently a

second whale, associated with the one captured, remained free-swimming in the southern part of Trinity Bay for at least three additional days (Sergeant and Fisher 1957). Recently, northern bottlenose whales have stranded in Bonavista Bay (2004) and the south coast of Newfoundland (2005) and it is suspected that the whales were pursuing nearshore squid (J. Lawson, pers. comm., October, 2010). There were no sightings of northern bottlenose whales reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-6). It appears possible that northern bottlenose whales may occur in the Nearshore Study Area, but sightings would be considered rare.

Long-finned Pilot Whale

Long-finned pilot whales are widespread in the North Atlantic (Jefferson et al. 2008). There is an estimated 31,139 individuals in the Northwest Atlantic (although that number could also contain some short-finned pilot whales) (Waring et al. 2009), and they are abundant year-round residents of Newfoundland waters (Nelson and Lien 1996). Hay (1982) estimated a total of 13,167 individuals in eastern Newfoundland and southern Labrador waters.

Pilot whales are sexually dimorphic, such that males are longer than females and have larger dorsal fins as well as more pronounced melons (Jefferson et al. 2008). Pilot whales studied in Nova Scotia seem to form long-term social groups of related individuals, with minimal dispersal from natal groups (Ottensmeyer and Whitehead 2003). Average group size was 20 individuals, but ranged from two to 135 (Ottensmeyer and Whitehead 2003). Pilot whales appear to associate with the continental shelf break, slope waters, and areas of high sub-surface relief, and often have inshore-offshore movements that coincide with their prey (Jefferson et al. 2008). Primary prey in nearshore Newfoundland has been identified as short-finned squid (Sergeant 1962), but they are also known to consume other species of cephalopod and fish (Nelson and Lien 1996).

Pilot whales are regular inhabitants of eastern Newfoundland. In the Jeanne d'Arc Basin, pilot whales were observed during all but the late fall 2005 seismic monitoring programs (Table 10-4), and were also frequently sighted in the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). The long-finned pilot whale was the second most frequently sighted non-SAR species in the Offshore Study Area, according to the DFO cetacean sightings database (Table 10-6). Long-finned pilot whales are expected to be common year-round in the Offshore Study Area, particularly during summer months.

Pilot whales also frequently occur in coastal Newfoundland. Prior to 1900, small harvests of pilot whales were taken in Newfoundland bays by whalers and fishermen driving groups ashore; commercial whaling began in 1947, centred on Trinity Bay, and continued until 1972 (Abend and Smith 1999). Hay (1982) estimated a density of 0.1115 pilot whales per square nautical mile in Trinity Bay, based on an August 1980 aerial survey, but it is unknown how many pilot whales currently use Trinity Bay. During the commercial whaling period, whales entered the bay in July and remained through October (Sergeant 1962). There were no long-finned pilot whales reported in the DFO

cetacean sightings database in the Nearshore Study Area (Table 10-5). Long-finned pilot whales may occur in the Nearshore Study Area year-round, and are likely one of the most common odontocetes to be present during summer and fall.

Risso's Dolphin

Risso's dolphins are widely distributed in tropical and warm temperate oceans (Jefferson et al. 2008). In the Northwest Atlantic, 20,479 individuals are estimated to occur from Florida to eastern Newfoundland (Waring et al. 2009). Eastern Canada appears to be at the upper limit of the Risso's dolphin's range, where an unknown number occur, but are considered rare (Baird and Stacey 1991).

Risso's dolphin group sizes generally range from 10 to 100 animals, but groups of up to 4,000 individuals have been reported (Jefferson et al. 2008). They are often sighted in association with other cetacean species, and are thought to be deep divers. Squid are presumed to be their primary prey, but Risso's dolphins also consume crustaceans and other cephalopods (Jefferson et al. 2008). Risso's dolphins are primarily associated with steep portions of the continental slope that may concentrate cephalopod prey (Baumgartner 1997). Off the northeast United States coast, they are distributed along the continental shelf edge during spring, summer, and autumn, but range into pelagic regions during winter (Waring et al. 2009).

Risso's dolphins are relatively abundant in warm temperate and tropical waters, but rarely range as far north as eastern Canada waters (Baird and Stacey 1991). In the Jeanne d'Arc Basin, there have been no sightings of Risso's dolphins during summer and fall monitoring programs (Table 10-4), nor have any been recorded in the deeper Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). Also, Risso's dolphins have not been recorded in the DFO cetacean sightings (Table 10-6). While Risso's dolphins may occur in the Offshore Study Area, particularly deeper portions, their presence is likely to be rare.

There are no published records of Risso's dolphins occurring in coastal Newfoundland waters (nor stranding records). Given the available information on Risso's dolphins occurrence and preference for deep waters, their presence in the Nearshore Study Area is likely to be very rare.

Common Bottlenose Dolphin

Bottlenose dolphins are distributed widely in tropical and temperate waters, occupying a variety of habitats (Jefferson et al. 2008). In the Northwest Atlantic, there are two morphologically and genetically distinct stocks, referred to as the coastal and offshore forms (Hoelzel et al. 1998). The offshore form tends to occur along the outer continental shelf and slope in the Northwest Atlantic while the coastal form occurs from New York to the Gulf of Mexico along the Atlantic coast (Waring et al. 2009). The population of the offshore form, potentially ranging into eastern Newfoundland waters, is estimated to contain 81,588 individuals (Waring et al. 2009).

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Groups of 2 to 15 animals are common among bottlenose dolphins, but they can also be observed offshore in groups of hundreds (Shane et al. 1986). Group organization can be fluid or long-term and is based on several factors like age, sex, individual relatedness, and reproductive condition (Connor et al. 2000). Bottlenose dolphins consume a variety of fish species, cephalopods, and shrimp by employing a number of foraging strategies (Connor et al. 2000).

The distribution of bottlenose dolphins in higher latitudes appears to be seasonal, with a more northerly range during summer months (Shane et al. 1986). Bottlenose dolphins are considered at the northern limit of their range in eastern Newfoundland waters (Baird et al. 1993b). None were sighted during the monitoring programs in the Jeanne d'Arc Basin (Table 10-4), but there was a single sighting of 15 individuals in the Orphan Basin (Moulton et al. 2006a). There were no bottlenose dolphins reported in the DFO cetacean sightings database (Table 10-6). While it is possible that bottlenose dolphins will occur in the Offshore Study Area, particularly during summer, they are likely to be rare.

There are no published records of bottlenose dolphins in nearshore eastern Newfoundland and this species was not recorded in the DFO cetacean sightings database (Table 10-5). The available information suggests that bottlenose dolphins will not occur in the Nearshore Study Area.

Short-beaked Common Dolphin

The short-beaked common dolphin is widely distributed over the continental shelf in temperate, tropical, and subtropical regions (Jefferson et al. 2008). In the Northwest Atlantic, their distribution ranges up to 47°N to 50°N off of Newfoundland (Jefferson et al. 2009). An estimated 120,743 individuals reside in the Northwest Atlantic (Waring et al. 2009), but an unknown number are found in eastern Canada (Gaskin 1992).

Short-beaked common dolphins form groups ranging in size from several dozens to over 10,000, often moving rapidly with many aerial behaviours like porpoising and bowriding (Jefferson et al. 2008). They are found in a variety of habitats, ranging from 100 to 2,000 m deep, but appear to prefer areas with high seafloor relief (Selzer and Payne 1988) and are often associated with features of the Gulf Stream (Hamazaki 2002). The abundance and distribution of short-beaked common dolphins also coincides with peaks in abundance of mackerel, butterfish, and squid (Selzer and Payne 1988).

Gaskin (1992) indicated that common dolphins can be abundant off the coast of Nova Scotia and Newfoundland for a few months during the summer. Whitehead and Glass (1985) reported seven sightings of common dolphins during surveys on the Southeast Shoal of the Grand Banks in June and July of 1982 and 1983, with group sizes ranging from five to 50 individuals. There were eight sightings of common dolphins on the Jeanne d'Arc Basin (Table 10-4). During monitoring programs in the adjacent Orphan Basin, there were a total of 13 common dolphin sightings (Moulton et al. 2006b; Abgrall et al. 2008b). There were 46 sightings of common dolphins reported in the DFO

cetacean sightings database in the Offshore Study Area (Table 10-6). During summer, it is likely that short-beaked common dolphins will occur in the Offshore Study Area.

Nearshore sightings of common dolphins in eastern Newfoundland are less frequent than offshore sightings. Whaling captains apparently did not frequently see common dolphins, but an individual dolphin was shot in Dildo Arm in Trinity Bay in July 1957 (Sergeant 1958, in Gaskin 1992). There were no common dolphins reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). While they apparently can occur in Trinity Bay, the occurrence of common dolphins in the Nearshore Study Area is likely uncommon.

Striped Dolphin

Striped dolphins are widely distributed in global warm temperate to tropical waters, with their northern range in the Atlantic Ocean extending into eastern Canada waters (Baird et al. 1993a). There are an estimated 94,462 striped dolphins in the Northwest Atlantic (Waring et al. 2009), but an unknown number use eastern Canada waters (Baird et al. 1993a).

Striped dolphins can form large groups of thousands of animals, but usually are found in group sizes of several dozen to 500 (Jefferson et al. 2008). Preferred habitats for striped dolphins include deep water areas along the edge and seaward of the continental shelf, especially areas with warm currents (Baird et al. 1993a). Striped dolphin distribution has also been associated with upwelling area or convergence zones (Au and Perryman 1985). Archer and Perrin (1999) suggested that striped dolphins are feeding at depths of 200 to 700 m, with small mid-water fishes or squid representing their primary prey. Sightings off the northeastern US coast have been focused along the 1,000-m depth contour in all seasons and associated with the northern edge of the Gulf Stream and warm core rings (Waring et al. 2009).

Offshore waters of the Grand Banks are considered to be at the northern limit of the striped dolphin's range. No striped dolphins have been observed within Jeanne d'Arc Basin (Table 10-4), but a group of approximately 25 individuals was sighted in the southern portion of the Offshore Study Area in September 2008 (Abgrall et al. in prep.). During monitoring programs in the Orphan Basin, there were a total of three sightings (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). There was a single report of a striped dolphin in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available information suggests that the presence of striped dolphins is likely to be uncommon in the Offshore Study Area, but they could potentially occur there during summer and fall.

There are no published records of striped dolphins occurring in coastal regions of eastern Newfoundland and this species was not recorded in the DFO cetacean sightings database (Table 10-5). Based on the paucity of striped dolphin nearshore records and the species apparent preference for

deep shelf edge and offshore waters, it is unlikely that striped dolphins will occur in the Nearshore Study Area.

Atlantic White-sided Dolphin

Atlantic white-sided dolphins are found in temperate and sub-Arctic regions of the North Atlantic, primarily in deep waters of the outer continental shelf and slope (Jefferson et al. 2008). At least three distinct stocks (Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea) may occur in the North Atlantic, but this has not been confirmed (Waring et al. 2009). There is an estimated 63,368 individuals in the Northwest Atlantic (Waring et al. 2009), but their abundance off eastern Newfoundland is unknown.

Atlantic white-sided dolphins are gregarious, with an average group size of 52.4 and ranging from two to 2,500; larger group sizes tend to be observed from August to October (Weinrich et al. 2001). Calving appears to occur from May to August, but peaks in June and July (Weinrich et al. 2001). Prey items range from cephalopods to pelagic or benthopelagic fishes like capelin, herring, hake, sandlance, and cod (Selzer and Payne 1988; Weinrich et al. 2001). Primary habitat appears to coincide with the 100-m depth contour of the continental shelf, with sightings more common in areas with high sub-surface relief with low sea surface temperatures and salinity (Selzer and Payne 1988).

Atlantic white-sided dolphins are regular inhabitants of eastern Newfoundland waters. They were the most frequently identified dolphin species during four years of summer and fall monitoring programs in the Jeanne d'Arc Basin (Table 10-4). Atlantic white-sided dolphins were also frequently observed in and near Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). There were 20 sightings of Atlantic white-sided dolphins reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available data indicates that Atlantic white-sided dolphins are common in the Offshore Study Area, particularly from June to October.

White-sided dolphins also occur in coastal eastern Newfoundland. Piatt et al. (1989) reported four sightings during June and July 1982-1985 from Witless Bay. Two male white-sided dolphins were driven ashore during a pilot whale harvest in Chapel Arm, Trinity Bay in July 1954 (Sergeant and Fisher 1957). Sergeant and Fisher (1957) indicated that white-sided dolphins were sighted during previous years in Trinity Bay and suggested that this species uses inshore Newfoundland waters during summer, often accompanying long-finned pilot whales, although they are less common than pilot whales. There were no Atlantic white-sided dolphins reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). It is expected that white-sided dolphins are common in the Nearshore Study Area, mostly from June to September.

White-beaked Dolphin

White-beaked dolphins occur in cold temperate and sub-Arctic waters in the North Atlantic and have a more northerly distribution than most other dolphin

species (Jefferson et al. 2008). There are an estimated 2,003 individuals in the Northwest Atlantic (Waring et al. 2009), but it is unknown how many occur off eastern Newfoundland.

Sometimes white-beaked dolphins are observed in association with other cetacean species, and group sizes are typically less than 30 individuals; however, groups sizes ranging up to many hundreds have been recorded (Lien et al. 2001). Prey items include squid, crustaceans, and a variety of small mesopelagic and schooling fishes like herring, cod, haddock, and hake (Jefferson et al. 2008). White-beaked dolphins are generally observed in continental shelf and slope areas, but are also known to use shallow coastal regions (Lien et al. 2001). It is presumed that white-sided dolphins remain at relatively high latitudes throughout the fall and winter (Lien et al. 2001).

While less common than some other dolphin species, white-beaked dolphins are thought to be year-round residents of eastern Newfoundland. White-beaked dolphins were seen during each summer and fall in the Jeanne d'Arc Basin, other than 2006 (Table 10-4). White-beaked dolphins were also sighted in and near the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). There were 21 sightings of white-beaked dolphins reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). Given the available information, it seems that white-beaked dolphins are common in the Offshore Study Area, especially during spring-fall.

White-beaked dolphins also occur in nearshore areas of eastern Newfoundland. Sergeant and Fisher (1957) suggested that white-beaked dolphins tend to occur in coastal Newfoundland during spring and fall, from at least March to May and October to November, with smaller group sizes (usually six to eight individuals) than those of Atlantic white-sided dolphins. Several reports of white-beaked dolphins in Conception Bay and Trinity Bay were provided, including reports of dolphins trapped by dense sea ice in the spring. Hay (1982) estimated a total of 5,539 individuals occur in eastern Newfoundland and southern Labrador based on observations during an August 1980 aerial survey, noting that high densities were recorded in Fortune and Placentia bays. One white-beaked dolphin sighting (of 30 animals) was reported in Witless Bay during the summers of 1982 to 1985 (Piatt et al. 1989). Fourteen white-beaked dolphins were trapped by wind-blown pack ice in Trinity Bay on 20 March 2005 (Ledwell and Huntington 2006). There was a single sighting of a group of 10 white-beaked dolphins reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). White-beaked dolphins are likely common in the Nearshore Study Area during spring and fall, although they are generally less common than other dolphin species.

10.3.2.3 True Seals (Phocids)

Four species of seals are known to occur in the Nearshore and Offshore Study Areas (see Table 10-2). Several fish species (primarily cod, capelin, sand lance, and halibut) and invertebrates (generally squid and shrimp) are consumed by seals, but diets can vary considerably among years, seal species, geographic regions, and seasonally (Hammill and Stenson 2000).

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Harbour Seal

Harbour seals have a widespread distribution in the northern hemisphere, but are generally only found in coastal waters (Jefferson et al. 2008). In the Northwest Atlantic, harbour seals range from northern Florida to northern Baffin Island and along Greenland's southern coast (Bigg 1981). There are an estimated 99,340 individuals in the Northwest Atlantic (Waring et al. 2009). Hammill and Stenson (2000) estimated a total of approximately 5,120 harbour seals in Newfoundland and Labrador in 1996, and further information suggests there may be at least 1,000 animals in coastal Newfoundland (Sjare et al. 2005a; COSEWIC 2007a).

Harbour seals are found in coastal areas, rarely more than 20 km from shore, and often enter bays, estuaries, and inlets where they sometimes also follow anadromous salmonids up coastal rivers (Baird 2001). They periodically haul out of the water at coastal sites, usually rocky outcroppings and intertidal ledges. Primary prey in Newfoundland include winter flounder, cod, and sculpins (Sjare et al. 2005a). In Nova Scotia, harbour seals pup in the spring, primarily in May and June, and pups are nursed for approximately 24 days (Bowen et al. 2001). No studies are available to describe pupping patterns in Newfoundland, but similar patterns are expected. Mating also tends to occur during pupping season. Moulting occurs from mid-summer to early fall, and harbour seals haul out more frequently than at other times of the year. Harbour seals are primarily considered a coastal species with limited dispersal from preferred haul out sites, but pups and juveniles have shown movements up to hundreds of kilometres over the continental shelf from haul out sites (Small et al. 2005). Harbour seals tagged in the St. Lawrence estuary were shown to migrate an average of 266 km to wintering locations exhibiting lower ice densities, but remained closer to shore (within 11 km) and in shallow areas, traveling only short distances (15 to 45 km), during ice-free conditions (Lesage et al. 2004).

Harbour seals are considered year-round residents of coastal Newfoundland (Sjare et al. 2005a). Relative to other seal species in Newfoundland waters, spatial and temporal distribution and abundance is poorly known (Hammill and Stenson 2000). None have been sighted during summer and fall observations on the northeastern Grand Banks, in the Jeanne d'Arc Basin or Orphan Basin (Moulton et al. 2005, 2006a; Lang et al. 2006; Abgrall et al. 2008a, 2008b; Lang and Moulton 2008). The Offshore Study Area is within the maximum range reported for harbour seals; however, harbour seals are unlikely to occur there based on their preference for coastal waters.

Sjare et al. (2005a) indicate that harbour seals do not regularly occur in Trinity Bay. Based on the absence of reports and sighting records within Trinity Bay, harbour seals are not expected to commonly occur in the Nearshore Study Area.

Harp Seal

The harp seal is found throughout the North Atlantic and Arctic Ocean, from the Gulf of St. Lawrence to Russia (Jefferson et al. 2008). Harp seals are the

most abundant seal in the Northwest Atlantic, with an estimated population size of 5.9 million in 2007 (DFO 2007b). The majority of these seals aggregate off the east coast of Newfoundland and Labrador to pup and breed, with the remainder of the animals whelping in the Gulf of St. Lawrence (Lavigne and Kovacs 1988).

Harp seal diets off eastern Newfoundland and Labrador were estimated to primarily consist of capelin, arctic cod, and sandlance, although Atlantic herring, Atlantic cod, redfish, and Greenland halibut were also significant contributors to their diet (Hammill and Stenson 2000). During the summer, the Northwest Atlantic population of harp seals is found in the Canadian Arctic and Greenland before migrating south in the fall (DFO 2000). Dedicated at-sea surveys and data from satellite-tagged animals indicate that harp seals spend the majority of their time in offshore areas of southern Labrador and eastern Newfoundland during the winter (Stenson and Sjare 1997; Lacoste and Stenson 2000). Pups are born on the ice in late February or March, are nursed for approximately 12 days, then mate as adults and disperse (DFO 2000). Births typically begin in early March and peak around March 8 to 10 (Stenson et al. 2005). Older seals also aggregate to moult off northeastern Newfoundland and in the northern Gulf of St. Lawrence in April and May before migrating northward (DFO 2000).

The Jeanne d'Arc Basin and adjacent areas overlap with regions where harp seals have been observed during January and February (Lacoste and Stenson 2000). In the Jeanne d'Arc Basin, there were 14 harp seal sightings (Table 10-4); all but one sighting occurred in June. There were also seven harp seal sightings in Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). Additionally, during years when pack ice extends into Jeanne d'Arc Basin, harp seals may use the region for spring pupping, mating, and moulting. Thus, from about December to June, harp seals will likely commonly occur in the Offshore Study Area.

Harp seals can also occur in nearshore areas of Newfoundland and Labrador during the spring, as evidenced by their incidental capture in the nearshore lumpfish fishery in northeast Newfoundland from April to July (Sjare et al. 2005b). However, local traditional knowledge suggests that harp seals (and harbour and grey seals) occur throughout Trinity Bay, although they may be more numerous in winter (DFO 2000). Based on the limited reports of harp seal occurrences in Trinity Bay, it is expected that they will be uncommon in the Nearshore Study Area.

Hooded Seal

Hooded seals occur in the North Atlantic, ranging from Nova Scotia to the high Arctic (Jefferson et al. 2008). However, it is not uncommon for hooded seals, particularly juveniles, to occur outside their normal range (Waring et al. 2009). There are four primary pupping and mating regions in the North Atlantic: the Gulf of St. Lawrence, northeast Newfoundland, Davis Strait, and east Greenland (Jefferson et al. 2008). A total of 593,500 individuals are estimated to occur in the Northwest Atlantic, with the majority of the

population, or 535,800 animals, pupping and mating off northeast Newfoundland (Hammill and Stenson 2006a).

Hooded seals seem to prefer deeper water and occur farther offshore than harp seals (Lavigne and Kovacs 1988). Birth takes place on the ice, and pups are weaned in about four days, after which pups are abandoned by the female (Lavigne and Kovacs 1988). On average, pupping off northeast Newfoundland is completed by 28 March, but has ranged from March 18 to April 4; pups may spend several more weeks on the ice before entering the water and dispersing (Hammill and Stenson 2006b). Following whelping, hooded seals aggregate in the pack ice off eastern Greenland to moult during June-July before dispersing to the Greenland Sea or Davis Strait during the summer and fall (see Hammill and Stenson 2006a). Little is known about their winter distribution, but they have been observed feeding around the northern edge of the Grand Banks during winter (Stenson and Kavanagh 1994). Recent work suggests that hooded seals move along the continental shelf to Davis Strait and Baffin Bay after moulting in July, followed by southerly migrations into the Labrador Sea before reaching breeding grounds in the spring (Andersen et al. 2009).

No hooded seals were sighted during the summer and fall monitoring programs in the Jeanne d'Arc Basin (Table 10-4), or during summer monitoring in the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). Recent studies of satellite-tagged hooded seals indicate that at least some individuals enter the Offshore Study Area in February, presumably to reach the Flemish Cap for winter foraging (Andersen et al. 2009); seals have also been shown to transit through and near the Offshore Study Area during transit to moulting areas in May and June (Bajzak et al. 2009). The available information on their offshore distribution suggests that hooded seals may occasionally occur in the Offshore Study Area during winter and spring, particularly if seasonal pack ice extends into the Offshore Study Area.

Hooded seals that breed in the Gulf of St. Lawrence predominantly migrate along the eastern and southern Newfoundland coast and enter (in December prior to breeding) or exit (by May following breeding) the Gulf via Cabot Strait; thus, animals presumably at least pass the entrance to Trinity Bay (Hammill 1993; Andersen et al. 2009; Bajzak et al. 2009). Juvenile hooded seals may also occasionally wander deeper into Trinity Bay and other coastal areas of eastern Newfoundland, especially during winter and spring. Based on available information, it is expected that hooded seals would be uncommon visitors to the Nearshore Study Area.

Grey Seal

Grey seals are found throughout cold temperate to sub-Arctic waters of the North Atlantic, including areas of Nova Scotia, the Gulf of St. Lawrence, and Newfoundland (Jefferson et al. 2008). The largest breeding colony in the North Atlantic is on Sable Island, south of Nova Scotia, consisting of approximately 250,000 individuals (Thomas et al. 2007). There are an estimated 304,000 animals that breed on Sable Island, Nova Scotia's eastern shore, and in the Gulf of St. Lawrence, accounting for essentially all of the

pup production in the Northwest Atlantic (Thomas et al. 2007). An unknown number are found off eastern Newfoundland.

Grey seals tend to be less tied to coastal and island rookeries than are harbour seals, but foraging still appears to be restricted to continental shelf regions (Austin et al. 2006). Grey seal prey species include herring, Atlantic cod, and sandlance (Lesage and Hammill 2001). Pupping occurs between September and March, with a peak in January in Canada (Lesage and Hammill 2001).

The number of grey seals entering either Study Area is unknown, but is likely small. None have been sighted during summer and fall monitoring programs in the Jeanne d'Arc Basin (Table 10-4) or during summer in the Orphan Basin (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). Based on available information, it is expected that grey seals would be rare in either the Offshore or Nearshore Study Area.

10.3.3 Sea Turtles

Sea turtles are likely not common in the Study Areas, but are important to consider given their threatened or endangered status, both nationally and internationally. Three species could potentially occur in the Nearshore and/or Offshore Study Areas (Table 10-8): the leatherback sea turtle (Dermochelys coriacea), loggerhead sea turtle (Caretta caretta), and Kemp's ridley sea turtle (Lepidochelys kempii). Both leatherback and loggerhead sea turtles are seen with some regularity (although loggerheads to a lesser extent) off Newfoundland in summer and fall (Goff and Lien 1988; Witzell 1999; Ledwell and Huntington 2009). Less is known about the distribution of Kemp's ridley sea turtles in eastern Canada, but they are considered rare. Of these species, only the leatherback sea turtle is listed under COSEWIC and SARA (as Endangered on Schedule 1), but all three species have special status on a global scale (see species profiles). The leatherback sea turtle is described further and assessed in Section 11.3.2.6.

Table 10-8 Sea Turtles Known to Occur in the Nearshore and Offshore Study Areas

Species	Bull Arm Study Area		Hebron Study Area		*SARA* Status[A]	COSEWIC Status[B]	Known Activities	Habitat
	Occurrence	Timing	Occurrence	Timing				
Leatherback sea turtle	Uncommon	July-Oct	Uncommon	June-Nov	Schedule 1: Endangered	E	Feeding	Channel, bays
Loggerhead sea turtle	Very rare	Summer	Rare	Summer	NS	E	Feeding	Channel
Kemp's ridley sea turtle	Very rare	Summer	Very rare	Summer	NS	NC	Feeding	Channel

Notes:
A Species designation under SARA; NS = No Status
B Species designation by COSEWIC; E = Endangered, NC = Not Considered

Marine mammal monitoring programs, as discussed in Section 10.3.2.1, provide relevant information on the spatial and temporal distribution of sea turtles in the area. As noted earlier, the data represent only the late spring, summer and fall seasons (and typically only portions of the summer), and sea

turtle observations may be biased by potential responses to noise from the airgun arrays.

During the monitoring programs in the Jeanne d'Arc Basin, there was a single sighting of a loggerhead sea turtle approximately 240 km south of Jeanne d'Arc Basin in September 2008 (Abgrall et al. 2008a, in prep.). Other sightings of leatherback sea turtles are described in Chapter 11.

10.3.3.1 Fisheries and Oceans Canada Sighting Database

DFO in St. John's (J. Lawson 2007, pers. comm.) is compiling a database of sea turtle sightings in waters around Newfoundland and Labrador. These data provide some indication of what species can be expected to occur in the area, but they cannot, at this point in the development of the database, provide any fine-scale quantitative information as the database typically does not include observation effort. However, no additional sea turtle observations were reported in the Nearshore or Offshore Study Areas that were not already described in the offshore monitoring of seismic activity in Jeanne d'Arc Basin or in the sea turtle entrapment records maintained by the Whale Release and Stranding Group (see Section 11.3.2.6).

10.3.3.2 Species Profiles

Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle have a more restricted distribution than other sea turtles, primarily in the Gulf of Mexico (Spotila 2004). Some juveniles exhibit the widest range, sometimes feeding along the US east coast and rarely into the Canadian Atlantic (Spotila 2004). It is estimated that there are only approximately 5,000 nesting females worldwide (Spotila 2004), but it is unknown how many enter Canadian waters annually. Kemp's ridley turtles have not been considered by COSEWIC and have no status under SARA, but are listed as Critically Endangered on the Red List of Threatened Species (IUCN 2009).

Nesting is focused within a small region of the central and southern Gulf of Mexico during May to late July, and only immature turtles seem to travel outside the Gulf of Mexico into more northerly waters (Morreale et al. 2007). Musick et al. (1994) suggested that juvenile Kemp's ridley sea turtles that travel north of Cape Hatteras, North Carolina probably do so in April and return southward by November. In general, it appears the Kemp's ridley sea turtles prefer shallow water.

While adults rarely range beyond the Gulf of Mexico, juveniles have been sighted along the southeast coast of Newfoundland near St. Mary's Bay and along southern Nova Scotia (Ernst et al. 1994). There are apparently no sightings or reports of Kemp's ridley sea turtles in Trinity Bay or the Jeanne d'Arc Basin. The available information suggests that their presence in both areas is likely to be very rare and only occur during summer or fall.

10.4 Project-Valued Ecosystem Component Interactions

Project activities can interact with marine mammals to create the following potential environmental effects:

- Change in Habitat Quantity: includes interactions which limit habitat availability to marine mammals and sea turtles
- Change in Habitat Quality: includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality
- Change in Habitat Use: includes interactions which affect the behaviour of marine mammals and sea turtles
- Potential Mortality: includes interactions which may cause the mortality of a marine mammal and/or sea turtle

The following sections describe how Project-VEC interactions during each phase of the Project may contribute to these potential environmental effects. For all Project phases in both the Nearshore and Offshore Project Areas, the activities that are most likely to interact with marine mammals and sea turtles are those that introduce noise into the water column and the activities that involve vessel traffic.

10.4.1 Nearshore Project Activities

In the Nearshore Project Area, underwater noise could result from Project activities such as bund wall construction (including pile-driving), in-water blasting, vessel traffic, dredging of the bund wall and possibly sections of the tow-out route to the deepwater site, removal of bund wall and disposal of materials, and geophysical surveys (i.e., side scan sonar and geohazard surveys). These activities could affect the habitat quality and habitat use by marine mammals and sea turtles. In addition, activities such as in-water blasting and dredging to remove the bund wall, and vessel traffic could affect marine mammals and sea turtles through direct mortality. Bund wall construction may also affect marine mammals and sea turtles through a reduction in habitat quantity, but this effect is expected to be negligible.

10.4.2 Offshore

10.4.2.1 Offshore Construction / Installation

During the construction / installation phase in the Offshore Project Area, underwater noise will result from activities such as (possible) clearance dredging, helicopter overflights, operation of vessels, excavated drill centre(s) dredging, seismic surveys, other geophysical and geotechnical surveys, site preparation activities for OLS / Platform installation, installation of the Platform, OLS and flowlines, rock cover and/or concrete mattresses, and subsea equipment and hook-up to Platform and commissioning. These activities could affect habitat quality and habitat use by marine mammals and sea turtles. In addition, operation of vessels could lead to direct mortality of individuals via collisions. Placement of the Hebron Platform at the offshore

site location may also affect the marine mammals and sea turtles through a limited reduction in habitat quantity.

10.4.2.2 Operations / Maintenance

During the operations / maintenance phase in the Offshore Project Area, underwater noise can result from activities such as drilling operations from the Platform and from a mobile offshore drilling unit (MODU) at future excavated drill centres, production operations, helicopter overflights, vessel traffic, and geophysical and seismic surveys. These activities may affect habitat quality and habitat use. Other activities that may affect Marine Mammals and Sea Turtles, are discharges (e.g., cooling water, storage displacement water, WBM drill cuttings and muds discharges from Hebron Platform, WBM and SBM drill cuttings and muds discharges from MODU drilling associated with potential expansion opportunities) and presence of structures (e.g., subsea equipment in drill centres, Platform, OLS). In addition, there is limited potential for direct mortality of marine mammals and sea turtles via collisions with vessels.

10.4.2.3 Decommissioning / Abandonment

During the decommissioning / abandonment phase in the Offshore Project Area, vessel traffic and helicopter overflights will produce underwater noise which may affect marine mammals and sea turtles. As previously mentioned, these activities could affect habitat quality and habitat use. Also, there is some potential for direct mortality as a result of collisions with vessels.

10.4.3 Summary

A summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present, and likely future Projects, is provided in Table 10-9. This table includes accidents, malfunctions, and unplanned events.

Table 10-9 Potential Project-related Interactions: Marine Mammals and Sea Turtles

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosqito Cove Zone followed by a deepwater site Zone)				
Bund Wall Construction (e.g., sheet/pile driving, infilling)	x	x	x	
Inwater Blasting		x	x	x
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site.)		x	x	x
Lighting			+	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site		x	+	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)		x	x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Platform Tow-out from Deepwater SIte		x	x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and testing		x	x	
Concrete Mattress Pads / Rock Dumping over OLS offloading lines		x	x	
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation		x	x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location		x	x	
Hookup and Commissioning of Platform			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	x
Air Emissions		x		
Lighting			+	
Potential Expansion Opportunities				
Presence of Safety Zone				
Excavated Drill Centre(s) Dredging and Spoils Disposal		x	x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation			x	
Hook-up and Commissioning of Drill Centres			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Offshore Operations and Maintenance				
Presence of Safety Zone				

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Presence of Structures		x	x	
Lighting			+	
Maintenance Activities (e.g., diving, ROV)			x	
Air Emissions		x		
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		x		
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)				
WBM Cuttings		x		
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)		x	x	x
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres		x	x	
Presence of Structures		x	x	
WBM and SBM Cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Platform and OLS Loading Points		x	x	
Lighting			x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	x
Surveys (e.g., geophysical, geohazard, geotechnical, environmental, ROV, diving)		x	x	
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture				
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blowout		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)		x	x	x
Marine Vessel Incident (i.e., fuel spills)		x	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Collisions (involving Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (drilling and production)		x	x	
Terra Nova Development (production)		x	x	
White Rose Oilfield Development and Expansions (drilling and production)		x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (nearshore and offshore)		x	x	x
Commercial Fisheries (nearshore and offshore)		x	x	x
+ indicates a positive interaction and possible decrease in mortality				

10.5 Environmental Effects Analysis and Mitigation

Potential environmental effects on marine mammals and sea turtles during all phases of the Project are discussed by Project phase and summarized at the end of the chapter.

10.5.1 Construction and Installation

10.5.1.1 Change in Habitat Quantity

Nearshore

In the Nearshore Study Area, the bund wall footprint represents unavailable habitat for marine mammals, although the shallow water depth would prevent most marine mammals from occurring there even in the absence of the bund wall. Thus, bund wall construction will result in minimal habitat loss for the Marine Mammal and Sea Turtle VEC.

The removal of the bund wall in the Nearshore Study Area could make previously unavailable habitat accessible to marine mammals. However, this habitat will be in shallow water (and thus less preferable to most marine mammals, as noted above) and disturbed. Thus, most marine mammals would not preferentially use this habitat and it is expected to result in negligible habitat loss for Marine Mammal and Sea Turtle VEC.

Offshore

The footprint of the Hebron Platform in the Offshore Project Area would occupy a very limited area that may be used by pelagic and migratory marine mammal and sea turtle species. Thus, the placement of the Hebron Platform

at the offshore site location will result in minimal habitat loss for marine mammals and sea turtles.

Excavated drill centre(s) dredging may occur over a limited area in the Offshore Study Area that may be used by pelagic and migratory marine mammals and sea turtles. Species that are primarily benthic foragers (e.g., some phocids) would be most affected by a disruption in benthic habitat. However, excavated drill centre(s) dredging in the Offshore Study Area will likely result in minimal habitat loss for marine mammals and sea turtles.

10.5.1.2 Change in Habitat Quality

This effect category includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality. Activities that are most likely to affect marine mammals and sea turtles are blasting, pile-driving, and seismic surveys which produce impulsive sound levels high enough to cause physical/physiological effects in marine mammals (and likely sea turtles). As discussed in detail below, sound levels thought high enough to cause a "change in habitat quality" typically occur very close to the sound source. The following section also summarizes relevant mitigation measures which will be used during the Project. These measures are designed to minimize the risk of injury to marine mammals and sea turtles.

The environmental effects of noise on marine mammals (and likely sea turtles) are highly variable, and can be categorized as follows (based on Richardson et al. 1995):

- The noise may be too weak to be heard at the location of the animal (i.e., lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both)
- The noise may be audible but not strong enough to elicit any overt behavioural response (i.e., the animal may tolerate it)
- The noise may elicit behavioural reactions of variable conspicuousness and variable relevance to the well-being of the animal; these can range from subtle effects on respiration or other behaviours (detectable only by statistical analysis) to active avoidance reactions
- Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat
- Any anthropogenic noise that is strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as surf noise or (at high latitudes) ice noise
- Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity, or other physical or physiological effects

(and in extreme cases (i.e., exposure to large explosives), mortality). Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift to occur. Received levels must be even higher for a risk of permanent hearing impairment

To aid in the assessment of potential effects of noise from Project activities on the marine mammals and turtles of the Study Areas, a description of the hearing abilities of marine mammals and sea turtles, a review of noise criteria for assessing effects, and a review of known physical effects of relevant noise sources on the these animals are provided below.

Hearing Abilities of Marine Mammals and Sea Turtles

Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Experiments also show that they hear and may react to many anthropogenic sounds.

The hearing abilities of baleen whales have not been measured directly. Behavioural and anatomical evidence indicates that they hear well at frequencies below 1 kHz (Richardson et al. 1995; Ketten 2000). For baleen whales as a group, the functional hearing range is thought to be about 7 Hz to 22 kHz and they constitute the "low-frequency" (LF) hearing group (Southall et al. 2007). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small toothed whales that have been studied directly. Thus, baleen whales are likely to hear low-frequency sounds (like airgun pulses and pile driving) farther away than can small toothed whales and, at closer distances, these sounds may seem more prominent to baleen than to toothed whales.

The small to moderate-sized toothed whales whose hearing has been studied have relatively poor hearing sensitivity at frequencies below 1 kHz, but extremely good sensitivity at, and above, several kHz. There are very few data on the absolute hearing thresholds of most of the larger, deep-diving toothed whales, such as the sperm and beaked whales. However, Mann et al. (2005) report that a Gervais' beaked whale showed evoked potentials from 5 to 80 kHz, with the most sensitivity at 80 kHz. Most of the odontocete species have been classified as belonging to the "mid-frequency" (MF) hearing group, and the MF odontocetes (collectively) have functional hearing from approximately 150 Hz to 160 kHz (Southall et al. 2007). However, individual species may not have quite so broad a functional frequency range. Very strong sounds at frequencies slightly outside the functional range may also be detectable. The remaining odontocetes (the porpoises, river dolphins, and members of the genera Cephalorhynchus and Kogia) are distinguished as the "high frequency" (HF) hearing group. They have functional hearing from approximately 200 Hz to 180 kHz (Southall et al. 2007).

Underwater audiograms have been obtained using behavioural methods for three species of phocid seals, two species of monachid seals, two species of otariids, and the walrus (reviewed in Richardson et al. 1995; Kastak and Schusterman 1998, 1999; Kastelein et al. 2002). The functional hearing range for pinnipeds in water is considered to extend from 75 Hz to 75 kHz

(Southall et al. 2007), although some individual species (especially the eared seals) do not have that broad an auditory range (Richardson et al. 1995). Compared to odontocetes, pinnipeds tend to have lower best frequencies, lower high-frequency cutoffs, better auditory sensitivity at low frequencies, and poorer sensitivity at the best frequency.

The limited available data indicate that the frequency range of best hearing sensitivity by sea turtles extends from approximately 250 to 300 Hz to 500 to 700 Hz (Ridgway et al. 1969; Bartol et al. 1999). Sensitivity deteriorates as one moves away from this range to either lower or higher frequencies. However, there is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz.

Noise Criteria for Assessing Physical Effects

The US National Marine Fisheries Service (1995, 2000) has concluded that whales should not be exposed to impulse noise at received levels exceeding 180 dB re 1 μPa (rms). The corresponding limit for seals has been set at 190 dB. These exposure criteria used by the US National Marine Fisheries Service (NMFS) were intended as a precautionary estimate below which hearing impairment (Temporary Threshold Shift or TTS) would not occur from airgun pulses. There was no empirical evidence about whether higher levels of pulsed sound would cause hearing or other injuries. In Canada, minimum exposure criteria for injury to marine mammals (and sea turtles) have not been established. Some jurisdictions in Canada have used the 180 dB re 1 μPa (rms) criteria for whales to establish a safety zone for seismic surveys.

In recent years, a panel of experts have worked to produce scientific recommendations for updated marine mammal noise exposure criteria (Southall et al. 2007). For various marine mammal groups and sound types, Southall et al. (2007) propose levels above which there is a scientific basis for expecting that noise exposure would cause injury to occur. These new exposure criteria incorporate frequency-weighting functions (M-weighting; see Section 3.2.2 in JASCO (2010)) for assessing the effects of sound on marine mammals, which accounts for the major differences in auditory capabilities across marine mammal groups and species. Minimum exposure criteria for injury are defined as the energy level at which single exposure is estimated to cause onset of permanent hearing loss (Permanent Threshold Shift or PTS). TTS was not considered an injury (Southall et al. 2007). Southall et al. (2007) concluded that PTS might occur if cetaceans and pinnipeds were exposed to peak pressures exceeding 230 dB re 1 μPa (peak) (or 198 dB re 1 μPa^2-s) or 218 re 1 μPa (peak) (or 186 dB re 1 μPa^2-s), respectively.

Nearshore

Acoustic modelling was undertaken (see JASCO (2010)) to provide estimates of received sound levels for blasting, pile driving, and vessel operations in the Nearshore Study Area. The results are summarized below as they pertain to sound thresholds which are known or expected to cause environmental effects in marine mammals.

Pile Driving

As previously discussed, pile driving, either vibratory or impact, will be required during bund wall construction (placement of sheet piles) and possibly during placement of moorings at the deepwater site in Bull Arm.

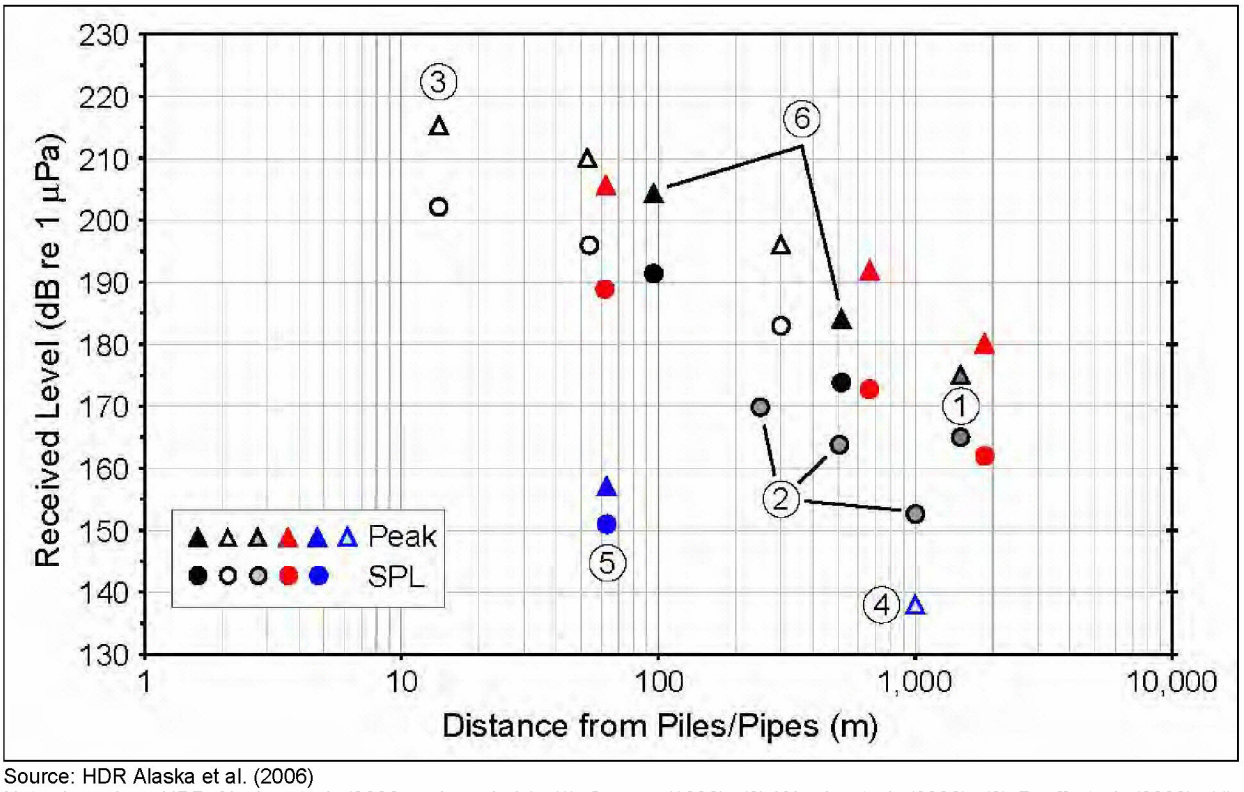
Pile driving produces impulsive sound levels high enough to cause hearing impairment effects, which may result in a change in habitat quality for marine mammals and sea turtles. Sound levels high enough to cause a change in habitat quality typically occur very close to the source.

Impact pile driving produces higher sound levels that are impulsive, whereas vibratory pile driving produces continuous sound at lower sound levels. The results of seven acoustic studies of impact pile (or pipe) driving are summarized in Figure 10-6 (HDR Alaska et al. 2006). The highest received sound level recorded during these studies was 202 dB re 1 uPa (rms) at 14 m (HDR Alaska et al. 2006). Sound levels from most impact pile driving sources diminished below 180 dB at distances less than 300 m. The dominant frequency range of pile driving is most likely related to differences in the size, shape and thickness of the piles. Most of the pulse energy typically falls between 50 to 2,000 Hz (HDR Alaska et al. 2006).

Results of acoustic modelling for the Nearshore Study Area (JASCO 2010) and available studies indicate that received sound levels >180 dB re 1 µPa (rms) do not typically extend beyond 300 m for pile-driving activities. Rather, acoustic modelling estimated that 180 dB re 1 µPa (rms) levels will extend to 260 m and 150 m at the bundwall and deepwater site, respectively. For 190 dB re 1 µPa (rms), sound levels occur at 60 m and 20 m from the bund wall and at the deepwater site, respectively. Thus, available information suggests that there is little risk for hearing impairment to marine mammals or sea turtles beyond 300 m from the pile driving equipment.

There is little risk for hearing impairment to marine mammals or sea turtles, given the sound levels typically recorded during impact pile-driving activities do not exceed 180 dB re 1 µPa (rms) beyond several hundred metres from the source. Sound levels which may cause PTS would occur much closer to the source. To the best of our knowledge, there is no evidence that marine mammals or sea turtles have experienced injury as a result of exposure to pile-driving sounds.

Underwater bubbles can inhibit sound transmission through water due to density mismatch and concomitant reflection and absorption of sound waves. The use of a bubble curtain around pile driving activity will be considered in consultation with DFO for this Project. Depending upon environmental conditions (e.g., current), a bubble curtain can have negligible influence on reducing underwater sound levels to reducing sound levels by as much as 20 dB (S. Blackwell, pers. comm.).



Source: HDR Alaska et al. (2006)
Note: based on HDR Alaska et al. (2006; red symbols); (1) Greene (1999); (2) Wursig et al. (2000); (3) Reyff et al. (2002); (4) Johnson et al. (1986); (5) Blackwell et al. (2004); and (6) Blackwell and Burgess (2004)

Figure 10-6 Summary of Peak and Sound Pressure Levels of Impact Pile/Pipe Driving

A monitoring protocol for marine mammals (and sea turtles) will be established by ExxonMobil Canada Properties (EMCP) prior to the start of construction activities. This protocol will be developed in consultation with DFO and may include the following parameters:

- A trained observer will monitor a designated radius near pile driving activities for at least 30 minutes prior to activation of the pile driver. Acoustic modelling will be conducted prior to construction activities in the Nearshore Project Area to reflect actual pile driving scenarios
- If a marine mammal or sea turtle is detected within the designated zone (conservatively assume 180 and 190 dB re 1 uPa (rms), for cetaceans and seals, respectively) pile driving will not occur until the animal(s) have left the safety zone, or it has not been re-sighted for 30 minutes
- Pile driving activities will be halted if a marine mammal or sea turtle enters into the safety zone and will not be resumed until the animal has left the zone or 30 minutes have passed since the sighting
- For sea turtles, the 180 dB zone will be used

Blasting

Of all the Project activities, blasting is most likely to cause physical effects in marine mammals, without proper mitigation. Inwater blasting explosives have a short rise time to a high peak pressure which is likely responsible for hearing damage causing a change in habitat quality for marine mammals and

sea turtles during detonations (see e.g., Ketten 1995). Explosives can cause mortality (see Section 10.5.1.4). Sound levels of 180 dB re 1 µPa (rms) are considered a precautionary criterion (NMFS 1995, 2000a, 2000b) below which hearing impairment (TTS) would not occur for cetaceans (and 190 dB re 1 µPa (rms) for pinnipeds). No comparable minimum exposure criteria for injury to marine mammals (and sea turtles) have been established in Canada.

Marine Mammals: Two humpback whales (found dead) with severe mechanical damage to their ears were linked to explosions at Mosquito Cove, Bull Arm during construction activities associated with the Hibernia Gravity Base Structure (GBS). Repeated sub-bottom blasting involving explosives (Tovex™) which ranged from 30 to 5,500 kg and averaged 960 kg were used (Todd et al. 1996). The auditory damage was similar to that in humans exposed to severe blast injury.

Sea Turtles: A controlled experiment using Kemp's ridley and loggerhead turtles designed to provide preliminary information on the extent of the impact zone created by the explosive removal of an offshore platform indicated that two individuals of each species that were exposed within 366 m of the explosion were rendered unconscious and one loggerhead turtle was rendered unconscious at a distance of 915 m (Klima et al. 1988). Other observed effects included the eversion of the cloacal lining through the anal opening of the Kemp's ridley exposed at 229 m and an abnormal pink coloration caused by dilated blood vessels at the base of the throat and flippers of all the loggerhead turtles that returned to normal in about three weeks. The received sound pressure levels were estimated to range from 209 dB re 1 µPa at 915 m to 221 dB re 1 µPa at 229 m (unspecified measure type; Klima et al. 1988).

Gitschlag and Herczeg (1994) reported the results from the placement of observers at offshore sites to monitor and protect sea turtles during explosive removals of oil and gas structures in the Gulf of Mexico. In 6,500 hours of monitoring at 106 structures, no injury (or mortality) of sea turtles was documented.

Results of acoustic modelling (JASCO 2010) for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998), indicate that 180 and 190 dB re 1 uPa (rms) sound levels (un-weighted) occur at 2.7 km and 0.99 km, respectively, from the blast site. Because the peak in source spectrum occurs at low-frequency, the application of M-weighting, results in smaller 180 and 190 dB zones for mid- and high-frequency cetaceans (see Table 9 in JASCO (2010)). Southall et al. (2007) concluded that PTS might occur if cetaceans and pinnipeds were exposed to peak pressures exceeding 230 dB re 1 µPa (peak) (or 198 dB re 1 μPa^2-s) or 218 re 1 µPa (peak) (or 186 dB re 1 μPa^2-s), respectively. The corresponding ranges to these sound levels were not estimated during acoustic modelling but would occur much closer to the sound source than 180 and 190 dB re 1 uPa (rms) sound levels.

Sea turtles are rare within the Nearshore Study Area, particularly at times other than late summer and early fall. Species most likely to be affected

include those predicted to be common within the Nearshore Study Area, including humpback whales, possibly minke and pilot whales, and multiple dolphin species, and are likely to be common during the summer months.

Blasting parameters will be such that they adhere to the DFO guidance outlined in Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopky 1998). As a minimum, proposed guidelines (Wright 2002) indicate that detonations cannot knowingly occur within 500 m of any marine mammal, "or alternately, there must be no visual contact by an observer using 7x35 power binoculars".

A monitoring protocol for marine mammals will be established by EMCP prior to the start of construction activities. This protocol will be developed in consultation with DFO and may include the following parameters:

- Prior to blasting, a blast impact assessment will be undertaken to determine appropriate marine mammal and sea turtle exclusion zones and ensure that a 100 kPa charge is not exceeded
- The sound levels in the water column will be evaluated to determine a safety zone for marine mammals
- The feasibility of using a bubble curtain to reduce sound levels will also be investigated
- Received sound levels of 180 dB re 1 µPa (rms) for cetaceans and sea turtles, and 190 dB re 1 µPa (rms) for phocids, modelled as 2.7 and 0.99 km for a 100 kPa charge, respectively, will be used as a guide for these zones
- Sound levels during blasting will be monitored at the shoreline and in the water to modify exclusion zones based on in-field measurements. These zones will be monitored by a trained observer for 30 minutes prior to and during blasting operations in the marine environment, and blasting operations will be temporarily suspended or halted if a marine mammal or sea turtle is sighted within or about to enter the zone. Activities will not resume until the animal(s) has left the zone or it has not been re-sighted for 30 minutes
- Depending on the size of the designated safety zone, more than one trained observer placed in different areas of the safety zone may be needed to adequately monitor the zone. Monitoring techniques and results of acoustic modelling will be reviewed and approved by DFO prior to blasting operations

Vessel Traffic

Sound levels from vessel traffic associated with the Project are not expected to be high enough to cause physical or physiological effects on marine mammals or sea turtles (see Richardson et al. 1995), resulting in a change in habitat quality. It is expected that the greatest and most continuous vessel noise source during construction will result from tugs and barges (see Blackwell and Greene 2006). Sound levels that have the potential to induce hearing impairment in marine mammals and sea turtles (180 and 190 dB re 1 µPa (rms)) have been modelled to occur in an area less than 10 m from a

tug operating at high power levels in the Nearshore Study Area (JASCO 2010). Project activities involving vessel traffic will avoid concentrations of marine mammals and sea turtles whenever possible.

Geophysical Surveys

The geophysical surveys that may take place in the Nearshore Study Area include side scan sonar and geohazard surveys. These surveys produce noise at lower source levels than those of airgun pulses from seismic surveys. Sounds are also typically emitted in a narrow beam, short duration, and sometimes at frequencies outside the range of marine mammal and sea turtle hearing abilities. Therefore, geohazard surveys and side scan sonar are less likely to affect marine mammals and sea turtles than seismic surveys. It is expected that surveys will be minimized, when possible. Additional information on the effects of geohazard surveys is presented below under the discussion of offshore effects.

Surveys will likely increase the presence of vessels in the Nearshore Study Area, increasing the potential environmental effects of vessel traffic (see above). Additional mitigation measures associated with vessel traffic are described above.

Other Activities

Air emissions are expected to have a negligible effect on the habitat quality of the Marine Mammal and Sea Turtle VEC. It is expected that air emissions will be minimized, when possible. All other activities expected to affect habitat quality could also lead to effects on habitat use. The impact of these activities on the Marine Mammal and Sea Turtle VEC in the Nearshore Study Area are reviewed in Section 10.5.1.3 (Habitat Use).

Offshore

Geophysical Surveys

In the Offshore, geophysical surveys will include seismic as well as geohazard surveys. Both seismic and geohazard surveys use airgun arrays, a key difference is the larger array size used in seismic surveys. The potential physical / physiological effects of noise from the geohazards equipment (typically a small airgun array, boomer, side scan sonar, and echosounders) are of less concern than airgun pulses from 2-D and 3-D surveys given their relatively lower source levels, emittence in a narrow beam, short duration of the geohazards program, and that some equipment operates at frequencies outside the range of marine mammal and sea turtle hearing abilities.

The potential physical/physiological effects of seismic programs on marine mammals and sea turtles have recently been reviewed for the StatoilHydro's 3-D program in Jeanne d'Arc Basin (LGL 2008a: Section 5.6.4) Petro-Canada's 3-D program in Jeanne d'Arc Basin (LGL 2007a: Section 5.6.6) and for Husky's program in northern Jeanne d'Arc Basin (LGL 2005b:

Section 6.5.12; Moulton et al. 2006b: Sections 6.1.2 and 6.1.3). Geohazard surveys are less likely to impact marine mammals and sea turtles as reviewed in three Environmental Assessments for Jeanne d'Arc Basin in 2005 (LGL 2005a, 2005b, 2005c, 2005d) and an update to one of the environmental assessments in 2007 (LGL 2007a).

Temporary or permanent hearing impairment is a possibility when marine mammals and sea turtles are exposed to very strong sounds. The minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS. The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage. As discussed earlier, current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds exceeding 180 and 190 dB re 1 μPa (rms), respectively (NMFS 2000a, 2000b). However, those criteria were established before there was any information about the minimum received levels of sounds necessary to cause TTS in marine mammals. The 180 dB criterion for cetaceans is probably quite conservative (i.e., lower than necessary to avoid auditory injury), at least for delphinids (Southall et al. 2007).

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds.

TTS: The magnitude of TTS depends on the level and duration of noise exposure, among other considerations (Richardson et al. 1995). For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies at which baleen whales are most sensitive are lower than those at which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales. Based on available data, TTS is not expected to occur among baleen whales exposed to seismic sound given the strong likelihood that they would avoid an approaching airgun(s) (or vessel) before being exposed to levels high enough for there to be any possibility of TTS (NSF and L-DEO 2006a, 2006b; Wilson et al. 2006). This assumes that mitigation consisting of ramp-up (soft start) procedures is used when commencing airgun operations. It is assumed that this approach provides the opportunity for whales near the seismic vessel to move away before they are exposed to sound levels that might be strong enough to elicit TTS (Wilson

et al. 2006). However, the effectiveness of this procedure has not been empirically studied.

For toothed whales exposed to single short pulses, the TTS threshold appears to be, to a first approximation, a function of the energy content of the pulse (Finneran et al. 2002, 2005). Given the available data, the received sound energy level of a single seismic pulse (with no frequency weighting) might need to be approximately 186 dB re 1 $\mu Pa^2 \cdot s$ (i.e., 186 dB SEL or approximately 221 to 226 dB peak-peak) in order to produce brief, mild TTS (Southall et al. 2007). Exposure to several strong seismic pulses that each have received levels near 175 to 180 dB SEL might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. For an odontocete closer to the surface, the maximum radius with greater than or equal to 186 dB SEL, or greater than or equal to 198 dB (rms), would be smaller. However, additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. At the present state of knowledge, it is necessary to assume that the effect is directly related to total energy, even though that energy is received in multiple pulses separated by gaps. However, the exposure levels necessary to cause TTS in toothed whales, when the signal is a series of pulsed sounds separated by silent periods, remains a data gap.

TTS thresholds for pinnipeds exposed to brief pulses (either single or multiple) of underwater sound have not been measured. There are some indications that, for corresponding durations of sound, the harbour seal may incur TTS at somewhat lower received levels than do small odontocetes (Kastak et al. 1999, 2005; Ketten et al. 2001; cf. Au et al. 2000). However, TTS onset in the California sea lion and northern elephant seal may occur at a similar sound exposure level as in odontocetes (Kastak et al. 2005).

There have been few studies that have directly investigated hearing or noise-induced hearing loss in sea turtles. The apparent occurrence of TTS in loggerhead turtles exposed to many pulses from a single airgun less than or equal to 65 m away (Moein et al. 1994) suggests that sounds from an airgun array could cause at least temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs. There is also the possibility of permanent hearing damage to turtles close to the airguns. However, there are few data on temporary hearing loss, and no data on permanent hearing loss in sea turtles exposed to airgun pulses.

PTS: When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, while in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the likelihood that some mammals close to an airgun array might incur at least mild TTS (see Finneran et al. 2002), there has been speculation about the possibility that some individuals occurring very close to airguns might incur PTS (Richardson et al. 1995, p. 372). The specific

difference between the PTS and TTS thresholds has not been measured for marine mammals exposed to any sound type. When exposure is measured in SEL units, Southall et al. (2007) concludes the PTS-onset to TTS-onset for marine mammal exposure to impulse sound is at least 15 dB. Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably more than 6 dB.

Although it is unlikely that airgun operations during most seismic surveys would cause PTS in marine mammals, caution is warranted given the limited knowledge about noise-induced hearing damage in marine mammals, particularly baleen whales. Commonly applied monitoring and mitigation measures, including visual monitoring, ramp-ups, and power-downs of the airguns when mammals are seen within the "safety radii", are expected to minimize the already-low probability of exposure of marine mammals to sounds strong enough to potentially induce PTS.

The study by Moein et al. (1994) indicates that sea turtles can experience TTS when exposed to moderately strong airgun sounds. However, there are no data to indicate whether or not there are any plausible situations in which exposure to repeated airgun pulses at close range could cause permanent hearing impairment in sea turtles.

Non-auditory Physiological Effects: Possible types of non-auditory physiological effects or injuries that could theoretically occur in marine mammals exposed to strong underwater sound might include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are limited. If any such effects do occur, they would probably be limited to unusual situations. Those could include cases when animals are exposed at close range for unusually long periods, or when the sound is strongly channeled with less-than-normal propagation loss, or when dispersal of the animals is constrained by shorelines, shallows.

In summary, very little is known about the potential for seismic survey (and geohazard survey) sounds to cause either auditory impairment or other non-auditory physical effects in marine mammals or sea turtles. Available data suggest that such effects, if they occur at all, would be limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in these ways. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are unlikely to incur auditory impairment or other physical effects.

As indicated in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines C-NLOPB 2011), mitigation measures will be implemented consistent with those provided for in the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment, including, but not limited to:

- Ramp-up of the airgun array over a minimum of 20 minutes
- Monitoring by a trained marine mammal observer
- Shutdown of the airgun array when a Schedule 1 endangered or threatened marine mammal or sea turtle is sighted within the 500 m safety zone
- Delay of ramp-up if any marine mammal or sea turtle is sighted within the 500 m safety zone

Considering the seismic survey mitigation measures, there will likely be minimal effects of seismic surveys on marine mammals and sea turtles.

Vessel Traffic

As stated above sound levels from vessel traffic associated with the Project are not expected to be high enough to cause physical or physiological effects in marine mammals or sea turtles (see Richardson et al. 1995), resulting in a change in habitat quality. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Other Activities

Air emissions are expected to have a negligible environmental effect on the habitat quality of the marine mammal and sea turtle VEC. It is expected that air emissions will be minimized, when possible. In the case of surveys that do not include seismic airguns, the main environmental effect of surveys on the marine mammal and sea turtle VEC is the operation of vessels (described above). All other activities expected to affect habitat quality could also lead to environmental effects on habitat use. The environmental effects of these activities on the marine mammal and sea turtle VEC in the Offshore Study Area are reviewed in Section 10.5.1.3 (Habitat Use).

10.5.1.3 Change in Habitat Use

This effect category includes behavioural effects of project activities on marine mammals and sea turtles. Noise introduced into the water column has the greatest potential to affect the behaviour of marine mammals and sea turtles, as noise is associated with almost every aspect of the construction, operations and maintenance, and decommissioning and abandonment phases of the Project and this VEC is known to be sensitive to noise.

Behavioural reactions of marine mammals (and sea turtles) to sound are difficult to predict in the absence of site- and context-specific data. Reactions to sound, if any, depend on species, state of maturity, experience, current

activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007). If a marine mammal reacts to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007).

Nearshore

Construction of the Bund Wall

Pile driving produces impulsive sounds whose levels are high enough to cause behavioural effects in marine mammals and sea turtles which may result in a change in habitat use. Southall et al. (2007) suggest that for all sound types, other than single pulses (like those from an explosive), behavioural effects will occur more commonly at sound levels below those involved with TTS or PTS. Based on available literature, a 160 dB re 1 µPa (rms) disturbance criterion is suggested for pile driving activities. Results of acoustic modelling (JASCO 2010) indicate that received sound levels greater than 160 dB re 1 µPa (rms) do not typically extend beyond 3.1 km for pile driving activities in the Nearshore Study Area at both the bund wall and deepwater mooring site. Rather, it is predicted that 160 dB re 1 µPa (rms) levels will extend to 2.9 km and 3.1 km from the bund wall and deepwater mooring site, respectively.

Indo-Pacific humpback dolphins (Sousa chinensis) that likely have similar hearing abilities as Northwest Atlantic delphinids occur in nearshore waters near Hong Kong, where in-water pile driving has been used extensively for building piers and other structures (Jefferson et al. 2009). A study indicated that some Indo-Pacific humpback dolphins exposed to sound pressure levels of 170 dB re 1 µPa (rms) remain within 300 to 500 m of the pile driving area before, during, and after operations (Würsig et al. 2000). Although some dolphins temporarily abandoned the work area, their numbers returned to close to those seen pre-construction during the follow-up survey seven months after construction activities ended (Würsig et al. 2000).

Several studies monitored harbour porpoises during construction of two offshore wind farms off the coast of Denmark (Tougaard et al. 2003, 2009; Carstensen et al. 2006; Teilmann et al. 2008). During pile driving activities (using both vibratory and impact techniques) at the Nysted offshore wind farm, a significant decrease in echolocating activities and abundance was reported within the construction area and in a reference area 10 km from the construction site. Two years after construction, echolocation and presumably porpoise abundance were significantly reduced (Carstensen et al. 2006; Teilmann et al., 2008). During percussion pile driving at the Horns Reef wind farm, harbour porpoise acoustic activities declined, although the recovery to baseline occurred only hours after completion of these activities (Tougaard et al. 2003, 2009; Teilmann et al. 2008). Behavioural changes

during the construction period included a decrease in feeding behaviour and a decrease in the number of individuals in the area (Tougaard et al. 2003).

Ringed seals exposed to pile-driving pulses exhibited little or no reaction to impact pipe-driving sounds at a shallow water site in the Alaskan Beaufort Sea (Blackwell et al. 2004). At the closest point (63 m), received levels were 151 dB re: 1 µPa (rms) and 145 dB re: 1 μPa^2-s SEL. Harbour seal haul-out behaviour was affected by pile-driving at an offshore wind farm (Nysted) in the western Baltic (Edrén et al. 2004). The authors found a 31 to 61 percent reduction during periods with pile driving versus no pile driving in the number of seals hauled out at a beach approximately 10 km from the construction site. Sound levels were not measured and observations of seals in the water were not made. The authors suggest that seals may have spent more time in the water because this is a typical response to disturbance or the seals may have used an alternate haul-out site. At an adjacent wind farm to Nysted (Horns Rev), no seals were observed during ship-based surveys in the wind farm during pile driving. The reactions of harbour seals to the pile driving appeared short-term because aerial surveys did not reveal any decrease in overall abundance during the construction period (2002 to 2003) (or operation period 2004 to 2005; Teilmann et al. 2006).

Based on this limited information and the literature for marine mammal response to low-frequency impulsive sounds (like airgun pulses - see Richardson et al. 1995 and Nowacek et al. 2007), baleen and toothed whales would likely exhibit at least localized avoidance of the pile driving sites. There is some evidence to suggest that harbour porpoise echolocation activity may decline, at least temporarily, and that seals may exhibit at least short-term avoidance of the area.

There are currently no published data available for behavioural effects of pile driving on sea turtles. Of note, sea turtles are considered rare in inner Trinity Bay near the sites of potential pile driving.

Mitigation measures associated with limiting effects to habitat quality were previously described (see Section 10.5.1.2) and will additionally minimize potential effects to habitat use by marine mammals and sea turtles.

In-water Blasting

Behavioural disturbance, resulting in a change in habitat use, is a potential effect of blasting operations. However, there are no specific sound levels for blasting activities that are linked with behavioural effects on marine mammals and sea turtles. Southall et al. (2007) use the onset of TTS as a criterion for "behavioural" disturbance of cetaceans exposed to a single pulse (see page 448 in Southall et al. 2007). The unweighted peak sound pressure of 224 dB re 1 uPa (peak) and weighted SEL values of 183 dB re 1 uPa^2-s are recommended as disturbance criteria (i.e., received levels that exceed either of these levels are considered to have greater potential to elicit a biologically significant behavioural response). For pinnipeds exposed to a single pulse in water, the peak sound pressure of 212 dB re 1 uPa (peak) and weighted SEL values of 171 dB re 1 uPa^2-s are recommended as disturbance criteria. The

US NFMS has often used a lower sound level criterion for disturbance of 160 dB re 1 uPa (rms) for marine mammals.

Acoustic modelling results (JASCO 2010) for the largest possible charge permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998) suggest that 160 dB re 1 µPa (rms) sound levels occur within 3.5 km from the blast site. Ranges to the criteria recommended by Southall et al. (2007) were not directly estimated but would be less than 1 km for cetaceans and less than 2.7 km for seals (see Table 9 in JASCO 2010).

Marine Mammals: Humpback whale responses to underwater (sub-bottom) explosions (associated with construction activity) at Mosquito Cove, Bull Arm, were monitored for a 19-day period in June 1992 (Todd et al. 1996). Surveys (photographic when possible) were conducted before, during and after explosions. Data were used to calculate residency, resighting rates, and net movement toward or away from the noise source. Acoustic recordings of the explosions as well as whale vocalizations were acquired. Explosives (Tovex™) ranged from 30 to 5,500 kg and averaged 960 kg. Todd et al. (1996) reported that received sound levels typically were 140 to 150 dB re 1 µPa (maximum 153 dB) near 400 Hz. The authors estimate a source level of 209 dB re 1 µPa at 1 m. It is not clear what acoustic metric is used (i.e., rms, 0-peak, peak-peak), nor what broadband sound levels resulted from the blasts. Behavioural observations of humpbacks in situ on their foraging grounds suggest that the whales were not reacting to the intense acoustic stimuli from the detonations (Todd et al. 1996). It is unclear if an increase in humpback entrapments in fishing nets in the area were related to underwater explosions.

Toothed whales, including belugas, bottlenose dolphins, false killer whales, and killer whales exposed to small explosive charges (received sound level of 185 dB re 1 µPa in one study) found limited or no effect on these marine mammals (Richardson et al. 1995). At higher received levels, explosions may elicit responses. Two captive bottlenose dolphins exposed to sounds simulating distant underwater explosions showed behavioural avoidance to sound with received levels from 196 to 209 dB re 1 µPa (peak to peak; Finneran et al. 2000).

Pinnipeds seem quite tolerant of noise pulses from "small" explosives (Richardson et al. 1995). Firecracker-like explosives initially startle seals and sea lions, and often induce them to move away but avoidance wanes after repeated exposure. Northern fur seals breeding on land did not exhibit any obvious response to nearby (0.6 to 2 km) blasts from quarries (Gentry et al. 1990). South American fur seals and sea lions as well as grey seals exposed to blasting operations showed little or no reactions. There is little chance of masking of any marine mammal sounds, as blasting operations will be intermittent in nature and the sound pulse is very short.

Sea Turtles: No information on the environmental effects of blasting on sea turtles is currently available, but sea turtles are considered rare in inner Trinity Bay near the site of potential blasting, particularly during times other than late summer and early fall.

Species most likely to exhibit changes in habitat use include marine mammals common in the Nearshore Study Area during blasting activities.

Mitigation associated with habitat use will be as described for habitat quality (see Section 10.5.1.2).

Dredging

In the Nearshore Project Area, dredging of the bund wall and possibly sections of the tow-out route may be required during the construction of the GBS.

In nearshore shallow water regions, dredges can be strong sources of low-frequency underwater noise (Richardson et al. 1995). Because low-frequency sound attenuates rapidly in shallow water, underwater sound produced by dredging is normally undetectable at ranges beyond 25 km (Richardson et al. 1995). Dredging that occurs consistently over long periods can create a higher potential for disturbance, which could result in changes in habitat use, for marine mammals and sea turtles. Limited information is available on the behavioural changes of marine mammals (and none for sea turtles) resulting from dredging operations, but generally animals have been reported to continue using habitats near dredging operations.

Marine Mammals: Gray whales in Laguna Guerrero Negro provide the best documented case of a long-term change in baleen whale distribution as a result of industrial activities including dredging. It is thought that constant dredging operations needed to keep a channel open for shipping of salt (from 1957 to 1967) may have been the main source of disturbance to the whales and decline of whale numbers from 1964 to 1970 (Bryant et al. 1984). Gray whales reoccupied the lagoon after shipping of salt subsided. However, recent surveys suggest that the seasonal abundance of gray whales in the lagoon has decreased 90 percent since the 1980s. Fishermen in the area suggested that this decline of whales may be due to the natural closure of the lagoon entrance as sand accumulates in the absence of dredging (Urbán-Ramirez et al. 2003).

In the MacKenzie Estuary, Canada, belugas have been reported to approach as close as 400 m to stationary dredges, but were more sensitive to barge traffic associated with the dredging (Ford 1977; Fraker 1977). In contrast, in 1999, Cook Inlet beluga whales were seen in waters near the docks at the Port of Anchorage, Alaska, during vessel transits from a dredging operation near Fire Island, but no whales were observed near the dredging site itself (Moore et al. 2000).

Marine mammals common within the Nearshore Study Area during dredging activities, particularly those present for extended periods, are most likely to be affected.

Sea Turtles: There are currently no published data available regarding the behavioural effects of dredging on sea turtles. However, sea turtles are considered uncommon in the Nearshore Study Area.

Dredging operations will be temporary and of limited duration. Dredging may only be required to prepare the tow-out channel from Great Mosquito Cove to the deepwater site. It is planned that proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammals and sea turtles.

Vessel Traffic

Noise generated by vessels associated with the Project has the potential to disturb marine mammals and sea turtles, causing changes in habitat use. Marine mammal responses to ships are presumably responses to noise, but visual or other cues are also likely involved. Sound source levels for most small ships, including tugs and barges, are above the 160 dB re 1 µPa (rms) criterion considered for behavioural disturbance (Richardson et al. 1995). Specific sound levels or estimates are not available for the specific vessels or the cumulative noise levels from vessels that will be used during the Project, but it is expected that the greatest and most continuous vessel noise source during construction and operations / maintenance phases will be tugs and barges (see Blackwell and Greene 2006).

Acoustic modelling of a tug boat operating at high power was conducted at both the bund wall and deepwater mooring site (see JASCO 2010). Relative to other sources of construction noise, estimated sound levels from a single tug were much lower relative to other sources of construction noise. Sound levels of 160 dB re 1 uPa (rms) were estimated to occur within 140 m and 60 m of the tug at the bund wall and deepwater mooring site, respectively.

Factors such as species, maturity, experience, current behaviour state, reproductive state, and time of day likely affect marine mammal and sea turtle responses to vessels. Marine mammal response (or lack thereof) to ships and boats are summarized in Richardson et al. (1995, p. 252-274) for studies pre-1995. A review of more recent studies assessing the responses of marine mammals to the presence of vessels is included in LGL (2007a: Section 5.6.6.3). For baleen whales in general, available studies indicate that rapid changes in vessel speed, close approaches, and head-on approaches elicit behavioural responses, including avoidance of areas and changes in dive patterns or swim speeds. Variable reactions, from minor to overt, have been noted for toothed whales. Animal responses include reductions in foraging, possible habituation, increased diving, frequent changes in direction, approach and bow-riding, increased rate and sound level of vocalizations, modified behavioural state, general avoidance, or selection of different habitat. Seals sometimes investigate oncoming vessels while others appear to avoid vessels. No data are currently available on the response of sea turtles to vessel traffic, but they rarely occur in the Nearshore Study Area and typically only during late summer or early fall. Marine mammals occurring in the Nearshore Study Area during periods of increased vessel traffic are most likely to be affected.

Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Additionally, vessels will maintain a steady vessel speed and course whenever possible.

Other Activities

Artificial light might attract prey species of the marine mammal and sea turtle VEC and result in a positive environmental effect on its habitat use. Air emissions are expected to have a negligible effect on the habitat quality of the marine mammal and sea turtle VEC. The creation of new moorings might attract prey species of the marine mammal and sea turtle VEC and result in a minimal positive environmental effect on its habitat use. The effects of tow-out of the Hebron Platform are most likely related to the presence of vessels and low-frequency engine noises discussed above. In the case of surveys that do not include seismic airguns, the main impact of surveys on the Marine Mammal and Sea Turtle VEC is vessel traffic (described above).

Offshore

Dredging

As described above for dredging activities in the Nearshore Study Area subsection, dredging that occurs consistently for extended periods could result in behavioural reactions and changes in habitat use for marine mammals and sea turtles. In general, the limited available information suggests that cetaceans tend to remain in occupied areas near dredging sites, but there is no available information on reactions of pinnipeds or sea turtles. Animals that remain near dredging activities for extended periods are most likely to be affected. Proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammals and sea turtles. Additionally, suction dredgers will be used to lessen sediment suspension during soil intake, and work periods will be minimized.

Vessel Traffic

The potential effects of vessel traffic on the habitat use of marine mammals and sea turtles were reviewed above in the Nearshore Study Area subsection. As described in that section and Section 10.5.1.2, project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Helicopter Overflights

Helicopters will be used to transfer personnel to the Hebron Platform, drilling units, and possibly seismic vessels. Baleen whale responses to aircraft (pre-1995 studies) are summarized in Richardson et al. (1995, p. 249-252). Those observations showed that whales often react to aircraft overflights by hasty dives, turns, or other changes in behaviour. Responsiveness depends on the activities and situations of the whales (e.g., gray whales; Moore and Clarke 2002). Whales actively feeding or socializing often seem rather non-

responsive. Whales in confined waters or with calves sometimes seem more responsive. In a more recent study, opportunistic observations of bowhead whale responses to a Bell 212 helicopter (and Twin Otter fixed-wing aircraft) were acquired during four spring migration periods in the Alaskan Beaufort Sea (Patenaude et al. 2002). The helicopter was found to have numerous prominent tones at frequencies up to approximately 340 Hz, with the most prominent peak at 22 Hz. Sound levels between the peaks were 10 to 15 dB above ambient noise levels. Helicopter overflights elicited detectable responses in 14 percent of 63 bowhead groups. Most observed reactions (abrupt dives, breaching, tail slapping, and brief surfacings) by bowheads (63 percent) to the helicopter occurred when it was at altitudes less than or equal to 150 m and lateral distances less than or equal to 250 m. In this and other studies, there was no indication that single or occasional aircraft overflights cause more than brief behavioural responses.

Toothed whale responses to aircraft (pre-1995 studies) are summarized in Richardson et al. (1995). Odontocetes reacting to aircraft may dive, slap the water with flippers or flukes, or swim away. The activity of a toothed whale sometimes appears to influence whether or not there is a behavioural response. In more recent studies, Richter et al. (2003) reported that male sperm whales off Kaikoura, New Zealand, spent more time at the surface and showed more frequent heading changes in the presence of aircraft (small fixed-wing planes and helicopters) involved in whale watching activities. The responses of beluga whales in the Alaskan Beaufort Sea to the noise of a Bell 212 helicopter (and Twin Otter fixed-wing aircraft) were assessed by Patenaude et al. (2002). Beluga whales reacted to the helicopter on 15 of 40 occasions. These reactions included immediate dives, changes in heading, changes in behavioural state, and apparent displacements. Reactions occurred more often when the helicopter passed at altitudes less than or equal to 150 m than when it passed at altitudes greater than 150 m and significantly ($p = 0.004$) more often when the helicopter's lateral distance from the whales was less than or equal to 250 m versus 250 to 500 m. Beluga whales reacted 50 percent of the time when the helicopter was stationary on the ice with the engines running. In this and other studies, there was no indication that single or occasional aircraft overflights cause more than brief behavioural responses in toothed whales.

Pinniped response to aircraft (pre-1995 studies) are summarized in Richardson et al. (1995). Pinnipeds hauled out on land or ice seem to be more responsive to overflights than pinnipeds in the water. Born et al. (1999) assessed the responses of ringed seals hauled out on the ice to overflights by fixed-wing twin-engine aircraft (Partenavia PN68 Observer) and a helicopter (Bell 206 III). Both aircrafts flew over seals at an altitude of 150 m. Overall, 6 percent of the seals (total = 5,040) escaped (left the ice) as a reaction to the fixed-wing aircraft and 49 percent of the seals (total = 227) escaped as a response to the helicopter. Some seals seem to habituate to frequent overflights. In this and other studies, there was no indication that single or occasional aircraft overflights cause more than brief behavioural responses in pinnipeds. Observations were made of ringed seal behaviour in response to industrial noise (pipe-driving, helicopter overflights) at an artificial island

(Northstar Island) in the Alaskan Beaufort Sea (Blackwell et al. 2004). During 55 h of observation, 23 observed ringed seals exhibited little or no reaction to any industrial noise except approaching Bell 212 helicopters; 10 seals looked at the helicopter, one seal departed from its basking site, and one seal showed no reaction.

There are currently no available systematic data on sea turtle reactions to helicopter overflights. Given the hearing sensitivities of sea turtles, they can likely hear helicopters, at least when the helicopters are at lower altitudes and the turtles are at relatively shallow depths. It is unknown how sea turtles would respond, but single or occasional overflights by helicopters would likely only elicit a brief behavioural response.

Thus, the available information suggests that helicopters flying at low altitude (i.e., when approaching a landing site) may disturb some marine mammals directly in its flight path, or, in the case of seals, when they are hauled out. Occasional aircraft overflights cause only brief behavioural responses by marine mammals, and there is no available information on the reaction of sea turtles to aircraft overflight. Additionally, it is unlikely that large numbers of marine mammals will be overflown, especially at low altitude.

To avoid disturbance of marine mammals and sea turtles, the helicopter will avoid flying at low altitudes whenever it is safe to do so. Helicopters will typically only reduce altitude on approach for landing. Helicopter landings at offshore platforms would probably affect a very small area with a radius less than 500 m.

Seismic and Other Geophysical Surveys

A change in habitat use, resulting from behavioural disturbance and avoidance, is the most likely effect, if any, of seismic and geohazard surveys on marine mammals and sea turtles. The following text provides summaries and updated literature from recent seismic and geohazard survey environmental assessments prepared for the Jeanne d'Arc Basin. The reader is referred to LGL 2005b (Section 6.5.12); Moulton et al. 2006b (Sections 6.1.2 and 6.1.3); LGL 2007a (Section 5.6.6); and LGL 2008 for a detailed review of seismic effects and LGL 2005b, 2005c, 2005d, 2007a for a review of geohazard survey behavioural effects on marine mammals and sea turtles.

Marine Mammals: Baleen whales tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to airgun pulses at distances beyond a few kilometres, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, studies done since the late 1990s of humpback and migrating bowhead whales show that reactions, including avoidance, sometimes extend to greater distances than documented earlier. Avoidance distances often exceed the distances at which boat-based observers can see whales, so observations from the source vessel are biased. Studies indicate monitoring over broader areas may be needed to determine the range of potential effects of some larger seismic surveys (Richardson et al. 1999; Bain and Williams 2006; Moore and Angliss 2006).

Some baleen whales show considerable tolerance of seismic pulses (Stone and Tasker 2006). However, when the pulses are strong enough, avoidance or other behavioural changes become evident. Because the responses become less obvious with diminishing received sound level, it has been difficult to determine the maximum distance (or minimum received sound level) at which reactions to seismic become evident and, hence, how many whales are affected.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160 to 170 dB re 1 μPa (rms) range seem to cause obvious avoidance behaviour in a substantial fraction of the animals exposed. In many areas, seismic pulses diminish to these levels at distances ranging from 4.5 to 14.5 km from the source. A substantial proportion of the baleen whales within this distance range may show avoidance or other strong disturbance reactions to the operating airgun array. In the case of migrating bowhead whales, avoidance extends to larger distances and lower received sound levels. Recent intensive study of western gray whales summering in feeding areas off Sakhalin Island, Russia showed that some whales (5 to 10 individuals) moved away from waters inshore of seismic operations to a core feeding area farther south (Yazvenko et al. 2007a) and that there was no measureable effect on bottom feeding by gray whales relative to the seismic survey (Yazvenko et al. 2007b).

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. Furthermore, effects likely vary between species, location, past exposure to seismic sounds. In general, among mammals, baleen whales are relatively long-lived, mature late, have relatively low reproductive rates, and require high maternal investment in young. This is particularly true for bowhead and right whales, although both species are unlikely to occur in the Offshore Area. Thus, the female's ability to provide adequate care to her offspring during a prolonged period of dependency is critical to the continued recovery and long-term viability of the population. These natural history traits support the need to avoid certain seasons or locations as addressed in this analysis (Wilson et al. 2006).

Some populations of mysticetes have continued to grow despite increasing anthropogenic activities, including seismic activities. Long-term data on gray whales show that they continue to migrate annually along the west coast of North America despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme et al. 1984). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years. Bowheads were often seen in summering areas where seismic exploration occurred in preceding summers (Richardson et al. 1987). They also have been observed over periods of days or weeks in areas repeatedly ensonified by seismic pulses. However, it is not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified areas.

Dolphins and porpoises are often seen by observers on active seismic vessels, occasionally at close distances (e.g., bow-riding). However, some studies show avoidance (Stone and Tasker 2006). Belugas summering in the Beaufort Sea tended to avoid waters out to 10 to 20 km from an operating seismic vessel (Miller et al. 2005a). In contrast, recent studies show little evidence of reactions by sperm whales to airgun pulses, contrary to earlier indications.

A recent at-sea controlled experiment on the effects of airguns on sperm whales in the Gulf of Mexico indicated that sperm whales do not exhibit avoidance reactions to airguns (Miller et al. 2009). The experiment did, however, suggest that airgun exposure could lead to subtle changes in the sperm whale foraging behaviour, such as delaying foraging behaviour. One animal that was resting at the survey before the onset of airgun activity remained resting at the surface throughout the duration of airgun activity, but initiated a foraging dive shortly after the airguns ceased (Miller et al. 2009).

There are no specific data on responses of beaked whales to seismic surveys, but it is likely that most if not all species show strong avoidance due to their documented tendency to avoid vessels in general. Of note, northern bottlenose whales have been observed to approach within 400 m of seismic vessels operating in the Orphan Basin when the airgun arrays were active (Moulton et al. 2006a).

Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behaviour (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005b). These studies indicate that pinnipeds frequently do not avoid the area within a few hundred metres of an operating airgun array. However, limited telemetry work suggests that avoidance and other behavioural reactions may be stronger than evident to date from visual studies (Thompson et al. 1998).

As reviewed in LGL (2007a, 2007b), masking (i.e., reduction in the effective communication or echolocation distance) is unlikely to be a significant issue for marine mammals exposed to the pulsed sounds from seismic and geohazard surveys.

In summary, short-term avoidance behaviour is not likely to cause any negative effects on the well-being of marine mammals. Furthermore, lack of avoidance is not necessarily a positive result if it means that the animals remain in a heavily ensonified area where (if the ship gets close enough) there is a possibility of temporary hearing loss or TTS (described earlier). In general, there seems to be a tendency for most baleen and toothed whales to show some limited avoidance of seismic vessels operating large airgun systems. Seals appear less likely to avoid seismic vessels operating airgun arrays.

Sea Turtles: There have been far fewer studies of the effects of airgun noise (or indeed any type of noise) on sea turtles than on marine mammals. Three studies (O'Hara and Wilcox 1990; Moein et al. 1994; McCauley et al. 2000) have focused on short-term behavioural responses of sea turtles in enclosures to single airguns; these studies showed that sea turtles generally

tend to show avoidance of an operating airgun at some received level. McCauley et al. (2000) found evidence of behavioural responses (increased swimming speed) by caged green and loggerhead turtles when the received level from a single small airgun (20 in^3 at 1500 psi) was 166 dB re 1 µPa (rms) and avoidance responses at 175 dB re 1 µPa (rms). Captive loggerhead sea turtles maintained a standoff range of about 30 m in response to a 10 in^3 airgun plus two 0.8 in^3 "poppers" operating at 2000 psi (O'Hara and Wilcox 1990). Avoidance appeared to have occurred at levels around 175 to 176 dB re 1 µPa (rms) (McCauley et al. 2000) or a few dB lower. Moein et al. (1994) also noted avoidance by enclosed loggerhead turtles in response to airgun sounds (up to 179 dB) at a mean range of 24 m; however, the avoidance response waned quickly. Moein et al. (1994) also noted that TTS apparently occurred in confined loggerhead turtles exposed to many pulses from a single airgun less than 65 m away. McCauley et al. (2000) estimated that, for a typical airgun array (2,678 in^3, 12-elements) operating in 100 to 120 m water depth, sea turtles may exhibit behavioural changes at approximately 2 km and avoidance around 1 km. Holst et al. (2006) reported behavioural changes and/or avoidance near a seismic vessel, but the distances or sound levels at which these responses occurred could not be determined.

The limited available data indicate that sea turtles will hear airgun sounds. Based on available data, it is likely that sea turtles will exhibit behavioural changes and/or avoidance within an area of unknown size near a seismic vessel. Seismic operations in or near areas where turtles concentrate are likely to have the greatest effect. There are no specific data that demonstrate the consequences to sea turtles if seismic operations do occur in important areas at important times of year. The Jeanne d'Arc Basin, including the Offshore Study Area, is not a breeding area for sea turtles and there are no known feeding areas or sensitive areas in part due to existing data gaps; thus, high concentrations of sea turtles are unlikely.

In summary, potential changes in habitat use of the Offshore Study Area by marine mammals and sea turtles resulting from seismic surveys include behavioural effects and avoidance. Baleen whales tend to avoid operating airguns, but at variable avoidance radii. Some dolphins occasionally approach active seismic vessels, but studies of toothed whale reactions to seismic surveys generally show temporary avoidance. Only slight (if any) avoidance has been shown by pinnipeds. Limited studies of the effects of seismic surveys on sea turtles suggest that they will exhibit behavioural and/or avoidance within some distance of an operating seismic vessel. Short-term avoidance behaviour, however, does not necessarily provide information about long-term effects such as reproductive rate or distribution and habitat use in subsequent days or years. Additionally, effects likely vary between species, location, and past exposure to seismic sounds.

Mitigation measures will be employed to minimize the potential for effects on marine mammals and sea turtles. To the extent possible, seismic surveys will occur outside of periods of spatial and temporal concentration of marine mammals and sea turtles. Additional mitigation measures to minimize

hearing impairment, as outlined by the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) and described above in Section 10.5.1.2, will also help minimize any potential environmental effects on marine mammals and sea turtles.

Other Activities

The main impact of tow-out / offshore installation on the Marine Mammal and Sea Turtle VEC is vessel traffic (described above). In the case of surveys that do not include seismic airguns, the main environmental effect of surveys on the Marine Mammal and Sea Turtle VEC is the operation of vessels (described above). Air emissions are expected to have a negligible effect on the habitat quality of the marine mammal and sea turtle VEC. Sounds associated with construction (discussed for the Nearshore Study Area) are most likely to elicit minor behavioural disturbance, resulting in changes in habitat use, for marine mammals and sea turtles. Artificial light might attract prey species of the Marine Mammal and Sea Turtle VEC and result in a positive environmental effect on its habitat use.

10.5.1.4 Potential Mortality

There are few Project activities which are known to cause direct mortality of marine mammals and sea turtles. Collisions with vessels and exposure to in-water blasting may result in mortality. It is thought that some marine mammal species may be at risk of stranding and mortality from exposure to seismic survey noises; this is discussed below.

Nearshore

Blasting

The short rise time to a high peak pressure of shock pulses from explosives appears to be responsible for much of the damage, including mortality, to marine mammals during these detonations (Ketten 1995). Sound levels associated with mortality in marine mammals from blasting have not been established.

Marine Mammals: Humpback whale mortality was linked to explosions at Mosquito Cove, Bull Arm during construction activities associated with the Hibernia GBS. Repeated sub-bottom blasting involving explosives (Tovex™) which ranged from 30 to 5,500 kg and averaged 960 kg were used (Todd et al. 1996). Two dead humpbacks with severe mechanical damage to the ears were found near the site (distance to the explosions is unknown) of repeated subbottom blasting. The auditory damage was similar to that in humans exposed to severe blast injury. It is likely the humpbacks were killed as a result of exposure to shock waves (Ketten et al. 1993; Ketten 1995).

In addition to baleen whales, large explosions can kill dolphins. Chinese river dolphins, Irrawaddy dolphins, and finless porpoises have been killed by explosions in rivers (Richardson et al. 1995, p. 307).

There are several reports that pinnipeds near explosives (detonated in the water) were killed, including some pinnipeds exposed to charges in the kilogram or larger range (Richardson et al. 1995, pp. 306-307).

Sea Turtles: There are no systematic data available for effects of blasting on sea turtles. However, a comparison of the number of sea turtle strandings during periods of high and low numbers of offshore explosions suggests that underwater offshore explosions may result in direct or indirect sea turtle mortality (Klima et al. 1988). Gitschlag and Herczeg (1994) reported the results of observers who monitored sea turtles during explosive removals of oil and gas structures in the Gulf of Mexico. During 6,500 hours of monitoring at 106 structure removals (42 percent in water less than 15 m, 30 percent in water 15 to 30 m, 22 percent in water 30 to 60 m, and 7 percent in water greater than 60 m), no mortality (or injury) of sea turtles was documented.

Considering the mitigation measures outlined in Section 10.5.1.2, there is likely limited potential of direct mortality on marine mammals and sea turtles from blasting.

Vessel Traffic

The presence of vessels during various Project activities can increase the risk of direct mortality via vessel collisions with marine mammals and sea turtles.

Marine Mammals: Fin whales are the most commonly reported whale to be struck by vessels, followed by humpback whales and North Atlantic right whales (Jensen and Silber 2003; Vanderlaan and Taggart 2007). Blue whales, fin whales and humpback whales were all struck in similar proportions, but to a lesser degree than North Atlantic right whales (Vanderlaan and Taggart 2007). Minke whales, sei whales, and sperm whales were not as frequently struck, proportionally, but have been reported (Vanderlaan and Taggart 2007). Published accounts of ship strikes suggest that most whales are not seen beforehand or are seen at the last minute (Laist et al. 2001).

Evidence suggests that a greater rate of mortality and serious injury to large whales is correlated with a greater vessel speed at the time of a ship strike (Laist et al. 2001; Vanderlaan and Taggart 2007). Most lethal and severe injuries to large whales resulting from documented ship strikes have occurred when vessels were travelling at 14 knots or greater (Laist et al. 2001). Vanderlaan and Taggart (2007), using a logistic regression modelling approach based upon vessel strike records, found that for vessel speeds greater than 15 knots, the probability of a lethal injury (mortality or severely injured) approaches 1.0. The probability of lethal injury declined to approximately 0.2 at speeds of 8.6 knots (Vanderlaan and Taggart 2007).

In a review of 58 large whale ship strikes in which the vessel speed was known, the average speed of vessels involved in ship strikes that resulted in mortality or serious injuries to the whale was found to be 18.6 knots (Jensen and Silber 2003). The frequency of incidents of ship strikes more than doubled when vessel speeds were 13-15 knots as opposed to 10 knots or

less (Jensen and Silber 2003). Most lethal or severe injuries are caused by vessels >80 m in length (Laist et al. 2001).

Sea Turtles: Sea turtle injury or mortality may also occur due to collisions with vessels, particularly with vessels traveling at speeds >4 km/h (Hazel et al. 2007).

Large species of whales and sea turtles that spend extended periods near the surface would be particularly susceptible to ship strikes. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Particularly in the Nearshore Study Area, vessels associated with the Project will typically be engaged in activities that require a slow speed or maintenance of a stationary position, which will also reduce the risk of a collision. Vessels will deviate from their course to avoid marine mammals and sea turtles, if necessary.

Offshore

Vessel Traffic

As discussed for mortality associated with vessel traffic in the Nearshore Study Area, there is a risk of vessel collision with marine mammals and sea turtles resulting in serious injury or mortality. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Vessels will reduce speed whenever possible and deviate their course to avoid marine animals.

Seismic Surveys

As discussed in the Nearshore Study Area subsection, marine mammals close to underwater detonations of high explosives can be killed (Ketten et al. 1993; Ketten 1995). However, explosives are no longer used either for seismic research or for commercial seismic surveys in marine areas; they have been replaced by airguns and other non-explosive sources. Airgun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a seismic survey (Malakoff 2002; Cox et al. 2006), has raised the possibility that beaked whales exposed to strong “pulsed” sounds may be especially susceptible to injury and/or behavioural reactions that can lead to stranding (e.g., Hildebrand 2005; Southall et al. 2007). Hildebrand (2005) reviewed the association of cetacean strandings with high-intensity sound events and found that deep-diving odontocetes, primarily beaked whales, were by far the predominant (95 percent) cetaceans associated with these events, with 2 percent mysticete whales (minke). However, as summarized below, there is no definitive evidence that airguns can lead to strandings or mortality even for marine

mammals in close proximity to large airgun arrays. In addition, beaked whales are not expected in the relatively shallow waters of the Offshore Project Area where seismic surveys would be conducted.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. There were suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004); these were not well founded (IAGC 2004; IWC 2007). In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the Lamont-Doherty Earth Observatory of Columbia University seismic vessel R/V Maurice Ewing was operating a 20-airgun, 8,490-in^3 airgun array in the general area. The evidence linking the stranding to the seismic survey was inconclusive and not based on any physical evidence (Hogarth 2002; Yoder 2002). The ship was also operating its multibeam echosounder at the same time, but this had much less potential than the aforementioned naval sonars to affect beaked whales. Nonetheless, the Gulf of California incident plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar suggest a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand 2005).

Sea turtle mortality has not been documented to occur as a result of exposure to seismic surveys.

The Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) will be followed to minimize environmental effects on Marine Mammals and Sea Turtles.

The environmental effects of Project construction / installation activities on Marine Mammals and Sea Turtles are summarized in Table 10-10.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible at the population level, there are not likely to be significant residual adverse environmental effects on marine mammals and sea turtles from construction or installation activities associated with the Project.

10.5.2 Operations and Maintenance

10.5.2.1 Change in Habitat Quantity

None of the Project activities during the operations and maintenance phase are expected to affect the habitat quantity of marine mammals and sea turtles.

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Table 10-10 Environmental Effects Assessment: Construction and Installation

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Equipment design • Potential use of bubble curtains • Safety Zone • Monitoring	2	3	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence to Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters • Potential use of bubble curtains • Safety Zone • Monitoring	2	3	2/1	R[B]	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch plant)	• Change in Habitat Use	• Equipment design	1	1	3/3	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	3/6	R[B]	2
Lighting	• Change in Habitat Use (+)		1	1	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use (+)	• Equipment design • Bubble curtains • Safety Zone • Monitoring	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Quality • Change in Habitat Use	• Planning • Equipment design	2	3	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains • Safety Zone • Monitoring	2	3	2/1	R[B]	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	3	1/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use	• Avoid animal concentrations when possible • Maintain steady speed and course when possible	1	3	2/1	R	2
Platform Tow-out of from deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Offshore Construction / Installation							
OLS Installation and Testing	• Change in Habitat Quality • Change in Habitat Use	• Equipment design	1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Quality • Change in Habitat Use		1	3	2/6	R	2
Underbase Grouting	• Change in Habitat Use	• Equipment design	1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour on Seafloor around Final Platform Location	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Hook-up and Commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low altitudes when possible	1	2	3/6	R	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	3/6	R[B]	2
Air Emissions	• Change in Habitat Quality	• Equipment design	N	5	3/6	R	2
Lighting	• Change in Habitat Use (+)		1	1	3/6	R	2
Potential Expansion Opportunities							
Excavated Drill Centre(s) Dredging and Spoils Disposal	• Change in Habitat Quality • Change in Habitat Use	• Planning • Equipment design	1	3	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use	• Adherenece to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	2/1	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

10.5.2.2 Change in Habitat Quality

As discussed previously, interactions that may result in physical / physiological effects are considered as a change in habitat quality. Noise effects from Project operations and maintenance activities can potentially diminish habitat quality and influence habitat use by marine mammals and sea turtles. Section 10.5.1.2 contains an extensive discussion on the effects of noise on marine mammals and sea turtles, including effects of vessel traffic and seismic surveys that may be conducted during the construction and/or operations phase of the Project. Refer to Section 10.5.1.3 for a detailed analysis of noise effects on habitat quality due to other Project activities that may be common to both construction and operations/maintenance phases (e.g., vessel traffic, seismic surveys).

Other activities that may contribute to an effect on habitat quality during Project operations include discharges that may reduce water quality in the Offshore Study Area. Air emissions are expected to have a negligible effect on the habitat quality of marine mammals and sea turtles.

Sanitary and domestic waste water will be discharged during drilling and production operations. Organic matter from sanitary wastes will be quickly dispersed (after maceration) and degraded by bacteria, and food waste may be shipped ashore. The environmental effects on marine mammals and sea turtles swimming in the receiving waters containing small amounts of organic matter and nutrients will be minimal.

The discharge of any blowout preventer fluid from an offshore platform will not affect marine mammals because glycol-water mixes will be used and the BOP fluid will have a low toxicity.

Water-based cuttings and production fluids will be discharged overboard in accordance with the Offshore Waste Treatment Guidelines (National Energy Board (NEB) et al. 2010). Synthetic-based cuttings will be re-injected into the subsurface. Drilling activities are unlikely to produce concentrations of heavy metals in muds and cuttings that are harmful to marine mammals (Neff et al. 1980, in Hinwood et al. 1994). In addition, none of the marine mammals that regularly occur in the Offshore Study Area are known to feed on benthos in the area. The bearded seal, which is considered a benthic feeder, may occasionally occur in the Offshore Study Area, but typically occurs much farther north near ice. These activities are expected to have minimal environmental effect on marine mammals and sea turtles.

10.5.2.3 Change in Habitat Use

Many Project activities predicted to have an effect on habitat use during the operations / maintenance phase of the Project have been discussed above under construction (e.g., seismic surveys, vessel and helicopter traffic) (refer to Section 10.5.1.3). Effects on habitat use specific to the operations phase are discussed below.

Drilling

Drilling may occur from the Hebron Platform and from MODUs at future excavated drill centres. Of note, dynamically positioned drill ships are typically noisier than semi-submersibles which, in turn, are noisier than jack-ups (Richardson et al. 1995). However, no sound level measurements are currently available for a platform.

Kapel (1979) reported numerous baleen whales – mainly fin, minke, and humpback whales – within visual range of active drillships off West Greenland. In more formal studies, bowhead whales reacted to drillship sounds within 4 to 8 km of a drillship when received levels were 20 dB above ambient or approximately 118 dB re 1 μPa (Greene 1985, 1987; Richardson et al. 1985b, 1990). Reaction was greater at the onset of the sound (Richardson et al. 1995). Thus, bowhead whales migrating in the Beaufort Sea avoided an area with a 10 km radius around a drillship, which corresponded to received sound levels of 115 dB re 1 μPa (Richardson et al. 1990). Some whales were less responsive and habituation may occur, so that in time bowheads may be seen within 4 to 8 km of a drillship (Richardson et al. 1985a, 1990). Sound attenuates less rapidly in the shallow Beaufort Sea where these experiments were conducted than in temperate waters with greater depths.

Off California, the reaction zone around a semi-submersible drilling unit was much less than 1 km for grey whales (Malme et al. 1983, 1984). Humpback whales showed no clear avoidance response to received drillship broadband sounds of 116 dB re 1 μPa (Malme et al. 1985).

Recently, the proximal part of the migration corridor of bowhead whales in the Alaskan Beaufort Sea has been monitored during construction, drilling, and production activities at an artificial island (Northstar) just inshore of the migration corridor (Richardson and Williams 2004). The primary objective of the monitoring program was to determine if, at high-noise times, underwater sound propagating from Northstar and its support vessels deflected the southern part of the bowhead migration corridor. An acoustical localization method was used to determine the locations of calling bowhead whales (Greene et al. 2004). Overall, the results showed evidence consistent with slight offshore displacement of the proximal edge of the bowhead migration corridor at some times when levels of underwater sound were unusually high. These high-noise occasions were attributable to support vessels operating near the production facility rather than to the island-based operation itself.

Beluga whales were exposed to playback sounds from a semi-submersible drill rig in an Alaskan river (Stewart et al. 1982). During the two tests, belugas swimming toward the sound source did not react overtly until they were within 50 to 75 m and 300 to 500 m, respectively; some belugas altered course to swim around the source, some increased swimming speed, and one reversed direction of travel. Reactions to sound from the semi-submersible drill unit were less severe than were reactions to motorboats with outboards (Stewart et al. 1982). Dolphins and other toothed whales show considerable tolerance

of drill rigs and their support vessels, particularly when there are not negative consequences from close approach to the activities (Richardson et al. 1995).

Ringed seals were often seen near drill ships drilling in the Arctic in summer and fall (several reports summarized by Richardson et al. 1995). Ringed seals and bearded seals approached and dove within 50 m of a projector transmitting drilling sound into the water (received sound levels were 130 dB re 1 μPa). More recent studies of seals near active seismic vessels (Harris et al. 2001; Moulton and Lawson 2002) confirm that seals are tolerant of offshore industrial activities.

There are currently no available systematic data on sea turtle reactions to noise from drilling rigs.

Other Activities

Potential effects of the presence of structures on marine mammals and sea turtles are mainly related to the effects of sound produced by offshore structures and activities. Marine mammals would most likely avoid the immediate area around drilling activities due to physical activities and underwater sound generated. Artificial light might attract prey species of the marine mammal and sea turtle VEC and result in a positive environmental effect on its habitat use.

10.5.2.4 Potential Mortality

As discussed in Section 10.5.2.1, the key routine Project activity which is most likely to result in mortality is the operation of vessels. The presence of vessels during various Project activities can increase the risk of direct mortality via vessel collisions with marine mammals and sea turtles. Large whales, particularly baleen whales, are the most commonly reported animals to be involved in vessel collisions, typically resulting in injury leading to indirect mortality or direct mortality. Additionally, evidence suggests that a greater rate of mortality and serious injury to large whales is correlated with a greater vessel speed at the time of a ship strike. Sea turtle injury or mortality may also occur due to collisions with vessels, particularly those traveling at high speeds. Large species of whales and sea turtles that spend extended periods near the surface would be most susceptible to ship strikes.

Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Speed will be minimized whenever possible and vessels will deviate from their course to avoid animals in their path. Section 10.5.1.4 includes additional detail on effects and mitigation related to vessel traffic and direct mortality effects.

The environmental effects of Project operations and maintenance activities on Marine Mammals and Sea Turtles are summarized in Table 10-11.

Table 10-11 Environmental Effects Assessment: Operations and Maintenance

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Quality • Change in Habitat Use		1	1	5/6	R	2
Lighting	• Change in Habitat Use (+)		1	1	5/6	R	2
Maintenance Activities (e.g., diving, ROV)	• Change in Habitat Use		1	2	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality	• Re-use of drill mud	1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	5/6	R[B]	2
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adherenece to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	3/2	R	2
Potential Expansion Opportunities							
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quality • Change in Habitat Use		1	3	3/6	R	2
Presence of Structures	• Change in Habitat Quality • Change in Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Adherence to Offshore Waste Treatment Guidelines (NEB et al. 2010)	1	1	5/6	R	2
Chemical Use and Management (BPO fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use	• Adherenece to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	2	4	3/2	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

Given that Project activities are localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine mammals and sea turtles from operations and maintenance activities associated with the Project.

10.5.3 Decommissioning and Abandonment

10.5.3.1 Change in Habitat Quantity

The removal of the Hebron Platform and OLS loading points will result in a minimal habitat gain for marine mammals and sea turtles. However, considering the lack of specific habitat in the offshore for marine mammals and limited offshore habitat use by turtles, the effect is not considered to be significant.

10.5.3.2 Change in Habitat Quality

Environmental effects of removing structures (Hebron Platform and OLS loading points), vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat quality. The potential effects of these activities are expected to be similar (or less than) those of construction or operation (assessed in Sections 10.5.1.2 and 10.5.2.2); therefore, no significant adverse environmental effects are predicted.

10.5.3.3 Change in Habitat Use

Environmental effects of removing structures (Hebron Platform and OLS loading points), plugging and abandoning wells, light emissions, vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat use. The potential effects of these activities are expected to be similar (or less than) those of construction or operation (assessed in Sections 10.5.1.3 and 10.5.2.3); therefore, no significant adverse environmental effects are predicted.

10.5.3.4 Potential Mortality

Similarly to construction and installation, and operations/maintenance phases, the key Project activity which has the potential to have an effect on direct mortality of marine mammals and sea turtles is the operation of vessels (assessed in Sections 10.5.1.4 and 10.5.2.4). The potential effects of this activity is expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

The environmental effects of Project decommissioning and abandonment activities on Marine Mammals and Sea Turtles are summarized in Table 10-12.

Given that Project activities are mostly localized, of low magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine mammals and sea turtles from decommissioning and abandonment activities associated with the Project.

10.5.4 Accidents Malfunctions and Unplanned Events

The following sections assess the effect of an accidental release of hydrocarbons in the nearshore and offshore. Spills in the nearshore would be attributable to vessel malfunctions and similar effects and mitigation discussed for the offshore is applicable to the nearshore scenarios; therefore, nearshore and offshore effects are assessed together. The type and probability of spills (blowout (surface and subsea) and batch) are discussed in Section 14.1 and spill trajectories on water in the Nearshore Study Area and Offshore Study Area are described in Sections 14.2 and 14.3, respectively. A detailed analysis is included in ASA (2011a, 2011b).

Oil spill response is included as part of the contingency planning undertaken for the Project and additional information regarding spill response planning is found is Section 14.4. Chapter 16 describes the Hebron Project's overall environmental management process.

Table 10-12 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Use		1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	2	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course	1	3	3/6	R/I [B]	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adherenece to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	3/2	R	2

KEY

Magnitude:
1 = Low: <10 percent of the population or habitat in the Study Area will be affected.
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected.
3 = High: >25 percent of the population or habitat in the Study Area will be affected.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

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10.5.4.1 Change in Habitat Quality

There are several physical and internal functions that may be affected by oil fouling of marine mammals. Whales and seals rely on a layer of blubber for insulation, and so oil has little effect on thermoregulation. It can be assumed that if oil contacted the eyes, effects would be similar to that observed in ringed seals (conjunctivitis, corneal abrasion, and swollen nictitating membranes), and that continued exposure to eyes could cause permanent damage (St. Aubin 1990). Damage to the visual system would likely limit foraging abilities, as vision is an important sensory modality used to locate and capture prey, particularly for marine mammals.

Animals could ingest oil with water, contaminated food, or oil could be absorbed through the respiratory tract; absorbed oil could cause toxic effects (Geraci 1990). Species like the humpback whale, right whale, beluga (Delphinapterus leucas), and harbour porpoise that feed in restricted areas (for example, bays such as the Nearshore Study Area) may be at greater risk of ingesting oil (Würsig 1990). Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982). Only small traces of oil were found in the blubber of a grey whale and liver of a killer whale exposed to Exxon Valdez oil (Bence and Burns 1995).

Inhalation of vapours from volatile fractions of oil from a spill or blowout could potentially irritate respiratory membranes and hydrocarbons could be absorbed into the bloodstream (Geraci 1990). Grey seals that presumably inhaled volatile hydrocarbons from the Braer oil spill exhibited a discharge of nasal mucous, but no causal relationship with the oil was determined (Hall et al. 1996). Stressed individuals that could not escape a contaminated area would be most at risk. Absorbed oil can cause toxic effects such as minor kidney, liver, and brain lesions (Geraci and Smith 1976; Spraker et al. 1994), but contaminated animals could depurate this oil when returned to clean water (Engelhardt 1982). In baleen whales, crude oil could coat the baleen and reduce filtration efficiency, but these effects are considered to be reversible (Geraci 1990). Seals fouled externally with heavy oil may also encounter problems with locomotion, with flippers becoming stuck to their sides (Seargent 1991).

Gross histologic lesions developed in loggerhead sea turtles experimentally exposed to oil, but most effects were apparently reversed by the tenth day after exposure (Bossart et al. 1995). Oil may also reduce lung diffusion capacity, decrease oxygen consumption or digestion efficiency, or damage nasal and eyelid tissue (Lutz et al. 1989).

10.5.4.2 Change in Habitat Use

Several species of cetaceans and seals have been documented behaving normally in the presence of oil (St. Aubin 1990; Harvey and Dahlheim 1994;

Matkin et al. 1994). Studies of both captive and wild cetaceans indicate that they can detect oil spills. Captive bottlenose dolphins (Tursiops truncatus) avoided most oil conditions during daylight and darkness, but had difficulty detecting a thin sheen of oil (St. Aubin et al. 1985). Wild bottlenose dolphins exposed to the Mega Borg oil spill in 1990 appeared to detect, but did not consistently avoid contact with, most oil types (Smultea and Würsig 1995). This is consistent with other cetaceans behaving normally in the presence of oil (Harvey and Dahlheim 1994; Matkin et al. 1994). It is possible that cetaceans swim through oil because of an overriding behavioural motivation (for example, feeding). Some evidence exists that indicates dolphins attempt to minimize contact with surface oil by decreasing their respiration rate and increasing dive duration (Smultea and Würsig 1995).

There is conflicting evidence on whether seals detect and avoid spilled oil. Some oiled seals hauled out on land are reluctant to enter the water, even when disturbances from intense cleanup activities occur nearby (St. Aubin 1990; Lowry et al. 1994). In contrast, several thousand grey and harbour seals apparently left Chedabucto Bay, Nova Scotia, after the grounding of the Arrow (Mansfield 1970, in St. Aubin 1990), although this movement may have been caused by the increased human disturbance during cleanup activities rather than by the presence of oil (St. Aubin 1990). Harbour seals observed immediately after oiling appeared lethargic and disoriented, which may be attributed to lesions observed in the thalamus of the brain (Spraker et al. 1994). Other seals have been observed swimming in the midst of oil spills (St. Aubin 1990). Oiling of both mother and pups does not appear to interfere with nursing (Lowry et al. 1994).

It is unknown whether sea turtles can detect and avoid oil slicks. Gramentz (1988) reported that sea turtles did not avoid oil at sea, and sea turtles experimentally exposed to oil showed a limited ability to avoid oil (Vargo et al. 1986).

10.5.4.3 Potential Mortality

Most marine mammals, with the exception of fur seals, polar bears, and sea otters (none of these species are expected to occur in either Study Area), are considered to be not directly susceptible to deleterious effects of oil. There is no clear evidence implicating oil spills with the mortality of cetaceans (Geraci 1990), although there was a significant decrease and lack of recovery in the population size of a fish-eating killer whale pod that uses the area of the Exxon Valdez oil spill (Dahlheim and Matkin 1994). Continued monitoring over sixteen years indicates that the killer whale pod had still not returned to its pre-spill population abundance, and the population's rate of increase was significantly less than other fish-eating pods in the area (Matkin et al. 2008). Howell and Gentile (2006) recognize the continued impact to the single pod of orcas, but not for the Prince William Sound population as a whole. They believe that this continuing effect relates to the altered social structure (loss of key matriarchs) which was partly to result of the oil spill and partly a result from preceding mortality from human conflicts over fish. Another mammal-eating killer whale pod declined significantly following the spill and is now

listed as "Depleted" under the US Marine Mammal Protection Act, although there may have been other contributing factors in the decline (Matkin et al. 2008).

There may have been a long-term decline by 36 percent in the number of moulting harbour seals at oiled haul-out sites in Prince William Sound following the Exxon Valdez oil spill (Frost et al. 1994). Pup mortality at these beaches was 23 to 26 percent, which may have been higher than natural mortality. Further analyses do not support high mortality, but indicated that seals moved away from some oiled haul-out sites (Hoover-Miller et al. 2001). The release of fuel oil from the Arrow into Chedabucto Bay, Nova Scotia in 1970 resulted in the fouling of 500 seals within the bay and 50 to 60 harbour and 200 grey seals on Sable Island (200 km south of the spill). Twenty-four seals were found dead and some had oil in their mouths and stomachs (Anon. 1970, 1971, in St. Aubin 1990). Oiled grey and harbour seals were found on the coast of Nova Scotia and Sable Island again in 1979 when the oil tanker Kurdistan sank in Cabot Strait. No causal relationship between oiling and death was determined (Parsons et al. 1980, in St. Aubin 1990). No mortalities were reported after a well blowout near Sable Island in 1984 and only two oiled grey seals were observed (St. Aubin 1990).

Hall et al. (1983) observed seven live and three dead sea turtles following an oil well blowout in 1979; two of the carcasses had oil in the gut but no lesions, and there was no evidence of aspirated oil in the lungs. However, hydrocarbon residues were found in kidney, liver, and muscle tissue of all three dead turtles, and prolonged exposure to oil may have disrupted feeding behaviour and weakened the turtles.

Stressed individuals or those that could not escape a contaminated area would be most at risk to potentially deleterious effects. Animals exposed to heavy doses of oil for prolonged periods could experience mortality. In cases where oil goes ashore, harbour seals may be particularly at risk because they exhibit site fidelity (Boulva and McLaren 1979; Yochem et al. 1987). Sea turtles are not expected to go ashore, since nesting does not occur in northern latitudes. Prolonged exposure from oil at a preferred haul-out site could cause the death of some seals. However, Jenssen (1996) reported that oil has produced little visible disturbance to grey seal behaviour and there has been little mortality despite the fact that approximately 50 percent of grey seal pups at Norway's largest breeding colony are polluted each year by oil.

Spill modelling at the site of the Hebron Platform shows that the majority of spills are predicted to travel eastward (ASA 2011b). Modelling was conducted for well blow-outs of crude oil, with oil released at either the seafloor or from the top of the drilling platform and durations of 30 to 120 days. Short duration (less than 24 hours) small volume batch transfer spills of crude oil and diesel fuel were also modelled. Additional extended duration spill simulations were completed for platform blow-out scenarios to track oil remaining on the sea surface 200 days beyond termination of the blow-out. Blow-out simulations >30 days duration are predicted to have a 0 to 3 percent probability of reaching segments of the Newfoundland shoreline (primarily the southern Avalon Peninsula). However, this probability

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increases to a maximum of 8 percent based on modelling of oil remaining 200 days beyond termination of a blow-out. If oil reaches the shoreline during summer (1 percent probability), it is predicted that approximately 5 km of shoreline may be oiled (at >0.01 mm thickness). If oil reaches the shoreline during winter (1 to 8 percent probability), it is predicted that up to 785 km of shoreline may be oiled (at >0.01 mm thickness).

Spill modelling based on the accidental release of fuel at the Bull Arm site predicts that 10.1 to 144.3 km of shoreline may be exposed to hydrocarbons (at 0.01 mm thickness) in the Nearshore Study Area. These predictions were based on modelling results in the absence of any spill intervention (ASA 2011a,b). Oil removal from the exposed and rocky shoreline of the Avalon Peninsula and Trinity Bay will be faster than removal from protected areas with softer substrate because of increased water penetration and flushing, and wave erosion (ASA 2011b). In addition, weathering processes (photolysis and biodegradation) will have reduced the amount of oil potentially reaching shorelines (ASA 2011b). Relatively few seals (primarily harbour and grey seals) are expected to use the shorelines of the southern Avalon and Trinity Bay for haul out. Mitigation measures will likely reduce effects of potential hydrocarbon spills on marine mammals in the Offshore and Nearshore Study Areas.

Tracker buoy data collected during the 2004 Terra Nova spill indicated that it took five weeks for the buoy to reach 40.00.0W and approximately 48.00.00N in November / December (and basically confirmed the oil spill trajectory modelling results conducted to date for the Grand Banks oil developments). If an uncontrolled spill (i.e., no spill countermeasures implemented) lasted more than 120 days, the modelling predicts that oil from a surface or sub-surface blowout at the Hebron Platform will extend beyond the model domain area and, therefore, could potentially (less than 10 percent probability) reach an international coastline with a thickness greater than 0.01 mm. However, any oil that did reach an international shoreline would be patchy, weathered oil.

It is difficult to predict with precision the effects of accidental events on biota, especially as they relate to the geographic extent of the effects. Numerous parameters (e.g., chemical composition of the hydrocarbon, behaviour of spilled substance at different times of year) influence hydrocarbon spill characteristics and there are many unknowns concerning specific effects on different marine mammal and sea turtle groups. It may be possible under calm conditions to clean up a large proportion of spilled petroleum hydrocarbons; however, only a small percentage offshore can be retrieved under typical wind and wave conditions, especially in winter. Therefore, there will be an emphasis on accident prevention at all phases of the Project.

Marine mammals and sea turtles are not considered to be at high risk from the effects of oil exposure, but some evidence implicates oil spills with seal mortality, particularly young seals. For marine mammals and sea turtles, it is probable that only small proportions of populations are at risk at any one time in either the Nearshore or Offshore Study Areas. Oil spill prevention measures, along with typical oil spill countermeasures (creating an oil spill response plan,

training, preparation, an equipment inventory, and conducting emergency response drills) will serve to reduce the number of animals exposed to oil.

Depending on the time of year, location of animals within the affected area, and type of oil spill or blow-out, the effects of a nearshore or offshore oil release on the health of cetaceans is predicted to range from negligible to low magnitude over varying geographic extents. Based on present knowledge of the Trinity Bay and Grand Banks ecosystems, the modelling exercises, and on past monitoring experience with large spills with much worse scenarios than offshore on the Grand Banks (e.g., Exxon Valdez, Arrow and others), it can be predicted with confidence that an oil spill associated with the Project will not result in any significant residual environmental effects to marine mammals or sea turtles in the Study Areas.

The environmental effects of Project accidental events on Marine Mammals and Sea Turtles are summarized in Table 10-13.

Table 10-13 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Spill (at Bull Arm Site)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	4-5	2/1	R[B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R [B]	2
Subsea Blowout	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	3/1	R [B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R [B]	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	1	2/1	R [B]	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Mortaliy	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	5	2/1	R [B]	2
Collisions (involving Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	3	2/1	R [B]	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
[B] Potential Mortality effects reversible at the population level and irreversible at the individual level

10.5.5 Cumulative Environmental Effects

Marine exploration, commercial fishery activity, marine transportation, and existing production activity (e.g., White Rose, Hibernia, and Terra Nova) all have the potential to interact with marine mammals and sea turtles (see Table 10-9). Hunting of marine mammals and sea turtles does not occur inside the Nearshore or Offshore Study Areas, other than a small harp seal harvest. Most, if not all, commercial seal hunting occurs outside the Study Areas in southern Labrador and northeast Newfoundland. It is very unlikely that routine activities associated with other marine exploration, existing production areas, marine transportation, and commercial fisheries have much environmental effect on Marine Mammals and Sea Turtles.

10.5.5.1 Nearshore

Cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area as fewer

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activities have the potential to interact with the current Project (see Section 10.5.5.2 for cumulative environmental effects assessment of the Offshore Study Area).

10.5.5.2 Offshore

Commercial fishing activities may cause incidental mortalities or disturbance to marine mammals and sea turtles. It is predicted that the Project activities will not cause any mortality to marine mammals and sea turtles and thus, there will be no or negligible cumulative environmental effect from fishing.

Major shipping routes pass in proximity to the Offshore Study Area, and additional marine traffic (e.g., cruise ships) typically occur inshore of the Offshore Study Area. Supply vessels and tankers are also associated with other developments on the Grand Banks. As assessed above, the most likely effect of vessel traffic on marine mammals and sea turtles is disturbance. It is predicted that the Project activities are very unlikely to cause any mortality and, thus, the cumulative environmental effects of marine transportation are predicted to be not significant.

Underwater sound associated with Project activities will likely have the greatest effect on marine mammals and sea turtles, particularly cetaceans. Most species will be able to hear sounds, if they are close enough, and will be able to avoid them if they so choose. Mitigation measures associated with seismic surveys are designed to prevent harm to marine mammals or sea turtles. Individuals traveling near one or more of the offshore developments or in proximity to other offshore exploration activities may be subject to cumulative environmental effects. However, these effects would most likely be limited to behavioural effects (i.e., localized avoidance). Cumulative environmental effects of other developments and exploration activities on the Grand Banks are predicted to be not significant.

A major hydrocarbon spill or blowout on the Grand Banks could affect marine mammals and sea turtles to varying degrees depending upon type, size, location, timing, and species and life stages involved. A major spill is statistically very unlikely to coincide among multiple developments on the Grand Banks. Nonetheless, cumulative environmental effects could occur from chronic discharge of oil bilges at sea by ships transiting the area or from other activities that could affect marine mammals and sea turtles. Overall, the effects of accidental events on marine mammals and sea turtles were predicted to be not significant, and thus, the overall cumulative environmental effects on marine mammals and sea turtles are also likely to be not significant.

Given the predicted minimal environmental effects of other projects / activities, the large size of the Offshore Study Area and the prediction that the residual environmental effects of the proposed Project's routine activities on the Marine Mammal and Sea Turtle VEC through the difference Project phases are not significant (see Section 10.5.6), the cumulative environmental effects on the Marine Mammal and Sea Turtle VEC are also predicted to be not significant. This is consistent with the predicted significance of between-

project cumulative environmental effects on the Marine Mammal and Sea Turtle VECs in the recently completed Husky Delineation / Exploration Drilling Program for Jeanne d'Arc Basin Area 2008-2017 (LGL 2007b) and Petro-Canada Exploration Drilling Program for Jeanne d'Arc Basin 2009-2017 environmental assessments (Christian 2008).

10.5.6 Determination of Significance

The determination of significance is based on the definition provided in Section 10.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Marine Mammals and Sea Turtles, after taking into account any proposed mitigation, is summarized in Table 10-14.

The environmental effects of routine activities associated with the construction / installation, operations / maintenance and decommissioning / abandonment phases of the Project on the Marine Mammal and Sea Turtle VEC, are predicted to be not significant (Table 10-14).

The environmental effects of routine activities associated with Accidents, Malfunctions and Unplanned Events of the Project on the Marine Mammal and Sea Turtle VEC, are also predicted to be not significant (Table 10-14).

As required by CEAA, an analysis of potential effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on Marine Mammals and Sea Turtles are predicted that could affect renewable resource use.

Table 10-14 Residual Environmental Effects Summary: Marine Mammals and Sea Turtles

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Environmental Effects	NS	3	N/A

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

10.5.7 Follow-up and Monitoring

The CEAA definition of "follow-up program" is "a program for (a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project". Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. Compliance monitoring on its own, does not satisfy the requirements for a follow-up program. Compliance monitoring is conducted to ensure that a project and its activities are meeting the relevant environmental standards, guidelines and regulations. Compliance monitoring will be conducted for the Project in accordance with regulatory requirements.

Specific Environmental Effects Monitoring (EEM) programs to verify the accuracy of assessment predictions and the efficacy of mitigation measures are not planned for Marine Mammals and Sea Turtles.

For nearshore Project activities where in-water blasting occurs, EMCP will implement a Marine Mammal observation program. The program will be developed in consideration of DFO blasting guidelines, and in consultation with DFO. For seismic activities in the Offshore Study Area, EMCP will implement a Marine Mammal and Sea Turtle observation program. The program will be consistent with the requirements outlined in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011). Data on Marine Mammal and Sea Turtle observations will be provided to DFO and the C-NLOPB where applicable.

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11 SPECIES AT RISK

For the purposes of this assessment, Species at Risk (SAR) refers to those species of marine fish, mammals, birds and reptiles listed federally under the Species at Risk Act (SARA), and/or assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which could potentially occur in either the Hebron Nearshore or Offshore Study Areas and, therefore, could be affected by Project activities. The assessment of SAR also includes the associated habitats that these species rely upon, as protected under SARA. Many of the issues of concern, and potential interactions with the Project, as well as mitigation measures and management strategies for SAR are similar to those presented for non-listed marine species in the Study Areas in other chapters of this report (i.e., Chapter 7, 9 and 10). On an ecosystem basis, the listed and non-listed species and their habitats are often highly integrated. This section assesses the potential effects of Project activities on SAR.

11.1 Environmental Assessment Boundaries

11.1.1 Spatial

The Nearshore and Offshore Study areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Section 4.3.2). The Study Areas and Project Areas are illustrated in Figures 11-1 and 11-2 for the nearshore and offshore, respectively. The Affected Areas for several Project activities have been determined by modelling (see AMEC 2010; ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

11.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are summarized in Table 11-1.

Table 11-1 Temporal Boundaries of Nearshore and Hebron Offshore Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

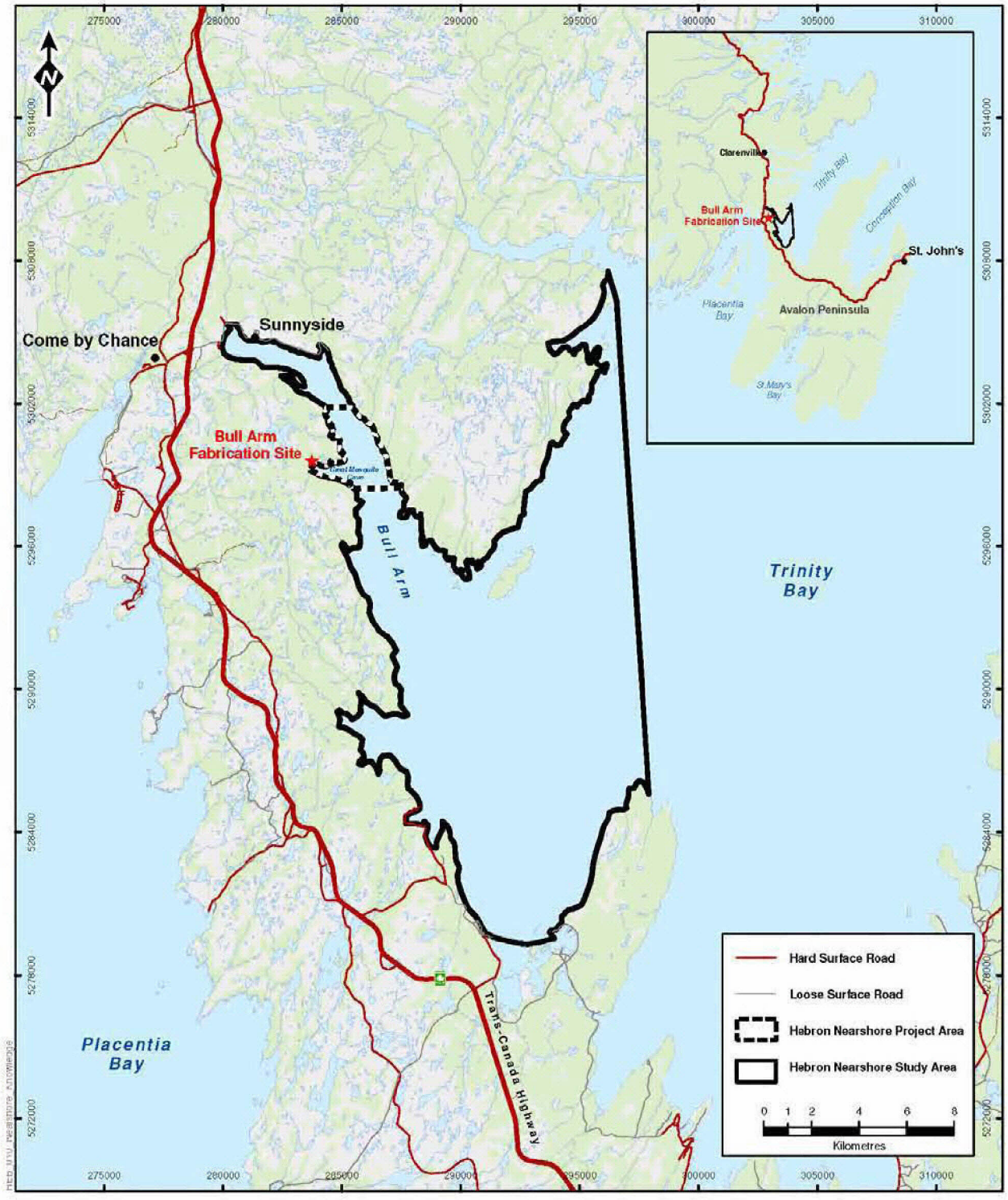

Figure 11-1 Hebron Nearshore Study and Project Areas

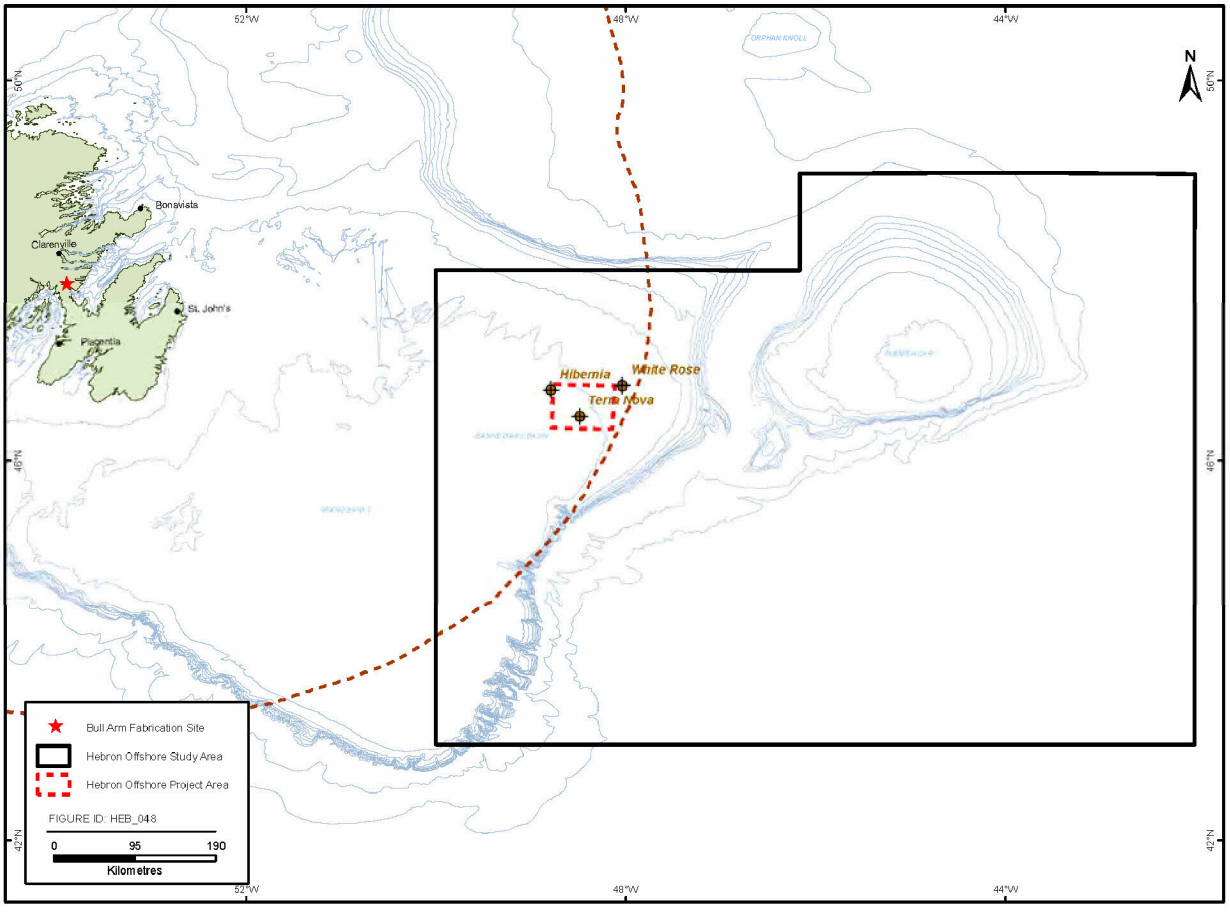

Figure 11-2 Hebron Offshore Study and Project Areas

11.1.3 Administrative

SAR are protected federally under the SARA, which is administered by Environment Canada, Parks Canada and Fisheries and Oceans Canada (DFO). The objective of SARA is to prevent Canadian indigenous species, subspecies and distinct populations of wildlife from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, and to manage species of special concern to prevent them from becoming endangered or threatened.

The official federal list of wildlife and plant SAR in Canada is Schedule 1 of SARA. Only species on Schedule 1 of SARA are subject to the permit and enforcement provisions of the Act. The List includes species of Special Concern, Extirpated, Endangered and Threatened Species. Schedules 2 and 3 of SARA contain species which had been assessed by COSEWIC prior to their adoption of new criteria in 1999. When SARA was proclaimed in 2003, the species in Schedule 2 and 3 were to be re-assessed by COSEWIC using the new criteria.

Section 32 of SARA prohibits the killing, harming, harassing, capturing or taking of an individual of a wildlife species that is listed as extirpated, endangered, or threatened. Section 33 prohibits the damage or destruction of the residence of an endangered, threatened or extirpated species.

Section 58 prohibits the destruction of critical habitat of any listed endangered or threatened species, or of any extirpated species for which a recovery strategy has been recommended. SARA defines critical habitat as the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified in the species' critical habitat in the recovery strategy or in an action plan for the species.

The main provisions of SARA are scientific assessment and listing of species, species recovery, protection of critical habitat, compensation, permits and enforcement. The Act also provides for development of official recovery plans for species found to be most at-risk, and management plans for species of Special Concern. As of March 2010, recovery strategies and/or management plans are in place for the blue whale (Balaenoptera musculus), North Atlantic right whale (Eubalaena glacialis), Atlantic wolffish (Anarhichas lupus), northern wolffish (Anarhichas denticulatus), spotted wolffish (Anarhichas minor) and leatherback turtle (Dermochelys coriacea).

Marine mammals and fish, including those species assessed at-risk, are protected in Canada through federal legislation under the Fisheries Act. Section 35 of the Fisheries Act prohibits the harmful alteration, disruption or destruction of fish habitat, while Section 36 prohibits the deposition of substances considered deleterious to fish. Marine mammals are included in the definition of fish under the Act. Environment Canada administers Section 36 of the Fisheries Act while DFO administers Section 35 of the Act. The Marine Mammal Regulations under the Fisheries Act stipulate that "No person shall disturb a marine mammal except when fishing for marine mammals under the authority of these regulations".

11.2 Definition of Significance

The criteria to evaluate the significance threshold for adverse environmental effects to SAR are defined as follows:

A significant, adverse residual environmental effect is one that, after application of feasible mitigation and consideration of reasonable Project alternatives:

- Will jeopardize the achievement of self-sustaining population objectives or recovery goals
- Is not consistent with applicable allowable harm assessments
- Will result in permanent loss of SAR critical habitat as defined in a recovery plan or an action strategy
- An incidental harm permit would not likely be issued

Due to the sensitive nature of SAR, residual adverse environmental effects on one individual may be considered significant.

A not-significant, adverse residual environmental effect is one that, after application of feasible mitigation and consideration of reasonable Project alternatives:

- Results in effects to individuals, residences or SAR critical habitat of listed species that does not jeopardize the survival or recovery of the species
- Is consistent with applicable allowable harm assessments
- Does not result in permanent loss of SAR critical habitat
- An incidental harm permit would likely be issued

11.3 Existing Conditions

A description of the physical environment within the Hebron Nearshore and Offshore Study Areas is provided in Chapter 3. Species profiles for non-listed Marine Fish and Fish Habitat, Marine Birds, and Marine Mammals and Sea Turtles are described in Sections 7.3, 9.3 and 10.3, respectively. While there is some overlap with these other report sections, the descriptions presented in this section focus exclusively on SAR.

The SAR that are most likely to be present and their expected use of the Hebron Study Areas are summarized in Table 11-2 and discussed in the subsections that follow.

Table 11-2 Species at Risk and Expected Use of Hebron Study Areas

SPECIES		SARA Status	COSEWIC Status	Expected Use of Hebron Study Areas	
Common Name	Scientific Name			Nearshore	Offshore
Fish					
Atlantic Cod (NL Population)	Gadus morhua	No Status	Endangered	Occurs	Occurs
American Plaice (NL Population)	Hippoglossoides platessoides	No Status	Threatened	Occurs	Occurs
American Eel	Anguilla rostrata	No Status	Special Concern	Occurs	Not likely to occur
Atlantic Wolffish	Anarhichas lupus	Schedule 1 – Special Concern	Special Concern	May occur	Occurs
Northern Wolffish	Anarhichas denticulatus	Schedule 1 - Threatened	Threatened	May occur	Occurs
Spotted Wolffish	Anarhichas minor	Schedule 1 - Threatened	Threatened	May occur	Occurs
Cusk	Brosme brosme	No Status	Threatened	Not likely to occur	Not likely to occur
Roughead Grenadier	Macrourus berglax	No Status	Special Concern	Not likely to occur	May occur
Roundnose Grenadier	Coryphaenoides rupestris	No Status	Endangered	Not likely to occur	May occur
Porbeagle Shark	Lamna nasus	No Status	Endangered	Not likely to occur	May occur
Blue Shark	Prionace glauca	No Status	Special Concern	Not likely to occur	Not likely to occur
Shortfin Mako	Isurus oxyrinchus	No Status	Threatened	Not likely to occur	Not likely to occur

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SPECIES		SARA Status	COSEWIC Status	Expected Use of Hebron Study Areas	
Common Name	Scientific Name			Nearshore	Offshore
White Shark	Carcharodon carcharias	No Status	Endangered	Not likely to occur	Not likely to occur
Basking Shark	Cetorhinus maximus	No Status	Special Concern	Not likely to occur	Not likely to occur
Deepwater Redfish (northern population)	Sebastes mentella	No Status	Threatened		May occur
Acadian Redfish (Atlantic population)	Sebastes fasciatus	No Status	Threatened		May occur
Mammals					
Blue Whale	Balaenoptera musculus	Schedule 1 - Endangered	Endangered	May occur in small numbers	Likely to occur in small numbers.
North Atlantic Right Whale	Eubalaena glacialis	Schedule 1 - Endangered	Endangered	Not likely to occur	Unknown
Fin Whale	Balaenoptera physalus	Schedule 1 – Special Concern	Special Concern	Occurs	Occurs
Sowerby's Beaked Whale	Mesoplodon bidens	Schedule 1 – Special Concern	Special Concern	Not likely to occur	Likely to occur in small numbers
Killer Whale	Orcinus orca	No Status	Special Concern	May occur in small numbers	Likely to occur in small numbers
Harbour Porpoise	Phocoena phocoena	Schedule 2 - Threatened	Special Concern	Likely to occur in small numbers	Likely to occur in small numbers
Birds					
Red Knot (rufa)	Calidris canutus	No Status	Endangered	Occurs	Does not occur offshore.
Ivory Gull	Pagophila eburnea	Schedule 1 - Endangered	Endangered	May occur	May occur
Reptiles					
Leatherback Sea Turtle	Dermochelys coriacea	Schedule 1 - Endangered	Endangered	May occur	Likely to occur in small numbers
Loggerhead Sea Turtle	Caretta caretta	No Status	Endangered	Not likely to occur	May occur
Note: Species listed on Schedule 1 of SARA are officially listed as SAR, while the species listed on Schedules 2 and 3 are species subject to reassessment by COSEWIC. The tables and document are dated as designations may change at any time					

11.3.1 Marine Fish Species at Risk

Site-specific fish and fish habitat data were collected from the Hebron Offshore Study Area during surveys in 2001 (Chevron 2002; 2003). These data are complemented by environmental effects monitoring (EEM) survey data collected by operators of adjacent offshore oil and gas projects since 1994, and by several descriptions of existing conditions for marine fish and fish habitat for other environmental assessments overlapping with the Hebron Offshore Study Area. DFO Research Vessel data from 3Lt have also been reviewed along with relevant fish and fish habitat primary literature for the Hebron Offshore Study Area.

Within the Nearshore Study Area, several fish and fish habitat baseline and EEM surveys from 1991 were conducted as part of the Hibernia Gravity Base Structure (GBS) construction project. Since then, an ocean disposal monitoring survey was conducted in Great Mosquito Cove (Lee 2005) and an extensive fish and fish habitat survey of Great Mosquito Cove was conducted for the Hebron Project in August 2009. Several researchers from Memorial University and DFO have conducted studies on fish and fish habitat within the Nearshore Study Area and those primary scientific papers were also used to compile existing information.

11.3.1.1 Atlantic Cod (Newfoundland and Labrador Population)

COSEWIC assessed the Newfoundland and Labrador and Laurentian North populations of Atlantic as endangered in 2003 and 2010, respectively. Neither population is currently listed under SARA. No SARA recovery or management plans are in place. The Newfoundland and Labrador Population occurs within the Hebron Nearshore and Offshore Study Areas. Cod in this population inhabit the waters ranging from immediately north of Cape Chidley (northern tip of Labrador) southeast to Grand Banks off eastern Newfoundland. For management purposes, cod in this population are treated as three separate stocks by DFO: Northern Labrador cod; "Northern" cod (i.e., those found off southeastern Labrador, the Northeast Newfoundland Shelf and the northern half of Grand Banks (NAFO Divisions 2J3KL); and Southern Grand Banks cod.

Cod within Trinity Bay are primarily a localized stock or “bay population”, but there is mixing with the offshore areas outside Trinity Bay and Bonavista Bay (DFO 2008b). Pinsent and Methven (1997) suggested that juvenile cod collected inshore in southern Trinity Bay originate from a combination of both inshore and offshore spawning events.

Atlantic cod eggs and larvae are planktonic during the spring and early summer. Larvae and pelagic juveniles are primarily zooplankton feeders but benthic and epibenthic invertebrates become the primary diet upon settlement.

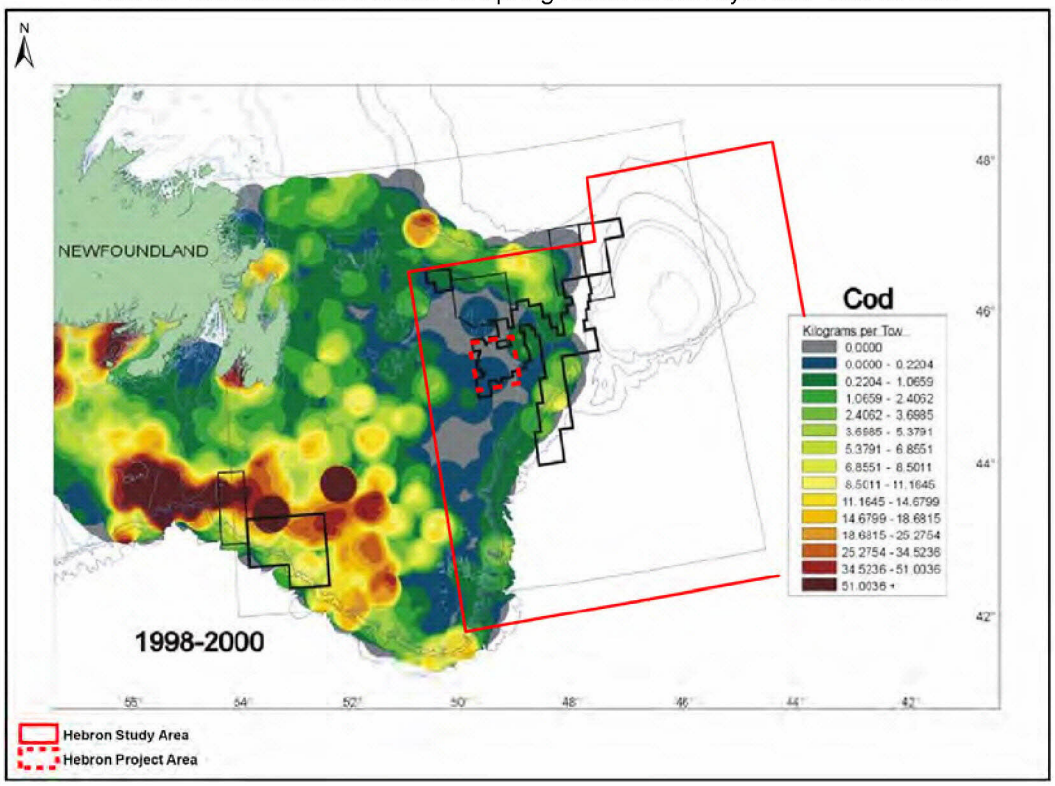
Pelagic juveniles can occupy rock reef, cobble, eelgrass (Zostera marina) beds and sand bottom (Tupper and Boutilier 1995a). Tupper and Boutilier (1995b) assumed that settling also occurred on macroalgae habitat, as noted by Keats et al. (1985) off eastern Newfoundland. Shallow water depths (<5 m) and a strong attraction to features on most substrata, except sand, afford settled juveniles an environment conducive to growth and survival (Tupper and Boutilier 1995a; Grant and Brown 1998). Juvenile cod primarily eat pelagic crustaceans, especially zooplankton, but also eat benthic species (e.g., gammarids and harpacticoids) (Grant and Brown 1998). Capelin is a major prey item for inshore adult cod (Lilly 1987), depending on the season (O’Driscoll and Rose 2000).

Historically, much of the northern cod stock (NAFO Divisions 2J3KL) migrated between overwintering areas in deep water near the shelf break and feeding areas in the shallower waters both on the plateau of Grand Banks and along the coasts of Labrador and eastern Newfoundland. Some cod remained in the inshore deep water during the winter. These cod spawned on the northeast Newfoundland shelf in late winter and spring, and then migrated shoreward across the shelf to the inshore feeding grounds, annually traversing distances of 500 km and more. Distribution maps (Figure 11-3) based on spring and fall DFO research vessel surveys between 1998 and 2000 indicate that catches of Atlantic cod within the Hebron Offshore Project Area were low (Kulka et al. 2003).

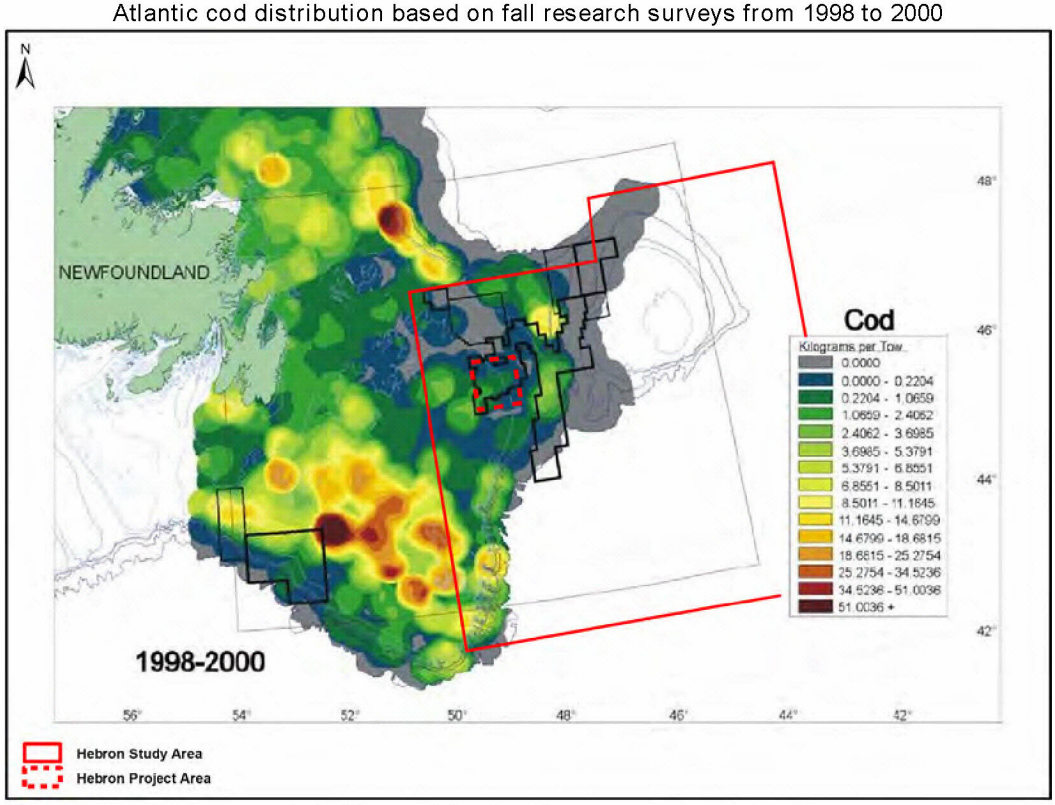
Based on annual autumn DFO research vessel trawl surveys, offshore abundance and biomass indices have been increasing since 2003 and spawning stock biomass has been increasing since 2005. The average abundance, biomass and spawning stock biomass of cod in the offshore over the last three years are 8 percent of the average during the 1980s. Winter acoustic surveys in 2007 and 2008 found a dense aggregation of cod in a traditional over-wintering area along the shelf edge in southern 3K. The aggregation in 2008 was much larger than was observed in 2007, and included approximately 20 percent mature fish.

There are three identified Sensitive or Special Areas (described and assessed in Chapter 12) within the Hebron Offshore Study Area that are related to Atlantic cod. The Southeast Shoal and Tail of the Banks Ecologically and Biologically Significant Areas (EBSA), proposed by DFO, is known as a spawning and nursery area for 3NO cod. The Southeast Shoal Vulnerable Marine Ecosystem (VME), proposed by NAFO, is located in the same area. The Virgin Rocks EBSA, proposed by DFO, supports spawning and breeding of Atlantic cod.

Atlantic cod distribution based on spring research surveys from 1998 to 2000



Atlantic cod distribution based on fall research surveys from 1998 to 2000



Grey shading represent areas sampled with no catch rate values.

Source: Kulka et al. 2003.

Figure 11-3 Atlantic Cod Spring and Fall Distribution

11.3.1.2 American Plaice

American plaice (Newfoundland population) was assessed as Threatened by COSEWIC in April 2009, but is not listed under SARA. Therefore, no SARA recovery strategies or management plans are currently in place. American plaice is widely distributed on both sides of the North Atlantic, from the Barents Sea to the British Isles in the east, and from northern Baffin Island to Rhode Island in the west. This population occurs from Hudson Strait to the southern limit of the Grand Banks, and westward north of the Laurentian Channel to the southwestern corner of Newfoundland (COSEWIC 2009). On the Grand Banks, they are found on both the northern and southern portions at low densities. The area of highest biomass of American plaice is at the southern part of the Grand Banks straddling NAFO Unit Areas 3NO (Morgan et al. 2003b). Distribution maps based on spring and fall research vessel surveys between 1992 and 2000 indicate that American plaice occur within the Offshore Project Area during both the spring and the fall (Kulka et al. 2003).

American plaice was likely the most abundant flatfish in the Northwest Atlantic, and the Newfoundland fishery was once the largest flatfish fisheries in the world (COSEWIC 2009). Over a 47-year period, abundance has declined approximately 96 percent. Overfishing is a major cause of decline, but an apparent increase in natural mortality in the 1990s, when the largest part of the decline occurred, may have contributed (COSEWIC 2009) to its decline. The decline now appears to have ceased, but numbers remain below the precautionary threshold estimated for this stock. Other possible contributing factors to the decline of the stock include: poorly regulated by-catches; selective gear size; cropping large individuals and reducing population reproductive potential. In addition, natural mortality has increased, which reduces the ability of the population to withstand fishing mortality. There have been signs of an increase on the Tail of the Bank since the mid-1990s (Kulka et al. 2003). However, overall, current population estimates are between 3 and 5 percent of the early 1980s level (Dwyer et al. 2003).

The species appears to be relatively sedentary, with a home range of less than 50 km (Pitt 1969; Morgan and Brodie 1991). However, evidence exists of a seasonal migration off the Grand Banks in the winter to warmer waters along the shelf edge (Morgan and Brodie 1991). American plaice in both the Hebron Nearshore and Offshore Study Areas are of the 3LNO stock, which has its northern boundary just north of the Grand Banks (Bowering and Brodie 1991). The 2J3K stock is mostly concentrated on the northeastern slopes of the Grand Banks, at depths between 92 and 183 m (Walsh 1982). American plaice occur in both the Hebron Nearshore and Offshore Study Areas. They can be found within the Hebron Offshore Project Area at low densities during spring and fall (Figure 11-4).

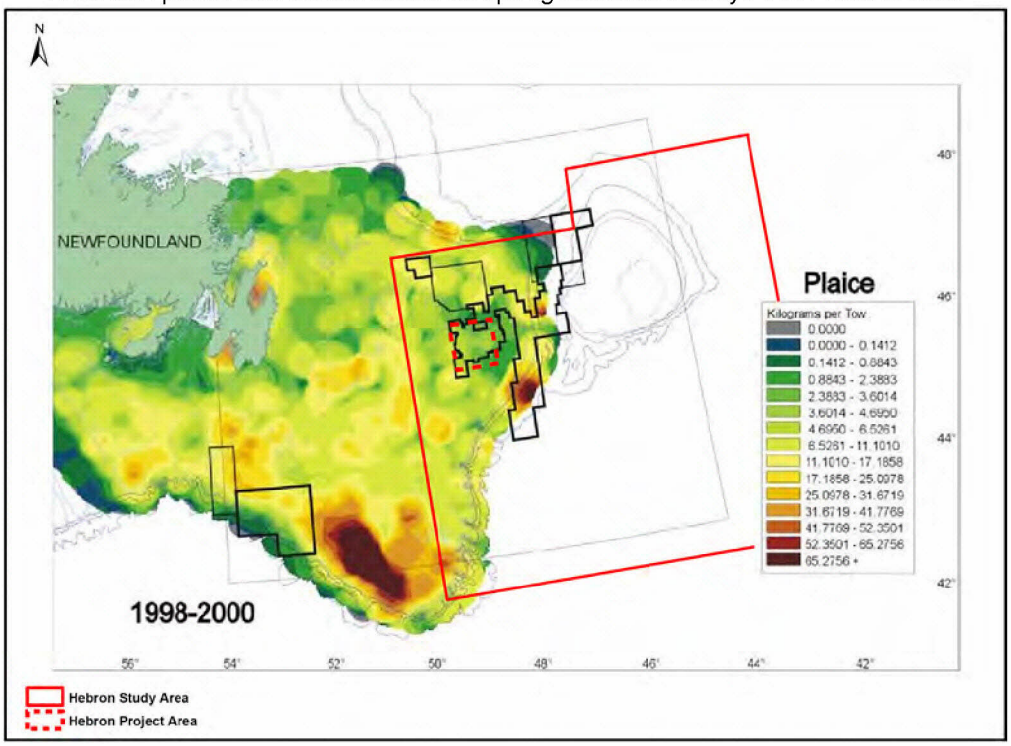
Females in spawning condition may be found throughout the Grand Banks (Morgan 2001), indicating the lack of a specific spawning ground. American plaice spawning is most intensive on the northern Grand Banks and occurs primarily from April to June at depths of 50 to 200 m (Morgan 2001). In recent years, spawning has occurred within the Hebron Offshore Study Area in June (Figure 11-5), but historically, within the area, spawning occurs in May (Ollerhead et al. 2004).

American plaice eggs float near the surface and hatch within 11 to 14 days at temperatures of 3.9°C. Larvae are concentrated near the thermocline at approximately 20 m (Frank et al. 1992) until they reach a length of approximately 25 mm, the average length for settlement (Scott and Scott 1988). Larvae, therefore, may settle to substrate far removed from where the eggs were fertilized. However, plaice larvae are retained on the eastern edge of the Grand Banks by the Labrador Current. Juveniles are typically found over homogenous silt or mud substrates (Walsh 1991). Adult plaice seem to prefer sand substrates over a mix of sand and gravel or gravel alone (Morgan 2000).

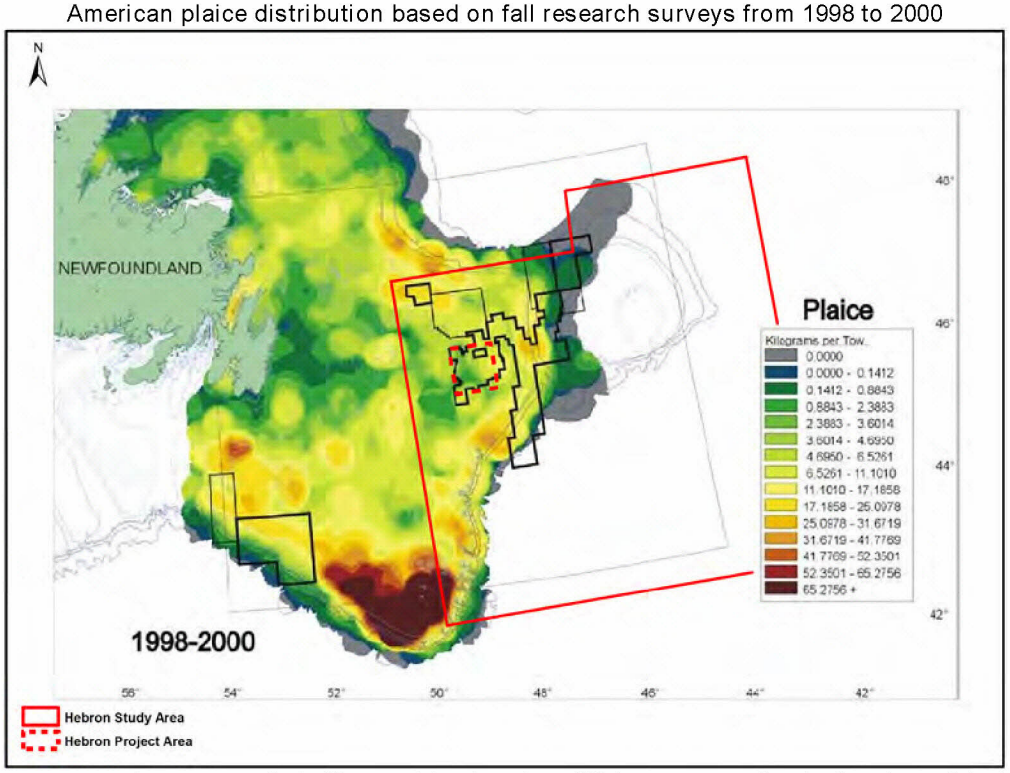
Juvenile American plaice prey upon echinoderms, especially brittle stars, but also sand dollars and sea urchins. As adults, their diets shifts more to sand lance and capelin, and the echinoderms become secondary (Methven 1999). Plaice appear to feed heavily in April, after a winter of fasting. Feeding rates are high during the summer and decrease in fall or early winter (Morgan and Brodie 1991).

As with Atlantic cod, there are three identified Sensitive or Special Areas (described and assessed in Chapter 12) within the Hebron Offshore Study Area that are related to American plaice. The Southeast Shoal and Tail of the Banks EBSA, proposed by DFO, contains important habitat for American plaice. The Southeast Shoal VME, proposed by NAFO, is located in the same area. The Virgin Rocks EBSA, proposed by DFO, supports spawning and breeding of plaice.

American plaice distribution based on spring research surveys from 1998 to 2000



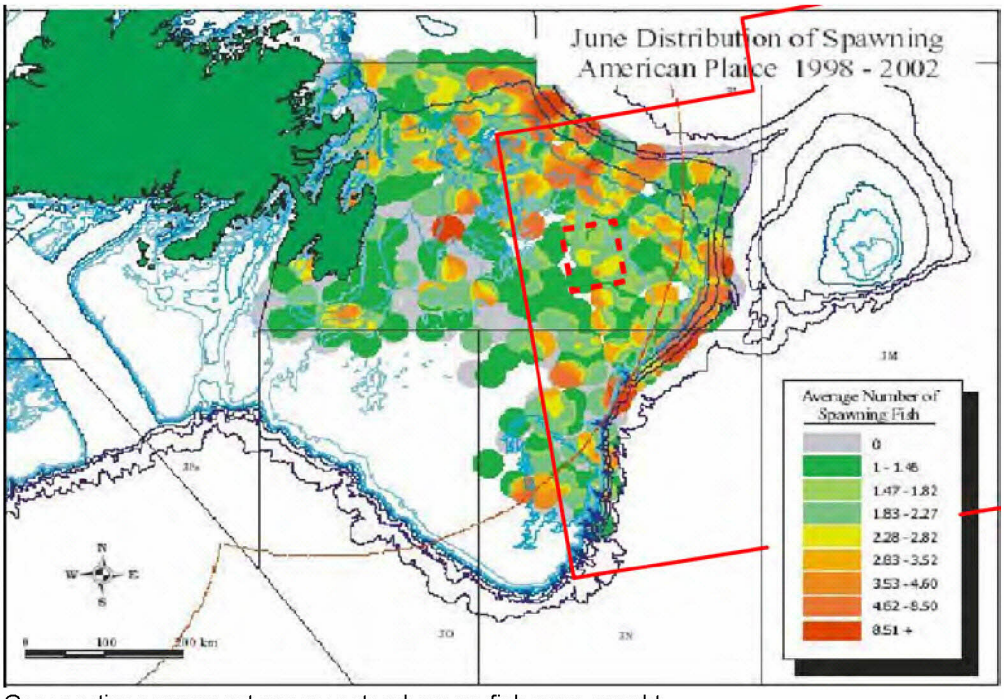
American plaice distribution based on fall research surveys from 1998 to 2000



Grey sections represent areas sampled with no catch rate values (Plaice on map refers to American plaice)

Source: Kulka et al. 2003

Figure 11-4 American Plaice Distribution



Grey sections represent survey sets where no fish were caught

Source: Ollerhead et al. 2004

Figure 11-5 June Distribution of Spawning American Plaice, 1998 to 2002

11.3.1.3 American Eel

The American eel was assessed by COSEWIC as a species of Special Concern, but is not listed under SARA. Therefore, no SARA recovery strategies or management plans are currently in place. Eels likely occur within the Hebron Nearshore Study Area as they enter or leave the Deer Harbour River or Bellevue River. Eels migrate from the rivers during August and September, and return in May. They are not likely to occur in the Hebron Offshore Study Area.

Eels from over the world spawn in the Sargasso Sea. Hatched larvae drift towards the Continental Shelf, where they metamorphose into small, transparent glass eels. As glass eels move into inshore waters, they develop pigmentation and become elvers. Elver arrival generally occurs in May and early June on the Atlantic coast. Some elvers remain in shallow protected salt water, some move into estuaries and some move into fresh water. Elvers become yellow eels, which have a dark back and a yellowish belly. Sexual differentiation occurs during the yellow phase.

The historic Canadian range includes accessible fresh water, estuaries and coastal marine waters connected to the Atlantic Ocean, up to the mid-Labrador coast. Continental shelves are used by juvenile eels arriving from the spawning grounds, and by silver eels returning to the spawning grounds. They are primarily benthic inhabitants, using substrate and bottom debris as protection and cover. Eels are not likely to occur in the offshore Study Area.

Long-term indices are not available for Newfoundland, but electrofishing survey results for the Northeast Brook on Trepassey Bay suggest a decline from the early 1980s to the mid-1990s (COSEWIC 2006b). A similar downward trend is found in densities in the Highlands River on Newfoundland's west coast. In Newfoundland and Labrador yellow and silver eels are fished principally in rivers, but there are many rivers which are not exploited. Although seven exploratory elver licenses were issued in 2004 in Newfoundland, fishing and effort data are not available. Possible causes of the observed decline, including habitat alteration, dams, fishery harvest, oscillations in ocean conditions, acid rain and contaminants, may continue to impede recovery (COSEWIC 2006b).

11.3.1.4 Wolffish

Wolffish, also known as catfish, are solitary bottom-dwelling fish. Wolffish are distributed at northern latitudes in moderately deep water in the Atlantic, Pacific and Arctic Oceans. Wolffish have a large distribution in the Northwest Atlantic, inhabiting most of the Labrador and Newfoundland shelves from the Davis Strait south to the Gulf of Maine (Kulka and DeBlois 1996). The Atlantic wolffish, the northern wolffish and the spotted wolffish occur within the Hebron Nearshore and/or Offshore Study Areas.

While the decline in abundance and biomass estimates for the three wolffish species has occurred throughout Newfoundland waters, it seems that the decline has been greater in the more northern areas (Divisions 2J, 3K and northern 3L) than in the southern areas (southern 3L, 3N, 3O) (Simpson and Kulka 2002).

Although not common, wolffish were identified in the Nearshore Study Area during a remotely operated vehicle (ROV) survey of fish habitat in Bull Arm, completed in August 2009.

Although no wolffish catches were reported in the Newfoundland-landed catches in 3Lh, 3Li, 3Lr and 3Lt during 2005 to 2008, two of the three wolffish species are known to occur within the Hebron Offshore Project Area. Further information on the distribution of wolffish is found in the following sections.

Since 1998, 87 15-minute trawl tows have been conducted as part of the Hibernia EEM Program, which is within the Hebron Study Area. Wolffish have only been collected in two of those tows, one Atlantic and one spotted wolffish. No wolffish were collected during the 2008 Terra Nova EEM program during sampling for American plaice.

A recovery strategy has been developed for northern wolffish, spotted wolffish and Atlantic wolffish (Kulka et al. 2007). A primary recommendation of the recovery strategy is the need for additional research and understanding of the biology and life history of these species. At the present time, critical wolffish habitat has not been specifically defined.

Atlantic Wolffish

Atlantic wolffish (striped wolffish) are listed as special concern on Schedule 1 of SARA. On the western side of the North Atlantic, they occur off the coast of west Greenland and southern Labrador, in the Strait of Belle Isle and the Gulf of St. Lawrence. It is also found off the east and west coasts of Newfoundland and on the Grand Banks. The Atlantic wolffish is a large bottom-dwelling predatory marine fish. Adults can weigh almost 20 kg and reach a length of 150 cm. Atlantic wolffish are found over hard clay bottoms at depths up to 918 m around Newfoundland and Labrador (Kulka et al. 2007), and in shallow nearshore waters during the summer. Mature Atlantic wolffish migrate to shallow, inshore waters in the spring and spawn in September (Simpson and Kulka 2002). Spawning typically occurs in boulder habitats; eggs are laid in a mass that adheres to the seafloor and the eggs are guarded by the male (Barsukov 1959; Keats et al. 1985; Kulka et al. 2007). Eggs hatch by mid-December. While the larvae are pelagic, they seldom swim near surface waters. The entire larval stage is spent close to where the eggs were deposited (see Simpson and Kulka 2002).

In the Northwest Atlantic, Atlantic wolffish feed primarily on benthic invertebrates such as echinoderms, molluscs and crustaceans, as well as small amounts of fish. No predators of adult Atlantic wolffish have been identified, but juveniles have been found in the stomachs of Atlantic cod (Scott and Scott 1988).

Available data indicate that the number of Atlantic wolffish in Canadian waters has declined by 87 percent from the late-1970s to the mid-1990s. The number of locations where the species occurs has declined and the range where the species is abundant may be shrinking. Even though the population has measurably declined, it is thought to be very widespread and to still exist in relatively large numbers (SARA website 2010). There are no data available on the direct causes of the declines of Atlantic wolffish in the Atlantic. The Atlantic wolffish was commercially fished at one time as a target species, but now only as bycatch. The impact of incidental capture of wolffish in many fisheries is thought to be the leading cause of human induced mortality (Kulka et al. 2007).

Atlantic wolffish migrate inshore during the spring and spawn in the autumn, with eggs hatching before mid-December. During an ROV survey of fish habitat in Mosquito Cove in August 2009, two Atlantic wolffish were identified. Their location is provided in Figure 11-6. The wolffish were observed at a depth of approximately 35 m, in 80 to 90 percent boulder habitat, which has been identified as potential spawning habitat (Barsukov 1959; Keats et al. 1985; Kulka et al. 2007). Of the 660,200 m^2 surveyed during the August 2009 habitat survey, approximately 800 m^2 (0.12 percent) was recorded as having 80 to 90 percent boulder coverage.

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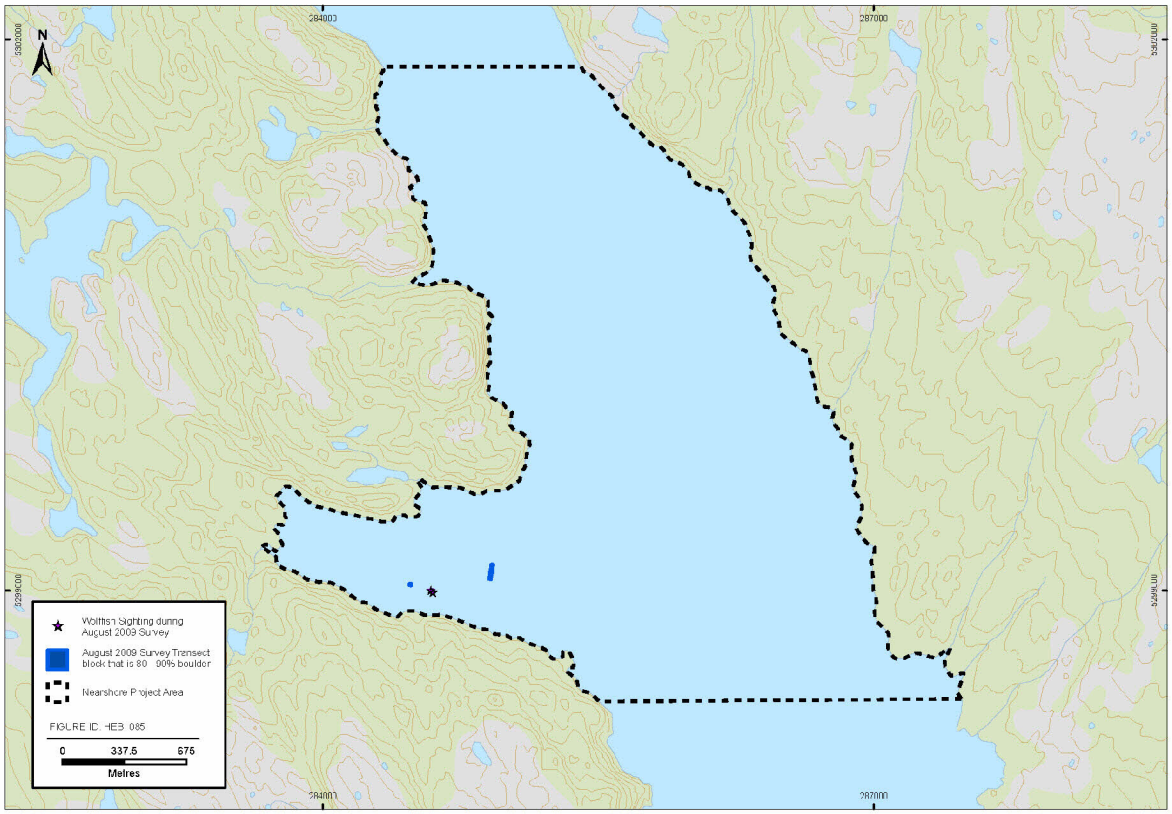


Figure 11-6 Location of Observed Wolffish during August 2009 Habitat Survey

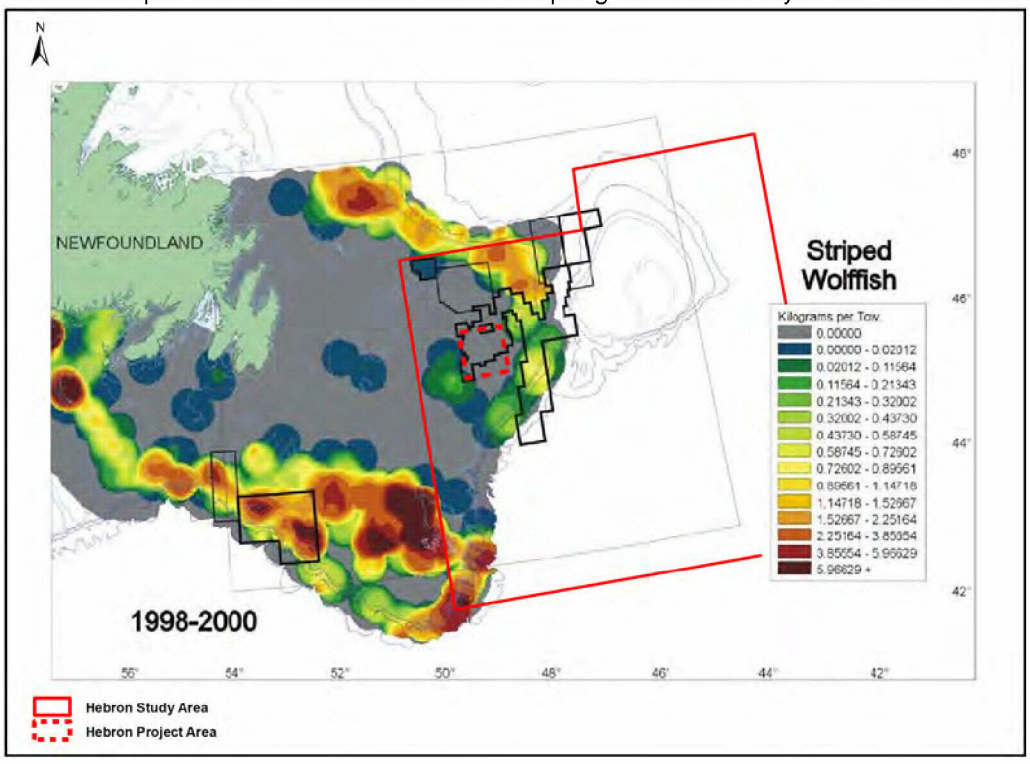
Distribution maps (Figure 11-7) based on spring and fall DFO research vessel surveys between 1998 and 2000 indicate that catches of Atlantic Wolffish within the Hebron Offshore Project Area were low. Higher concentrations occur in other areas of the Hebron Offshore Study Area, particularly the areas to the south and north of the Hebron Offshore Project Area.

There are two identified Sensitive or Special Areas (described and assessed in Chapter 12) within the Hebron Offshore Study Area that are related to the Atlantic wolffish. The Southeast Shoal and Tail of the Banks EBSA, proposed by DFO, is known to support the densest concentration of Atlantic wolffish. The Southeast Shoal VME, proposed by NAFO, is located in the same area.

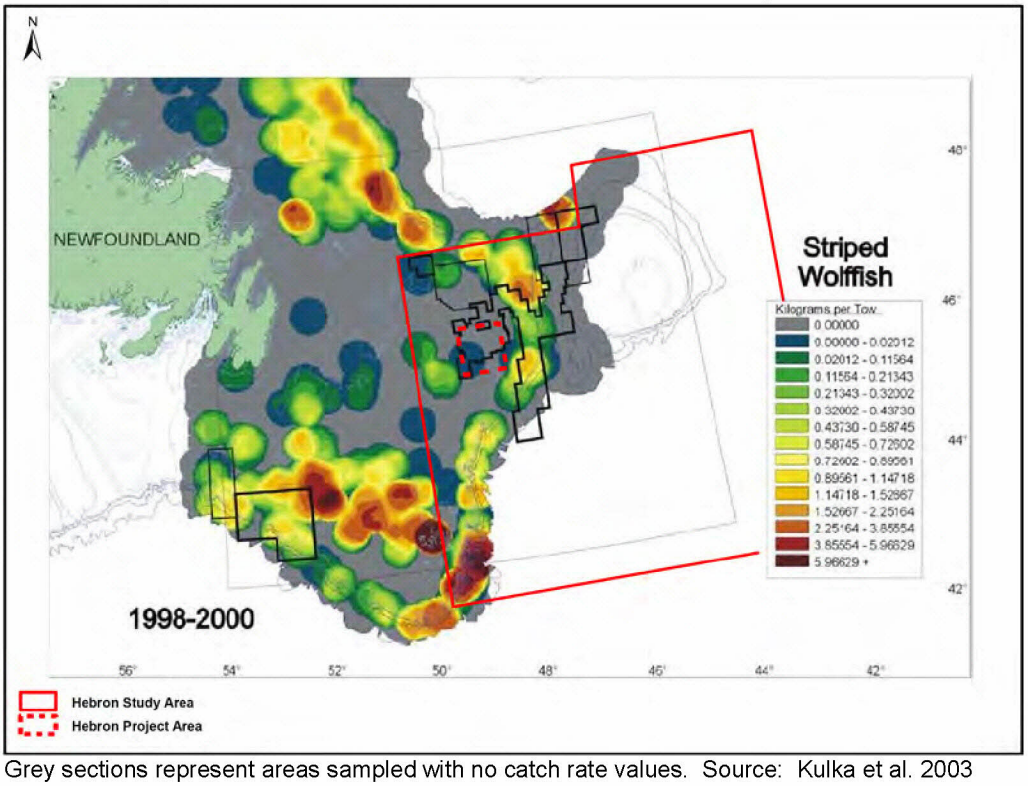
Northern Wolffish

Northern wolffish in the Northwest Atlantic is treated as a single population and is listed as Threatened on Schedule 1 of SARA due to the rapid decline along the Northeast Newfoundland / Labrador Shelf and the Grand Banks. This species prefers depths from 500 to 1000 m, though it has been recorded at depths less than 200 m and more than 1,500 m (Kulka et al. 2007; Scott and Scott 1988). Given this range, it is possible that this species of wolffish could be present in the Hebron Nearshore Study Area where the Bull Arm area reaches a depth of approximately 200 m. It is known to occur in the Hebron Offshore Study Area, with a lower occurrence in the Hebron Offshore Project Area (Figure 11-8).

Atlantic/striped wolffish distribution based on spring research surveys from 1998 to 2000

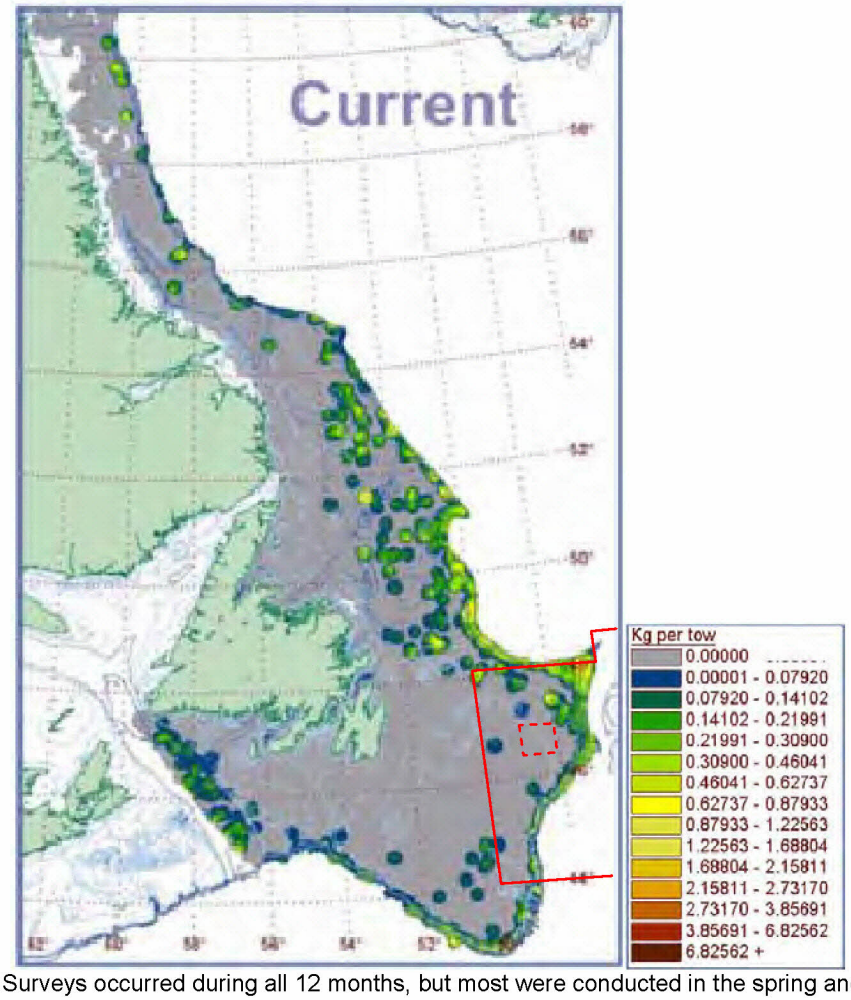


Atlantic/striped wolffish distribution based on fall research surveys from 1998 to 2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003

Figure 11-7 Atlantic Wolffish Distribution, 1998 to 2000



Surveys occurred during all 12 months, but most were conducted in the spring and fall

Source: Kulka et al. 2004c

Figure 11-8 Northern Wolffish Distribution, 1995 to 2003

Northern wolffish are pelagic fish, spending a great deal of time swimming and feeding in open waters. In summer, mature females lay up to 30,000 extremely large eggs in a nest on the sea floor. Adult northern wolffish are somewhat sedentary and are non-migratory. The northern wolffish favours open Continental Shelf water that is cold (usually between 2°C to 5°C). This species is thought to prefer a rocky or muddy sea floor, but is found over various types of ocean bottoms. There is little known about the reproductive biology of this species, but spawning is believed to occur late in the year (DFO 2004b). Fertilized eggs are deposited on the bottom, but larvae are pelagic (Simpson and Kulka 2002).

Although the northern wolffish is not targeted by the fishing industry, it is taken as bycatch by offshore trawlers. Groundfish trawls also accidentally kill or maim individuals. Bottom trawling for fish, and dredging for scallops and clams, can damage spawning habitat by disturbing rocks and boulders, which are used for shelter and spawning nests.

Spotted Wolffish

Spotted wolffish, which are treated as a single population in the Northwest Atlantic, are listed as Threatened on Schedule 1 of SARA, due to the rapid decline along the northeast Newfoundland/Labrador Shelf and the Grand Banks. In the western North Atlantic, they occur primarily off northeast Newfoundland. Since 1978, scientific surveys in the western Atlantic show a 96 percent decline in the Canadian population of spotted wolffish over three generations of wolffish. Spotted wolffish are a predatory bottom-dweller, inhabiting waters of 56 to 1046 m, but usually found at depths of 200 to 750 m (Kulka et al. 2007). As with the northern wolffish, this species could potentially occur in the Hebron Nearshore Study Area, but it is more likely to be present in the Hebron Offshore Study Area.

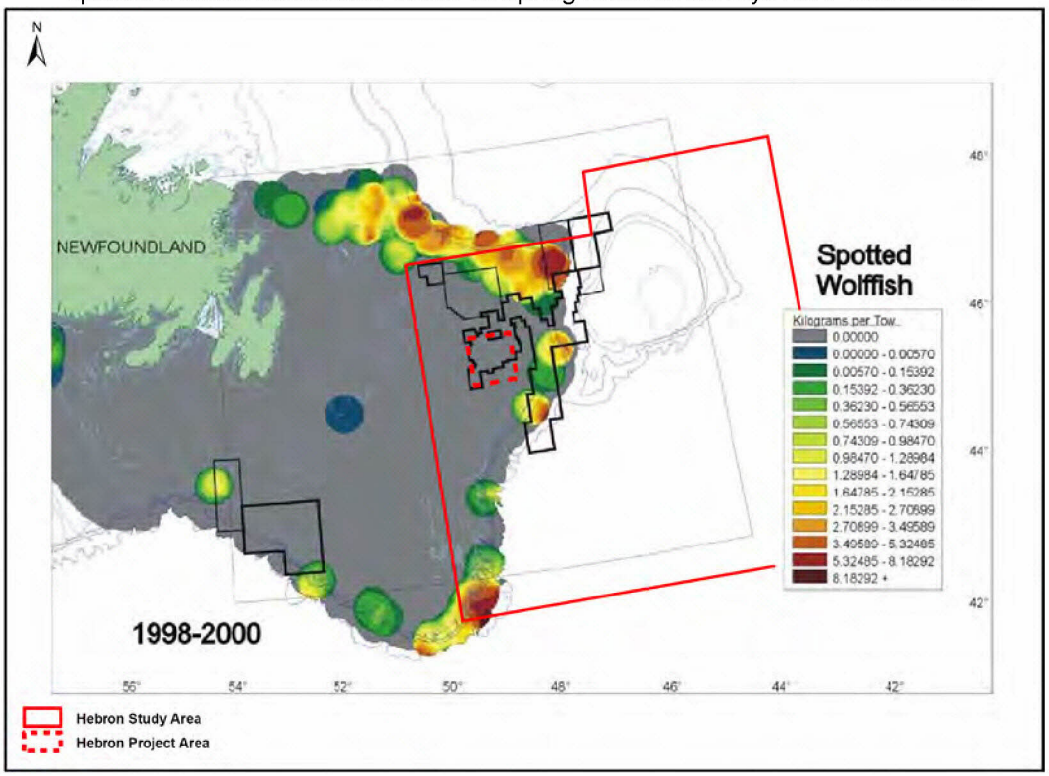
Spotted wolffish spawning is thought to occur late in the year (DFO 2004b). Spotted wolffish are found over various ocean-bottom types. The spotted wolffish favours cold, open continental shelf water, with water temperatures between 2°C to 5°C. Distribution maps (Figure 11-9) based on spring and fall DFO research vessel surveys between 1998 and 2000 indicate that catches of Spotted wolffish within the Hebron Offshore Project Area were low.

The Northeast Shelf and Slope EBSA, proposed by DFO and described and assessed in Chapter 12 as one of the identified Sensitive or Special Places within the Hebron Offshore Study Area, is known to support aggregations of Spotted wolffish in the spring.

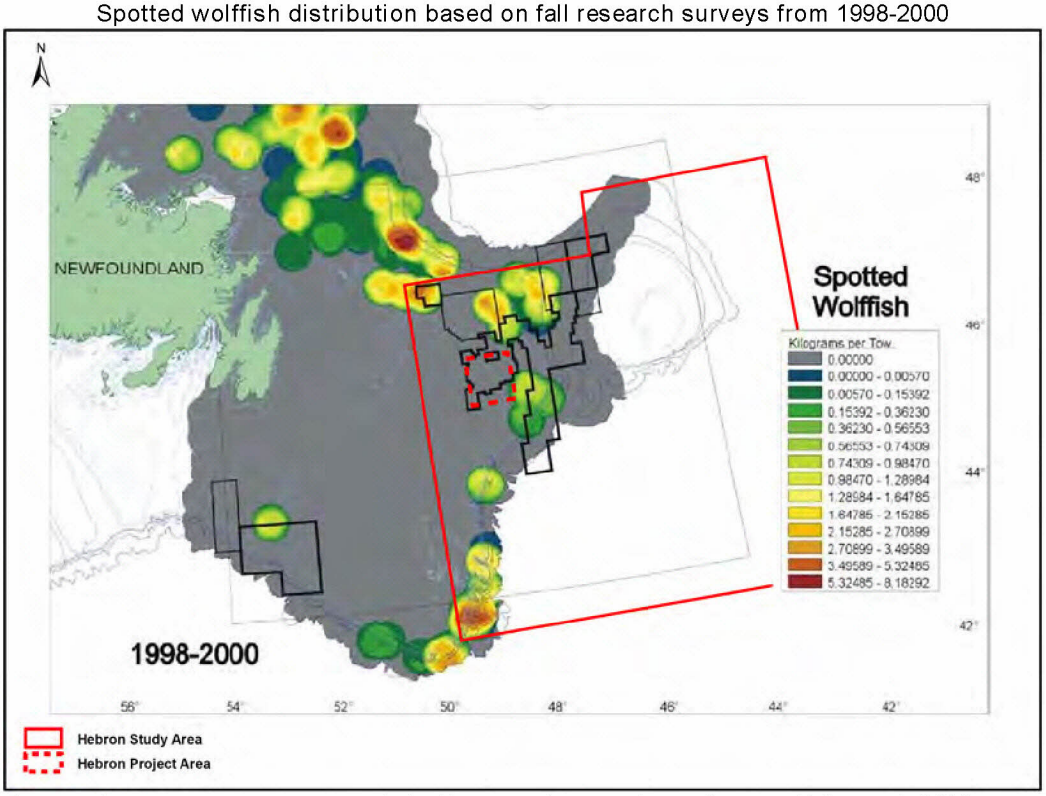
11.3.1.5 Cusk

Cusk are considered Threatened by COSEWIC, but currently have no status under SARA. Cusk are at the extreme northern fringe of their range on the southern Grand Banks and would only be itinerant in the Hebron Offshore Project Area. Cusk were rare or absent in each year of DFO surveys from 1980 to 2000 within the Hebron Offshore Study Area. When present, they were located sporadically on the Flemish Cap, and around the Nose and Southwest Slope of the Grand Banks (Kulka et al. 2003). They are not likely to occur in the Hebron Nearshore Study Area.

Spotted wolffish distribution based on spring research surveys from 1998 to 2000



Spotted wolffish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003.

Figure 11-9 Spotted Wolffish Distribution, 1998 to 2000

11.3.1.6 Grenadier

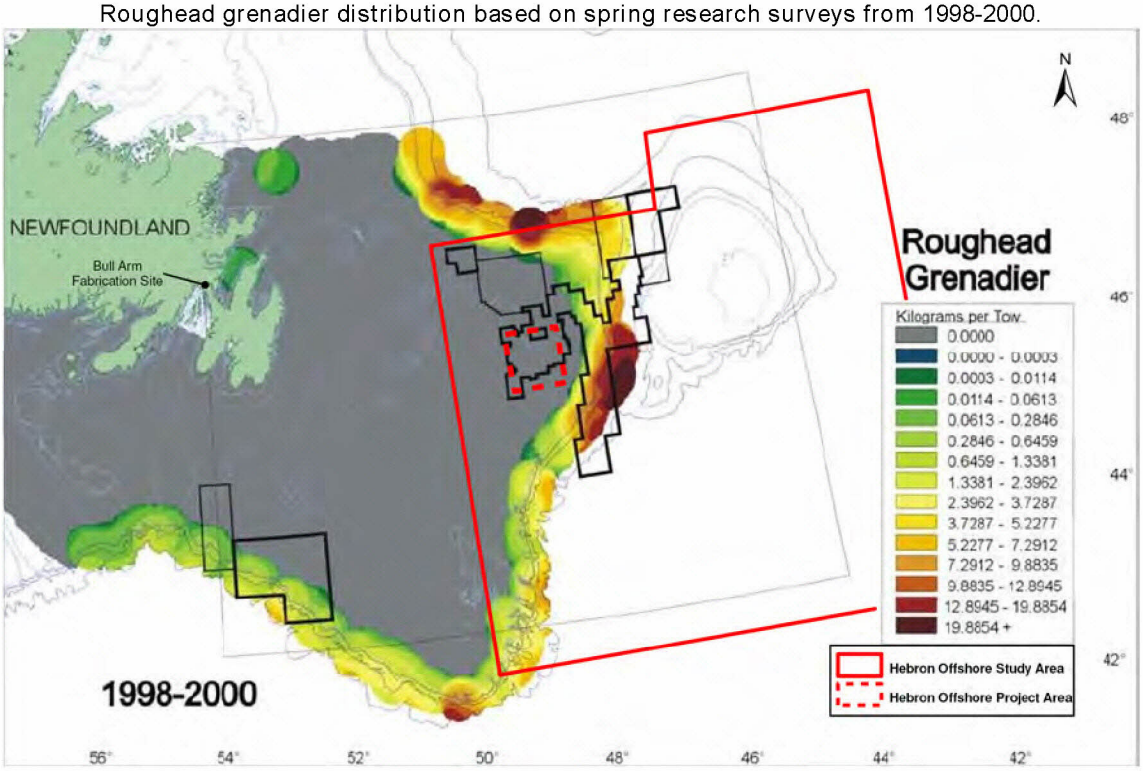
Roughead grenadier were assessed by COSEWIC as a species of Special Concern, but currently have no status under SARA. Roughead are primarily a deepwater species located on the slope of the northeast Newfoundland Shelf, the Flemish Pass and along the edge of the Grand Banks (Kulka et al. 2003). Roughead grenadier have been reported within and near the Hebron Offshore Study Area during DFO spring and fall surveys for several years (Kulka et al. 2003). Concentrations of roughead have been higher in the Hebron Offshore Study Area during fall surveys (Figure 11-10). Spawning occurs during winter and early spring and is believed to occur on the southern and southeastern slope of the Grand Banks (Scott and Scott 1988). Larger grenadier eat molluscs, shrimp and a variety of fish. Smaller individuals prefer bivalves, shrimp, starfish and polychaetes (Scott and Scott 1988).

Roundnose grenadier are listed as Endangered by COSEWIC, but currently have no status under SARA. Roundnose grenadier have increased in abundance in recent years along the edge of the Grand Banks (Figure 11-11), primarily along the southeast slope (Kulka et al. 2003). Roundnose are nocturnal pelagic feeders. Their diet varies by location, but is composed primarily of lanternfish on the northeastern slope of the Grand Banks (Scott and Scott 1988). Feeding is apparently seasonal and peaks during fall and winter, diminishing during the summer (Scott and Scott 1988). Predators of the roundnose grenadier include Greenland halibut, whales and redfish (Scott and Scott 1988). Little is known about the spawning time.

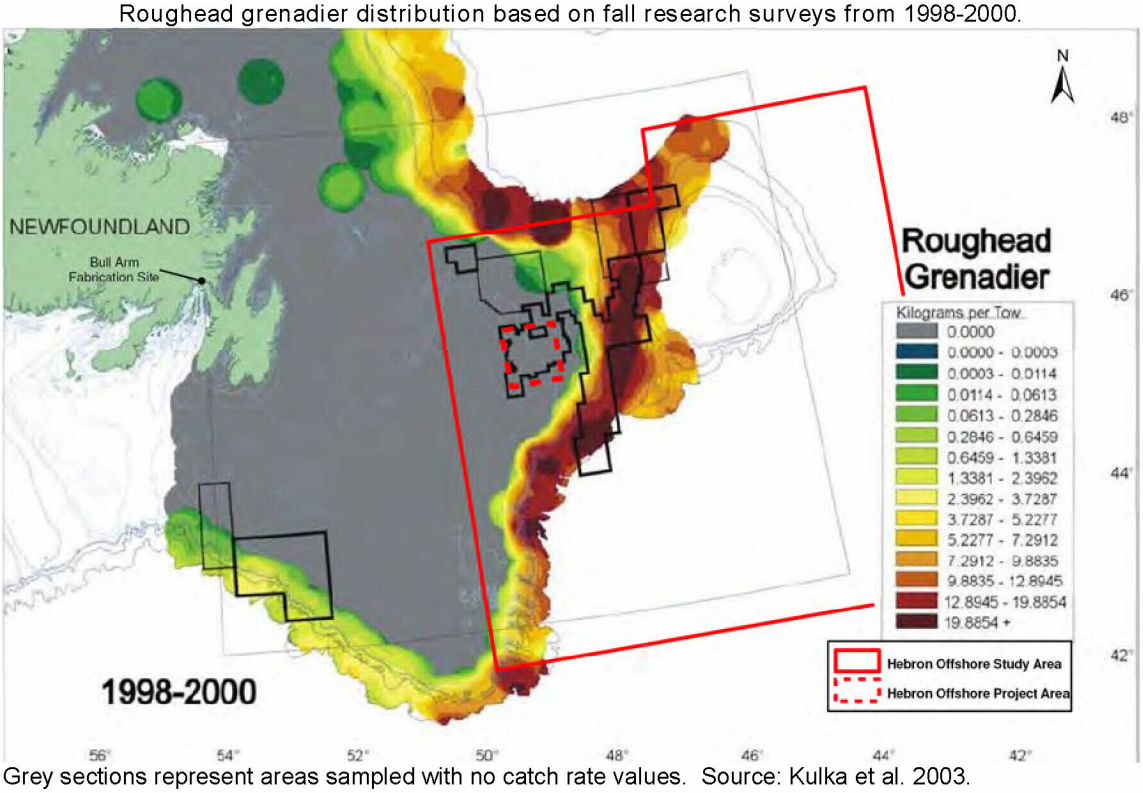
11.3.1.7 Porbeagle Shark

Porbeagle shark is considered Endangered by COSEWIC and is currently not listed by SARA. Therefore, there are no SARA recovery or management strategies in place. Porbeagle shark is a large cold-water pelagic shark distributed in the western Atlantic from Greenland to Bermuda (COSEWIC 2004). In the waters off Newfoundland, it is widely distributed, and can be specifically found on the St. Pierre Bank and in the Laurentian Channel in the spring and summer months (Scott and Scott 1988). The porbeagle shark is believed to constitute a single population in the Northwest Atlantic. The porbeagle shark is unlikely to occur in the Hebron Nearshore Study Area and may occur in the Hebron Offshore Study Area.

Roughead grenadier distribution based on spring research surveys from 1998-2000.



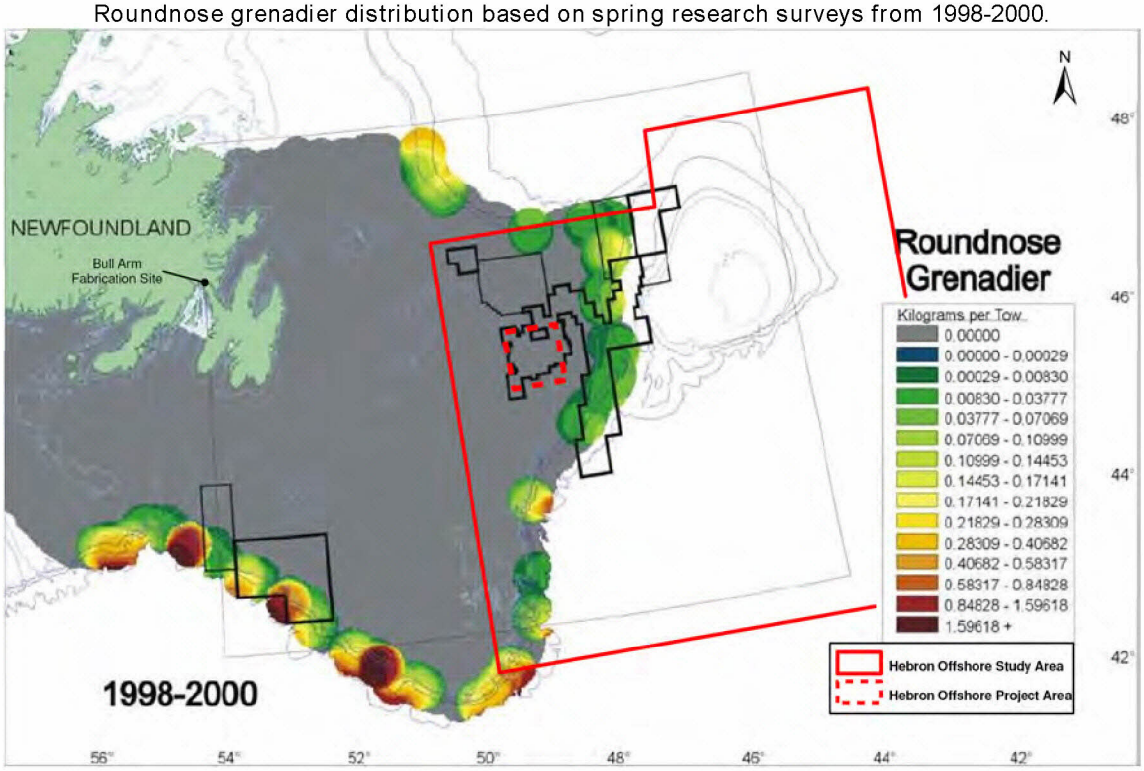
Roughead grenadier distribution based on fall research surveys from 1998-2000.



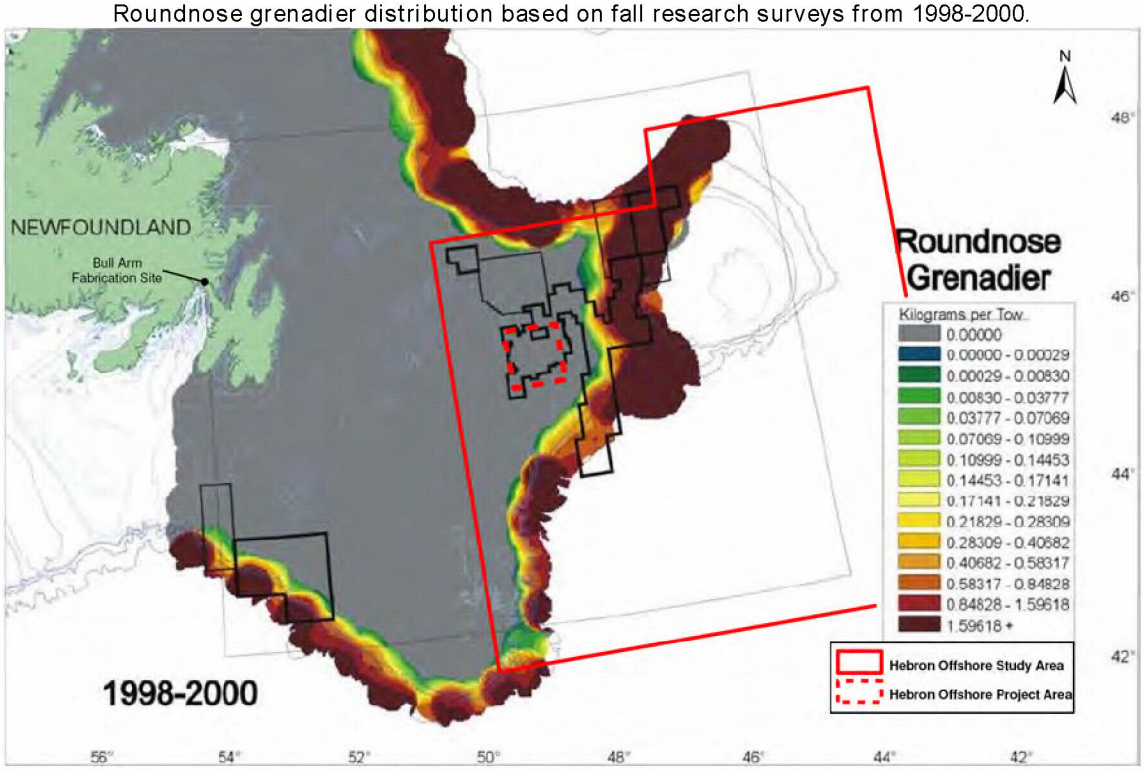
Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003.

Figure 11-10 Roughead Grenadier Distribution

Roundnose grenadier distribution based on spring research surveys from 1998-2000.



Roundnose grenadier distribution based on fall research surveys from 1998-2000.



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003.

Figure 11-11 Roundnose Grenadier Distribution

Adults undertake annual migrations between the Gulf of Maine and Georges Bank, to the waters off Newfoundland and the Gulf of St. Lawrence, at a preferred temperature between 5°C and 10°C (Campana et al. 2001, cited in COSEWIC 2004). They may be found singly or in schools, and are occasionally found close to shore in shallow water during the summer (Campana 2001, cited in COSEWIC 2004). They are primarily a mid-water species and feed opportunistically on benthic, pelagic and epipelagic fish species (Joyce et al. 2002, cited in COSEWIC 2004), such as the lancetfish (Alepisaurus spp.), cod and flatfish. Squid also constitute a major portion of their diet (Joyce et al. 2002).

Mating is believed to occur from August to November in the Cabot Strait, off southern Newfoundland and on the Grand Banks. Gestation is approximately eight to nine months and self-reliant young are born from early April to early June (Jensen et al. 2002, cited in COSEWIC 2004). Juveniles are not known to migrate and are most common on the Scotian Shelf. Prior to 1991, the most abundant age-class off southern Newfoundland in the fall months was 10 to 15 years old. This is consistent with the use of the area as a mating ground. Between 1998 and 2000, the most abundant age classes in this area were less than age 3 (Campana et al. 2002).

Abundance of porbeagle has declined greatly since it was commercially harvested in the 1990s (COSEWIC 2004). Its life history characteristics, including late maturity and low fecundity, make this species vulnerable to overexploitation (COSEWIC 2004).

11.3.1.8 Blue Shark

The blue shark is considered to have a single, highly migratory population in the North Atlantic, a portion of which is present in Canadian waters seasonally. They can be found throughout Atlantic Canada waters, with a peak occurrence in the late summer and fall. Blue sharks have been found in southeastern Newfoundland and the Grand Banks, mainly between July and December. The abundance index is considered to best represent the whole population and has declined 60 percent from 1986 to 2000, but another index shows no long-term trend for the whole population from 1971 to 2003 (COSEWIC 2006c). The blue shark was assessed by COSEWIC as a species of Special Concern. It is considered not likely to occur in either the Hebron Nearshore or Offshore Study Areas.

Blue sharks are pelagic, most commonly encountered offshore between the surface of the water and 350 m. They prefer offshore habitats, but have been observed inshore on occasion (COSEWIC 2006c). Water temperature appears to influence their depth and latitudinal distributions, as well as size and sex distributions. Blue sharks are known to occur in waters between 5.6°C to 28°C.

Canada's waters (Atlantic and Pacific) provide habitat for primarily sub-adult (immature) individuals, although adult (mature) specimens are occasionally encountered. Occurrence of blue sharks within the Study Area and Project Area is considered rare.

This species is a relatively productive shark (mature at four to six years, with 25 to 50 pups every two years), but other species are susceptible to increased mortality from several sources, including from human activities. The primary threat against this species is as a bycatch in the pelagic longline fisheries. Although the threat is understood and is reversible, it is not being effectively reduced through management. Assessing the effect of bycatch on the population would benefit from more reliable information regarding survival rate of the discarded individuals. Blue sharks used to be taken in both the porbeagle shark and swordfish fisheries. It appears that recent fishery catches in the North Atlantic have been several tens of thousands of tons annually. Estimated Canadian bycatch has been declining since the early 1990s and recently have averaged approximately 600 t/yr. Loss of habitat is not considered a threat for this species (COSEWIC 2006c).

11.3.1.9 Shortfin Mako

COSEWIC assessed the shortfin mako shark as Threatened in 2006, and is currently under consideration for SARA listing. At this time, there are no SARA recovery strategies or management plans in place.

The shortfin mako has been recorded from Georges and Browns Bank, along the Continental Shelf of Nova Scotia, the Grand Banks off Newfoundland and even into the Gulf of St. Lawrence. These sharks are not abundant in Canadian waters, due to their preference for warm waters, but neither are they uncommon. The species is highly migratory, with tagging results suggesting that there is a single, well-mixed population in the North Atlantic. Atlantic Canada represents the northern extension of their range, and most of their population is believed to reside in more temperate waters. In Canadian waters, the shortfin mako is most closely associated with warm waters such as the Gulf Stream. They prefer temperate to tropical waters, with temperatures between 17°C and 22°C. The shortfin mako would be considered a rare occurrence within the Hebron Nearshore or Offshore Study and Project Areas.

They occur from the surface to 500 m depths and typically well offshore, but shortfin makos have occasionally been observed in littoral zones. They feed on fish and marine mammals. There are no known breeding areas in Canadian waters. The status of the shortfin mako population in Canadian waters was assessed for the first time in 2004, revealing the north Atlantic population had declined since 1986. There are no known shark surveys or fishery-independent surveys for shortfin mako in Canadian waters. Therefore, abundance indices are based on data from commercial or recreational fisheries. Shortfin mako used to be taken in both the porbeagle and swordfish fisheries. There are no reliable means for estimating the total abundance of mature individuals in Canadian waters. Shortfin mako bycatch by foreign fleets in the North Atlantic are the most important source of mortality for the population. In Atlantic Canada, shortfin makos have at times been misidentified as porbeagle shark.

11.3.1.10 Basking Shark

The Atlantic population of basking shark has recently been assessed as a species of Special Concern by COSEWIC; it has no status under SARA (SARA 2010). The basking shark is found in the western North Atlantic from northern Newfoundland south to Florida and occurs in Canadian Waters from May to September (Scott and Scott 1988). It is the second largest fish, with a maximum length of 15 m (COSEWIC 2010b), but average from 5 to 7 m in the Atlantic region (Scott and Scott 1988). Females do not reach maturity until 16 to 20 years old and gestate to 2.6 to 3.5 years (producing litters of approximately six young), resulting in extremely low productivity. The Canadian population ranges from approximately 5,000 to 10,000 individuals (COSEWIC 2010b).

The primary threat to the basking shark is incidental by-catch from trawl, longline and gillnet fisheries and collision with shops (COSEWIC 2010b).

11.3.1.11 White Shark

White sharks are rare in Canadian waters and are recorded mostly in the Bay of Fundy area. They are extremely rare as far north as the Hebron Nearshore or Offshore Study Areas. The white shark was assessed by COSEWIC as a Threatened species. At this time, there are no SARA recovery strategies or management plans in place.

11.3.1.12 Redfish

There are primarily two species of redfish in the Hebron Offshore Study Area, Acadian redfish (Sebastes fasiatus) (Atlantic population) and the deepwater redfish (Sebastes mentella) (northern population). These species are very similar in appearance and are managed together and not separated in the fishery (DFO 2004c). They are most abundant at depths between 100 to 700 m, along the edge and upper slope of the Continental Shelf, primarily on the outer edge of the northeast Newfoundland Shelf, the Flemish Cap, and along the Laurentian Channel slope. Redfish occurrence within the Hebron Offshore Study Area is patchy and variable (Kulka et al. 2003), but more likely to occur in the spring than fall (Figure 11-12). Redfish are slow-growing and long-lived. They are pelagic, nocturnal feeders, preying primarily on copepods, shrimp, amphipods and euphausiids; lancetfish (Alepisaurus spp.) and lanternfish also make up a small component of the diet of larger redfish (Methven 1999). Mating takes place in the fall and larvae hatch within the female and are released during April to July (LGL 2005e). Spawning on the northeastern edge of Grand Banks occurs in June at depths greater than 200 m (Ollerhead et al. 2004). Live larvae, as opposed to gametes, are released from April to July over the Grand Banks. Redfish larvae have been abundant during pelagic surveys on the northern Grand Banks in August and September (Anderson et al. 1999). In the early 1990s, the landings of redfish in Unit 1 (NAFO Divisions 4RST) dropped from approximately 60,000 tonne in 1993 to approximately 19,500 tonne in 1994 (DFO 2001); the directed redfish fishery was closed in 1995 as a result of low stock levels (DFO 2001; LGL 2007d). In April 2010, the status of both species of redfish potentially found in

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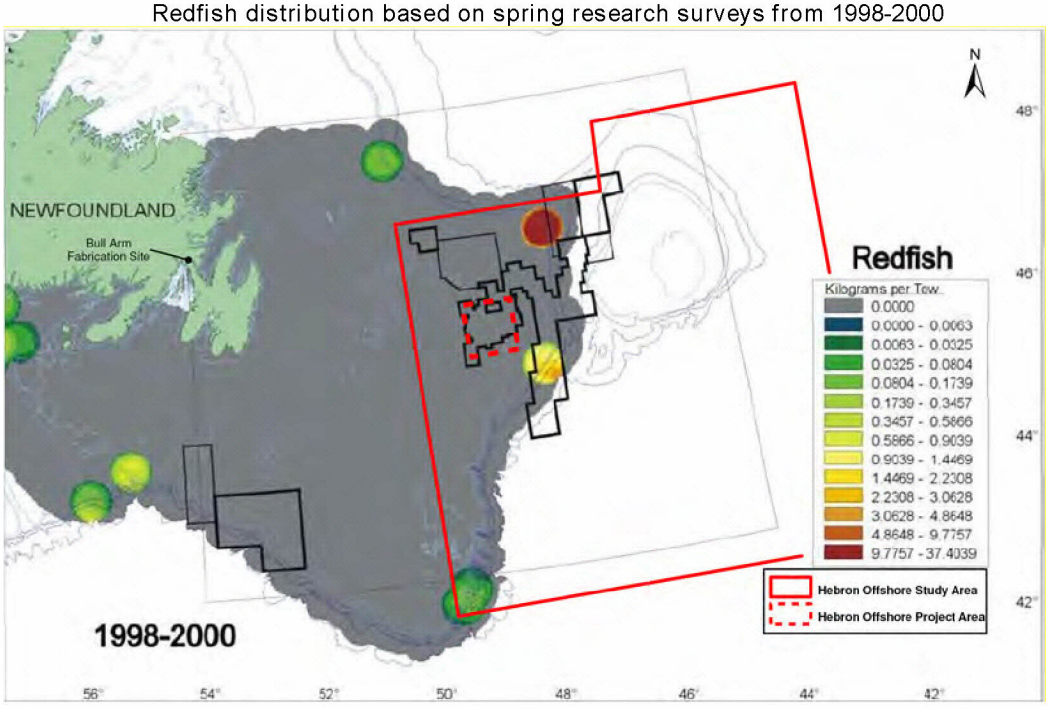
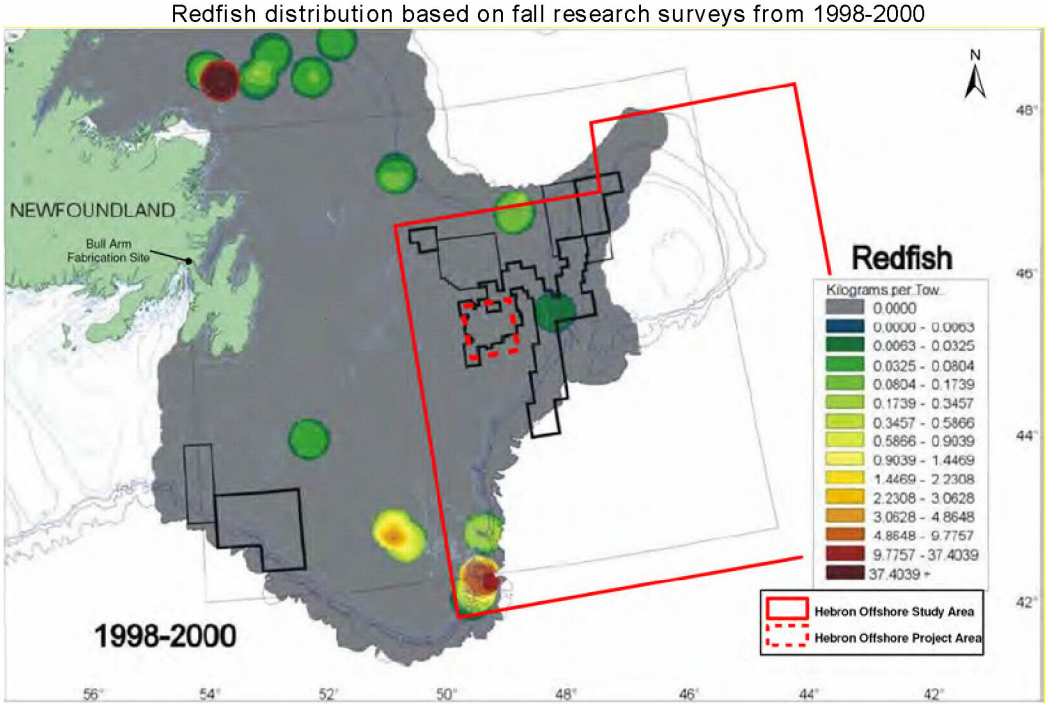
the Project Areas was re-examined and both the northern population of deepwater redfish and the Atlantic population of Acadian redfish were designated as Threatened. The deepwater redfish has decline by 98 percent since 1984 and the Acadian redfish has declined by 99 percent, in areas of historical abundance over two generations. The major treats to both species are directed fishing and incidental harvest (COSEWIC 2010c).

Redfish distribution based on spring research surveys from 1998-2000



Redfish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003

Figure 11-12 Redfish Distribution

11.3.2 Marine Mammal and Sea Turtle Species at Risk

Six species are included in marine mammal and sea turtle SAR: the blue whale, fin whale, Sowerby's beaked whale, killer whale, harbour porpoise, and leatherback sea turtle (see Table 11-2). The blue whale, fin whale and leatherback sea turtle are listed on Schedule 1 of SARA. Neither the Hebron Nearshore nor Hebron Offshore Study Areas represent critical habitat for these species. It is also possible that North Atlantic right whale (Eubalaena glacialis) may occur in the Hebron Offshore Study Area, but their occurrence is considered extremely rare. As such, this species is not considered further in this chapter.

At the time of this writing, no recovery strategies were available for these species other than blue whale (Beauchamp et al. 2009), the North Atlantic right whale (Brown et al. 2009) and leatherback sea turtle (Atlantic Leatherback Turtle Recovery Team 2006).

Species profiles for each of the marine mammal and sea turtle SAR are provided below.

11.3.2.1 Blue Whale

The blue whale is cosmopolitan in distribution, but tends to be more common in pelagic than coastal environments (Jefferson et al. 2008). Following large-scale depletion from industrial whaling, blue whales occur at low densities in the North Atlantic (COSEWIC 2002b). The National Marine Fisheries Service (NMFS) (1998) estimated that up to 1,400 individuals are found in the North Atlantic. The size of the Northwest Atlantic population is currently unknown, but Beauchamp et al. (2009) cites experts that estimate that the number of mature animals is unlikely to exceed 250 individuals and are observed year round on the Grand Banks. Blue whales are considered Endangered by COSEWIC and Schedule 1 of SARA, and are on the Red List of Threatened Species (COSEWIC 2010a; IUCN 2009).

A Recovery Strategy was recently finalized and published for the Northwest Atlantic population of blue whales (Beauchamp et al. 2009). The Recovery Strategy targets the identification of critical habitat for the blue whale by 2014. The Strategy identifies nine threats to the blue whale population including whaling, natural mortality, anthropogenic noise, food availability, contaminants, collisions with vessels, whale watching, accidental entanglement in fishing gear, epizootics and toxic algal blooms, and toxic spills (Beauchamp et al. 2009). It concludes that the recovery of the Northwest Atlantic blue whale population is feasible and sets a target of increasing the current population to 1,000 mature individuals.

Blue whales are most often observed as single animals, but also occur in small groups (Jefferson et al. 2008). Blue whales are regular occupants of the Gulf of St. Lawrence, where at least 308 individuals have been uniquely identified (Sears et al. 1987) and average group size is 1.4 (although concentrations of 20 to 40 animals have also been seen) (Sears et al. 1991). Euphausids are their primary prey in the Gulf of St. Lawrence, where they commonly feed near the 100 m depth contour (Sears et al. 1987) and their

distribution has been linked to heterogeneous seafloor topography and the presence of thermal fronts (Doniol-Valcroze et al. 2007).

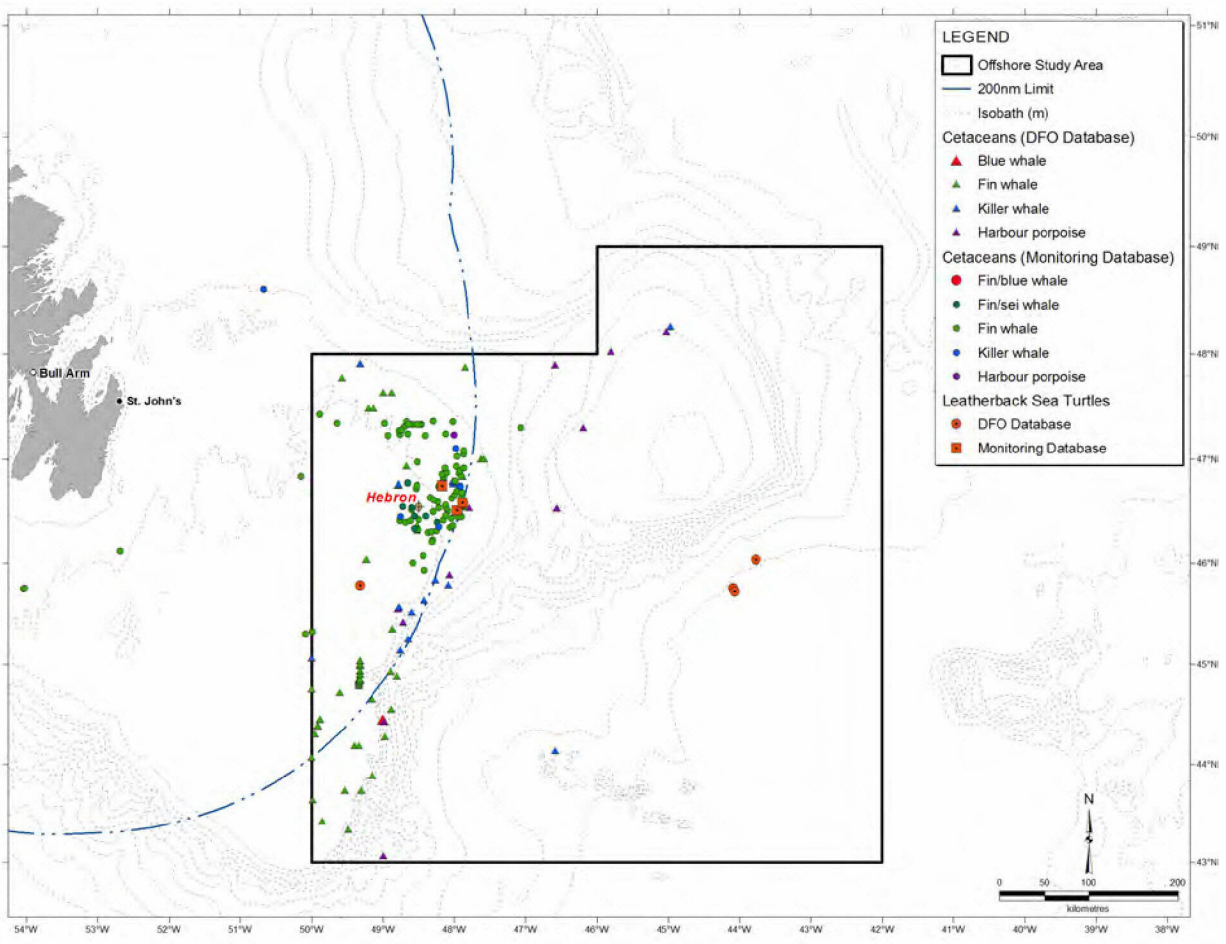
Relative to other cetacean species, blue whales are uncommon in eastern Newfoundland waters. There was a single possible blue whale sighting (recorded as a fin or blue whale) during seismic monitoring programs in the Jeanne d'Arc Basin, and only two sightings in the adjacent Orphan Basin (both occurring in August and water depths >2,000 m; Abgrall et al. 2008b) (see Figure 11-13). There was only one sighting of a blue whale reported in the DFO cetacean sightings database within the borders of the Hebron Offshore Study Area (Figure 11-13; DFO 2007c). Blue whales are not expected to commonly occur in the Hebron Offshore Study Area.

Blue whale records have been more common off the south coast of Newfoundland. In general, the available monitoring results suggest that baleen whales are typically less abundant on the Grand Banks in late fall versus summer, and it is possible that blue whales occur in the Hebron Offshore Study Area at low densities.

Blue whales are not expected to commonly occur in the Hebron Nearshore Study Area. There is little available information on the presence of blue whales in Trinity Bay. No blue whales were reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007c).

11.3.2.2 Fin Whale

Fin whales are found in oceans worldwide, making seasonal migrations between low-latitude wintering areas and high-latitude feeding grounds (COSEWIC 2005). Fin whales have a cosmopolitan distribution, but are most common in temperate and polar regions (Jefferson et al. 2008). It is one of the most frequently observed cetacean species in Continental Shelf waters of the Northwest Atlantic, from the mid-United States to eastern Canada (Waring et al. 2009). An estimated 35,500 fin whales occur in the North Atlantic (IWC 2007), with 2,269 to 2,814 found in the Northwest Atlantic (COSEWIC 2005; Waring et al. 2009). In Canada, fin whales are classified as of Special Concern on Schedule 1 of SARA and by COSEWIC (COSEWIC 2010a). They are also considered Endangered on the Red List of Threatened Species (IUCN 2009).



Source: Based on DFO (2007c) and seismic monitoring programs (2005 to 2008)

Figure 11-13 Locations of Marine Mammal and Sea Turtle SAR Sightings in the Offshore Study Area

Genetic analyses suggest that there are likely several different populations of fin whales in the North Atlantic, with western North Atlantic animals distinct from those in Iceland, West Greenland and the eastern North Atlantic (Bérubé et al. 1998). Fin whales use lunge feeding to consume euphausiids and small fishes, and their distribution has been associated with thermal fronts or shallow areas with heterogeneous sub-surface topography that may help concentrate their prey (Woodley and Gaskin 1996; Doniol-Valcroze et al. 2007). They often occur singly or in small groups of two to seven animals, but have also been observed in feeding aggregations of up to 20 individuals, sometimes with humpback and minke whales (Jefferson et al. 2008). Average fin whale group size off eastern Newfoundland was reported as 2.6 during an aerial survey in August 1980 (Hay 1982).

Fin whales regularly occur in eastern Newfoundland waters, particularly from early summer to late fall. Of the identified baleen whales, fin whales were the second most commonly sighted species (after humpback whales) in the Jeanne d'Arc Basin during seismic monitoring programs from 2005 to 2008 with 69 sightings; there was at least one sighting each year from May to October (Figure 11-13). There were also several fin whale sightings within

the Hebron Offshore Study Area or west of the Jeanne d'Arc Basin in 2005, and six other sightings in 2008 (Lang et al. 2006; Abgrall et al. in prep.). Fin whales were also frequently observed in deep waters (typically >2,000 m) of the adjacent Orphan Basin during summer, most often in July and August (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). According to the DFO cetacean sightings database, the fin whale was the second most frequently sighted species in the Hebron Offshore Study Area; there were 80 sightings of 162 individuals (Figure 11-13; DFO 2007c). Fin whales likely occur in the Hebron Offshore Study Area year-round, but are most common from June to October.

Fin whales are also common in coastal regions of Newfoundland, with group size linked to the size of capelin schools, their primary summer prey. In the nearshore, group sizes ranged from 1 to 10 individuals (Whitehead and Carlson 1988). Fin whales appear to be slightly less common than minke and humpback whales in the nearshore environment (Piatt et al. 1989), and have occasionally been recorded as entangled in nearshore fishing gear (Lien 1994). Fin whales were more often observed feeding in the middle of large deep-water bays, over 1 nautical mile (nm) from shore, relative to minke and humpback whales that most frequently fed less than 1 nm from shore (Perkins and Whitehead 1977). Hay (1982) estimated a density of 0.0118 fin whales per square nautical mile in Trinity Bay during an August 1980 aerial survey, an intermediate density relative to other surveyed regions of coastal Newfoundland (from St. Mary's Bay to White Bay). Fin whales were occasionally reported in the Hebron Nearshore Study Area in the DFO cetacean sightings database; there were six sightings of seven individuals reported (DFO 2007c). Fin whales could commonly occur in the Hebron Nearshore Study Area, especially from June to October.

11.3.2.3 Sowerby's Beaked Whale

The Sowerby's beaked whale is found only in the cold temperate waters of the North Atlantic, where just one record in the Northwest Atlantic occurs outside the area between Labrador and New England (MacLeod 2000; MacLeod et al. 2006). The number of Sowerby's beaked whales in eastern Newfoundland is unknown, and the best population estimate for the Northwest Atlantic (of 3,513 individuals) combines sightings of all Mesoplodon spp. and Ziphius cavirostris (but these other species have more southerly distributions) (Waring et al. 2009). Sowerby's beaked whales are considered of Special Concern by COSEWIC and on Schedule 1 (Special Concern) of SARA (COSEWIC 2010a), but they are considered Data Deficient on the Red List of Threatened Species (IUCN 2009).

Little is known, in general, about beaked whales, but most information on Sowerby's beaked whales in Newfoundland is based on stranding records or a few opportunistic sightings (Lien and Barry 1990). Sowerby's beaked whales are also relatively difficult to detect at sea due to their short surface durations, apparent offshore distribution, and barely detectable blows (Hooker and Baird 1999b). They have most often been observed in deep waters and continental shelf edges or slopes (Kenney and Winn 1987; COSEWIC 2006d)

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and presumably make deep dives to forage on medium to large-bodied squid (COSEWIC 2006d).

Sowerby's beaked whales are expected to occur most frequently in deeper waters, although in relatively low numbers, of the Hebron Offshore Study Area. There were two unidentified beaked whale sightings during seismic monitoring in the Jeanne d'Arc Basin during 2005 to 2008 (Section 10.3.1.1). One of these sightings was deemed a species other than a northern bottlenose whale, and the observer suggested that it was likely a Sowerby's beaked whale (Lang et al. 2006). There was only one confirmed sighting of a Sowerby's beaked whale during four years of monitoring in the adjacent and deeper Orphan Basin; the sighting of four individuals occurred in 2,500 m of water during September (Moulton et al. 2005, 2006a; Abgrall et al. 2008b). There were no sightings of Sowerby's beaked whales reported in the DFO cetacean sightings database in the Hebron Offshore Study Area (DFO 2007c).

Lien (1994) reported that there was one record of a Sowerby's beaked whale entangled in a nearshore fishing gear during the period of 1979 to 1990. There have also been occasional strandings of individuals or groups (of up to six individuals) in eastern Newfoundland, dating from 1952 to 2004 (COSEWIC 2006d). Causes of death were typically not determined, and it is unknown if these whales entered nearshore waters prior to death or if the carcasses washed ashore. One Sowerby's beaked whale was found dead, stranded on 22 May 2008 in Harcourt, Trinity Bay (Ledwell and Huntington 2009). There were no sightings of Sowerby's beaked whales reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007c). It is possible, but very unlikely, that Sowerby's beaked whales will occur in the Hebron Nearshore Study Area.

11.3.2.4 Killer Whale

Killer whales have a cosmopolitan distribution, occurring in oceans from polar pack-ice to the equator, but seem to be most common in coastal waters at higher latitudes (COSEWIC 2008; Jefferson et al. 2008). It is unknown how many killer whales occur in the Northwest Atlantic (Waring et al. 2009). In Newfoundland and Labrador, at least 63 animals have been individually identified to date (Lawson et al. 2007). Killer whales in Atlantic Canada were recently assessed by COSEWIC as of Special Concern, but currently have no status under SARA (COSEWIC 2010a). They are considered Data Deficient on the Red List of Threatened Species (IUCN 2009).

Killer whales exhibit marked sexual dimorphism, with adult males having a much more pronounced and taller dorsal fin and being generally larger than females (Ford et al. 2000). Generally, killer whale movements are linked to the distribution and abundance of their primary prey, which can include fish, marine mammals, marine birds and cephalopods (Ford et al. 2000). Sympatric killer whales populations in some regions have divergent preferred prey, presumably as a mechanism to share available resources (Baird 2000). For example, there are distinct fish- or marine mammal-eating killer whale populations in the northeast Pacific that sometimes overlap temporally and

geographically. Killer whales in Atlantic Canada have been observed approaching, attacking, and/or consuming other cetaceans, seals, marine birds, and several species of fish; it is not known if local populations specialize on particular prey groups (Lawson et al. 2007). Most groups in Newfoundland and Labrador are comprised of three to seven individuals, and some individuals have been documented moving as much as hundreds of kilometres between re-sightings from year to year (Lawson et al. 2007). In the northeast Pacific, long-term and stable associations are maintained among matrilineal-related individuals and pods within fish-eating populations, as well as within mammal-eating populations, although to a lesser extent among the latter (Bigg et al. 1990). It is unknown whether such associations are maintained in the Northwest Atlantic, but preliminary social groups have been identified by Lawson et al. (2007).

Killer whales are considered a year-round resident of eastern Newfoundland, although they occur in relatively low densities (Goff and Lien 1988; Lawson et al. 2007). In the Jeanne d'Arc Basin, there were four killer whale sightings (totalling 21 individuals) during the 2008 seismic monitoring program (Figure 11-13); two sightings occurred in each of June and September, group sizes ranged from 1 to 12 individuals, and water depths ranged from 65 to 153 m (Abgrall et al. in prep.). Outside of Jeanne d'Arc Basin, a single killer whale was also sighted to the northwest in October 2005 (Lang et al. 2006). There was also one sighting of three individuals in August 1999 during a supply vessel transit between oil platforms in the Jeanne d'Arc Basin and St. John's (Wiese and Montevecchi 1999).

Whitehead and Glass (1985) recorded two sightings (one of 15 individuals and the other of 12) during surveys of the Southeast Shoal (southeastern Grand Banks) during June and July in 1982 and 1983. In August 2007, a single killer whale was sighted during monitoring in the Orphan Basin (Abgrall et al. 2008b). There were 17 sightings of killer whales reported in the DFO cetacean sightings database in the Hebron Offshore Study Area (Figure 11-13; DFO 2007c). The available information suggests that killer whales occur year-round at low densities in the Hebron Offshore Study Area, but are most common during summer.

Killer whales have also been observed in coastal areas of eastern Newfoundland (Mitchell and Reeves 1988). Killer whales were occasionally reported to be associated with minke or pilot whales being pursued by shore-based whalers from Dildo, Trinity Bay (Mitchell and Reeves 1988). There was a single sighting of a pair of killer whales reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007c). Given the available information, killer whales likely occur year-round in the Hebron Nearshore Study Area, but only occasionally and predominantly during spring to fall.

11.3.2.5 Harbour Porpoise

Harbour porpoises are found in Continental Shelf regions of the Northern Hemisphere, and from southern Baffin Island to New England in the Northwest Atlantic (Jefferson et al. 2008). At least three populations of

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harbour porpoises exist in the Northwest Atlantic, including the eastern Newfoundland and Labrador, Gulf of St. Lawrence, and Gulf of Maine / Bay of Fundy populations (Palka et al. 1996; Wang et al. 1996). There is an unknown number of harbour porpoises in the Northwest Atlantic, as well as in the Newfoundland population (COSEWIC 2006a). The Northwest Atlantic population of harbour porpoises was assessed by COSEWIC as a species of Special Concern and is listed as Threatened on Schedule 2 of SARA (COSEWIC 2010a), but harbour porpoises are considered of Least Concern on the Red List of Threatened Species (IUCN 2009).

Harbour porpoises tend to occur singly or in small groups of up to three animals, but occasionally form larger groups (COSEWIC 2006a). They consume small schooling fishes and apparently prefer areas with coastal fronts or topographically generated upwellings over the Continental Shelf, although there also appears to be an offshore component to their distribution (Westgate et al. 1998; Read 1999). Harbour porpoises appear to have an annual reproduction cycle; pregnant females were collected during late summer and early autumn from the Gulf of Maine/Bay of Fundy population (Palka et al. 1996).

There is little information regarding movements and distribution of the Newfoundland and Labrador population (COSEWIC 2006a). Harbour porpoises occur in coastal shelf waters of Labrador and the eastern and southeastern Newfoundland coasts during spring and summer. They range up to Baffin Bay and deeper waters of the Labrador Sea during summer, but the offshore boundaries of their spring and summer distributions are unknown (Palka et al. 1996). The winter range for this population is undefined (Palka et al. 1996; COSEWIC 2006a). During summer and fall monitoring in the Jeanne d'Arc Basin from 2005 to 2008, there was a single harbour porpoise sighting of two individuals; the water depth at the time of the sighting was 165 m (Lang et al. 2006). Harbour porpoises were sighted more frequently in the deeper Orphan Basin, including nine and one sighting during monitoring programs in 2005 and 2004, respectively (Moulton et al. 2005, 2006a). There were thirteen sightings of harbour porpoises reported in the DFO cetacean sightings database in the Hebron Offshore Study Area (Figure 11-13; DFO 2007c). While harbour porpoises may occur in the Hebron Offshore Study Area throughout the year, they are likely uncommon relative to other cetacean species and generally are observed from spring to fall.

Harbour porpoises often occur in coastal Newfoundland waters during summer months. Inshore fisherman reported porpoise bycatch in cod traps during June and July, and they have been observed in southern Trinity Bay from late May to late July (Sergeant and Fisher 1957). Sergeant and Fisher (1957) also indicated that porpoises leave Trinity Bay after late July. Lawson et al. (2004) estimated that approximately 1,500 to 3,000 harbour porpoises were incidentally caught during the 2002 nearshore cod gillnet fishery in Newfoundland, a year with much reduced fishing effort relative to previous years. Bycatch reports occurred most often from July to September, but bycatch was also reported during the remainder of the year (Lawson et al.

2004). There were eight sightings of harbour porpoises reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007e; Section 10.3.1.2). Harbour porpoises are expected to be common in the Hebron Nearshore Study Area based on available reports and sighting data, at least during summer.

11.3.2.6 Leatherback Sea Turtle

The leatherback sea turtle is the largest and widest ranging of sea turtles, occurring from sub-polar foraging grounds to tropical and sub-tropical nesting areas; it is found in the world's oceans (Spotila 2004). Globally, there are an estimated 26,000 to 43,000 individuals (Dutton et al. 1999), but there are no estimates of the population size in Canada. Adult leatherbacks are considered regular seasonal inhabitants of Newfoundland waters (Goff and Lien 1988; Witzell 1999). Leatherback sea turtles are assessed as Endangered by COSEWIC and listed as Endangered Schedule 1 of SARA (COSEWIC 2010a). The Red List of Threatened Species lists leatherback sea turtles as Critically Endangered (IUCN 2009).

Adult leatherback sea turtles make routine migrations between temperate and tropical waters, presumably to optimize foraging in high latitudes and nesting in the tropics (Spotila 2004). In the North Atlantic, they are predominantly pelagic, with wide-ranging oceanic movements, and consume primarily gelatinous zooplankton (Hays et al. 2004; Eckert 2006; Witt et al. 2007). They nest from March to July in the Caribbean and Central and South America (Spotila 2004). Leatherbacks satellite-tagged off of Cape Breton and mainland Nova Scotia during summer months remained off eastern Canada and the northeastern US coast before migrating south in October (James et al. 2005). Tags remained attached to some of these animals to observe return migrations northward; animals left their nesting areas during February and March and typically arrived in the Northwest Atlantic (north of 38°N) during June. Most individuals returned to within several hundred kilometres of where they were observed during the previous year, and some individuals ranged into areas just east of St. John's and along the edge of the Grand Banks. Individuals that have been sampled in Nova Scotia areas are either large sub-adults or adults, with a significant sex-bias towards females (1.86 females:1 male) among mature individuals (James et al. 2007).

Leatherbacks are often observed off Nova Scotia and Newfoundland from June to October, with peak occurrence in August and September. They are the most likely sea turtle to occur within either the Hebron Nearshore or Offshore Study Area. Witzell (1999) described the distribution of sea turtles incidentally captured in the U.S. pelagic longline fishery from 1992 to 1995; nearly half of the leatherbacks caught in an area from the Caribbean to Labrador were captured in waters on and east of the 200 m isobath off the Grand Banks (although effort was also predominantly concentrated in these areas). Animals were caught in this area from June to November, but catches were highest from July to September. Twenty leatherbacks were reported off Newfoundland between 1976 and 1985, including an individual swimming amongst icebergs in Trinity Bay (Goff and Lien 1988).

Three leatherbacks were sighted during summer and fall monitoring programs in the Jeanne d'Arc Basin (Figure 11-13; Abgrall et al. 2008a; in prep.), and a single sighting occurred in the Downing Basin (approximately 70 NW of the Project) in June 2008 (Ledwell and Huntington 2009). There were also four leatherback sea turtle sightings within the Offshore Study Area in the DFO database (Figure 11-13; DFO 2007c). Leatherback sea turtles are expected to occur in low densities within the Hebron Offshore Study Area during summer and fall, particularly from July to September.

Leatherbacks are also known to wander into Trinity Bay during summer and fall with some regularity. As noted above, Ledwell and Huntington (2009) described several leatherback reports in Trinity Bay, occurring from August to October 2008, with the majority occurring from September 19 to 28. They have also been recorded in Trinity Bay during previous years. The available information suggests that leatherback sea turtles will occur occasionally within the Hebron Nearshore Study Area during summer and fall, particularly in August and September.

A Recovery Strategy for the Leatherback Turtle has been developed (Atlantic Leatherback Turtle Recovery Team 2006). It identifies several threats to turtles in the marine environment including entanglement in fishing gear, collisions, marine pollution, and acoustic disturbances. Critical habitat for this species has not yet been identified.

11.3.2.7 Loggerhead Sea Turtle

Loggerhead sea turtles occur in temperate and tropical areas of the Atlantic, Pacific, and Indian oceans, with the majority of nesting occurring along the western rims of the mid- and equatorial Atlantic and Indian oceans (Spotila 2004). Globally, there are an estimated 43,000 to 45,000 nesting females (Spotila 2004). Its distribution is largely constrained by water temperature and it does not generally occur where the water temperature is below 15°C (Brazner and McMillan 2008), which limits its northern range. Loggerhead sea turtles are considered Endangered by COSEWIC (2010d) and have no status under SARA. This species is listed as Endangered on the Red List of Threatened Species (IUCN 2009).

Loggerheads can migrate considerable distances between near-equatorial nesting areas that are occupied from late April to early September (Spotila 2004) and temperate foraging areas, some moving with the Gulf Stream into eastern Canada waters during the summer and fall (Hawkes et al. 2007). Information to date indicates a seasonal population of juvenile loggerheads in Atlantic Canada (Witzell 1999; COSEWIC 2010d) but the number occurring in Canadian waters is unknown. While foraging at sea, loggerheads likely consume gelatinous zooplankton and squid (Spotila 2004); there is no diet information available for Canadian waters (DFO 2010d).

Loggerheads may be seen in the open seas during migration and foraging. They have not been reported in the Project Area but have been reported south of the Flemish Cap in the eastern portion of the Study Area (COSEWIC 2010d). Most loggerhead records offshore Newfoundland have occurred in

deeper waters south of the Grand Banks and sightings have extended as far east as the Flemish Cap (Figures 6 and 7 in COSEWIC 2010d). None were sighted during summer and fall seismic monitoring programs in the Jeanne d'Arc Basin, although one was observed 237 km south of that area in early September 2008 (Abgrall et al. in prep.). While the available information suggests that loggerhead sea turtles do occur in the eastern portion of the Offshore Study Area, their presence is likely limited to small numbers and during late summer to fall.

There are no records or reports of loggerhead sea turtles occurring in Trinity Bay, or any other nearshore area of Newfoundland. It is possible that loggerhead sea turtles could occur in the Nearshore Study Area, but their presence is presumed to be very rare.

11.3.3 Marine Birds Species at Risk

There are two marine bird SAR that could potentially occur in the Hebron Nearshore and/or Offshore Study Areas: the Red Knot and Ivory Gull. No recovery strategies exist, nor have critical habitat areas been assessed, for either species.

11.3.3.1 Red Knot

Three subspecies of Red Knot (Calidris canutus) occur in Canada and have been assessed independently by COSEWIC (2007b): Calidris canutus rufa (Endangered), Calidris canutus roselaari (Threatened), and Calidris canutus islandica (Special Concern). To date, the subspecies of Red Knot (rufa subspecies) that occurs in Newfoundland and Labrador has not been listed on SARA Schedule 1. As a whole, Red Knot is considered of Least Concern on the Red List of Threatened Species (IUCN 2009). The breeding range of Calidris canutus rufa is confined to the central Canadian Arctic with primary wintering grounds located in Tierra del Fuego and Patagonia, Argentina and Chile. The subspecies roselaari, comprised of three subpopulations, includes two populations that winter in Florida / southeast US and northeast Brazil, which presumably breed in the central and western Canadian Arctic. Calidris canutus islandica breeds in the Canadian High Arctic (and Greenland) and winters along the European coast.

During migration, Red Knot prefers staging areas of sandy beaches near the mouths of bays, tidal inlets and estuaries where they feed on benthic and epifaunal bivalves and other invertebrates (Harrington 2001). On the eastern seaboard, Delaware Bay serves as an important spring staging area for rufa and roselaari knots to replenish food reserves prior to continuing northward migration. A large component of the diet of Red knots and other shorebirds at Delaware Bay are horseshoe crab (Limulus polyhemus) eggs (Castro and Myers 1993). Overfishing in the late 1990s has resulted in a reduction in the availability of both breeding crabs and egg densities. Consequently, reduced food availability has led to Red Knots being unable to obtain adequate energetic requirements before the flight to Arctic breeding grounds, at least in some years (Baker et al. 2004). The most important staging areas in eastern Canada for rufa knots are along the north shore of the St. Lawrence River.

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The current population size for Calidris canutus rufa is 13,500 to 15,000 adults, based on counts from the wintering areas in Tierra del Fuego and Patagonia (COSEWIC 2007b). This represents a population decrease of 70 percent since 1982, which is supported by similar declines throughout its migration range, as opposed to a redistribution or range shift. The recent estimate for the Calidris canutus roselaari subpopulation wintering in Florida / southeast US is approximately 3,375 adults, a decline of 70 percent since 1982. The overall decline for this subspecies is 47 percent (COSEWIC 2007b). The population of Calidris canutus islandica wintering in Europe is greater than 200,000 adults, but has declined by about 17 percent since the late 1990s.

Red Knot is an uncommon southbound migrant during autumn in coastal Newfoundland. In Newfoundland, Red Knots are found on open sandy beaches, often with rotting kelp piles and extensive mud flats. Bellevue Beach, Trinity Bay, is ideal habitat for Red Knot, where it occurs annually from late August to September / October with counts ranging up to a maximum of 23 individuals (B. Mactavish, LGL Ltd., unpublished data 2009). There are no other locations of particularly good Red Knot feeding habitats in southern Trinity Bay. While Red Knot is known to occur in the Hebron Nearshore Study Area, it would not be present in the Hebron Offshore Study Area.

11.3.3.2 Ivory Gull

The Ivory Gull has a circumpolar breeding distribution and is associated with pack ice throughout the year. In Canada, Ivory Gull breeds exclusively in Nunavut. Breeding colonies occur on southeastern Ellesmere Island, eastern Devon Island and northern Baffin Island. Among Canadian waters, Ivory Gulls occur among the pack ice of the Davis Strait, the Labrador Sea, Strait of Belle Isle, and northern Gulf of St. Lawrence. The Ivory Gull is assessed as Endangered by COSEWIC, and listed as Endangered on Schedule 1 of SARA, and considered Near Threatened on the Red List of Threatened Species (COSEWIC 2010a; IUCN 2009).

In comparison to most gulls, Ivory Gulls have reduced reproductive output, in that they usually only lay one to two eggs (Haney and MacDonald 1995). They depart from colonies immediately following breeding for offshore foraging areas associated with the ice edge of permanent, multi-year pack ice. At sea, the Ivory Gull is a surface-feeder where its main prey includes small fish and macro-zooplankton. It is also an opportunistic scavenger of carrion found on ice and marine mammals killed by large predators (Haney and MacDonald 1995).

Currently, the Canadian breeding population is estimated at 500 to 600 individuals (COSEWIC 2006e). Surveys conducted from 2002 to 2005 indicate a total decline of 80 percent and an annual decline of 8.4 percent over the last 18 years. If this decline continues at a steady rate, the breeding population will decrease by a further 62 percent over the next decade, to approximately 190 individuals. A March 2004 survey conducted within the pack ice off the coast of Newfoundland and Labrador observed a decrease in

Ivory Gull observations as compared to 1978 results. The number of Ivory Gulls observed per 10-minute watch period were 0.69 and 0.02 individuals for 1978 and 2004, respectively (COSEWIC 2006e). Considering that changes to the breeding environment have been insignificant, causes for the observed decline are likely related to factors occurring during migration or on the wintering grounds (Stenhouse 2004).

During heavy ice winters, the Ivory Gull may occasionally reach the northern part of the Hebron Offshore Study Area late in the winter or early spring when sea ice reaches the maximum southern extremity. The thirty-year median of ice concentration shows ice extending into the northern edge of the Grand Banks east to 48°W from late February to late March. A total of 21 Ivory Gulls reported from drill platforms on the northeast Grand Banks from 1999 to 2002 seems improbable, especially considering that most sightings were reported during ice-free periods.

Occasional sightings of Ivory Gulls are reported along the eastern coastlines of Newfoundland and Labrador, particularly the Northern Peninsula of Newfoundland. It is considered extremely rare in and near the Hebron Nearshore Study Area because it typically winters well north of Trinity Bay. However, on 17 January 2009 a single adult Ivory Gull was observed at Islington, Trinity Bay and two adult and one immature Ivory Gull were observed nearby at Hearts Delight, Trinity Bay (B. Mactavish, LGL Limited, unpublished). These sightings were part of an unusual influx of Ivory Gulls in southern Newfoundland In January 2009.

11.4 Marine Fish Species at Risk

11.4.1 Project-VEC Interactions

Potential interactions between the Project and marine fish SAR are similar to what is described for non-listed marine fish in Chapter 7. The key difference with SAR is that the abundance and spatial and temporal presence of these species differs considerably from non-listed species. SAR are typically less abundant and are more widely dispersed in the marine environment. These factors affect the likelihood of Project activities interacting with SAR and their respective habitats.

Project activities with similar interactions on marine fish SAR have been grouped into four categories to provide a complete and comprehensive environmental effects analysis. Instead of assessing each Project activity separately, the grouping of activities with similar potential effects on Marine Fish SAR, allows for a cumulative assessment of within-Project activities.

The interactions summary categories are:

- Change in Habitat Quantity
  - Project activities that may result in physical alteration of fish habitat, and may be declared a harmful alteration, disruption or destruction (HADD) of fish habitat by DFO and require a Section 35(2) Fisheries Act Authorization

- Change in Habitat Quality
  - Project activities that may result in a change in the biological or physical properties of fish habitat. For example, Project activities creating suspended sediment in the water column, creating contamination, affecting a potential food source, or otherwise potentially causing sub lethal physiological effects on marine fish SAR are assessed as potential changes in fish habitat quality
- Change in Habitat Use
  - Project activities that may result in marine fish SAR changing their behaviour. Some activities may cause avoidance behaviour in fish or shellfish, whereas other activities may attract some species
- Potential Fish Mortality
  - Project activities that may result in marine fish SAR mortality

11.4.1.1 Nearshore

The primary nearshore Project activities during construction that could potentially interact with marine fish SAR include:

- Construction of the bund wall for the drydock at Great Mosquito Cove
- Subsequent removal of the bund wall and possible at-sea disposal of bund wall material
- Possible dredging along sections of the tow-out route to allow the GBS to transit to the Bull Arm deepwater site
- Dredge spoils disposal
- Underwater noise from sheet pile installation during bund wall construction, blasting and vessel traffic
- Watering and dewatering of the drydock

11.4.1.2 Offshore

Offshore Construction / Installation

The primary offshore Project activities during construction and installation that could potentially interact directly or indirectly with marine fish SAR include:

- Dredging during the construction of excavated drill centre (potential expansion opportunity)
- Dredge spoils disposal
- Site preparation activities for OLS / Platform installation
- Installation of Hebron Platform, flowlines and Offshore Loading System (OLS), concrete mattresses and/or rock cover
- Installation of subsea equipment and flowlines, including placement of flowline protection measures (rock cover, concrete mattresses), hook-up to the Hebron Platform and commissioning (potential expansion opportunity)

- Installation of subsea equipment and flowlines, including placement of flowline protection measures, hook-up to the Hebron Platform and commissioning (potential expansion opportunity)
- Vessel traffic
- Geophysical surveys (possibly seismic, geohazards and/or geotechnical surveys)

Operations / Maintenance

The primary offshore Project activities / components during operations and maintenance that could potentially interact directly or indirectly with marine fish SAR include:

- Operational discharges (e.g., cooling water, storage displacement water, firewater, produced water, grey/black water (refer to Chapter 2 for all operational discharges))
- Drill cuttings and muds discharges (WBM from the Hebron Platform, WBM and SBM from mobile offshore drilling unit (MODU) drilling associated with potential expansion opportunities)
- Geophysical, geological, environmental and geotechnical surveys, as required
- Presence of Structures (e.g., subsea equipment in drill centres, Hebron Platform, OLS, flowlines)

11.4.1.3 Decommissioning / Abandonment

The primary decommissioning and abandonment activities that could potentially affect marine fish SAR is the removal of structures / materials on or above the seafloor (Hebron Platform, OLS, flowlines, subsea infrastructure in drill centres). All exposed hard surfaces are expected to be colonized during the life of the Project. Removal of such structures will remove the artificial reef effect likely created by these structures, thereby reducing localized productivity. The removal of the structures may create temporary localized turbidity as well.

11.4.1.4 Accidents, Malfunctions, and Unplanned Events

During the construction and operation phases of the Hebron Project, there are several hydrocarbon products onboard vessels, barges, drill rigs and platforms. These include crude oil, diesel oil, synthetic drilling mud, synthetic drill (base) fluid, lubricating oils, and hydraulic oils. Spills may occur as a result of human error, equipment failure or loss of well control (blow-out). An oil spill, although highly unlikely, could affect marine fish SAR and potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project.

11.4.1.5 Summary

A summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present, and likely future projects, is

provided in Table 11-3. This table includes accidents, malfunctions, and unplanned events.

Table 11-3 Potential Project-related Interactions: Marine Fish Species at Risk

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zones (Great Mosquito Cove zone followed by a deepwater site zone)				+
Bund Wall Construction (e.g., sheet / pile driving, infilling)	x	x	x	x
Inwater Blasting	x	x	x	x
Dewater Drydock / Prep Drydock Area	x	x	x	
Concrete Production (floating batch plant)		x		
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passender ferry to / from deepwater site)		x	x	
Lighting			x	
Air Emissions				
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	x	x	x	x
Removal of Bund Wall and Disposal (dredging / ocean disposal)	x	x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)		x	x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site		x	x	
Hook-up and Commissioning of Topsides		x	x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Platform Tow-out from Deepwater site		x	x	
Offshore Construction / Installation				
Safety Zone				+
OLS Installation and Testing	x	x	x	x
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines	x	x	x	
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation			x	
Underbase Grouting		x		
Possible Offshore Solid Ballasting		x		
Placement of Rock Scour Protection on Seafloor around Final Hebron Platform Location	x	x	x	
Hookup and Commissioning of Hebron Platform		x		
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	
Air Emissions				
Lighting			x	
Potential Expansion Opportunities				
Presence of Safety Zone				+
Excavated Drill Centre Dredging and Spoils Disposal	x	x	x	x
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	x	x	x	x
Hook-up and Commissioning of Drill Centres		x	x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Offshore Operations and Maintenance				
Presence of Safety Zone				+
Presence of Structures	x	x	x	

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Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Lighting			x	
Maintenance Activities (e.g., diving, ROV)			x	
Air Emissions				
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water), deck drainage		x	x	
Chemical Use / Management/Storage (e.g., corrosion inhibitors, well treatment fluids)		x	x	
WBM Cuttings	x	x	x	
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)		x	x	
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	x
Potential Expansion Opportunities				
Presence of Safety Zone			x	+
Drilling Operations from MODU at Future Excavated Drill Centres	x	x	x	
Presence of Structures	x	x	x	
WBM and SBM cuttings	x	x	x	
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x	x	
Geophysical/Seismic Surveys		x	x	x
Offshore Decommissioning / Abandonment				
Presence of Safety Zone			x	x
Removal of the Hebron Platform and OLS Loading Points	x	x	x	x
Lighting			x	
Plugging and Abandoning Wells		x	x	
Abandoning the OLS Pipeline		x	x	
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture		x		x
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blow-out		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)		x	x	x
Marine Vessel Incident (i.e., fuel spills)		x	x	x
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)		x	x	
Terra Nova Development (production)		x	x	
White Rose Oilfield Development and Expansions (drilling and production)		x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (Nearshore and Offshore)		x	x	
Commercial Fisheries (Nearshore and Offshore)	x	x	x	x
+ indicates a positive interaction and possible decrease in mortality				

11.4.2 Environmental Effects Analysis and Mitigation Measures

Potential environmental effects of the Project on non-listed marine fish species are assessed and described in detail in Section 7.5. Many of the issues of concern with respect to environmental effects for SAR, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine fish species in the Nearshore and Offshore Study Areas. On an ecosystem basis, the listed and non-listed species and their habitats are often highly integrated.

11.4.2.1 Construction and Installation

Change in Habitat Quantity

Nearshore

The predicted change in marine fish habitat quantity as a result of Project activities in the nearshore is assessed in Section 7.5.1.1. As stated in this section, while construction of the bund wall, dredged areas and any in-water dredge spoil disposal areas may be declared a habitat alteration, disruption and destruction (HADD) by DFO, a habitat compensation program will be developed in conjunction with DFO and area fishers as a mitigation measure for the net loss of fish habitat resulting from the Hebron Project.

The marine fish SAR species most likely to occur in the Hebron Nearshore Study Area include Atlantic cod, American plaice, and American eel. In addition, Atlantic wolffish may occur. For all of these species, habitat in the Nearshore Project Area has not been assessed as critical habitat. Habitat compensation programs may be designed to address SAR and/or non-listed fish species. Portions of the remaining bund wall, if 80 to 90 percent boulder, may create potential Atlantic wolffish spawning habitat.

Offshore

Activities affecting habitat quantity during offshore construction include Hebron Platform and OLS installation / protection, flowline installation and excavated drill centre construction. The predicted change in marine fish habitat quantity as a result of Project activities in the offshore is also assessed in Section 7.5.1.1. As with the nearshore and in accordance with the DFO policy of no net loss of fish habitat, a habitat compensation program will be developed in conjunction with DFO and area fishers as a mitigation measure for the net loss of fish habitat resulting from the Hebron Project.

The marine fish SAR species known to occur in the Offshore Study Area include Atlantic cod, American plaice, Atlantic wolffish, northern wolffish, and spotted wolffish. Porbeagle shark may occur, while the other species considered in this assessment are not likely to occur in this area.

For each of these species, the Hebron Offshore Project Area, which encompasses the extent of any change in habitat quantity as a result of Project activities, is of lesser importance to these species in terms of distribution and productivity than other regions within the Hebron Offshore

Study Area. The Hebron Offshore Project Area has not been identified as critical habitat for any of these species.

With the proposed habitat compensation program, the predicted recovery of benthic communities and general productivity of disturbed areas after several generations and the lower importance of the Project Area to these species, any reduction of habitat quantity as a result of Project activities will be of minimal importance to the marine fish SAR.

Change in Habitat Quality

Nearshore

There are several Project activities in the nearshore that could affect the quality of fish habitat for marine fish SAR. Bund wall construction and removal, drydock dewatering, concrete washwater discharge, dredging, blasting and pile driving are the primary nearshore construction activities which could affect the quality of fish habitat in the Nearshore Project Area. The potential effects of these activities include suspended sediment, contamination, and noise and blasting. These effects are fully assessed in Section 7.5.1.2 and mitigation is proposed. This assessment and mitigation is considered applicable to the marine fish SAR species that may occur in the nearshore.

As stated in Section 7.5.1.2, shellfish and eggs and larvae of shellfish and finfish are more susceptible to the effects of sedimentation. Fish SAR are not known to spawn within the Hebron Nearshore Study Area, but newly settled juvenile cod are known to occur and Atlantic wolffish were observed in potential spawning habitat (80 to 90 percent boulder habitat). The localized area of effect from suspended solids and the high potential for reversibility will limit the magnitude of effects as a result of sedimentation.

The EEM results within Bull Arm during the Hibernia GBS construction phase (Christian and Buchanan 1998) tested for the effects of contamination and indicated no detectable effect on fish health as measured by Mixed Function Oxygenase activity, histopathology, bile metabolites or gill parasitism. Mitigation measures will be in place to reduce the risk of contamination during nearshore construction.

With respect to noise and blasting, fish with swim bladders and specialized auditory couplings to the inner ear (e.g., herring) are considered to be most sensitive to sound pressure. Fish with a swim bladder but without a specialized auditory coupling (e.g., Atlantic cod) are moderately sensitive, while fish with a reduced or absent swim bladder (e.g., wolffish, American plaice and American eel) have low sensitivity (Fay 1988).

In-water blasting will be temporary and will be governed by a series of mitigation measures designed to reduce potential effects on marine fish SAR (including wolffish). Any blasting that may be required will adhere to DFO's Guidelines for Use of Explosives in Canadian Fisheries Waters (Wright and Hopky 1998).

Offshore

There are several construction and installation activities in the Offshore Project Area that could affect the quality of fish habitat. Installation of the OLS, flowlines, and Hebron Platform; and geophysical surveys (possibly seismic, VSP, geohazard surveys and/or geotechnical surveys) are the primary offshore construction activities which could affect the quality of fish habitat. Dredging of excavated drill centres and spoils disposal (a potential expansion opportunity) could also potentially affect the quality of fish habitat. The potential effects of these activities include suspended sediment, contamination and noise. These effects are assessed in Section 7.5.1.2 for non-listed fish species. This assessment along with the proposed mitigation measures are considered equally applicable to the protection of marine fish SAR. Seismic activities associated with the Project will adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment, as referenced in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011).

Change in Habitat Use

Nearshore

The increased noise and activity levels associated with dredging, bund wall construction, vessel traffic, blasting, lights and surveys (e.g., geophysical, geohazard, geotechnical, environmental) may affect habitat use by causing avoidance or attraction of marine fish SAR. These effects and potential mitigation are fully discussed in Section 7.5.1.3 for non-listed fish species and are considered applicable to marine fish SAR.

Acoustic modelling of pile driving and blasting at the drydock site in Great Mosquito Cove was conducted. The pile driving model estimated a source level of 216 dB re 1 µPa @ 1 m and that a sound pressure of >190 dB re 1 µPa (rms) will extend to approximately 300 to 400 m from the bottom of Great Mosquito Cove, depending on distance of the bund wall from the shoreline (JASCO 2010). Underwater noise levels from a tug vessel were estimated at 185 dB re µPa @ 1 m during transit and as 193 dB re µPa @ 1 m when the vessel is doing an anchor pull. These are conservative assumptions used for modelling (JASCO 2010). The sound pressure level emitted by the tug is not expected to cause any physical injury to fish, since the 193 dB is the maximum sound pressure expected within 1 m of the tug's propeller (see JASCO 2010). There is limited risk of these interactions occurring given that fish are expected to avoid the area near in-water construction activity.

If blasting were required in Great Mosquito Cove (to provide adequate draft or channel width for the GBS tow-out to the deepwater site), results of acoustic modelling for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998) indicate that greater than 200 dB re 1 uPa (rms) sound exposure levels would occur for approximately 50 m from the blast source, and that sound pressures of between 190 and 199 dB re 1 uPa (rms) sound levels would occur from the

mouth of Great Mosquito Cove to the eastern side of Bull Arm (JASCO 2010). Sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario and therefore, injury to egg and larval stages is not expected (Turnpenny and Nedwell 1994). However, egg masses located in the potential Atlantic wolffish spawning habitat may be subject to increased predation if male Atlantic wolffish abandon the nest due to noise.

Most available literature indicates that the effects of noise on fish are transitory, and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on marine fish SAR (including Atlantic wolffish) as a result of noise should result in negligible effects on individuals and populations.

Offshore

Dredging of excavated drill centres and spoils disposal; installation of the OLS, flowlines, and Hebron Platform; and geophysical, seismic, geohazard and/or geotechnical surveys) are the primary offshore construction activities which could affect the behaviour of marine fish SAR and therefore habitat use. Seismic surveys are expected to produce the highest levels of sound pressure of all the geophysical surveys proposed for this Project. The effects of seismic activities on habitat use in the offshore environment are fully discussed in Section 7.5.1.3, along with proposed mitigation. While this discussion is in the context of non-listed fish species, it is also considered applicable to marine fish SAR.

Atlantic cod may also occur within the Hebron Offshore Project Area. Although cod is being re-assessed by COSEWIC, it is not a species listed under Schedule 1 of SARA. Compared to other species, cod is considered a moderately sensitive species in terms of hearing. A measurable behavioural response is anticipated in the range of 160 to 188 dB re 1 µPa (Turnpenny and Nedwell 1994), likely a temporary avoidance of the immediate area around the noise. DFO (2004a) concludes that some fish exposed to seismic sounds are likely to exhibit a startle response, a change in swimming pattern and/or a change in vertical distribution. However, these effects are expected to be short term and of low ecological significance except where fish reproductive activity may be affected. The greatest risk from noise would also apply to cod eggs and larvae near the surface. Cod larvae may be present on the northern Grand Banks from May to July (Dalley et al. 2000). Cod have not spawned near the Offshore Project Area in recent years, but have done so historically (Ollerhead et al. 2004).

Wolffish may also occur within the Hebron Offshore Project Area, although in lower densities than elsewhere in the Hebron Offshore Study Area. The Recovery Strategy for Northern Wolffish and Spotted Wolffish and Management Plan for Atlantic Wolffish in Canada (Kulka et al. 2007) specifically addresses the potential effects of seismic activity on wolffish. While the report concludes that the impact of seismic activity needs to be quantified with respect to wolffish and their habitat and little is known about the possible effect on wolffish species at any stage of their life history, it is acknowledged that there are no documented cases of mortality of any fish

species upon exposure to seismic sound under field operating conditions (DFO 2004b).

The life stage most likely to be affected by seismic activity is the near surface larval stages. Adults and eggs are generally found on or near bottom at distances of 100 to 900 m away from the surface, reducing the potential for any harm from seismic activities. Therefore, there is a greater potential for effects from seismic activity that overlaps with periods of larval hatching. Kulka et al. (2007) speculate that it is possible that wolffish adults guarding nests could leave the area of disturbance to the detriment of the egg cluster, although there is no information to confirm potential effects for wolffish.

Seismic activities associated with the Project will adhere to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011).

Potential Mortality

Nearshore

Mortality of marine fish SAR during nearshore construction could result from dredging, spoils disposal, bund wall construction and blasting. These effects and proposed mitigation are fully described in Section 7.5.1.4. Past construction experience with the Hibernia Project indicates that suspended sediment levels are unlikely to reach the levels required to incur mortality in finfish (Christian and Buchanan 1998).

The blasting program in the nearshore will be designed to minimize the risk of mortality to fish. Nearshore and in-water blasting will adhere to DFO's Guidelines for Use of Explosives in Canadian Fisheries Waters (Wright and Hopky 1998), which is designed to mitigate fish mortality. In-water sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario (see JASCO 2010) and therefore, fish mortality of marine fish SAR (including Atlantic wolffish) is not expected (Turnpenny and Nedwell 1994).

Offshore

Dredging of excavated drill centres and spoils disposal; installation of the OLS, flowlines, and Hebron Platform; and geophysical, seismic, geohazard and/or geotechnical surveys) have the potential to cause mortality of marine fish SAR. These effects and proposed mitigation are fully described in Section 7.5.1.4 in the context of non-listed marine fish.

Mortality of finfish is unlikely due to increased suspended solids. If elevated levels of suspended solids result from dredging operations before or during a plankton bloom, a localized decrease in primary productivity could result from the inhibition of light penetration. In turn, the food supply for pelagic life stages of fish SAR could be diminished. This could have a localized effect on prey selection for juveniles in some fish species. Juvenile American plaice are the mostly likely fish SAR to be exposed to elevated suspended solids.

Wolffish species and Atlantic cod spawning areas are outside potential dredging areas (Kulka et al. 2007, DFO 2009c).

The environmental effects of the Project during the construction and installation phase and the mitigations to be implemented are summarized in Table 11-4. Where there is more than one potential effect, the evaluation criteria rating is assigned to the effect with the greatest potential for harm.

Table 11-4 Environmental Effects Assessment: Construction and Installation - Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Presence of Safety Zones (Great Musquito Cove zone followed by a deepwater site zone)	• Potential decrease in Mortality (+)		1	2	2/6	R	2
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains or in-water siltation control meadures, if feasible • HADD authorization and compensation • Investigate feasibility of using washed-rock in bund wall construction	1-3	1	3/1	R	2
Inwater Blasting	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters • Bubble curtains, if required • Compliance with terms of Section 32 Fisheries Act authorization (if required)	1-3	2	2/1	R	2
Dewater Drydock and Prep of Drydock Area	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch plant)	• Change in Habitat Quality	• Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be directed to a settling basin • The settling basin will be cleaned on an as required basis to ensure that the retention capacity is maintained at all times	1	1	3/3	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge.)	• Change in Habitat Quality • Change in Habitat Use	• Vessels will use steady speed thereby minimizing noise.	1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route (may require at-sea disposal)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Investigate use of in-water siltation control • Fish Habitat Compensation	1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal).	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• In-water siltation control measures, if feasible • Compliance with terms of Section 32 Fisheries Act authorization (if required)	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Quality • Change in Habitat Use	•	1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Quality	• EMCP will implement a chemical management system, similar to one used during operations offshore	1	1	2/2	R	2
Surveys (e.g., geophysical, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Surveys will only use the power required to attain the data , therby minimizing noise. • Adherence to the Statement	1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Offshore Construction / Installation							
Presence of Safety Zone	• Potential descrease in Mortality (+)		1	2	3/6	R	2
OLS Installation and Testing	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Minimal seabed disturbance, where possible • EMCP will implement a chemical management system • Adherence to relevant regulations	1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quantity • Change in Habitat Use • Change in Habitat Quality	• Minimal seabed disturbance, where possible • EMCP will implement a chemical management system • Adherence to relevant regulations	1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Use		1	4	2/6	R	2
Underbase Grouting	• Change in Habitat Quality	• Use of best practices, continous improvement programs and best available technology	1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Quality		1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Final Platform Location	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Hookup and Commissioning of Platform	• Change in Habitat Quality		1	1	2/1	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / diving / ROVs)	• Change in Habitat Quality • Change in Habitat Use		1	2	3/6	R	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Potential Future Expansion Opportunities							
Presence of Safety Zone	• Potential decrease in Mortality (+)		1	2	3/6	R	2
Excavated Drill Centre Dredging and Spoils Disposal	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Fish Habitat Compensation	1	2	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Minimal seabed disturbance (including seabed debris survey), where possible • Fish Habitat Compensation	1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Quality • Change in Habitat Use	• All chemicals will be screened in accordance with EMDC chemical selection management protocols	1	2	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	2/1	R	2

KEY

Magnitude:
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Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
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No significant residual adverse environmental effects on marine fish SAR from construction and installation activities nearshore and offshore are expected. Effects are generally low in magnitude, of limited geographic extent and reversible. Project environmental effects are not expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1)).

11.4.2.2 Operations and Maintenance

Change in Habitat Quantity

The potential effects of the Project during the operations and maintenance phase on fish habitat quantity will result from the presence of new subsea structures and WBM drill cuttings. There may also be environmental effects associated wit WB and SBM cuttings discharge from a potential future MODU. Primarily the Hebron Platform, and the rock mattress and/or concrete mattress cover over the flowline and OLS will provide new hard substrate habitat to be colonized and perform as an artificial reef. This is more fully discussed in Section 7.5.2.1. No adverse environmental effects are likely for marine fish SAR as a result of changes in habitat quantity during Project operations and maintenance.

The placement of physical structures on or in the bottom substrate / water column could affect wolffish habitat although in a very spatially limited manner compared to the widespread distribution of wolffish and their habitat (Kulka et al. 2007). Wolffish and cod are the most likely marine fish SAR to be attracted by the habitat complexity introduced by subsea structures like flowlines and rock piles, but the attraction may be offset by avoidance at other subsea structures during drilling and dredging activities due to sound. If wolffish or cod are attracted to the structures, the Safety Zones around each structure (minimum of 500 m) should eliminate the chance of individuals being caught in commercial by-catch while they remain in the area.

The environmental effects of excavated drill centre construction are discussed in Section 7.5.1.2. It is anticipated that the same potential environmental effects on non-species at risk marine fish would be applicable to marine fish SAR.

Change in Habitat Quality

Operational discharges (WBMs, seawater discharges, storage displacement water, produced water, drill cuttings, grey and black water; drains) could affect habitat quality for marine fish SAR. In addition, the environmental effect of the discharge of cuttings from a MODU at future excavated drill centres could also affect habitat quality of marine fish SAR. The effects of both drilling and liquid discharges are fully discussed in Section 7.5.2.2 in the context of non-listed fish species. This discussion, along with the proposed mitigation is considered applicable to marine fish SAR.

The environmental effects of drill cuttings discharge from MODU drilling on fish habitat quality are discussed in Section 7.5.2.2. It is anticipated that the same potential environmental effects on non-species at risk marine fish would be applicable to marine fish SAR.

Change in Habitat Use

During the Hebron Project operations and maintenance phase, there is potential for noise generated by geophysical surveys, dredging, vessel traffic, and drilling to affect marine fish SAR habitat use. In addition, the environmental effect of the discharge of cuttings from a MODU at future excavated drill centres could also affect habitat use of marine fish SAR. These effects are fully assessed in Section 7.5.2.3 in the context of non-listed species and this discussion is considered applicable to marine fish SAR.

Since wolffish, cod and plaice are benthic species, they are not expected to be attracted to the surface by increased illumination due to the rig and vessel lights or flares. There are no reports of the porbeagle shark being attracted to lights.

The environmental effects of noise from MODU drilling are discussed in Section 7.5.2.3. It is anticipated that the same potential environmental effects on non-species at risk marine fish would be applicable to marine fish SAR.

Potential Mortality

Seismic surveys have the potential to cause mortality of larval stages of native fish SAR. These effects and proposed mitigation are fully described in Section 7.5.1.4. Operational discharges of WBMs are not likely to result in mortality of marine fish SAR given the motility of each of the species. The presence of a Safety Zone may in effect serve to as a refuge for marine fish SAR.

11.4.2.3 Summary of Environmental Effects of Operation and Maintenance Activities on Marine Fish Species at Risk

The environmental effects of the Project during the operations and maintenance phase and the mitigations to be implemented are summarized in Table 11-5. Where there is more than one potential effect, the evaluation criteria rating is assigned to the effect with the greatest potential for harm.

Operations and maintenance activities are not expected to result in any significant adverse environmental effects on marine fish SAR and habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible. The presence of structures and Safety Zones will create reef and refuge effects, respectively. Results from the EEM programs at Hibernia, White Rose and Terra Nova have confirmed the respective assessment predictions of no significant environmental effect on the marine environment for those production projects.

Table 11-5 Environmental Effects Assessment: Operations and Maintenance – Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Offshore Operations and Maintenance							
Presence of Safety Zone	• Potential decrease in Mortality (+)		1	2	5/6	R	2
Presence of Structures	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Minor positive reef effect, no mitigation required	1	1	5/6	R	2
Lighting	• Change in Habitat Use		1	1	5/6	R	2
Maintenance Activities (e.g., diving, ROV)	• Change in Habitat Use		1	1	5/3	R	2
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)	• Change in Habitat Quality • Change in Habitat Use		1	2	5/6	R	2
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality • Change in Habitat Use	• Screening of chemical in accordance with EMDC's chemical management system	1	2	5/6	R	2
WBM Cuttings	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Re-use of drill mud	1	2	5/2	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Use • Change in Habitat Quality		1	1	5/6	R	2
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	3	3/2	R	2
Potential Expansion Opportunities							
Presence of Safety Zone	• Potential decrease in Mortality (+) • Change in Habitat Use (+)		1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Presence of Structures	• Change in Habitat Quantity • Change of Habitat Quality • Change of Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quantity • Change in Habitat Quality		1	2	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality • Change in Habitat Use	• Screening of chemical in accordance with EMDC's chemical management system	1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	3	3/2	R	2

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2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected.
3 = High: >25 percent of the population or habitat in the Study Area will be affected.

Geographic Extent:
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Duration:
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Reversibility:
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Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects.

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

ExxonMobil Canada Properties (EMCP) will monitor the SARA registry. If new species that are likely to occur in the Study Areas are added to Schedule 1, or if recovery strategies or monitoring plans are implemented, mitigation measures will be reviewed and updated where required, to ensure that they meet their requirements of the SARA.

11.4.2.4 Offshore Decommissioning and Abandonment

The Hebron Project will be decommissioned and abandoned according to C-NLOPB requirements and Newfoundland Offshore Petroleum Production and Conservation Regulations and any other applicable laws and industry practices at that time.

Change in Habitat Quantity

The removal of offshore subsea infrastructure during Project decommissioning and abandonment may affect the quantity of fish habitat in the Hebron Offshore Project Area for marine fish SAR present at that time; however, of less magnitude and geographic extent than during Project construction (see Section 7.5.1.1). The removal of the Hebron Platform, rock and/or concrete mattress cover structures over the OLS and or flowlines, will remove the reef and refuge effect that these structures created.

Change in Habitat Quality

Project decommissioning and abandonment activities may affect the quality of habitat for the marine fish SAR present at that time during the removal of subsea structures through vessel noise and suspended sediments. The environmental effects of these activities are expected to be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and suspended sediments on fish habitat quality are discussed in Section 7.5.3.2.

Change in Habitat Use

Project decommissioning and abandonment activities could affect the behaviour of marine fish SAR present at that time and therefore habitat use. The noise and underwater activity required for removal of subsea structures (e.g., OLS, flowlines and wellhead) will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and underwater activity on fish habitat use are discussed in Section 7.5.3.3.

Potential Mortality

Project decommissioning and abandonment activities have the potential to cause mortality of marine fish SAR present at that time during the removal of subsea structures. Activities will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential for underwater construction activity to cause mortality of fish is discussed in Section 7.5.3.4.

A minor negative environmental effect could result from the removal of a Safety Zone around the Hebron Platform, OLS and flowlines. The refuge effect created by the Safety Zone for some species will be removed upon Project decommissioned and abandoned.

The environmental effects of the Project during the decommissioning and abandonment phase and the mitigations to be implemented are summarized in Table 11-6. Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm.

Table 11-6 Environmental Effects Assessment: Decommissioning and Abandonment – Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Safety Zone	• Potential Mortality • Change in Habitat Use		1	2	3/6	R	2
Removal of the Platform and OLS Loading Points	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Use of best practices, continous improvement programs and best available technology	1	2	2/1	R	2
Lighting	• Change in Habitat Use	• Use of best practices, continous improvement programs and best available technology	1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs and best available technology	1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs and best available technology	1	2	3/1	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use	• Excessive power will not be used therefore reducing noise	1	3	3/6	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	3	3/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]: Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
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Geographic Extent:
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Duration:
1 = < 1 month
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3 = 13-36 months
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Frequency:
1 = <11 events/year
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Reversibility:
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Ecological / Socio-economic Context:
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Decommissioning and abandonment activities are not expected to result in any significant adverse environmental effects on the marine fish SAR present at that time and their associated habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible.

11.4.3 Accidents, Malfunctions and Unplanned Events

The environmental effect of an accidental release of hydrocarbons without the implementation of control measures in the Hebron Nearshore and Offshore Study Areas on marine fish and fish habitat is fully assessed in Section 7.5.4. This assessment is considered applicable to SAR.

11.4.3.1 Change in Habitat Quantity

As described in Section 7.5.4.1, Habitat Quality (nearshore and offshore) could be affected by an uncontained release of marine diesel or IFO-180 or from a blowout offshore. In addition, an accidental release of cuttings and muds (WBMs and/or synthetic-based muds (SBMs)) would likely be contained within the cuttings footprint resulting from routine drilling activities, so would not be considered a loss of available habitat to marine SAR.

11.4.3.2 Change in Habitat Quality

As described in Section 7.5.4.2, the quality of fish habitat is most vulnerable to a diesel spill in the Nearshore Study Area. In the unlikely event of spill (and in the unlikely absence of a spill response), diesel fuel is expected to

reach the shoreline (see Section 14.2). The quality of habitat for marine fish SAR would be most affected by the toxic effects of diesel on potential prey items in shallow subtidal habitats. American plaice are the most likely marine fish SAR to use shallow subtidal habitats within the Nearshore Study Area.

The quality of marine fish SAR habitat in the Nearshore and Offshore Study areas may also be affected by a spill on the surface of the water where eggs or larvae within the slick may experience sub lethal effects, depending on concentration and duration of exposure to hydrocarbons. Depending on the magnitude and extent of a surface spill, pelagic life stages of American plaice or wolffish may be present in the Nearshore and Offshore Study Areas.

In the unlikely event of a subsea blow-out in the Offshore Study Area, the quality of habitat for marine fish SAR is compromised by hydrocarbons in surficial sediments on the seafloor. The availability and condition of prey for American plaice and wolffish would potentially be affected by a subsea blow-out.

Tracker buoy data collected during the 2004 Terra Nova spill indicated that it took five weeks for the buoy to reach 40.00.0W and approximately 48.00.00N in November / December (and basically confirmed the oil spill trajectory modelling results conducted to date for the Grand Banks oil developments). If an uncontrolled spill (i.e., no spill countermeasures implemented) lasted more than 120 days, the modelling predicts that oil from a surface or sub-surface blow-out at the Hebron Platform will extend beyond the model domain area and, therefore, could potentially (less than 10 percent probability) reach an international coastline with a thickness greater than 0.01 mm (i.e., a sheen). However, any oil that did reach an international shoreline would be patchy, weathered oil.

11.4.3.3 Change in Habitat Use

As described in Section 7.5.4.3, an accidental event in the Nearshore or Offshore Study areas could cause a change in fish behaviour and thus affect use of a particular habitat. Juvenile and adult finfish have been known to avoid contaminated areas (Irwin 1997). The ability of fish to avoid a contaminated area must be considered within the context of their habitat requirements. Presumably, if fish were avoiding an area of contamination, they would seek the next uncontaminated area of similar habitat. The habitat seeking behaviour may have consequences on the mortality rates of juvenile fish through predation and on the success of foraging of all life stages, if alternate habitats are not readily available. This scenario is more applicable to the Nearshore Study Area; however, since a spill offshore is unlikely to affect benthic habitat use.

11.4.3.4 Potential Mortality

Fish and shellfish mortality in the Nearshore Project Area may result from the unlikely event of a rupture in the bund wall. Depending on the rate of collapse of the bund wall, some fish near the rupture point maybe entrained in the

surge of water into the drydock area. Fish outside the immediate entrainment area would likely avoid the risk.

In the unlikely event of a spill in either the Nearshore or Offshore Study Areas, lethal effects on eggs and larvae are more likely during an oil spill than adult fish mortality. Eggs and larvae tend congregated in the upper water column where they maybe directly exposed if they occur at the same time and in the same space as an oil spill. This is fully discussed in Section 7.5.4.4. Given the high rate of natural mortality of eggs and larvae, the environmental effects of a localized spill would be undetectable, and recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of a spawning area were lost (Rice 1985).

Oil spill prevention will be incorporated into the design and operations of the Hebron Project. All offshore systems and structures, procedures and programs will be designed with consideration of preventing the loss of any hydrocarbons or chemicals. EMCP will also undertake all of the necessary planning, training, and exercising to ensure that the appropriate spill response capability is in place for all phases of the Project, in the unlikely event of an accident release. Oil spill response will be included as part of the contingency planning undertaken for the Project.

The environmental effects of the potential accidental events and the mitigations to further reduce the likelihood of occurrence and potential effects is summarized in Table 11-7. Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm.

Due to the reversibility and limited duration of an accidental event, potential residual environmental effects of a spill (hydrocarbon or chemical), blow-out or bund wall rupture on marine fish SAR and fish habitat is considered adverse but not significant and not likely to occur. Natural recruitment is expected to re-establish the population to its original level and avoidance of the area is expected to be temporary should an accidental event occur.

Table 11-7 Environmental Effects Assessment: Accidental Events – Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan	1	1	1/1	R	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Spill (at Bull Arm Site)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan	1	3	2/1	R	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	1	5	2/1	R	2
Subsea Blow-out	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	2	5	3/1	R	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Prevention through design standards and maintenance	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan	1	1	2/1	R	2
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Ship operations will adhere to Annex I of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	1	35	2/1	R	2
Collisions (involving Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance	1	3	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

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11.4.4 Cumulative Environmental Effects

11.4.4.1 Nearshore

Cumulative environmental effects on marine fish SAR and fish habitat in the Hebron Nearshore Study Area could occur as a result of the proposed Project in combination with commercial fisheries, which can contribute to physical disturbance during trawling and noise effects, and marine transportation, which can contribute to contamination and noise effects.

It is unlikely that nearshore routine activities associated with marine transportation would have much adverse direct environmental effects on marine fish SAR and fish habitat within the Nearshore Study Area. There is some recreational marine transportation, but other than commercial fisheries-related transportation; there is little commercial vessel traffic within the Nearshore Study Area.

11.4.4.2 Offshore

In the Hebron Offshore Study Area, cumulative environmental effects on marine fish SAR and fish habitat could occur as a result of the proposed Project in combination with the following activities:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activity
- Offshore exploration seismic activity
- Marine transportation and
- Commercial fisheries

A full assessment of the cumulative environmental effects on marine fish and fish habitat offshore is found in Section 7.5.5.2 and is considered applicable to marine fish SAR as well.

For marine fish SAR, overfishing, habitat degradation, pollution and natural variability of the population have caused adverse environmental effects. Fishing pressure and subsequent bottom dragging techniques are significant stresses on some fish resources. Cod are assessed as endangered by COSEWIC due to overfishing. Fishing pressures are expected to remain high to meet market demands which continue the decline or lack of recovery in some fish stocks. Bottom dragging fish gear impacts fish habitat by removing plants, corals, sessile food items, overturning rocks, levelling rock outcrops and re-suspending sediments, ultimately homogenizing the habitat. The proposed Project will represent a negligible incremental increase to the overall cumulative environmental effects to fish SAR as the effect on the seafloor will be localized, of short duration, and any affects on habitat are not expected to overlap between projects. As discussed earlier, the Hebron Offshore Project Area has not been identified as critical habitat for any of the marine fish SAR being assessed and most species occur are less likely to frequent the Project Area than other parts of the Study Area.

Given that the predicted environmental effect of the proposed Project is not significant and given that other oil and gas activities in the Hebron Offshore Project Area are likely to have similar environmental effects on fish and fish habitat and given the limited nature of commercial fishing in the area, and the temporal and spatial overlap with other projects is limited, the cumulative environmental effects of the Project on marine fish SAR are predicted to be not significant. No additional mitigation or follow-up, beyond that identified in Section 7.5.7, is considered necessary.

11.4.5 Determination of Significance

The determination of significance is based on the definition provided in Section 11.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding

analysis. Significance is determined at the population level within the Study Area.

Project construction, operation and decommissioning activities, including malfunctions and accidents and cumulative environmental effects, are predicted to have a not significant residual adverse environmental effect on marine fish SAR. Several of the SAR considered in the assessment are not likely to occur in the Hebron Nearshore or Offshore Project Areas, and there is no critical habitat in the Hebron Nearshore or Offshore Project Areas for any of the species considered. Due to the lack of critical habitat, the transient nature of movements of SAR in the Project Areas, and the low probability of interactions with Project activities, no significant adverse environmental effects are expected on habitat quantity, quality or use, or due to mortality. Mitigative measures planned for the project will also reduce the potential for adverse environmental effects on SAR.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and marine fish SAR, after taking into account any proposed mitigation, is summarized in Table 11-8.

As required by CEAA, an analysis of potential environmental effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on marine fish SAR are predicted that could affect renewable resource use.

Table 11-8 Residual Environmental Effects Summary: Marine Fish Species at Risk

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	2	N/A
Cumulative Environmental Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

11.4.6 Follow-up and Monitoring

EMCP will implement nearshore and offshore EEM programs. The development of the programs will consider fish SAR that may be affected by Project activities.

A fish habitat compensation program will also be implemented.

A monitoring program may be implemented in accordance with the Canadian Environmental Protection Act respecting Ocean Disposal.

11.5 Marine Mammal and Sea Turtle Species at Risk

11.5.1 Project-Valued Ecosystem Component Interactions

Potential interactions between the Project and non-listed marine mammals and sea turtles are evaluated in Chapter 10. The nature of the interactions between the Project and marine mammal and sea turtle SAR will be similar to what is described in this chapter.

Potential interactions between nearshore / offshore Project activities and marine mammal and sea turtle SAR are provided in Table 11-9. Project-VEC interactions are categorized into four types of effects:

- Change in Habitat Quantity: includes interactions which limit habitat availability to marine mammal and sea turtle SAR
- Change in Habitat Quality: includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality
- Change in Habitat Use: includes interactions which affect the behaviour of marine mammal and sea turtle SAR
- Potential Mortality: includes interactions which may cause the mortality of a marine mammal and/or sea turtle SAR

For all Project phases in both the nearshore and offshore Project Areas, the activities that are most likely to interact with marine mammals and sea turtles are those that introduce noise into the water column and the activities that involve vessel traffic.

Table 11-9 Potential Project-related Interactions: Marine Mammal and Sea Turtle Species at Risk

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosquito Cove zone followed by a deepwater site zone)				
Bund Wall Construction (e.g., sheet / pile driving, infilling)	x	x	x	
Inwater Blasting		x	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passender ferry to / from		x	x	x
Lighting			x	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require		x	x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Platform Tow-out from deepwater site		x	x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and testing		x	x	
Concrete Mattress Pads/ Rock Dumping over OLS Offloading Lines		x	x	
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation	x	x	x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location		x	x	
Hookup and Commissioning of Platform			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	x
Air Emissions		x		
Lighting			x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Excavated Drill Centre(s) Dredging and Spoils Disposal		x	x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform,			x	
Hook-up and Commissioning of Drill Centres			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures		x	x	
Lighting			x	
Maintenance Activities (e.g., diving, ROV)			x	
Air Emissions		x		
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		x		

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Chemical Use / Management/Storage (e.g., corrosion inhibitors, well treatment fluids)		x		
WBM Cuttings		x		
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges /		x	x	x
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical,		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres		x	x	
Presence of Structures			x	
WBM and SBM cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Platform and OLS Loading Points	x	x	x	
Lighting			x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	x
Surveys (e.g., geophysical, geological, environmental, ROV, diving)		x	x	
Accidents, Malfunctions, and Unplanned Events				
Bund Wall Rupture			x	
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blow-out		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS,		x	x	x
Marine Vessel Incident (i.e., fuel spills)		x	x	x
Collisions (involving Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)		x	x	
Terra Nova Development (production)		x	x	
White Rose Oilfield Development and Expansions (drilling and production)		x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (nearshore and offshore)		x	x	x
Commercial Fisheries (nearshore and offshore)		x	x	x

11.5.1.1 Nearshore

In the Nearshore Project Area, underwater noise can result from Project activities such as bund wall construction (including pile-driving), in-water blasting, vessel traffic, dredging of the bund wall and possibly sections of the tow-out route to the deepwater site, removal of the bund wall and disposal of materials, and surveys (i.e., geophysical, geohazard, and geotechnical data acquisition). These activities can affect the habitat quality and habitat use by marine mammal and sea turtle SAR. In addition, activities such as in-water blasting and blasting to remove the bund wall, and vessel traffic could affect marine mammal and sea turtle SAR through mortality. Bund wall construction may also affect marine mammals and sea turtles through a limited reduction in habitat quantity.

11.5.1.2 Offshore

Offshore Construction / Installation

During the construction / installation phase in the Hebron Offshore Project Area, underwater noise will result from activities such as (possible) clearance dredging, helicopter overflights, operation of vessels, excavated drill centre dredging, seismic surveys, and other geophysical and geotechnical surveys. These activities could affect habitat quality and habitat use by marine mammal and sea turtle SAR. Other activities that may affect marine mammals and sea turtle SAR include site preparation activities for OLS / Hebron Platform installation and potential expansion opportunities (dredged spoil disposal, installation of subsea equipment and flowlines, placement of flowline protection measures and hook-up to Hebron Platform and commissioning). In addition, operation of vessels could lead to mortality of individuals via collisions. Placement of the Hebron Platform, OLS and flowlines, rock cover and/or concrete mattresses at the offshore site location could also affect the marine mammal and sea turtle SAR through a very limited reduction in habitat quantity.

Operations / Maintenance

During the operations / maintenance phase in the Hebron Offshore Project Area, underwater noise will result from activities such as drilling operations from the Hebron Platform and from a MODU at future excavated drill centres, production operations, helicopter overflights, vessel traffic, presence of subsea equipment and seismic / geohazard surveys. These activities could affect habitat quality and habitat use. Other activities that may contribute to an effect on habitat quality during Project operations include discharges that may reduce water quality in the Offshore Project Area. In addition, there is limited potential for mortality of marine mammal and sea turtle SAR via collisions with vessels.

11.5.1.3 Decommissioning / Abandonment

During the decommissioning / abandonment phase in the Hebron Offshore Project Area, vessel traffic and helicopter overflights and the removal of structures on or above the seafloor will produce underwater noise which may affect marine mammals and sea turtles. As previously mentioned, these activities can affect habitat quality and habitat use. Also, there is some potential for mortality as a result of collisions with vessels.

11.5.1.4 Accidents, Malfunctions, and Unplanned Events

During the construction and operation phases of the Hebron Project, there are several hydrocarbon products carried and used onboard vessels, barges, drill rigs and platforms. These include crude oil, diesel oil, synthetic drilling mud, synthetic drill (base) fluid, lubricating oils, and hydraulic oils. Hydrocarbon spills may occur as a result of human error, equipment failure or loss of well control (blow-out). An oil spill, although highly unlikely, could affect marine mammal and sea turtle SAR and potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. Potential transboundary effects are discussed in Section 11.4.3.2.

11.5.2 Environmental Effects Analysis and Mitigation Measures

Potential environmental effects of the Project on non-listed marine mammals and sea turtle species are assessed and described in detail in Chapter 10. Many of the issues of concern with respect to environmental effects for SAR, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine species in the Study Area in other chapters of this report. On an ecosystem basis, the listed and non-listed species and their habitats are often highly integrated.

The marine mammal and sea turtle SAR that are likely to occur in the Hebron Nearshore Project Area are fin whales and harbour porpoises. The killer whale may occur in small numbers and the blue whale and Sowerby's beaked whale are considered unlikely to occur in the nearshore area. The leatherback turtle may also occur. These are the species upon which the following assessment focuses.

In the Hebron Offshore Project Area, the fin whale is considered the most likely SAR marine mammal to occur, while the harbour porpoise and killer whale may be regular occupants occurring only in small numbers. The Sowerby's beaked whale and blue whale are uncommon in the Offshore Project Area, although Sowerby's beaked whale may be more common in the deep water portions of the Offshore Study Area. The leatherback turtle may also regularly occur, but in small numbers.

11.5.2.1 Construction and Installation

Change in Habitat Quantity

Nearshore

As discussed and assessed in Section 10.5.1.1, while there will be very minimal loss of marine habitat associated with nearshore Project construction, this habitat will be in shallow water. Thus, most marine mammal and sea turtle SAR would not preferentially use this habitat and it is expected to result in a negligible habitat loss for these species. The Hebron Nearshore Project Area has not been identified as critical habitat for any of the marine mammal and turtle SAR considered in this assessment.

Offshore

As discussed and assessed in Section 10.5.1.1, the area of habitat likely to be affected by offshore construction activities would result in a very minimal habitat loss for marine mammal and sea turtle SAR. The Hebron Offshore Project Area has not been identified as critical habitat for any of the marine mammal and turtle SAR considered in this assessment.

Change in Habitat Quality

Changes in habitat quality may result in physical/physiological effects upon the marine mammal and sea turtle SAR. Activities most likely to affect the marine mammal and sea turtle SAR for this Project are blasting, pile-driving, and seismic surveys which produce impulsive sound levels high enough to cause physical / physiological effects in marine mammals (and likely sea turtles). The environmental effects of noise on marine mammals and sea turtles is fully assessed in Section 10.5.1.2. The identified mitigation measures to minimize the risk of injury to marine mammals and sea turtles are considered applicable to SAR as well as non-listed species.

Nearshore

The assessment of noise levels associated with pile driving (Section 10.5.1.2) indicate that there is little risk for hearing impairment to marine mammals or sea turtles beyond 300 m from the pile driving equipment. A monitoring protocol for marine mammals will be established by EMCP prior to the start of construction activities. This protocol will be developed in consultation with DFO and may include the following parameters.

- A trained observer will monitor a designated radius near pile driving activities for at least 30 minutes prior to activation of the pile driver. If a marine mammal or sea turtle (including SAR) is detected within the designated zone (conservatively assume 180 and 190 dB re 1 uPa (rms), for cetaceans and seals, respectively) pile driving will not occur until the animal(s) have left the safety zone, or it has not been re-sighted for 30 minutes

- Pile driving activities will be halted if a marine mammal or sea turtle (including SAR) enters into the safety zone and will not be resumed until the animal has left the zone or 30 minutes have passed since the sighting
- For sea turtles, the 180 dB zone will be used

Of all the Project activities, blasting is most likely to cause physical effects in marine mammals, without proper mitigation. The potential effects of blasting on marine mammals and sea turtles are fully assessed in Section 10.5.1.2. Blasting parameters will be such that they adhere to the DFO guidance outlined in "Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters" (Wright and Hopky 1998). In addition, prior to blasting, a blast impact assessment will be undertaken to determine appropriate marine mammal and sea turtle exclusion zones and these will be implemented during blasting activities. Further detail on this proposed mitigation is found in Section 10.5.1.2.

Sound levels from vessel traffic associated with the Project are not expected to be high enough to cause physical or physiological effects on marine mammals or sea turtles (Richardson et al. 1995). Project activities involving vessel traffic will avoid concentrations of marine mammals and sea turtles whenever possible.

Sounds produced from geohazard surveys generally occur at lower source levels than those of airgun pulses from seismic surveys. Sounds are also typically emitted in a narrow beam, short duration, and sometimes at frequencies outside the range of marine mammal and sea turtle hearing abilities. Standard mitigation measures will be followed for any surveys that use a “seismic air source to generate acoustic waves that propagate through the earth” as per the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment as appended to the Geophysical, Geotechnical, Environmental and Geological guidelines (C-NLOPB 2011).

Offshore

The potential effects of seismic and geohazard sounds on marine mammals and sea turtles in the offshore are fully assessed in Section 10.5.1.2 and considered applicable to SAR. Mitigation measures identified for non-listed species are also considered applicable to marine mammal and sea turtle SAR.

In summary, very little is known about the potential for seismic survey (and geohazard survey) sounds to cause either auditory impairment or other non-auditory physical effects in marine mammal or sea turtle SAR. Available data suggest that such effects, if they occur at all, would be limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals or turtles that might be affected in these ways. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are unlikely to incur auditory impairment or other physical effects.

Mitigation measures will follow those outlined in the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment as appended to Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) considering the seismic survey mitigation measures, there will likely be minimal effects of seismic surveys on marine mammal and sea turtle SAR.

As with the nearshore, sound levels from vessel traffic associated with the Offshore Project activities are not expected to be high enough to cause physical or physiological effects on marine mammal or sea turtle SAR (Richardson et al. 1995). Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Change in Habitat Use

Noise introduced into the water column has the greatest potential to impact the behaviour of marine mammals and sea turtles, as noise is associated with almost every aspect of the construction, operations and maintenance, and decommissioning and abandonment phases of the Project and this VEC is known to be sensitive to noise. The potential for this effects on marine mammals and sea turtles is fully assessed in Section 10.5.1.3 and is considered applicable to marine mammal and sea turtle SAR.

Nearshore

Pile driving produces impulsive sound levels high enough to cause behavioural effects in marine mammal and sea turtle SAR which may result in a change in habitat use. Based on the assessment in Section 10.5.1.3, baleen and toothed whales would likely exhibit at least localized avoidance of the pile-driving sites. There is some evidence to suggest that harbor porpoise echolocation activity may decline, at least temporarily, and that seals may exhibit at least short-term avoidance of the area. There are currently no published data available for behavioural effects of pile driving on sea turtles. Of note, sea turtles are considered rare in inner Trinity Bay near the sites of potential pile driving. Proposed mitigation measures for pile-driving activities should minimize potential effects to habitat use by marine mammal and sea turtle SAR.

Behavioural disturbance, resulting in a change in habitat use, is also a potential effect of blasting operations. However, there are no specific sound levels for blasting activities that are linked with behavioural effects on marine mammals and sea turtles. But as blasting operations will be intermittent in nature and the sound pulse is very short and as further discussed in Section 10.5.1.3, there is little chance of masking of any marine mammal sounds. No information on the environmental effects of blasting on sea turtles is currently available, but sea turtles are considered rare in inner Trinity Bay near the site of potential blasting, particularly during times other than late summer and early fall. The mitigation measure discussed earlier for nearshore blasting operations will serve to further minimize any environmental effects on marine mammal and sea turtle SAR.

Limited information is available on the behavioural changes of marine mammals (and none for sea turtles) resulting from dredging operations, but generally animals have been reported to continue using habitats near dredging operations. Marine mammals common within the Nearshore Study Area during dredging activities, particularly those present for extended periods, are most likely to be affected. Sea turtles are considered uncommon in the Nearshore Study Area. Dredging operations will be temporary and of limited duration. It is planned that proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammal and sea turtle SAR.

Noise generated by vessels associated with the Project has the potential to disturb marine mammals and sea turtles, causing changes in habitat use. Marine mammal and sea turtle responses to ships are presumably responses to noise, but visual or other cues are also likely involved. Tugs and barges will likely produce the greatest and most continuous vessel noise during construction in the Hebron Nearshore Study Area. Factors such as species, maturity, experience, current behaviour state, reproductive state, and time of day likely affect marine mammal responses to vessels. No data are currently available on the response of sea turtles to vessel traffic, but they rarely occur in the Hebron Nearshore Study Area and typically only during late summer or early fall. Marine mammals occurring in the Hebron Nearshore Study Area during periods of increased vessel traffic are most likely to be affected. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible. Additionally, vessels will maintain a steady vessel speed and course whenever possible.

Offshore

As with the nearshore, dredging that occurs consistently for extended periods is most likely to result in behavioural reactions and changes in habitat use for marine mammal and sea turtle SAR. In general, the limited available information suggests that cetaceans tend to remain in occupied areas near dredging sites, but there is no available information on reactions of pinnipeds or sea turtles. It is planned that proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammal and sea turtle SAR. Additionally, suction dredgers will be used to lessen sediment suspension during soil intake, and work periods will be minimized.

The potential effects of vessel traffic on the habitat use of marine mammals and sea turtles are discussed above for the nearshore. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible.

The potential behavioural effects of helicopter overflights in the offshore on marine mammals and sea turtles is assessed in Section 10.5.1.3 and considered appropriate to SAR. Available information suggests that helicopters flying at low altitude (i.e., when approaching a landing site) may disturb some marine mammals directly in its flight path. Occasional aircraft

overflights cause only brief behavioural responses by marine mammals, and it is unlikely that large numbers of marine mammals will be overflown, especially at low altitude. There is no available information on the reaction of sea turtles to aircraft overflight, but single or occasional overflights by helicopters would likely only elicit a brief behavioural response. To avoid disturbance of marine mammals and sea turtles, the helicopter will avoid flying at low altitudes whenever it is safe to do so. Helicopters will typically only reduce altitude on approach for landing. Helicopter landings at offshore platforms would probably affect a very small area with a radius less than 500 m.

A change in habitat use, resulting from behavioural disturbance and avoidance, is the most likely effect of seismic and geohazard surveys on marine mammals and sea turtles, including SAR. A full assessment of this potential effect is found in Section 10.5.1.3 and is considered appropriate to SAR as well as non-listed species. In summary, potential changes in habitat use of the Hebron Offshore Study Area by marine mammals and sea turtles, including SAR resulting from seismic surveys include behavioural effects and avoidance. Baleen whales tend to avoid operating airguns, but at variable avoidance radii. Some dolphins occasionally approach active seismic vessels, but studies of toothed whale reactions to seismic surveys generally show temporary avoidance. Only slight (if any) avoidance has been shown by pinnipeds. Limited studies of the effects of seismic surveys on sea turtles suggest that they will exhibit behavioural and/or avoidance within some distance of an operating seismic vessel. Short-term avoidance behaviour, however, does not necessarily provide information about long-term effects such as reproductive rate or distribution and habitat use in subsequent days or years. Additionally, effects likely vary between species, location, and past exposure to seismic sounds.

Mitigation measures will be employed to minimize the potential for effects on marine mammals and sea turtles. Mitigation measures will follow those outlined in the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment as appended to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011).

Potential Mortality

Nearshore

Sound levels associated with mortality in marine mammals from blasting have not been established. The short rise time to a high peak pressure of shock pulses from explosives appears to be responsible for much of the damage, including mortality, to marine mammals during these detonations (Ketten 1995). While there is potential for mortality of marine mammals or sea turtles to occur as a result of nearshore blasting (Section 10.5.1.4), the mitigation measures proposed for this Project will make this occurrence unlikely.

The risk of mortality due to vessel collisions is also of concern (Section 10.5.1.4). Large species of whales like blue and fin whales and sea turtles that spend extended periods near the surface would be particularly

susceptible to ship strikes. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Particularly in the Hebron Nearshore Study Area, vessels associated with the Project will typically be engaged in activities that require a slow speed or maintenance of a stationary position, which will also reduce the risk of a collision. Vessels will deviate from their course to avoid marine mammals and sea turtles, if necessary.

Offshore

As discussed for the nearshore, there is a risk of vessel collision with marine mammal and sea turtle SAR resulting in serious injury or mortality. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Vessels will reduce speed whenever possible and deviate their course to avoid marine animals.

The potential for seismic surveys to result in serious injury, death, or stranding for marine mammals and sea turtles is assessed in Section 10.5.1.4 and is considered applicable to SAR. This discussion concludes that there is no definitive evidence that airguns can lead to strandings or mortality even for marine mammals in close proximity to large airgun arrays. Sea turtle mortality has not been documented to occur as a result of exposure to seismic surveys. The mitigation measures outlined in the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment as appended to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) will be followed to minimize environmental effects on marine mammals and sea turtles, including SAR.

The environmental effects of the Project construction and installation activities on marine mammal and sea turtle SAR are summarized in Table 11-10.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible at the population level, there are not likely to be significant residual adverse environmental effects on marine mammal and sea turtle SAR from construction or installation activities associated with the Project. Project environmental effects are not expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1)).

Table 11-10 Environmental Effects Assessment: Construction and Installation – Marine Mammal and Sea Turtle Species at-Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Potential use of bubble curtains • Safety Zone • Monitoring	2	3	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters • Potential use of bubble curtains • Safety Zone • Monitoring	2	3	2/1	R/I [B]	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch)	• Change in Habitat Use		1	1	3/3	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	3/6	R/I [B]	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use	• Potential use of bubble curtains • Safety Zone • Monitoring	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Quality • Change in Habitat Use	• Planning • Equipment design	2	3	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Change in Habitat Quality • Change in Habitat Use	• Potential use of bubble curtains • Safety Zone • Monitoring	1	3	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	3	1/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use	• Avoid animal concentrations when possible • Maintain steady speed and course when possible	1	3	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Use		1	1	3/6	R	2
Offshore Construction / Installation							
OLS Installation and Testing	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Quality • Change in Habitat Use		1	3	2/6	R	2
Underbase Grouting	• Change in Habitat Use		1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour on Seafloor around final Platform Location	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Hookup and commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low altitudes when possible	1	2	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course	1	3	3/6	R/I [B]	2
Air Emissions	• Change in Habitat Quality		N	5	3/6	R	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Potential Expansion Opportunities							
Excavated Drill Centre(s) Dredging and Spoils Disposal	• Change in Habitat Quality • Change in Habitat Use	• Planning	1	3	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use	• Adherenece to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	2/1	R	2

KEY

N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

11.5.2.2 Operations and Maintenance

Change in Habitat Quantity

None of the Project activities during the Operations and Maintenance phase are expected to affect the habitat quantity of marine mammal and sea turtle SAR.

Change in Habitat Quality

Noise effects from Project operations and maintenance activities can potentially diminish habitat quality and influence habitat use by marine mammal and sea turtle SAR. These potential noise effects are discussed above in Section 10.5.2.1.

Other activities that may contribute to an effect on habitat quality during Project operations include discharges that may reduce water quality in the Hebron Offshore Study Area. Air emissions are expected to have a negligible effect on the habitat quality of marine mammal and sea turtle SAR. These discharges are fully assessed in Section 10.5.2.2 for marine mammals and sea turtles and this assessment is considered applicable to SAR, including identified mitigation. These activities are expected to have minimal effect on marine mammal and sea turtle SAR.

Change in Habitat Use

Many Project activities predicted to have an effect on habitat use during the operations and maintenance phase of the Project have been discussed above under construction (e.g., seismic surveys, vessel and helicopter traffic). Effects on habitat use specific to the operations phase including noise associated with drilling are assessed in Section 10.5.2.3 for marine mammals and sea turtles and are considered applicable to SAR.

Potential effects of the presence of structures on marine mammals and sea turtles including SAR are mainly related to the effects of sound produced by offshore structures and activities. Marine mammals would most likely avoid the immediate area around drilling activities due to physical activities and underwater sound generated. Artificial light might attract prey species of the marine mammal and sea turtle SAR and result in a positive environmental effect on its habitat use.

Potential Mortality

As discussed above for the construction phase, the key routine Project activity which is most likely to result in mortality is the operation of vessels. The presence of vessels during various Project activities can increase the risk of mortality via vessel collisions with marine mammal and sea turtle SAR. Large species of whales (such as blue and fin whales) and sea turtles (like leatherback sea turtles) that spend extended periods near the surface would be most susceptible to ship strikes. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and

course in order to avoid potentially fatal collisions with marine mammals and sea turtles, including SAR. Vessels will deviate from their course to avoid animals in their path.

The environmental effects of operation and maintenance activities on Marine Mammal and Sea Turtle SAR are summarized in Table 11-11.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible, there are not likely to be significant residual adverse environmental effects on marine mammal and sea turtle SAR from operations and maintenance activities associated with the Project.

Table 11-11 Environmental Effects Assessment: Operations and Maintenance – Marine Mammal and Sea Turtle Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Quality • Change in Habitat Use		1	1	5/6	R	2
Lighting	• Change in Habitat Use		1	1	5/6	R	2
Maintenance Activities (e.g., diving, ROV)	• Change in Habitat Use		1	2	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)	• Change in Habitat Quality		1	1	5/6	R	2
Chemical Use/Management / Storage (e.g., corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality		1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	5/6	R/I[B]	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	3/2	R	2
Potential Expansion Opportunities							
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quality • Change in Habitat Use		1	3	3/6	R	2
Presence of Structures	• Change in Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Treatment of SBM cuttings in accordance with the OWTG	1	1	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use	• Adherence to Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011) • Safety Zone • Monitoring • Delay start, shutdown • Ramp-up source	2	4	3/2	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2= Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

11.5.2.3 Offshore Decommissioning and Abandonment

Change in Habitat Quantity

The removal of the Hebron Platform and OLS loading points will result in a minimal habitat gain for marine mammal and sea turtle SAR. However, considering the lack of specific habitat for marine mammals and limited habitat use by turtles, the effect is not considered to be significant.

Change in Habitat Quality

Removing structures (Hebron Platform and OLS loading points), plugging and abandoning wells, light emissions, vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat quality. The potential effects of these activities are expected to be similar (or less than) those of construction or operation and maintenance (assessed in Sections 10.5.1.2 and 10.5.2.2); therefore, no significant adverse environmental effects are predicted.

Change in Habitat Use

Removing structures (Platform and OLS loading points), plugging and abandoning wells, light emissions, vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat use. The potential effects of these activities are expected to be similar (or less than) those of construction or operation (assessed in Sections 10.5.2.1 and 10.5.2.2); therefore, no significant adverse environmental effects are predicted.

Potential Mortality

Similarly to construction, and operations / maintenance phases, the key Project activity which has the potential to have an effect on mortality of marine mammal and sea turtle SAR is the operation of vessels (see Chapter 10). The potential effects of this activity is expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

The environmental effects of Project decommissioning and abandonment on marine mammal and sea turtle SAR are summarized in Table 11-12.

Given that Project activities are mostly localized, of low magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine mammal and sea turtle SAR from decommissioning and abandonment activities associated with the Project.

Table 11-12 Environmental Effects Assessment: Decommissioning and Abandonment – Marine Mammal and Sea Turtle Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Habitat Quantity • Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Use		1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	2	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course	1	3	3/6	R/I [B]	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	3/2	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected.[B] Reversible at the population level but irreversible at the individual level

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

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11.5.3 Accidents, Malfunctions and Unplanned Events

The effect of an accidental release of hydrocarbons without the implementation of control measures in the nearshore and offshore on marine mammals and sea turtles is assessed in Section 10.5.4 and considered applicable to SAR. Spills in the nearshore would be attributable to vessel malfunctions and similar effects and mitigation discussed for the offshore are applicable to the nearshore scenarios; therefore, nearshore and offshore effects are assessed together.

It is difficult to predict with precision the effects of accidental events on biota, especially as they relate to the geographic extent of the effects. Numerous parameters (e.g., chemical composition of the hydrocarbon, behaviour of spilled substance at different times of year) influence hydrocarbon spill characteristics and there are many unknowns concerning specific effects on different marine mammal and sea turtle groups.

For marine mammal and sea turtle SAR, it is probable that only small proportions of populations are at-risk at any one time in either the Nearshore or Offshore Study Area (see Section 10.5.4). Typical oil spill countermeasures (oil spill response plan, training, preparation, an equipment inventory, and conducting emergency response drills) and the associated disturbance would likely reduce the number of animals exposed to oil. Depending on the time of year, location of animals within the affected area, and type of oil spill or blow-out, the effects of a Nearshore or Offshore oil release on the health of cetaceans is predicted to range from negligible to low magnitude over varying geographic extents (Table 11-13). These geographic extents were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b). Based on present knowledge of the Trinity Bay and Grand Banks ecosystems, the modelling exercises, and on past monitoring experience with large spills with much worse scenarios than offshore on the Grand Banks, it can be predicted with confidence that an oil spill associated with the Project will not result in any significant residual environmental effects to marine mammal or sea turtle SAR in the Study Areas.

11.5.4 Cumulative Environmental Effects

Hebron Project activities are considered in combination with the following activities in the assessment of cumulative environmental effects:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activity
- Offshore exploration seismic activity
- Marine transportation and
- Commercial fisheries

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Table 11-13 Environmental Effects Assessment: Accidental Events – Marine Mammal and Sea Turtle Species at-Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Use		1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	4-5	2/1	R/I [B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R/I [B]	2
Subsea Blow-out	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	3/1	R/I [B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R/I [B]	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	1	2/1	R/I [B]	2
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Mortaliy	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	5	2/1	R/I [B]	2
Collisions (involving Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	3	2/1	R/I [B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
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Duration:
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Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
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2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

11.5.4.1 Nearshore

Cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area as fewer activities have the potential to interact with the current Project (see Section 11.5.4.2 for cumulative environmental effects assessment of the Offshore Study Area).

11.5.4.2 Offshore

The potential for cumulative environmental effects on marine mammal and sea turtle SAR is essentially the same as the potential cumulative environmental effects on non-listed species, although it is acknowledged that due to the status of these populations, they may be more vulnerable to even limited Project effects compared to more stable populations. In general, the proposed Project's contribution to any cumulative environmental effects is limited in comparison to the influences on these species throughout their range that have caused these species to reach their current population levels.

Routine offshore oil and gas activities that can affect marine mammals at-risk include geophysical surveys, construction and drilling and production activities. As discussed in previous sections, the most likely environmental effects from these activities are disturbance. As described above, all operators must adhere to the Geophysical, Geological, Environmental and

Geotechnical Guidelines (C-NLOPB 2011), thereby reducing the potential for cumulative environmental effects from geophysical surveys.

Marine mammal reaction to construction is likely temporary avoidance behaviour. Richardson et al. (1995) predicted the radius for a response to noise during development and production activities for baleen and odontocetes to be less than 100 m. Collisions between support vessels and marine mammals at-risk are not likely given the vessel speeds within the Project Area. No cumulative environmental effects are expected with helicopter traffic due to the localized and temporary nature of this disturbance. The overall potential for cumulative environmental effects of these projects and activities on marine mammal SAR is considered non significant.

Routine offshore oil and gas activities resulting in noise and disturbance impacts to sea turtles could result in cumulative environmental effects. Few studies have been undertaken on the effects of anthropogenic noise on sea turtles; however, it is assumed that noise from the various offshore sources could result in temporary disturbance to individuals. Although the environmental effects of noise from this Project are not expected to be significant, it will add noise that sea turtles are exposed to within the Study Area. Sea turtles densities are low in the Project Area. There is no evidence to suggest that oil and gas activities and increased vessel traffic result in adverse significant environmental effects to sea turtles populations. Based on the environmental effects criteria, the disturbance effects are considered non-significant and not to add measurably to cumulative environmental effects on sea turtles.

In offshore Newfoundland waters, leatherback turtles feeding in the area may be affected by entanglement in and ingestion of debris. Entanglements in fishing lines, lobster pot lines, nets and other fishing gear have been reported. Sea turtles either ingest baited hooks or become entangled or hooked externally or both (Witzell 1999; Smith 2001). There is no known directed take of sea turtles in Canadian waters. The take of sea turtles at sea or on nesting beaches in other areas is seen as a threat to all species of sea turtles.

Given the predicted minimal effects of other projects / activities, the large size of the Offshore Study Area and the prediction that the residual environmental effects of the proposed Project's routine activities on the marine mammal and sea turtle SAR through the difference Project phases are not significant (see Section 11.5.5), the cumulative environmental effects on marine mammal and sea turtle SAR are also predicted to be not significant.

11.5.5 Determination of Significance

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and marine mammal and sea turtle SAR, after taking into account any proposed mitigation, is summarized in Table 11-14.

Table 11-14 Residual Environmental Effects Summary: Marine Mammal and Sea Turtle Species at Risk

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Environmental Effects	NSW	3	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Levels of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

The environmental effects of routine activities associated with the construction / installation, operations / maintenance, and decommissioning / abandonment phases of the Project on marine mammal and sea turtle SAR are predicted to be not significant (Table 11-14).

The environmental effects of routine activities associated with accidents, malfunctions and unplanned events of the Project on the marine mammal and sea turtle SAR are also predicted to be not significant (Table 11-14).

As required by CEAA, an analysis of potential effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on marine mammal and sea turtle SAR are predicted that could affect renewable resource use.

11.5.6 Monitoring

For nearshore Project activities where in-water blasting occurs, EMCP will implement a marine mammal observation program. The program will be developed in consideration of DFO blasting guidelines, and in consultation with DFO. For seismic activities in the Offshore Study Area, EMCP will implement a marine mammal and sea turtle observation program. The program will be consistent with the requirements outlined in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011). Data on marine mammal and sea turtle observations will be provided to DFO and the C-NLOPB where applicable.

Specific follow-up programs to verify the accuracy of assessment predictions and the efficacy of mitigation measures are not planned for marine mammal and sea turtle SAR.

11.6 Marine Bird Species at Risk

11.6.1 Project-VEC Interactions

Potential interactions between the Project and non-listed marine birds are evaluated in Chapter 9. The nature of the interactions between the Project and marine bird SAR will be similar to what is described in these sections. In the nearshore, the Project could interact with the Red Knot or Ivory Gull. In the offshore, the Ivory Gull is the only marine bird SAR expected to occur in the Study Area.

Potential interactions between nearshore/offshore project activities and marine bird SAR are provided in Table 11-15. Project-VEC interactions are categorized into four types of effects:

- Change in Habitat Quantity: includes interactions which limit habitat availability to marine birds
- Change in Habitat Quality: includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality
- Change in Habitat Use: includes interactions which affect the behaviour of marine birds and
- Potential Mortality: includes interactions which may cause the mortality of a marine bird

Table 11-15 Potential Project-related Interactions: Marine Bird Species at Risk

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Musquito Cove zone followed by a deepwater site zone)				
Bund Wall Construction (e.g., sheet / pile driving, infilling)	x		x	
Inwater Blasting		x	x	x
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)			x	
Lighting		x	x	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)			x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	
Tow-out of GBS to Bull Arm deepwater site			x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Platform Tow-out from deepwater site	x		x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and Testing			x	
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines			x	
Installation of Temporary Moorings			x	
Platform Tow-out / Offshore Installation			x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location			x	
Hookup and Commissioning of Platform			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)			x	
Air Emissions		x		
Lighting		x	x	
Potential Expansion Activities				
Presence of Safety Zone				
Excavated Drill Centre(s) Dredging and Spoils Disposal			x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation			x	
Hook-up and Commissioning of Drill Centres			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures			x	
Lighting		x	x	
Maintenance Activities (e.g. diving, ROV)			x	
Air Emissions		x		
Flaring			x	x
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		x		x
Chemical Use/Management / Storage (e.g., corrosion inhibitors, well treatment fluids)		x		
WBM Cuttings		x		
Operation of Helicopters			x	

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Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)			x	x
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres			x	
Presence of Structures			x	
WBM and SBM cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Platform and OLS Loading Points			x	
Lighting		x	x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)			x	
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture		x	x	
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blow-out		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)		x	x	x
Marine Vessel Incident (i.e., fuel spills)		x	x	x
Collisions (involving Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (drilling and production)	x	x	x	x
Terra Nova Development (production)	x	x	x	x
White Rose Oilfield Development and Expansions (drilling and production)	x	x	x	x
Offshore Exploration Drilling Activity	x	x	x	x
Offshore Exploration Seismic Activity			x	
Marine Transportation (nearshore and offshore)			x	x
Commercial Fisheries (nearshore and offshore)			x	x

11.6.1.1 Nearshore

Nearshore Project activities may have effects on habitat quantity, habitat quality, and habitat use for marine bird SAR. Activities most likely to cause disturbance (i.e., change in habitat use) include pile driving (bund wall construction), blasting, vessel traffic and dredging. Lighting during periods of darkness may attract marine bird SAR, which may strike vessels or infrastructure leading to injury or strandings (although SAR are more likely to become airborne again after stranding than some non-listed marine birds). Several activities (e.g., blasting, dredging, pile driving, and vessel traffic) may also lead to temporary disturbance of marine birds in a localized area. Direct mortality of marine bird SAR is not expected to be an environmental effect of most routine activities in the Hebron Nearshore Study Area.

11.6.1.2 Offshore

Offshore Construction / Installation

Offshore construction / installation activities may result in effects on habitat use, and, to a lesser extent, habitat quality and habitat quantity (e.g., placement of Hebron Platform). Activities most likely to cause disturbance (e.g., effects on habitat use) include the operation of helicopters, the operation of vessels, seismic surveys and dredging activities. Lighting at night throughout the Project may attract Ivory Gull, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality. However, Ivory Gull are less likely to strand than other marine bird species (such as Leach's Storm-Petrel, discussed in Chapter 9) since they can easily become airborne again after landing. The risk of hearing impairment to Ivory Gull from seismic surveys is low as this species would not spend considerable amounts of time below the surface of the water or in close proximity to airgun pulses. In addition, several activities may also lead to temporary disturbance of Ivory Gull in a localized area. With the exception of collisions with infrastructure, mortality of Ivory Gull is not expected to be an environmental effect of activities in the Offshore Study Area during the construction / installation Phase.

Operations / Maintenance

Operations / maintenance activities may result in changes to habitat quality and habitat use, with flaring being the primary routine Project activity that may result in mortality effects. Lighting and flaring at night and periods of low visibility for the duration of the Project may attract Ivory Gull, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality (although Ivory Gull are more likely to become airborne again after stranding than some other marine birds). Activities that are most likely to cause disturbance include the operation of helicopters, the operation of vessels and seismic surveys. The discharges of fluids or solids could foul the feathers of Ivory Gull and possibly lead to ingestion of non-biological substances, which may lead to mortality. The risk of hearing impairment to Ivory Gull from

seismic surveys is low as this species would not spend considerable amounts of time below the surface of the water or in close proximity to airgun pulses.

Decommissioning / Abandonment

Effects of Project decommissioning / abandonment activities may affect habitat use by Ivory Gull, similarly to those effects experienced during the construction and operations phases. Lighting may attract birds, which may strike vessels or platform infrastructure leading to injury, strandings, or mortality (although, as noted above, this is less of a concern for Ivory Gull than other marine birds). In addition, the operation of helicopters and vessels may also lead to temporary disturbance in a localized area.

Accidents, Malfunctions and Unplanned Events

The unintentional release of hydrocarbons is the primary accidental event with the potential to affect marine bird SAR. An oil spill, although unlikely, could occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. Accidental events could result in a change in habitat quality and/or mortality.

11.6.2 Environmental Effects Analysis and Mitigation Measures

Potential environmental effects of the Project on non-listed marine bird species are assessed and described in detail in Chapter 9. Many potential effects for marine bird SAR, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine bird species.

There is limited information and few detailed studies regarding the effects of construction and offshore industrial activities on marine birds. However, noise and routine discharges are the most likely activities to affect the habitat quality of marine birds, while lighting, vessel traffic and helicopter overflights are the most likely activities to affect the habitat use of marine birds. Blasting and flaring, as well as collisions with infrastructure, may also lead to mortality of marine birds.

Two species comprise the marine bird SAR VEC: the Red Knot and the Ivory Gull (see Table 11-2). As stated previously, neither marine bird species is common in the Nearshore or Offshore Study Area.

11.6.2.1 Construction

Change in Habitat Quantity

Nearshore

In the Nearshore Project Area, construction of the bund wall could result in a limited reduction of available habitat. However, it should be noted that this will represent a relatively small footprint within an area that has previously been disturbed during construction activities of other projects (i.e., does not represent a loss of important marine bird habitat).

Offshore

The placement of the Platform at the offshore site location could result in minimal habitat loss for the Ivory Gull. Given the relatively small footprint of the Hebron Platform within total available habitat, rare occurrence of the Ivory Gull offshore, and reversibility of the effect once the Hebron Platform is removed, this effect is not considered to be significant.

Change in Habitat Quality

The effects of Project construction activities on habitat quality for marine birds are fully assessed in Section 9.5.1.2 and are considered applicable to marine bird SAR, including the identified mitigation.

Nearshore

Pile driving produces impulsive sound levels high enough that it may temporarily disturb marine bird SAR that are present in close proximity. The effects of pile driving on the Red Knot or Ivory Gull are not known. Pile driving activities will occur in a small area and it is unlikely that either species will occur in close proximity to the bund wall location.

As described in Section 9.5.1.2, blasting is the construction activity that is most likely to affect marine bird SAR in the Nearshore Study Area. Underwater shock waves resulting from blasts could injure or kill birds that are present at the time of the blast. Birds that are underwater are more likely to be affected than those on the surface of the water. Available information suggests that the estimated safe ranges to avoid death or severe injury for birds on the surface, 1 m below the surface, and at 15 m depth are 8, 119 and 262 m, respectively. No information is available on the likelihood of injury to birds on the shore at the time of a blast, but it is expected that effects will be reduced versus birds on the water. In the case of the Red Knot and Ivory Gull, it is very unlikely that either species will occur within 300 m of the blasting location in the Nearshore Study Area. Furthermore, neither species spends considerable time below the water's surface.

EMCP will develop protocols that will include an observer placed nearby the blasting site to monitor if the Red Knot or Ivory Gull is present within the safety zone of the blast location. If a bird enters the safety zone, blasts will be delayed until the birds(s) move outside the designated safety zone (which will be determined in consultation with the Canadian Wildlife Service (CWS) after details of the blasting program are known).

Increased lighting at night or in low-light periods, can attract birds, which may cause them to strike lights and associated infrastructure. This effect is much more likely for marine birds other than the Red Knot and Ivory Gull. Given the reduced susceptibility of these species and their rare presence in the vicinity of lighted structures associated with the Project, no individuals are expected to be affected due to lighting.

Offshore

The Red Knot is not expected to occur in the Offshore Study Area and will not be considered further in the assessment of offshore activities. Activities that are most likely to affect the Ivory Gull include lighting, operation of vessels, operation of helicopters, and seismic surveys.

As described above, Ivory Gulls could be attracted to lights at night or in low visibility conditions (e.g., fog). This effect is much more likely for marine birds other than the Ivory Gull, as described in Section 9.5.1.2. Given the reduced susceptibility of the Ivory Gull and its rare presence in the vicinity of lighted offshore structures associated with the Project, no individuals are expected to be injured due to lighting in the Offshore Study Area.

Sounds from seismic surveys may cause physical effects to marine birds that are underwater and are in close proximity to operating airguns. However, the Ivory Gull is not expected to dive more than 1 m below the water's surface, and thus has a much reduced risk of adverse environmental effects of seismic sound exposure. Therefore, the remaining disturbance effects related to seismic surveys on the Ivory Gull are those associated with the operation of vessels. However, Ivory Gulls are only expected to occur occasionally in the Offshore Study Area (i.e., during the winter), when the likelihood of seismic operations is reduced.

Change in Habitat Use

Nearshore

Very little information is available specific to the effects of construction or offshore operations on either the Ivory Gull or the Red Knot. One study (Burger et al. 2007) included an assessment of Red Knot disturbance by humans, cars, airplanes and dog presence. The shorebirds that were studied, responded most strongly to the presence of dogs and did not return to the location within the 10-minute post-disturbance monitoring period. Red Knots also appeared to be more responsive to humans than to cars or planes, showing moderate signs of recovery to pre-disturbance levels within 30 seconds of car or plane disturbance relative to periods greater than the defined 10 minutes for human disturbance. In the same study, Laughing and Herring Gulls recovered to pre-disturbance levels within 5 minutes. When studying the relative number of estuarine waterbirds as a function of distance to human-made structures, Burton et al. (2002) found that Red Knot numbers were measurably lower in areas where a human footpath was within 150 m. However, no such effects were observed in association with roads, railroads, or towns.

The Red Knot or Ivory Gull may be temporarily disturbed by passing vessels associated with activities in the Nearshore Study Area. The limited available information suggests that the Red Knot is temporarily disturbed by boat presence, although the approach distances that elicit disturbance are not known. Some gull species may also be attracted to vessels, but it is unknown if Ivory Gulls are attracted to vessels. Vessels of large size, which are fast-

moving, or move with an erratic course are more likely to disturb birds, but vessels operating within the Nearshore Study Area will typically be moving at slow speeds or will remain stationary for extended periods of time.

To the extent practicable, vessels associated with the Project will maintain a steady course and speed. Vessels will maintain a distance from Bellevue Beach to avoid disturbing the Red Knot, particularly from late August to October. Areas where the Ivory Gull or Red Knot occur in the Nearshore Study Area will be avoided to the extent practicable.

For Red Knot in particular, known areas of use have been identified for this species at Bellevue Beach. This location is outside of the Nearshore Project Area and therefore would have little interaction with routine Project construction activities other than passing vessel traffic.

Offshore

As described above, vessel operations may lead to temporary and localized disturbance of the Ivory Gull. However, the Ivory Gull could also be attracted to Project vessels, similar to responses seen in other gull species, particularly if food waste or other waste is discharged overboard. Vessels will maintain a steady speed and course, and waste discharges from vessels will be limited to the extent practicable and will conform with MARPOL requirements. Most marine birds flush or dive in response to low-flying aircraft, presumably including the Ivory Gull, but it is thought that the significance of these disturbances is low for infrequent flights at low altitudes. Low altitude flights will typically only occur during landings in the Offshore Study Area.

As with current regular helicopter servicing of offshore platforms in the Jeanne d'Arc Basin, helicopters used for the Project will likely be based at St. John's Airport and will generally fly "straight" to the Offshore Study Area. Helicopters will be directed to avoid the closest marine bird colonies (e.g., Witless Bay Ecological Reserve) and any known concentrations. The Wilderness and Ecological Reserves Act states that no aircraft will fly lower than 300 m or take off or land within the reserve during the period 1 April to 1 September.

Potential Mortality

The only routine Project construction / installation activity that may result in mortality of marine birds SAR is blasting in the nearshore. The mitigation in place for blasting (i.e., use of an observer near the blasting site to monitor if the Red Knot or Ivory Gull is present within the safety zone of the blast location) will reduce the potential for any injury or mortality to marine bird SAR as a result of nearshore construction activities.

The environmental effects of Project construction/installation on marine bird SAR are summarized in Table 11-16.

Table 11-16 Environmental Effects Assessment: Construction and Installation – Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (e.g., sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Use		1	2	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters • Monitor appropriate safety zone for diving birds	1	2	2/1	R/I [B]	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch)	• Change in Habitat Use		1	1	3/3	R	2
Vessel Traffic (e.g., supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	• Change in Habitat Use	• Maintain steady course and speed	1	2	3/6	R	2
Lighting	• Change in Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds per CWS protocol	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Use		1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging/ocean disposal)	• Change in Habitat Quality • Change in Habitat Use	• Monitor appropriate safety zone for SAR	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental)	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Use		1	1	3/6	R	2
Offshore Construction/Installation							
OLS Installation and Testing	• Change in Habitat Use		1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Use • Change in Habitat Quantity		1	4	2/6	R	2
Underbase Grouting	• Change in Habitat Use		1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Final Platform Location	• Change in Habitat Use		1	1	2/1	R	2
Hook-up and Commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes, where possible	1	1	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shutle tankers / barges / diving / ROVs)	• Change in Habitat Use	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	5	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	2	3/6	R	2

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Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Potential Expansion Opportunities							
Excavated Drill Centre(s) Dredging and Spoils Disposal	• Change in Habitat Use		1	1	2/1	R	2
Installation of pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use		1	3	2/1	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2= Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

Given that Project activities are highly localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine bird SAR from construction or installation activities associated with the Project. Project environmental effects are not expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1)).

11.6.2.2 Operations and Maintenance

The environmental effects and mitigation measures of routine operations in the Offshore Study Area on marine birds, including SAR, are assessed in Section 9.5.2. The Red Knot is not expected to occur in the Offshore Study Area and will not be considered further in the assessment of offshore activities.

Change in Habitat Quantity

None of the Project activities in the Offshore Study Area during the operations and maintenance phase are predicted to result in changes in habitat quantity for marine birds SAR.

Change in Habitat Quality

Primary Project activities that could result in changes in habitat quality for Ivory Gulls include lighting and flaring, operational discharges and seismic surveys. Lighting and seismic surveys are discussed above for construction (Section 11.6.2.1).

Night-migrating or night-active marine birds might be attracted by flaring in the Offshore Study Area, similar to the effect described for lighting (above). This is less likely to affect the Ivory Gull. The heat and noise generated by the flare may also deter marine birds from the immediate area under most night-time conditions. When attracted to the flare, marine birds may strike infrastructure and become injured or strand. However, the Ivory Gull is more likely to become airborne again after stranding than other marine birds (see Chapter 9). EMDC will develop protocols for monitoring marine birds. As in the case of lighting (described above), a program to search the platform in the morning, followed by release of stranded birds (per the protocol of Williams and Chardine (1999)) will reduce the impact on marine birds.

Gulls may be attracted to vessels and the platform; these birds may rest on the water, making them more likely to come in contact with discharges. Some marine birds, particularly gulls, may be attracted to sewage particles, but the small amount discharged below the surface over short periods are unlikely to increase the abundance of marine birds in the Hebron Offshore Study Area. To minimize the possibility of fouling marine bird feathers, fluids will be discharged below the water's surface whenever possible. It is predicted that the residual environmental effect of fluid/solid storage or discharge on the habitat quality of marine birds in the Offshore Study Area will affect a limited area and be of low magnitude.

Change in Habitat Use

Potential changes in habitat use during Hebron Project operations relate primarily to the presence of the structures (and associated lighting), vessel and helicopter traffic, seismic surveys, and other activities that generate noise / light that could induce temporary and localized disturbance of marine birds.

The physical structure of the platform and support vessels could affect marine birds by attracting them. Additionally, it is possible that the artificial reef effect, created by stationary structures will affect marine bird prey. Shearwaters, Northern Fulmars, and gulls are the species most likely to be attracted to the platform and may rest on the water nearby. It is unknown if Ivory Gull are attracted to structures like other gull species.

Various other activities associated (e.g., lighting, flaring) with the operations and maintenance phase in the Offshore Study Area may induce temporary and localized disturbance of marine birds. These activities are not expected to occur near any Ivory Gull nesting colonies, so will not affect that portion of their life cycle. Disturbance is possible for small feeding concentrations of marine birds that are common in the Offshore Study Area; however, Ivory Gull would not be considered common in the Offshore Project Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

11.6.2.3 Potential Mortality

It is possible that marine birds attracted by gas flaring at night might become incinerated, collide with platform structures, or strand on the platform, thereby causing mortality (Russell 2005; Montevecchi 2006). However, this is less likely to affect the Ivory Gull than other marine bird species.

As discussed in greater detail below in the effects assessment for accidental malfunctions and unplanned events, exposure to oil can be fatal to marine birds. Although free oil is usually removed from produced water before discharge, oil sheens are sometimes associated with produced water discharges (e.g., ERIN Consulting Ltd. and OCL Services Ltd. 2003). Data on the relationship between sheen thickness and lethality to marine birds are lacking (Hartung 1995).

The environmental effects of Project operations and maintenance on marine bird SAR are summarized in Table 11-17.

Given that Project activities are mostly localized, of low magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine bird SAR from the operation and maintenance activities associated with the Project.

EMCP will monitor the SARA registry. If new species that are likely to occur in the Study Areas are added to Schedule 1, or if recovery strategies or monitoring plans are implemented, mitigation measures will be reviewed and updated where required, to ensure that they meet their requirements of the SARA.

Table 11-17 Environmental Effects Assessment: Operations and Maintenance – Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Use		1	1	5/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	2	5/6	R	2
Maintenance Activities (e.g., diving, ROV)	• Change in Habitat Use		1	1	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Flaring	• Change in Habitat Use • Potential Mortality		1	1	5/6	R/I [B]	2
Wastewater (e.g., produced water, storage displacement water, deck drainage)	• Change in Habitat Quality • Potential Mortality	• Subsurface discharge	1	2	5/6	R/I [B]	2
Chemical Use / Management / Storage (e.g., corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes where possible	1	4	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Use	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed	1	4	5/6	R	2
Surveys (e.g., geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Maintain steady course and speed	1	3	3/2	R	2
Potential Expansion Opportunities							
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Use		1	1	3/6	R	2
Presence of Structures	• Change in Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Chemical Use and Management (BOP fluids, well treatment fluids, corrosion inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use		1	3	3/2	R	2

KEY

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4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

11.6.2.4 Offshore Decommissioning and Abandonment

None of the Project activities in the Offshore Study Area during the decommissioning and abandonment phase are predicted to result in changes in habitat quantity, or mortality for marine bird SAR. Lighting may affect habitat quality as discussed previously during the construction and operation and maintenance Phases. Changes in habitat use are described below.

Activities associated with the removal of the Hebron Platform and OLS loading points may induce temporary and localized disturbance of marine bird SAR. These activities are not expected to occur near any known nesting colonies, so will not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common in the Offshore Study Area; however, Ivory Gull is not considered common in the Offshore Project Area.

Effects and mitigation associated with lighting, vessel traffic and helicopter traffic have been discussed under the construction (Section 11.6.2.1) and are applicable to the decommissioning / abandonment phase.

The environmental effects of Project decommissioning and abandonment on marine bird SAR are summarized in Table 11-18.

Table 11-18 Environmental Effects Assessment: Decommissioning and Abandonment – Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effect[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies • Avoid flying at low altitudes where possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / ROVs)	• Change in Habitat Use	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed	1	3	3/6	R	2
Surveys (e.g., geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use	• Maintain steady course and speed	1	2	3/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effect[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

The potential effects of decommissioning activities are expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

11.6.3 Accidents, Malfunctions and Unplanned Events

The potential effects of accidents, malfunctions and unplanned events without the implementation of control measures on marine birds are fully assessed in Section 9.5.4 and considered fully applicable to marine bird SAR.

Known seasonal habitat for Red Knot has been identified at Bellevue Beach. Spill modelling at the Bull Arm site shows that there is a 1 to 10 percent probability of a diesel fuel spill reaching Bellevue Beach. This probability increases to 10 to 30 percent for IFO-180 fuel released in summer. These probabilities were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b). The Ivory Gull is also considered an occasional seasonal visitor to both the Nearshore and Offshore Study Areas; therefore, the likelihood of an accidental spill affecting numbers of individuals would be unlikely. Potential transboundary effects are discussed in Section 11.4.3.2.

Mitigation for accidental hydrocarbon spills will consist of following the protocols detailed in the spill response plan. A spill response plan will identify sensitive areas in the nearshore area that may be affected by oil spills.

Response plans will identify specific countermeasures for these sensitive areas, specific to the shoreline type. Depending on the nature and tiered response required, mitigations include the provision for spill response equipment and the rescue and rehabilitation of oiled marine birds. Marine bird rehabilitation will be facilitated through ExxonMobil's North American support network. These procedures will minimize the potential mortality from such accidental events.

The environmental effects of Project accidents, malfunctions and unplanned events on marine bird SAR are summarized in Table 11-19. The geographic extents provided in Table 11-19 were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b).

Table 11-19 Environmental Effects Assessment: Accidental Events– Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Change in Habitat Use	• Prevention through design standards and maintenance • Emergency Response Contingency Plan	1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	4-5	2/1	R/I [B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	6	2/1	R/I[B]	2
Subsea Blow-out	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	6	3/1	R/I[B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	6	2/1	R/I[B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	1	2/1	R/I[B]	2
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2
Collisions (involving Platform, vessel and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	3	2/1	R/I[B]	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
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Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
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Frequency:
1 = <11 events/year
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3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

11.6.4 Cumulative Environmental Effects

Marine oil and gas exploration, commercial fishery activity, marine transportation and existing production activity (e.g., White Rose, Hibernia, and Terra Nova) could affect marine birds (see Table 11-15). Hunting of marine birds occurs in the Nearshore Study Area, but not for SAR. It is unlikely that routine activities associated with other offshore oil and gas exploration, existing production areas, marine transportation, and commercial fisheries have substantive environmental effects on marine bird SAR (see, for example, LGL 2007d; Christian 2008). The one exception would be an accidental hydrocarbon spill or blow-out in the Offshore Study Area.

11.6.4.1 Nearshore

Cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area, as fewer activities may interact with the current Project (see Section 11.6.4.2 for cumulative environmental effects assessment of the Offshore Study Area).

11.6.4.2 Offshore

With respect to marine bird SAR, the main projects and activities that could result in cumulative environmental effects include other oil and gas activities, tankering, shipping and commercial shipping. Effects of seismic activities on marine birds were considered to be negligible; therefore, no significant cumulative adverse environmental effects are predicted with respect to a spatial overlap of seismic programs within the Affected Area. As described above, the Project is a sufficient distance from other platforms in the region to not have a cumulative environmental effect with respect to attraction of birds to lights and flares.

It was estimated that an annual average of 315,200 (±45,600) marine birds suffered oil-related mortalities due to the effects of oiling from illegal bilge pumping and chronic spills from vessel off southeast Newfoundland during the winter periods, 1998 to 2001 (Weise and Robertson 2004). Any cumulative environmental effects of oiling from illegal bilge pumping and chronic spills as a result of other vessel activities would be additive and density dependent. Operations will be managed to minimize the probability of Project-related spills from the Hebron Platform and, in the unlikely event of a spill, implement appropriate spill response measures in an attempt to minimize effects.

11.6.5 Determination of Significance

The determination of significance is based on the definition provided in Section 11.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

Project construction, operation and maintenance and decommissioning activities, including malfunctions and accidents and cumulative environmental effects, are predicted to be not significant on marine bird SAR. Due to the lack of critical habitat, the transient and occasional nature of movements of SAR in the Project Area and the low probability of interactions with Project activities, no significant adverse environmental effects are expected on habitat quantity, quality or use, or due to mortality. Mitigation measures planned for the project will also reduce the potential for adverse environmental effects on SAR.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and marine bird SAR, after taking into account any proposed mitigation, is summarized in Table 11-20.

As required by CEAA, an analysis of potential environmental effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on marine SAR or their respective habitats are predicted that could affect renewable resource use.

Table 11-20 Residual Environmental Effects Summary: Marine Birds Species at Risk

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	S	1	1
Cumulative Environmental Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

11.6.6 Follow-up and Monitoring

For MODU drilling operations, EMCP will implement a marine bird observation program similar to those conducted during exploration drilling programs in the Newfoundland and Labrador Offshore Area. EMCP supports initiatives such as the recent Environmental Studies Research Fund marine bird monitoring program and will investigate the development of a marine bird observation program from Hebron Project supply vessels, where space is available. Marine bird monitoring protocols will take into consideration those established by CWS. Data will be provided to the C-NLOPB and CWS.

Specific follow-up programs to verify the accuracy of assessment predictions and the efficacy of mitigation measures are not planned for marine bird SAR.

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12 SENSITIVE OR SPECIAL AREAS

Sensitive or Special Areas have been selected as a Valued Ecosystem Component (VEC) due to stakeholder and regulatory concerns about the vulnerability of sensitive or special areas to potential Project-related effects, including potential exposure to contaminants from operational discharges and accidental spills from the Project. Sensitive or Special Areas are often identified with rare or unique marine habitat features, habitat that supports sensitive life stages of valued marine resources, and/or critical habitat for species of special conservation status. For the purposes of this assessment, Sensitive or Special Areas are defined as:

- An area that is afforded some level of protection under federal or provincial legislation (i.e., National Parks, ecological reserves, Oceans Act Marine Protected Areas (MPAs), National Marine Conservation Areas (NMCAs), National Historic Sites, fishery management areas)
- An area that may be under consideration for such legislative protection (i.e., potential or proposed coastal or marine protected areas)
- An area that is known to have particular ecological or cultural importance and is not captured under federal or provincial regulatory frameworks (e.g., corals; spawning, nursery, rearing, or migratory areas; areas of high productivity; rare or unique habitats; Important Bird Areas (IBAs); Ecologically and Biologically Significant Areas (EBSAs); areas of traditional harvesting activities)

The above definition is based on that used by the C-NLOPB (2009a). The identification of an area as sensitive or special does not automatically imply that this area will require the application of non-typical mitigations or restriction on activities. The timing, spatial extent, and nature of proposed Project activities, in addition to mitigations prescribed by legislation, will determine the level of restriction or mitigation that will be required.

As per the Scoping Document (C-NLOPB 2009), the Sensitive or Special Areas included in this assessment include important or essential habitat to support marine resources (see Chapters 7 to 10) or areas identified through the Placentia Bay-Grand Banks (PBGB) Large Ocean Management Area (LOMA) Integrated Management Plan Initiative. In the Nearshore Study Area, these Sensitive or Special Areas include capelin beaches (e.g., Bellevue Beach) and eelgrass beds (Figure 12-1). Offshore Sensitive or Special Areas include those designated by the Northwest Atlantic Fisheries Organization (NAFO), specifically the Southeast Shoal Vulnerable Marine Ecosystem (VME) and various canyon areas and seamount and knoll VMEs. In addition, the following EBSAs, as identified by Fisheries and Oceans Canada (DFO), occur within the Offshore Study Area: Northeast Shelf and Slope; Virgin Rocks (immediately adjacent to the Offshore Study Area); Lily Canyon-Carson Canyon and Southeast Shoal and Tail of the Banks (Figure 12-2). The special areas atlas prepared by the Canadian Parks and Wilderness Society (CPAWS 2009) is also referenced where a special area has been identified within either the Nearshore or Offshore Study Area. The Bonavista

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Cod Box is located outside of the Offshore Study Area and is therefore not considered.

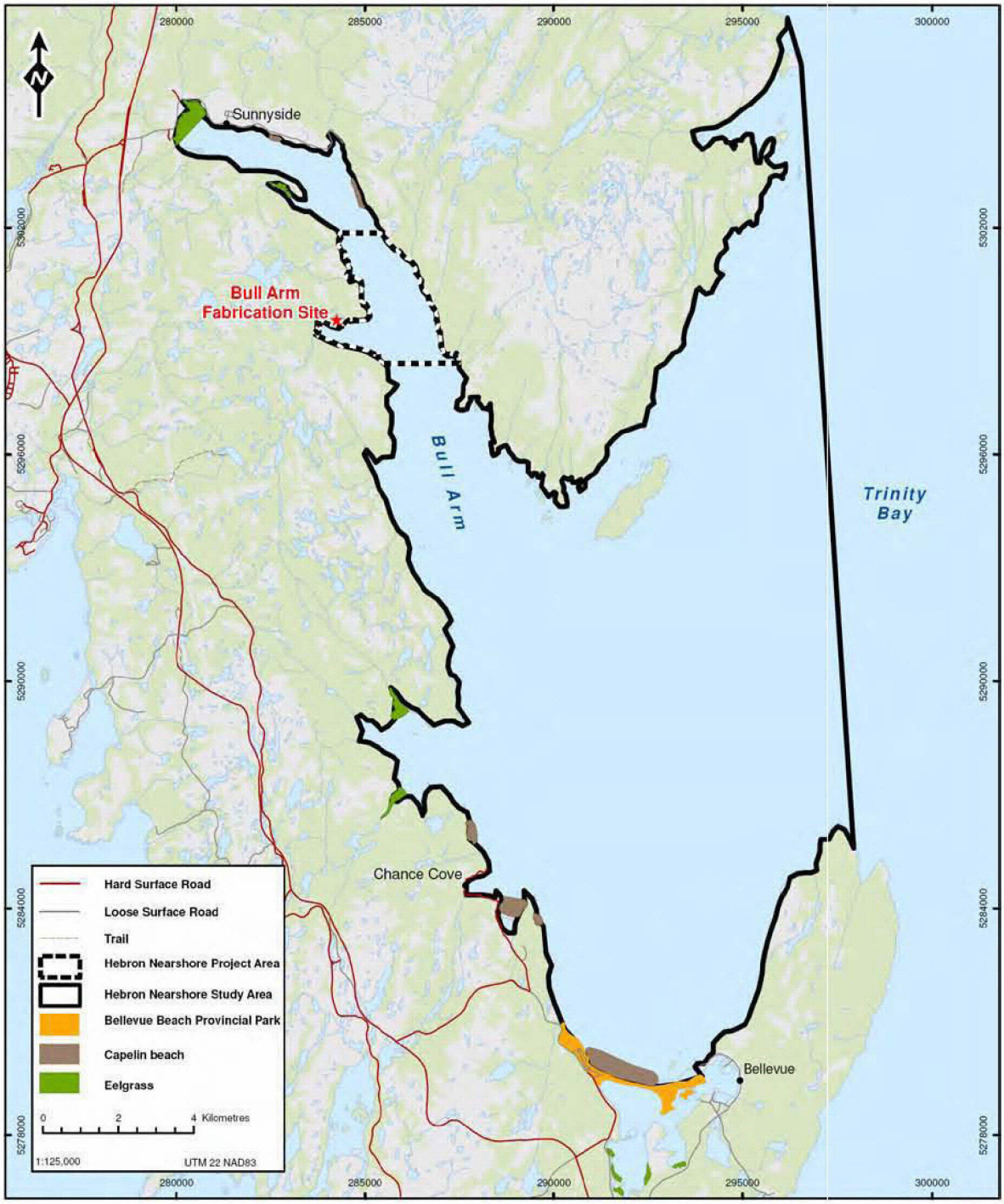

Figure 12-1 Identified Sensitive or Special Areas within the Nearshore Study Area

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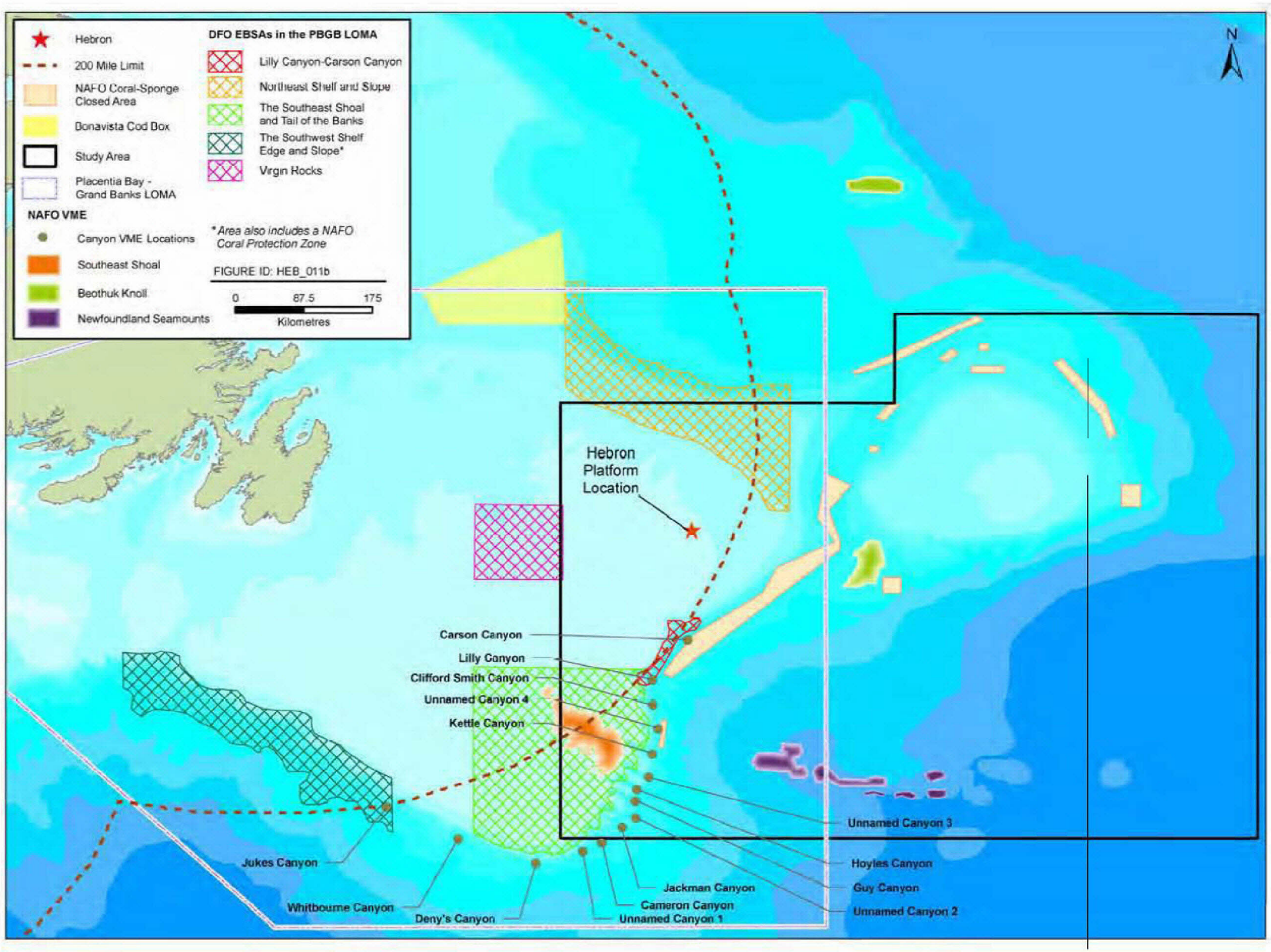

Figure 12-2 Identified Sensitive or Special Areas within the Offshore Study Area

This VEC is directly linked to several other VECs as Sensitive or Special Areas represent the physical habitat areas supporting biological resources that are also assessed separately including, Marine Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10) and Species at Risk (Chapter 11).

12.1 Environmental Assessment Boundaries

12.1.1 Spatial and Temporal

12.1.1.1 Nearshore

The Nearshore Study Area and Nearshore Project Area are defined in the Environmental Assessment Methods Chapter (Chapter 4). The affected area will vary by Project activity, the nature of the VEC and the sensitivity of different species within the VEC. The Affected Areas for several Project activities have been determined by modelling (see AMEC 2010; ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

The temporal boundary for the environmental assessment is determined by the schedule and duration of Project activities. These are further described in Table 12-1.

Table 12-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

12.1.1.2 Offshore

The Offshore Study Area and Offshore Project Area are defined in the Environmental Assessment Methods Chapter (Chapter 4). For this VEC, the Offshore Affected Area of most relevance is that for an accidental oil spill. The identified Offshore Sensitive or Special Areas are all located outside of the predicted zones of influence of routine Project-related activities.

As well, while the Affected Area for an oil spill in some cases may overlap with a portion of an identified sensitive or special area, in these cases the assessment considers the potential for Project-related environmental effects on the identified area as a whole.

Ecologically, some of the identified Sensitive or Special Areas would be more vulnerable to Project-related environmental effects at certain times of the year and these vary between areas dependent on the species known to use the

habitat. For instance, the Northeast Shelf and Slope EBSA is known to attract aggregations of spotted wolffish and Greenland halibut in the spring. The Lily Canyon-Carson Canyon EBSA attracts year-round aggregations of marine mammals for feeding and overwintering.

12.1.2 Administrative

The administrative boundaries for Sensitive or Special Areas overlap with those for Marine Fish and Fish Habitat as many of the identified sensitive or special areas are related to the protection of critical life stages of marine fish. A full discussion of administrative boundaries related to Marine Fish and Fish Habitat is found in Section 7.1.3.

Protection of marine sensitive areas is also provided by DFO's Oceans Act. The Oceans Act, which was passed in 1997, allows for the development of a national oceans strategy based on the principles of sustainable development, integrated management and the precautionary approach. Importantly, the Act also authorizes DFO to provide enhanced protection to marine areas which are determined to be ecologically or biologically significant (DFO 2004d). The Offshore Project Area is within an area currently being considered as part of an Integrated Management Plan for the PBGB LOMA. As part of this plan, DFO has identified EBSAs, which may require specific management measures. Some EBSAs may be put forward as Areas of Interest for MPA status and other EBSAs may be considered for protection under other management tools. The potential management implications for these EBSAs are still being determined through ongoing planning processes within DFO. Currently, none of the EBSAs within the Offshore Study Area (Figure 12-2) have been recommended as Areas of Interest or are subject to any special legislated protection measures or restrictions, although it is acknowledged that these may be implemented for some of the EBSAs at some point in the future.

Other Sensitive or Special Areas within the Offshore Study Area are those identified by NAFO, which has committed to identifying VMEs in the offshore environment. A number of proposed VMEs have been identified offshore Newfoundland, within the context of managing deep sea fisheries and their potential environmental implications of these activities. Other than restrictions on fishing in these areas, there are no management procedures in place that would be applicable to or affect planned Project activities.

Sensitive or Special Areas can also be linked to the federal Species at Risk Act (SARA), which protects the critical habitat of species assessed as Threatened or Endangered. Where identified, Sensitive or Special Areas are known to support Species at Risk; these are identified within the description of existing conditions.

12.2 Definition of Significance

A significant adverse residual environmental effect is one that alters the valued habitat of the identified Sensitive or Special Areas physically, chemically or biologically, in quality or extent, to such a degree that there is a

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decline in abundance of key species or species at risk or a change in community structure, beyond which natural recruitment (reproduction and immigration from unaffected areas) would not return the population or community to its former level within several generations.

An adverse residual environmental effect that does not meet the above threshold is considered to be not significant.

12.3 Existing Conditions

The following description of Sensitive or Special Areas in the Nearshore Study Area is based on existing data sources, supplemented by information supplied by local fishers in the area (B. Warren, pers. comm.). The description of Sensitive or Special Areas in the Offshore Study Area is based on existing government and scientific sources.

12.3.1 Nearshore

Two types of Sensitive or Special Areas are identified and considered in the nearshore: eelgrass beds and capelin beaches.

12.3.1.1 Eelgrass Beds

Eelgrass (Zostera marina L.) is a type of submerged aquatic vegetation that grows in estuaries and shallow bays. It is a perennial flowering plant that grows both by vegetative growth and by seed germination. Eelgrass abundance varies seasonally, with winter die-off and spring / summer re-growth, and annually due to a variety of factors. These can include physical and chemical disturbance, changes in nutrient availability, and changes in water quality parameters such as turbidity and salinity (Eelgrass Fact Sheet, http://www.oregon.gov/DSL/SSNERR/tides/tidesA13_eelgrassfacts.pdf).

Eelgrass has been recently assessed by DFO, and in eastern Canada, DFO has determined that eelgrass has characteristics which meet the criteria of an Ecologically Significant Species (DFO 2009i). These criteria include the following:

- By its structure, it creates habitat that is used preferentially by other species
- It physically support(s) other biota, and provides either settlement substrate or protection for this associated community
- It is abundant enough and sufficiently widely distributed to influence the overall ecology of that habitat

Eelgrass beds perform important ecological functions including filtering of the water column, stabilizing sediment, and buffering shorelines from erosion (DFO 2009i). Eelgrass beds are highly productive ecosystems due to both rapid turnover of eelgrass leaves and epiphytic algae on leaf surfaces and represent a valuable component of the coastal food chains and contributor to the nutrient cycle. Densities of a variety of invertebrate species are high in eelgrass beds as they feed on the epiphytes on eelgrass. The organisms, in

turn, support higher trophic levels. The fish species that are likely to be present in the eelgrass include juvenile and adult cunner, juvenile lumpfish, juvenile lobster and pelagic juvenile Atlantic cod (between June and October), recently post-settled demersal juvenile Atlantic cod and herring. Eelgrass beds are also an important feeding area for some species of migrating birds.

Eelgrass is considered to meet the criteria for an ESS as severe perturbation of these species is deemed to have far greater ecological consequences than an equal perturbation of most other species associated with this community (DFO 2009i). Based on current knowledge, eelgrass, where it presently exists, can have controlling influence over key aspects of the nearshore marine ecosystem structure and function.

Based on existing surveys, eelgrass is distributed around Newfoundland with the greatest abundance on the southwest coast (DFO 2009i). While eelgrass occurs commonly in eastern Canada where there are suitable conditions, it is generally absent from rocky, high energy coastlines or areas of high turbidity. Therefore, eelgrass is constrained in many coastal areas around Newfoundland by both coastal features and the extent of ice scour. While there are no estimates of areal coverage in Newfoundland, except in a small number of individual embayments (e.g., Newman Sound), there are several large beds on the west coast of the island. The location of several eelgrass beds within the Nearshore Study Area, as identified by local fishers (B. Warren, pers. comm.), is provided on Figure 12-1.

Declines in eelgrass beds have been documented around the world with possible explanations for these declines in the Maritime Provinces including eutrophication, disturbance by invasive green crab (Carcinus maenas), human activities, and environmental changes (DFO 2009i). In Newfoundland, however, there appears to be a general increase in eelgrass abundance in the last decade based on local knowledge. The increases in some locations may be due to improved conditions for eelgrass (milder temperatures, more favourable sea ice conditions) (DFO 2009i).

12.3.1.2 Capelin Beaches

Capelin (Mallotus villosus) have been addressed in the Marine Fish and Fish Habitat VEC; Section 7.3.2.4 provides a description of expected spawning behaviour of this species.

Local fishers (B. Warren, pers. comm.) have identified five smaller capelin beaches within the Nearshore Study Area (Figure 12-1). In addition, Bellevue Beach is located in the southern extent of the Nearshore Study Area. It is one of largest capelin spawning beaches on the east coast of Newfoundland and has been the subject of an annual production survey since 1990 (Nakashima and Wheeler 2002). Demersal spawning of capelin near Bellevue Beach is also reported (CPAWS 2009). Eelgrass, kelp and Irish moss beds have also been reported in the area of Bellevue Beach (CPAWS 2009).

Historically, capelin have spawned on Newfoundland beaches in June and July as three- and four-year-old fish. Beginning early in the 1990s, several

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changes in spawning behaviour were observed and continue to occur (DFO 2008c) as documented from observations at Bellevue Beach. Spawning now generally occurs four weeks later in July and August and is comprised of mostly two- and three-year-old fish. The amount of off-beach spawning is assumed to vary from year to year. As well, the average size of mature capelin continues to be smaller than that observed in the 1980s. While the initial shift in spawning behaviour appeared to be linked to below-average seawater temperatures, these trends have continued over time despite higher seawater temperatures since the mid-1990s.

DFO (2008c) indicates that Bellevue Beach continues to be a key spawning beach for capelin, with egg deposition in Bellevue Beach in 2007 being the fifth highest since 1990 and larval emergence from Bellevue Beach in 2007 being the fourth highest since 1990. While there are no recent estimates of abundance available for the entire capelin stock, spring acoustic surveys estimated abundances that are considerably lower than those from the late 1980s. Increases in the offshore abundance of capelin in 2007 and 2008 from spring acoustic surveys complement observations by fish harvesters that abundance has been increasing since 2006.

12.3.2 Offshore

The following text describes the Sensitive or Special Areas identified in the Offshore Study Area (refer to Figure 12-2); the descriptions are based on existing sources of data.

The Nearshore and Offshore Project Areas are within an area currently being considered as part of an Integrated Management Plan for the Placentia Bay-Grand Banks (PBGB) Large Ocean Management Area (LOMA) and falls within Canada's Newfoundland-Labrador Shelves Marine Ecoregion. This is relevant as the biogeographic classification system is used for: i) assessing and reporting on ecosystem status and trends; and ii) spatial planning for the conservation of ecosystem properties and management of human activities. As part of the LOMA plan, DFO has identified EBSAs that may require special management measures. Some EBSAs may be put forward as Areas of Interest for MPA status and other EBSAs may be considered for protection under other management tools. EBSAs are tools that are used to highlight an area of high biological or ecological significance and as such additional protections or management strategies may be applied to these areas. None of the EBSAs overlap with the Offshore Project Area. There are no MPAs within or immediately adjacent to the Offshore Project Area.

12.3.2.1 Ecologically and Biologically Significant Areas

As stated above, the Offshore Project Area is within an area currently being considered as part of an Integrated Management Plan for the PBGB LOMA. As part of this plan, DFO has identified EBSAs which may require specific management measures. None of the EBSAs overlap with the Offshore Project Area (Figure 12-2). The closest, which is the Northeast Shelf and Slope EBSA, is located 39 km from the Offshore Project Area. The other EBSAs are all located south of the Project Area, with the exception of the

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Virgin Rocks, which is adjacent to the western boundary of the Offshore Study Area.

EBSAs are identified based on pre-established criteria, including primary criteria of uniqueness, aggregation and fitness consequences and secondary criteria of resilience and naturalness (DFO 2004d). In total, 11 EBSAs have been identified, evaluated and ranked for the PBGB LOMA (DFO 2007d). Of these 11, the Southeast Shoal and Tail of the Banks EBSA was given the highest priority ranking. The other three EBSAs being considered within this assessment were ranked in the bottom four. Each of these areas and the rationale for selection as an EBSA is provided in more detail below as described in DFO (2007d).

The Southeast Shoal and Tail of the Banks Ecologically and Biologically Significant Area

The Southeast Shoal and Tail of the Banks EBSA is an area east of 51°W and south of 45°N, extending to the edge of the Grand Bank (DFO 2007d). The Southeast Shoal has the warmest bottom water temperatures on the Grand Banks and a well-defined gyre making it very productive area for plankton (CPAWS 2009). It is unique in that it is the only shallow sandy offshore shoal in the LOMA, it contains relict populations of blue mussel, wedge clam and capelin associated with beach habitats, and it contains the highest benthic biomass on the Grand Bank. It is also known to be:

- The only known offshore spawning site for capelin
- The single nursery area of the entire stock of yellowtail flounder
- A spawning area for several groundfish species (American plaice, yellowtail flounder and Atlantic cod)
- An important nursery area for NAFO Division 3NO cod and American plaice
- An area that attracts large aggregations of marine mammals (especially humpbacks and northern bottlenose) and marine birds due to presence of forage species
- An area with the densest concentration of striped wolffish (listed as 'special concern' SARA and assessed as "special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)
- An area which supports the highest density of American plaice on the Grand Banks since the mid-1990s

The Southeast Shoal and Tail of the Banks EBSA is a naturally dynamic sandy bottom habitat that is subject to regular physical disturbance by wave action from storms and is thus less sensitive to disturbance. Fishing has greatly altered the ecosystem within the EBSA and, therefore, DFO (2007d) concludes that ecosystem and community resilience in the Southeast Shoal area has been diminished and is likely sensitive to further disturbance.

Northeast Shelf and Slope Ecologically and Biologically Significant Area

The Northeast Shelf and Slope EBSA is on the northeastern Grand Bank, starting at the Nose of the Bank, from 48°W to 50°W, and from the edge of

the shelf (e.g., 200 m depth contour) to the 1,000 m depth contour (Figure 12-2). It is ranked ninth of the eleven identified EBSAs in the PBGB LOMA and is identified as an EBSA because portions of the area are known for:

- Aggregations of spotted wolffish (listed as "threatened" under SARA and assessed as "threatened" under COSEWIC) in spring
- High concentrations of Greenland halibut in spring
- Aggregations of marine mammals, particularly harp seals (Sackville Spur west), hooded seals (Sackville Spur east) and pilot whales
- Two important coral areas at Tobin's Point and Funk Island Spur (CPAWS 2009).

While the area is important to the function of some species, it is not considered otherwise unique. The area is also not considered particularly sensitive to disturbance as compared to other slope areas occurring in the region.

Lily Canyon-Carson Canyon Ecologically and Biologically Significant Area

Lily Canyon-Carson Canyon is an area from 44.8°N to 45.6°N along the 200 m depth of the southeast slope of Grand Bank and is ranked eighth of the eleven identified EBSAs in the PBGB LOMA. The area is assigned a low ranking for uniqueness as various other canyons occur throughout the Grand Banks, and while the area is important to the feeding and productivity of Iceland scallops, the species is known to occur elsewhere. The EBSA received a high ranking for aggregation as a high proportion of Iceland scallops are known to occur in the canyons, as well as year-round aggregations of marine mammals for feeding and overwintering (CPAWS 2009). The EBSA is also ranked high for fitness consequences (i.e., the degree that natural activities take place that contribute significantly to the survival or reproduction of a species or population) and naturalness as the area remains highly productive, and the deeper parts of the canyons are relatively undisturbed.

Virgin Rocks Ecologically and Biologically Significant Area

The Virgin Rocks EBSA comprises the area from 46°N to 46.8°N and from 50°W to 51°W (located outside of but immediately adjacent to the Offshore Study Area). It is ranked lowest in priority of the 11 identified EBSAs. The area is considered geologically unique, as large nearly exposed rocks on the Grand Banks are a one of a kind geological feature/habitat in the LOMA. The area is known to attract aggregations of capelin and marine birds and support spawning and breeding of Atlantic cod, American plaice and yellowtail flounder, although these species are known to spawn elsewhere (CPAWS 2009). While the physical habitat of this EBSA has low sensitivity to disturbance, intensive fishing has resulted in the decline of several of the traditionally abundant species in the area thereby reducing the resiliency of the community and ecosystem.

12.3.2.2 Northwest Atlantic Fisheries Organization Vunerable Marine Ecosytems

As identified above in Section 12.2.2, NAFO has committed to identifying candidate VMEs using criteria that have received general consensus internationally (i.e., the Food and Agriculture Organization (FAO) of the United Nations International Guidelines for the Management of Deep Sea Fisheries in the High Seas) (NAFO 2008). The NAFO Ecosystem Working Group has proposed a number of VMEs, including many of the canyons along the shelf edge, seamounts and knolls, the Southeast Shoal, cold seeps, and carbonate mounds and hydrothermal vents, in the NAFO regulatory area.

Candidate VMEs are identified within the context of managing deep sea fisheries and their potential environmental implications of these activities. Therefore, the focus in identifying candidate VMEs has been on the areas that are currently fished (where the necessary benthic data to identity candidate VMEs is available), or that are currently technically feasible for fishing. For this reason, VMEs are being defined where data has been collected and where the bottom depth is less than the presumed current maximum trawl depth of approximately 2,000 m (NAFO 2008). Areas outside of the existing fishing area will be subject to new fishing area protocols in the future, and VMEs will be later identified as part of that process. Identified and delineated VMEs in the existing fishing areas will likely be subject to additional management measures aimed to protect the high species biodiversity within these special regions (NAFO 2008).

The FAO guidelines suggest five criteria for identifying VMEs:

- Uniqueness or rarity
- Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g., nursery grounds or rearing areas), or of rare, threatened or endangered marine species
- Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities
- Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates, late age of maturity, low or unpredictable recruitment, or long-lived
- Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features

Sessile and very low mobility organisms (e.g., corals, sponges, bivalves) were identified by NAFO (2008) as the most likely foundation organisms for VMEs. Corals create vertical relief and increase the availability of microhabitats. This in turn attracts and provides for aggregations of feeding species, a nursery area for juveniles, fish spawning aggregation sites and attachment substrate for fish egg cases and sedentary invertebrates. These functions are known to be served by deep water coral habitats, creating areas high in invertebrate biodiversity and supporting a large abundance of fish. Concentrations of sponges, particularly those of large size, are also known to be habitat-forming

structures, often with numerous other species living within and around their body structures.

Bottom trawling is known to have deleterious effects on complex habitats. The structural characteristics and long-lived nature of some deep water corals make them especially vulnerable to damage by the mechanical effects of bottom fishing activities. In identifying coral VME components, the size, structural complexity, gregariousness, fragility, vulnerability to fishing gears, rarity, longevity, role in the ecosystem (associated species, biodiversity) and international recognition of status were considered.

Canyon Vunerable Marine Ecosytems

Geological features, such as canyons are known to support vulnerable species, communities or habitats and therefore qualify as VMEs (NAFO 2008). Canyon ecosystems can support diverse biological communities, including sensitive structure-forming coldwater corals and deep sea fishes (Gordon and Fenton 2002; Rutherford and Breeze 2002).

Thirteen offshore canyons, which occur along the continental shelf break, have been identified as potential VMEs and are located within the Hebron Offshore Study Area (NAFO 2008). These include: Denys Canyon, Unnamed Canyon 1, Cameron Canyon, Jackman Canyon, Unnamed Canyon 2, Guy Canyon, Hoyles Canyon, Unnamed Canyon 3, Kettle Canyon, Unnamed Canyon 4, Clifford Smith Canyon, Lilly Canyon, and Carson Canyon (Figure 12-2).

The upper limit of these canyons were delineated by the 200 m depth contour, while the lower limit varied but generally was determined by the 2,000 m depth contour. NAFO recognizes that the ecology of these canyons is not well documented, but has based their proposals on research from other canyons such as The Gully (Gordon and Fenton 2002), which suggests that these features support vulnerable species and communities.

Seamounts and Knolls Vunerable Marine Ecosytems

A seamount is an elevation of the sea floor, 1,000 m or higher, that can be flat-topped or peaked and can occur as isolated peaks or as a chain of peaks. Ecosystems surrounding these features are considered sensitive to anthropogenic disturbance because they are comprised of species that are mostly slow-growing, long-lived, late to mature, and experience low natural mortality. Corals and sponges are often associated with these features, as well as aggregations of deep sea fishes.

In proximity to the Offshore Study Area, there is one seamount chain, the Newfoundland Seamounts, located in deep water beyond the continental slope and one isolated knoll, known as the Beothuk Knoll (Figure12-2). Despite the lack of detailed survey information, there is evidence of the occurrence of coldwater corals and potentially vulnerable deep sea fishes on these seamounts, which is why they have been proposed as VMEs (NAFO 2008).

Proposed Southeast Shoal Vunerable Marine Ecosytems

The Southeast Shoal is the shallowest area on the southeastern Grand Banks (Figure 12-2) and attracts many fish and marine mammal species that feed in summer and apparently overwinter (NAFO 2008; CPAWS 2009). Although the area is shallow and much of the bottom is comprised of sand, the Southeast Shoal is still considered to qualify as a VME based on several of the suggested FAO criteria.

The area is considered physically unique on the Grand Banks, as the last area to remain above sea level prior to the last glacial period. As past beach habitat, it supports two possible relict bivalve populations, including the wedge clam (Mesoderma deauratum). It is the only known offshore area for the spawning of 3NO capelin (currently under moratorium) and is important habitat for several other species under moratorium or at-risk, including cod, American plaice and striped wolffish. The Southeast Shoal is an area of high productivity and biodiversity, and is an important feeding area for several marine mammals, including humpback whales, as well as for various marine birds. The proposed VME is located within the boundaries of DFO's Southeast Shoal and Tail of the Banks EBSA.

12.4 Project-Valued Ecosystem Component Interactions

12.4.1 Nearshore

With respect to eelgrass beds and potential interactions with nearshore Project-related activities, the major concern is the potential for physical and/or chemical alteration or disturbance of areas in which eelgrass is present. Eelgrass beds (Figure 12-1) are located at sufficient distance from the Nearshore Project Area such that there is no potential for physical disturbance of these sensitive habitats from routine Project activities and physical works, including Project-related sedimentation. Eelgrass is common in areas of high sedimentation such as estuaries (Short et al. 2002). There is potential for species that use eelgrass bed habitats (including pelagic juvenile Atlantic cod (between June and October) and recently post-settled demersal juvenile Atlantic cod) to experience disturbance and/or avoidance effects due to Project-related noise and lights. These potential effects are fully considered and assessed in the respective VECs (i.e., Marine Fish and Fish Habitat, Marine Birds). The residual adverse environmental effects have been rated as not significant and these interactions are not further assessed in this VEC.

There is potential for eelgrass beds to be physically affected by an accidental spill in the nearshore environment during construction, which could result in a potential widespread die-off of meadows as will as individual plants. This potential interaction is fully assessed below (Section 12.5.1.1).

Similar to eelgrass beds, the identification of potential interactions between capelin beaches and Project activities has to be inclusive of the potential for physical alteration or disturbance of capelin beaches and potential interactions with spawning capelin within the Nearshore Study Area. Routine

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Project activities and physical works are not expected to spatially overlap with capelin beaches in a manner that could result in measureable physical alteration or disturbance of these habitats. While spawning capelin could interact with various Project activities that generate noise and lights, the resulting potential for disturbance / avoidance has been fully assessed in the Marine Fish and Fish Habitat VEC (Chapter 7) and the residual adverse environmental effects have been rated as not significant. This effect is not further assessed in this VEC.

There is potential for capelin beaches to be physically affected by an accidental oil spill in the nearshore environment during construction resulting in a reduction of habitat quality. This potential interaction is fully assessed below.

12.4.2 Offshore

The identified Sensitive or Special Areas located in or proximate to the Offshore Study Area are all located outside of the Hebron Offshore Project Area (Figure 12-2). The closest identified Sensitive or Special Area is the Northeast Shelf and Slope EBSA, which is located 39 km from the Project Area. Due to the degree of separation, there will be no spatial overlap and resulting interactions between routine Project activities and the identified Offshore Sensitive or Special Areas.

There is potential for a number of accidental event scenarios resulting in release of hydrocarbons to interact with identified Sensitive or Special Areas within the Offshore Study Area, resulting in a reduction of habitat quality. The potential for interactions as a result of accidents, malfunctions and/or unplanned events is fully assessed in Section 12.5.1.2.

12.4.3 Summary

In summary, both the nearshore and offshore assessments are limited to the potential for interactions resulting from accidents, malfunctions and/or unplanned events. This interaction creates the potential for changes in habitat quality. For nearshore eelgrass beds, there is also the potential for mortality of individual plants as a result of oiling. Effects on species using the sensitive areas (e.g., change in habitat use and direct mortality) are addressed in their respective VEC sections (Marine Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10) and Species at Risk (Chapter 11)) and are not further assessed in this VEC.

As the potential for interactions between Project activities and the Sensitive or Special Areas in the Nearshore and Offshore are limited to accidental events which are not considered likely Project effects, cumulative environmental effects are not assessed in relation to these accidental events.

A summary of the potential environmental effects resulting from Project-VEC interactions resulting from accidents, malfunctions and unplanned events is included in Table 12-2.

Table 12-2 Potential Project-related Interactions: Sensitive or Special Areas

Project Activities and Physical Works	Potential Environmental Effects	
	Habitat Quality	Mortality
Accidents, Malfunctions and Unplanned Events		
Nearshore Bund Wall Rupture		
Nearshore Spill (at Bull Arm Site)	x	x[A]
Offshore Failure or Spill from OLS	x	
Offshore Subsea Blowout	x	
Offshore Crude Oil Surface Spill	x	
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform) [B]	x	
Marine Vessel Incident (i.e., fuel spills)	x	
Collisions (involving Platform, vessel, and/or iceberg)[B]	x	

A A spill could result in mortality of individual plants in the eelgrass beds. The potential for mortality of other species using Sensitive or Special Areas, including marine fish, birds, mammals and species at risk are assessed in their respective VECs (Sections 7.5, 9.5, 10.5, 11.4, 11.5 and 11.6, respectively)
B Interactions can occur both nearshore and offshore

12.5 Environmental Effects Analysis and Mitigation

12.5.1 Accidents, Malfunctions and Unplanned Events

Although unlikely, an accidental event can occur at any time of the year, and therefore a conservative approach has been taken in conducting the following effects assessment, assuming that an accidental event could occur at the most sensitive time of year for any of the identified Sensitive or Special Areas.

12.5.1.1 Nearshore

The assessment of the nearshore environment is limited to oiling of eelgrass beds and capelin beaches (refer to Figure 12-1) as a result of an accidental release of hydrocarbons during the construction of the Hebron Gravity Base Structure at the Bull Arm Fabrication Site. This assessment considers the unlikely worst case scenario of a construction vessel accident resulting in 100 m^3 of marine diesel or 1,000 m^3 of IFO-180 (a heavier form of diesel) of fuel being spilled without any response or action to contain or clean up the spill. Based on the results of the spill modelling (ASA 2011a), spills of 100 m^3 of marine diesel have a 60 percent chance of hitting the Bull Arm shoreline in summer, and 30 percent probability to do so in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of impacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season without the application of spill response measures. Conservatively, the following assessment is based on the worst-case scenario of diesel fuel reaching these Sensitive or Special Areas.

Eelgrass Beds

Sea grasses are sensitive to hydrocarbon uptake and oiling. Direct contact with oil causes eelgrass plants to lose their leaves Dean et al. 1998). As eelgrass leaves are rough and without a mucous layer like many seaweeds, oil will readily stick. Direct oiling can occur where eelgrass beds occurs in very shallow water and form a canopy layer on the water surface, allowing oiling of the floating eelgrass tops (Den Hartog and Jacobs 1980). However, direct oiling is uncommon, with uptake of hydrocarbon from the water column being the main concern. Moderate hydrocarbon concentrations in the water column for a few hours or low concentrations for a few days will result in mortality of individual plants, with a bed of eelgrass possibly taking several years to recover from die-off resulting from oiling (Fingas 2001).

The effects of oil spills can be more pronounced for eelgrass beds growing in sheltered bays that are poorly flushed, as oil will tend to persist for longer periods resulting in chronic contamination (Dean and Jewett 2001). The timing of a spill will also influence the nature of the effects. In the spring, seed production and viability could be affected (Beak Consultants 1975), while a spill in late summer or winter when leaf sloughing is at its peak, may encounter mats of drift blades which will tend to catch and retain oil for later decomposition in the intertidal zone. Hatcher and Larkum (1982) also indicates that the surfactants applied to mitigate oil spills could have a permanent and more significant detrimental effect on eelgrass than the spill itself.

Studies of the effects of oil spills on eelgrass communities have been conducted in association with the Exxon Valdez oil spill in Prince William Sound, Alaska, and the Amoco Cadiz spill near Roscoff, France, and are discussed below. The results of both studies indicate that recovery of the eelgrass beds can occur within a couple of years, although there may be a longer effect for some components of the benthic communities. Thus, it is the associated faunal communities that tend to be more sensitive to hydrocarbon pollution than the eelgrass plants themselves. There is very little information on the effect of diesel oil on eelgrass in particular. Even though diesel can be more toxic than crude oil initially, these studies are useful in assessing the longer term effects of polycyclic aromatic hydrocarbons (PAHs) in the sediment of an eelgrass bed.

Dean et al. (1998) compared populations of eelgrass at oiled versus reference sites between 1990 and 1995 following the Exxon Valdez spill. Injury to eelgrass beds in heavily oiled bays appeared to be slight and did not persist for more than a year after the spill. Populations recovered from possible injuries by 1991 and there were no differences in shoot or flowering shoot densities between oiled and reference sites in 1990 or subsequent years.

Jewett and Dean (1997) did report effects on eelgrass communities as a result of the Exxon Valdez spill. Dominant taxa within the eelgrass community, including infaunal amphipods, infaunal bivalves, helmet crabs, and leather stars were less abundant at oiled than at reference sites in 1990.

Other taxa, including several families of opportunistic or stress-tolerant infaunal polychaetes and gastropods, epifaunal polychaetes and mussels, and small cod, were more abundant at oiled sites. By 1995, there was evidence of a recovery of most, but not all, community constituents. Exceptions may relate to oiling or the inherent site differences not associated with the oil spill (Harwell and Gentile 2006). Some evidence of slight hydrocarbon contamination still existed at some sites, and three infaunal bivalves, two amphipods, a crab, and a sea star were still more abundant at reference sites than at oiled sites.

These results are consistent with observations reported by Den Hartog and Jacobs (1980). During 1976 to1978, the ecology of eelgrass communities near Roscoff (France) was studied. When a spill of crude oil and bunker fuel occurred in March 1978 and covered the eelgrass communities in question, the study was continued to document the effects of this spill. The results indicated that the eelgrass itself and the general structure of the eelgrass beds showed little effects from the spill. In the short-term, plants had black "burnt" leaves, but these were shed according to the pattern normal for the species. The study of mobile animals demonstrated that the oil spill had a considerable, but selective influence: effects on the Gastropoda were minimal; representatives of the Cumacea, Tanaidacea and Echinodermata recovered within a year; effects on the Isopoda were detectable but questionable due to low numbers before the spill occurred; and the effects on Amphipoda was of high magnitude (of the 26 species found before the oil spill 21 were not observed after the spill).

Den Hartog and Jacobs (1980) speculated that the difference in effect may have been attributable to the location of the eelgrass beds below the level of mean low water neap tide, which implied that contact between the oil slick and the eelgrass lasted only for at most six hours a day. During this time, the flat-lying eelgrass leaves formed a buffer between the oil slick and the bottom. Due to the firm rhizome mat, mixing of oil and sediment was not possible in the eelgrass bed. This could result in filter feeders such as most Amphipoda and some families of Polychaeta being more affected. The Amoco Cadiz spill occurred in the early spring, just after the winter peak of a number of littoral organisms, and before the start of the rapid development of the eelgrass. The authors were uncertain of potential fate and effects of a spill in the summer.

Bokn et al. (1993) discussed the effects of the water-accommodated fractions of diesel on rock shore populations. In a rocky littoral, diesel oil spills usually result in extensive animal mortalities, and variable, but less severe impacts on seaweeds (e.g., Blumer et al. 1971; Pople et al. 1990). Data for the Solbergstrand mesocosms suggest that animal populations were most affected by oil treatments and indicate that a chronic low-level exposure to water-accommodated fractions of diesel oil may have only limited direct effect on seaweed stocks (Bokn et al. 1993).

Research on eelgrass disturbance and recovery in Newfoundland coastal waters suggests that eelgrass may recover from disturbance (i.e., physical removal) in two to three years (Laurel et al. 2003); however, only the removal

of the above-substrate biomass (shoots and blades) was investigated, as underground rhizomes remained intact after the disturbance. The recovery of eelgrass meadows could take much longer if any spill resulted in appreciable mortality of the underground rhizomes in affected eelgrass beds.

Should an accidental spill of diesel hydrocarbons occur in the nearshore environment as a result of this Project, plans will be in place to quickly initiate response and clean-up measures, limiting the potential for diesel to reach eelgrass beds. In the scenario of a diesel hydrocarbon spill in Bull Arm reaching areas with eelgrass beds present (10 percent or less probability of this occurring based on modelling results (ASA 2011a) without the implementation of spill countermeasures), existing knowledge and experience indicates that damage to eelgrass would likely be slight with recovery occurring within a year of the spill. Exposure and subsequent recovery should be aided by the coastal features of the study area (i.e., this area would not be considered sheltered or poorly flushed). Experience from the sites of other spills indicates that there could be a change in the composition of mobile benthic communities associated with the eelgrass beds. While most components are likely to recover within several years following a spill, some taxa such as Amphipoda and some families of Polychaeta, may take longer to return. In addition, relatively low levels of oil retained in intertidal or shallow subtidal sediments could potentially affect a variety of species. Payne et al. (1988, in Hurley and Ellis 2004) conducted laboratory experiments that exposed male winter flounder to sediments contaminated with a range of Venezuelan crude oil concentrations for approximately four months and observed sub-lethal effects from sediment containing aromatic hydrocarbons as low as 1 ppm. Considering the community level effects of the invertebrate community within an eelgrass bed, the residual adverse environmental effect of an accidental event in the worst case scenario is rated as significant. The probability of this residual adverse environmental effect occurring is considered low as: accidental events will be prevented through spill prevention procedures; a contingency plan will be in place to limit exposure of sensitive areas to hydrocarbons should a spill occur; and modelling has indicated that the probability of an uncontained spill of diesel fuel reaching an eelgrass bed is 10 percent or less.

Capelin Beaches

Pebble beaches where capelin are known to spawn are shore accumulations of coarse sediment that form in a higher energy wave environment compared to sand beaches. They are permeable (except to semi-solid oils) with a mobile and unstable surface layer that supports little life.

Oil that interacts with pebble beaches is less likely to stay stranded at lower tide zones, but will be more concentrated on the upper beach. Oil persistence is a function of oil type, penetration depth, and wave energy. Oil will penetrate a pebble beach to occupy the spaces between pebbles, although oil-in-sediment amounts are usually very low. Very light oil, such as diesel, though able to penetrate the sediment, would be washed through the beach sediment and into the sea by wave action. This is assumed to be the

likely fate of a diesel fuel spill in the Hebron Nearshore Study Area, although some small amounts could become buried in the sediments.

Sensitive flora and fauna may be adversely affected by diesel fuel on shore and in the water column. A spill between May and July could likely interact with a capelin spawning event (up to 100 percent (IFO-180) probability based on modelling results without the implementation of spill countermeasures). If this occurs during the spawning period, the spill would not only affect the physical beach environment, but may also affect fish and fish eggs and larvae. This potential effect has also been addressed in the Marine Fish and Fish Habitat VEC (Section 7.5.4).

As discussed above, the typical fuel used by marine vessels is (a marine diesel and IFO-180 (a heavier diesel that is more persistent). Several diesel oil spills have been studied in the past, focusing on the physical properties and movement of diesel, along with the biological effects of diesel in the marine environment (Hooper and Morgan 1999). Diesel has been found to have an immediate toxic effect on many intertidal organisms, including periwinkles, limpets, gastropods, amphipods and most meiofaunal organisms within several kilometres of the original spill (Wormald 1976; Stirling 1977; Pople et al. 1995; Cripps and Shears 1997). One such spill was found to have contaminated the water and shoreline with diesel within a 2 km radius of the original spill. Intertidal areas were most directly affected, but all components of the surrounding ecosystem were contaminated during the first weeks after the spill. Hydrocarbons were detected in tissues from birds, limpets, algae, calms, fish and crustaceans in harbours a couple of kilometres away (Kennicutt et al. 1991). Based on this, eggs and larvae within the beach would be more at risk from the physiological effects of a spill, being unable to actively avoid the fuel.

Recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of the spawning area were lost (Rice 1985). Thus, while the effects of a spill in the nearshore environment during capelin spawning are considered significant in relation to spawning success at beaches in the Hebron Nearshore Study Area, the effect of this relatively localized spill on egg and larval survival would likely be undetectable at the population level given the high rate of natural mortality (Leggett et al. 1983). There are many capelin beaches along the coast of Newfoundland that would remain unaffected.

Recommended mitigation for oiling of pebble / cobble beaches is to flush the area with water quickly, while the spilled oil is still fresh. Low-pressure flushing may assist in moving light oil (such as diesel) through the sediment into the ocean for collection. Manual cleaning can also be effective, although sediment removal should be avoided. Responders must be careful to minimize sediment removal. All cleanup methods employed require measures to ensure the collection and proper disposal of oil as it is liberated from the shore.

The following response methods are recommended for pebble beaches in British Columbia and include recommendations applicable to diesel fuels (http://www.env.gov.bc.ca/eemp/resources/pdf/shorelines_and_diesel.pdf):

- Natural recovery is preferred for small spills of light oils (e.g., diesel) in remote areas
- Flooding can flush mobile oils from surface and subsurface sediments for collection
- Low-pressure cold washing can flush mobile oil from surface and subsurface sediments (more effective for viscous oils than flooding)
- Manual removal minimizes the amount of oiled and un-oiled sediments that may be collected (not practical for deeply penetrated / buried oil) and is useful for asphalt patches, tar patties and oiled debris in smaller areas
- Mechanical removal of oiled sediment is useful for large amounts of semi solid oils (front-end loaders may be the equipment of choice)
- Sorbents may be helpful for recovering small volumes of light / medium oils
- Mechanical tilling / aeration is appropriate for light oils in surface and subsurface sediments used in combination with surf washing
- Sediment reworking or surf washing is appropriate on exposed coasts after mobile oil is removed or for small areas of oiled sediments (minimizes erosion) but is dependent on availability of wave energy
- Avoid excessive removal of sediment (natural replacements are slow and it could lead to erosion of the beach)
- Avoid large volumes of waste that contain low amounts of oil from sediment removal
- Avoid spreading oil into lower tidal zones or flushing it deeper into sediments

A contingency plan, specific for nearshore construction activities at Bull Arm, will take into account various coastal habitats in the nearshore environment and will adjust to incorporate response and clean-up measures as appropriate.

While considered unlikely, there is a low potential for diesel fuel to be carried into the sediments and become buried. In this scenario, hydrocarbon contamination can persist for years before natural physical and biological degradation diminishes potential effects. In this case, the sensitive life stages of eggs and larvae can continue to affect the productivity of the capelin beach. Therefore, the residual adverse environmental effect is rated as significant.

The likelihood of a spill occurring is low; spill prevention procedures, education and training will be implemented site-wide. In the event of a spill, a contingency plan will be in place to limit exposure of sensitive areas to hydrocarbons.

12.5.1.2 Offshore

In the Offshore Study Area, the Sensitive or Special Areas, as discussed in Section 12.2, have a combination of unique physical features, which in turn

result in high productivity and/or aggregations of species. In assessing the potential environmental effects of an accidental event on these Sensitive or Special Areas, it is important to consider the potential habitat effects as well as the potential effects on the species that may be present in the area should an accidental event occur. Therefore, there is potential overlap with the environmental effects assessment undertaken for other VECs, including, Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10) and Species at Risk (Chapter 11). This is discussed below.

Note that the following assessments are based on the conservative approach that hydrocarbons from an accidental event were to reach the Sensitive or Special Area at the most sensitive time of year. Spill prevention and contingency plans will be in place to reduce both the likelihood of an accidental event occurring and the likelihood of hydrocarbons reaching any of the Sensitive or Special Areas identified in the offshore. The areas discussed in the following paragraphs are shown in Figure 12-2.

The Southeast Shoal and Tail of the Banks Ecologically and Biologically Significant Area

The Southeast Shoal and Tail of the Banks EBSA contains a shallow sandy offshore shoal that is unique in the LOMA. While an accidental event is unlikely to affect the substrate within this area, hydrocarbons on the surface or in the water column as a result of a spill may affect the species present in the area. Capelin, Atlantic cod and yellowtail flounder may spawn here and aggregations of striped wolffish, marine mammals (especially humpbacks and northern bottlenose), and marine birds are known to occur.

This Sensitive or Special Area is located 158 km south of the Hebron Project Area. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. If hydrocarbons did reach the area, fish eggs and larvae present at that time could be affected. Yellowtail larvae can be near the surface for several days to two weeks, and have been caught on the Grand Bank from June to September (Walsh 1992). Thus, there is potential for effects on larvae if a spill occurred in August and September. Yellowtail flounder are batch spawners, with individuals from the same population spawning multiple times throughout the season, so population level effects are not expected.

Based on the above, any decline in productivity is unlikely to be at a level beyond which natural recruitment would not return the population or community to its former level within several generations. The residual adverse environmental effect is, therefore, rated as not significant. The potential for adverse environmental effects to occur as a result of the Project is also considered unlikely given the low probability of an accidental event occurring.

Northeast Shelf and Slope Ecologically and Biologically Significant Area

The Northeast Shelf and Slope EBSA is the closest Sensitive or Special Area to the Project Area at a distance of 39 km north to northeast. Based on spill trajectory models for a spill during any month of the year, there is a probability of 30 percent or less that hydrocarbons from an accidental event (without the implementation of countermeasures) will reach this EBSA. Habitat in the area is not considered particularly unique, although it is known to support aggregations of wolffish and Greenland halibut in spring, and aggregations of marine mammals, particularly harp seals, hooded seals and pilot whales. The potential residual adverse environmental effects of oiling on fish, birds, marine mammals and those individual species considered at-risk has been assessed separately (see Chapters 7, 9, 10 and 11, respectively) and is rated as not significant. This rating is considered applicable to this EBSA as the effects will be temporary and at a level from which natural recruitment could return the population or community to its former level within several generations.

Lily Canyon-Carson Canyon Ecologically and Biologically Significant Area

The Lily Canyon-Carson Canyon EBSA is located 91 km south east of the Project Area. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. Lily Canyon-Carson Canyon is similar to other canyon habitat that occurs along the slope of the Grand Banks, but is particularly important for Iceland scallops, and marine mammals aggregate in the area to feed and overwintering. As any hydrocarbons from an accidental event would be present at the surface or in the water column, the bottom habitat present in this EBSA is unlikely to be affected. Benthic species, like Iceland scallops, are also at low risk of potential effects. The residual adverse environmental effects of oiling on marine mammals have been assessed separately (see Chapter 10) and rated as not significant. While there is a potential for productivity of the EBSA to be diminished if hydrocarbons from accidental releases reach this EBSA, the effects will be temporary and at a level from which natural recruitment could return the population or community to its former level within several generations.

Virgin Rocks Ecologically and Biologically Significant Area

The Virgin Rocks EBSA is considered geologically unique as the rocks are near the surface on the middle of the Grand Bank. Schools of capelin have been reported to occur which would attract marine birds. Atlantic cod, American plaice and yellowtail flounder are reported to spawn near the Virgin Rocks (Ollerhead et al. 2004). The Virgin Rocks EBSA is located 90 km to the west of the Project Area and is actually located adjacent to the western boundary of the Study Area (i.e., immediately adjacent to but outside of the Study Area; Figure 12-2). Trajectory models indicate that hydrocarbon released during an accidental event would generally move in an easterly direction. Therefore, based on modelling, there is less than a 10 percent probability that hydrocarbons will reach this EBSA. As any hydrocarbons

from an accidental event would be present at the surface or in the water column, the bottom habitat present in this EBSA is unlikely to be affected. Any adverse environmental effects on individuals of fish eggs and larvae and marine birds are assessed separately in Chapters 7 and 9, respectively. While there is a potential for productivity of the EBSA to be diminished if hydrocarbons reach this EBSA, the effects will be temporary and at a level from which natural recruitment could return the population or community to its former level within several generations. Therefore, the residual adverse environmental effect on this EBSA is rated as not significant.

Canyon Vulnerable Marine Ecosystems

The potential canyon VMEs identified within the Offshore Study Area are known to support diverse biological communities, including sensitive structure-forming coldwater corals and deep sea fishes. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. Hydrocarbons reaching these VMEs at the surface or even the water column would be unlikely to adversely affect sensitive deepwater corals and deep sea fishes located at or near the seafloor. The productivity and diversity of the benthic community is therefore not at risk and the residual adverse environmental effects are therefore rated as not significant.

Seamounts and Knolls Vulnerable Marine Ecosystems

Like the canyon VMEs, seamount and knolls support communities of invertebrate species that are mostly slow growing, long-lived, late to mature, and experience low natural mortality. Corals and sponges are often associated with these features, as well as a variety of deep sea fishes. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. Hydrocarbons reaching these VMEs at the surface or in the water column would be unlikely to adversely affect sensitive deep-water corals and/or sponges on the ocean floor and deep sea fishes. The productivity and diversity of the benthic community is not considered at risk and the residual adverse environmental effects are therefore rated as not significant.

Proposed Southeast Shoal Vulnerable Marine Ecosystem

The proposed VME is located within the boundaries of DFO's Southeast Shoal and Tail of the Banks EBSA. Therefore the assessment provided above for the Southeast Shoal and Tail of the Banks EBSA is considered applicable to this VME (i.e., not significant).

A summary of the residual environmental effects assessment from accidental events on Sensitive or Special Areas is provided in Table 12-3.

Table 12-3 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Nearshore Spill	• Change in Habitat Quality • Potential Mortality (For eelgrass beds only)	• Emergency Response Contingency Plan • Spill prevention and Response Plan	3	3	2/1	R	2
Offshore Failure or Spill from OLS	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Offshore Subsea Blowout	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Offshore Crude Oil Surface Spill	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)[A]	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	1	2/1	R	2
Marine Vessel Incident (i.e., fuel spills)	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Collisions (involving Platform, vessel and/or iceberg)[A]	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	3	2/1	R	2

KEY

Magnitude:
1 = Low: <10 percent of any Sensitive or Special Area will be affected
2 = Medium: 11 to 25 percent of any Senstitive or Special Area will be affected
3 = High: >25 percent of any Sensitive or Special Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Activity can occur both nearshore and offshore

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12.5.2 Cumulative Environmental Effects

CEAA requires that environmental assessments consider the cumulative environmental effects that are likely to result from the Project in combination with other projects or activities. For the Sensitive or Special Areas VEC, the assessment of potential Hebron Project-related environmental effects for both the nearshore and offshore are limited to accidental events, and are considered unlikely to occur, because of spill prevention activities and spill response procedures. Therefore an assessment of cumulative environmental effects in relation to these accidental events is not required under CEAA or considered appropriate here.

The potential for Project-related cumulative environmental effects on the various species that may use these Sensitive or Special Areas, but may also be present in the Nearshore and Offshore Project Areas at other times and therefore exposed to routine Project activities, is considered and assessed in the respective VECs (i.e., Marine Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10), and Species at Risk (Chapter 11)).

12.5.3 Determination of Significance

The determination of significance is based on the definition provided in Section 12.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis (Table 12-4).

Table 12-4 Residual Environmental Effects Summary: Sensitive or Special Areas

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Accidents, Malfunctions and Unplanned Events	S	3	1

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria

Significant adverse residual environmental effects are predicted for identified Sensitive or Special Areas in the Nearshore Study Area; however, no significant adverse residual environmental effects are predicted for identified Sensitive or Special Areas in the Offshore Study Area. Using a precautionary approach, it is concluded that there is potential for a significant residual

adverse environmental effect to the Sensitive or Special Areas VEC should hydrocarbons from an accidental event reach the identified nearshore eelgrass beds. However, the likelihood of a significant residual adverse environmental effect occurring is considered low.

12.5.4 Follow-up and Monitoring

Potential Project effects assessed in association with this VEC are limited to accidental events. Depending on the nature, timing and extent of an accidental event associated with the Project, a monitoring program will be implemented to determine environmental effects related to the event (refer to Chapter 14 for more information on accidental event mitigation and contingency plans). This would be particularly important for sensitive or special nearshore areas, where experience from other accidental events indicates the potential for multi-year effects.

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13 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

13.1 Introduction

The Hebron Development Project Scoping Document (Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) 2009) requires a description of relevant physical environment parameters, including "Effects of the environment on the Project". Section 2(1) of the Canadian Environmental Assessment Act (CEAA) defines environmental effect to include "any change to the project that may be caused by the environment". This chapter provides a discussion of the expected and potential effects of the oceanographic environment on the Project's design, construction and operation.

Currently, there are three operating oil and gas fields on the Grand Banks within approximately 50 km of the proposed Hebron Project location. One is producing using a Gravity Base Structure (GBS) platform (Hibernia) and the other two (White Rose and Terra Nova) are being developed with Floating Production Storage and Offloading vessels. The Hibernia project has been in operation since 1997 and has produced over 680 MMbbls of oil. The Terra Nova project commenced operations in 2002 and has produced over 294 MMbbls, whereas White Rose has been operational since 2005, with over 141 MMbbls of oil produced to date. As with the Hebron Project, these developments were designed to withstand the environmental conditions that occur in this area, and they have demonstrated that oil and gas projects can be successfully operated in the same environmental conditions within which Hebron will be situated.

13.2 Context

Ultimately, to mitigate the effects of the physical environment on the Project, there must be adequate planning, design and operations procedures that consider the expected normal and extreme physical environmental conditions that may be encountered.

There must also be adequate monitoring and forecasting of physical environment conditions. Through adequate monitoring and forecasting, Project activities can be adjusted to maintain a safe working environment. All outside activities are affected by the physical environment.

This description considers those marine environment parameters discussed in Sections 3.1.2 and 3.2.2 for the Nearshore and Offshore Study Areas, respectively.

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13.3 Nearshore Potential Marine Effects

13.3.1 Bathymetry

Nearshore bottom topography is complicated, with steep drops along the coast and narrow central channels and small coves. During construction of the GBS, bathymetry will be considered for installation of mooring systems and for marine operations and traffic management such as barge towing, vessel and remotely-operated vehicle (ROV) manoeuvring.

The GBS drydock site is situated in Great Mosquito Cove. The cove is 1.5 km long and has an average width of 500 m. The GBS drydock is approximately 16.5 m deep and has a diameter of 180 m. The coastline approaching Great Mosquito Cove drops sharply to depths of 30 to 88 m and in the Cove, depths increase from 13 to 33 m at only 300 m from shore, reaching 45 m in the middle. At the mouth of Great Mosquito Cove, the water is deep, ranging from 51 to 132 m near the centre of Bull Arm.

Bathymetry may be a factor during tow-out, depending on final GBS dimensions and route selected. If required, dredging may be undertaken within the tow-out channel to provide sufficient depth.

All of these factors will be considered in the Project development; however, none of these suggest that a bathymetric "effect" on the Project could occur. These sorts of activities have been successfully carried out previously for other developments.

13.3.2 Wind, Waves and Currents

Extreme wind, waves and currents have the potential to increase stress on surfaces and vessels and disrupt scheduling of marine operations. Wind, waves and currents will be considered during construction of the GBS, mooring system design, barge manoeuvring, tow vessel, support vessel and ROV operations.

For the nearshore, extreme wind, waves and currents can affect towing operations and vessel manoeuvring and increase stress on moorings, which can lead to mooring failure. Also, extremes can increase stress on or over-top the bund wall and/or row(s) of sheet pile that surround the existing GBS drydock facility at Bull Arm, leading to flooding and/or failure of the bund wall.

The Hibernia Development Project Environmental Specifications (Topside Engineering 1992) reports a 100-year extreme maximum significant wave height (Hs) of 2.6 m and extreme heights of 4.8 m for two deepwater sites in Bull Arm in winter months. The 100-year extreme current for deepwater sites in Bull Arm ranges from 1 m/s at depths of 5 to 80 m to 0.4 m/s at the surface (Section 3.1.3.2).

Site-specific weather and oceanographic data are typically collected as part of a physical environment monitoring program, which would enhance the physical database for the area, and will be collected for the Hebron Project.

These values and their potential effects will be considered for all marine Project activities in the nearshore region.

All wind, wave and current extreme value estimates will be considered in the design of moorings and the operation of vessels and barges.

13.3.3 Tsunamis

A detailed discussion on tsunamis is provided in Section 3.1.2.3. The following is a summary of observations from that Section.

While tsunamis have been observed in eastern Newfoundland and their effects can be devastating, they are not a frequent occurrence in this part of Canada. Based on the limited historical record, it can be estimated that a return period of approximately 50 to 100 years, or longer for a destructive tsunami like the 1929 event, might be possible for parts of Newfoundland; this would likely be much longer for Bull Arm, given its more sheltered location (compared with the tip of the Burin Peninsula in 1929) from the open ocean. The fact that construction nearshore will take place over approximately four years, a relatively "short" lifetime, means that the likelihood of occurrence during this period is low and therefore, it is estimated there is a low risk of tsunamis effects for the Project nearshore.

13.3.4 Tides, Water Levels, and Storm Surge

The first stage of GBS construction will be to re-instate the drydock at Great Mosquito Cove. The drydock will be enclosed by a bund wall and/or row(s) of sheet pile that will subsequently be removed (ExxonMobil Canada Properties (EMCP) 2009). Tides and storm surges can raise water levels considerably. Therefore, the potential exists for flooding of the drydock and this will be considered during the construction phase.

An estimate of 100-year maximum water level is +1.52 m above mean water level (MWL) (Marex 1992). This includes the standard deviation of the MWL, the dominant (M2 and S2) tide, the 50-year storm surge and the standard deviation of the 50-year surge. A 100-year minimum water level of -1.20 m below MWL is similarly estimated.

A more conservative estimate of extreme maximum water level would be +1.68 m above MWL taken as the sum of highest astronomical tide (HAT) (0.80 m above MWL) and the 100-year positive surge amplitude (0.88 m above MWL). Similarly, a more conservative estimate of extreme minimum water level would be -1.45 m below MWL taken as the sum of lowest astronomical tide (LAT) (-0.91 m below MWL) and the 100-year negative surge amplitude (-0.54 m below MWL) (Marex 1992).

All tide, water level and storm surge extreme estimates will be considered in the design of moorings and the operation of vessels and barges.

13.3.5 Temperature

The design, construction and installation of the GBS will consider the sea temperature. Low water temperatures can lead to vessel icing and exposure

to water at this temperature may pose a risk to personnel and to exposed surfaces. There will be need for winter protection during open construction.

Surface sea temperature in the area can fall below 0°C from January to August; therefore, exposure to water at this temperature may pose a risk to personnel and to exposed surfaces. The combination of low air and sea temperature, strong winds and high waves can lead to vessel icing. A vessel, or structure in the case of the GBS, itself is also a critical factor for icing potential. The size and hull design (which may affect the amount of spray produced) and the amount of superstructure present (which can act as a "trap" for spray accumulation) are other considerations.

13.3.6 Sea Ice and Icebergs

Pack ice presence in Trinity Bay from year to year is variable, based on a review of the weekly Canadian Ice Service (CIS) charts from 1983 to 2008, inclusive (Environment Canada CIS 2010). Trinity Bay has pack ice in one form or another present on a ratio of one-in-three years. Most sea ice within the bay is formed off southern Labrador and drifts south to enter the bay around the mid-March timeframe. From mid-March through to early May, the bay experiences first year ice (see Table 3-10), which can range in thickness from 30 to 120 cm.

The Trinity Bay region does not lie on a primary aerial ice reconnaissance route; the low numbers of icebergs sighted each year, therefore, may be related to the low number of flights over that area. If this is true, the number of icebergs in the Trinity Bay area may be under-detected and under-reported. In addition, iceberg distribution can fluctuate greatly from year to year. The maximum number of icebergs sighted in one year (1979) over the period of study was 129; the mean annual number for Trinity Bay is 32. The majority (89 percent) of the icebergs observed in Trinity Bay fall within the small to medium categories.

Sea ice conditions will be monitored and managed in accordance with the Ice Management Plan. The Ice Management Plan, which will be developed for offshore operations, will outline requirements for monitoring and managing sea ice conditions for the Hebron Platform.

13.3.7 Geohazard

While there are not enough data at Bull Arm to rule out the presence of any geohazards, it does have a successful track record as a development site.

13.3.8 Climate Change

The nearshore construction will take place over approximately four years, a relatively short period, so that climate change is unlikely to have an environmental effect within that timeframe.

13.4 Offshore Potential Marine Effects

13.4.1 Bathymetry

Depending on final Hebron Platform dimensions, and route selected, bathymetry, particularly clearance over the Offshore Project Area, will be relevant for Hebron Platform tow-out and installation on the seabed, though no "effect" of the bathymetry is expected. The tow-out routes will be carefully selected and confirmed for suitability (depth). If required, sections of the tow-out channel may require dredging.

13.4.2 Wind, Waves and Currents

Extreme wind, waves and currents have the potential to increase stress on surfaces and vessels and disrupt scheduling and operations. The design, installation and operation of the Hebron Platform, offshore loading system (OLS) and supporting infrastructure will consider wind, wave and currents loads. Wind, wave and current data are typically collected as part of a physical environment monitoring program, which would enhance the physical database for the area.

The Hebron Metocean Criteria (ExxonMobil 2009) reports a 1-year return period extreme Hs of 10.5 m and associated 1-hour wind speed at 10 m of 26.2 m/s. The 100-year return period extreme Hs is 14.8 m, with an associated 1-hour wind speed of 33.2 m/s. The maximum individual wave height for a 1-year return period is 19.7 m, and for 100-years is 27.8 m. Extreme crest elevations are 13.3 m for a 1-year return period and 19.4 m for 100-years.

Estimates of one-year return period currents range from 0.64 m/s near-surface to 0.46 m/s at mid-depth, to 0.42 m/s near-bottom (ExxonMobil 2009). One hundred-year return period currents range from 1.16 m/s near-surface to 0.77 m/s at mid-depth, to 0.66 m/s near-bottom. The near-surface value of 1.16 m/s is comparable to the maximum measured currents reported by Bedford Institute of Oceanography of 0.96 m/s at 18 m (Gregory et al. 1996). The largest near-surface currents occur from August to October, while mid-depth and near-bottom currents are greatest from September to March (ExxonMobil 2009).

Wave conditions offshore will limit supply vessel loading and offloading of cargo. In addition, vessel iceberg towing and spill response operations, if required, would be affected. The sea state may limit the safety and effectiveness of supply vessel operations (e.g., deployment and use of spill containment equipment, or the deflection of icebergs).

Based on favourable persistence analysis of historical Grand Banks conditions, the average length of time that, in any given month, seas (including swell) will persist below the given Beaufort Force (BF) (see Table 13-1) sea state thresholds[1] is illustrated in Figure 13-1.

[1] Beaufort Scale (e.g., http://www.tc.gc.ca/MarineSafety/Tp/Tp10038/80-wi-beaufort-scale.htm)

Table 13-1 Beaufort Force Scale

Hs (m)	Beaufort Force Scale
<1.0	3
≥1.0 and ≤1.5	4
>1.5 and ≤0.5	5
>2.5 and ≤4.0	6
>4.0 and ≤5.5	7
>5.5 and ≤7.5	8
>7.5 and ≤10.0	8
>10.0 and ≤12.5	10
>12.5 and ≤16.0	11
>16	12

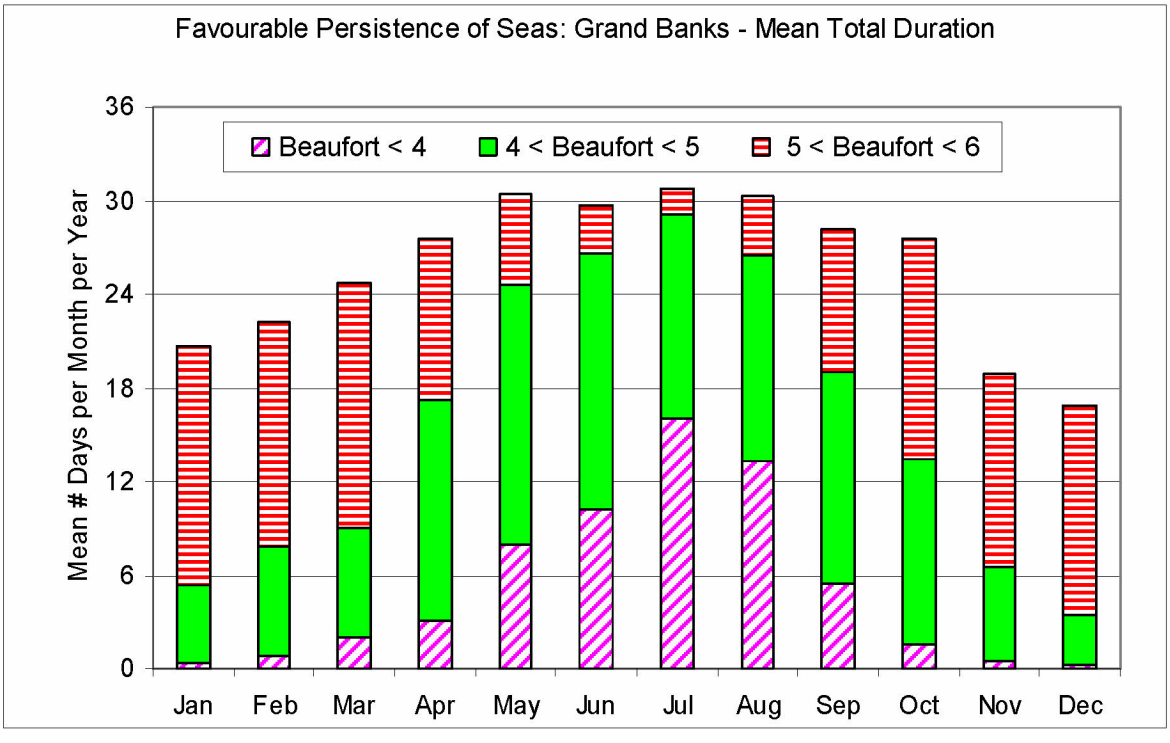

Figure 13-1 Favourable Persistence of Seas: Grand Banks - Mean Total Duration

The analysis was of the nine-year Hibernia wind, wave, and current (for five-year) time-series, where waves include swell. BF was assigned based on Hs, with the following mapping as a function of probable maximum height of waves:

An intent of the work is to quantify conditions and show that while seas can get quite large on the Grand Banks, there are windows of opportunity that, depending on the threshold, may be conducive to marine operations. For example, in November to February, less than one day per month would have conditions that are below BF4 (Hs = 1.5 m), while in June to August, it is over 10 days per month. During the winter, approximately 8 to 12 days per month could have conditions persist above BF6 (i.e., waves over 4 m, near gale

force or higher). Conversely, in the summer, these conditions will be experienced rarely, as the bars top out at approximately 30 days; conditions are more favourable to marine operations in summer.

Another wave-related environmental influence on vessel operations is iceberg towing and deflection, which can be routinely required during ice season. Marine conditions can play an important role in the success of these activities. Several observations (e.g., as recently described by McClintock et al. 2007) are noted here in this regard.

Propeller washing, generally a successful technique for small ice mass deflection, can be difficult in high seas and reduced in its effectiveness. High sea states can further complicate matters, as they may affect the success of radar detection of smaller icebergs and growlers.

High sea states can sometimes increase the risk of tow line slippage during iceberg towing. Tow techniques, including the two-vessel iceberg net tow (C-CORE 2004), offer benefits of improved safety (including less crew time on back decks of supply vessels) and efficiency in higher sea states, and is one potential mitigation of wave effects on vessel operations.

These examples serve to illustrate, that in addition to design considerations, the marine environment can affect Project activities. EMCP will establish appropriate plans and procedures for all activities to maximize the safety of personnel, equipment and the environment, and to optimize the likelihood for success in all such undertakings.

13.4.3 Tsunamis

A detailed discussion on tsunamis is provided in Section 3.2.2.3. The following is a summary of observations as relates to potential effects.

The wave height of a passing tsunami offshore is small, approximately 1 m or less, and is not expected to be an issue for the offshore operation, particularly given the long period of the waves. Associated current speeds up to 70 cm/s could possibly be a concern for moorings and hoses. Tsunamis Warning Systems are aimed at managing coastal risk; however, they may also provide useful mitigative information for offshore operations. Given the low likelihood of tsunami occurrence and the anticipated low consequence should they occur, no tsunami effects offshore are anticipated.

13.4.4 Tides and Storm Surges

Tides and storm surges can cause an increase or decrease of water levels as large as 50 cm. These factors will be considered for the tow-out, installation and operation of the Hebron Platform.

13.4.5 Temperature

Sea temperature, combined with strong winds and high seas, is a contributing factor for marine vessel and structure icing during Project operations in winter.

13.4.6 Sea Ice and Icebergs

The Hebron location has experienced sea ice incursions in approximately 25 percent of the years spanning 1972 to 2008. These incursions are bi-modal and have peak probabilities centered on two periods: the first peak in the last week of February; and the second in the first week of April. The duration of the incursions vary from a low of one week to a high of seven weeks. Of the 11 years that ice was present, the average duration was three weeks. These statistics are based on Environment Canada CIS's Sea Ice Charts (1983 to 2008).

The number of icebergs drifting south of 48°N each year has varied from a low of zero in 1966 and 2006 to a high of 2,202 in 1984, with the average over the last 20 years (using 1989 to 2008 PAL data) ranging between 725 to 752 icebergs. Of these, only a small proportion has passed through the Offshore Project Area. Over the last 10 years, the average annual number of icebergs sighted in the Hebron Offshore Project Area has been 31. The majority (73 percent) of the icebergs south of 48°N fall within the small to medium categories.

The design, installation and operation of the Hebron Platform, OLS and supporting infrastructure will consider sea ice and icebergs. An Ice Management Plan will be prepared and ice conditions will be monitored.

13.4.7 Geohazard

In terms of other constraints to development, no shallow faults have been identified that penetrate the near-surface stratigraphy within the vicinity of the Hebron Platform. Potential shallow gas pockets have not been identified within the upper 100 m or more of the sediment column (McGregor and Fugro Jacques GeoSurveys 1998; Sonnichsen and King 2005). Boulders may be present at, or beneath the seabed, and potentially at depths of tens of metres sub-seabed (Sonnichsen and King 2005). As evidenced in seismic profiles, there is potential for near-surface channels within the Offshore Project Area. A detailed geohazard assessment will have to be performed at any drilling locations selected, via a dedicated geohazard survey (or based on existing data) as per Canada-Newfoundland and Labrador offshore Petroleum Board (C-NLOPB) guidelines.

The earthquake-generation process in eastern Canada is indirect, and potential zones of weakness are widespread, resulting in diffuse seismicity patterns. Earthquakes may take place on a series of buried crustal faults, in locations that cannot be precisely foreseen. Most earthquakes show predominantly thrust faulting, with some strike-slip component, consistent with high regional compressive stresses; however, there are not any focal mechanisms for earthquakes in the Jeanne d'Arc or other nearby basins. The Hebron Platform is located within the eastern Canadian continental margin that is characterized by low to moderate levels of seismic activity, with infrequent large earthquakes (URS Corporation 2006) While overall rates of seismicity are relatively low, there are zones of clustered higher rate seismicity and historical earthquakes up to Magnitude 7.3 (1929 Grand Banks

earthquake) have occurred in the region. There are currently no data indicating known seismic source faults in the vicinity of the proposed Hebron Platform. A seismic hazards study determined the following return periods for various levels of earthquakes at the Hebron Platform (URS Corporation 2006):

- Abnormal Level Earthquake: 3,000 years
- Extreme Level Earthquake: 600 years
- Operating Level Earthquake: 300 years
- Safety Level Earthquake: 3,000 years

The Operating and Safety Level Earthquake risk levels are usually determined by the facility owner (URS Corporation 2006).

13.4.8 Climate Change

A detailed discussion on climate change is provided in Section 3.2.6. The following is a summary of considerations for the offshore:

- Sea-level rise: Estimates of sea level rise globally over the next 50 years due to climate change alone are from 2.5 cm (Kolker and Hameed 2007) to as much as 15 cm (Hu et al. 2009). The productive life of the Hebron Project is currently estimated at 30 years; therefore, sea level rise to some degree may occur. The design of the Hebron Platform will account for sea level rise
- Waves: Increased storm intensity may result in higher associated peak wave heights and more frequent occurrence of extreme wave events. However, climate simulations for the next century show almost no change in peak Hs for the western North Atlantic, consistent with recent trends in observed data. With increased temperature, more tropical storms can be expected to survive farther north, bringing with them higher waves during the tropical storm season. The design of the Hebron Platform will account for more frequent occurrence of peak wave heights
- Sea Surface Temperatures: there is considerable uncertainty as to the question of warming sea surface temperatures, since glacial melt north of Newfoundland would exert a cooling influence on the offshore waters. A slight change of sea surface temperature may not directly affect the Project, but may contribute to increased storm frequency and icing intensity

The Project will be designed to withstand these possible variations in normal and extreme marine environment conditions.

13.4.9 Biofouling

Biofouling epiflora and epifauna are usually found in the photic zone, and the species found in the upper 50 m (during studies in the North Sea) are primarily comprised of seaweeds, hydroids, soft corals, anemones and mussels. Below 50 m, the biofouling communities are primarily comprised of hydroids, soft corals, anemones and tubeworms (Welaptega 1993, in Husky 2000).

While biofouling epifauna and epiflora do attach themselves to the walls of the Hibernia platform within the depths of light penetration, they do not make visual inspections more difficult or contribute to fatigue or corrosion to the infrastructure of the platform (HMDC 2005).

13.5 Environmental Events

The selection of appropriate events is a key to identifying risks that are most realistic within the context of the assessment (Table 13-2). In order to accomplish this, it is necessary to address a wide range of events. The following is a discussion of the events that could be considered as having a potential effect, together with how adverse that effect might be, and an indication of mitigations that should be implemented to reduce the hazard.

Table 13-2 Environmental Effects on the Project

Marine Environmental Event	Mitigation
Nearshore Events	
Wind / Waves – ROV operations	Safe Operating Procedures, Site Monitoring / Forecasts
Wind / Waves – barge, tug or support vessel operations	Safe Operating Procedures, Site Monitoring / Forecasts
Wind / Waves – access to GBS at deepwater site	Safe Operating Procedures, Site Monitoring / Forecasts / FEED / Facility Design
Waves – bund wall failure	Site Monitoring / Forecasts / FEED / Facility Design
Waves / Currents – mooring failure	Site Monitoring / Forecasts / FEED / Facility Design
Storm surges / high water levels - flooding and damage to drydock/bund wall	Site Monitoring / Forecasts / FEED / Facility Design
Sea Temperature - contributor to vessel and structure icing potential	Site Monitoring / Forecasts
Sea Temperature - exposure to personnel	Safe Operating Procedures
Offshore Events	
Tsunamis – OLS / Tanker disruption (high currents)	Warning Systems, Site Monitoring / Forecasts / FEED / Facility Design
Wind / Waves – tug or support vessel operations (e.g., ice, spill response, Search and Rescue)	Safe Operating Procedures, Site Monitoring / Forecasts
Waves / Low water level – affecting Hebron Platform installation on seabed	Safe Operating Procedures, Site Monitoring / Forecasts / FEED / Facility Design
Currents – OLS / Tanker disruption	Site Monitoring / Forecasts
Sea Temperature - contributor to vessel and structure icing potential	Site Monitoring / Forecasts / FEED / Facility Design
Sea Temperature - exposure to personnel	Safe Operating Procedures
Seasonally-occurring Sea Ice and Icebergs	Ice Management Plan / FEED / Facility Design
Climate Change – Sea level rise	FEED / Facility Design
Climate Change - Waves	FEED / Facility Design
Climate Change - Sea Surface Temperature	FEED / Facility Design
Climate Change - Sea Ice and Icebergs	Ice Management Plans / FEED / Facility Design

13.5.1 Mitigation Measures

The range of effects on the Project due to the physical environment can range from minor facility improvement to catastrophic failure. The primary mitigation tool is the use of sound planning. All engineering design will adhere to national / international standards. These standards document the proper engineering design for site-specific normal and extreme physical environmental conditions and provide design criteria that the regulatory agencies consider satisfactory for withstanding the potential physical environmental conditions. These codes consider physical environmental criteria such as temperature, wind, snow, wave and ice loading, and drainage. In addition, the design life is taken into consideration so that materials are chosen with sufficient durability and corrosion resistance.

Physical management of icebergs in the Offshore Study Area is conducted well up-stream in an attempt to deflect any icebergs that may encroach on the operational areas of production facilities. In general terms, most physical iceberg management consists of towing or deflecting the iceberg off its free-drifting track. The attempts historically consisted of deploying a long floating tow rope around the iceberg, and then applying force with a supply vessel in the direction they desired the iceberg to move. In the past 30 years, other methods have been used with varying degrees of success, but this basic method has remained the staple of iceberg management, having been used in nearly 500 documented iceberg tows. The recent development of an iceberg tow net has gained popularity for management operation on the Grand Banks. The iceberg tow net was designed to reduce the amount of rope slippage and provide a reduction in iceberg rolling while being managed.

Sea ice management procedures have long been used in Canadian water (e.g., to break up sea ice to assist shipping). Because of the loose nature of the pack in the area of the Grand Banks, sea ice management primarily consists of using support vessels to break up any large ice floes that meet or exceed the design limits of the facility. Over the 2008 and 2009 ice seasons, experience has been gained using water cannons to open a path in the pack as it advanced towards facilities. The method used a support vessel stationed a few hundred metres ahead of the production facility. By sweeping the vessels water cannon left and right, a path or lead is opened up, keeping the loose pack clear of the facility.

Beginning in late 1988, all operators on the Grand Banks adopted a coordinated ice management approach. Under this system, the joint operators share ice information and ice management resources, along with adopting a strategy and procedures for managing icebergs over the whole Jeanne d'Arc Basin area. EMCP will explore synergies with existing operations regarding ice management.

13.5.2 Definition of Significance

A significant effect of the environment on the Project is determined to be one that:

- Harms Project personnel or the public
- Results in a substantial delay in construction (e.g., more than one season) or shutdown of producing operations
- Damages infrastructure and compromises public safety
- Damages infrastructure to the extent that repair is not economically or technically feasible

It should be noted that:

- Tsunami frequency or likelihood is improbable for nearshore (unlikely so as to assume will not occur) and remote for offshore (unlikely but possible) (i.e., these are <<10 events/year)
- Particularly with climate change events, there is an element of uncertainty as to the "change" and whether it is greater or less (e.g., for large waves) and/or by how much (e.g., sea level rise).

13.6 Conclusion

The Project design and operations planning incorporates metocean criteria. Physical metocean site monitoring will be undertaken. As such, no significant effects on the Project are anticipated. The effects of ice, including icebergs, on the Project are predicted to be minimal. GBS design basis incorporates the potential for ice impact with the structure. This, in addition to the provision of ice management procedures, will result in a minimal effect from sea ice or icebergs on the Project. Therefore, there are no likely significant environmental effects on the Project.

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14 ACCIDENTAL HYDROCARBON SPILL EVENTS

A hydrocarbon spill or accidental release is the accidental event of greatest concern because it can result in higher magnitudes of environmental effects, compared to other Project-environment interactions. A hydrocarbon spill can affect marine mammals and birds, and the commercial fishery. For these reasons, it is important to understand the probability of its occurrence and fate, for planning and response purposes. To this end, the probability of varying sizes of hydrocarbon spills have been estimated using historical data from Newfoundland and other offshore oil and gas development regions, and the trajectories of credible spill scenarios have been modelled. The results are presented in this chapter.

For the purposes of the environmental assessment, two types of accidental events during drilling and production operations – blow-outs and "batch" spills – are assessed. Blow-outs are continuous spills lasting hours, days or weeks that could involve the discharge of large volumes of associated gas into the atmosphere, discharge of crude oil and certain amounts of gas condensate (a very low viscosity, highly volatile type of liquid petroleum oil) into surrounding waters. Blow-outs could occur from accidents during development drilling, well-completion activities, workovers and various production activities including wirelining, coiled tubing and snubbing operations. Batch spills are instantaneous or short-duration discharges of hydrocarbon that could occur from accidents on the drilling or production platforms where hydrocarbon is stored and handled. An oil spill could potentially occur during offloading and/or transfer of crude oil at the offshore loading system (OLS).

Compared with other industries that have potential for discharging petroleum hydrocarbon into the marine environment, the industry of exploring, developing and producing offshore oil and gas (the offshore E&P industry) has a good record. A recent study on marine hydrocarbon pollution by the US National Research Council (NRC 2002) indicates that accidental petroleum discharges from platforms contribute only 0.07 percent of the total petroleum input to the world's oceans (0.86 thousand tonnes per year versus 1,300 thousand tonnes per year - see Table 14-1).

This section derives spill and blow-out statistics for the Hebron Project from world-wide statistics. The practices and technologies that will be used on the Project are world-class and will be in accordance with Canadian regulations and best practices.

The petroleum industry usually uses the oil volume unit of petroleum barrel (bbl), which is different than a US barrel and a British barrel. There are 6.29 bbl in 1 cubic metre (m^3) and there are approximately 7.5 bbl per tonne. Most spill statistics used here are taken from publications that use the oil volume units of bbl, and bbl are used in the subsequent statistical analysis as a result.

Table 14-1 Best Estimate of Annual Releases (1990 to 1999) of Petroleum by Source

Source	North America in thousands of tonnes	World-wide in thousands of tonnes
Natural Seeps	160	600
Extraction of Petroleum	3.0	38
Platforms	0.16	0.86
Atmospheric Deposition	0.12	1.3
Produced waters	2.7	36
Transportation of Petroleum	9.1	150
Pipeline Spills	1.9	12
Tank Vessel Spills	5.3	100
Operational Discharges (cargo washings)	Na [A]	36
Coastal Facility Spills	1.9	4.9
Atmospheric Deposition	0.01	0.4
Consumption of Petroleum	84	480
Land-Based (River and Runoff)	54	140
Recreational Marine Vessel	5.6	nd [B]
Spills (non-tank vessels)	1.2	7.1
Operational Discharges (vessels 100 GT)	0.10	270
Operational Discharges (vessels <100 GT)	0.12	nd [C]
Atmospheric Deposition	21	52
Jettisoned Aircraft Fuel	1.5	7.5
TOTAL	260	1,300

Source: NRC 2002
Notes:
A Cargo washing is not allowed in US waters, but is not restricted in international waters. Thus, it was assumed that this practice does not occur frequently in US waters
B World-wide populations of recreational vessels were not available
C Insufficient data were available to develop estimates for this class of vessels

Data sources used in this chapter have varying dates of publication. Sources such as the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, until recently known as the Minerals Management Service, MMS) are updated regularly, and the most recent data available are used in this report. Other sources used, notably Scandpower (2000), and NRC (2002) have not been updated.

14.1 Hydrocarbon Spill Probabilities

Spill probabilities are discussed separately for blow-outs and for other “batch” spills from drilling and production platforms, and for a range of spill sizes. The definitions of oil spill sizes are provided in Table 14-2.

Table 14-2 Definition of Hydrocarbon Spill Sizes

Hydrocarbon Spill Type	Spill Size	
	bbl	m^3
Extremely Large	>150,000	>23,850
Very Large	>10,000	>1,590
Large	>1,000	>159
Small	<1	<0.159

Note: The top three categories are cumulative; for example, the large-spill category (>1,000 bbl) includes the very large and extremely large spills, and the very large category includes extremely large spills. This follows the approach used by BOEMRE statisticians upon which the "large" spill frequencies are derived. For the small category, more detailed statistics are available and a further breakdown is made with discrete size ranges, specifically: 50 to 999 bbl, 1 to 49 bbl, 1 L to 1 bbl (159 L), and less than 1 L.

14.1.1 Extremely Large and Very Large Oil Spills from Blow-outs

In the oil and gas industry, a distinction is made between two stages of petroleum field drilling: exploration drilling (including "delineation" drilling), where knowledge of the geological and depositional environment is speculative or limited; and development drilling, where the structure is better defined and drilling is under better control. Because exploration drilling at the Hebron site is now completed, the analysis concentrates on statistics related to development drilling, although reference is made to exploration-related statistics where appropriate. Blow-outs can also happen during production, workovers and well completion activities, and these are also addressed.

In Canada, there have been no large petroleum spills from blow-outs. In the US, since offshore drilling began in the mid-1950s, there have been three oil-well blow-outs involving hydrocarbon spills greater than 50,000 bbl. Therefore, data from jurisdictions beyond North America must be used to develop a reasonable database on very large and extremely large oil-well blow-outs. All world-wide blow-outs involving the spillage of more than 10,000 bbls each are listed in Table 14-3.

Using the definition of "extremely large" spills (i.e., hydrocarbon spills greater than 150,000 bbls), there have been six such spills in the history of offshore drilling, one of which occurred during development drilling, three of which occurred during production or workover activities and two occurred during exploration drilling.

14.1.1.1 Blow-outs during Drilling

Spill frequencies are best expressed in terms of a risk exposure factor such as number of wells drilled. On a world-wide basis it has been estimated that 66,469 offshore development wells were drilled as of May 2010 (Deloitte 2010).

Table 14-3 Historical Extremely and Very Large Hydrocarbon Spills from Offshore Oil Well Blow-outs

Area	Reported Spill Size (bbl)	Date	Operation Underway	Duration (days)	Intervention Method
Extremely Large Spills (>150,000 bbl)					
US, Gulf of Mexico (GOM)[A]	4,000,000	2010	Exploration drilling	91	Relief well
Mexico (Ixtoc 1)[B]	3,000,000	1979	Exploratory Drilling	293	Relief well
Iran[C]	see note	1983	Production	--	
Mexico	247,000	1986	Workover	??	
Nigeria	200,000	1980	Development Drilling	14	Bridged
North Sea / Norway	158,000	1977	Workover	7	Capped
Very Large Spills (10,000)					
Iran	100,000	1980	Development Drilling	8	
US, Santa Barbara	77,000	1969	Production (Platform)	11	Capped
Saudi Arabia	60,000	1980	Exploratory Drilling	8	Capped
Mexico	56,000	1987	Exploratory Drilling	51	
US, S. Timbalier 26	53,000	1970	Wireline	138	Relief well & Capping
US, Main Pass 41	30,000	1970	Production (Platform)	49	Capped (three relief wells also initiated)
Australia[D]	30,000	2009	Development drilling (primarily gas)	74	Relief well
US, Timbalier Bay / Greenhill	11,500	1992	Production	11	
Trinidad	10,000	1973	Development Drilling	4	

Source: Gulf 1981, updated to 2010 by reference to the Oil Spill Intelligence Report and other sources

A Varying estimates of spill volume, most recent estimate reported

B Spill volume widely believed to be underestimated

C The Iranian Norwuz oil well blow-outs in the Gulf of Arabia, which started in February 1983, were not caused by exploration or drilling accidents, but were a result of military actions during the Iraq / Iran war

D Currently under investigation, spill volume is best estimate and may be subject to revision

There has been one extremely large spill during offshore development drilling, so the frequency up to 2010 is (1/66,469) 1.5x 10^{-5} spills per well drilled, or one such spill for every 66,000 wells drilled. A similar analysis can be done for very large spills. Up to 2010, four development-drilling blow-outs have produced spills in the very large spill category (including spills in the extremely large category; refer to Table 14-3) including the recent incident in Australia. The spill frequency for these is (4/66,469) 6.0 x 10^{-5} spills per well drilled, or one such spill per every 17,000 wells drilled.

14.1.1.2 Blow-outs during Production and Workovers

Table 14-3 shows that there were two extremely large (not including the 1983 war-related spill in Iran) and six very large hydrocarbon spills from blow-outs during production and workovers (including extremely large spills in the very large category. Lack of production statistics makes it difficult to develop an exact risk exposure for these events. However, it is estimated that the total oil produced offshore on a world-wide basis up to 2002 has been approximately 125 billion bbl, and that the total producing oil well years has been 250,000 well-years (based on information in Gulf (1981), NAS (1985), E&P Forum (1992), MMS (1997) and current internet sources). Generally, in analyzing accidents in the oil and gas industry, the exposure variable of "well-years" is used to normalize data for the continuous operation of production. This exposure is also convenient to use for workovers inasmuch as these maintenance activities, although not continuous, usually occur with regularity, approximately every five to seven years during the lifetime of a well.

On this basis, the world-wide frequency of extremely large hydrocarbon spills from oil-well blow-outs that occurred during production or workovers is 8.0×10^{-6} blow-outs/well-year. For very large, the number is 2.4×10^{-5} blow-outs/well-year.

14.1.1.3 Summary of Extremely Large and Very Large Oil Spills from Blow-outs

The above calculation of spill frequencies is based on an estimate of 250,000 oil-well years of world-wide experience and does not include gas-well experience, which, according to US OCS activity, could be 75 percent as much as oil-well experience. In other words, the frequencies calculated above, however low, are actually substantially lower when considering gas-well experience as well as oil-well experience. Because world-wide gas-well experience is not easy to estimate, the above spill frequencies will be used as a conservative case.

Finally, it is emphasized that the very low spill frequencies derived above for extremely large spills are based on spills in countries (except Norway) that do not generally have regulatory standards as stringent as those existing in North America. For example, one of the largest hydrocarbon spills in history, the Ixtoc I oil-well blow-out in the Bay of Campeche, Mexico, that occurred in 1979, was caused by drilling procedures (used by PEMEX, Mexico's national oil company) that are not practiced in US or Canadian waters and that are contrary to US and Canadian regulations and to the accepted practices within the international oil and gas industry. Therefore, extremely large spill frequencies in North America are expected to be even lower.

In spite of this declining trend, large blow-out events can still occur. On April 20, 2010, a fire and explosion occurred on Transocean's Deepwater Horizon drilling facility while drilling an exploration well on British Petroleum's Mississippi Canyon Block 252, approximately 66 km offshore Louisiana in the US GOM. At the time of writing this report, the cause of this incident is still under investigation. The well was initially reported to be discharging

approximately 5,000 bbls per day; more recent estimates place the rate at 12,000 to 19,000 bbl/day.

Despite this recent event, the overall trend of spills and blow-outs is decreasing world-wide. A spill of the magnitude of the Deepwater Horizon blow-out in recent years is unprecedented. An investigation will likely result in lessons learned in terms of improved technology, operational, safety and environmental procedures. However, in spite of potential improvements and advancements in spill prevention technology and practices, there still remains an element of safety and environmental risk in any drilling operation.

With respect to the Hebron Project, there will be an estimated 40 development wells drilled, and an estimated 200 well-years of production[1]. Using the above world-wide spill frequency statistics as a basis for prediction, the spill frequencies estimated for the Project would be as follows:

- Predicted number of extremely large hydrocarbon spills from blow-outs during a drilling operation, based on an exposure of wells drilled: $40 \times 1.5 \times 10^{-5} = 6.0 \times 10^{-4}$
- Predicted number of very large hydrocarbon spills from drilling blow-outs based on an exposure of wells drilled: $40 \times 6.0 \times 10^{-5} = 2.4 \times 10^{-3}$
- Predicted number of extremely large hydrocarbon spills from production / workover blow-outs, based on an exposure of well-years: $200 \times 8.0 \times 10^{-6} = 1.6 \times 10^{-3}$
- Predicted number of very large hydrocarbon spills from production / workover blow-outs, based on an exposure of well-years: $200 \times 2.4 \times 10^{-5} = 4.8 \times 10^{-3}$

14.1.2 Blow-outs Involving Smaller Discharges of Oil or Only Gas

Gas blow-outs from offshore wells that do not involve a discharge of liquid petroleum are generally believed to be relatively innocuous to the marine environment. However, such blow-outs may represent a threat to human life and property because of the possibility of explosion and fire.

Two sources are used for historical statistics on blow-outs involving only gas or small hydrocarbon discharges. A particularly good source for US blow-outs is the BOEMRE web page (www.boemre.gov), because BOEMRE keeps track of spills down to 1 bbl in size. This is not the case in other parts of the world. Scandpower (2000) provides a report on blow-outs in the North Sea and in the US GOM, although the report provides no information as to whether or not hydrocarbon spills were involved in the reported blow-outs.

The US Outer Continental Shelf (OCS) data, representing the 34-year period from 1972 to 2006, are provided in Table 14-4 (Note that BOEMRE updates their data on a regular basis, but the most recent data they have published is for 2006). There are no large spills in the entire database. The 2010

[1] Assumes half of all development wells are “oil producers” and that production wells have an average well-life of 10 years.

blow-out in the US Gulf of Mexico (US GOM) would fit into the extremely large category, but is classified as an exploratory well.

The total number of development wells drilled in the US OCS from 1972 to 2006 is not shown in Table 14-4, but an estimate of 21,000 can be inferred from other sections of MMS (1997), E&P Forum (1996) and from current internet sources. The number of blow-outs from development drilling is 87 (with the four blow-outs from sulphur drilling removed); therefore, the blow-out frequency is 4.1×10^{-3} blow-outs per well drilled.

The statistic, based mostly on US OCS drilling and blow-out records over the past 30 years, is derived on a conservative basis and does not take into account recent improvements in safety and blow-out prevention that have tended to reduce blow-out frequencies. There is also concern over gas releases and their effect on workers. For this reason, a more realistic assessment of the probability of a gas blow-out is required. The main factors that need to be re-considered are: (1) the differences between "shallow gas" blow-outs and deep-well blow-outs; (2) special blow-out prevention activities that exist for deep well drilling in Canada; and (3) decreases in blow-out frequency in recent years due to improvements in blow-out prevention. All three issues are covered thoroughly in Scandpower (2000).

Table 14-4 Blow-outs and Spillage from US Federal Offshore Wells, 1972 to 2006

Year	Well Starts	Drilling Blow-outs				Non-drilling Blow-outs								
		Exploration		Development		Production		Workover		Completion		Total Blow-outs		OCS Production
		No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	MMbbl
1972	845	2	0	2	0	1	0	0	0	0	0	5	0	396.0
1973	820	2	0	1	0	0	0	0	0	0	0	3	0	384.8
1974	816	1	0	1	0	4	275	0	0	0	0	6	275	354.9
1975	372	4	0	1	0	0	0	1	0	1	0	7	0	325.3
1976	1,038	1	0	4	0	1	0	0	0	0	0	6	0	314.5
1977	1,064	3	0	1	0	1	0	3	0	1	0	9	0	296.0
1978	980	3	0	4	0	0	0	3	0	1	0	11	0	288.0
1979	1,149	4	0	1	0	0	0	0	0	0	0	5	0	274.2
1980	1,307	3	0	1	0	2	1	1	0	1	0	8	1	274.7
1981	1,284	1	0	2	0	1	0	3	64	3	0	10	64	282.9
1982	1,035	1	0	4	0	0	0	4	0	0	0	9	0	314.5
1983	1,151	5	0	5	0	0	0	2	0	0	0	12	0	350.8
1984	1,386	3	0	1	0	0	0	1	0	0	0	5	0	385.1
1985	1,000	3	0	1	0	0	0	2	40	0	0	6	40	380.0
1986	1,538	0	0	1	0	0	0	1	0	0	0	2	0	384.3
1987	772	2	0	0	0	3	0	1	0	2	60	8	60	358.8
1988	1,007	1	0	1	0	0	0	1	0	0	0	3	0	332.7
1989	911	2	0	[A]5	0	3	0	1	0	0	0	11	0	313.7
1990	987	1	0	1	0	0	0	3	9	1	0	6	9	304.5
1991	667	3	0	[B]3	0	0	0	0	0	0	0	6	0	326.4
1992	943	3	100	0	0	0	0	0	0	0	0	3	100	337.9

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Year	Well Starts	Drilling Blow-outs				Non-drilling Blow-outs								
		Exploration		Development		Production		Workover		Completion		Total Blow-outs		OCS Production
		No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	MMbbl
1993	717[C]	1	0	2	0	0	0	0	0	0	0	3	0	352.7
1994	717[C]	0	0	0	0	0	0	1	0	0	0	1	0	370.4
1995	717[C]	1	0	0	0	0	0	0	0	0	0	1	0	429.2
1996	921	1	0	1	0	0	0	0	0	2	0	4	0	433.1
1997	1,333	1	0	3	0	0	0	0	0	1	0	5	0	466.0
1998	1,325	1	0	1	0	2	0	3	0	0	0	7	2	490.5
1999	364	1	0	2	0	0	0	1	0	0	0	5	0	534.6
2000	1,061	5	200	4	0	0	0	0	0	0	0	9	200	551.6
2001	1,007	1	0	4	1	2	0	2	0	1	0	10	1	591.5
2002	828	1	0	2	0	2	350	1	1	0	0	6	351	602.1
2003	835	1	0	1	0	2	1	1	10	0	0	5	11	594.7
2004	861	2	16	0	0	0	0	2	1	0	0	4	17	567.0
2005	1,232	3	0	1	0	0	0	0	0	0	0	4	0	497.4
2006	1,586	0	0	0	0	0	0	1	0	1	50	2	50	503.1
Total	34,576	67	316	91	1	24	627	39	125	15	110	207	1181	13,963.9

A Two of the drilling blow-outs occurred during drilling for sulphur
B Two of the drilling blow-outs occurred during drilling for sulphur
C Estimated: cumulative total correct

14.1.2.1 Shallow Gas versus Deep Blow-out

A blow-out might occur if shallow gas is encountered unexpectedly during drilling operations. The driller has interest in shallow gas from the mudline to approximately 914 m (3,000 feet) and below. Gas that is trapped in the shallow sediments can originate from deeper gas reservoirs, but can also come from biogenic activity in the shallow sediments. The probabilities of the various blow-out categories are shown in Table 14-5, abstracted from Scandpower (2000).

The values in Table 14-5 (for the US GOM) are reasonably consistent with the values in Table 14-4, which show 29 blow-outs for the period 1980 to 1997. This means that the BOEMRE (the US regulator) classifies “blow-outs” in Table 14-5 as *all* categories in Table 14-5 (i.e., well releases as well as blow-outs). The blow-out frequency from Table 14-5 for the US GOM is $28/8{,}466 = 3.3 \times 10^{-3}$ blow-outs / releases, which is close to the value derived earlier (4.1×10^{-3}).

The important statistic to note in Table 14-5 is that the vast majority of blow-outs and well releases are of the shallow gas variety. Specifically, the breakdown for shallow gas blow-out frequency versus deep blow-out frequency is shown in Table 14-6. It is clearly seen that: (1) shallow gas blow-out frequencies are approximately four times lower in the North Sea compared to the US GOM OCS; and (2) deep blow-out / release frequencies can be (e.g., for the US GOM) as much as six times lower than shallow gas blow-out / releases.

Table 14-5 Development Drilling and Blow-outs in the US Gulf of Mexico Outer Continental Shelf and North Sea, 1987 to 1997

Area	Number of Development Wells	Shallow Gas Blow-outs	Shallow Gas Release during Drilling	Deep Blow-outs	Deep Well Releases during Drilling	Total Blow-outs and Releases
US GOM	8,466	13	10	4	1	28
UK	3,086	1	0	0	2	3
Norway	1,202	1	1	0	0	2
Totals	12,754	15	11	4	3	33

Source: after Scandpower (2000)
Notes:
- A blow-out is an incident where hydrocarbons flow from the well to the surface, all barriers are non-functional and well control can only be regained by means that were not available when the incident started
- A deep blow-out is defined as one that occurs after the Blow-out Preventor (BOP) is set
- A shallow gas blow-out is a release of gas prior to the BOP being set
- A well release is an incident where hydrocarbons flow from the well to the surface and is stopped by one or several barriers that were available when the incident started. In this case, hydrocarbons do not enter the environment

Table 14-6 Blow-out Frequencies for the US Gulf of Mexico and North Sea, 1980 to 1997

	Shallow Gas Blow-out / Release		Deep Blow-out / Release	
	US GOM	North Sea	US GOM	North Sea
Blow-outs / Releases per Wells Drilled	27×10^{-4}	7.0×10^{-4}	5.9×10^{-4}	4.7×10^{-4}
Wells Drilled per Blow-out / Release	370	1400	1700	2100

Deep blow-outs (and not well releases) are the primary concern because releases by definition do not involve a discharge of hydrocarbons into the environment. There have been four deep blow-outs from development drilling in the US GOM and none in the North Sea from 1987 to 1997 (Table 14-5). The reason for this, according to Scandpower (2000), is that North Sea operators are required by law to always have two barriers during exploration and development drilling, and this is not the case in the US. Regulations in Canada (i.e., two barriers) are similar to those in the North Sea, so it is fair to derive blow-out frequencies for Canada on the basis of North Sea statistics.

Finally, it is worth noting (Table 14-7) that shallow gas blow-out frequencies in the North Sea and in the US GOM have been on the decline in the most recent years of the record.

A more recent study by IAOGP (2010), is based on the 20-year record to 2005, and indicates a deep blow-out frequency of 4.8×10^{-5} blow-outs per well drilled. Using this figure results in a probability of one blow-out for every 21,000 wells drilled.

Table 14-7 Shallow Gas Exploration and Development Drilling Blow-out Frequencies over Time, 1980 to 1997

Time Period	No. of Blow-outs	Number of Exploration and Development Wells Drilled	Blow-out Frequency
18 years (1980 to 1997)	53	22,084	24.0×10^{-4}
10 years (1988 to 1997)	23	13,870	16.6×10^{-4}
5 years (1993 to 1997)	5	7,581	6.6×10^{-4}
3 years (1995 to 1997)	1	4,924	2.0×10^{-4}
Source: Scandpower (2000)			

14.1.2.2 Blow-outs During Production Operations

The best accident exposure variable to use for production and wireline operations is well-years. It is also convenient to link completions and workovers to well-years of operation. The number of oil and gas well-years for the population in Table 14-4 from 1972 through 2006 can be estimated from other tables in MMS references; the number is approximately 250,000 producing well-years.

For all the gas-producing areas and oil-producing areas of the US OCS, 78 blow-outs occurred during production, workovers and completions (Table 14-4). This yields a blow-out frequency of $78/250{,}000 = 3.12 \times 10^{-4}$ blow-outs per well-year. The equivalent number for the US OCS and North Sea areas for the period 1980 to 1997 is 1.83×10^{-4} blow-outs per well-year (Table 14-8).

Table 14-8 Frequency over Time of Blow-outs during Production, Wireline Operations, Workovers and Completions, US Gulf of Mexico and North Sea, 1980 to 1997

Period	Blow-outs: Production and Wireline	Blow-outs: Completions and Workovers	Total Blow-outs	Well-years	Blow-out Frequency
18 years (1980 to 1997)	10	21	31	168,583	1.83×10^{-4}
10 years (1988 to 1997)	3	7	10	108,357	9.92×10^{-5}
5 years (1993 to 1997)	1	3	4	55,188	7.25×10^{-5}
3 years (1995 to 1997)	1 [a]	3	4	34,895	1.15×10^{-4}
Source: Scandpower (2000)					

As was done for the case of blow-outs during development drilling, it is important to note that blow-out frequencies during production operations in the North Sea and in the US GOM have been on the decline over recent years (Table 14-8).

IAOGP (2010) does not allow a comparison for each of the operations listed in Table 14-8, but confirms the overall blow-out frequency for production, wireline operations, completions and workovers in recent years. The data, based on the 20-year record to 2005, indicate an overall blow-out frequency for these operations of 1.85×10^{-4} blow-outs per well year, based on 33 incidents over 177,474 well-years.

A certain percentage of the blow-outs involved some discharge of hydrocarbon. Of the 78 blow-outs that occurred during the four operations of production, wirelining, workovers and completions, only 12, or 15.4 percent, involved hydrocarbon (note that the average size of the 12 spills was only 72 bbl). Therefore, the frequency of blow-outs that produced a hydrocarbon spill from well blow-outs during the four above-noted operations is calculated to be $0.154 \times 1.85 \times 10^{-4} = 2.8 \times 10^{-5}$ blow-outs/well-year.

14.1.2.3 Summary of Blow-out Frequencies Involving Smaller Discharges of Oil or Only Gas

There are an estimated 40 wells to be drilled for the Project, so the likely number of deep blow-outs during development drilling becomes $40 \times 4.8 \times 10^{-5} = 1.92 \times 10^{-3}$.

For gas blow-outs occurring during production and workovers, the statistic for Hebron becomes 200 well-years x 1.17×10^{-4} blow-outs/well-year $= 2.34 \times 10^{-2}$.

For gas blow-outs that occur during production and workovers that involve some hydrocarbon discharge (>1 bbl), the statistic for Hebron becomes 200 well-years x 2.8×10^{-5} blow-outs/well-year $= 5.6 \times 10^{-3}$.

14.1.3 Large Platform Spills

There have been very few large spills from platforms operating in US OCS waters. In addition to the six from blow-outs noted in Table 14-3 there have been seven others, which includes all US platform spills up to the present (Table 14-9). Note, that this does not include the 2010 Deepwater Horizon blow-out, which occurred during exploration drilling.

Table 14-9 Hydrocarbon Spills of Greater than or Equal to 1,000 bbl from Platforms on the US Outer Continental Shelf, 1964 to 2010

Date	Location	Size (bbl)	Cause
04/08/64	Eugene Island Block 208	2,559	Collision
10/03/64	Eugene Island Ship Shoal	11,869	Hurricane (7 platforms)
07/19/65	Ship Shoal Block 29	1,688	Blow-out (condensate)
01/28/69	Santa Barbara Channel	77,000[A]	Blow-out
03/16/69	Ship Shoal Block 72	2,500	Collision, weather
02/10/70	Main Pass Block 41	30,000	Blow-out
12/01/70	South Timbalier Block 26	53,000	Blow-out
01/09/73	West Delta Block 79	9,935	Storage tank rupture
11/23/79	Main Pass Block 151	1,500[B]	Collision, weather, tank spill
11/13/80	High Island Block 206	1,456	Pump failure, hurricane, tank spill
09/29/92	Timbalier Bay / Greenhill	11,500[C]	Production well blow-out
09/24/05	Cameron / Eugene Is. / Green Canyon	3,915	Hurricane (9 platforms)

Source: BOEMRE OCS Spill Database, April 2010, www.boemre.gov/stats/index.htm

A Estimates vary between 10,000 to 77,000 bbl

B Refined product

C This spill was in Louisiana State waters and not OCS waters, but is included for interest

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All but two of the OCS spills in Table 14-9 occurred prior to 1980. BOEMRE statisticians responsible for analyzing and predicting hydrocarbon spill frequencies associated with offshore oil and gas activities in the OCS have decreased the estimate gradually over the past 15 years, mostly in recognition of a statistical trend towards lower spill frequency. The estimate derived from statistics in Anderson and LaBelle (2001) is 1.5×10^{-5} spills/well-year for spills equal or greater than 1,000 bbl and 5.5×10^{-6} spills/well-year for spills equal or greater than 10,000 bbl[2].

The production well-years for Hebron is 200; therefore, the predicted number over the 30-year life of the Project would be $200 \times 1.5 \times 10^{-5} = 3 \times 10^{-3}$ events for 1,000-barrel spill, and $200 \times 5.5 \times 10^{-6} = 1.1 \times 10^{-3}$ events for a 10,000 barrel spill.

Note that the above statistic for spills >10,000 bbl (i.e., 5.5×10^{-6} spills/well-year) is almost four times smaller than the statistic derived earlier for production blow-out spills >10,000 bbl (i.e., 2.0×10^{-5}). This is impossible because the first category includes blow-out spills. The reason for the anomaly is that the US record was used for the former and the world-wide record was used for the latter. The world-wide statistic is higher than the US-derived one because the former was developed on a very conservative basis, which considered an exposure of only oil wells and not gas wells.

It is noted that there has been one production-related spill in Newfoundland and Labrador waters greater than 1,000 bbl, in 2004. There have been no spills greater than 10,000 bbl. Given the limited statistical database of Newfoundland and Labrador production operations, the US statistics are used in the frequency calculation.

14.1.4 Platform Spills Involving Small Discharges

Small spills occur with some regularity at offshore platforms. The data in Table 14-10 are derived from a more detailed table in MMS (1997) and covers small spills of all pollutants from facilities and operations on Federal OCS leases from the period 1971 to 1995. The spills involved various pollutants including crude oil, condensate, refined product, mineral oil and diesel. The period between 1971 and 1995 involved the production of 8.5 billion bbl of oil and condensate and 186,058 well-years of oil and gas production activity (MMS 1997). See Table 14-10 for the spill frequency.

Table 14-10 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (US OCS 1971 to 1995)

Spill Size Range	Number of Spills
1 to 49.9 bbl	1,898
50 to 999 bbl	90
Total volume of 1,898 + 90 spills = 123,023 bbl	

[2] These numbers are derived from statistics developed by Anderson and LaBelle (2001), who use an exposure of "billions of barrels of oil produced" and consider the period 1964 to 1999. During this period, 46,000 bbl of oil were produced per well-year, considering both oil and gas wells. The frequencies derived by the authors for spills greater than 1,000 bbl and 10,000 bbl are 0.32 and 0.12 spills per billion bbl produced, respectively. The equivalent numbers for the last 15 years are considerably less.

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There have been very few large spills related to development or production in Canadian waters, which has necessitated the use of US and world-wide statistics. However, there is a reasonably-sized database on small spill incidents in Newfoundland and Labrador waters. Spill statistics are maintained and reported by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) (C-NLOPB 2010d).

Production in Newfoundland and Labrador waters commenced in 1997 at the Hibernia location, with Terra Nova coming on stream in 2001 and White Rose in 2004. Using the well statistics on the C-NLOPB website, these three fields have a total of 472 producing well-years to the end of 2010. Tables 14-11 through 14-14 provide an overview of spill statistics for the Newfoundland and Labrador Offshore area. The spill incidents involving 1 bbl or more of hydrocarbon during that period are listed in Table 14-11. These spills include spills of crude, diesel and other hydrocarbons resulting from production and loading operations. Spills of synthetic-based muds are provided in Table 14.14. As noted in Section 14.1.3, there was one crude oil spill greater than 1,000 bbl, in 2004.

Table 14-11 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (Newfoundland and Labrador Waters, 1997 to 2010)

Spill Size Range	Number of Spills
1 to 49.9 bbl	12
50 to 999 bbl	0

A disproportionate number (7 of 12) of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of production experience (Table 14-12). For the years 2000 to 2010, there were a total of 452 producing well-years.

Table 14-12 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (Newfoundland and Labrador Waters, 2000 to 2010)

Spill Size Range	Number of Spills
1 to 49.9 bbl	5
50 to 999 bbl	0

For the smallest size range, statistics from Newfoundland and Labrador operations can be used, but as there have been zero spills in the second category, US GOM statistics will be used. Based on this, the frequency of spills in the range of 1 to 49.9 bbl is 1.1×10^{-2} (5/452) and for the range 50 to 99 bbl is 4.8×10^{-4} (90/186,058).

The C-NLOPB also provides a statistical record of spills of greater than 1 L but less than 1 bbl (159 L), and of spills of 1 L and less; these are presented in Table 14-13. As in the previous category of spill size, a disproportionate number of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of production experience – 2000 to 2010. For these years (2000 to 2010), there were a total of 452 producing well-years, with 86 spills in the 1 to 159 L category, and 218 spills less than 1 L. Note that the totals in Table 14-13 indicate all spills

from 1997 to 2010. Based on this, the average spill frequency is 0.190 spills per well-year in the 1 to 159 L category, and 0.482 spills per well-year less than 1 L.

Table 14-13 Record of Very Small Spills in Newfoundland and Labrador Waters, 1997 to 2010

Year	Spills Greater Than 1 L and Less Than 159 L (1 bbl)		Spills of 1 L and Less	
	Number	Total volume (L)	Number	Total volume (L)
1997	7	123	0	0
1998	20	638	3	1.6
1999	23	636.4	9	4.72
2000	2	62	2	1.1
2001	7	126	8	4.21
2002	5	25.6	19	5.2
2003	10	185.8	9	2.48
2004	18	188.9	30	8.97
2005	11	180.7	28	8.96
2006	5	20	27	9.24
2007	3	93	34	4.28
2008	11	335.5	22	2.89
2009	11	288.3	22	4.97
2010	3	20.3	17	4.21
Total	136	2923.5	230	62.83

Regarding spills from the OLSs for all production facilities from 1997 to 2010, there were 10 spills greater than 1 L. Of these, one was in the range of 1 to 49.9 bbl, none in the 50 to 999 bbl range, and none greater than 1,000 bbl.

14.1.5 Spills of Synthetic-based Muds

The C-NLOPB records spills of synthetic-based mud (SBM) and fluids, and these are summarized in Table 14-14 for the years 1997 through 2010. In the largest such spill to date, in 2004, approximately 96,600 L (608 bbl) of SBM were spilled from the diverter line of the GSF Grand Banks at the White Rose location. The spill frequency is calculated based on the 219 wells spudded during this period.

Table 14-14 Spills of Synthetic-based Muds, 1997 to 2010

Spill Size Range	Number of Spills	Frequency, per well
>1 L	36	0.16
159 to 7,934 L (1 to 49.9 bbl)	18	0.082
7,935 to 159,000 L (50 to 999 bbl)	5	0.023
>159,000 L (1,000 bbl)	0	0

14.1.6 Summary of Blow-out and Spill Frequencies

The calculated hydrocarbon spill probabilities for the Project are summarized in Table 14-15.

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Table 14-15 Summary of Probable Number of Blow-outs and Spills for the Hebron Project

Event	Historical Frequency	Hebron Exposure[B] (per project Life)	Probable number of occurences (over project life)
Blow-outs			
1. Deep blow-out during development drilling	4.8×10^{-5}/wells drilled	40 wells drilled	1.92×10^{-3}
2. Blow-out during production involving some hydrocarbon discharge >1 bbl	2.8×10^{-5}/well-years	200 well-years	5.6×10^{-3}
3. Development drilling blow-out with hydrocarbon spill >10,000 bbl	6.0×10^{-5}/wells drilled	40 wells drilled	2.4×10^{-3}
4. Development drilling blow-out with hydrocarbon spill >150,000 bbl	1.5×10^{-5}/wells drilled	40 wells drilled	6.0×10^{-4}
5. Production / workover blow-out with hydrocarbon spill >10,000 bbl	2.4×10^{-5}/well-year	200 well-years	4.8×10^{-3}
6. Production / workover blow-out with hydrocarbon spill >150,000 bbl	8.0×10^{-6}/well-year	200 well-years	1.6×10^{-3}
Platform Spills[A] (including blow-outs)			
7. Hydrocarbon spill >10,000 bbl	5.5×10^{-6}/well-year	200 well-years	1.1×10^{-3}
8. Hydrocarbon spill >1000 bbl	1.5×10^{-5}/well-year	200 well-years	3×10^{-3}
9. Hydrocarbon spill 50 to 999 bbl	4.8×10^{-4}/well-year	200 well-years	9.6×10^{-2}
10. Hydrocarbon spill 1 to 49 bbl	1.1×10^{-2}/well-year	200 well-years	2.2 spills over the life of the Project
11. Hydrocarbon spill 1 L to 1 bbl (159 L)	0.190/well-year	200 well-years	38 spills over the life of the Project
12. Hydrocarbon spill less than 1 L	0.482/well-year	200 well-years	96.4 spills over the life of the Project

A Platform spills greater than 150,000 bbl are not included in the table as it would simply duplicate the statistic for blow-outs greater than 150,000 bbls: it would be virtually impossible to have a spill of this size from anything other than a blow-out.

B Hebron Exposure is the number of events ove the life of the Project. This is either defined as number of well-years for production related activities, or number of wells drilled for drilling related activities.

14.1.7 ExxonMobil Experience

As reported by the C-NLOPB and CNSOPB, since 2001, ExxonMobil drilling operations in eastern Canada have not had a reportable spill greater than 1 bbl for the 63 wells drilled in the region. There were 14 wells drilled with a jack-up drilling unit in Nova Scotia, 46 wells were drilled from the Hibernia Platform, and three wells were drilled from floating mobile offshore drilling units (MODU) in Nova Scotia and on the Grand Banks. In the Newfoundland and Labrador offshore area, ExxonMobil has not had a crude spill greater than 1 L associated with its drilling operations.

ExxonMobil's well control philosophy is focused on prevention using safety / risk management systems, management of change procedures and global

standards. ExxonMobil has a mature Operations Integrity Management System (OIMS) that emphasizes relentless attention to Safety, Well Control and Environmental Protection. This includes proper preparation for wells (well control equipment inspections / tests), detecting the influx early, closing-in the well efficiently (personnel training / drills) and circulating out the kick with kill-weight mud in a controlled manner.

Defining "blow-out" as an uncontrolled flow that was not brought under control using the rig's well control system, the last offshore drilling "blow-out" experienced by Exxon was in the GOM in 1983 (Penrod 52 jackup rig). The last offshore "blow-out" was experienced by Mobil in the North Sea in 1990 (Maersk Vinlander semisubmersible rig). Both were shallow gas "blow-outs" with no personnel injuries or release of liquid hydrocarbons to the sea. ExxonMobil has had other well control incidents, but were safely brought under control using well control equipment and procedures. None escalated into "blow-outs".

Since the implementation of OIMS (circa 1992), neither Exxon nor ExxonMobil have experienced a "blow-out" during offshore drilling operations.

14.2 Fate and Behaviour of Hebron Hydrocarbon Spills in the Nearshore Study Area (Trajectory Modelling)

A spill trajectory modelling exercise, specific for Hebron Project activities in Bull Arm, Trinity Bay, was undertaken. This section provides an overview of the results of the modelling. The full report is provided in Applied Science Associates (ASA) 2010a.

The objective of this work is to undertake spill trajectory modelling for the accidental release of marine diesel fuels in Bull Arm, Trinity Bay. ASA used its SIMAP model system to simulate spills of fuel oil in Bull Arm, Trinity Bay. The model uses wind data obtained from model hindcasts and field measurements and current data from a hydrodynamic model. The SIMAP model was used in stochastic and deterministic modes to determine the range of possible water surface, subsurface and shoreline hydrocarbon contact predicted to occur. A complete description of the spill trajectory model is provided in the full report (ASA 2011a).

14.2.1 Model Inputs and Spill Scenarios

In the event of an accidental release of diesel at the Bull Arm construction site, the primary objective would be to stop the flow and implement spill countermeasures as quickly as possible. Spill response equipment will be contained on-site and staff will be trained to effectively respond to any accidental event.

Marine-based activities may primarily involve vessels that use standard marine diesel. The estimated maximum fuel storage capacity is approximately 100 m^3 per vessel. The mating of the topsides with the GBS, and likely tow-out of the GBS to the offshore location, (single events) may require larger vessels that use a heavier marine diesel product, Intermediate

fuel oil (IFO-180). The total fuel capacity of these vessels is approximately 1,000 m^3. Therefore, for the purposes of environmental assessment, two fuels were used in the simulation of spills. Simulations were performed for releases on the water surface both summer and winter conditions. The following spill scenarios were modelled:

- Instantaneous surface release of 100 m^3 of marine diesel fuel, summer, winter (no ice), and winter with approximately 65 percent ice coverage (ice coverage in Bull Arm can range from 0 to 100 percent through the winter season, depending on the month and the severity of the winter). Vessel operations during the construction of the Hebron GBS will likely not occur when ice concentration exceeds 65 percent broken ice coverage; therefore, all winter spill scenarios with sea ice present assume that Bull Arm and Trinity Bay are covered with a 65 percent concentration.
- Instantaneous surface release of 1,000 m^3 of (IFO-180), summer, winter (no ice), and winter with approximately 65 percent ice coverage
- All models were run for 30 days

Simulations of the fuel oil spills in Bull Arm use multiple 30-year wind speed and direction time series from the MSC50 model grid nodes in combination with a 30-year modified wind- time series in Bull Arm. Two separate hydrodynamic simulations were carried out using the HYDROMAP model in order to capture the combined tide and wind-driven currents in Bull Arm and Trinity Bay. Tidal current simulations were conducted to develop tidally-driven surface currents over the entire region. Wind-driven current simulations were conducted for eight wind directions using a constant wind speed of 8 m/s and then added to the tidal current simulation to create a combined current. This results in a current field covering Trinity Bay and Bull Arm that accounts for tide and wind-driven currents and is used to drive the oil spill simulations. A total of 18 scenarios (three oil threshold criteria times six spill scenarios) were modelled for the nearshore area.

The shoreline in Bull Arm was defined as one of two types: the beaches in Bull Arm were classified as Gravel Beach, and the remainder of the shoreline was classified as Seaward Rocky Shore. The eelgrass beds are subtidal habitats and not considered a shoreline type with oil holding capacity. The shoreline width, maximum oil thickness and oil removal half-times used in the oil spill modeling are listed in Table 14-16.

Table 14-16 Shoreline Width, Maximum Shoreline Oil Thickness and Removal Half-life Times for Various Shore Types

Shore Type	Width (m)	Maximum Oil Thickness (mm)	Oil Removal Half-time (days)
Exposed Rocky Shore	3	0.5	1
Gravel Beach	6	2	10
Source: Based On Gundlach 1987			

Spill trajectories were simulated for 30 days because at this point, the fuel oil has lost most of its volatile components, has reached its minimum thickness,

and if it has exited Trinity Bay, is moving out into the open sea by the end of the 30-day period.

14.2.2 Model Outputs

14.2.2.1 Stochastic Model Results

The stochastic model was used to determine the probability of finding hydrocarbons on the water surface, on the shoreline and in the water column exceeding the following thickness and concentration thresholds:

- Surface diesel average thickness >0.01 mm (10 µm)
- Shoreline diesel average thickness over a shoreline segment >0.01 mm (10 µm)
- Subsurface diesel (entrained in water) average concentration >10 ppb

The stochastic analysis provides two types of information to describe the potential spills: 1) areas that might have oil contact (as defined by a threshold oil thickness of 0.01 mm) and the associated probability; and 2) the shortest time required for hydrocarbons to reach any location and/or threshold in the areas predicted to have oil contact. This information is presented for surface oil, shoreline oil and subsurface oil in maps and in summary tables in this report. Total hydrocarbons, the group of chemical that make up crude oil, are divided into two categories, aromatic hydrocarbons, the toxic component of oil, and aliphatic hydrocarbons. For this study only the non-dissolved total hydrocarbons are tracked.

All results describe probabilities of oil occurring at the surface, in the water column, or at the shoreline; they do not depict an actual spill event, nor do they include the use of any spill countermeasures (e.g., booms, skimmer, dispersants).

SIMAP's stochastic simulation results provide insight into the probable behaviour of potential oil spills under the environmental conditions expected to occur in the study area during each season. The 100 individual model simulations from each stochastic model scenario were ranked to determine the individual spill resulting in the 95th percentile for shoreline oiling, water surface oiling and for oil entrained in the water column. For example, the 95th percentile spill for surface oiling is the single spill resulting in a surface area oiled at a thickness exceeding 0.01 mm that is greater than or equal to 95 percent of all spills simulated.

Summer winds are more often from the southwest, which can drive diesel onto the northeast coast of Bull Arm. Any diesel exiting Bull Arm in the summer will most likely be driven northeastward up and out of Trinity Bay. Winter winds are most often from the northwest, which can move surface oil out of Bull Arm and onto the shoreline at the southern end of Trinity Bay, and less frequently towards the northeast and the mouth of Trinity Bay. The probability and minimal arrival time from a release of 100 m^3 marine diesel and 1,000 m^3 IFO-180 in summer and winter are provided in Figures 14-1 to 14-4. Note, for any of these simulations, they were modelled without the use of spill response equipment (i.e., booms, skimmers, dispersants, etc.).

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The following figures do not represent the size of a potential spill; rather, the figures show the probability of finding 0.01 mm of diesel on the surface of the water at any location over the model time period. Hence, the time for surface oiling, also shows the time for the probability of surface oiling to occur, and does not represent an actual slick. In addition, the results do not include the use of any spill countermeasures (i.e., booms, skimmers, absorbents, dispersants).

Entrained marine diesel oil is predicted to exceed a concentration of 10 ppb 100 percent of the time within Bull Arm during the summer and winter seasons. Probabilities of finding 0.01 mm diesel oil on the water's surface drop quickly outside of Bull Arm to 10 to 30 percent during summer and winter seasons for a small area of southwest Trinity Bay. IFO-180 is a highly viscous fuel that shows almost no entrainment into the water column.

Without the use of spill countermeasures, the smaller volume 100 m^3 marine diesel spills are predicted to have a 10 to 20 percent probability of leaving Bull Arm during the summer and a 30 to 40 percent probability of leaving Bull Arm under winter conditions. Spills of 1,000 m^3 of IFO-180 have a 60 to 70 percent probability of leaving Bull Arm during the summer, and a 70 to 80 percent probability of entering Trinity Bay during the winter season.

The model predicts that oil from both the 100 m^3 marine diesel and 1,000 m^3 IFO-180 spills have a small (<5 percent) probability of leaving Trinity Bay (via the northeast corner of the model grid. This oil is >10 days old, the volatile components have evaporated, the oil is at the minimum thickness and moving into open ocean.

Spills of 100 m^3 of marine diesel have a 60 percent chance of making contact with the Bull Arm shoreline in summer, and a 30 percent probability in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of contacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season. The minimum time to potential shoreline contact is 0 to 1 days within Bull Arm.

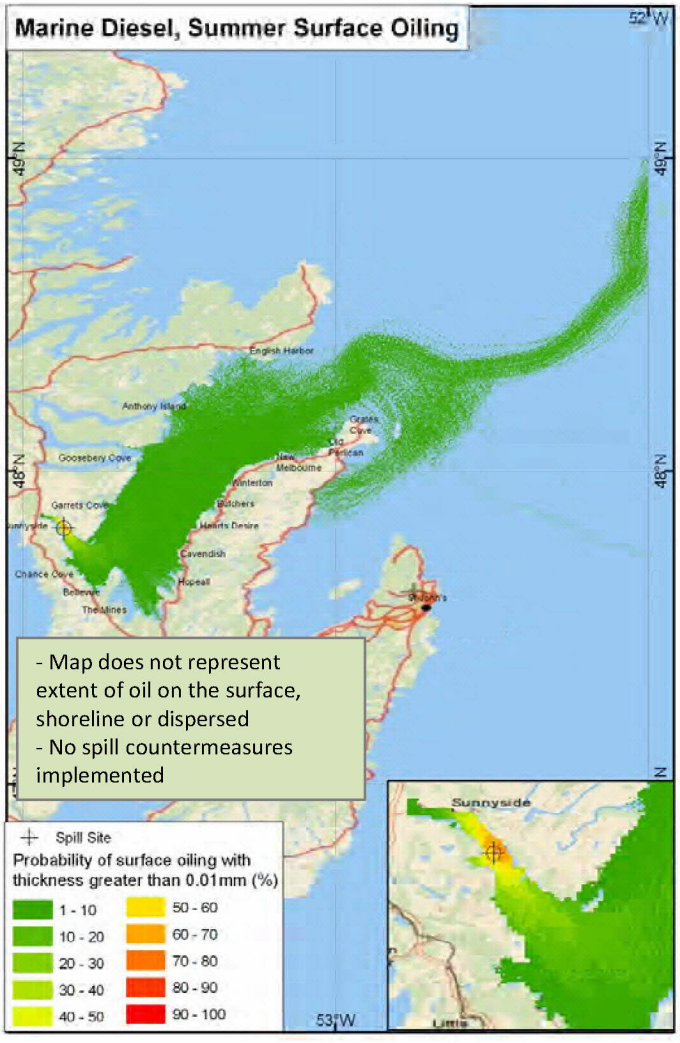

Figure 14-1 Probability of Surface Contact from a Release of 100 m^3 of Marine Diesel at the Bull Arm Site in Summer

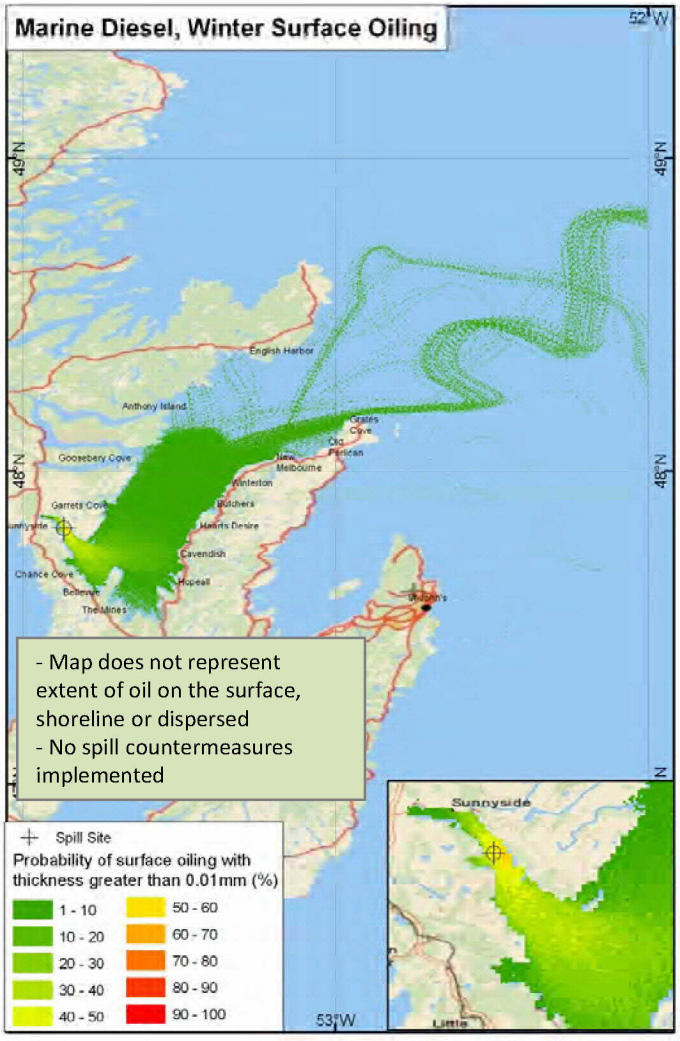

Figure 14-2 Probability of Surface Contact from a Release of 100 m^3 of Marine Diesel at the Bull Arm Site in Winter

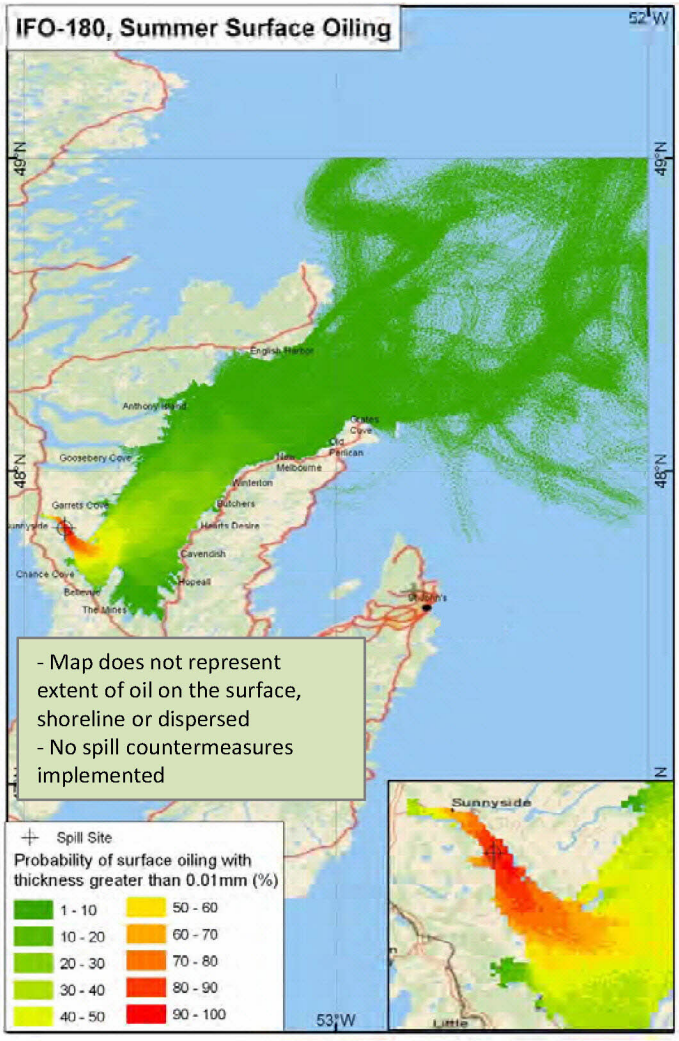

Figure 14-3 Probability of Surface Contact from a Release of 1,000 m^3 of Intermediate Fuel Oil (IFO-180) at the Bull Arm Site in Summer

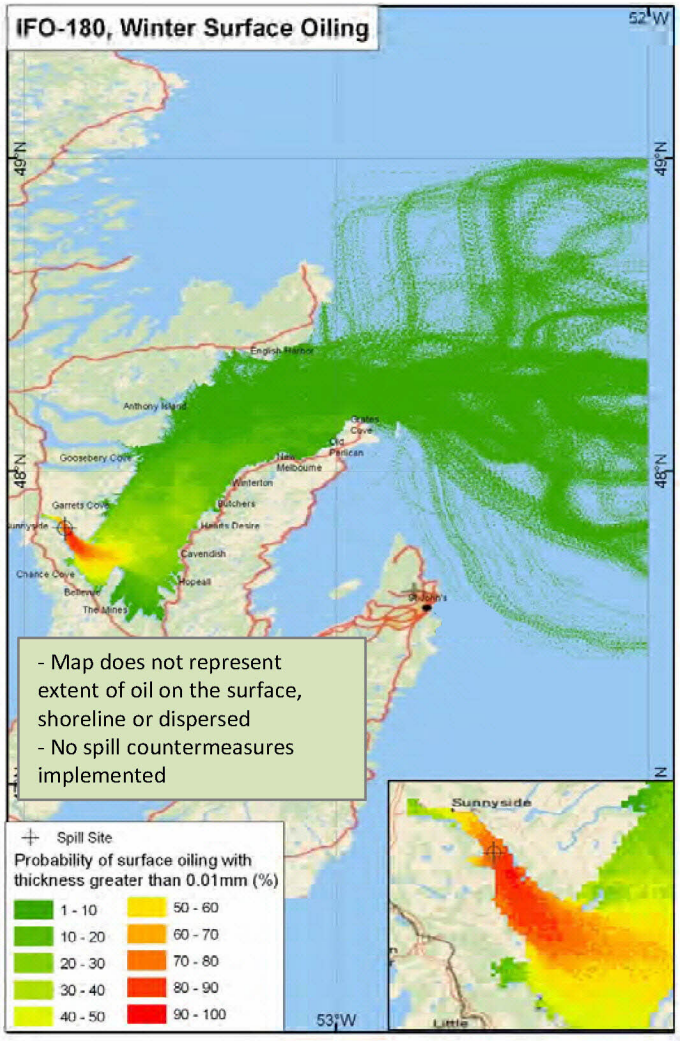

Figure 14-4 Probability of Surface Contact from a Release of 1,000 m^3 of Intermediate Fuel Oil (IFO-180) at the Bull Arm Site in Winter

14.2.2.2 Deterministic Model Results

The deterministic trajectory and fate simulations using the 3D Fates Model are performed for the 95th percentile simulations identified in each stochastic analysis as defined in Section 14.2.2. The 95th percentile result is chosen because it represents the upper end of the possible results (only 5 percent of simulations result in a larger value). The 18 simulations (three oil threshold criteria times six spill scenarios) provide a time history of oil weathering over the duration of the spill, expressed as the volume of spilled oil on the water surface, on the shore, evaporated, entrained in the water column and decayed.

Each scenario simulates the movement and weathering of the spilled oil for a period of 30 days, a length of time sufficient to allow for all of the weathering processes to occur. The mass balance results for all of the deterministic spill scenarios at the end of the 30-day simulation are provided in Table 14-17.

Table 14-17 Summary of Deterministic Model Mass Balance at the End of the 30-day Simulations

Oil Release	95th Percentile	Season	Surface Oil (m^3) >0.01 mm Thickness	Evaporated Oil (m^3)	Entrained Oil (m^3) > 10 ppb	Oil Ashore (m^3) >0.01 mm Thickness	Decayed Oil (m^3)
100 m^3 Marine Diesel	Sea Surface Oiling	Summer	0	52	19	16	13
		Winter - No Ice	0	13	65	0	22
		Winter – Ice	0	49	0	44	7
	Shoreline Oiling	Summer	0	56	18	14	12
		Winter - No Ice	0	25	46	10	19
		Winter – Ice	0	50	1	42	7
	Subsurface Oiling	Summer	0	18	59	2	21
		Winter - No Ice	0	11	66	1	22
		Winter – Ice	0	51	0	43	6
1,000 m^3 IFO-180	Sea Surface Oiling	Summer	30	170	0	420	220
		Winter - No Ice	20	160	0	510	210
		Winter – Ice	0	160	0	680	160
	Shoreline Oiling	Summer	0	170	0	610	220
		Winter - No Ice	0	160	0	610	220
		Winter – Ice	0	170	0	690	140
	Subsurface Oiling	Summer	0	155	0	475	200
		Winter - No Ice	25	155	0	570	210
		Winter – Ice	80	170	0	580	170

Results of the deterministic modelling for shoreline exposure to hydrocarbons with average thickness greater than 0.01 mm are depicted in Figures 14-5 to 14-10. It should be kept in mind that each map displays the results from a different individual simulation and depict one possible outcome for a spill at the Bull Arm site.

If a spill of marine diesel oil or IFO-180 was to occur, and spill countermeasures were not implemented, the spill trajectory model predicts the following results. Spills of 100 m^3 of marine diesel oil, representing the 95th percentile for surface contact, are predicted to remain entirely within Trinity Bay during the winter and to result in small amounts of weathered oil leaving the Bay during summer. In the winter season, approximately 12 percent of the diesel fuel is predicted to evaporate by the end of the 30-day simulation; more than 50 percent of the diesel fuel is predicted to evaporate in the summer season spill. The difference in evaporation is due to higher winter wind speeds, which entrain more oil in the water column, making it unavailable for evaporation.

Without the implementation of spill countermeasures, spills of 100 m^3 of marine diesel oil representing the 95th percentile for shoreline contact are predicted to affect much of the Bull Arm shoreline and isolated segments of the Trinity Bay shoreline in both the summer and winter seasons.

Spills of 100 m^3 of marine diesel oil representing the 95th percentile for entrained oil are predicted to exceed the 10 ppb concentration threshold for all of Bull Arm and for an area of southwest Trinity Bay in both the summer and winter seasons.

The presence of 65 percent ice cover reduces the sea surface area covered by marine diesel oil but results in more widespread shoreline effects. The presence of ice on the sea surface restricts the movement of surface oil, resulting in a reduced surface oil footprint. Because the surface oil footprint is reduced, the thickness of that surface slick must be increased to contain the same volume of oil. It is likely that the thicker surface slick contains sufficient oil volume so that when it goes ashore, the thickness threshold for shoreline contact is exceeded. Ice cover substantially reduces the area predicted to exceed the entrained oil concentration of 10 ppb. This is because the presence of 65 percent ice cover reduces the effectiveness of the wind to entrain oil into the water column.

Spills of 1,000 m^3 IFO-180 are predicted to make surface contact in Bull Arm and extend the length of Trinity Bay during the summer and winter seasons. Approximately 16 percent of the IFO-180 is predicted to evaporate by the end of the 30-day simulation during both the summer and winter seasons. The IFO-180 is highly viscous, which limits its entrainment and enhances conditions for evaporation.

Spills of 1,000 m^3 of IFO-180, representing the 95th percentile for shoreline contact, are predicted to make contact with much of the Bull Arm shoreline and segments of the Trinity Bay shoreline in both the summer and winter seasons. The summer shoreline contact is restricted to the east and west shorelines in the southern half of Trinity Bay. Winter season shoreline contact is restricted to primarily the east coast of Trinity Bay.

Spills of 1,000 m^3 of IFO-180, representing the 95th percentile for entrained oil, are predicted to exceed the 10 ppb concentration threshold for small areas of Bull Arm close to the release site. The IFO-180 is highly viscous and does not readily entrain.

The presence of 65 percent ice cover reduces the sea surface area covered by IFO-180 and does not substantially change shoreline contacts compared with the no-ice condition. The presence of 65 percent ice cover is predicted to eliminate any entrained oil concentrations greater than 10 ppb.

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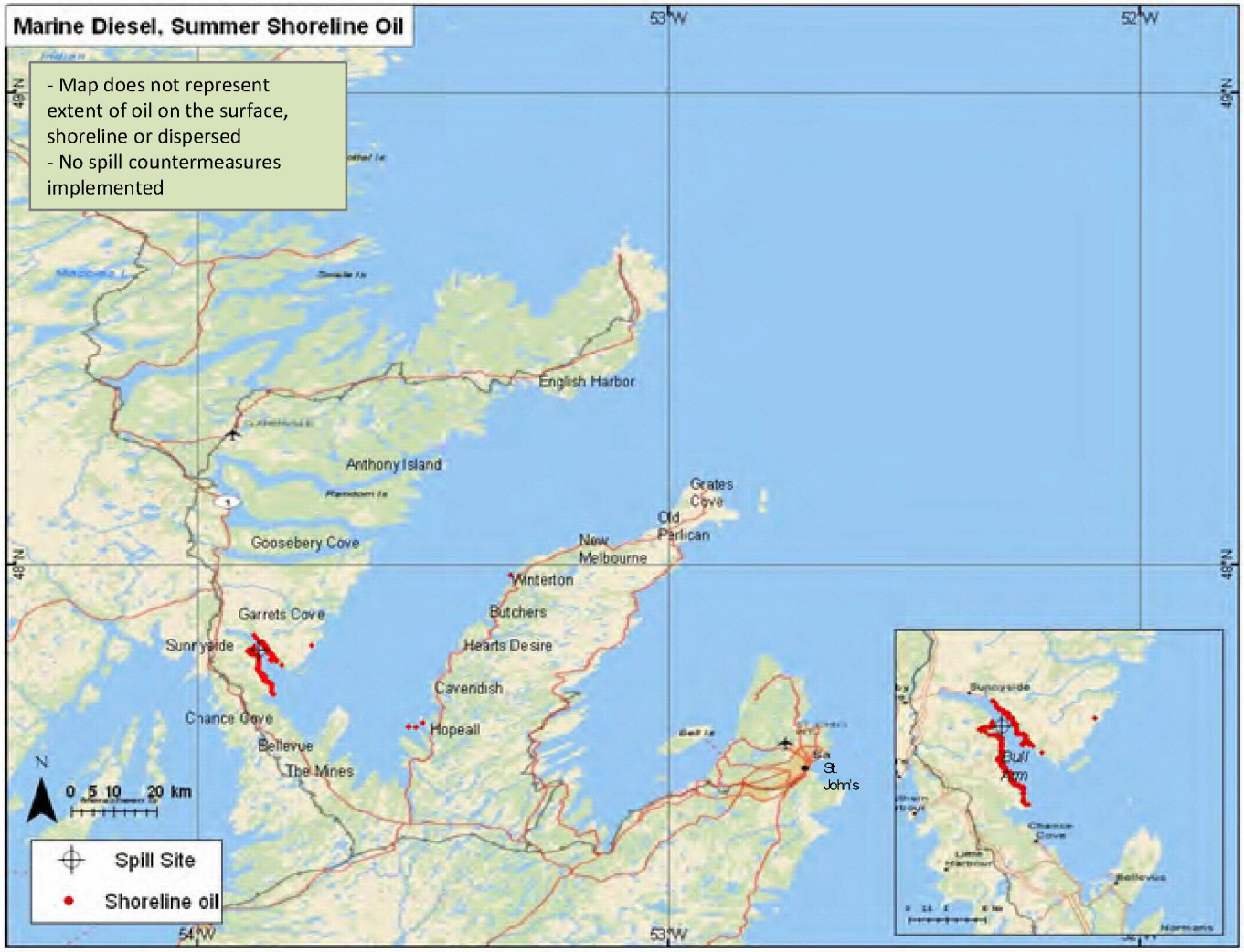

Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-5 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 100 m^3 Release of Marine Diesel in the Summer

Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-6 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 100 m^3 Release of Marine Diesel in the Winter

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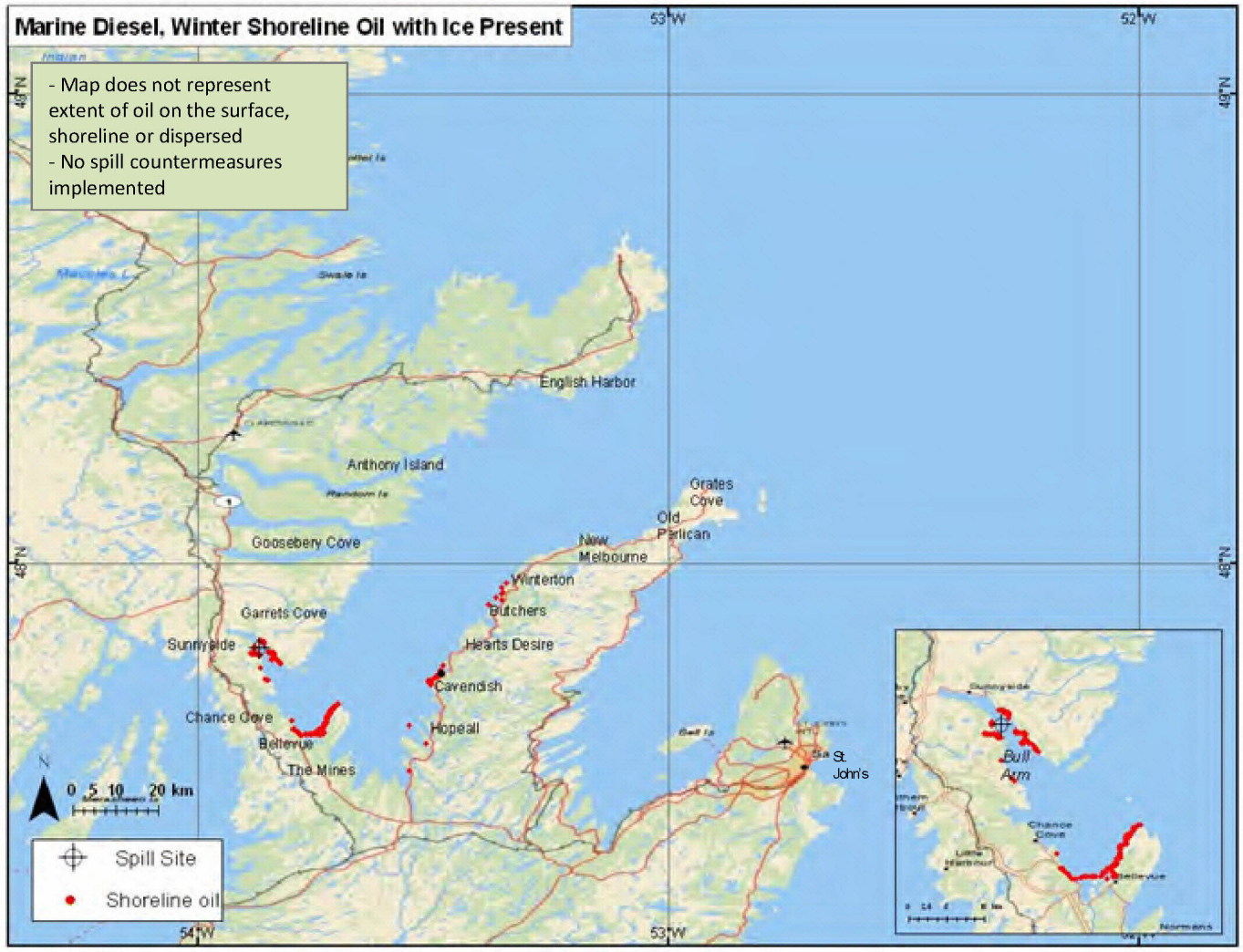

Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-7 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 100 m^3 Release of Marine Diesel in the Winter with 65 Percent Ice Coverage

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Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-8 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 1,000 m^3 Release of IFO-180 in the Summer

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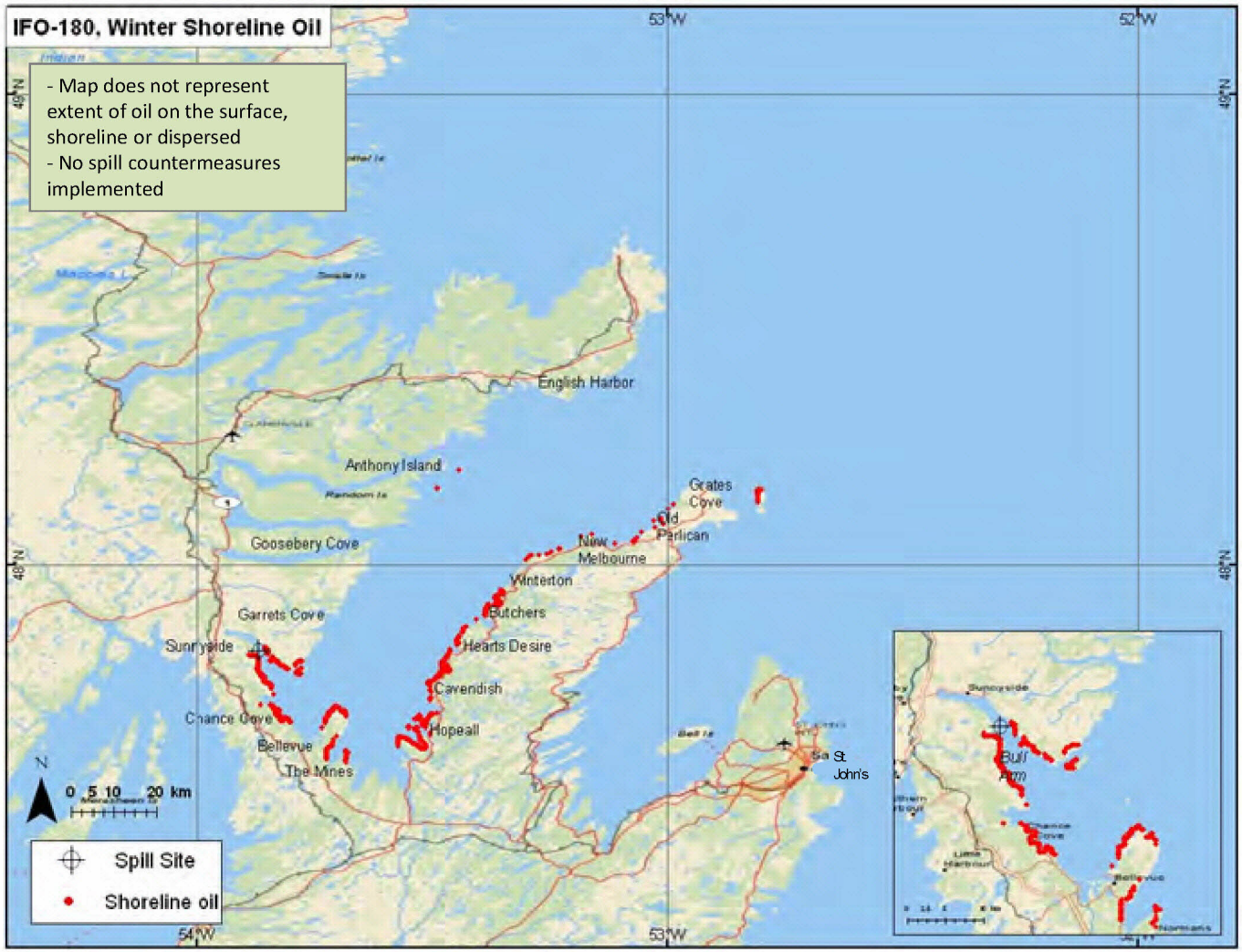
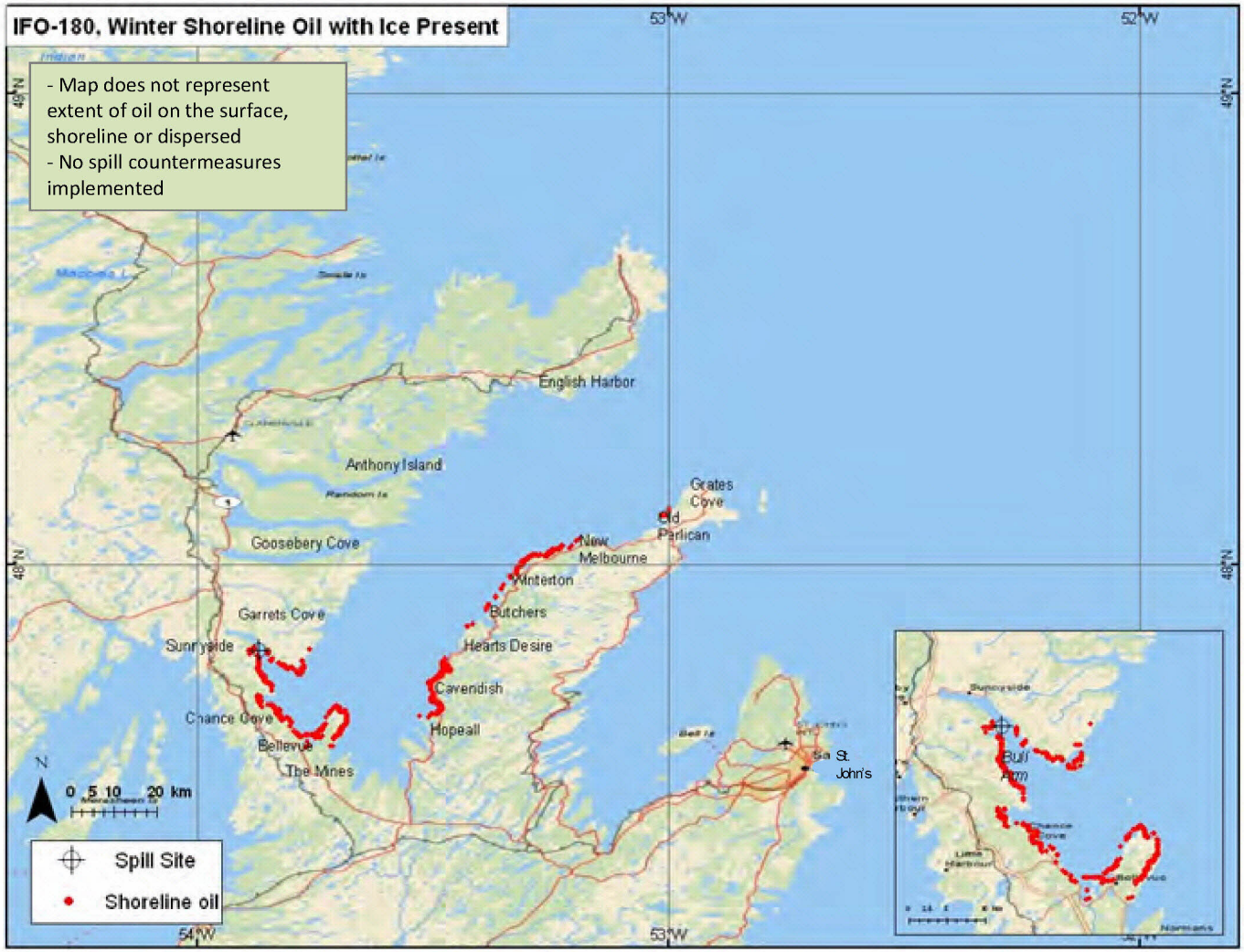


Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-9 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 1,000 m^3 Release of IFO-180 in the Winter



Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-10 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 1,000 m^3 Release of IFO-180 in the Winter with 65 Percent Ice Coverage

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14.2.3 Model Summary

Summer winds are more often from the southwest which drives oil onto the northeast coast of Bull Arm. Any oil exiting Bull Arm in the summer is driven northeastward up Trinity Bay. Winter winds are most often from the northwest which moves surface oil out of Bull Arm and onto the shoreline at the southern end of Trinity Bay and less frequently towards the northeast and the mouth of Trinity Bay.

Without the implementation of spill countermeasures, the smaller volume 100 m^3 marine diesel spills are predicted to have a 10 to 20 percent probability of leaving Bull Arm during the summer and a 30 to 40 percent probability of leaving Bull Arm under winter conditions. Spills of 1,000 m^3 of IFO-180 have a 60 to 70 percent probability of leaving Bull Arm during the summer, and a 70 to 80 percent probability of entering Trinity Bay during the winter season.

The model predicts that oil from both the 100 m^3 marine diesel and 1,000 m^3 IFO-180 spills have a small (<5 percent) probability of leaving Trinity Bay. Some of the surface oil exits the northeast corner of the model grid. This oil is >10 days old, the volatile components have evaporated; the oil is at the minimum thickness and moving into open ocean.

Spills of 100 m^3 of marine diesel have a 60 percent chance of hitting the Bull Arm shoreline in summer, and 30 percent probability to do so in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of impacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season.

Entrained marine diesel oil from a 100 m^3 spill is predicted to exceed a concentration of 10 ppb 100 percent of the time within Bull Arm during the summer and winter seasons. Probabilities drop quickly outside of Bull Arm to 10 to 30 percent during summer and winter seasons for a small area of southwest Trinity Bay. IFO-180 is a highly viscous fuel that shows almost no entrainment into the water column for spills of 1,000 m^3.

Results from the stochastic model simulations are summarized in Table 14.18.

Table 14-18 Summary of Surface Oiling from the Stochastic Simulations of Marine Diesel and Intermediate Fuel Oil-180 Released at the Bull Arm Site

Oil Release	Season	Surface Area Oiled at >0.01 mm (km^2)	Shoreline Oiled at >0.01 mm (km)	Entrained Oil Volume after 30 days (m^3)
100 m^3 Marine Diesel	Summer	581.4	19.8	58.6
	Winter	371.2	10.1	65.3
1,000 m^3 IFO-180	Summer	1,524.8	144.3	0.017
	Winter	1,670.5	137.5	0.024

14.3 Fate and Behaviour of Hebron Hydrocarbon Spills from a Platform or Seafloor Blow-out in the Offshore Study Area (Trajectory Modelling)

Hydrocarbon spill trajectory analysis for the Grand Banks has been previously carried out for environmental assessments for offshore exploration drilling and production programs. As a result of the Deepwater Horizon incident (2010) in the Gulf of Mexico, the approach taken here represents a departure from what has been done for most other trajectory studies either here on the Grand Banks or elsewhere in the world. A thorough analysis was done of potential situations that could result in an uncontrolled release of hydrocarbons in the Offshore Study Area. This analysis included an upper end estimate of potential flow rates should a blow-out occur and a rigorous estimate as to how long it could take to stop the flow of fluids from the well. Such an event results in putting a significant amount of oil on the sea's surface, rivalling that of the Deepwater Horizon incident, and modelling its movement for extended periods of time.

The present exercise provides an analysis using recent environmental data inputs and presents results in the context of the Hebron setting and neighbouring oil production platforms. ASA (2010b) provides a discussion of the spill trajectory analysis.

The SIMAP model was used to simulate crude oil spills at the Hebron offshore site. The model scenarios use wind data obtained from model hindcasts and field measurements, and current data from multiple hydrodynamic models. The SIMAP model was used in stochastic and deterministic modes to determine the range of possible oiling predicted to occur at the water surface, entrained in the water column or deposited on the shoreline. The ASA blow-out model simulates the near-field dynamics of the plume of gas / oil mixture discharged from the seafloor well blow-out, and the SIMAP model simulates the far-field transport and weathering of the oil released into the water column or at the surface (see ASA 2010b for a complete description of the model and its results).

14.3.1 Model Inputs and Spill Scenarios

There are two types of spill events that may occur during production operations at the Hebron Platform: batch spills and blow-outs. Batch spills are instantaneous or short-duration discharges of hydrocarbons that could occur from the handling and/or transfer of hydrocarbons (i.e., loading of diesel). Blow-outs are uncontrolled releases of fluids (crude oil and water) and gases from underground reservoirs.

The scenarios presented consider the rate at which oil could flow under a well blow-out scenario for the Hebron Field. This rate was derived based on existing knowledge of Hebron crude properties, known reservoir properties for the Hebron field and assumptions made for specific well conditions at the time of the blow-out. Reservoirs differ greatly from one to another and their properties (pressure, volume, oil / gas ratio) are unique to each reservoir.

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Therefore, the flow rates described below reflect the properties of the Hebron Field. Historical flow rates from other spill events are not predictive of what would happen in other reservoirs; however, they can be used to put specific events into perspective.

Flow rates for Hebron platform wells were estimated at 5,600 m^3/d (approximately 35,000 bbl/d) based on the Hebron reservoir properties, assuming a blow-out to atmosphere (e.g., approximately 70 m above mean sea level) and accounting for the viscous (thick - difficult to flow) nature of the oil from this reservoir.

Flow rates for MODU wells were estimated at 3,200 m^3/d (approximately 20,000 bbl/d) based upon the properties of its reservoir, a seafloor blow-out (approximately 90 m below sea level) and a lighter, less viscous oil. ExxonMobil's well control philosophy is focused on prevention using safety / risk management systems, management of change procedures and global standards. ExxonMobil has a mature OIMS that emphasizes relentless attention to Safety, Well Control and Environmental Protection. This includes proper preparation for wells (well control equipment inspections / tests), detecting the influx early, closing-in the well efficiently (personnel training / drills) and circulating out the kick with kill-weight mud in a controlled manner.

In the event of a blow-out, ExxonMobil's primary objective would be to stop the flow as quickly as possible. For both surface and seafloor wells, this would involve shutting in at the wellhead and killing the well through the wellhead. Relief well drilling, and the subsequent dynamic kill, is considered a back-up strategy in the event shut-in and/or killing through the wellhead is not possible or is unsuccessful.

In developing these scenarios the following factors were considered. Spill trajectory modelling was conducted for two potential scenarios where the blowout might occur above sea level from the platform or at the seafloor while drilling from a Mobil Offshore Drilling Unit (MODU).

Platform Blow-out (above sea level to the atmosphere):

- For a blow-out through a surface wellhead, multiple options are available to stop the flow, depending on the magnitude and composition of the flow, configuration of the blow-out preventer (BOP) and the accessibility of the wellhead. If the wellhead is accessible, capping the well would result in a relatively short flow duration, as surface capping equipment, such as safety valves for inside pipe flow, are maintained on the rig and manual BOP closing is possible. Depending on the scenario, the duration to cap the well and stop flow may be within just a few hours, or if initial attempts are unsuccessful, is estimated at two to three weeks. If a fire renders the platform inaccessible, the most appropriate method to access the well would be evaluated given the condition of the platform and surrounding wells.
- If Platform-based well interventions were not successful, the time it would take to secure a drilling unit locally, secure the required well equipment, mobilize the unit to the Hebron location, and drill a relief well is estimated to be 100 days in the summer months and 120 in the winter months. If a

MODU was sourced internationally, approximately 144 days in the summer months and 165 days in the winter months would be required to plan and execute the full relief well program.

Seafloor Blow-out (while drilling from a MODU):

- If the seafloor wellhead is accessible and the drilling rig on the MODU is intact, operational and can work over the wellhead, the rig would be used to cap or kill the well. In this scenario, multiple options exist to kill the well, including wellbore intervention to perform a dynamic kill or to set a packer. In addition, using the existing BOP stack or a capping BOP stack to shut-in the well is also possible. If the drilling rig is intact and the wellbore is accessible, a dynamic kill could take place within days of the blow-out. If it is necessary to assemble and mobilize a capping stack and a second MODU, then a time period of approximately 60 days would be required. If a MODU is available locally and the rig stack can be used as a capping stack, this time period is reduced to 30 days.
- If it is not possible to work over the wellhead, or if the wellhead is inaccessible, then a relief well will be required to kill the well. If a MODU was sourced locally, the time it would take to secure a drilling unit locally, secure the required well equipment, mobilize the unit it to the Hebron location, and drill a relief well is estimated to be 100 days in the summer months and 120 in the winter months. If a MODU was sourced internationally, approximately 144 days in the summer months and 165 days in the winter months would be required to plan and execute the full relief well program.

As stated above, the probability of a blow-out from development drilling or production operations resulting in the need to drill a relief well is low. Therefore, for the purposes of environmental assessment, the environmental effects analysis will focus on two plausible, albeit low probability blow-out events: a Platform blow-out flowing crude oil at a rate of 5,600 m^3/d for 30 days, and a seafloor blow-out flowing crude oil at a rate of 3,200 m^3/d for 100 days. The batch spills modelled include an instantaneous release of 800m^3 of diesel, and a batch release of 5,000 m^3 crude from the offshore loading system. Additional information on the spill trajectory modelling results can be found in the spill trajectory report completed by Applied Science Associates, Inc. (ASA 2010b).

Note that the 30 day duration blow-out scenarios were also run using a 60-day duration in order to track the oil for an additional 30 days. These extended simulations use the same blow-out duration, rate of release and total release volume as the 30 days scenarios; however, the model run time was extended to 60 days.

Also note that the types of oil differ for each of the blow-out scenarios due to the different reservoirs. The characteristics of the oil types used in the spill simulations are listed in Table 14-19.

Table 14-19 Characteristics of Oil used in Spill Trajectory Modelling

Oil	Spill	API Gravity	Density (g/cm^3)	Viscosity (cP)
Hebron D-94 Crude	Platform blow-out Batch OLS Transfer	20.1	0.92691 @ 25° C	265.374 @ 25° C
Ben Nevis L55 Well	Seafloor blow-out	30.8	0.8711 @ 15° C	15.556 @ 25° C
Marine Diesel Fuel	Batch Transfer Spills	37.6	0.82910 @ 25° C	4.0 @ 25° C

Wind data for offshore model simulations were obtained from two sources: MSC50 Wind Hindcast (Swail et al. 2006), a model reanalysis product that provides hindcast winds for the North Atlantic for the period 1954 through 2008 at sites clustered around the Hebron Platform; and National Centers for Environmental Prediction at multiple locations (more widely spaced) across the North Atlantic. Annual wind directions and speeds from the MSC50 model hindcast data were obtained for Grid Point M6010632 (adjacent to the Hebron Platform). The wind comes from all directions at this site but it comes most frequently from the northwest through the south. There is seasonality in the wind at this location that differentiates the summer and winter seasons. Winter wind speeds are higher than in summer and more frequently from the west and north. Oil spill simulations were run using summer and winter season winds in order to capture the seasonal differences. Currents for the North Atlantic region were acquired from the HYbrid Coordinate Ocean Model circulation model, an ocean general circulation model that evolved from the Miami Isopycnic-Coordinate Ocean Model (Halliwell et al. 1998, 2000; Bleck 2002). Hindcast currents from the HYbrid Coordinate Ocean Model were obtained for the period November 2003 through September 2010 for the North Atlantic region. These currents were used in SIMAP for modeling oil spills originating at the Hebron Platform and from the seafloor blow-out. Spill trajectory modelling in the winter months was run with and without ice present. The presence of sea ice in Newfoundland and Labrador waters was below normal during the winter of 2009-2010 (CIS 2010). The total accumulated ice coverage in east Newfoundland waters set a new record low during last year's winter season. Ice data used for oil spill modelling were obtained from the National Snow and Ice Data Center for the months of February and March, 1990 to define the ice coverage for these months. The SIMAP model accounts for the presence of ice at 0 to 30 percent, 30 to 80 percent and 80 to 100 percent when calculating surface oil advection, evaporation, entrainment into the water column and surface oil spreading.

14.3.2 Model Output

14.3.2.1 Stochastic Model Results

The stochastic model is used to determine the probability of finding oil on the water surface, the shoreline and in the water column based on specified thickness and concentration thresholds. The thresholds used for the stochastic model simulations in this study include:

- Average thickness of surface oil >0.01 mm (10 µm)

- Average thickness of oil over the shore segment (length of one grid cell times typical width for the shoreline type) >0.01 mm (10 µm)
- Average concentration of oil entrained in water (over the water cell) >10 ppb

Winds and currents at the Hebron Platform are such that the majority of spills are predicted to travel eastward. The distance traveled is controlled by the blow-out duration. Simulations of blow-outs of 100 days or longer duration and without any response or interdiction are predicted to oil large areas of the North Atlantic.

Winter wind speeds are higher than in summer and more frequently from the west and north, which drives oil greater distances to the east than summer winds. Both summer and winter spill simulations of greater than 30 days duration are predicted to reach segments of the Newfoundland shoreline.

Both of the crude oils used in the simulations are persistent and do not disperse into the water column readily from natural processes. This characteristic, combined with the long duration release of oil into the water, result in most of the oil remaining on the sea surface. The area of sea surface oiled increases linearly with an increase in total spill volume.

The probability for surface oiling exceeding the above thresholds for the 30-day Hebron Platform blow-out scenario in the summer and winter and winter in ice seasons are depicted in Figures 14-11 to 14-13. The probability for surface oiling exceeding the above thresholds for the 30-day / 60-day extended Hebron Platform blow-out scenario in the summer, winter and winter (with ice) seasons are depicted in Figures 14-14 to 14-16. The probability for surface oiling exceeding the above thresholds for the Hebron seafloor blow-out scenario for 100 days in summer and 120 days winter (with and without ice) are depicted in Figures 14-17 to 14-19. The probability for surface oiling exceeding the above thresholds for the Hebron Platform blow-out 100 and 120 days scenarios are very similar to the seafloor 100-day and 120-day cases; these figures can be found in ASA 2010b. It should be noted that the maps do not show that oil will cover the entire area depicted, only the probability that surface oil will enter the model domain in excess of the given threshold (i.e., > 0.01 mm thickness) sometime during the modeling period.

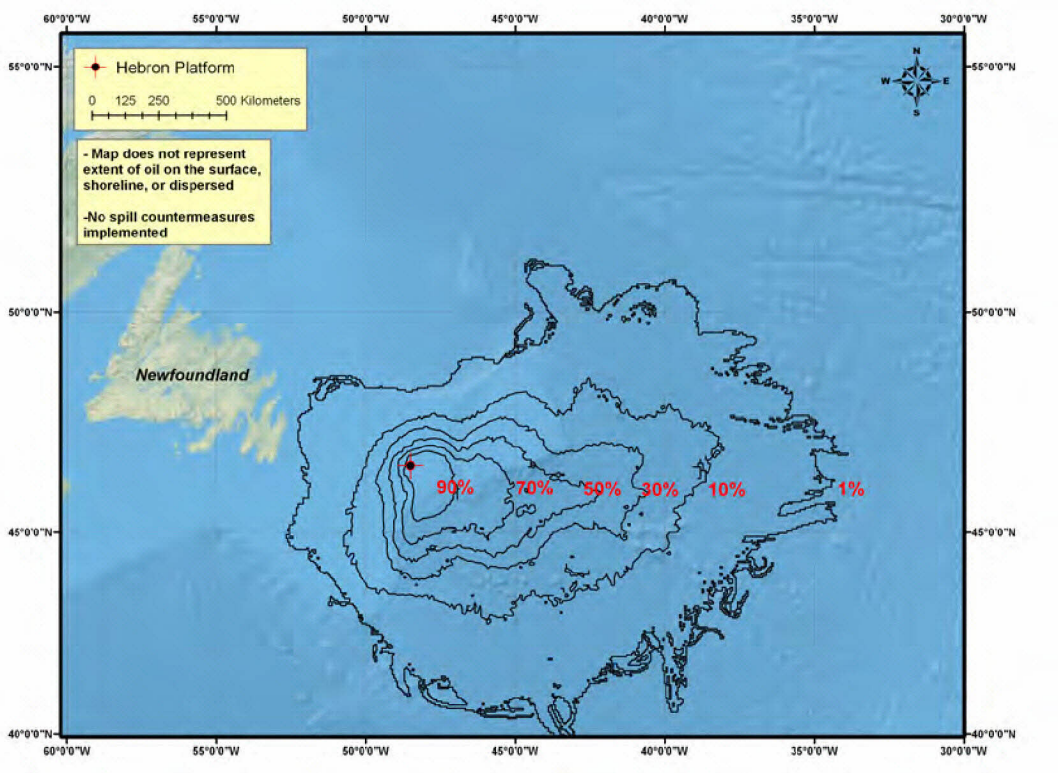

Figure 14-11 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period during Summer

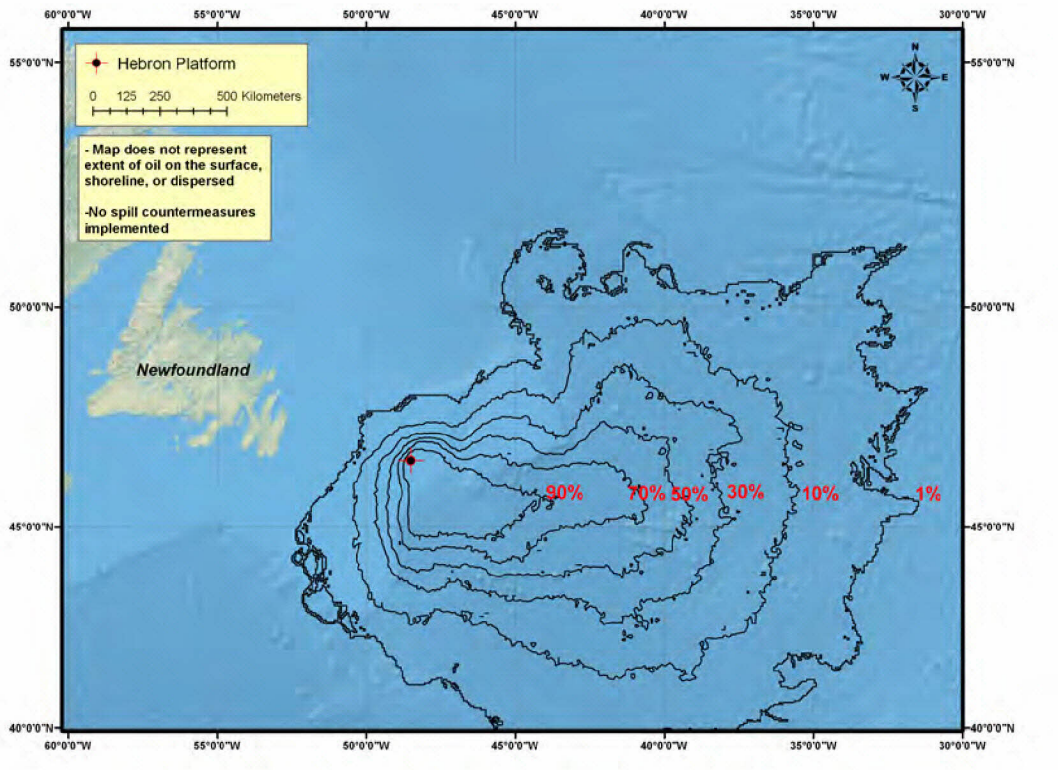

Figure 14-12 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period during Winter

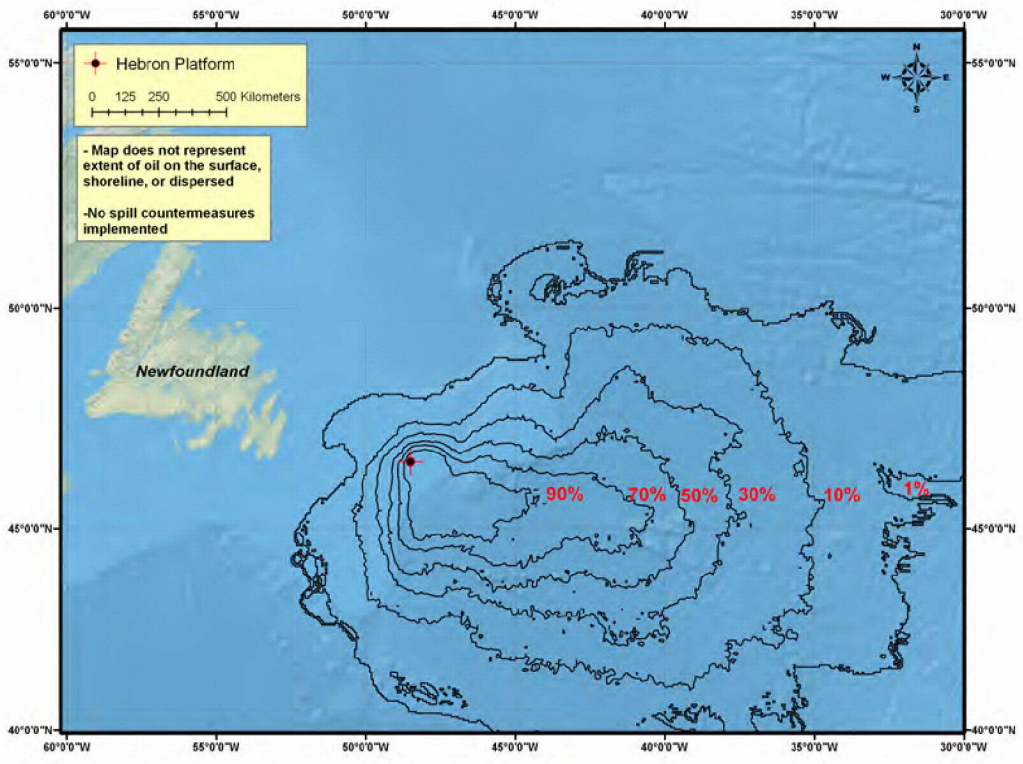

Figure 14-13 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period during Winter (ice present)

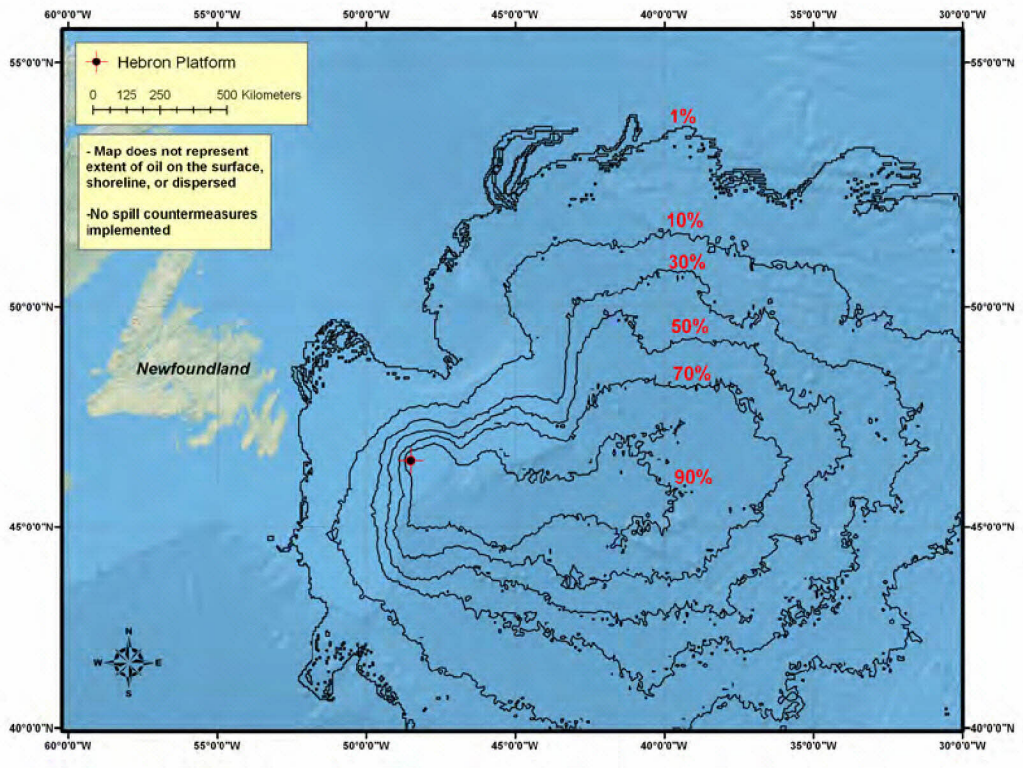

Figure 14-14 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period Simulated for 60 Days during Summer

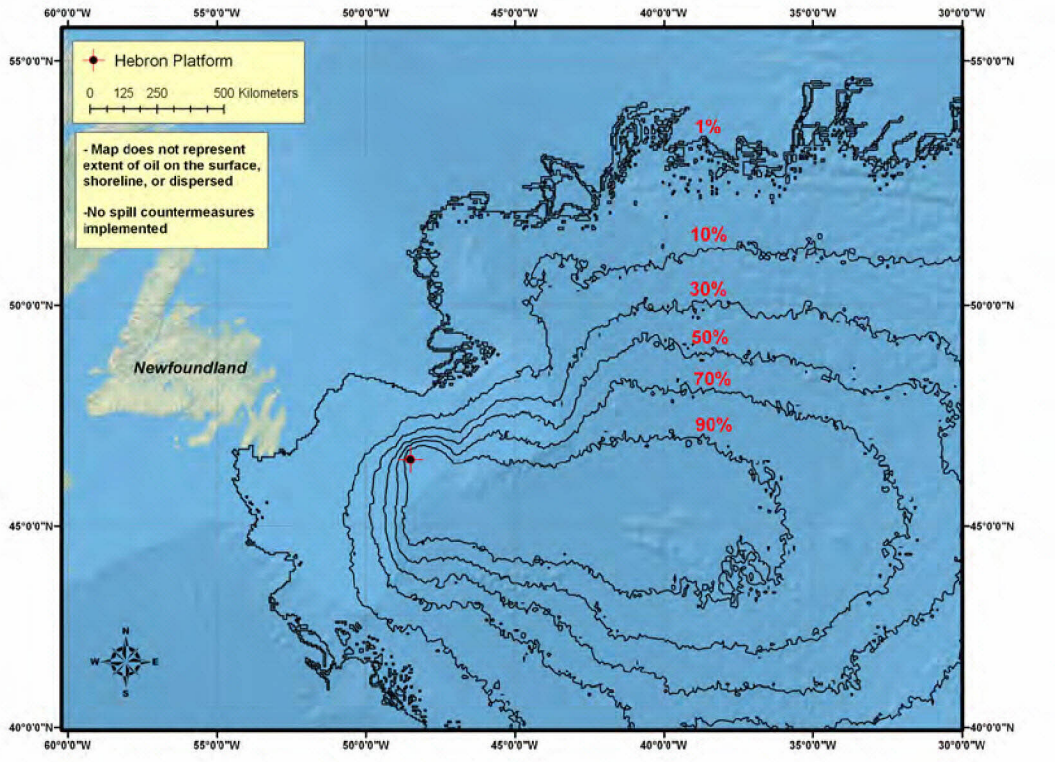

Figure 14-15 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period Simulated for 60 Days during Winter

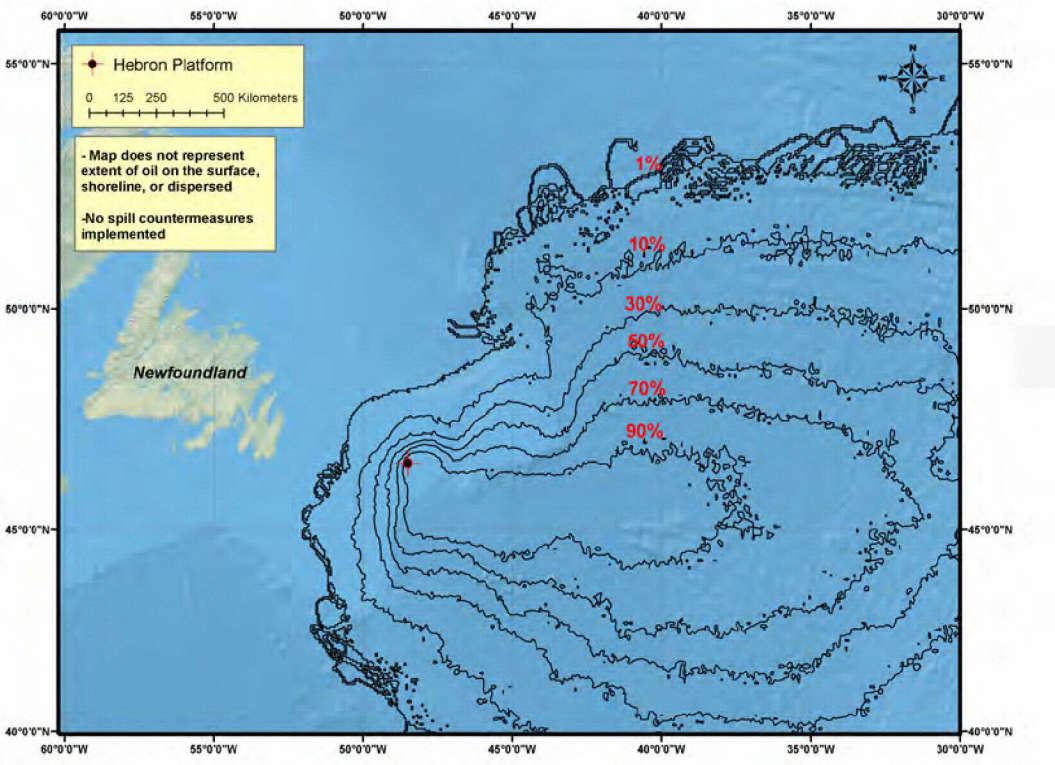

Figure 14-16 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period Simulated for 60 Days during Winter (ice present)

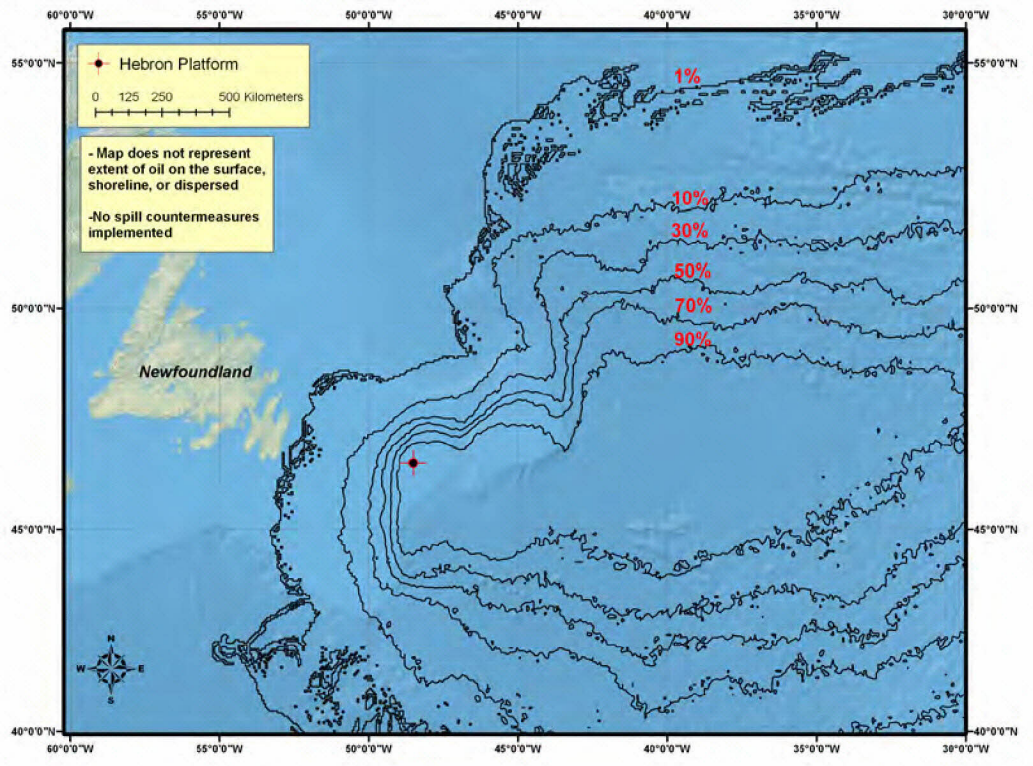

Figure 14-17 Surface Oiling Probabilities Greater than 0.01 mm from a Seafloor Blow-out over a 100-day Period during Summer

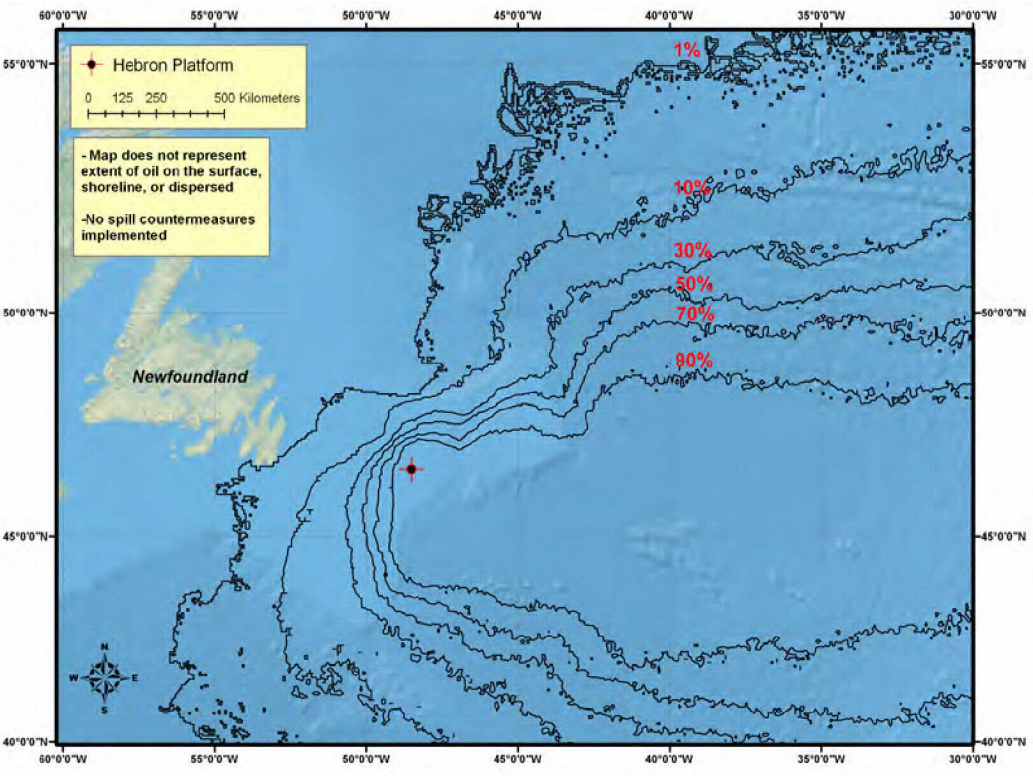

Figure 14-18 Surface Oiling Probabilities Greater than 0.01 mm from a Seafloor Blow-out over a 120-day Period during Winter

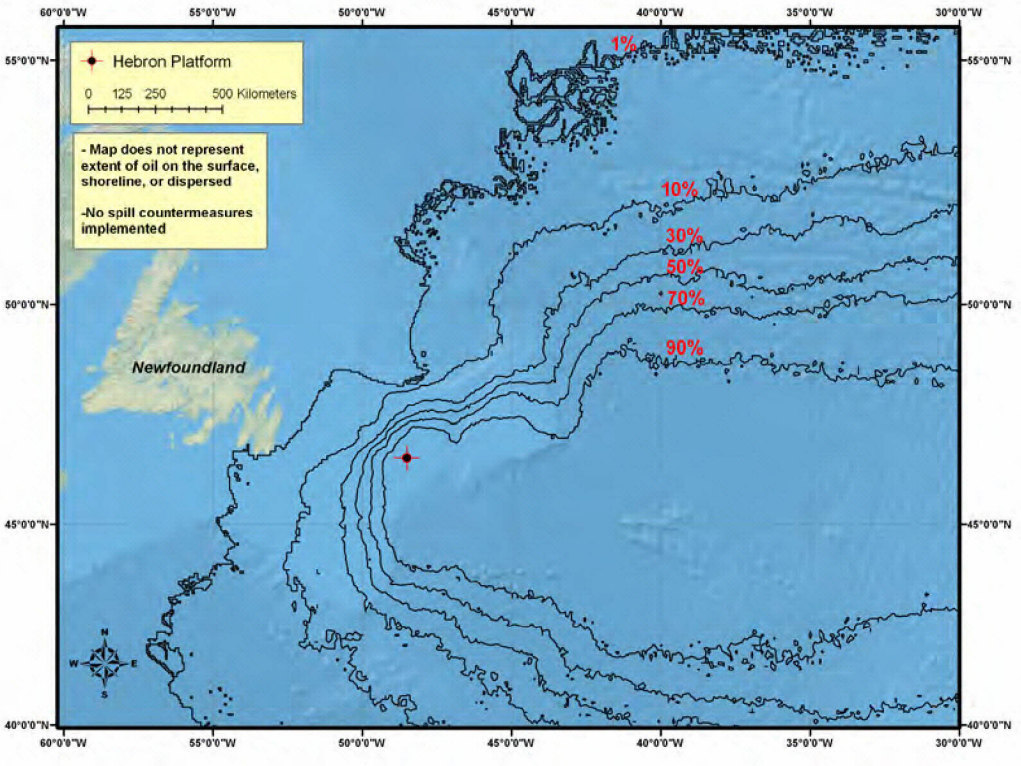

Figure 14-19 Surface Oiling Probabilities Greater than 0.01 mm from a Seafloor Blow-out over a 120-day Period during Winter (with ice present)

Not all of the stochastic model simulations predict oil will hit the Newfoundland coast. For those simulations where shoreline contact is predicted, there is a less than 5 percent probability that oil from either a platform or seafloor blow-out will reach the Newfoundland shore without the implementation of spill countermeasures. The stochastic model shoreline contact summary is provided in Table 14-20. The values listed in the table are from the individual spill from each stochastic model scenario that resulted in the maximum amount of oil on the Newfoundland shore. A zero probability of contact means that none of the 100 spills completed in the stochastic model scenario reached the Newfoundland coastline; a 1 percent probability of shoreline contact means that one of the 100 runs reached the shoreline. The predicted affected shoreline during summer and winter from a Hebron Platform and seafloor blow-out is illustrated in Figures 14-20 to 14-26.

Table 14-20 Newfoundland Stochastic Model Shoreline Contact Summary

Scenario	Probability of Oiling (%)	First Arrival of Oil (days)	Shoreline Length Oiled (km)	Shoreline Area Oiled (m^2)	Expected Mean Mass (g/m^2)
Hebron Platform Blow-out					
Surface 30 day Summer	0	-	-	-	-
Surface 30 day Winter	0	-	-	-	-
Surface 30 day Extended Run Summer	0	-	-	-	-
Surface 30 day Extended Run Winter	1	41	142.7	428,100	20
Surface 30 day Extended Run Winter w/ice	0	-	-	-	-
Surface 100 day Summer	1	23	5.3	15,900	0.2
Surface 120 day Winter	1	108	285.5	856,500	20
Surface 120 day Winter w/ice	3	21	137.8	413,500	60
Seafloor Blow-out					
Seafloor 100 day Summer	1	39	5.3	15,900	0.8
Seafloor 120 day Winter	3	21	127.2	381,600	39
Seafloor 120 day Winter w/ice	1	40	116.6	349,900	20
Batch Spills					
Marine Diesel Batch Transfer Summer	0	-	-	-	-
Marine Diesel Batch Transfer Winter	0	-	-	-	-
Diesel Mairne Batch Transfer Winter – w/ice	0	-	-	-	-
Crude Oil Batch OLS Transfer Summer	0	-	-	-	-
Crude Oil Batch OLS Transfer Winter	0	-	-	-	-
Crude Oil Batch OLS Transfer Winter – w/ice	0	-	-	-	-
Note: Values listed are from the individual spill within each stochastic scenario that resulted in the largest volume of oil stranded on the shore					

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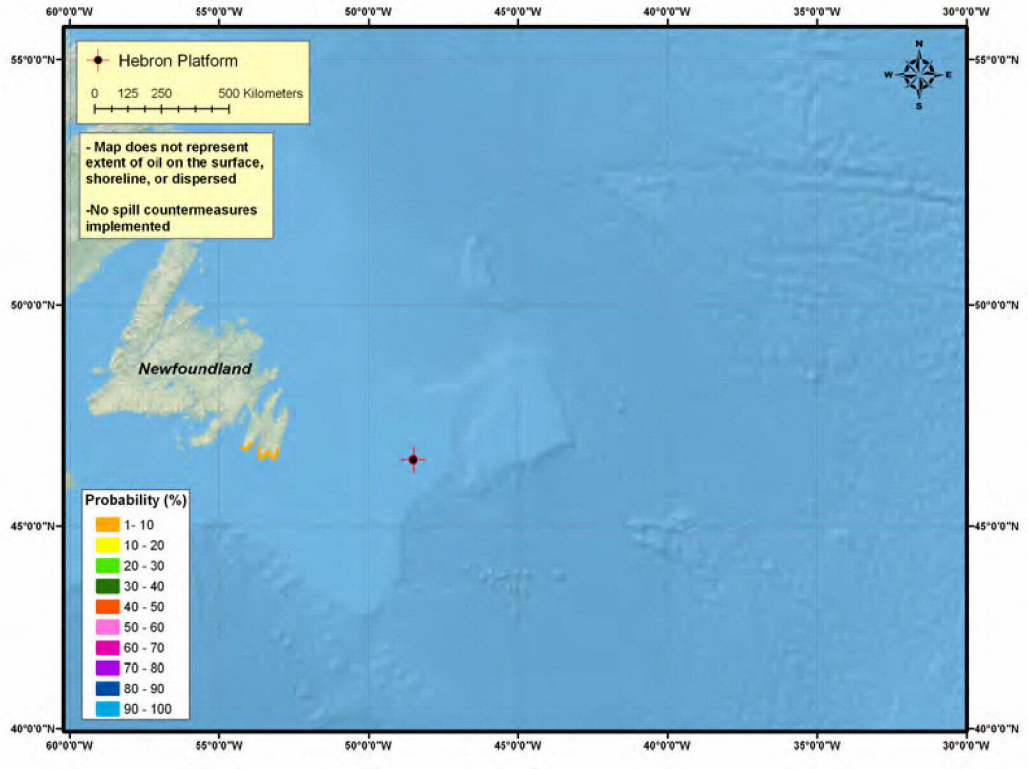

Figure 14-20 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 30-Day Extended (60-day) Run Winter

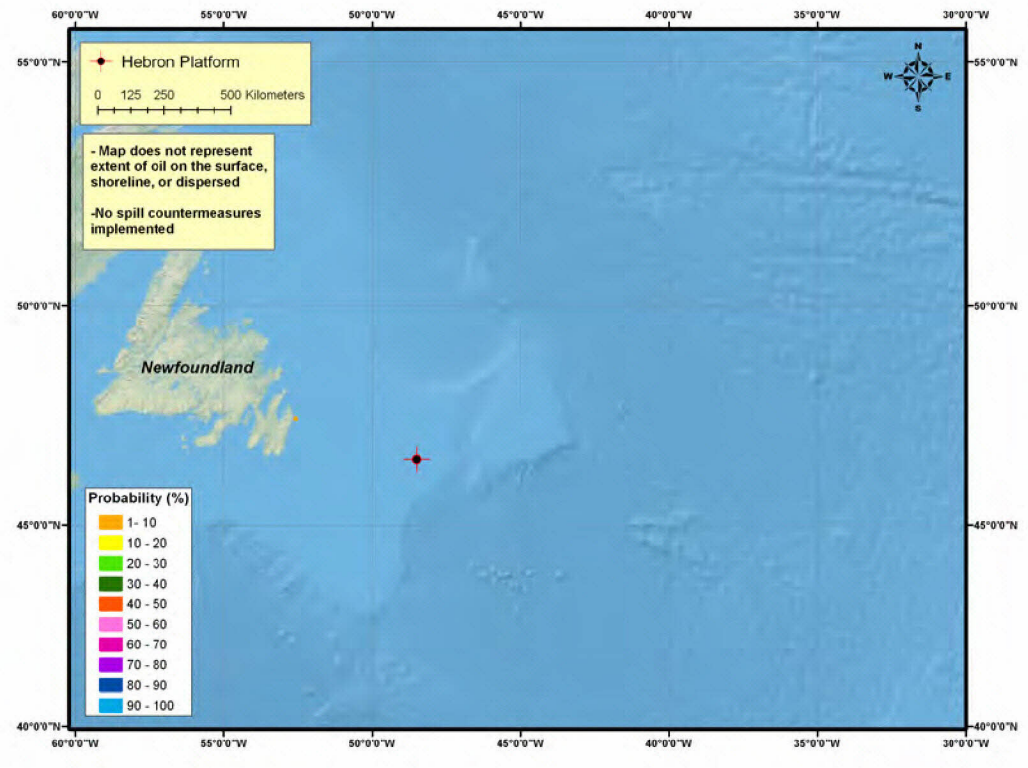

Figure 14-21 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 100 Days Summer

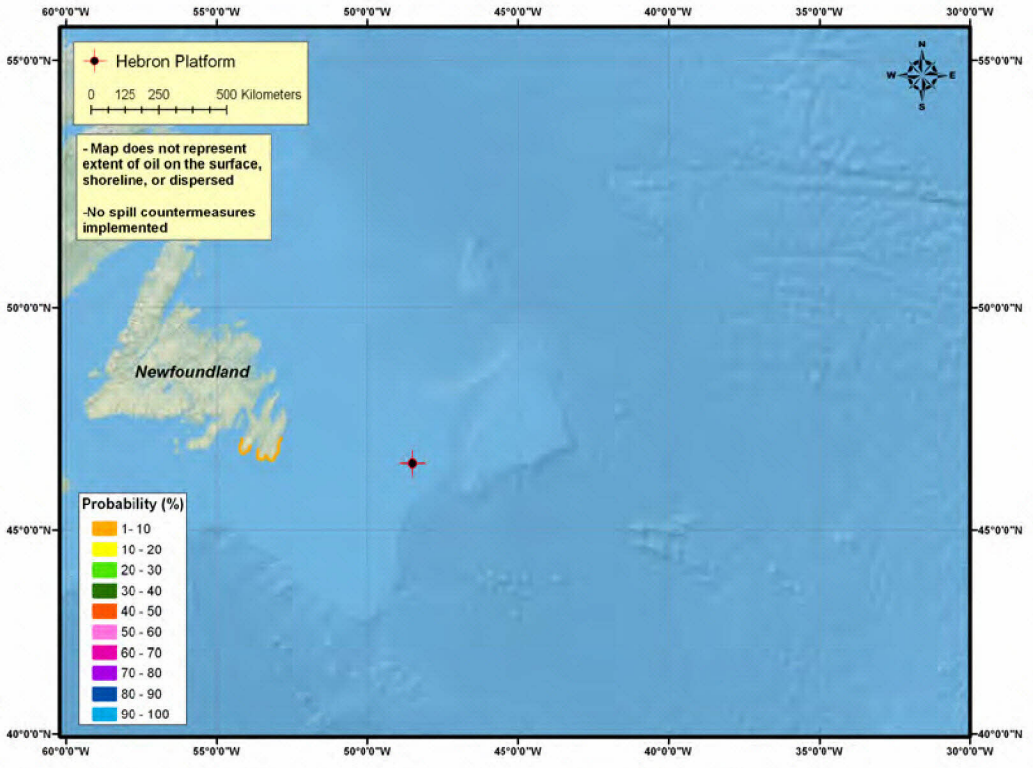

Figure 14-22 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 120 Days Winter

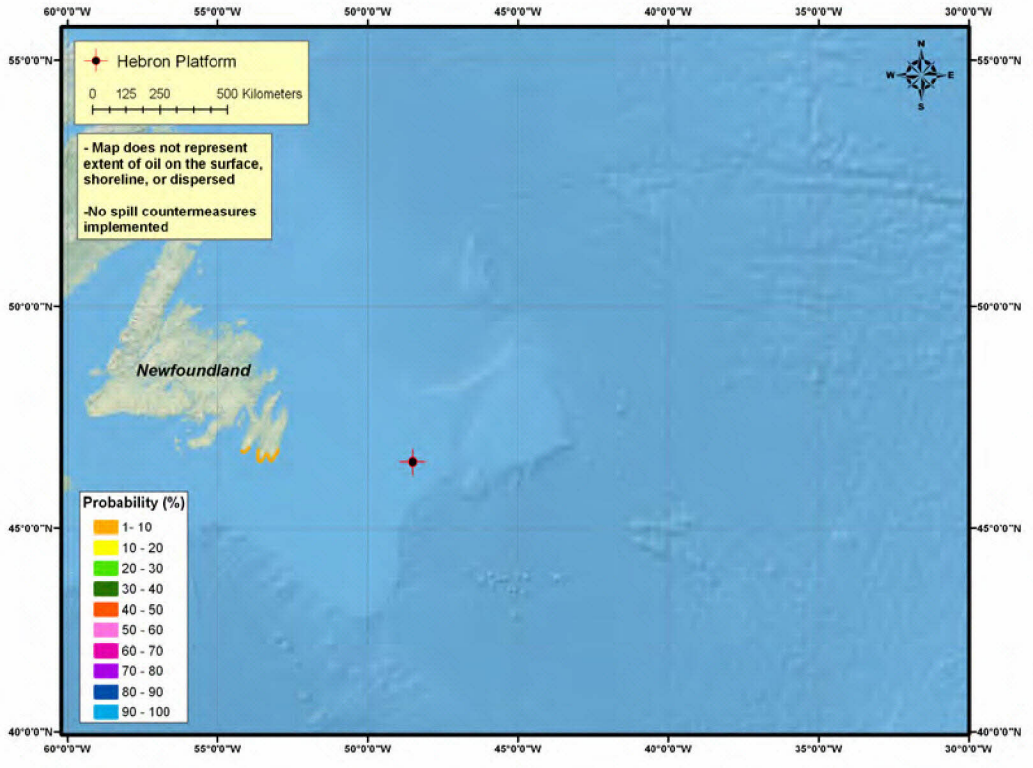

Figure 14-23 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 120 Days Winter (with ice present)

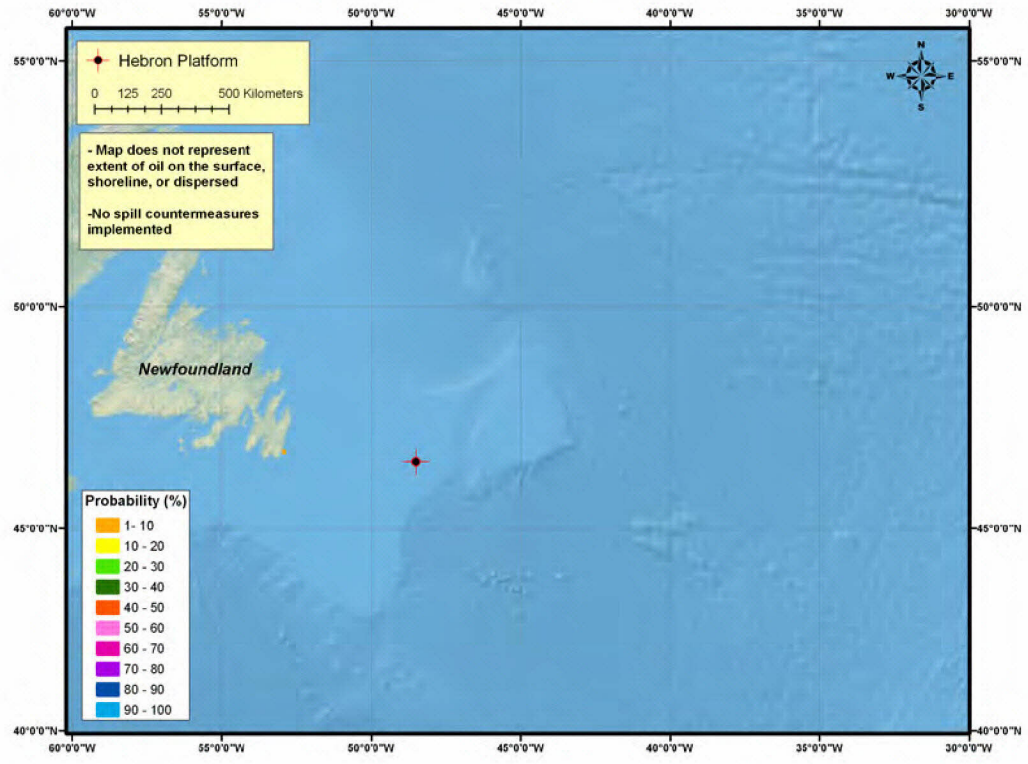

Figure 14-24 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Seafloor Blow-out, 100 Days Summer

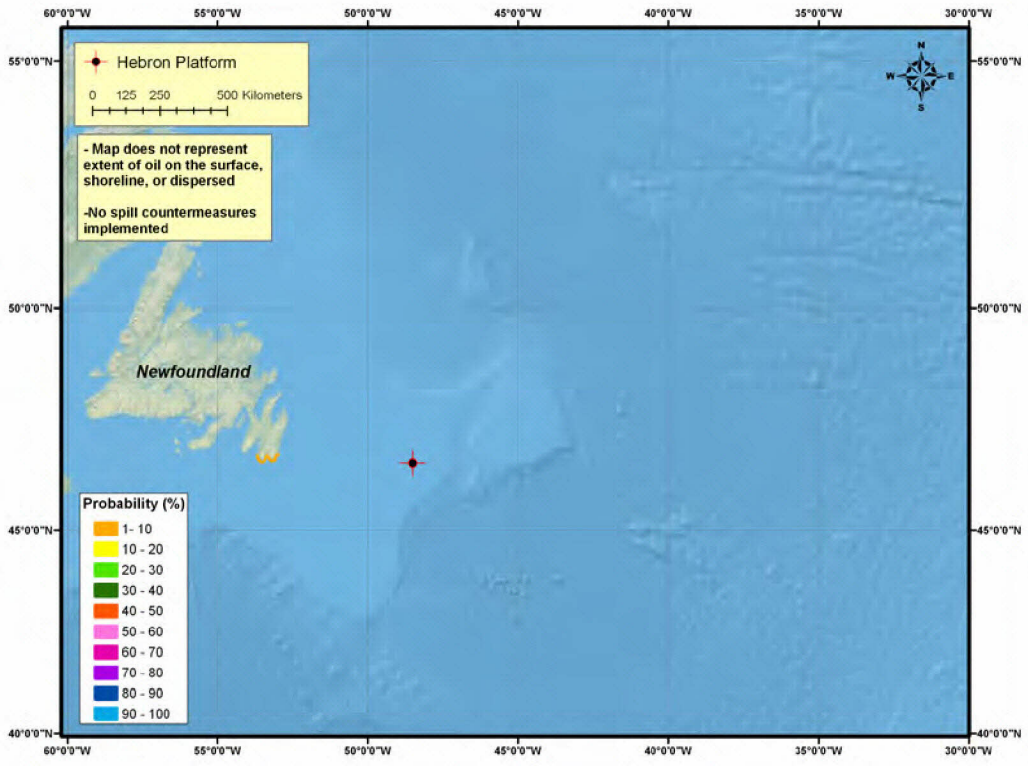

Figure 14-25 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Seafloor Blow-out, 120 Days Winter

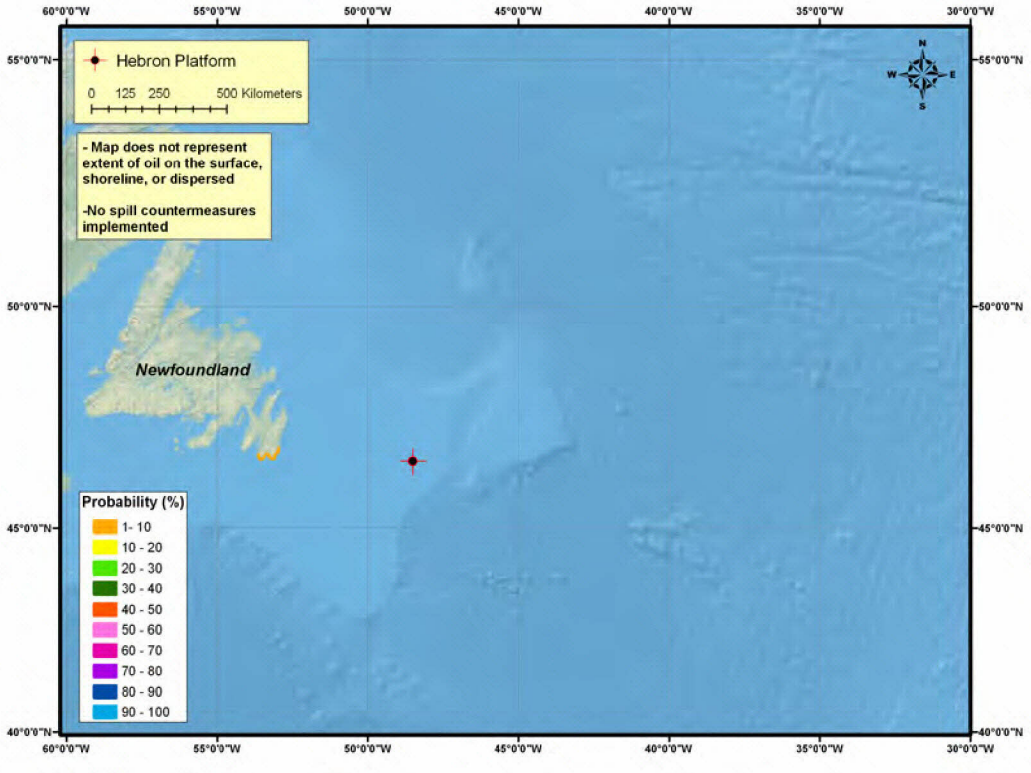

Figure 14-26 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Seafloor Blow-out, 120 Days Winter (with ice present)

14.3.2.2 Deterministic Model Results

The deterministic model results depict the results from one model simulation chosen from the 100 individual simulations completed by the stochastic model. The simulations were selected because they result in the 95th percentile for sea surface oiling area, shoreline oiling length or entrained oil volume. It should be kept mind that each map displays the results from a different simulation.

The deterministic model was used to investigate individual spill events identified in the stochastic model as resulting in the 95th percentile for surface oiling. The deterministic model results show the maximum surface oil thickness for the entire spill period as areas of color corresponding to oil thickness (see Table 14-21).

Table 14-21 Summary of Offshore Deterministic Model Results

Release Type	Spill Scenario	Total Spill Volume (m^3)	Surface Oil (%)	Evap. (%)	Water Column (%)	Oil Ashore (%)	Oil Decayed (%)
Platform Blow-out (5,600 m^3/day (35,000 bpd))	Summer: 30 day	168,000	79	8.2	0.2	0	12.6
	Winter: 30 day	168,000	79	8.3	0.2	0	12.5
	Winter – ice: 30 day	168,000	79	7.8	0.2	0	13
	Summer: 30/60 day	168,000	56	11.7	0.3	0	32.0
	Winter: 30/60 day	168,000	56	11.3	0.3	0.2	32.2
	Winter – ice 30/60 day	168,000	56	11.3	0.3	0.01	32.4
	Summer: 100 day	560,000	56	10.2	0.2	0.02	33.6
	Winter: 120 day	672,000	51	11.4	0.3	0.4	36.9
	Winter – Ice: 120 day	672,000	51	11.2	0.3	0.4	37.1
Seafloor Blow-out (3,200 m^3/day (20,000 bpd))	Summer	320,000	35	28.6	9.9	0	26.5
	Winter	384,000	31	29.8	9	0.09	30.1
	Winter - ice	384,000	29	32.3	9.1	0.2	29.4
Batch Transfer (Marine Diesel)	Summer	800	0	45.2	39.6	0	15.2
	Winter	800	0	6.4	69.7	0	23.9
	Winter - ice	800	0	6.2	69.8	0	24.0
Batch OLS Transfer (Crude Oil)	Summer	5,000	64	12.9	0.5	0	22.6
	Winter	5,000	64	12.5	0.5	0	23.0
	Winter - Ice	5,000	64	12.6	0.4	0	23.0

Note: The percentages in the table are the fraction of oil volume in each location or weathering category at the end of the simulation

The volume of oil remaining on the sea surface at the end of each Hebron Platform model simulation ranges from 51 to 79 percent of the total volume released. In general, as the oil release duration increases, the fraction of oil remaining on the sea surface decreases. This relative decrease in surface oil corresponds with an increase in the rate of natural decay. Decay, which accounts for 12 to 37 percent of the total Hebron Platform blow-out spill volume, occurs as the result of photolysis, a chemical process energized by ultraviolet light from the sun, and by biological breakdown from organisms in the water. The decrease in surface oil over time may in some instances correspond to surface oil stranding on the shoreline, reducing the amount of oil on the surface. While the fraction of surface oil volume is predicted to decrease over time, the sea surface area covered by oil thicker than 0.01 mm

is predicted to increase as the duration of the blow-out increases. The increase in sea surface area exposed to oil is due to the rapid and continual spreading of the surface slick. The fraction of oil lost to evaporation does not vary greatly, ranging from 7.8 to 11.4 percent of the total volume released. The amount of oil entrained in the water column through natural dispersion processes is less than 0.5 percent for all Hebron Platform blow-out spill scenarios.

The volume of oil remaining on the sea surface at the end of each of the seafloor blow-out simulations ranges from 29 to 35 percent, considerably less than the Hebron Platform blow-outs. The seafloor blow-out introduces oil directly into the water column where oil makes up 9 to 10 percent of the spilled volume throughout the duration of the blow-out. As with the Hebron Platform blow-out, as the oil release duration increases, the fraction of oil remaining on the sea surface decreases due to an increasing rate of natural decay. Decay accounts for 26 to 30 percent of the released oil. Oil lost to evaporation in the seafloor blow-out spills is predicted to be more than twice the amount in the Hebron Platform blow-outs, ranging from approximately 29 to 32 percent. This is due primarily to differences in the physical and chemical makeup of the platform crude oil modelled compared to the seafloor crude oil modelled.

14.3.3 Batch Spills

Similar to the blow-out releases of crude oil, marine diesel and crude oil released in batch transfer spills are predicted to travel primarily toward the east away from Newfoundland. The marine diesel fuel is more easily dispersed into the water column than the crude oil and modelling predicts slightly higher entrained oil fractions for these spills. The marine diesel is capable of achieving a smaller minimum thickness than the crude oil, resulting in a relatively higher sea surface area exposed to oil. None of the batch transfer spills are predicted to reach the Island of Newfoundland shoreline (Figures 14-27 to 14-22).

None of the marine diesel oil released in the batch transfer spill remains on the sea surface at the end of the 30-day simulation. This is primarily because the diesel is more readily entrained into the water column than the crude oil and in the summer season has a higher rate of evaporation. Between 40 and 70 percent of the diesel is predicted to become entrained in the water column, while 0.4 to 0.5 percent of the crude will entrain. The model predicts between 15 and 24 percent of the diesel and 22 to 23 percent of the crude will decay.

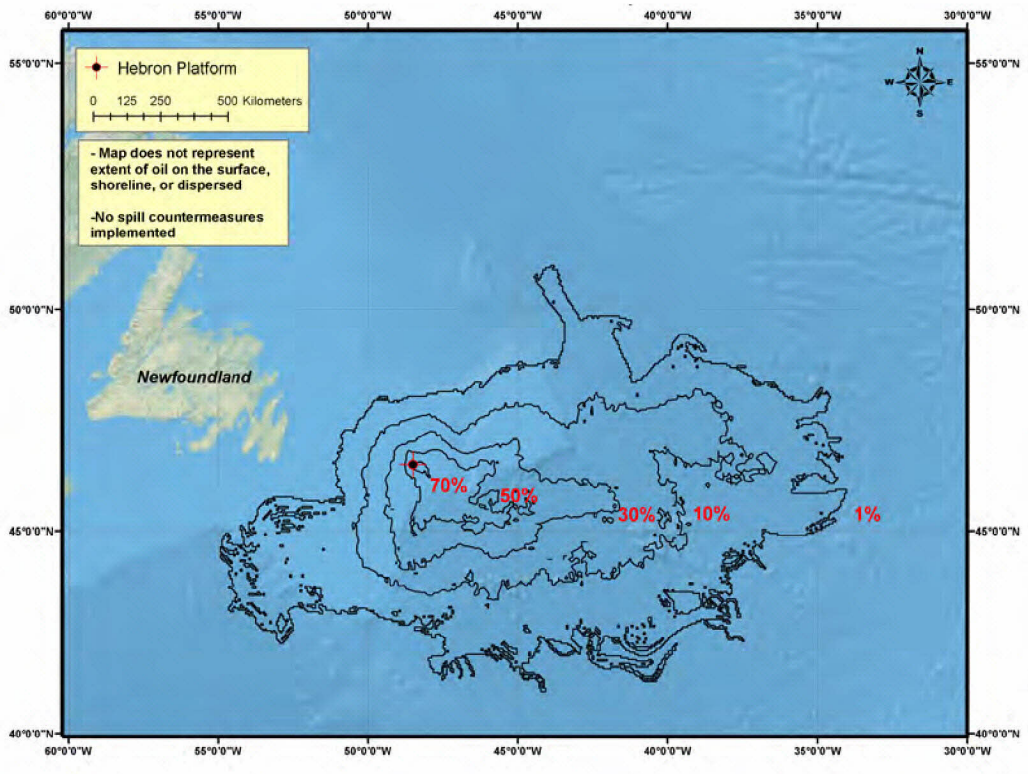

Figure 14-27 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Transfer Release of 800 m^3 of Diesel during Summer

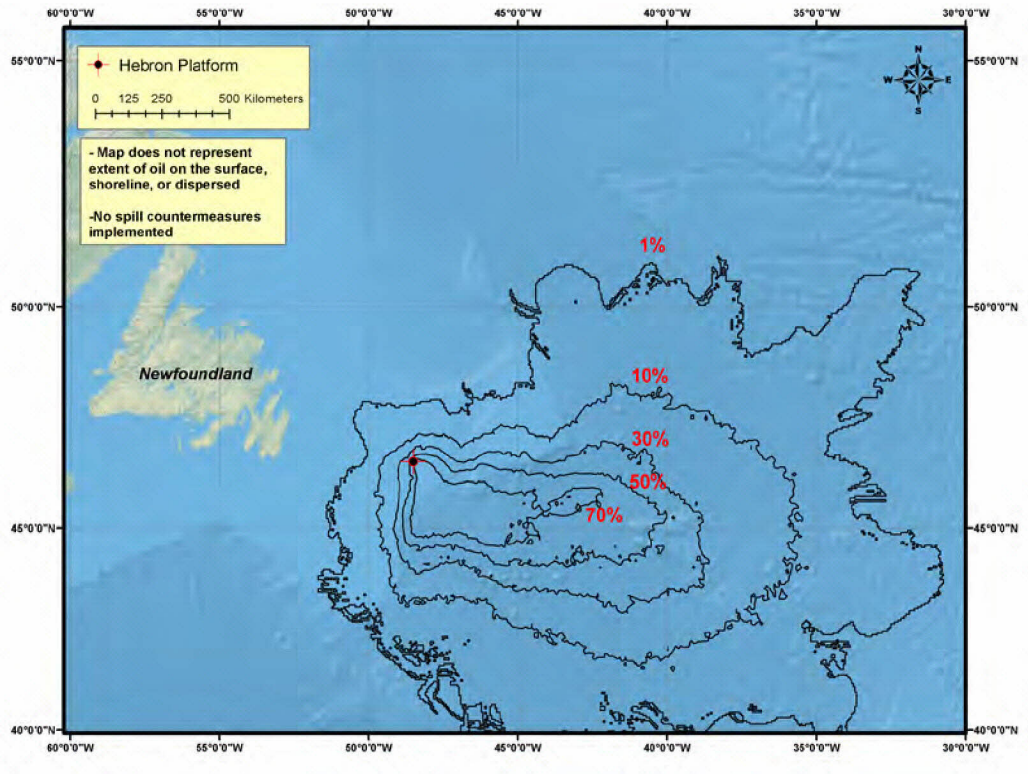

Figure 14-28 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Transfer Release of 800 m^3 of Diesel during Winter

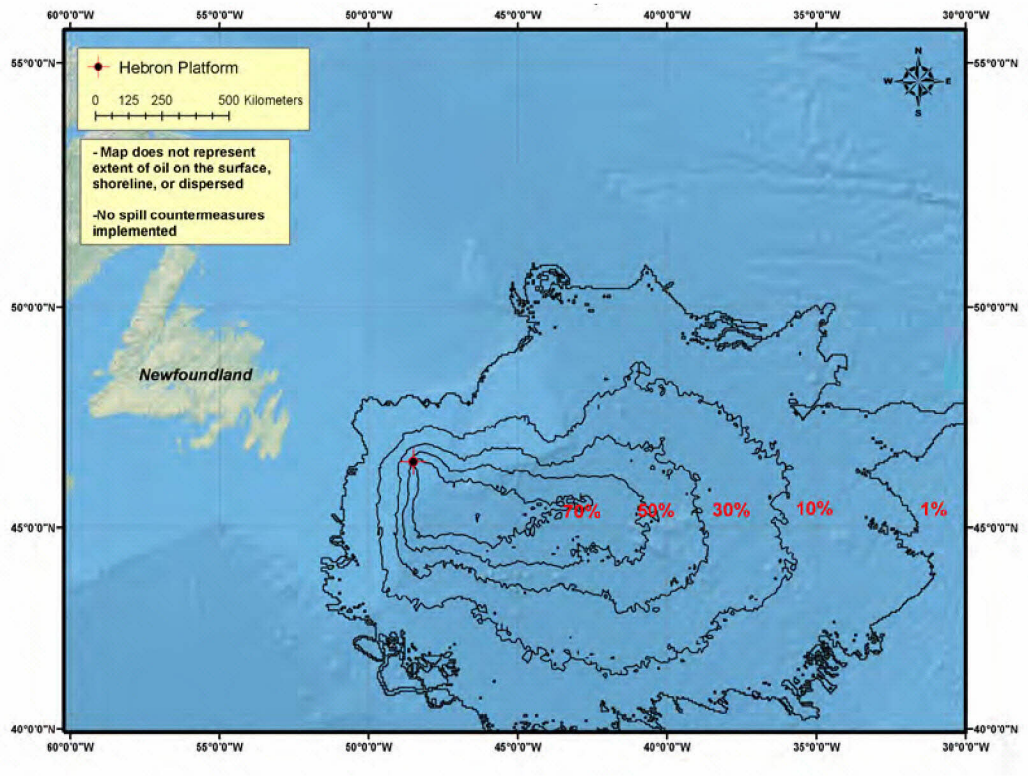

Figure 14-29 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Transfer Release of 800 m^3 of Diesel during Winter (with ice present)

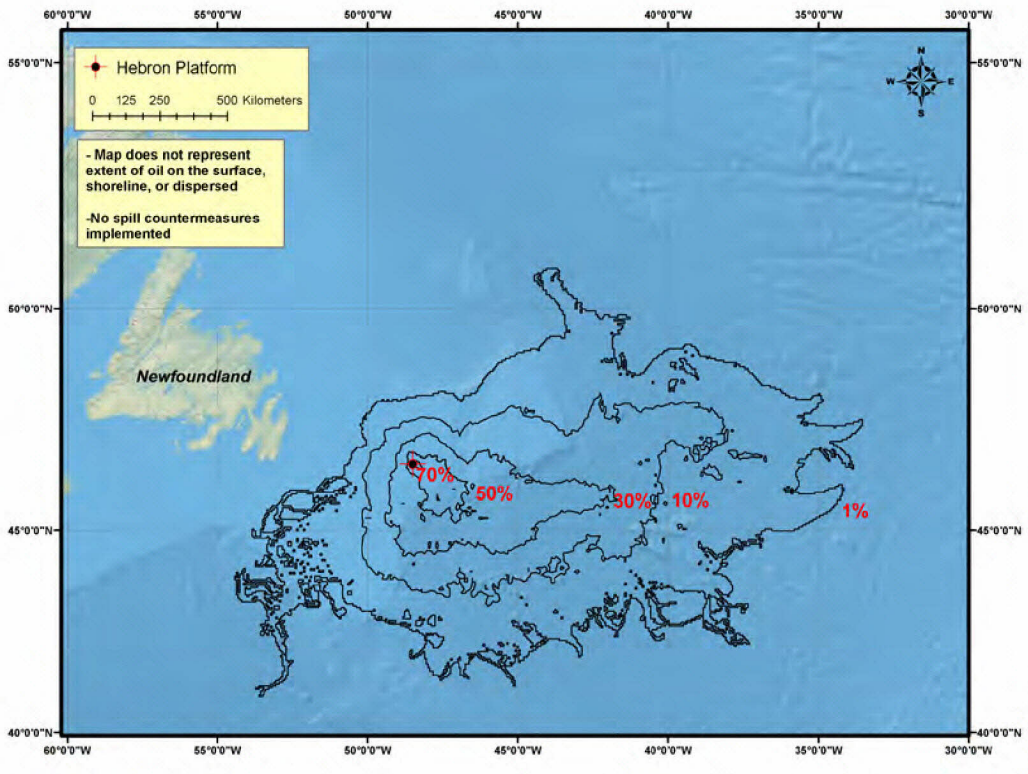

Figure 14-30 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Offshore Loading System Transfer Release of 5,000 m^3 of Crude Oil during Summer

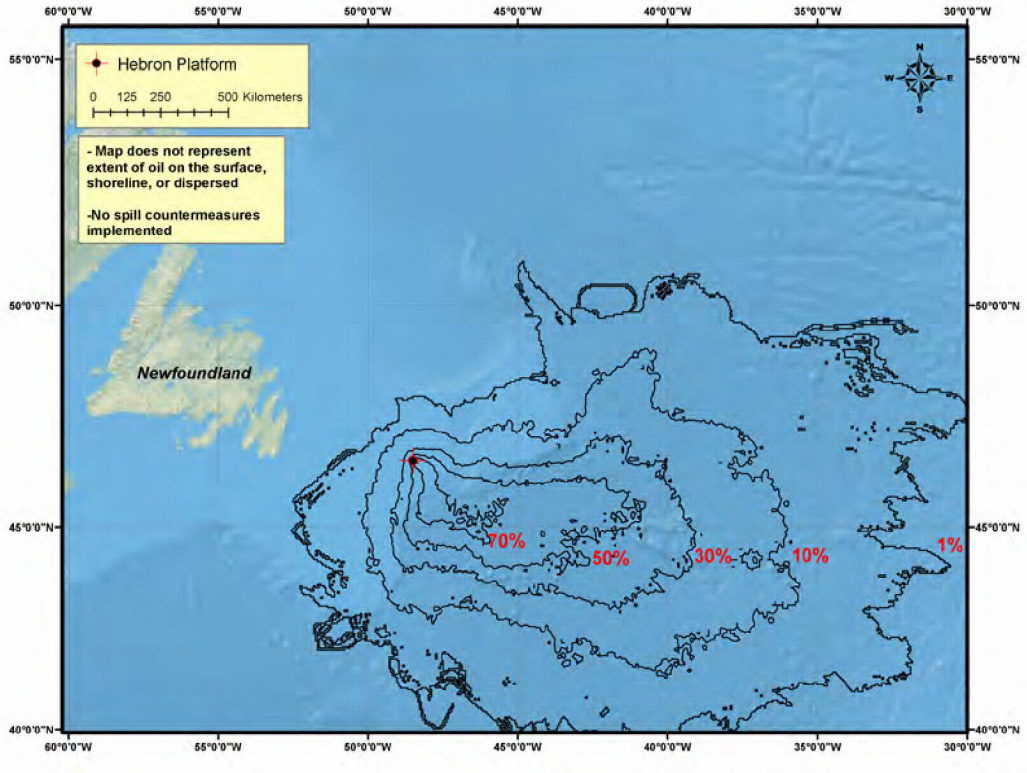

Figure 14-31 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Offshore Loading System Transfer Release of 5,000 m^3 of Crude Oil during Winter

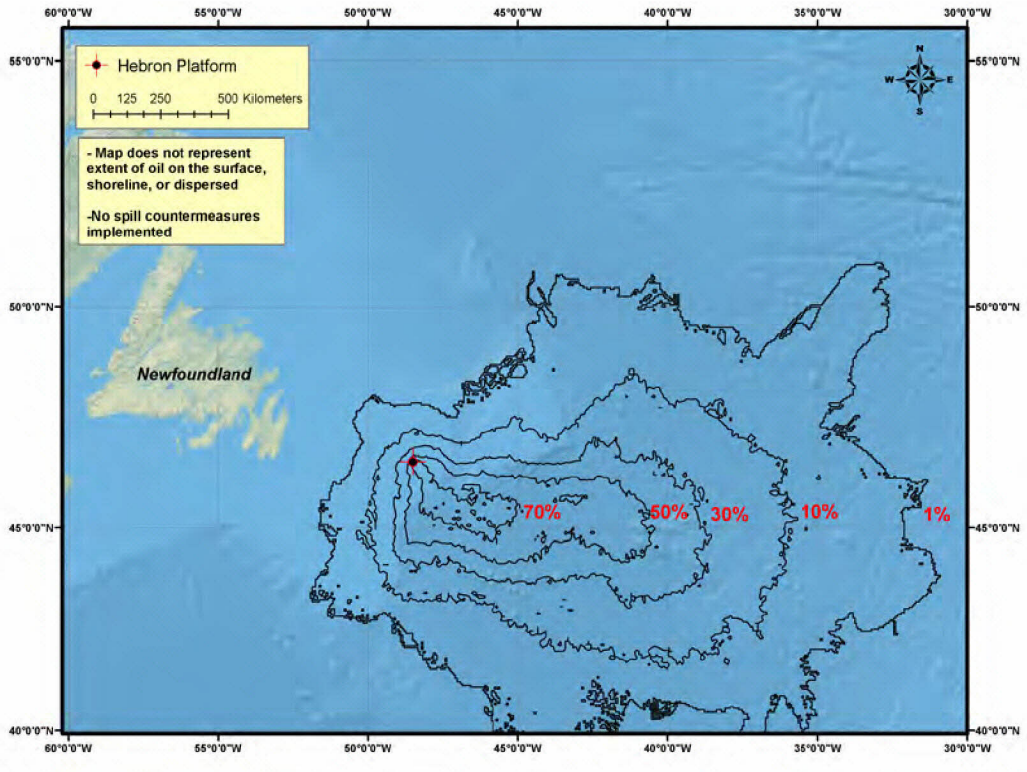

Figure 14-32 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Offshore Loading System Transfer Release of 5,000 m^3 of Crude Oil during Winter (with ice present)

14.3.4 Trajectory Modelling Summary

The majority of Hebron Platform and seafloor blow-out spills at the site are predicted to travel eastward. The distance travelled is generally controlled by the blow-out duration and the season. Winter winds on average are at a higher velocity resulting in greater oil transport. A subset of the summer and winter blow-out spill simulations of greater than 30 days duration are predicted to reach segments of the Newfoundland shoreline. Similar to the blow-out releases of crude oil, marine diesel and crude oil released in batch transfer spills is predicted to travel primarily toward the east away from Newfoundland. None of the batch transfer spills are predicted to reach the Newfoundland shoreline. A summary of the trajectory modelling is provided in Table 14-22.

Table 14-22 Summary of the Stochastic Simulations of the Platform and Seafloor Blow-outs at the Hebron Well Site (values for each parameter represent the 95th percentile)

Release	Season	Sea Surface Area Oiled at >0.01 mm (km^2)	Entrained Oil Volume after 30 days (m^3)
Platform Blow-out	Summer 30/60 Day	1,383,242	501
	Winter 30/60 Day	1,901,033	573
	Winter 30/60 Day Ice	1,791,808	550
	Summer 100-Day	2,306,565	159,925
	Winter 120-Day	4,225,306	263,493
	Winter 120-Day Ice	4,841,586	263,493
Seafloor Blow-out	Summer 100-Day	2,416,717	3,706,057
	Winter 120-Day	4,415,367	4,309,446
	Winter 120-Day Ice	4,615,041	4,182,299

Note: 95th percentile values are determined by ranking all 100 spills in each scenario according to the area of sea surface exposed to oil, the length of shoreline exposed to oil and the volume of entrained (naturally dispersed) oil above the stated thresholds.

Trajectory model results (ASA 2011b) demonstrate that for all blow-out scenarios very little oil becomes entrained in the water column (0.2 to 0.3 percent) or is deposited on shorelines (0 to 0.4 percent) even with a constant input of oil for extended periods of time (up to 120 days). During this period approximately 10 to 11 percent of the oil from a Platform blow-out is evaporated versus approximately 30 percent of the oil from a seafloor blow-out. Similarly approximately 32 to 37 percent of the oil from the Platform blow-out decayed versus approximately 26.5 to 30 percent for the seafloor blow-out. These differences are primarily due to the differences in the properties of the crude oils rather than other environmental factors.

Approximately 51 to 56 percent of the oil from the Platform blow-out is found on the surface of the water after 100 days of flow compared to approximately 29 to 35 percent for a seafloor blow-out. In both cases, much of this surface oil has already left the model domain after 100 days and is no longer present to further affect the VECs in the Grand Banks region. Trajectory model

results suggest that it takes about 30 days for the surface oil to approach the boundaries of the model domain and that by 60 days, it has extended beyond the model domain. This is in excellent agreement with tracker buoy data collected during the 2004 Terra Nova spill, which indicated that it took five weeks for the buoy to reach 40.00.0ºW and approximately 48.00.00ºN in November / December.

The offshore oil spill model (ASA 2011b) predicted, that without the implementation of spill countermeasures, there is <10 percent probability of oil small amounts of weathered oil reaching Newfoundland shores from a Platform spill if the oil remains on the surface for an extended period of time. The summer and winter with ice simulations indicated that no shoreline would be oiled, and approximately 143 km (428,100 m^2) of shoreline would be oiled in the winter without ice, with oil first reaching the shoreline in approximately 41 days.

In situations where a MODU would need to be internationally sourced to drill a relief well (up to approximately 165 days to stop flow in winter months), a larger volume of oil would be potentially released into the water, if no other mitigations were implemented. The potential environmental impacts to Newfoundland waters and shores, including the Grand Banks, would be similar to the cases described above. Surface oil would take approximately 30 to 60 days to approach 40.00.0°W, with <10 percent probability that small amounts of weathered oil will reach Newfoundland shorelines.

14.4 Contingency Planning

ExxonMobil Canada Properties (EMCP) recognizes that prevention is the most effective way to avoid environmental effects from hydrocarbon spill events. Prior to the start of the Project, EMCP will implement the necessary policies, procedures, equipment and training programs necessary to reduce the probability of hydrocarbon spill incidents and to minimize the environmental effects of spills should they happen.

14.4.1 Scope of Planning

Prior to commencement of drilling and production operations, EMCP will develop contingency plans that will serve as the guidelines for the company's response to an emergency at the Hebron Project. Contingency plans will be developed to address emergencies that will be identified in operations-specific hazard and risk analyses. The plans will outline the necessary procedures, personnel, equipment and logistics support required to respond to an emergency incident in a safe, prompt, coordinated manner. The plans will be distributed to designated personnel who will be responsible for emergency response actions. The content of the plans will contain sufficient detail to enable personnel to respond in a coordinated and effective manner.

In this section, a general overview of the EMCP's emergency preparedness structure will be described. This chapter will briefly describe the generic EMCP emergency response process, and then focus on hydrocarbon spill

response preparedness for both the construction and the operational phases of the Project.

14.4.1.1 ExxonMobil Canada Properties Emergency Response Philosophy

EMCP, as operator of the Hebron Project, maintains a strong commitment to health, safety and environmental stewardship. The company conducts its business activities with a progressive approach and is committed to monitoring and improving its performance. Central to this commitment is a corporate Safety, Security, Health and Environment (SSH&E) management system, which governs all aspects of loss control management. EMCP's emergency response philosophy is to minimize the impact of an emergency on people, environment and the corporation. EMCP will always be prepared to act as follows:

- If responsible, react rapidly and effectively
- If the responsibility is unclear, be prepared to act and offer assistance to authorities
- If not responsible, offer technical or advisory assistance with appropriate legal safeguards
- Respond rapidly to life-threatening situations

ExxonMobil's Canada Properties Emergency Response Model is:

- Safeguard People (safety and health of the public, contractors and employees)
- Protect the Environment
- Protect Company Assets
- Protect Company Reputation

These are commonly called the "PEAR" objectives.

14.4.1.2 ExxonMobil Canada Properties Corporate Contingency Planning

As part of the corporate SSH&E management system, EMCP has developed a company-wide approach to contingency planning. All EMCP facilities are equipped with emergency response plans and procedures that share common format and content. Each plan reflects local conditions and addresses the risks to the specific facility, but is similar enough to plans for other facilities that it may be quickly supported by any trained EMCP personnel.

EMCP will use the same philosophy and approach that has been established throughout the company when developing contingency plans for the Project. In addition to environmental protection plans (EPPs) to be developed for all phases of Hebron production operations, EMCP will require a suite of operational risk management and emergency response plans for use in production operations. Facility-specific alert and emergency response procedures and vessel-specific contingency plans will be developed to cover the details of local response procedures.

14.4.1.3 Emergencies Covered by ExxonMobil Canada Properties Contingency Planning

An emergency will be defined as any unexpected occurrence resulting in or having the potential to result in:

- Death or serious injury / illness requiring hospitalization
- Environmental impact
- Major or significant damage to Operator or contractor property
- Concern for the integrity of EMCP operations in the eyes of the public or regulatory agencies

Several types of emergencies will be covered by EMCP contingency plans. The response to any the following incidents (which are not all inclusive) will require immediate action:

- Accidental injury
- Explosion or fire
- Loss of well control
- Hydrocarbon or chemical spills
- Unintentional discharge of any material at levels above those in permits
- Loss of or damage to aircraft supporting production operations
- Loss of or damage to support or standby vessels
- Loss or disablement of the Gravity Base Structure (GBS), Hebron Platform or mobile offshore drilling unit (MODU)
- Equipment damage due to equipment failure or operator error
- Imminent threat to operations posed by weather, sea ice, or icebergs
- Collision or threat of collision with an ocean-going vessel
- Gas leak
- Radioactive source
- Person overboard
- Hydrogen sulphide leak
- Loss of power
- Diving operations
- Threatened or actual damage to subsea pipelines or hardware
- Security incidents such as extortion, bomb threat, or criminal / terrorist acts

14.4.1.4 Proposed Contingency Plan Development

Contingency planning for the Project will be addressed in a number of inter-related documents that each cover a specific aspect of production operations. Overviews of the individual documents that, collectively, will dictate all emergency response operations are presented in Tables 14-23 and 14-24. At this stage of the Project, the plan names used in the tables are generic. The final structure and naming of each plan will be finalized during the development of the Project production program.

Table 14-23 Overview of ExxonMobil Canada Properties Offshore Contingency Plans

Plan	Description
Offshore Emergency Response Plan	A plan which describes on-site response actions at the Hebron Platform: • Provides very specific role descriptions for Hebron Platform personnel for a number of potential emergencies • Provides a link between all offshore facilities and onshore responders
Collision Avoidance Plan	A specific plan for identifying and avoiding a potential collision with a vessel approaching a rig or platform • Identifies potential collision situations involving the Platform or MODU • Describes communications with the threatening vessel • Lists actions to be taken on the Hebron Platform or MODU in the event that the threatening vessel does not respond • Developed specifically for offshore use and directly related to the Offshore Emergency Response Plan
Ice Management Plan	A plan which defines how EMCP operations personnel will manage the threat of icebergs and pack ice approaching the Hebron Field: • The plan provides a link between all ice management operations offshore and onshore • The plan describes the procedures for • Monitoring the movement of icebergs that might pose a threat to offshore activities • Determining the need for specific countermeasure operations including iceberg deflection
MedEvac Plan	A plan which describes how ill or injured workers will be transported to shore for medical care: • Assigns authority • Defines decision making processes • Describes logistics arrangements • Suggests onshore emergency team involvement
Spill response Plan Procedures	Procedures developed specifically for the first response to hydrocarbon spills originating at the Hebron Platform: • Directly related to the Offshore Emergency Response Plan and the Hebron Spill Response Plan; • Applies for both Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and Canada Shipping Act (CSA) jurisdictions • Includes • Specific actions to be taken by Hebron Platform and support vessel personnel, and • Specific strategies for the response to anticipated hydrocarbon spill scenario situations
Standard Operating Procedures	Pre-established procedures for specific technical activities undertaken by offshore emergency action teams: • Fire • First aid • Helideck • Coxswains

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Table 14-24 Overview of ExxonMobil Canada Properties Onshore Contingency Plans

Plan	Description
Onshore Emergency Response Plan	A plan that describes actions taken onshore during an offshore emergency: • Provides general activation and support procedures for any emergency • Directs actions of shore-based personnel • Provides the link between offshore actions (coordinated by the Hebron Platform or MODU Offshore Installation Manager (OIM)) and corporate emergency teams • Integrates response actions after the emergency phase has passed • Allows for increasing onshore and corporate responsibility as the incident escalates
Oil Spill Response Plan	Procedures developed specifically for the response to hydrocarbon spills originating from the Hebron Platform: • Covers situations where EMCP is the responsible party or may be required to take a responsible action • Applies for both C-NLOPB and CSA jurisdictions • Includes • Specific actions to be taken by Hebron Platform and support vessel personnel • Management or coordination actions taken by shore-based company and contractor personnel • Specific strategies for the response to anticipated hydrocarbon spill scenario situations • The plan provides a link between all spill response operations offshore and onshore • Details procedures for Incident Command System (ICS)-based spill response management when the incident escalates above Tier 1 • The plan provides a link between EMCP and other operators • Directly related to the Tier 1 Spill response Procedures, and the Onshore Emergency Response Plan
Family Support Plan	A plan to assist family members and friends of offshore personnel during an emergency situation: • Description of the operation of a family information service and a family support centre • Protocols for contacting family members in a constructive and proactive manner • Guidelines for volunteer family responders in how to deal with concerned relatives and friends
Emergency Communications Plan	A comprehensive guide to all communications with affected individuals, the public and the media during an emergency response • Description of the operation of a media response centre • News release and statement templates • Sample media questions and answers • Media information packages • Website development

14.4.1.5 Geographic Area Covered by Planning

Emergency response planning for Hebron production operations will focus on the area immediately adjacent to the production site or future excavated drill centres. The initial Safety Zone around the Hebron Platform will include an area of 500 m from the perimeter of the Platform and the OLS. This area will be defined as the Safety Zone established around the production site to ensure collision avoidance with ocean-going vessels. This is the area that will be under the jurisdiction of the Atlantic Accord Acts and administered by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB).

14.4.2 Emergency Response Escalation

14.4.2.1 Phases of an Emergency Response

The response to an event will develop in phases that are based on the level of planning that is required. During the emergency phase, the situation will be dynamic and limited information will be available. The response to the actual emergency will likely be reactive and will be based on set procedures, training and contingency plans. As the situation is better understood, the response will become more proactive. The process will become strategic and be based on a regular cycle of assessment, planning and implementation, until operations are no longer necessary.

14.4.2.2 Escalation Based on Increasing Scope

Response organization will be comprised of the following components:

- At-site emergency teams
- At-site Emergency Coordination Centre
- EMCP onshore Emergency Operations Centre and
- EMCP Emergency Support Group

The role of each of these components is described in terms of scope below.

14.4.2.3 Management System Processes

Notification

Once an emergency has been declared, timely notification of response personnel, management and external agencies will be critical. In some cases, notification may include a written report. Contingency plans will include instructions for all personnel who have a notification responsibility.

On-Scene Command

All emergencies covered by this plan will take place at the Bull Arm Construction Site, offshore, or at or near the Hebron field. In most cases, regardless of the level of the emergency, the Offshore Installation Manager (OIM) on the Hebron Platform or a rig will act as On-Scene Commander (OSC) and be in command of response operations. Exceptions would be:

- Loss of the facility (OSC would shift to another platform or standby vessel)
- Search and Rescue Operations, in which case Joint Rescue Coordination Centre (at Department of National Defence - Halifax) or the Marine Rescue Sub Centre (Canadian Coast Guard (CCG) - St. John's) will take command
- Major hydrocarbon spill, in which case incident command will be based in St. John's after the initial response at site and on-scene command will transfer to a designated EMCP Representative on the lead response vessel

14.4.3 Spill Response Escalation

While many of the response management processes will be similar to those implemented in a conventional spill response, it is possible to also classify a spill response according to the level of effort required. For response planning purposes, the severity of potential hydrocarbon spills has been divided into three levels, or Tiers. This classification allows for an appropriate initial response to each level of spill, and provides for the escalation of the response should the potential impact of the spill increase. Each Tier will require a successively higher level of operational effort and management.

The parameters to be considered in selecting the appropriate level of response include:

- Size and nature of the spill
- Environmental and operational conditions at the time of the spill
- Vessel and equipment availability
- Numbers and qualifications of personnel available at site
- On-site waste hydrocarbon storage
- Corporate exposure to risk and liability as a result of the hydrocarbon spill

The three levels are defined as follows:

- A Tier 1 spill poses the least threat of impact, and can be managed using resources available at site
- A Tier 2 spill response requires local shore-based management support and resources in addition to those already at site
- A Tier 3 hydrocarbon spill has the potential to affect EMCP and shareholder company business operations and may require considerable corporate and contract resources drawn from local, regional, and international sources

14.4.4 Response Organization for a Major Spill

14.4.4.1 Incident Command System

In the event of a major spill (see Section 14.1.1), the operational component of the response will be managed by using a structure based on the Incident Command System (ICS) organizational structure for emergency response management. The ICS structure has been widely adopted by emergency response agencies throughout North America as a means of sustaining a long-term response effort by adopting a function-based approach that allows personnel to rotate through positions over an extended period. Hibernia Management and Development Company Limited, Terra Nova, Husky Energy and major hydrocarbon spill response contractors have all also developed ICS-based hydrocarbon spill response procedures.

The specific tasks that individuals will be assigned in an ICS environment will be determined over time as a result of the evolution of the incident and consultation between functional groups.

Key features of this system include:

- Operational management, which is divided into five functional groups (Command, Planning, Operations, Logistics and Finance). While each group has its own responsibilities, considerable interaction between groups is necessary to ensure efficiency in the response operation
- Integrated field operations, tactical planning and logistics support through continuous situation analysis
- Information exchange through continuous interaction of supervisory personnel, scheduled review meetings, routine written reports and daily proposed action plans
- A continuing cycle of planning, prioritization and implementation, regardless of the phase of the response
- Plans developed for a defined period and focused on meeting defined objectives in consideration of environmental resources at risk, operating conditions, available resources and performance during previous operating periods
- A planning cycle that provides the basis for both tactical and strategic budgeting. When plans are authorized by EMCP, Operations receives both financial and operational authority to proceed with the next stage of the response

The roles of the five ICS functional groups are described briefly in Table 14-25.

Table 14-25 Incident Command System Section Functions

ICS Section	Focus	Duties
Command	What are the prioritized objectives	Overall vision, clarity of purpose, health and safety of all personnel
Planning	What has happened What is happening now What are the plans for the future?	Information management and action plans
Operations	What is being done to meet the planned objectives	Organize and manage all operations including: containing and recovering spilled hydrocarbon; protecting sensitive resource areas; cleaning affected areas; and disposal of waste
Logistics	What resources are needed to support operations	Provide personnel, vessels, aircraft, trucking, equipment, security and communications
Finance	Financial control	Accounts payable, insurance claims, cash flow and cost monitoring

14.4.4.2 Spill Response Contractors

In general, EMCP emergency response management personnel will be drawn from in-house resources. However, in the event of a hydrocarbon spill, the incident may require considerable resources over an extended period. In such a case, EMCP will engage the services of a response organization.

14.4.4.3 North American Regional Response Team

EMCP can also be supported by the ExxonMobil North American Regional Response Team (NARRT). NARRT is a pool of experienced responders from various business units within the ExxonMobil corporation. During a major spill, this team may be activated and mobilized in St. John's. NARRT provides oil spill experts to support the EMCP response under way at the Hebron field.

14.4.5 External Assistance

14.4.5.1 Mutual Aid with Other Operators

As with existing offshore oil and gas operations, EMCP will establish a mutual aid agreement with other Grand Banks operators. This agreement provides for the release of personnel, vessels and equipment for logistics support and exchange of operational information. Under this agreement, operators are required to provide support, if requested by a second mutual aid operator. The level of this support is limited to that effort that can be provided without jeopardizing the safe operation of the supporting operator's facilities. Mutual aid will be most evident in logistics support, ice management, and spill response efforts.

In order that mutual aid may be effective, the mechanism for interaction between operators will be clearly stated in all EMCP contingency plans.

Logistics

Other offshore platforms may be used to provide nearby staging or refuelling platforms in support of an EMCP emergency. These platforms may also provide temporary accommodation for evacuated Hebron Platform personnel.

Ice Management

The Project will require an ice management program similar to those in operation for the existing Grand Banks operators.

Relief Well Considerations

In the event of a well site loss control emergency, it may be necessary to drill a relief well. Throughout the lifetime of the Hebron production program, EMCP will maintain a listing of drilling vessels that could be brought to Hebron at short notice to drill the relief well.

ExxonMobil operates and maintains a world-wide drilling operation that encompasses a fleet of drilling units and drilling equipment inventory. Knowledge and awareness of ongoing operations is maintained company-wide. In the event a relief well is required and the required materials are not available in local stock, ExxonMobil will access this world-wide inventory to procure necessary materials to execute the required operations and/or will obtain the materials directly from vendors through our Global Procurement

organization. The time to source these materials has been considered in the oil spill scenarios described in Section 14.3.1.

14.4.5.2 Spill Response

Response Organization

The Project will be supported by a response organization contracted to provide response services as required in the event of an offshore spill event.

Canadian Coast Guard

The CCG has a Memorandum of Understanding (MOU) with the C-NLOPB. If that MOU is activated, the CCG will provide response advice to the C-NLOPB, as well as field monitoring of the response mounted by the responsible party on behalf of C-NLOPB.

Oil Spill Response

ExxonMobil is a shareholding member of Oil Spill Response (OSR). This is a large spill response cooperative that specializes in providing global spill response services from their bases in Southampton, England and Singapore. In addition to the services that OSR can provide directly, ExxonMobil also has access to other international oil spill cooperatives such as Clean Caribbean Cooperative in Miami, and Marine Spill Response Corporation throughout the United States, through OSR's participation in the Global Alliance.

14.4.5.3 Regional Environmental Emergency Team

The Regional Environmental Emergency Team (REET) is a group of environmental specialists chaired by Environment Canada that can provide knowledgeable advice to support response operations. In the event of a spill, REET may be activated either by C-NLOPB or Environment Canada.

Most REET members are government (federal and provincial) representatives and are from the local area. Private sector personnel may also be included in REET. Environment Canada may choose to draw on regional or national expertise as required to provide the best possible advice. Some REET members also have regulatory responsibilities and may be the best contact if permits are needed for operational activities.

14.4.6 Emergency Preparedness

14.4.6.1 Personnel Training

Designated EMCP personnel, including contractors, will receive directed emergency training.

All personnel will undergo an orientation to elements of emergency response planning. Offshore personnel will receive a general overview of evacuation alarms and procedures and response organization. Offshore emergency teams will receive specialized training with emphasis on hands on experience.

14.4.6.2 Response Exercises

A regular program of exercises will be instituted to ensure the readiness of all personnel. The purposes of the program exercise include:

- Continuing familiarization of all personnel with emergency procedures
- Testing of the preparedness of all personnel
- A means of developing continued improvement to emergency procedures

Exercises will be conducted in three areas:

- Communications
  - Personnel call out
  - Inter-facility communications testing
  - Media and public information training
- Table Top
  - Methodical response to an emergency scenario using established processes
  - Interaction between ERT, operational, regulatory and external personnel
- Logistics
  - Hands on training and experience for marine and technical personnel
  - Field response operations for marine crews and emergency personnel
  - Confirmation of the effectiveness of established field procedures

14.5 Spill Response at Bull Arm

The GBS will be built by a general contractor at the fabrication facility at Bull Arm.

14.5.1 Responsibility

14.5.1.1 ExxonMobil Canada Properties Responsibility

During construction, responsibility for all GBS operations will rest with primary EPC contractor for the Bull Arm facility. EMCP will require EPC contractor to meet the expectations of ExxonMobil spill response.

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14.5.1.2 Contractor Responsibility

The EPC Contractor, as operator at the construction site, will be responsible for spill response under federal legislation governing marine spills and under provincial legislation for land spills, or for spills originating from shore. In the capacity of Responsible Party, EMCP's general contractor will be requested to undertake the following preventative measures:

- Identify, assess and understand the spill level of risk for land and marine spills at the Bull Arm Site
- Determine prevention barriers and measures
- Develop spill response countermeasures appropriate for the risks
- Develop a response capability for small marine and land spills
- Acquire the necessary equipment, machinery, response vessels and materials
- Provide equipment storage facilities at the Bull Arm Site
- Form on-site spill response teams for marine and land spills
- Provide adequate training for all site spill responders
- Ensure all vessels work at or visiting the site have arrangements with a Response Organization as required under the Canada Shipping Act
- Ensure all trucks carrying petroleum products to or from the Bull Arm Site are covered by the Canadian Petroleum Products Institute Land Spill Emergency Preparedness program
- Enter an agreement with a response organization for response to marine spills from construction

EMCP will assist its general contractor with spill response preparedness planning to ensure that:

- Spill risks are identified, understood and planned for
- Appropriate marine and land spill response capabilities are developed
- Appropriate back up resources and services are in place should they be needed

In the event of a spill, the Contractor must be prepared to undertake the following response actions:

- Report the spill to the CCG
- Respond to the spill with on-site responders
- Manage the spill response through the site emergency response structure
- Activate the appropriate spill response contractors, as required
- Monitor and document each spill response

14.5.2 Spill Prevention

Each contractor working on the Bull Arm Site will be responsible for spill prevention and proper storage and handling of the fuels and lubricants used on site, and for the collection, temporary storage, transport and disposal of all waste hydrocarbons generated. Prevention will be addressed through risk identification and assessment, good design, appropriate preparedness and training, good work practice, inspections and audits. These include:

- Inspection
- Repairs
- Prevention
- Spill clean-up / containment

14.5.3 Spill Preparedness

EMCP will periodically audit the general contractor's spill response preparedness program to ensure it meets the Hebron Project requirements.

14.5.3.1 Canada Shipping Act Requirements

Under the Canada Shipping Act, 2001, each vessel working at Bull Arm will be required to have a Shipboard Oil Pollution Emergency Plan and a contract with a readily available Response Organization.

14.5.3.2 On Site Capability

EMCP will have its General Contractor develop a spill response capability at Bull Arm to respond to:

- Small marine spills within a clearly defined zone around the Bull Arm facility
- Spills of any size on land within the Bull Arm facility

An appropriate land spill response capability that is suited to the spill risks at the Bull Arm Site will be available on site. The objective will be continuous improvement of awareness and understanding of spill risks, preparedness and response through the life of the construction project. Field assessments will be conducted to assess the petroleum product storage and handling to determine:

- Spill risks
- Likely pollution pathways after a spill
- Barriers needed for prevention and response
- Countermeasures strategies

The general contractor will have sufficient hydrocarbon containment boom on site to contain any marine spill arising from the work.

14.5.3.3 Storage of Petroleum Products Used during Construction

Petroleum product storage facilities will be compliant with provincial and federal legislation. Contractors will be expected to store fuels, lubricants and waste hydrocarbon in facilities constructed to provincial government standards. All vehicles carrying petroleum products into the Bull Arm Site will be required to carry a spill kit with items needed for initial spill containment in the event spills during transfer or as the result of a vehicle accident.

14.5.3.4 Training and Awareness

All construction personnel will receive orientation training in health, safety and environment objectives and issues, which will include an awareness component on hydrocarbon spill prevention and response. The Bull Arm construction site will have personnel working on-site, trained in response methods for spills on land and on the water. Refresher training will be provided.

14.5.4 Spill Response Actions

14.5.4.1 Situation Analysis and Safety Assessment

For all spills, the initial spill situation and location will be assessed to define the safety issues, the human and environmental resources at risk of being affected, and the possibility of the situation escalating into a larger incident. A disciplined approach will be used for response. The greatest priorities are:

- Protect people, property and the environment
- Stop the source of the spill
- Contain the spill

On-site security will be an important response component in achieving these objectives. All response actions will be organized as work orders assigned to teams, each having a team lead.

14.5.4.2 Net Environmental Benefit

All response actions should have a net benefit to the environment after completion. If in doubt, the OSC will consult further with the appropriate authority.

14.5.4.3 Security and Public Protection

Each major Contractor will be responsible for security and the protection of spill responders and the public. If warranted, the EPC Contractor will notify the local police detachment if assistance is required in protecting the public, or if there are security issues where assistance is required.

14.5.4.4 Spill Management for Construction-Related Spills

An OSC will be assigned by the EPC Contractor to direct the spill response effort. This person will be supported by the General Contractor's site emergency team and will be responsible for: spill site health and safety, response operations, and logistics. Generic components for each of these functions will be detailed in the General Contractor's contingency plan. The OSC will ensure that the actions taken during the spill response are documented hour by hour. Logs will be used to compile both the initial report and detailed report for a spill incident that will be submitted to authorities.

14.5.4.5 Spill Investigation

All spill incidents in the Nearshore Project Area will be investigated to determine root causes and to recommend any corrective action required to prevent similar incidents. EMCP believes that due diligence in this area will foster continuous improvement in spill prevention.

14.6 Offshore Spill Response Operations

Hydrocarbon spill prevention will be incorporated into the day-to-day operations at the Hebron Platform. All offshore systems and structures, procedures and programs will be designed with due regard to preventing the loss of any hydrocarbons. At the same time, EMCP will undertake all the necessary planning, training and exercising to ensure that the appropriate response capability is in place for all phases of the Hebron Project.

In the event of a spill, as part of its oil spill response plan, EMPC will develop a wildlife recovery plan that will identify key sensitive areas, detail what will be done to protect those areas and, in the event of oil effects upon wildlife, what they will do to recover and rehabilitate oiled wildlife.

Mitigation measures are discussed in relation to the environmental effects assessment of each VEC in the following sections:

- Fish and Fish Habitat – Section 7.5.4; Table 7-14
- Commercial Fisheries – Section 8.5.3.1; Table 8-15
- Marine Birds – Section 9.5.4; Table 9-13
- Marine Mammals and Sea Turtles – Section 10.5.4; Table 10-13
- Species at Risk – Sections 11.4.3, 11.5.3 and 11.6.3; Tables 11-7, 11-13 and 11-19
- Sensitive of Special Areas – Section 12.5.1; Table 12-3

14.6.1 Spill Risk

In Section 14.1, the risks of various levels of petroleum spill have been assessed based on worldwide historical statistics. The probability of smaller spills, especially involving fuel or crude transfers, is much higher than for large and very large spills. Even though the probability of a major spill is expected to be very low, EMCP will, nevertheless, prepare for such an incident in its oil spill response plan. Planning standards that detail the

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amount of hydrocarbon spilled and operating conditions at the time of the spill will allow EMCP to ensure that the level of effort is adequate for any planning scenario. Based on probable drilling and production activities, several potential spill scenarios can be considered.

14.6.2 Spill Prevention

Standard Operating Procedures to reduce or eliminate the chance of a spill, even in the case of equipment failure, will be instituted for all hydrocarbon handling operations. Routine maintenance and testing schedules will be established for all aspects of the production program, with particular attention paid to well control, product storage and handling and fuel transfer systems. Prior to production, practices for operating in poor weather, high sea state, or sea ice or iceberg conditions will be established. Good communications and sound marine practices for all vessels will also improve the ability to prevent spills.

Proper environmental operating practices will be assured through regular inspections and audits of the Hebron Platform. The general awareness of offshore workers will be increased through training, seminars and safety meetings. Personnel will be encouraged to report potential problems and 'near miss' incidents in an attempt to avoid a re-occurrence that could result in a loss of containment or other release of petroleum or other hydrocarbons.

14.6.3 Characteristics of Spilled Crude Oil at Hebron

Previous testing of Jeanne d'Arc Basin crude oils indicate that consideration of oil characteristics and weathering properties of Hebron crude should be considered in developing specific response plans. Some characteristics that may affect response activities include:

- The potential for forming viscous emulsion
- The effects of wax on evaporation
- The effects of cold water on higher crude oil pour points

14.6.4 Spill Strategies and Technology

Strategy development should consider a range of offshore spill response options. The decision when to use each of these is based on an evaluation of operating conditions, the anticipated characteristics of the hydrocarbon, the effectiveness of the option and effects on the environment.

14.6.4.1 Response Options

While every spill response will be unique, there are a few basic options that can be practically considered (Table 14-26).

Table 14-26 Potential Response Options at Hebron

Option	Comments
Natural Dispersion / Degradation	• Weathered hydrocarbon breaks into small droplets by wave action • Droplets are naturally metabolized by micro-organisms • Effectiveness improves as wind and sea state increase • Only option when winds >25 to 30 knots, sea state >2.5 to 3.0 m
Surveillance And Monitoring	• Always necessary • Local surface surveillance using EMCP vessels and regional surveillance • Helps determine scope of problem prior to forming a strategy • Confirms effectiveness of response actions • More difficult in darkness or low visibility • Monitoring is the only response option in poor conditions • Hydrocarbon spill tracker beacons will be on EMCP supply vessels
Mechanical Dispersion	• Prop washing or high pressure water spray (Fire Monitor) • Good for small spills / thin layers of hydrocarbon, not good for crude • Quick implementation, no equipment required
Chemical Dispersion	• Authorization required from C-NLOPB before application • Use of dispersants currently being investiagted by offshore Newfoundland and Labrador operators as the next frontier of oil spill response
Containment And Recovery	• Containment and recovery through absorbent booms, Single Vessel Side Sweep and ocean-rated skimmers and booms is currently world-class • Effective but limited by sea state, encounter rate of boom system and need for high logistics support • Low recovery rates as slick spreads • Sorbent boom will be on EMCP supply vessels • Single Vessel Side Sweep system offshore • Tier 2/3 containment and recovery equipment will be available through a contracted Response Organization
Wildlife Measures	• Surveillance necessary to determine distribution of marine wildlife and potential for impact by floating hydrocarbon • Modified Candian Wildlife Service (CWS) survey techniques to determine marine bird population density • Techniques for deterring wildlife are limited to loud noise
Hydrocarbon and Wildlife (e.g., marine birds, sea turtles) Sampling	• Sampling kits will be placed on EMCP supply vessels for the collection of oil and water, oil on wildlife and oiled wildlife samples • Environment Canada requires that all oiled birds collected be retained as samples for further assessment on shore • Protocols for marine bird monitoring during spill events will be established • EMCP will require a permit from CWS for collection of oiled birds

14.6.4.2 Logistics Considerations

EMCP logistics infrastructure will be employed to obtain equipment and materials specified by response managers, to transport operations personnel and equipment to and from the spill site, and to source additional operational platforms required.

The Hebron Project is at the conceptual stage of development. The Oil Spill Response Plan (OSRP) has not been developed. The Hebron crude has a lower API than the crude of existing offshore Newfoundland operations, and is therefore a heavier product. In developing the Hebron offshore OSRP, as with existing offshore oil and gas OSRPs, the OSRP will outline a tiered response to oil spills. Depending on the size and nature of the spill (i.e., Tier 1, 2 or 3), the OSRP will include the type and quantity of response equipment specific for Hebron crude. In addition, it will identify equipment

that will be available within local, regional and global Response Organizations and equipment that may be available through mutual aid agreements with other operators. For a Tier 2 or Tier 3 response, Hebron can request oil spill project management support through ExxonMobil corporate response organization. Estimated response times for deployment will also be identified.

The Hebron Project is aware of the recent initiative currently being undertaken between the existing Newfoundland and Labrador operators regarding the evaluation of the level of equipment and its capability to respond to oils spills on the Grand Banks. Existing Tier 2 oil containment equipment is being upgraded and supply vessels are being configured for quick installation of the equipment. Enhanced training for vessel crews will also be provided. During the development of the Hebron OSRP, the Hebron Project will consider the response equipment available, the time it will take to deploy, if it is capable of handling Hebron crude, and determine if additional resources are required.

Tier 1 equipment will be available on-site and will be appropriate for Hebron crude.

Current Tier 2 equipment readily available onshore consists of industry and Eastern Canada Response Corporation (ECRC) equipment. In addition, and if required, the Canadian Coast Guard has an inventory of oil spill response equipment stored at their depot in Mount Pearl, some of which is suitable for offshore use.

ECMP will commit to continue working with other Grand Banks operators to enhance the existing pool of equipment based on the best available technology to support production operations.

In addition to maintaining and operating the producing operators' equipment, the Response Organization, ECRC (located in Mount Pearl) has its own open ocean containment and recovery equipment, temporary storage tankage, and oil transfer pumps.

In addition to the equipment available for a Tier 2 response, it is likely that Tier 3 resources available to Hebron production operations will be sourced from agencies outside of Newfoundland and Labrador. Principle sources include:

- The installation of diving and ROV systems to support production field maintenance programs
- ECRC equipment in other eastern Canada depots (e.g., Ocean Buster high-speed boom stationed in Quebec)
- Equipment sources identified through the ExxonMobil Corporate response organization
- OSR aerial dispersant capability based in Southampton, England
- Appropriate oil spill response equipment secured from international Tier 3 response organizations by either ECRC and OSR through their membership in the Global Response Network

Estimated response times will be outlined in the Hebron OSRP. Again, depending on the nature of the spill and the required response, response times will vary.

Tier 1 resources will be available immediately at site. Sorbent boom can be deployed in less than one hour after the spill occurs. Other equipment can take up to three to six hours to deploy.

Deployment time for Tier 2 resources will depend on their location and are staged for rapid deployment. Including mobilization and delivery of gear, and activation of necessary field personnel a Tier 2 response vessel could be ready to sail from St. John's within two to three hours. Fastest transit to the spill site from St. John's would be approximately 12 to 18 hours in good conditions.

Response times for Tier 3 equipment will depend on source location.

The Hebron Project will develop synergies with the Hibernia Project and will augment the current two standby vessel, one supply vessel arrangement supporting Hibernia. It is anticipated that in order to meet production and drilling operations for Hebron, an additional standby vessel and supply vessel will be added to the pool of resources.

With regard to the availability of vessels, the industry has demonstrated that it can cope with unusual demands on vessel resources. During the spring of 2009, the core fleet was temporarily increased to a high of eighteen to meet the following demands:

- The installation of diving and ROV systems to support production field maintenance programs
- A heavy ice season that required vessels to be involved in increased ice management operations as well as unscheduled rig moves
- The grounding of all helicopter traffic to and from the Grand Banks requiring that all personnel had to travel offshore by vessel
- A high level of shipyard time for scheduled and unscheduled maintenance of vessels and platforms
- The installation of diving and ROV systems to support production field maintenance programs

To ensure that operations could continue, several additional vessels from throughout Atlantic Canada were also contracted. While not all of these vessels were capable of assuming full platform supply or standby duties, they were all useful.

Through mutual aid agreements with the Grand Banks operators, vessel assignment during an oil spill response may be similar to the spring 2009 case. Vessels of opportunity may be sourced from existing operations, where available, or sourced regionally.

14.6.4.3 Response Methods

Response methods include:

- Containment and recovery
- Emulsion breaking
- Chemical dispersion

14.6.4.4 Availability of Containment and Recovery Equipment

Even with ongoing improvements, offshore collection and recovery equipment is still limited by sea state and would be suitable for use in Grand Banks conditions for a small proportion of the year. Containment and recovery equipment must be suitable for harsh open-ocean conditions. In this section, current and proposed spill response equipment available to the Hebron Project offshore will be discussed.

For first response actions, there will be a dedicated first response capability at the Hebron facilities. EMCP's Tier 1 capability will meet or exceed the current standard for production operations.

Under mutual aid, Terra Nova, Hibernia and White Rose Tier 1 and Single Vessel Side Sweep resources may also be available. The addition of EMCP equipment will increase the pool of personnel and equipment and improve the efficiency of maintenance, spares and training. For Tier 2 and 3 response operations, larger containment and recovery systems will be mobilized onshore.

14.6.4.5 Waste Hydrocarbon – Temporary Storage and Disposal Options

The progress of any hydrocarbon spill clean-up is ultimately limited by the ability to store and dispose the collected hydrocarbon. In the field, temporary storage of hydrocarbon, oily water and emulsified oil is an important issue. Storage on the collection platform, either in portable deck tanks or permanent built-in tanks, is an easy temporary measure. As the volume of collected hydrocarbon increases with time, barges or tankers will be required to hold the hydrocarbon.

Most newly built vessels currently operating offshore Newfoundland are built to DNV oil-recovery standards. ECMP will ensure that the core vessels chartered for Hebron operations meet current pollution class standards.

Ultimately, the hydrocarbon may be disposed of in a number of ways: through re-introduction to the production stream on the Hebron Platform; as fuel in the boilers of one of an industrial steam plant; or through a refining or re-cycling process. The recovered hydrocarbon may require some level of processing to meet specifications of the disposal facility (to remove water and/or debris). The spill response plan will detail viable disposal options.

14.6.4.6 Effects Monitoring

As part of its oil spill response plan, EMCP will develop a process to implement a dedicated environmental effects monitoring (EEM) program to determine the effects of a major spill. The elements of the EEM program will be determined based on the circumstances of the spill and will consider the structure of the EEM program established for routine production activities at Hebron. The decision to implement such a program will be made after consultation between EMCP and the C-NLOPB.

14.6.5 Investing in Industry Spill Response Capability

Several recent actions indicate a more proactive approach to spill response in the Newfoundland offshore industry. This movement is similar to that undertaken in other offshore jurisdictions where operators have come to realize that there is a Tier 2 preparedness gap between measures implemented at site and membership in international spill response associations. The preferred method for filling this gap is to form some sort of cooperative between operators to develop consistency and standards on a local or regional level and to share the costs of a comprehensive oil spill program.

Since 2006, industry has been working with a local Response Organization, ECRC, to develop a more interactive relationship. As a certified Response Organization under the Canada Shipping Act, ECRC's primary focus has been in the general shipping and marine terminal sectors that fall under the Act. Both Suncor and Husky have an integration agreement in place with ECRC to provide Tier 1 and 2 oil spill response training for vessel crews and third-party responders. ECRC also conducts inspections and maintenance of Tier 1 and 2 oil spill response equipment as part of this contract. Industry's future relationship with a Response Organization may include a large oil spill preparedness component, which will provide for personnel training, equipment maintenance and response planning.

In 2007-2008, Grand Banks production operators cooperated in the purchase of a state-of-the-art open ocean containment and recovery equipment system consisting of:

- 400 m Norlense 1200 self-inflating boom
- Framo Transrec 150 self-contained skimmer

This investment represents the first purchase of Tier 2 equipment by the industry since 1991, and is important as it signals a more proactive approach to spill response. The system has been further enhanced by the successful demonstration of the installation of permanent deck mounts on the supply vessel Maersk Chancellor for the annual SYNERGY on water exercise in September 2009.

In 2009, the Canadian Association of Petroleum Producers (CAPP), on behalf of Suncor Energy, Husky Oil Operations and Hibernia Management and Development Company, as the operators of the Terra Nova, White Rose and Hibernia fields, respectively, prepared the Marine Hydrocarbon Spill

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Response Capability Assessment Jeanne d'Arc Basin Production Operations (CAPP 2009). The report provides an evaluation of the oil spill response capability currently in place to support offshore oil and gas production operations in Newfoundland and Labrador. The report is not finalized, as the review process is ongoing. EMCP will take into consideration, and incorporate, where appropriate, recommendations regarding spill response capability that may result.

EMCP will work with other operators on continuing initiatives towards the development of consistent standards regarding spill response capability.

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15 FOLLOW-UP AND MONITORING

The follow-up and monitoring programs for this Project will be designed to meet several legislative and regulatory requirements, as well as internal corporate standards and requirements. Pursuant to the Canadian Environmental Assessment Act (CEAA), a follow-up program is mandatory for Projects requiring Comprehensive Studies with the purpose of "(a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project." Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. While the Responsible Authority is responsible for the Follow-Up Program, it may also delegate any part of its design and delegation.

The Canada-Newfoundland and Labrador Offshore Petroleum Board's (C-NLOPB) Development Plan Guidelines (C-NLOPB 2006) also requires an environmental assessment to include a follow-up monitoring program which it says "may include, but not be limited to, implementation monitoring, environmental effects monitoring, compliance monitoring, and any monitoring of identified species at risk (Species at Risk) that may be required pursuant to the Species at Risk Act." The Development Plan Guidelines (C-NLOPB 2006) also include the requirements for the following monitoring programs to be addressed: Biological Observation Requirements, Physical Environmental Observation Program and Forecasting Programs.

There are a number of other federal and provincial regulations and guidelines are applicable to this Project including that may require monitoring to verify compliance. In addition, ExxonMobil Canada Properties (EMCP) has committed to undertake observational and monitoring programs associated with certain Project activities.

The following sections address all of the above requirements.

15.1 Environmental Effects Monitoring

A key component of monitoring the construction and operations of a project is the Environmental Effects Monitoring (EEM) program. EEM programs take repetitive measurements of environmental variables over time to detect changes caused by external influences directly or indirectly attributable to a specific anthropogenic activity or development (Duinker 1985). Ultimately, EEM programs are an assessment tool to help determine the sustainability of human activities on ecosystem health. EEM programs verify environmental effects predictions and the effectiveness of mitigative measures, as well as facilitate the identification of any unforeseen environmental problems that may arise, thereby allowing them to be addressed in a timely and effective manner.

EEM programs are designed using an iterative process that allows for opportunities to review the EEM design over the life of a project and address

project changes, as well as changing priorities in environmental management policies and practices while allowing for the incorporation of new and/or improved technologies and methodologies.

15.1.1 Proposed Offshore Environmental Effects Monitoring Program

The development and design of EEM programs in the Newfoundland and Labrador offshore oil and gas industry has built upon the considerable knowledge and experience gained from industry monitoring in the North Sea and the Gulf of Mexico. Each of the subsequent Canadian EEM programs (i.e., Cohasset-Panuke, Hibernia, Sable Gas, Terra Nova and White Rose) has sought input from the regional, national and international scientific community, regulatory agencies and other stakeholders to further define expectations and goals of their EEM programs. The following describes the process that has been used to date in the development of EEM programs in the Newfoundland and Labrador offshore oil and gas industry. EMCP is proposing to use a similar process in the development of the EEM for this Project.

The initiation of the EEM process has typically consisted of the identification of the parameters to be measured, data gaps to be addressed and the overall goals and purpose of the EEM program. This step typically includes a literature and data review and identification of marine resources of interest as well as the establishment of boundaries and scale for the monitoring program. A conceptual model may also be developed at this stage, which describes the underlying cause-and-effect links of the project that may be used to generate environmental effects predications to be tested in the EEM program.

During this initial stage of the EEM process, input from the scientific community, regulatory agencies and key stakeholders groups is solicited through a series of formal and informal meetings and/or consultations. These meetings and consultations assist in developing a focused monitoring strategy by:

- Defining the purpose of the EEM Program
- Defining interactions from project discharges
- Determining the appropriate parameters to be monitored and the rationale for their inclusion / exclusion for the program
- Determining the means by which to measure environmental effects predictions
- Determining the requirement for new or additional site specific baseline data
- Determining the spatial design and statistical methodologies to be used for the various EEM components
- Reporting and incorporating information into the overall Environmental Protection Plan (EPP) to facilitate decision-making

Where an EEM program identifies unanticipated environmental effects, or where mitigation is found to be ineffective, EMCP will work with the applicable regulatory authorities to amend the EEM program and/or mitigation strategies to ensure that the Project does not result in significant adverse environmental

effects. EMCP will include the EEM program as a part of the overall Management System outlined for the Project in Chapter 16 of this Comprehensive Study Report (CSR).

As stated above, under CEAA, the Responsible Authority has overall responsibility for ensuring necessary mitigation and that a Follow-Up Program is designed and implemented in accordance with CEAA. EMCP, in consultation with the C-NLOPB, will engage the other regulatory agencies to ensure the results of the EEM program are communicated in a manner that facilitates the obligations of Responsible Authorities to report on the EEM program. Where EEM requirements are identified through the permitting stage (i.e., authorizations under the Canadian Environmental Protection Act), these programs will be incorporated into the overall EEM program framework.

In addition to the operational EEM program, EMCP is committed to a fish habitat compensation monitoring program. The details regarding fish habitat compensation monitoring will be determined in consultation with DFO. A fish habitat compensation monitoring survey is conducted following completion of the compensation works to verify the amount and productivity of habitat created.

In addition, should an accidental release of oil occur from a spill or blow-out, a spill EEM program will be instituted.

15.1.2 Existing Offshore Environmental Effects Monitoring Programs

The three EEM programs currently approved for the Newfoundland and Labrador offshore oil and gas industry have core similarities with some differences that make each program unique (Petro-Canada 2007; HMDC 2005; Husky Energy 2007). The core components of the EEM programs are sediment, water and commercial fish analyses (Figure 15-1).

The EEM programs conducted to date offshore Newfoundland and Labrador have typically adopted a radial gradient sampling design for sediment quality monitoring; parameters are measured at increasing distances along transect radii from the drill site(s). Gradient designs have been found to provide the greatest statistical power to detect changes associated with production and drilling activities, and to provide information on the scale of disturbance effects (Ellis and Schneider 1997; Green 2003). The sediment quality monitoring program is primarily designed to detect and monitor changes associated with the release of solid discharges from the operating platforms.

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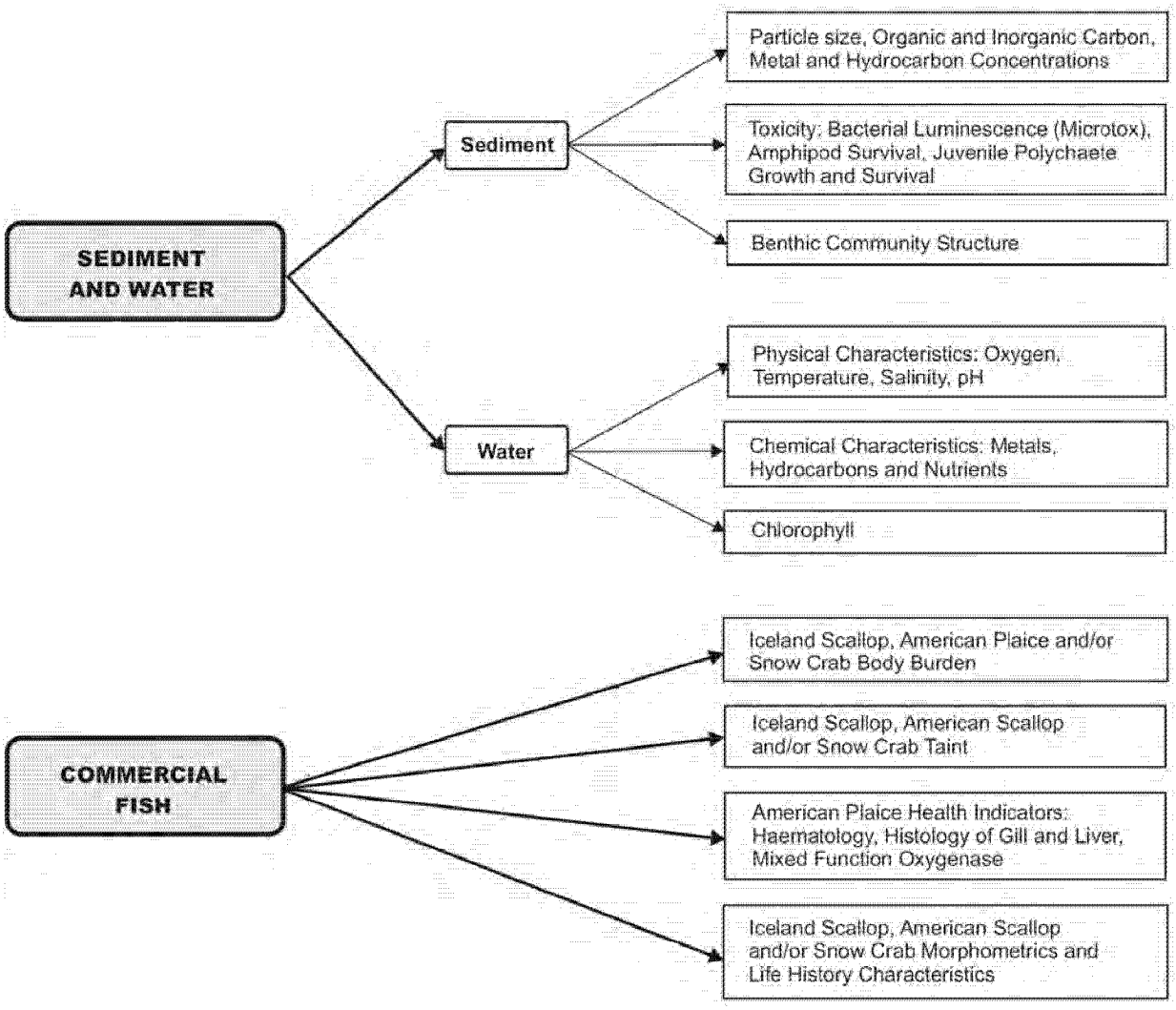

Figure 15-1 Environmental Effects Monitoring Program Components

Commercial fish parameters in Newfoundland and Labrador EEM programs have been typically examined in a control-impact design, where samples collected and parameters measured are examined from both study and control areas. The commercial fish programs are used to detect changes associated with both solid and liquid discharges.

Water sampling EEM programs have, for the most part in Newfoundland and Labrador, been based on a control-impact design or a modification of the control-impact design. These programs are designed to detect and monitor changes related to the release of liquid discharges, primarily produced water from the operating platforms.

All current EEM programs in Newfoundland and Labrador use more than one far-field reference station and have both baseline and operational EEM programs. The actual type(s) of EEM sampling design ultimately used for the Hebron Project will be chosen during the EEM design process. This process may be similar to that described above, and will build upon knowledge and data gained from existing Jeanne d'Arc Basin EEM programs. Upon

completion of a draft EEM design for the Hebron Project, the design will be formally submitted to the C-NLOPB for review and comment. Upon receipt of regulatory and other stakeholder comments, the Hebron EEM program will be finalized and implemented. Subsequent EEM programs will be reviewed and refined as necessary during the life of the project in order to ensure continual improvement.

15.1.3 Nearshore Environmental Effects Monitoring Program

EMCP will implement a nearshore EEM program to verify impact predictions in the marine environment in Bull Arm. The details of the nearshore EEM program will be developed in consultation with regulatory agencies and key stakeholders.

In addition, should an accidental release of oil occur from a spill, a spill EEM program will be determined based on criteria established with EMCP's Offshore Oil Spill Response Plan.

15.2 Environmental Compliance Monitoring

Environmental compliance monitoring (ECM) programs refers to activities used to ensure compliance with all regulatory and self-imposed environmental requirements. ECM assures regulators and the public that environmental regulations and standards are followed.

EMCP will implement a comprehensive Environmental Protection Plan (EPP) for the Nearshore Project Area and the Bull Arm Site. In addition, pursuant to the Drilling and Production Regulations, an EPP will be implemented for the offshore drilling and production operations.

15.2.1 Nearshore Environmental Compliance Monitoring

During construction activities at the Nearshore Project Area, as required by regulation, or as may be prescribed in the EPP and consistent with ExxonMobil standards, EMCP will implement an audit and compliance monitoring program. This program will incorporate compliance reporting requirements for applicable federal and provincial regulations governing activities at the Bull Arm Site. These regulatory instruments include, but are not limited to:

- Section 36 of the federal Fisheries Act, which prohibits the discharge of deleterious substances into any type of water frequented by fish
- Section 32 of the federal Fisheries Act, which prohibits the destruction of fish by any means other than fishing
- Section 35 of the Migratory Birds Convention Act, 1994, which prohibits the deposit of oil, oil wastes or any other substance harmful to migratory birds in any waters or any area frequented by migratory birds
- Oil Pollution Prevention Regulations of the Canada Shipping Act, which details how fuel transfers between ship and shore or between ships are conducted

- The Hazardous Products Act, which is the basis for Workplace Hazardous Materials Information System (WHMIS), which promotes proper labelling of controlled products and requires workers to receive education and training safe storage, use and handling of controlled products
- The Authorization for Works or Undertakings Affecting Fish Habitat, issued by Fisheries and Oceans Canada (DFO) under the Fisheries Act, and the Permit to Alter a Body of Water under the Water Resources Act, which details how infilling will be conducted
- Ocean disposal requirements under the Canadian Environmental Protection Act
- Newfoundland and Labrador Department of Environment and Conservation (NLDEC) Guidance Documents Dredge Spoils Disposal GD-PPD-028-1 and Leachable Toxic Waste, Testing and Disposal GD-PPD-026-1, which details the testing and disposal requirements of dredged materials from marine construction activities. The removal and disposal of dredge spoils from within the marine/freshwater environment requires testing as per GD-PPD-026-1 and approval from the Government Service Centre
- Garbage Pollution Prevention Regulations, Pollutant Substance Regulations, Pollutant Discharge Reporting Regulations and Oil Pollution Prevention Regulations as required by the CSA, which will govern all vessel activities
- The NLDEC Water and Sewer Regulations for waste water discharge, which requires testing of the water from any on-land settling ponds prior to discharge

15.2.2 Offshore Environmental Compliance Monitoring

The ECM program requirements for the offshore oil and gas industry are detailed in the Offshore Waste Treatment Guidelines (OWTG) (National Energy Board (NEB) et al. 2010). The OWTG (NEB et al. 2010) outline the recommended practices and standards for the treatment and disposal of wastes and the sampling and analysis of waste streams. All operations will adhere to the most recent version of the guidelines.

The OWTG (NEB et al. 2010) provide minimum standards for the treatment and disposal of specific waste streams, including air emissions, produced water, drilling muds, drilling solids, storage displacement water, bilge and ballast water, deck drainage, produced sand, well treatment fluids, cooling water, desalination brine, sewage and food wastes, water for testing fire control systems, monoethylene glycol, naturally-occurring radioactive material and other substances, wastes and resides. For further information with respect to the standards for the treatment, disposal and monitoring of waste streams listed above, the reader is referred to the OWTG (NEB et al. 2010).

An Authorization for Works or Undertakings Affecting Fish Habitat will also be issued under the Fisheries Act for Project components occurring at the Offshore Project Area.

EMCP will adhere to ocean disposal requirements under the Canadian Environmental Protection Act for disposal of dredge spoil from any potential future excavated drill centres.

15.3 Other Required Programs

EMCP has committed to undertaking monitoring and reporting of various VECs during certain activities associated with the Hebron Project. In addition, pursuant to C-NLOPB guidelines and regulatory requirements, EMCP may have to undertake monitoring programs associated with the issuance of permits / authorizations. These may include, but are not limited to:

- Collection of data on marine mammals, sea turtles and marine birds during blasting programs at Bull Arm
- Collection of data on marine mammals and marine birds during geophysical programs. Marine mammal and sea turtle monitoring and observation protocols will be consistent with the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011). Marine bird observations will be undertaken, where applicable, as per the pelagic marine bird monitoring protocol developed by the Canadian Wildlife Service
- Compliance monitoring to ensure that the Navigable Waters Protection Act Conditions of Approval are implemented as outlined by Navigable Waters Protection Program of Transport Canada
- Collection and reporting of physical environmental data
- Project activities affecting fish habitat evaluated as part of the fish habitat compensation program. All fish habitat compensation measures will be monitored to ensure no net loss of productive capacity in fish habitat. A fish habitat compensation monitoring survey is conducted following completion of the compensation works to verify the amount and productivity of habitat created. In addition, compensation monitoring to determine the continued functioning of the habitat will be conducted for a period of time and at intervals agreed upon by DFO and EMCP. The timelines for monitoring will be included in the Fish Habitat Compensation Plan, which will be provided as a condition of Section 35(2) of the Fisheries Act

15.4 Environmental Assessment Validation

Various program activities during the life of the Hebron Project will require authorization under the Atlantic Accord Acts (e.g., drilling, dredging, geotechnical, geohazard and seismic surveys). Authorizations may be valid for one to five years at the discretion of the C-NLOPB. The schedule of Project activities outlined in this environmental assessment is based on the best available knowledge at this time. EMCP recognizes the requirement to ensure that the environmental assessment is kept current and valid to support the renewal of any applicable authorizations and/or any important changes in environment or resource use in the Project Areas during that time. Therefore, during the life of the Project, as authorizations are renewed or new ones are

required, EMCP will submit documentation to the C-NLOPB and federal regulatory authorities to confirm that:

- The scope and nature of activities planned and addressed under this environmental assessment have not changed
- The nature of the species at risk in the Project and Study Areas have been validated and have not changed (including review of Recovery Strategies and Management Plans)
- The nature and extent of the fishing activities in the Project Area have been validated and have not changed
- The mitigation measures defined and committed to in the environmental assessment are still valid

As part of its continuous improvement and stakeholder engagement, EMCP will consult with stakeholders, including fishers, regarding ongoing operations, as necessary.

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16 ENVIRONMENTAL MANAGEMENT

Environmental leadership and performance for the Hebron Project will be managed by taking a sound science, risk-based, life cycle approach. Environmental management is an evergreen process that is continuously monitored and enhanced throughout Project life.

ExxonMobil Canada Properties (EMCP) recognizes that important environmental-related decisions are often made during initial planning and concept selection. In many cases, these early decisions can effectively reduce environmental effects without measurably affecting a project's cost or schedule. Early identification of potential environmental effects can help narrow the scope of concept alternatives, develop appropriate environmental mitigation approaches and optimize a project's environmental footprint by addressing energy needs, water usage, land use, air emissions, effects on sensitive environments and effects on local communities.

For the Hebron Project, EMCP will use an established ExxonMobil Corporation (ExxonMobil) Environmental Management Process that covers the complete life cycle of a new development (facility design, construction, operation and decommissioning). A number of planning and decision-making tools and processes are used to address identified environmental challenges and to ensure that the desired level of environmental performance is achieved. Environmental risk assessments, alternatives analyses and adherence to internal environmental standards will guide the Project throughout this planning and construction process.

This Comprehensive Study Report (CSR), as well as the Socio-economic Impact Statement (SEIS), was prepared after the concept was selected and approved. An Environmental Management Plan (EMP) or Environmental Protection Plan (EPP) (as required by Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) for operations) will also be prepared to document environmental impact avoidance and/or mitigation measures. This EMP will include a description of the roles and responsibilities of Project-associated personnel, environmental-related regulatory requirements and environmental performance expectations.

During the operations stage, Project personnel will track environmental measurements to ensure that the required level of environmental performance is obtained. Facilities will be dismantled and reclaimed at the end of the Project's life per C-NLOPB requirements. A life cycle approach, from initial project concept to final decommissioning, will ensure the proper stewardship of the environmental aspects for the Hebron Project.

Environmental management for the Hebron Project will be guided by ExxonMobil's Environment Policy, expectations from the "Protect Tomorrow. Today." initiative and management systems. These systems provide a systematic, structured and disciplined approach to environmental management.

16.1 ExxonMobil Corporation Environment Policy

The Board of Directors of ExxonMobil have adopted and oversee the administration of ExxonMobil's Standards of Business Conduct, which include the foundation policies of ExxonMobil. ExxonMobil's approach to environmental protection is guided by the ExxonMobil's Environment Policy, as shown in Figure 16-1.

It is ExxonMobil Corporation's policy to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. The Corporation is committed to continuous efforts to improve environmental performance throughout its operations.

Accordingly, the Corporation's policy is to:

- comply with all applicable environmental laws and regulations and apply responsible standards where laws and regulations do not exist;
- encourage concern and respect for the environment, emphasize every employee's responsibility in environmental performance, and foster appropriate operating practices and training;
- work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risks, costs, and benefits, including effects on energy and product supply;
- manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels; design, operate, and maintain facilities to this end;
- respond quickly and effectively to incidents resulting from its operations, in cooperation with industry organizations and authorized government agencies;
- conduct and support research to improve understanding of the impact of its business on the environment, to improve methods of environmental protection and to enhance its capability to make operations and products compatible with the environment;
- communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance;
- undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

Figure 16-1 ExxonMobil Corporation Environment Policy

16.2 Corporate Environmental Initiative

ExxonMobil senior management has reinforced environmental performance expectations to all ExxonMobil's business lines in order to achieve superior performance. This leadership-driven initiative is called "Protect Tomorrow. Today." (Figure 16-2).

ExxonMobil seeks to deliver superior environmental performance, and in this spirit, an Environmental Management Process has been developed, which is integrated with project design and operations processes and procedures and has been deployed consistently around the world. This process allows ExxonMobil to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. ExxonMobil is committed to continuous efforts to improve environmental performance.

"Protect Tomorrow. Today."

- Deliver superior environmental performance, leading to competitive advantage.
- Drive environmental incidents with real impact to zero, through a process of continuous improvement.
- Achieve industry leadership in key environmental areas relevant to each business.

Figure 16-2 "Protect Tomorrow. Today." Principles

16.3 Management Systems

Long-term sustainable performance will be established through use of the ExxonMobil management systems, including operations integrity, controls integrity, reliability and capital projects management. The Environmental Management Process is integrated into two of these management systems: the Operations Integrity Management System (OIMS) and the ExxonMobil Capital Projects Management System (EMCAPS).

16.3.1 Operations Integrity Management System

ExxonMobil's OIMS Framework establishes common worldwide expectations for addressing risks inherent in its business. The term “operations integrity” is used by ExxonMobil to address all aspects of its business that can affect personnel and process safety, security, health and environmental performance at ExxonMobil facilities worldwide.

OIMS is a framework of management systems designed to identify hazards and manage the associated risks. It provides a systematic, structured and disciplined approach across businesses and facilities worldwide and enables ExxonMobil to measure progress and ensure management accountability in these areas. OIMS also ensures that ExxonMobil appropriately engages with the communities in which it operates. Business-line managers are expected to adhere to all OIMS requirements, from project inception to ongoing operations, and conduct OIMS assessments on a frequent basis.

OIMS is embedded into ExxonMobil's day-to-day work processes to establish common worldwide expectations that every operating unit must fulfill to proactively manage risk globally. Over time, it has become a part of ExxonMobil's culture and the way it does business, improving operations reliability, and reducing safety, security, health and environmental risks and effects.

The overall effectiveness of OIMS is reviewed every five years and the system is adjusted accordingly. As a result, OIMS has been continuously

improved to include behaviour-based safety, security, environmental matters and enhanced community involvement.

In 2007, Lloyd's Register Quality Assurance, Inc. (LRQA) attested that OIMS meets the requirements of the ISO 14001 standard for environmental management systems. Furthermore, LRQA recognized that OIMS also meets all the requirements of the Occupational Health and Safety Assessment Series for health and safety management systems (OHSAS 18001).

EMCP is establishing the management systems, including the Environmental Management System, to address the requirements and expectations of the OIMS framework. These systems incorporate five essential characteristics:

- Scope and Objectives: scope defines the system's boundaries and interfaces with other systems, organizations and facilities. Objectives clearly define the system's purpose and expected results
- Processes and Procedures: processes address the steps that describe what the system does and how it functions. Procedures address the key tasks within a process
- Responsible and Accountable Resources: the approval authority, experience and training necessary for specific roles and responsibilities in implementation and execution of the system are specified
- Verification and Measurement: a system must be checked to see whether it is functioning as designed and is achieving its stated purpose
- Feedback and Improvement Mechanisms: these mechanisms help ensure actions are taken to continuously improve a system's suitability, capability and effectiveness

The OIMS framework has 11 elements (Figure 16-3), each with clearly defined expectations that every operation must fulfill. Environmental aspects are integrated throughout OIMS. The specific basis for the Environmental Management System is within Element 6, Operations and Maintenance.

16.3.2 ExxonMobil Capital Projects Management System

The EMCAPS provides a framework for guiding project development and execution. This system requires several deliverables to be completed by specific decision points in the life of a project. Two key EMCAPS deliverables related to the Environmental Management Process are the EMP and the Regulatory Compliance Plan.

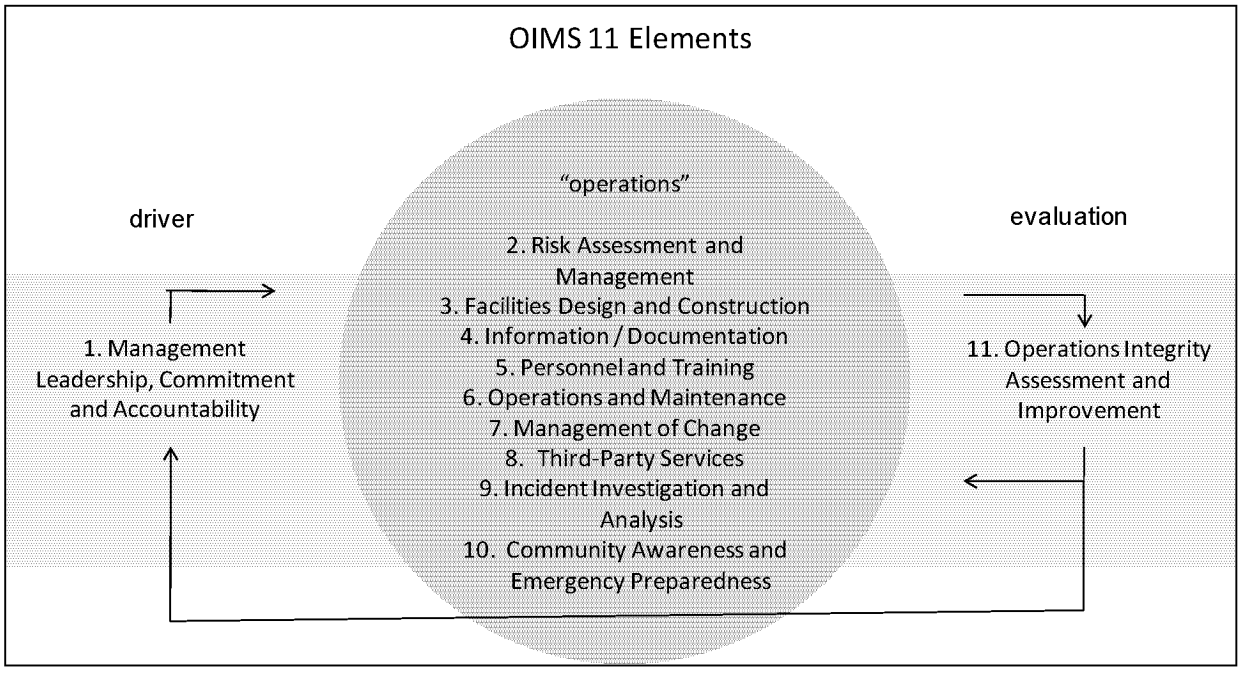

Figure 16-3 OIMS 11 Elements

16.4 Environmental Management Process

ExxonMobil's structured Environmental Management Process ensures that a variety of tools, plans and processes are in place to safeguard the environment - its biodiversity, cultural heritage and value. These features are a priority in business planning throughout a project's life cycle. The Environmental Management Process requires an early engagement approach to identifying environmental issues and alternatives, even before the project concept is determined. In the project's early stages, alternatives analyses guide project concepts and decisions as more knowledge about site characteristics and facility designs become known. Decisions early in a Project's life can lead to an overall reduced environmental footprint.

The Environmental Management Process for the Hebron Project has been broken down into five stages of activity that follow the timeline for developing and operating a project (Figure 16-4).

Implementation of a structured Environmental Management Process with organized and well-defined associated systems, tools and processes is the key to managing the environmental, socio-economic and health challenges of the Hebron Project.

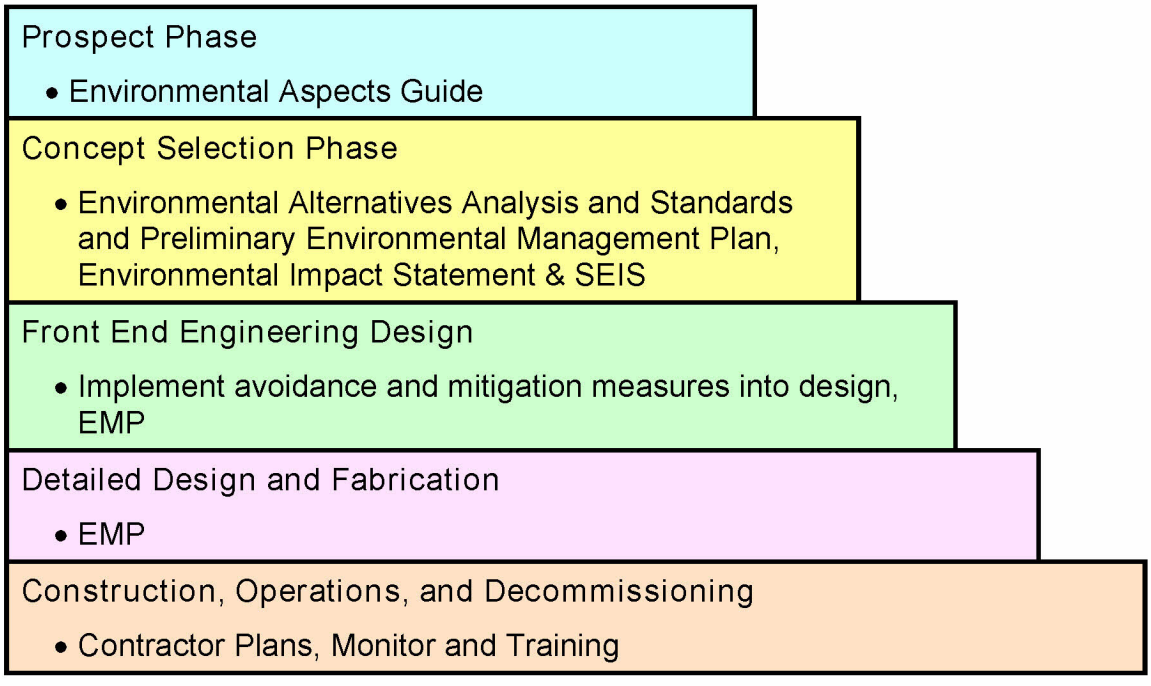

Figure 16-4 The Five Project Stages and Related Environmental Tools and Processes

16.4.1 Prospect Phase

The tool developed to guide this process and ensure that a wide range of potential environmental sensitivities are considered is the ExxonMobil Environmental Aspects Guide. This Guide provides a comprehensive list of environmental sensitivities for consideration and a systematic process for the initial assessment of activities, products and services that interact with the environment. The Guide promotes early engagement with the applicable engineering, geoscience and management teams and straightforward high-level mitigation approaches in order to reduce environmental effects. This Guide was used to steer Hebron Project environmental and regulatory planning, as well as development of the environmental assessment and Preliminary Environmental Management Plans (PEMP).

This phase of the Environmental Management Process usually involves the environmental and regulatory evaluation of various Project alternatives or concepts. The environmental risks associated with the alternative modes of development for the Hebron Project were evaluated and a preferred concept was selected prior to ExxonMobil becoming the operator (as described in Section 2.4).

From the earliest stages of the Project, the management team has actively promoted a safety, security, health and environment (SSH&E) culture, to both those working on the Project and to the public. EMCP is committed to working with the provincial government, the Workplace Health, Safety and Compensation Commission, the Building Trades Council and others toward improved safety in the province. EMCP hosted an initial contractor SSH&E Forum in June 2009 and has carried its message of safety ("Nobody Gets

Hurt."), security ("Security is everybody's business.") and environment ("Protect Tomorrow. Today.") to the public through presentations at Open Houses, in schools and at conferences. The Open Houses in the fall of 2009 were one means of bringing the information about the Project and the environmental assessment to the interested public.

16.4.2 Concept Selection Phase

In the normal process, once a new hydrocarbon resource has been determined to represent a viable development opportunity, several concepts for developing the resource are contemplated. For each of these concepts, a more detailed level of environmental alternative analysis is conducted. These analyses consider the various environmental impacts associated with each of the different design concepts and technologies being considered.

16.4.2.1 Alternatives Analyses

During the concept selection phase, the tool that is used to manage environmental reviews is the Early Project Environmental Alternatives Analysis. This tool focuses on select environmental aspects that can be reasonably evaluated at an early stage, allowing for practical decisions to be made. Another tool, developed to enhance early project decisions, is a series of ExxonMobil Environmental Standards that address aspects related to air, water, land and local communities.

16.4.2.2 Environmental Standards

EMCP is committed to meeting provincial and federal regulations for environmental performance and, where no local regulations exist, to operate to standards that are protective of the environment. These standards were developed by ExxonMobil and are based on sound science and comprehensive risk assessments. They provide an additional layer of environmental protection assurance, especially in regions where environmental requirements are not comprehensive. The existing environmental standards include nitrogen oxides emissions, offshore drill cutting discharges, flare and venting reduction, water management, waste management, land use, energy efficiency and greenhouse gases, socio-economic management, air emissions and marine geophysical operations. These standards assist in identifying environmental improvement opportunities early in project planning when they can be implemented most effectively.

16.4.2.3 Environmental and Socioeconomic Impact Statements

An Environmental Impact Statement (EIS) is required by Canadian and Newfoundland and Labrador legislation. Pursuant to the Canadian Environmental Assessment Act, the EIS is a CSR. Per these requirements, the scope and detail of the CSR and SEIS for the Hebron Project are based on the conceptual level of engineering design, the Project environment's sensitivity, existing socio-economic conditions, the scope of the Project and

the nature of anticipated environmental issues / effects. These tools are valuable to many Project team members, since decisions made by Project personnel will be influenced by its findings and recommendations.

The CSR and SEIS processes are detailed and rigorous, and ensure that a project is appropriately designed, constructed and operated in an environmentally responsible manner. The results of these assessments lead to the development of environmental effects avoidance and mitigation plans. These avoidance and mitigation measures, as well as specific monitoring and measuring procedures, are documented in subsequent project documents and plans, starting with the PEMP.

16.4.2.4 Preliminary Environmental Management Plan

During this phase, a PEMP was prepared to describe the process for managing its associated environmental-related issues in view of the Project schedule and other needs. This plan identified and organized the key issues and processes necessary for managing the Project's environmental aspects, including applicable environmental-related regulatory requirements, external financing-related environmental requirements (if applicable), roles and responsibilities of specific project personnel and environmental-related requirements for Project engineering and construction contracts and contractors. The PEMP provides a roadmap of environmental-related expectations as the details of the Project design and construction plans continue to be defined.

16.4.3 Front End Engineering Design

The results of the CSR, SEIS and PEMP prepared during the Concept Selection Stage, including recommended environmental issues / effects avoidance, mitigation and monitoring measures, will be integrated into the Project design during FEED. The appropriate environmental standards will be used to evaluate design changes as necessary. As design progresses during this stage, the PEMP will be updated and results documented as an EMP.

16.4.3.1 Environmental Management Plan

The EMP for the Hebron Project will integrate the environmental and socio-economic issues / effects avoidance, mitigation and monitoring measures, identified in the CSR and SEIS, into the Project's activities and operations. This includes integrating them into the overall Project schedule and in the supporting engineering and contractor plans and contracts. Deviations from agreed-upon strategies require a stringent, documented review and approval process. Any approved changes are incorporated into the Project schedule and documentation. The EMP includes plans for public consultation, environmental training of project personnel, waste management and other specific plans as appropriate. Depending on the environmental, socio-economic and health challenges associated with each Project phase, other specific plans may be needed to support the EMP.

The Hebron Project EMP will provide the basis for the EPP that will be submitted to the C-NLOPB for approval.

16.4.4 Detailed Design and Fabrication

When the Project's designs become finalized and fabrication begins, the EMP will help guide Project activities at various contractor sites. Prior to beginning significant onsite construction and installation activities, the environmental advisors will conduct a series of assessments with each major segment of the Project, such as the installation, logistics, procurement coordinators and production operations personnel to review the Project's environmental-related requirements and commitments. These assessments are documented and reviewed for endorsement by key Project managers. During this stage, the EMP will continue to be updated as the Project matures.

16.4.5 Construction, Operations and Decommissioning

The above-mentioned systems, tools and standards are primarily used for Project geophysical, planning, engineering, fabrication, construction and drilling activities. A plan will be developed to transition the EMP to the production operations group several months prior to anticipated "start-up". The plan includes the identification and documentation of key activities and responsibilities. During this commissioning process, it is optimal for construction and operations EMP implementation and compliance monitoring personnel to overlap in order to ensure a smooth transition. The development phase tools, plans and standards continue to be applicable during the production phase. At the end of Project life the Project facilities will be decommissioned.

16.4.5.1 Environmental Effects Monitoring

Throughout the construction and operations phases, the work is monitored in view of the applicable environmental and regulatory obligations and requirements. Tools such as a proprietary menu-driven database are used by ExxonMobil to track the completion of these obligations and requirements. This database is available continuously and globally so that all project team members have access to it when needed. Since it is a "live" database, updates and changes made are viewable at all times.

Regulatory Compliance Assessments are also conducted to review the various aspects of the project, including its environmental requirements, and highlights areas for improvement. Follow-up actions are monitored to ensure closure.

16.4.5.2 Contractor Requirements

Contractual requirements for each of the Project contractors will require them to develop their own EMP and Regulatory Compliance Plan specific to their scope of work. These plans are reviewed and endorsed by the Project team to ensure that the contractor will meet ExxonMobil's environmental and regulatory expectations and requirements. Project team members are

assigned to each contractor to monitor their work throughout the construction phase.

16.4.5.3 Management of Change Process

The systems and processes used to develop and construct a project include a Management of Change (MOC) Process. The MOC Process provides a means to ensure that changes are reviewed and endorsed regarding their health, safety, environmental, regulatory, security and operational implications, and any other requirements before they are endorsed.

16.5 Capacity Building

16.5.1 Training

In order to ensure that the Environmental Management Process is consistently implemented, ExxonMobil has developed a training curriculum for its environmental advisors (Figure 16-5). These sessions are taught by experts and are designed to build technical capacity and share information on ExxonMobil's environmental, socio-economic and health management philosophy and approach. Project studies are shared and problems are worked in groups to provide instruction regarding how to approach the types of decisions and issues related to environmental matters arise when undertaking major projects.

Figure 16-5 Example Training Sessions

16.5.2 Environmental Management Process Workshops

In addition to project host-country employment and business use opportunities, ExxonMobil provides workshops to explain its Environmental Management Process, how it works and ExxonMobil's overall environmental expectations and requirements. Recent workshops have included a wide range of audience, including Project teams, contractors and key government agency representatives.

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17 SUMMARY AND CONCLUSIONS

17.1 Summary of Proposed Activities

The Hebron Project is a proposed oil and gas development located offshore Newfoundland, approximately 340 km east of St. John's. Forecasted cumulative oil recovery for the initial development phase after 30 years of producing life ranges from 87 Mm^3 (548 MBO) to 140 Mm^3 (883 MBO) from an anticipated 41 wells The Ben Nevis Pool within the Hebron Field is the core of the Hebron Project, and is anticipated to produce approximately 80 percent of the Hebron Project's crude oil.

The intent is to develop the Hebron oil field using a concrete Gravity Base Structure (GBS) with an integrated Topsides facility. The GBS will be a reinforced concrete structure designed to withstand impacts from sea ice and icebergs and the meteorological and oceanographic conditions at the Hebron Field. It will accommodate up to 52 well slots with J-tubes connected to the base of the GBS for potential expansion opportunities. An Offshore Loading System (OLS) will be installed to off-load crude oil from the platform to tankers.

Potential expansion opportunities may include subsea tieback to the Hebron Platform from excavated drill centres.

The scope of the Hebron Project includes GBS construction activities at the Nalcor Energy-Bull Arm Fabrication site in Trinity Bay, Newfoundland, which are scheduled to begin in 2011, and the installation, operation and future decommissioning activities of the Project offshore, with first oil targeted for 2017. The environmental assessment is therefore focused on activities in both the Nearshore and Offshore Project Areas.

17.2 Summary of Assessment Findings

Under the Canadian Environmental Assessment Act (CEAA), the Hebron Project requires environmental assessment at a comprehensive study-level of assessment. The Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and other federal Responsible Authorities (RAs) have set out the required scope of this environmental assessment in a Scoping Document (C-NLOPB 2009). This Comprehensive Study Report (CSR) meets these requirements, as well as meeting the requirements of the C-NLOPB Development Plan Guidelines (C-NLOPB 2006).

The potential environmental effects of each Project phase have been evaluated for each of the selected Valued Ecosystem Components (VECs) (i.e., those components of the environment that are valued socially, economically, culturally and/or scientifically and are of interest when considering the potential environmental effects of the Project). The VECs selected for this environmental assessment reflect the issues raised by stakeholders and include Air Quality (air quality and greenhouse gas (GHG)

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emissions), Marine Fish and Fish Habitat, Commercial Fisheries, Marine Birds, Marine Mammals and Sea Turtles, Marine Species at Risk (SAR) (marine fish species SAR, marine mammal and sea turtle SAR and bird SAR) and Sensitive or Special Areas.

17.2.1 Summary of Residual Effects

A summary of the residual environmental effects assessment for each of the identified VECs is provided in Table 17-1. The only potential for significant residual adverse environmental effects as a result of the Hebron Project is in association with an accidental event. In such an unlikely event, significant adverse environmental effects have been predicted for Marine Birds, bird SAR and the Sensitive or Special Areas located in the Nearshore Project Area, however, the likelihood of this occurring is considered very low. Emphasis on both pollution prevention and effective response planning will further reduce the potential for these unlikely significant environmental effects to occur.

Table 17-1 Significant and Not Significant Residual Environmental Effects on Valued Ecosystem Components

VEC	Significance of Residual Environmental Effect					
	Construction / Installation	Operation and Maintenance	Decommissioning and Abandonment	Accidents, Malfunctions and Unplanned Events	Project Overall	Cumulative Environmental Effects
Air Quality	NS	NS	NS	NS	NS	NS
Fish and Fish Habitat	NS	NS	NS	NS	NS	NS
Commercial Fisheries	NS	NS	NS	NS	NS	NS
Marine Birds	NS	NS	NS	S	NS	NS
Marine Mammals and Sea Turtles	NS	NS	NS	NS	NS	NS
Species at Risk: Marine Fish	NS	NS	NS	NS	NS	NS
Species at Risk: Marine Mammals and Sea Turtles	NS	NS	NS	NS	NS	NS
Species at Risk: Birds	NS	NS	NS	S	NS	NS
Sensitive or Special Areas	NS	NS	NS	S	NS	NS
S = Significant residual environmental effects NS = Not significant residual environmental effect						

17.2.2 Summary of Proposed Mitigation Measures

The proposed mitigation measures identified in association with each of the VECs is outlined in Table 17-2 for the following phases: nearshore construction activities, offshore construction and installation, potential expansion opportunities, offshore operations and maintenance, potential expansion opportunities, decommissioning and abandonment and accidental events.

Table 17-2 Proposed Mitigation by Project Phase and Valued Ecosystem Component

Applicable VECs	Mitigation
Construction	
Nearshore Construction	
• Air Quality and GHG Emissions	• Limited periods when vessels are idling • Vessel maintenance and inspection
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Birds)	• During blasting use of bubble curtains, if required • Harmful alteration, disruption or destruction (HADD) authorization and compensation • Use of sediment control measures • Adherence to the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopky 1998) • During blasting, monitor appropriate safety zone for diving birds, marine mammals and sea turtles • Compliance with terms of Section 32 Fisheries Act Authorization (if required) • Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems directed to a settling basin • Proper release of stranded birds per Canadian Wildlife Service (CWS) protocol • For deepwater site moorings, restrict disturbance to mooring sites • Vessels to maintain steady course and speed and to avoid concentrations of marine birds and marine mammals • Vessels to deviate course to avoid concentrations of marine mammals • Use of best practices, continuous improvement programs and best available technology
• Commercial Fisheries	• Fisheries liaison committee • Safety zone • Timing • Vessel traffic management plan • Fisheries compensation plan • Notification and communication • Fisheries Liaison Officer (FLO) • Single point of contact (SPOC)
Offshore Construction and Installation	
• Air Quality and GHG Emissions	• Ensure the use of properly maintained and functioning equipment • Limited periods when vessels and helicopters are idling • Vessel and helicopter maintenance
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Birds)	• Use of best practices, continuous improvement programs and best available technology • Survey vessels and equipment will only use the power required to attain the data, thereby minimizing noise • Proper release of stranded birds per CWS protocol • Helicopters to avoid active marine bird colonies, including Witless Bay Ecological Reserve, and to avoid flying at low altitudes, where possible • Vessels to maintain minimum distance of 2 km from active marine bird colonies, maintain steady course and speed and avoid concentrations of marine birds or marine mammals • Vessels to deviate course to avoid concentrations of marine mammals • Adherence to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) • Adherence the Section 35(2) Fisheries Act Authorization and completion of associated fish habitat compensation and related monitoring

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Applicable VECs	Mitigation
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program • Compliance with Navigable Waters Protection Act – Conditions of Approval
Potential Expansion Opportunities	
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish and Marine Mammals and Sea Turtles)	• Fish habitat compensation • Efficient Installation with minimal seabed disturbance • Use of best practices, continuous improvement programs and best available technology • Proper release of stranded birds per CWS protocol • Adherence the Section 35(2) Fisheries Act Authorization and completion of associated fish habitat compensation and related monitoring
• Commercial Fisheries	• Notification and communication • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Offshore Operations and Maintenance	
• Air Quality and GHG Emissions	• Investigate the use of efficient / reduced emission technology, where appropriate, and where technologically sound and economically justifiable incorporate into the design • Monitor the number of flaring events • Develop and implement standard operating procedures (SOPs) for all chemical handling operations • Vessel and helicopter maintenance
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Marine Birds)	• Use of best practices, continuous improvement programs and best available technology • Synthetic-based mud (SBM) reinjection • Adherence to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) • Subsurface discharge of wastewater and water-based mud (WBM) cuttings • Proper release of stranded birds per CWS protocol • Helicopters to avoid active marine bird colonies, including Witless Bay Ecological Reserve, and to avoid flying at low altitudes, where possible • Vessels to maintain minimum distance of 2 km from active marine bird colonies, maintain steady course and speed and avoid concentrations of marine birds • Vessels to deviate course to avoid concentrations of marine mammals
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Potential Expansion Opportunities	
• Fish and Fish Habitat • Marine Birds • Marine Mammals and	• Use of best practices, continuous improvement programs and best available technology • Adherence to the Geophysical, Geological, Environmental and

Applicable VECs	Mitigation
Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Marine Birds)	Geotechnical Program Guidelines (C-NLOPB 2011) • Plan surveys to avoid concentrations of members of Alcidae • Proper release of stranded birds per CWS protocol • Subsurface discharge of WBM and SBM cuttings • Temporal avoidance of marine mammals • For seismic surveys minimize sound levels
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Decommissioning and Abandonment	
• Air Quality and GHG Emissions	• Vessel and helicopter maintenance
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Marine Birds)	• Use of best practices, continuous improvement programs and best available technology • Proper release of stranded birds per CWS protocol • Helicopters to avoid active marine bird colonies, including Witless Bay Ecological Reserve, and to avoid flying at low altitudes, where possible • Vessels to maintain minimum distance of 2 km from active marine bird colonies, maintain steady course and speed and avoid concentrations of marine birds • Helicopters to avoid low overflights when possible • Vessels to avoid animal concentrations when possible and deviate course to avoid animals • Vessels to maintain steady speed and course • Adherence to the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011)
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Accidents, Malfunctions and Unplanned Events	
• Air Quality and GHG Emissions • Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Birds) • Sensitive or Special Areas • Commercial Fisheries	• Train staff in spill prevention and awareness • Spill response equipment • Blowout prevention design • Alert / Emergency Response Contingency Plan • SOPs for oil handling operations • SOPs for chemical handling and storage • Prevention through design standards and maintenance • Oil Spill Response Plan • Adherence with all standard navigation procedures, Transport Canada requirements, Coast Guard requirements and navigation systems • Risk awareness and training, preparation, equipment inventory, prevention, and emergency response drills • Fisheries Compensation Plan • Control and containment of debris

A Project-specific Environmental Management Plan will be developed for the Hebron Project for the Nearshore and Offshore phases.

During construction, ExxonMobil Canada Properties (EMCP) will implement an Environmental Protection Plan (EPP) for all activities at the Bull Arm Site. This EPP will be developed in consultation with regulators and area residents, in particular the commercial fish harvesters.

For offshore drilling and production operations, EMCP will comply with all regulatory requirements respecting environmental protection in accordance with the Drilling and Production Regulations, Operations will adhere to C-NLOPB guidance (e.g., Offshore Waste Treatment Guidelines (National Energy Board (NEB) et al. 2010), Offshore Chemical Selection Drilling and Production Guidelines (C-NLOPB and CNSOPB 2011), Environmental Protection Plan Guidelines (NEB et al. 2011), Offshore Physical Environmental Guidelines (NEB et al. 2008),).

Prior to commencement of Project activities, EMCP will develop contingency plans that will serve as the guidelines for EMCP's response to an emergency at the Hebron Project. EMCP's emergency response philosophy is to minimize the effect of an emergency on people, environment and the corporation.

Throughout all phases of the Project, EMCP will actively engage stakeholders and community representatives regarding Hebron Project activities.

17.3 Summary of Monitoring and Follow-Up

EMCP will develop and implement environmental effects monitoring (EEM) programs for Nearshore and Offshore activities. These EEM programs will build on the previous Bull Arm (Hibernia) EEM program and the experience of the other three existing offshore production EEM programs. The programs for both nearshore and offshore Project activities will be developed in discussion with federal and provincial regulators, as well as the area fish harvesters, and will be closely linked to the EPP.

EMCP will undertake a fish habitat compensation monitoring program for habitat compensation works offshore and nearshore.

EMCP will use environmental observers to collect data on marine mammals, and possibly marine bird occurrences, as well as to record weather and ice conditions and oversee mitigations such as proper marine bird handling procedures and documentation. An oceanographic monitoring program will also be conducted.

17.4 Conclusions

The Project will benefit from the experience of the existing production projects offshore Newfoundland and Labrador, with respect to many key items, including reducing resource conflicts with commercial fishers, development of effective monitoring programs and effective emergency response planning.

Ecological processes will not be disturbed outside natural variability, and ecosystem structure and function will not be critically affected by the Hebron Project. Most environmental effects are reversible, and of limited duration, magnitude and geographic extent. While significant adverse environmental effects have been predicted for Marine Birds, bird SAR and Sensitive or Special Areas (those located in the nearshore only) in the case of an accidental event, the likelihood of this occurring is considered very low. EMCP will have pollution prevention measures and emergency response procedures in place.

The various routine components and activities associated with the proposed Project are predicted to result in not significant residual adverse environmental effects on Air Quality, Fish and Fish Habitat, Commercial Fisheries, Marine Birds, Marine Mammals and Sea Turtles, Marine SAR and Sensitive or Special Areas.

EMCP acknowledges that the scope of the Project being assessed in this CSR extends over several decades, during which time the regulatory and biophysical environment may change from that assessed in this report. EMCP recognizes the requirement to ensure that the environmental assessment is kept current and valid to support the renewal of any applicable authorizations and/or any important changes in environment or resource use in the Project Areas during that time. During the life of the Project, as authorizations are renewed or new ones are required, EMCP will submit documentation to the C-NLOPB and federal regulatory authorities to confirm that proposed activities are captured within the scope of the Project and that environmental assessment predictions remain valid, including those for Species at Risk.

EMCP is committed to maintaining open communication with regulators and stakeholders and to an adaptive management approach with respect to environmental management of the Hebron Project.

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19 GLOSSARY, ACRONYMS AND ABBREVIATIONS

19.1 Glossary

Word	Definition
Abandonment	The decommissioning of facilities, including the plugging of wells and removal of offshore structures following production of reserves
Abiotic	Non-biological; a process not mediated or resulting from the activity of organisms. Ocean currents and weather are examples of abiotic processes
Advection	The process of, or referring to the transport of one fluid mass (air, water) by the movement of another
Aerobic	A process requiring the presence of air or oxygen
Alcids	A group of shorebirds, predominantly of northern coasts, including auks, puffins, murres and guillemots
Anomaly	A geological feature, especially in the subsurface, distinguished by geological, geophysical or geochemical means, that is different from the general surroundings and is often of potential economic value, (e.g., a magnetic anomaly)
Anoxic	Deficient in oxygen
Anthropogenic	Derived or resulting from human activity
Artificial Reef	An underwater artificial structure that provides habitat similar to that provided by a natural reef
Artificial Reef Effect	The effect generated by the placement of an undersea structure in an area where previously there were no similar habitats. Benthic organisms colonize the structure and, subsequently, fish and other organisms are attracted to it in search of food
Astronomical Tides	The alternate rise and fall of the surface of oceans, seas and the bays, rivers, connected with them, caused by the gravitational attraction of the sun and moon
Baleen	Comb-like semi-rigid plates with frayed edges that hang from the roof of a baleen whale's mouth; used when feeding to filter prey from the water
Ballast	(a) A relatively heavy material, such as lead, iron or water, placed in a ship to ensure stability or to maintain the proper draft or trim; (b) To pump seawater into empty fuel tanks of a ship to ensure its stability or suitable draft and trim for seaworthiness
Ballast Water	Water carried in tanks on a vessel (e.g., tanker) to maintain sea-going stability
Barite	A mineral (barium sulphate); used as a weighting material for drilling because of its high specific gravity
Bathymetry	The measurement of depths of water in oceans, seas and lakes; also the information derived from such measurements
Bedrock	A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material

Word	Definition
Benthos	Marine plants and animals that live on, in, or attached to the ocean bottom
Bentonite	A clay formed from volcanic ash decomposition
Bergy Bit	A piece of floating glacier having a sail greater than 1.5 m but less than 5 m and a water plane area greater than 20 m^2 but less than 300 m^2. Size approximates that of a small house and mass is between 120 and 5,400 t
Bilge	The nearly horizontal part of a ship's bottom
Biocide	A chemical agent that destroys bacteria
Biofouling	The encrustation of submerged structures by barnacles and molluscs, seaweeds and other marine life; also known as marine fouling
Biomass	The amount of living matter of a specified type given as a concentration per unit area or volume
Biota	The flora and fauna of a region
Bioturbation	The churning and stirring of a sediment by organisms
Bloom	Rapid growth of a population of planktonic organisms
Blowout	A change in the gas or oil pressure of the well, that cannot be handled by the well's control system, resulting in uncontrolled flow
Blowout Preventer (BOP)	A stack or an assembly of heavy duty valves attached to the top of the casing to control well pressure
Borehole	The hole in the earth made by the drill; the uncased drill hole from the surface to the bottom of the well
By-catch	Organisms that are caught commercially but are not the target species, (e.g., haddock is often a by-catch of the cod fishery)
Caisson	A large-diameter pipe that houses a submudline wellhead
Chlorophyll	A green pigment found in all algae and higher plants. Responsible for light capture in photosynthesis
Climax	A community that has reached a steady-state under a particular set of environmental conditions
Cobble	A rounded rock fragment between 64 and 256 mm in diameter
Comprehensive Study Report (CSR)	A level of environmental assessment required pursuant to CEAA Sections 16(1)(2)
Continental Shelf	Gently sloping, shallowly submerged marginal zone of the continents extending from the shore to an abrupt increase in bottom inclination; greatest average depth less than 183 m, slope generally less than 1 to 1,000, local relief less than 18.3 m, width ranging from very narrow to more than 320 km
Crude Oil	Unrefined petroleum
Delineation Wells	Wells drilled after the initial exploration well to give a better understanding of the extent and performance of the reservoir
Demersal	Referring to animals, usually fish, associated with, but not living on, the sea bottom

Word	Definition
Detrital	Particles occurring in sedimentary rocks that were derived from pre-existing igneous, sedimentary or metamorphic rocks, or other pre-existing material
Detritus	Dead or decaying organic matter, and associated microorganisms that are responsible for its decomposition
Development Application	The official title of all the documentation submitted in support of the development of Hebron Project
Diatoms	Microscopic algae characterized by "pill-box like" cell walls containing silica
Dinoflagellate	A chiefly marine one-celled organism with resemblances to both plants and animals. Hard parts preserved as microfossils are important for dating and correlating Mesozoic and Cenozoic deposits
Drilling Mud	A special mixture of clay, water and chemical additives pumped down the wellbore through the drill pipe and drill bit to cool the rapidly rotating bit, lubricate the drill pipe as it turns in the wellbore, and carry rock cuttings to the surface; may have a water base or a synthetic oil base fluid
Ecosystem	The complex of a community and its environment functioning as an ecological unit in nature
Endangered	Descriptive of a species that is in danger of extinction within all or part of its range (the region to which it is native)
Environmental Impact Statement (EIS)	A document that attempts to predict the environmental effects a major development might have on the human and natural environments of a given geographic area. An EIS is prepared to enable industry, government and the public to consider the environmental and socio-economic costs and benefits of a development project. Based on the information in the EIS, decisions can be made on whether to proceed with the development project
Epifauna	Benthic animals living attached to or crawling over the bottom
Fault	A fracture or fracture zone along which there has been displacement of the sides relative to each other parallel to the fracture. The displacement may be a few millimetres or many kilometres
Fecundity	Potential reproductive capacity of an organism or population. In fish, fecundity is measured by the number of eggs
Flare	An arrangement of piping and burners used to burn combustible vapours - a part of emergency pressure relief system
Flaring	Disposal of surplus combustible vapours by burning at the discharge of the flare tower
Flatfish	Fish with a flattened body and both eyes on one side of the head. Includes plaice, flounder and halibut
Flowline	(a) A pipeline that takes fluids from a single well or a series of wells to a gathering centre. (b) Seabed piping that connects field components such as wells, manifolds and riser bases
Formation Water	See produced water
Geology	The study of the structure, origin, history and development of the Earth
Geostrophic	Pertaining to deflecting force resulting from the Earth's rotation

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Word	Definition
Grain	A general term for sedimentary particles of all sizes (from clay to boulders), as used in the expressions “grain size”, “fine-grained” and “coarse-grained”
Gravity Base Structure (GBS)	The base of an offshore drilling and production platform, usually made of concrete, and of such weight that it is held securely on the ocean bottom without the need for piling or anchors
Grey Water	Water that has been used for washing, showers, laundry, or in the galley and contains no hydrocarbons or high concentrations of chemicals
Groundfish	Species of fish that are collected by bottom gear trawls (e.g., cod, haddock and flounder)
Growler	The smallest category of iceberg size, with a sail extending less than 1.5 m above sea level and a water plane area of approximately 20 m^2. Comparable in size to a car and having a mass of less than 120 t
Gyre	Circular movement of water masses
Habitat	The place where an animal or plant lives, often characterized by some physical condition (e.g., stream habitat)
HADD	Harmful alteration, disruption or destruction (of fish habitat)
Hebron Unit	Comprises the four Hebron Significant Discovery Licences (SDL 1006, SDL 1007, SDL 1009 and SDL 1010)
Hertz (Hz)	Unit of sound frequency equal to one cycle per second
Heterotrophs	Organisms that receive nourishment by ingesting and breaking down organic matter from the surrounding water
Hurricane	A tropical cyclone with sustained wind speeds over 118 km/h, usually accompanied by rain, thunder and lightning
Hydroids	Typical colonial polyps with variously branched bushy or feathery growths. Each polyp has a crown of tentacles around the mouth
Ichthyoplankton	Collective term for fish eggs and larvae when planktonic
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
Inhibitor	A substance that is capable of stopping or retarding a chemical reaction
Injection Water	Water pumped into the formation to maintain reservoir pressure (secondary recovery technique); offshore, injection water is filtered seawater treated with biocides, an oxygen scavenger and scale inhibitor
Interannual	Year-to-year
Isobath	A line on a map or chart connecting points of equal water depth
Isopods	A group of crustaceans
Juvenile	Fish past the larval stage of development, but not yet large enough to be caught in the commercial fishery (e.g., cod remains juvenile for approximately four years)
Larvae	The first immature phases of many animals after hatching of eggs and before assuming the adult form and habit
Manifolds	A piece of equipment where the fluids from several wells are received and combined

Word	Definition
Megaripple	A large, gentle, ripple-like feature composed of sand in subaqueous environments having a wavelength grreater than 1 m or a ripple height greater than 10 cm. Wavelengths reach 100 m and amplitude approximately 0.5 m; may be formed by tidal currents
Mitigation	A procedure designed to reduce or negate the possible harmful effects of a substance or process on a species, habitat or environment
Mollusc	An animal possessing an external or vestigial calcium carbonate shell; including clams, snails and squid
Nursery Area	An area that supports fish during their first year of life
Operations Phase	The period following First Oil until cessation of all oil production from the Hebron Field, includes post-First Oil development drilling, offshore installation activities, production, operations, maintenance, well abandonment, decommissioning and removal from the Hebron Field of all facilities, equipment and vessels used in the production system
Operator	When capitalized in this document, refers to ExxonMobil Canada Properties (EMCP)
Pack Ice	Any area of sea ice, except fast ice, composed of a heterogeneous mixture of ice of varying ages and sizes and formed by the packing together of pieces of floating ice
Pebbles	Smooth rounded stones ranging in diameter from 2 to 64 mm
Pelagic Species	Animals which live or feed within the water column
Petroleum	Oil and natural gas
Photosynthesis	The use of the sun by plants to combine water and carbon dioxide into simple sugars
Phytoplankton	Planktonic (i.e., floating or swimming) photosynthesizing organisms that are mostly single-celled, although some are colonial; some are capable of swimming, while others are incapable of independent motion
Plankton	Plant (phytoplankton) and animal (invertebrate (zooplankton) and fish eggs and larvae (ichthyoplankton)) organisms that drift with ocean currents
Platform	A large structure used during the development and production phases to support such facilities as the drilling rigs, living quarters, production equipment and helipads
Plume	a column of one fluid or gas moving through another
Polychaete	A marine worm with true body segments and hard spines
Pool	A unique accumulation of petroleum whose limits are established by subsurface geologic factors
Porosity	The volume of the pore space expressed as a percentage of the total volume of the rock mass
Primary Production	Carbon fixation during photosynthesis by plants including phytoplankton
Produced Water	Water brought up from hydrocarbon bearing strata during the extraction of oil and/or gas and can include formation water, injection water, small volumes of condensed water and trace amounts of treatment chemicals

Word	Definition
Production Platform	An offshore structure equipped to receive oil or gas from offshore wells where primary processing, compression and pumping are carried out before transportation of the oil or gas to shore
Productivity	(a) Production rate of oil, gas or water per unit differential pressure; (b) The rate of production of new biomass by populations of organisms
Recruitment	The addition of individuals to a population through reproduction and immigration
Reserves	That part of an identified resource from which a usable mineral or energy commodity can be economically and legally extracted at the time of determination
Reservoir	A subsurface rock body in which gas or oil has accumulated; most reservoir rocks are porous and permeable, usually limestones, sandstones or dolomites (or a combination)
Residual Environmental Effect	Those environmental effects remaining after enhancement and mitigation measures have been applied
Resource	An initial volume of oil and gas that is estimated to be contained in a reservoir
Rig	Refers to the combination of equipment used to drill wells
Riser	A section of pipe involving vertical or near-vertical flow
Satellite	In this document, satellite refers to a remote facility or installation that cannot operate entirely independently of a central facility
Scour	(a) Seafloor trench caused by the ploughing motion of an iceberg grounding on the ocean floor. (b) Seafloor erosion caused by strong currents, resulting in the redeployment of bottom sediments and formation of holes and channels
Sea Ice	Any ice floating in the sea
Sediment	Solid material, both mineral and organic, that is being or has been transported from its site of origin by air, water or ice, and has come to rest on the Earth's surface either above or below sea level
Seismic	Pertaining to, characteristic of or produced by earthquakes or Earth's vibration
Seismicity	The phenomenon of Earth's movements; seismic activity
Sessile	Organisms that are fixed to substrate
Shuttle Tanker	A ship with large tanks in the hull for carrying oil or water back and forth over a short route
Significant Discovery License (SDL)	The document of title by which lands are held within a Significant Discovery Area. Ownership of a Significant Discovery License must be homogeneous; therefore, there may be several Significant Discovery Licenses comprising a Significant Discovery Area if ownership of the Significant Discovery Area is multi-partied
Silt	A detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 0.004 to 0.0625 mm

Word	Definition
Stock	A species, group or population that maintains and sustains itself over time in a definable area. A stock is characterized by constancy of the genetic information in the gene pool, and constancy of expression of particular characters controlled either genetically or environmentally. Examples include maintenance of colour variations or particular growth rates
Storm Surge	A rise above normal water level due to the action of wind on the water surface and the rise in level because of atmospheric pressure reduction
Stratification	Division of the water column into layers, or strata, because of differences in water density, structure or temperature
Surficial	Characteristic of, pertaining to, formed on, situated at, or occurring on the Earth's surface; especially, consisting of unconsolidated residual, alluvial or glacial deposits lying on the bedrock
Tectonic	Of, or relating to the deformation of the Earth's crust; the forces involved in or producing such deformation, and the resulting forms
Template	Template in this context refers to the subsea structure designed to support a collection of wells
Thermocline	A temperature gradient as in a layer of sea water, in which the temperature decrease with depth is greater than that of the overlying and underlying water
Threatened Species	In Canada, an indigenous species that is likely to become endangered if the factors affecting its vulnerability are not reversed
Topside Facilities	All the oil and gas separation, treatment and production equipment and related equipment such as compressors, flares and accommodations located on top of an offshore facility
Transshipment Facility	An intermediate onshore facility that receives and stores crude oil from oilfield shuttle tankers and subsequently transfers the oil to market via tanker
Tree	a) An arrangement of valves placed on top of a well to control flow from the well b) An arrangement of valves and fittings attached to the tubing head to control flow and provide access to the tubing string (also referred to a an Christmas tree)
Trophic Level	The position an organism occupies in the food web, determined by the number of energy transfer steps needed to get to that point
Tropical Storm	A tropical cyclone with sustained wind speeds from 61 to 118 km/h
Tsunami	A long-period sea wave produced by a submarine earthquake, also known as a seismic sea wave. It may travel for thousands of kilometres
Upwelling	Light surface water transported away from a coast (by action of winds parallel to it) and replaced near the coast by heavier subsurface water
Viscosity	The measure of the resistance of a fluid to flow; the lower the viscosity number, the more readily the fluid will flow
Water-based Mud (WBM)	A drilling mud in which the continuous phase is water
Water Column	The vertical dimension of a body of water (i.e., the water between a reference point or area on the surface and one located directly below it on the bottom)
Wave Hindcasting	Prediction of waves based on past meteorological conditions

Word	Definition
Well Completion	The final sealing-off of a drilled well from the borehole with valving and safety and flow-control devices, following final cementing and perforation of the casing at the production zone and removal of the drilling apparatus from the borehole
Wellhead	The equipment installed at the top of the wellbore used to support the casing strings and upon which the tree is installed; it controls the rate of flow of liquid and gas from the well
Zooplankton	The animal component of those organisms drifting or weakly swimming in the ocean, largely at the mercy of prevailing currents

Note: Bolded words within a definition are themselves defined

19.2 Acronyms

Acronym	Definition
ACAP	Atlantic Coastal Action Program
API	American Petroleum Institute
asl	Above sea level
BIO	Bedford Institute of Oceanography
BOEMRE	US Bureau of Ocean Energy Management, Regulation and Enforcement
BTEX	Benzene, toluene, ethylbenzene, xylene
CAC	Criteria air contaminants
CAPP	Canadian Association of Petroleum Producers
CCG	Canadian Coast Guard
CCME	Canadian Council of Minsters of the Environment
CEAA	Canadian Environmental Assessment Act
CEA Agency	Canadian Environmental Assessment Agency
CFU	Compact Flotation Unit
CH_4	Methane
CHS	Canadian Hysrographic Service
CIS	Canadian Ice Service
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPA	Closest Point of Approach
CPAWS	Canadian Parks and Wilderness Society
CSA	Canada Shipping Act
CWS	Canadian Wildlife Society
DFO	Fisheries and Oceans Canada

Acronym	Definition
DSM	Drilling Support Module
EBSA	Ecologically and Biological Significant Area
ECM	Environmental Compliance Monitoring
ECRC	Eastern Canada Response Corporation
EEM	Environmental Effects Monitoring
EEZ	Exclusive Economic Zone
EL	Exploration Licence
ENGO	Environmental Non-Governmental Organization
EOC	Emergency Operations Centre
EPP	Environmental Protection Plan
FEED	Front-end Engineering and Design
FFAW	Fish, Food and Allied Workers Union
FGCP	Fishing Gear Compensation Program
FLO	Fisheries Liaison Officer (on-board)
FPSO	Floating Production, Storage and Offloading (facility)
FRCC	Fisheries Resources Conservation Council
GHGs	Greenhouse ggases
GLC	Ground-level concentration
H_2S	Hydrohen sulphide
Hmax	Maximum individual wave height
Hs	Significant Wave Height
HSE	Hibernia South Extension
HUC	Hookup and Commissioning
IBA	Important Bird Area
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
ICS	Incident Command System
IIP	International Ice Patrol
IPCC	Intergovernmental Panel on Climate Change
MANMAR	Manual of Marine Observations
MCP	Marine Code of Practice
MMS	US Minerals Management Service
MODU	Mobile Offshore Drilling Unit
MOU	Memorandum of Understanding
MP / HP	Medium pressure / high pressure
MSL	Mean Sea Level
N_2O	Nitrous oxide
N&C	Notification and Communications
NAAQ	National Ambient Air Quality
NAF	Non-Aqueous Fluid used for drilling (e.g., SBM)

Acronym	Definition
NAFO	Northwest Atlantic Fisheries Organization
NAO	North Atlantic Oscillation
NARRT	North American Regional Response Team
NEB	National Energy Board
NLDEC	Newfoundland and Labrador Department of Environment and Conservation
NMCA	National Marine Conservation Area
NMFS	US National Marine Fisheries Service
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NOAA	US National Oceanic and Atmospheric Administration
NPRI	National Pollutant Release Inventory
OIM	Offshore Installation Manager
OLS	Offshore Loading System
OSC	On-Scene Commander
OSP	Oil Spill Response
OSRP	Oil Spill Response Plan
OWTG	Offshore Waste Treatment Guidelines
PAH	Polycyclic Aromatic Hydrocarbon
PAL	Provincial Aerospace Ltd.
PBGB LOMA	Placentia Bay-Grand Banks (PBGB) Large Ocean Management Area (LOMA)
PM	Particulate Matter
PTS	Permanent Threshold Shift
PWRI	Produced water re-injection
RA	Responsible Authority
REET	Regional Environmental Emergency Team
ROV	Remote Operated Vehicle
RV	Research Vessel
SAR	Species at Risk
SARA	Species at Risk Act
SBM	Synthetic-based mud
SO_2	Sulphur dioxide
SOP	Standard Operating Procedure
SPOC	Single Point of Contact
SSH&E	Safety, Security, Health and Environment
THmax	Wave period associated with Hmax
Tp	Peak wave period
TPH	Total Petroleum Hydrocarbons
TPM	Total Particulate Matter

Acronym	Definition
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
UPM	Utilities and Processing Module (Integrated Deck)
VDS	Volatile Deposited Solids
VEC	Valued Ecosystem Component
VFA	Volatile Fatty Acid
VME	Vulnerable Marine Ecosystem
VOC	Volatile Organic Compund
VSP	Vertical Seismic Profile
VTMP	Vessel Traffic Management Plan
WHGBS	Wellhead Gravity-base Structure
WHMIS	Workplace Hazardous Management Information System

19.3 Abbreviations (units of measure)

Abbreviation	Definition
bbl	Barrel (approximately 159 L)
BF	Beaufort Force
cm	centimetre
dB	Decibel
h	Hour
Hz	Hertz
kbd	Thousand barrels per day
kHz	Kilohertz
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometre
L	Litre
m	Metre
m^3	Cubic metre
m^3/day	Cubic metre per day
Mbbl	Thousand barrels
MBO	Million barrels of oil
mg	Milligram
mg/L	Milligram per Litre
mm	Millimetre
MSCFD	Thousand Standard Cubic Feet Per Day
MW	Megawatt

Abbreviation	Definition
nm	nautical mile
ppb	Parts per billion
ppm	Parts per million
s	Second
t	Metric tonne
µg	Microgram
µm	Micrometre

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Consultation Report

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The Hebron Project

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1.0 INTRODUCTION

ExxonMobil Canada Properties (EMCP), as Operator, on behalf of the Hebron Project Proponents, ExxonMobil Canada Ltd., Chevron Canada Limited (Chevron), Suncor Energy, Statoil Canada Limited (Statoil) and Nalcor Energy – Oil and Gas Inc. (Nalcor), is leading the development of the Hebron Project. As the Operator, EMCP is required to submit a Development Plan (the Comprehensive Study Report (CSR) fulfils the requirement of the Environmental Impact Statement (EIS) supporting document) for approval. An EIS is required as a component of this Application. Therefore, this environmental assessment of the Hebron Project will address the requirements of the *Canadian Environmental Assessment Act* (CEAA) and the *Canada-Newfoundland Atlantic Accord Implementation Act* (S.C. 1987, c.3) and the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (R.S.N.L. 1990, c. C-2).

ECMP recognizes the importance of communications with federal, provincial and municipal regulatory agencies, stakeholders, and the public and conducted an extensive stakeholder consultation program as part of the issues scoping exercise for the Project. This document outlines the formal consultation program initiated by EMCP, which met the requirements of CEAA.

2.0 METHODOLOGY

The scoping and consultation program focused primarily on the areas most likely to be affected by the Project, including the Isthmus region, Marystown and St. John's. However, it also reached a wider audience through meetings in other communities and through general solicitation of input from press releases, advertisements and the Project website.

To the end of December 2009, the public information and consultation program included:

- Three Key Informant Workshops (one each in Clarenville, Marystown, and St. John's)
- One Inshore Fisher Workshop (Bellevue)
- One Offshore Fisher Workshop (St. John's)
- One workshop with Environmental Non-Governmental Organizations (ENGOs) (St. John's)
- One follow-up meeting with ENGOs (St. John's)
- Eight open houses (two each in Clarenville, Marystown, St. John's and Corner Brook)
- One Safety, Security, Health and Environment (SSH&E) information session for contractors (St. John's)
- Four Procurement Information Sessions for business owners (one each in Clarenville, Marystown, St. John's and Corner Brook)

- Meetings with community, women's and business groups (Clarenville, Arnold's Cove, Marystown, St. John's and Corner Brook) and
- Meetings with municipal leaders (Clarenville, Arnold's Cove, Marystown, St. John's and Corner Brook)

The following tools were used to provide information to the public and to obtain input:

- Project Description as submitted to the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB)
- Overview presentations given at each of the workshops, which provided an overview of the Project including information on the Project description, overview of ExxonMobil, Project schedule and Benefits Agreement
- Display boards and take-home booklets of the display boards
- Comment forms
- Project website (www.hebronproject.com) and
- Media briefings

3.0 WORKSHOPS

Workshops were conducted with key stakeholder groups to provide information on the Project and to discuss concerns or questions raised by the participants. At all sessions, a PowerPoint presentation was given by an EMCP representative, describing the Project design, activities and schedule, with reference to similarities and differences between the current Project and the Hibernia project because of their similar design and construction process. A total of 66 people participated in the six workshops.

3.1 Commercial Fisher Workshops

As an introduction to the Project, EMCP participated in a fishers conference held by One Ocean in February 2009. The conference was held in St. John's and was attended by over 100 people. EMCP representatives presented an overview of the Project. Some concerns were raised at this conference regarding potential impacts that the Project could have on commercial fishers.

Following the One Ocean Conference, two Commercial Fisher Workshops were held to provide additional information on the Project and to record the issues and concerns of commercial fishers who work in the Bull Arm Project Area and the Offshore Study Area (Table 3-1).

Table 3-1 Fisher Workshop Attendance

Type of Workshop	Location	Date	Actual Number of Participants
Inshore Commercial Fishers	Bellevue	August 12, 2009	9
Offshore Commercial Fishers	St. John's	December 3, 2009	12
Total			21

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The Inshore Commercial Fisher Workshop was held in Bellevue on August 12, 2009, with the goal of providing information to local fishers and gaining knowledge of their experiences with previous large construction projects in Bull Arm. A total of seven commercial inshore fishers from local Bull Arm communities and representatives from the Fish, Food and Allied Workers Union and One Ocean attended the Workshop. Three members of the EMCP team, including environmental, regulatory and engineering representatives, were present to provide information on the Project design, activities and schedule and provided copies of the Project Description report to all attendees. Attendees were encouraged to ask questions and provide comment throughout the presentation and all concerns were recorded. The discussion focused on local fisheries (historic, current and future), past experience with construction projects in the region, waste management, types of activity at the site before and during construction and concern that the knowledge of local fishers be incorporated and used by the Project team.

The Offshore Commercial Fisher Workshop was held in St. John's on December 3, 2009. It was attended by 12 people, including local offshore fishermen and representatives from the Fish, Food and Allied Workers Union and One Ocean. Similar to the Inshore Commercial Fisher Workshop, Project representatives presented information about the Project to attendees and encouraged them to provide comment and ask questions throughout the session. Some of the concerns that were expressed by attendees included effects of the oil and gas industry on travel routes to and from fishing grounds, damage to fishing gear from seismic activity and timing public meetings and report reviews during non-fishing season so that more fishers can participate. There was also some concern that the oil and gas industry would displace fishers from traditional fishing grounds and that oil spills would destroy fishing areas.

3.2 Key Informant Workshops

Three Key Informant Workshops were held in Clarenville, Marystown and St. John's in August 2009 to ensure that community issues and concerns were identified and to learn about past experience with other large industrial construction Projects, such as Hibernia and White Rose. Invitations to attend were sent to key informants to ensure that a wide range of local interests were represented, that people with an appropriate level of experience with past projects were present, and so that the group size was conducive to an open discussion. A total of 39 people participated in the three workshops, representing a range of community sectors and interests including local business and development associations, municipal and provincial government, housing, education, recreation and public safety (Table 3-2). Three representatives from EMCP attended each workshop.

Table 3-2 Key informant Workshop Attendance

Location	Date	Actual Number of Participants
Clarenville	August 18, 2009	18
Marystown	August 19, 2009	9
St. John's	August 20, 2009	12
Total		39

Each workshop involved a PowerPoint presentation given by an EMCP representative providing an overview of the Project design, activities and schedule. This was followed by an informal, facilitated discussion of issues and concerns. The main concerns voiced by participants related

to housing and rent costs, a need to consult with the youth and encourage appropriate training, highway safety, the definition of 'local benefits' and the need for the communities adjacent to Bull Arm to benefit and the need for further, timely, communication about Project activities.

3.3 Environmental Non-Governmental Organization workshop

The ENGO Workshop was held on September 11, 2009, in St. John's. Three members of the EMCP team and six ENGO representatives participated. The ENGOs that attended are listed in Table 3-3.

The purpose of the Workshop was to provide Project information to the ENGO representatives, answer any questions, and to document their concerns regarding the Project directly to the EMCP team. A PowerPoint presentation on the Project design, activities, and schedule, was given by an EMCP representative and copies of the Project Description report were provided to attendees. Discussion was encouraged throughout the presentation and was focused on small/chronic oil spills and their effects on sea birds, flaring and sea birds, marine mammals, tanker traffic and responsibility for vessels and their discharges, access to and transparency of monitoring data, produced water re-injection, and ice management.

Table 3-3 Environmental Non-Governmental Organization Workshop Attendance

Location	Date	Groups in Attendance	Number of Participants
St. John's	September 11, 2009	Sierra Club Natural History Society Newfoundland and Labrador Environmental Association Northeast Avalon Atlantic Coastal Action Program (ACAP) Alder Institute Canadian Parks and Wilderness Society (CPAWS) Whale Release and Stranding Newfoundland and Labrador Environmental Network	6

A follow-up meeting with ENGOs was held on January 27, 2010, in response to letters received from Atlantic Coastal Action Program (ACAP) and Canadian Parks and Wilderness Society (CPAWS) posing questions about the Project Description. Three members from the EMCP team and three ENGO (ACAP, CPAWS and Natural History Society) representatives were in attendance. EMCP team members opened the meeting with an overview of the status of the Project and the environmental assessment process. The team then proceeded to answer the questions from the ENGOs' letters, which pertained to the transportation of materials, including oil and mud, the origin of well fillers, discharge of produced water and availability of Project information to the general public.

4.0 OPEN HOUSES

A series of eight open houses were held in September 2009, with two sessions each held in Clarenville, Marystown, St. John's and Corner Brook. Attendance was open to all members of the public, with 222 people attending (Table 4-1). The sessions were held from 2 to 4 pm and from 7 to 9 pm in each community, allowing people to attend at their convenience.

Table 4-1 Open House Attendance

Location	Venue	Date	Time	Number in Attendance
Clarenville	Clarenville Inn	September 14, 2009	2:00-4:00 pm	16
			7:00-9:00 pm	21
Marystown	Hotel Marystown	September 15, 2009	2:00-4:00 pm	22
			7:00-9:00 pm	7
St. John's	Delta Hotel	September 17, 2009	2:00-4:00 pm	79
			7:00-9:00 pm	38
Corner Brook	Greenwood Inn	September 21, 2009	2:00-4:00 pm	15
			7:00-9:00 pm	24
Total				222

The open houses provided an opportunity for the general public to speak directly with the senior Hebron Project Management Team to voice their interests or concerns. At least 10 EMCP representatives were present at each open house to answer any questions and document issues raised, including engineering representatives and coordinators of the Development Application, including the CSR, Socio-economic Impact Statement (SEIS) and Benefits Plan.

4.1 Public Notification

Advertisements for the open houses were placed in regional weekly newspapers, in *The Telegram* (daily publication), on the Project website, and broadcast on local radio stations.

The newspaper advertisements listed the location, date, time and location for each event (Appendix A). The papers that ran the ads and the publication dates are listed in Table 4-2.

Table 4-2 Newspaper Publications for Open Houses

Location	Paper	Publication Dates
St. John's	*The Telegram*	September 7, 9, 12, 16th
Corner Brook	*The Western Star*	September 12, 16, 19th
Port aux Basques	*The Gulf News*	September 14th
Bay Roberts	*The Compass*	September 15th
Stephenville	*The Georgian*	September 15th
Clarenville	*The Packet*	September 10th
Placentia	*The Charter*	September 8th
Grand Bank	*The Gazette*	September 8th

A total of 236 advertisements were broadcast on various radio stations (Table 4-3). Each ad ran for 30 seconds.

Table 4-3 Radio Announcements for Open Houses

Location	Radio Station	Number of Ads	Broadcast Dates
St. John's	VOCM	40	September 8-17
Clarenville	VOCM	38	September 5-13
Marystown	VOCM	38	September 5-14
Corner Brook	VOCM	40	September 8-21
Corner Brook	K-ROCK	40	September 8-21
Island Wide	OZ-FM	40	September 9-21

4.2 Open House Format

Each open house began with a brief presentation on ExxonMobil's corporate structure, experience with large projects, introduction of the Project team, and gave an overview of the Project design, schedule and Benefits Agreement with the Province. Slides from the presentation are provided in Appendix B. The presentation was followed by a question and answer session with the Senior Project Management Team. Display boards were set up in the room describing ExxonMobil, the Project, regulatory requirements, benefits and procurement / contracting. A booklet containing small versions of the display boards were provided to all attendees. The display boards are provided in Appendix C. After the question and answer session, attendees were given the opportunity to discuss concerns and pose questions one-on-one to members of the EMCP team who were stationed near their respective display boards.

Comment forms were provided to attendees upon sign-in and 134 of these were completed and returned to the Project team. The comment form is provided in Appendix D. In addition to providing feedback, these forms were used to draw for door prizes at each open house. In general, attendees expressed a positive attitude toward the Project, were pleased with the content and delivery of the presentation and seemed eager to receive any updated information in the future. Some participants expressed an interest in receiving information about possible employment opportunities.

4.3 Summary of Comment Forms

The primary discussion at the open houses was related to benefits, including ensuring economic and employment benefits will be delivered at the local community level, the role of unions in construction, how individuals can find information on employment during construction, diversity, how the Benefits Agreement will influence Project contracting and skill requirements and training opportunities. Other items noted were the use of tankers and the Newfoundland Transshipment Terminal by the Project, the need to engage youth, Research and Development spending and the need for information regarding the construction camp at Bull Arm.

4.4 Project Team

Project Team members from Exxon Mobil who attended the open houses are listed in Table 4-4.

Table 4-4 Project Team Members

Team Member	Position	Open Houses Attended
Hareesh Pillai	Sr. Project Manager	All
David McCurdy	Technical Manager	All
Lynn Ann Nicholosi	Business Manager	All
Margaret Bruce-O'Connell	Public Affairs Manager	All
Lynn Evans	Public Affairs Advisor	All
Leslie Grattan	Environmental/Regulatory Advisor	All
Kim Coady	Environmental Lead	All
Steve Young	Benefits Manager	All
Karen Thomas	Gravity Base Structue (GBS) Interface Lead	All
Wes Whalen	Safety Advisor	All
Randy Mercer	Security Advisor HMDC	All
Cathy Trask	Diversity Manager	All but Corner Brook
Chuck Mueller	GBS and Offshore Loading System (OLS) Manager	St. John's
Ted O'Keefe	Regulatory Lead	St. John's

5.0 CONTRACTOR FORUMS

Two types of forums for potential contractors were organized by EMCP in 2009: Procurement Information Sessions; and a Contractor SSH&E Forum.

5.1 Procurement Information Sessions

A series of Procurement Information Sessions were held in St. John's, Clarenville, Marystown and Corner Brook in April 2009 (Table 5-1). The purpose of these sessions was to provide information to local businesses regarding the contracting strategies to be employed by EMCP for the Hebron Project and enable local companies to prepare for upcoming opportunities. A total of 565 people attended these sessions.

Table 5-1 Contractor Forum Attendance

Location	Date	Number of Participants
St. John's	April 7, 2009	392
Clarenville	April 8, 2009	72
Marystown	April 9, 2009	44
Corner Brook	May 13, 2009	57
Total		565

5.2 Contractor Safety, Security, Heath and Environment Forum

The Contractor SSH&E Forum was held on June 30, 2009, in St. John's. The purpose of the Forum was to promote and share best practices in safety, security, health and environment. It was attended by 269 people. The safety session was advertised on the Project and Newfoundland Ocean Industries Association (NOIA) websites, as well as in the *Telegram* on May 30, June 3, June 13, June 20 and June 24. The SSH&E Forum advertisement is in

Appendix E. Invitations were sent to presenters and to heads of key government departments and organizations.

6.0 OTHER CONSULTATION/ISSUES SCOPING ACTIVITIES

6.1 Other Community Meetings

EMCP representatives have held meetings with municipal leaders and regional business groups between April and September 2009 while preparing the CSR. Meetings were held with representatives from the towns of Arnold's Cove, Come By Chance, Clarenville, Burin, St. Lawrence, Marystown, St. John's and Corner Brook, as well as chamber of commerce representatives in the isthmus and Marystown regions (Appendix F). At each of these meetings, EMCP gave brief presentations about the Project and addressed questions posed by participants. Discussions were focused primarily on economic benefits and development. Approximately 1,500 people attended these meetings.

In addition to these meetings, EMCP gave a Project overview presentation at the annual oil and gas industry conference hosted by NOIA in June 2009. After the brief presentation there was an opportunity for questions which included questions on concept selection.

A presentation was also given to the membership of the Association of Professional Engineers and Geoscientists of Newfoundland and Labrador (PEGNL) in June 2009. This presentation was attended by 200 members of PEGNL.

6.2 Meetings with Government Departments and Agencies

Since the Project was first proposed, key government officials and regulators (municipal, provincial and federal) have been consulted, both formally and informally, on an ongoing basis. The objective of these consultations was to provide information and updates on the Project and the environmental assessment, and also to receive input and guidance as appropriate. The C-NLOPB and following Federal Authorities have been regularly consulted both before and since filing of the Project Description:

- Major Projects Management Office
- Canadian Environmental Assessment Agency
- Transport Canada
- Fisheries and Oceans Canada
- Environment Canada and
- Industry Canada

There have also been on-going meetings with provincial Minister of Natural Resources and deputy ministers and assistant deputy ministers, to keep them apprised of Project developments.

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These consultations have involved one-on-one meetings (locally and in Ottawa), telephone conversations and e-mail correspondence.

6.3 Media Briefings and Tracking

EMCP responds to media inquiries as appropriate and has provided information about the project to local, national and international media. A media briefing was provided on October 1, 2008, when Exxon Mobil assumed operatorship of the Project.

EMCP has been regularly monitoring the provincial media, including print, broadcast and electronic news media. Issues that are noted are incorporated into EMCP's issues tracking database. Media briefings and newspaper articles about the Project and Exxon Mobil are included in this Appendix G.

6.4 Project Website and Telecommunications

To increase accessibility and communication, EMCP has established a Project website (http://www.hebronproject.com), which has been widely advertised and promoted during presentations at Workshops and open houses. It contains information about the Project, including a full Project description, information about procurement and SSH&E and the presentation that was provided at open houses.

The website is updated regularly and it has a feedback section inviting users to provide comment on the website. Between September 1 and December 19, 2009, the website received a total of 9,310 visits. Of these, 4,941 were from absolute unique visitors, 34.75 percent were from direct traffic, 25.57 percent were from referring sites and 39.68 percent were from search engines. Two visitors filled out the online feedback form.

6.5 Project Information Distribution

Information was made available to the public primarily through the Project and NOIA websites, through media interviews and through targeted stakeholder meetings and those organizations subsequently providing updates to their members, as well as through presentations at industry and other events.

7.0 SUMMARY OF COMMENTS, QUESTIONS, ISSUES AND CONCERNS

The main message heard throughout the scoping / consultation program was that most participants are supportive of the Project and want to see it proceed in a manner that provides the maximum benefit, especially to those communities adjacent to the construction sites at Bull Arm and Marystown.

Issues raised throughout the consultation program related to the environmental effects of the Project have been incorporated in Project planning and are reflected in this CSR. A summary of

concerns raised by participants in the Key Stakeholder Workshops and open houses, and the section within the CSR or SEIS where they are addressed, is provided in Table 7-1.

Table 7-1 Issues Identified Through Issues Scoping Process

Comment	Response or Section
Accidental Events	
Include oil / chemical spills associated with tanker traffic	CSR Section 2.9.5
Include chronic small oil/chemical spills in modelling and predictions	CSR Sections 14.1.3, 14.2, 14.3
Include and specify oil spill data from Newfoundland and Labrador	CSR Sections 14.1, 14.2, 14.3
Effects and probability of blowouts	CSR Sections 7.5.4, 8.5.3, 9.5.4, 10.5.4, 11.4.1.4, 11.4.3, 11.5.3, 11.6.3, 12.5.1, 14.1.1
Probability of impact from icebergs and modelling scenarios used	CSR Sections 2.9, 2.9, 3.1.4, 3.2.3, 13.3, 13.4, 14.4, 14.6, 17.1
Birds	
Impacts of flaring on sea birds	CSR Section 9.5.2
Impacts of chronic small oil spills on sea birds	CSR Section 9.5.4
Monitoring programs for sea birds	CSR Section 9.5.7
Business	
Need to maximize benefits to local businesses, contractors and suppliers	Hebron Benefits Plan, SEIS Chapter 4
Accommodation of employees during construction – construction camp *vs.* living/renting in adjacent communities	SEIS Section 6.1.3
Will there be business opportunities in western Newfoundland?	Hebron Benefits Plan, SEIS Section 2.1
Commercial Fisheries	
Need to time blasting to prevent impact on migrating fish populations	CSR Sections 8.4.1, 8.5.1, 8.5.4
Concerns regarding local crab populations near the deepwater mooring site if any dredging or dumping were to take place.	CSR Sections 8.4.1, 8.5.1, 8.5.4
Concern that nearshore fishers would be prohibited from fishing grounds in Bull Arm, specifically near the Deepwater Site	CSR Sections 8.4.1, 8.5.1, 8.5.4
Concern that activities and additional vessel traffic associated with GBS construction will disrupt harvesting operations	CSR Sections 8.4.1, 8.5.1, 8.5.4
Effects of construction-related noise and lights on catchability	CSR Sections 8.4.1, 8.5.1, 8.5.4
Concern related to loss and damage to fishing gear	CSR Section 8.4.1
Concern that offshore fishing grounds will be lost due to additional safety zones and exclusion zones	CSR Section 8.4.1
Effects of on-going oil and gas exploration and production on the Grand Banks on future fisheries	CSR Section 8.4.1
Economy and Economic Benefits	
Compensation for fishers who are displaced from their usual fishing grounds due to the Project	CSR Section 8.5.1, SEIS Sections 7.4.5, 7.4.6
Need to maximize benefits to communities adjacent to the construction site(s), including employment and business opportunities	Hebron Benefits Plan, SEIS Chapters 4 and 5
Need to maximize employment of Newfoundlanders and Labradorians	Hebron Benefits Plan, SEIS Chapter 4
What topside modules will be fabricated in Newfoundland and Labrador?	CSR Sections 2.7, 2.8.4
Where will engineering work be completed?	CSR Section 2.9, Hebron Benefits Plan
Education and Training	
Need to work with schools and youth (especially girls) to encourage participation in trades programs	Hebron Benefits Plan, Hebron Diversity Plan, SEIS Appendix A
Need to encourage school-age girls to enter non-traditional careers	Hebron Diversity Plan, SEIS Section 7.5 and Appendix A
What forms of training will EMCP provide?	Hebron Benefits Plan, SEIS Section 7.5.4

Comment	Response or Section
Employment	
Where will the 3,000 qualified workers for construction come from?	SEIS Section 4.3
Project employment during Operations?	Hebron Benefits Plan, SEIS Section 4.3
Aside from Bull Arm, where will construction work be completed?	Hebron Benefits Plan, SEIS Section 4.0
Need to provide timely information regarding employment to residents of Newfoundland and Labrador working in western Canada who may want to return to the Province	Hebron Benefits Plan
Need to work with unions to maximize employment opportunities for qualified individuals from communities adjacent to construction site	Hebron Benefits Plan
Will there be employment opportunities for non-union tradespeople?	Hebron Benefits Plan
Need to work with unions to develop hiring practices to encourage hiring of members of diversity groups (women, aboriginal persons, persons with disabilities, and visible minorities)	Hebron Benefits Plan
Need to work with education and training institutions to ensure there are enough people to meet Project requirements during both Construction and Operations	Hebron Benefits Plan
Will the Project be designated as a 'Special Project' by the provincial government?	To be addressed in the Development Application
Endangered or Special Status Species	
Effects of planned discharges on marine life and sea birds	CSR Section 11.4.2, 11.6.2
Effects of chronic small oil / chemical spills on marine life and sea birds.	CSR Section 11.4.3, 11.6.3
Effects of blowouts on marine life and sea birds	CSR Section 11.4.3, 11.6.3
Environmental Assessment/Development Application	
Inclusion of tanker traffic associated with the Project in the assessment	CSR Section 2.9.5
Incorporate comments from previous offshore assessments	CSR (general)
Environmental Management	
Local fishers should be consulted in regard to monitoring programs for fish and fish habitat	CSR Section 8.5.1
Fish and Fish Habitat	
Impacts of chronic small oil/chemical spills on marine life	CSR Section 7.5.4
Effects of dredging in Bull Arm on water quality	CSR Section 7.5.1.2
Effects of blasting on pelagic fish species (herring, mackerel, capelin)	CSR Section 7.5.4
Effects of oil spill on herring spawning grounds in Bull Arm	CSR Section 7.5.4, 12.5.1.1
Health and Safety	
Road safety, especially on highways, during winter months	SEIS Section 5.3.3
Lack of cell phone coverage on the Burin Peninsula highway	SEIS Section 5.3.3
Marine Mammals	
Effects of blasting on marine mammals	CSR Section 10.5.1
Monitoring	
Provide public access to 24-hour monitoring raw data for produced water and other waste streams	CSR Chapter 15
Provide public access to Environmental Effects Monitoring (EEM) raw data	CSR Chapter 15
Monitoring programs for fish and fish habitat	CSR Section 7.5.7
Public Involvement	
Need to consult with small communities adjacent to the Bull Arm site which are serviced by Local Service Councils	SEIS Section 7.5.8
Direct communication between EMCP and the public needs to be ongoing	CSR Section 5.1
Need to engage youth	Hebron Benefits Plan, SEIS Appendix

Comment	Response or Section
Important to communicate the results of the CSR and Socio-economic Impact Statement to the public	CSR Section 5.1
Research and Development	
The oil industry needs to fund fish/fishery research as they are displacing the fishing industry	Hebron Benefits Plan
What percentage of the $120 million committed to Research and Development will be spent on basic and applied research?	Hebron Benefits Plan
Services and Infrastructure	
Capacity of local communities to house in-migrants and the effect on housing / rent prices	SEIS Section 6.1
Health and social service requirements resulting from the Project	SEIS Section 5.2
Accomodation of employees during construction – construction camp *vs.* living/renting in adjacent communities	SEIS Section 6.1.3
Traffic concerns on Trans Canada Highway due to Project-related commuting of people and materials, especially during winter months	SEIS Section 5.3.3
Concern that local infrastructure (roads, wharves) are not adequate to accommodate industrial use without incurring damage	SEIS
Concerns regarding women's employment and access to childcare	Hebron Benefits Plan, Hebron Diversity Plan
Technical / Project Description	
Will the GBS have an ice wall? Will the GBS be built to withstand impact from an ice berg?	CSR Sections 2.6, 2.7, 2.8.2
Will there be underwater blasting for creation of the berm at Bull Arm?	CSR Section 2.8.1
What is the size of the drydock in Bull Arm?	CSR Section 2.8.1
Will the production platform be able to produce natural gas in addition to oil?	CSR Section 2.11
Quantify amount of flaring	CSR Sections 2.9, 6.3.2, 2.6.2.2
Does the Project include pre-drilling of wells offshore?	CSR Section 2.8.6
What is the transportation process of oil to market?	CSR Section 2.9.5
What is the transportation methods for drilling muds and drill cuttings to and from the offshore site?	CSR Section 2.9
Where will oil well fillers (drill muds and cuttings) originate from?	CSR Section 2.9.5
Could the Project office be located in Clarenville?	Project offices tend to be located near the hub of technical expertise and near an airport, which at this point in the project is St. John's (from the response at the Open House in Clarenville, Sept 14 2009)
Waste Management	
Concern regarding floating debris / waste from the deepwater construction site	SEIS Section 7.4.8
Waste from the construction sites may exceed capacity of local waste management sites	SEIS Section 7.4.8

Issues raised during the consultation program related to industrial benefits, employment, development concept, and construction and operational matters are addressed in the Project Development Application.

APPENDIX A

Open House Advertisement

022834

Hebron

You're invited to a

Public Information Session on the Hebron Project

Your opinion matters.

Interested members of the public are invited to attend public information sessions with the senior decision makers of the Hebron project. It's an opportunity to speak directly with the project leaders and share your input on the development of the Hebron project as it relates to you, your community and your province.

The Hebron project team will be visiting the following locations:

Date	Community	Venue	Times
September 14	Clarenville	The Clarenville Inn	2:00 – 4:00 & 7:00 – 9:00
September 15	Marystown	Hotel Marystown	2:00 – 4:00 & 7:00 – 9:00
September 17	St. John's	The Delta Hotel	2:00 – 4:00 & 7:00 – 9:00
September 21	Corner Brook	The Greenwood Hotel	2:00 – 4:00 & 7:00 – 9:00

www.hebronproject.com

ExxonMobil Canada Properties is the operator of the Hebron Project – an oil field located offshore Newfoundland and Labrador in the Jeanne d'Arc Basin, 350 km southeast of St. John's, NL.

ExxonMobil Chevron SUNCOR ENERGY StatoilHydro nalcor energy

022836

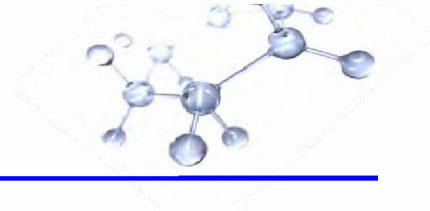
C0814-987

APPENDIX B

Open House Presentation

022838

C0814-989



Hebron

Public Information Session
Opening Address

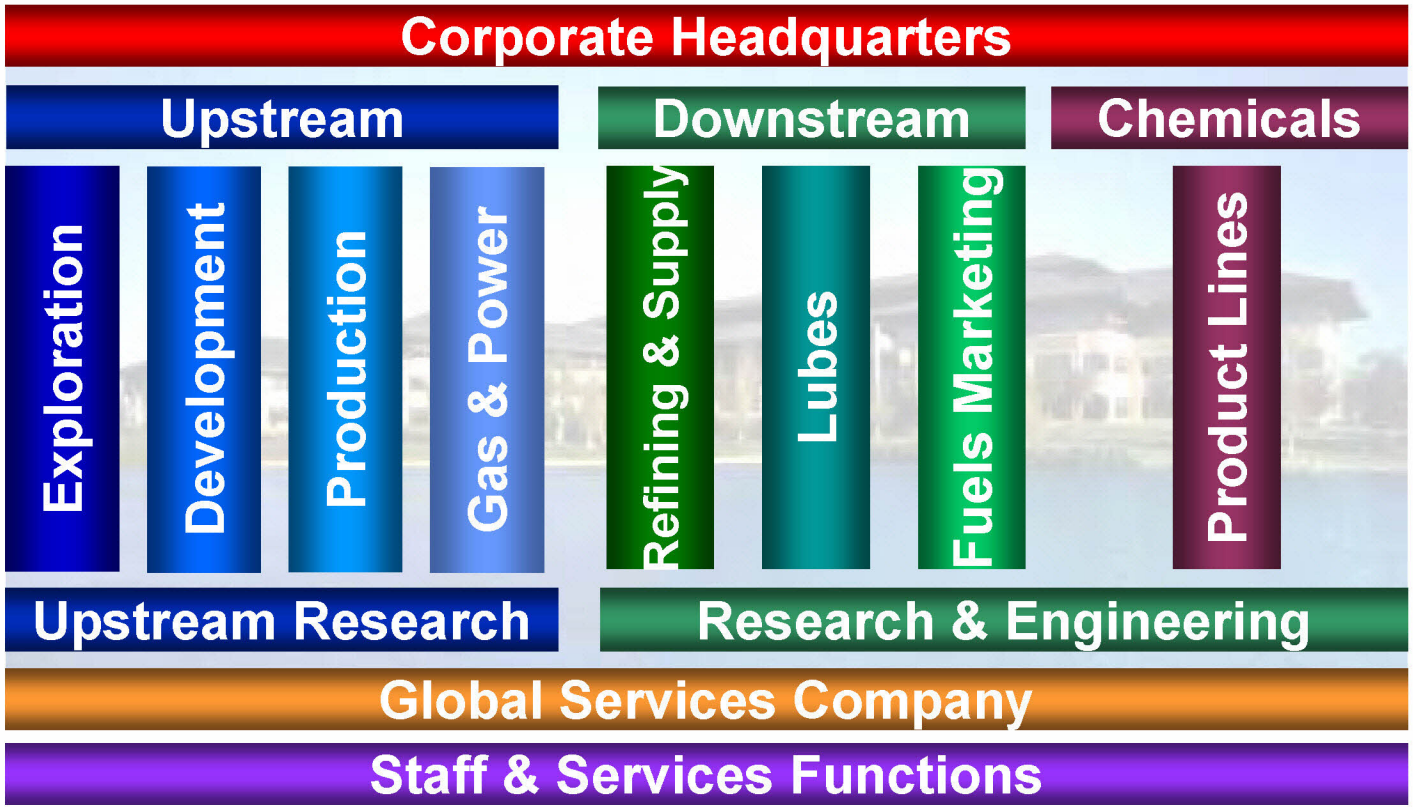
Hareesh Pillai
VP & Senior Project Manager,
ExxonMobil Canada

ExxonMobil Chevron SUNCOR ENERGY StatoilHydro nalcor energy

C0814-990

ExxonMobil Overview

- Operations on six continents
- 82,000 employees

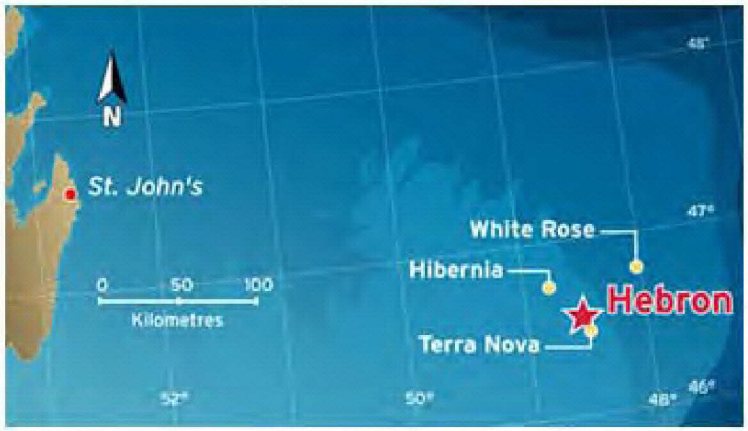


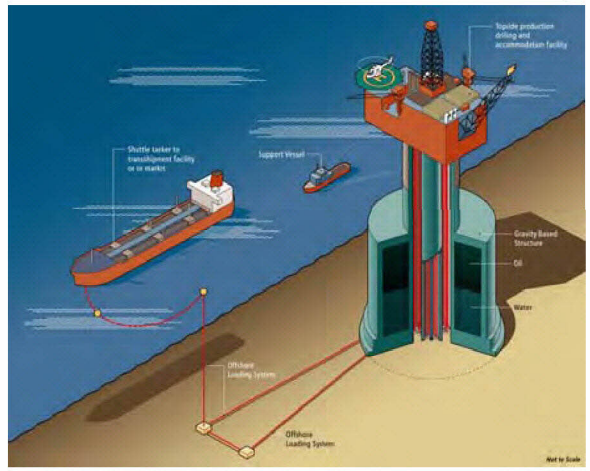
C0814-991

ExxonMobil's Approach to Project Management

- Safety, health and environmental performance
- Disciplined project management systems
- Innovation in application of technology
- Promote local content & capabilities
- Community support & involvement
- Meet our commitments

Project Overview



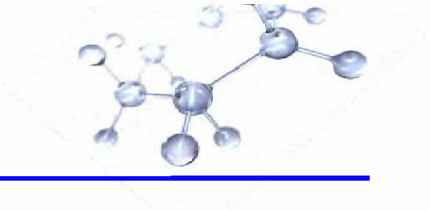


- Operator is ExxonMobil Canada
- 350 km offshore Newfoundland in Jeanne d'Arc Basin
- 100 m water depth
- 400-700 million barrels recoverable oil for the base development
- First oil: before the end of 2017

- Stand-alone concrete gravity-based structure (GBS) with offshore loading of crude
- 1.3 million barrels of oil storage
- 150,000 barrels of oil per day at peak production
- Construction of GBS is to begin in 2012 at the Bull Arm Site

C0814-993

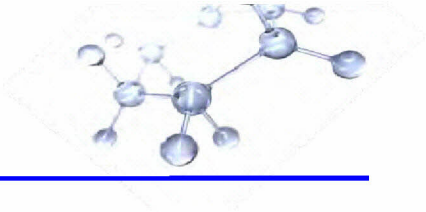
Benefits Agreement

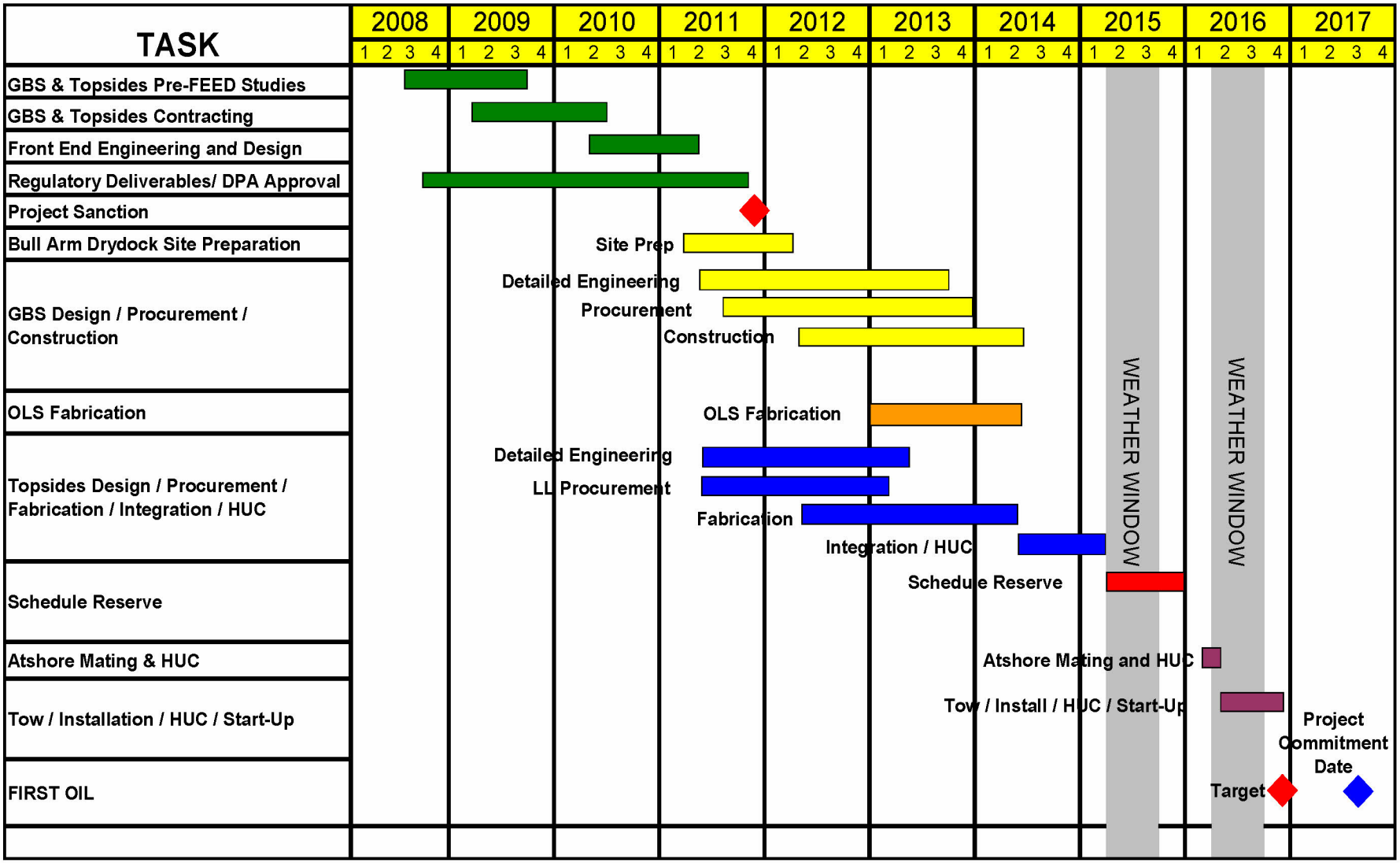


- Local Project office with decision-making authority
- In-Province Engineering, Construction and Research
  - 1.0 M+ hrs for Project Management Team
  - 1.2M+ hrs Detailed Engineering for locally fabricated components
  - $120M for Research & Development
  - Fabrication of risers, flare boom, heli-deck, lifeboat stations, sub-sea template and docking mechanism
  - Drilling module, living quarters subject to capacity and resource considerations
  - GBS to be built at Bull Arm site including 50k hours FEED, all detailed design and 4.1 M hrs construction
- Process and utilities module to be bid and awarded on a fully international competitive basis
- First consideration of NL contractors/suppliers
- Gender equity and diversity commitments
- Development of local skills, industry capability/capacity, and training

C0814-994

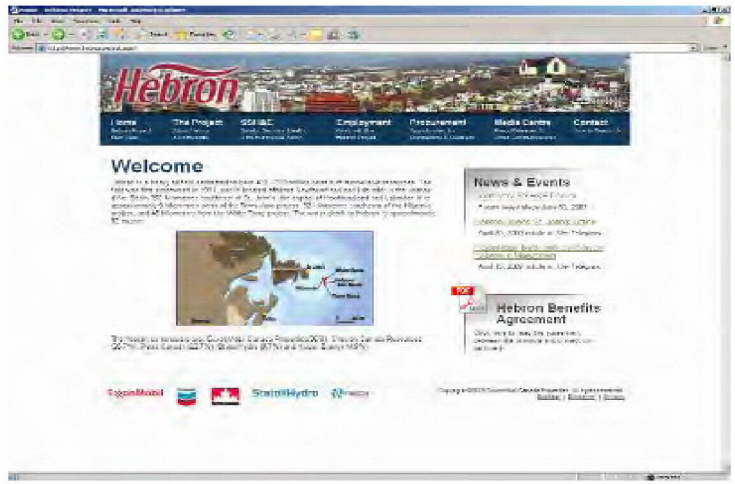
Preliminary Project Schedule

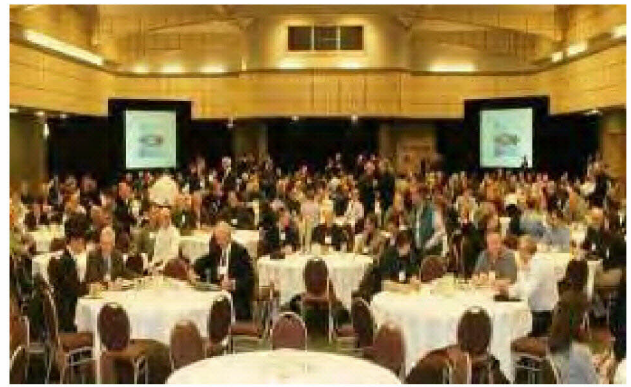




Good Progress on All Fronts

- Opened Atlantic Place office; seeking space for next phase
- Significant progress on concept refinement activities
- Continuing community engagement activities
- Building base of local talent
- Conducted Vendor-Supplier information sessions
- Significant local contracting
- Launched website (www.hebronproject.com)
- Progressing FEED and EPC contracting for GBS & Topsides
- Progressing regulatory deliverables





C0814-996

Our Commitments

- Highest levels of Safety, Health, Environment & Security performance
- Meet Benefits Agreement commitments
- Deliver execution certainty and world class execution
- Build sustainable relationships with community

APPENDIX C

Display Boards

022848

ExxonMobil

ExxonMobil is the world's largest publicly-traded international oil and gas company. We operate facilities and market products in over 200 countries around the world, and explore for oil and natural gas on six continents.

We are also a technology company, applying science and innovation to find better, safer and cleaner ways to deliver energy to the world.

Every day, employees at ExxonMobil are committed to the pursuit of operational excellence. We do this by delivering safe, reliable operations, improving energy efficiency, safeguarding the environment, and maintaining strong business controls.

We believe that maximizing the value of resources – through disciplined investments, developing breakthrough technologies, improving processes, and integrated operations – generates the most benefit for resource owners, society and our shareholders.

Our long-term success also depends on promoting the development of our employees and the communities in which we operate, as well as helping to prepare today's students to take on tomorrow's challenges.

022850

C0814-998

ExxonMobil Canada will leverage the services of ExxonMobil Development Company, which has approximately 3,000 employees and contractors who manage some of the world's largest and most complex oil and gas projects.

We are proud to add Hebron to our portfolio.

ExxonMobil

022851

Project Overview

Hebron is an oil field located offshore Newfoundland and Labrador (NL) in the Jeanne d'Arc Basin, 350 kilometres (km) southeast of St. John's, NL.

The Hebron field is 9 km north of the Terra Nova project, 32 km southeast of the Hibernia project, and 46 km southwest of the White Rose project.

ExxonMobil Canada Properties is the operator of the Hebron Project. The Hebron co-venturers are:

- ExxonMobil Canada Properties (36%)
- Chevron Canada Resources (26.7%)
- Suncor Energy Inc (22.7%)
- StatoilHydro Canada (9.7%)
- Nalcor Energy - Oil and Gas (4.9%)

Project Summary

- 100 metres water depth
- 400-700 million barrels recoverable oil
- 150,000 barrels of oil per day at peak production
- produced using a stand-alone concrete gravity-based structure (GBS) with offshore loading of crude
- 1.3 million barrels of oil storage

022852

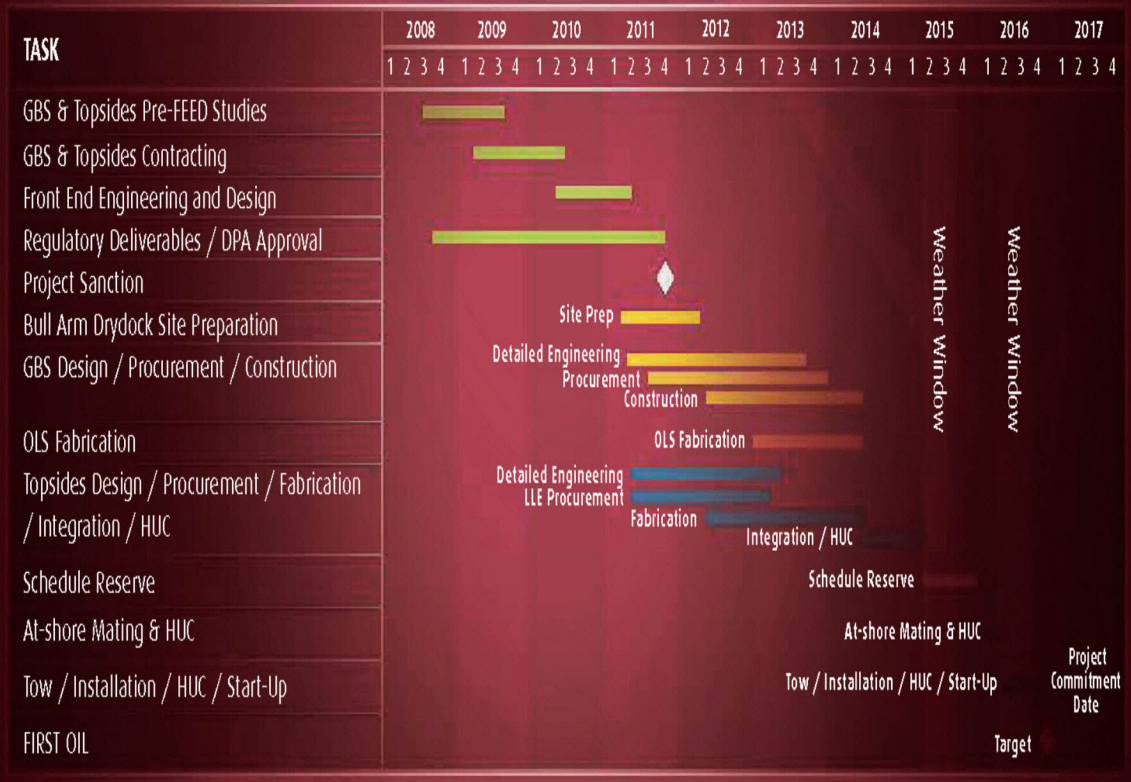
C0814-1000

Project Commitments

- highest levels of safety, health, environment and security performance
- meet Benefits Agreement commitments to the Province of NL
- deliver execution certainty and world-class project performance

Construction of the GBS is scheduled to begin in 2012 at the Bull Arm site, located 130 km northwest of St. John's, NL. The site is operated by Nalcor Energy - Bull Arm Fabrication. First oil is anticipated before the end of 2017.

Hebron Project Schedule



Project Overview

022853

C0814-1001

Safety, Health & Security

At ExxonMobil, excellence in safety, health and security is a core value.

Our safety motto, for both on and off the work site, is **Nobody Gets Hurt**. We will relentlessly pursue the ultimate objective of an injury- and illness-free work place and we will not compromise our focus on safety.

We will promote safety early in the Hebron Project through annual contractor and supplier workshops and ensure that safety, health and security priorities are factored into and emphasized when pre-qualifying contractors and suppliers.

We will develop a strong safety and health culture early in the project by:

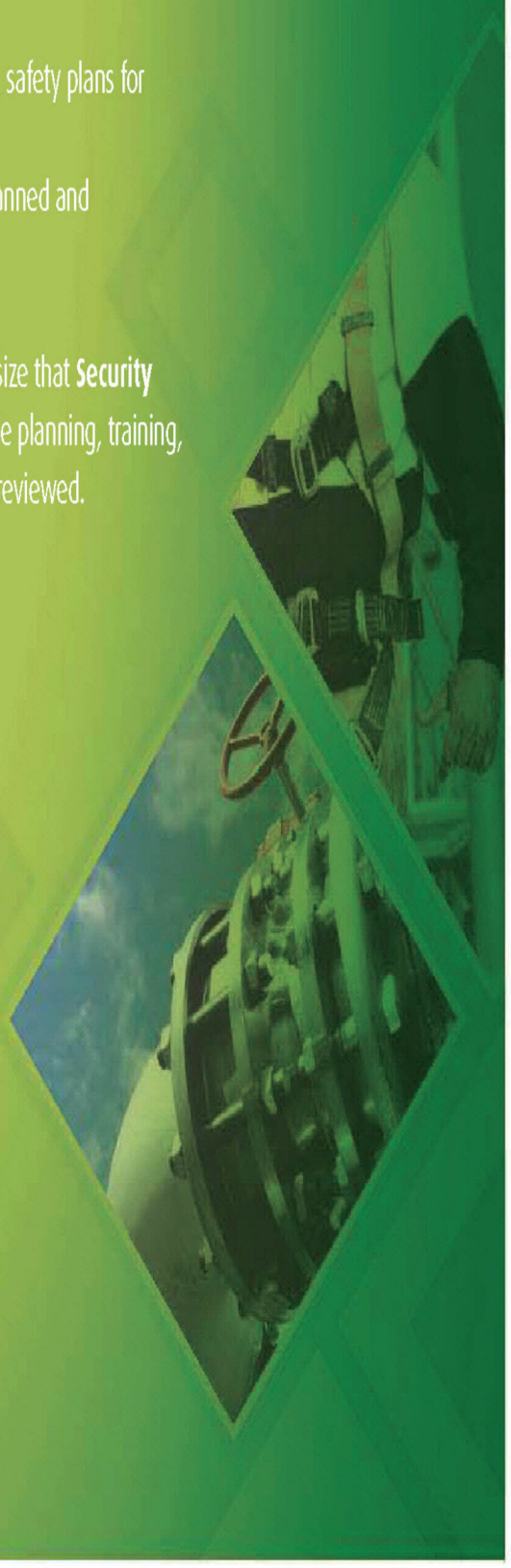
- setting high expectations and sharing best practices
- providing safety training for employees and contractors prior to construction
- employing lessons learned from our global experience

022854

C0814-1002

- employing best practices, tools and specialists, including developing safety plans for the project and each work site
- ensuring appropriate and timely occupational health controls are planned and critical service delivery resources are available

Both individual and workplace security is also a priority and we emphasize that **Security is Everybody's Business**. Site security plans will be required and include planning, training, and assessment activities. Security programs will be tested and results reviewed.



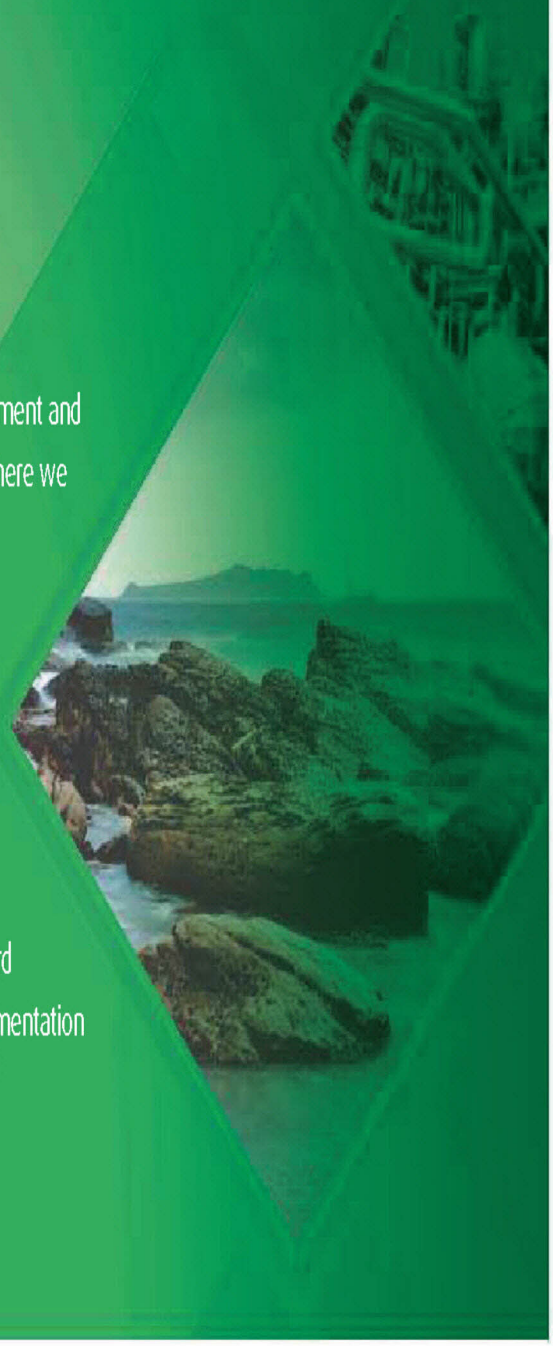
Safety, Health & Security

022855

Environment & Regulatory

ExxonMobil is committed to operating in a way that protects the environment and takes into account the economic and social needs of the communities where we operate. We will act consistent with our corporate environmental motto, **Protect Tomorrow. Today**.

Wherever we operate, we encourage concern and respect for the environment and we comply with all applicable environmental regulations. The environmental and regulatory process for Hebron is governed primarily by the following pieces of legislation: the Canadian Environmental Assessment Act, the Canada-Newfoundland Atlantic Accord Implementation Act and the Canada-Newfoundland and Labrador Implementation Newfoundland and Labrador Act.



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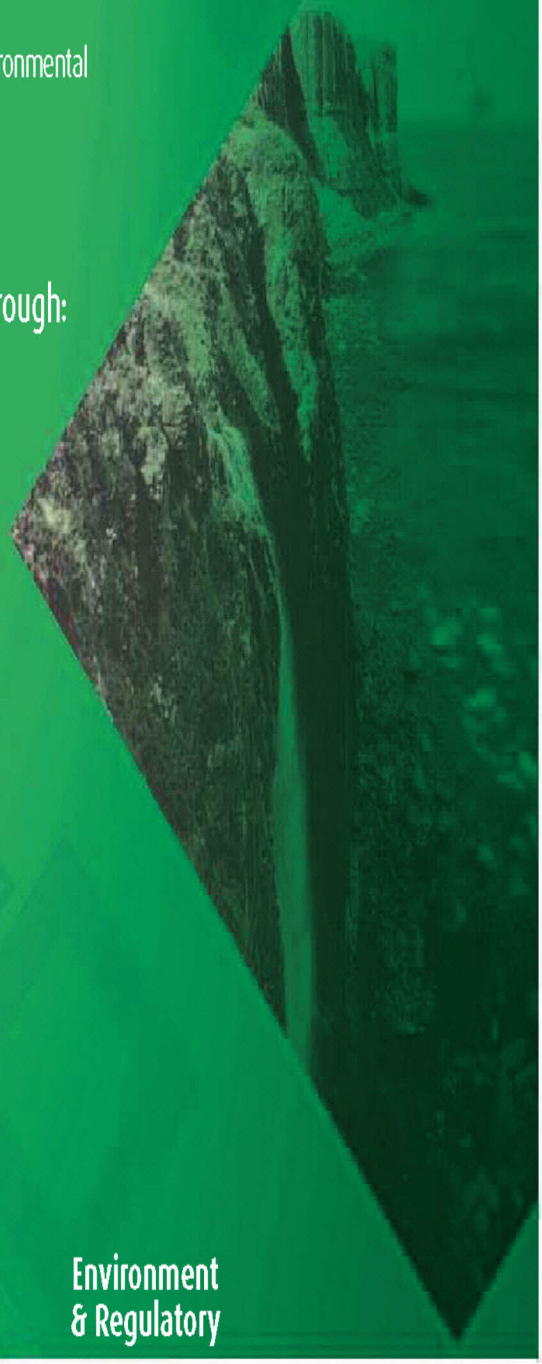
We will be an environmental and regulatory leader by:

- requiring facilities to be designed and operated with the goal of minimizing emissions and waste
- managing activities with the goal of preventing incidents
- responding quickly and effectively if incidents occur
- conducting and supporting research to improve understanding of environmental protection methods
- undertaking reviews and measuring progress

We will demonstrate our environmental commitment through:

- rigorous and sustainable environmental compliance performance
- application of environmental standards
- effective regulatory approval strategies
- establishing and maintaining positive relationships with stakeholders



Environment
& Regulatory

022857

Reservoir

The Hebron oil field is located offshore NL in the Jeanne d'Arc Basin, 350 kilometres (km) southeast of St. John's, NL.

The Hebron field contains separate oil pools in at least four stratified rock intervals: Ben Nevis Reservoir, the Avalon Reservoir, the Hibernia Reservoir and the Jurassic Jeanne d'Arc Reservoir.

The Ben Nevis Reservoir within the Hebron field contains a heavy, viscous oil and is the core of the Hebron Project. This reservoir is anticipated to produce about 80 per cent of the project's proposed initial oil resource development.

Drilling highlights

- 35-45 wells will be drilled to develop oil reservoirs in Hebron field
- wells drilled to depths of 1700 to 4500 metres
- certain oil production wells will include horizontal production intervals
- water injection for pressure support and oil sweep

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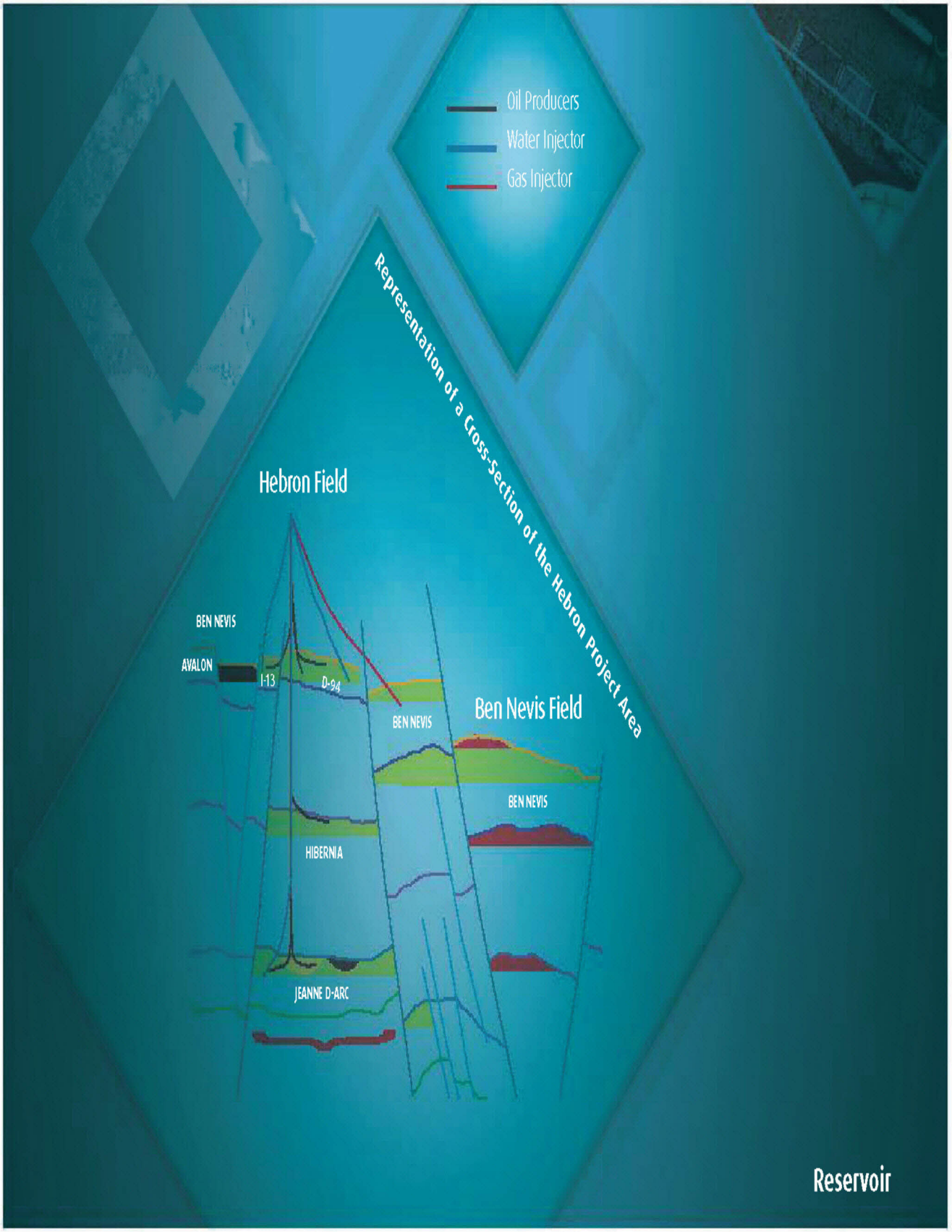

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Gravity-Based Structure

The Hebron field will be developed using a stand-alone, gravity-based structure (GBS) that sits on the ocean floor. The GBS will consist of a reinforced concrete structure designed to withstand sea ice, icebergs, and meteorological and oceanographic conditions at the offshore location.

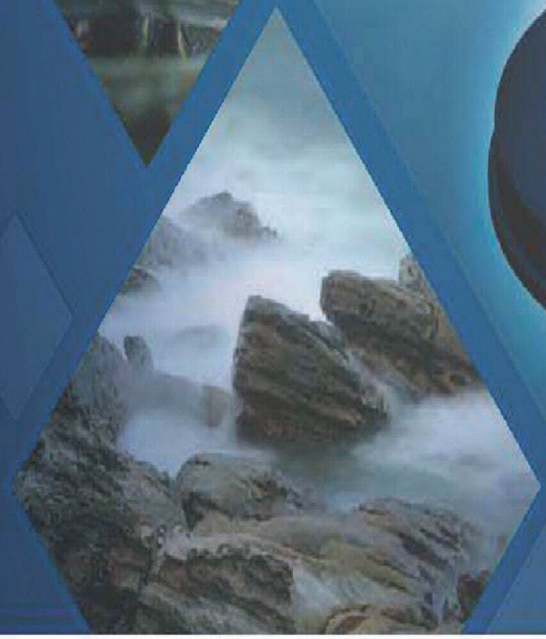
The GBS will support the topsides for drilling and oil production, and the GBS base will contain storage for more than one million barrels of crude. An offshore loading system (OLS), complete with a looped pipeline and two separate loading points, will be installed to offload the oil from the GBS onto ice-strengthened tankers for transfer to a transshipment facility or transport directly to market.

Preliminary Description

- Height: 120 metres
- Base Diameter: 135 - 145 metres
- Supports 25,000-35,000 metric tonnes of topsides
- Weight: 400,000 metric tonnes
- Shaft Space for 50 - 55 wells
- J-Tubes to tie in potential future developments

022860

GBS construction will begin in 2012 at the dry dock at the Bull Arm Fabrication site, located 130 km northwest of St. John's, NL. The GBS will then be transferred to the Bull Arm deepwater site for completion and then towed to the Hebron field for final installation.



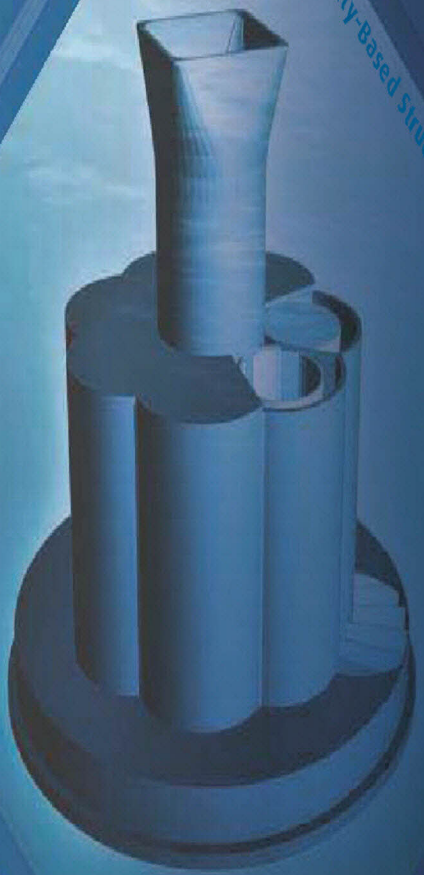


Illustration of Gravity-Based Structure

Gravity-Based Structure

022861

Topsides

The topsides facilities accommodate all drilling, production and utility equipment on the Hebron platform, and provide living quarters for platform workers.

Preliminary Description

- preliminary estimated weight: 25,000 – 35,000 tonnes
- 150,000 barrels of oil processed per day at peak production
- Modules will include:
  - Integrated Process and Utilities Module including separation/oil treating, compression, process heating/cooling, metering, water treating/injection, chemical storage/pumping, control and electrical rooms, power generation, utilities, well bay
  - Derrick Equipment Set including derrick, draw works, top drive and driller's cabin
  - Drilling Support Module including bulk cement and drilling fluids systems
  - Living Quarters including rooms, life boat station, helideck, medical clinic, recreation rooms, mess hall

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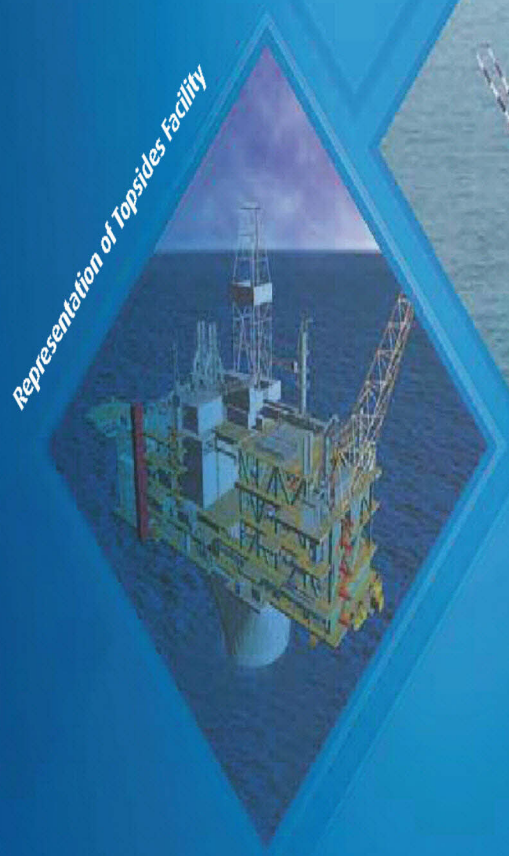
C0814-1010

Specific topsides components will be fabricated in the province. Components fabricated offsite from the Bull Arm Fabrication site will be transported to Bull Arm for final assembly, hook-up and commissioning.



Representation of Topsides Facility

Topsides

022863

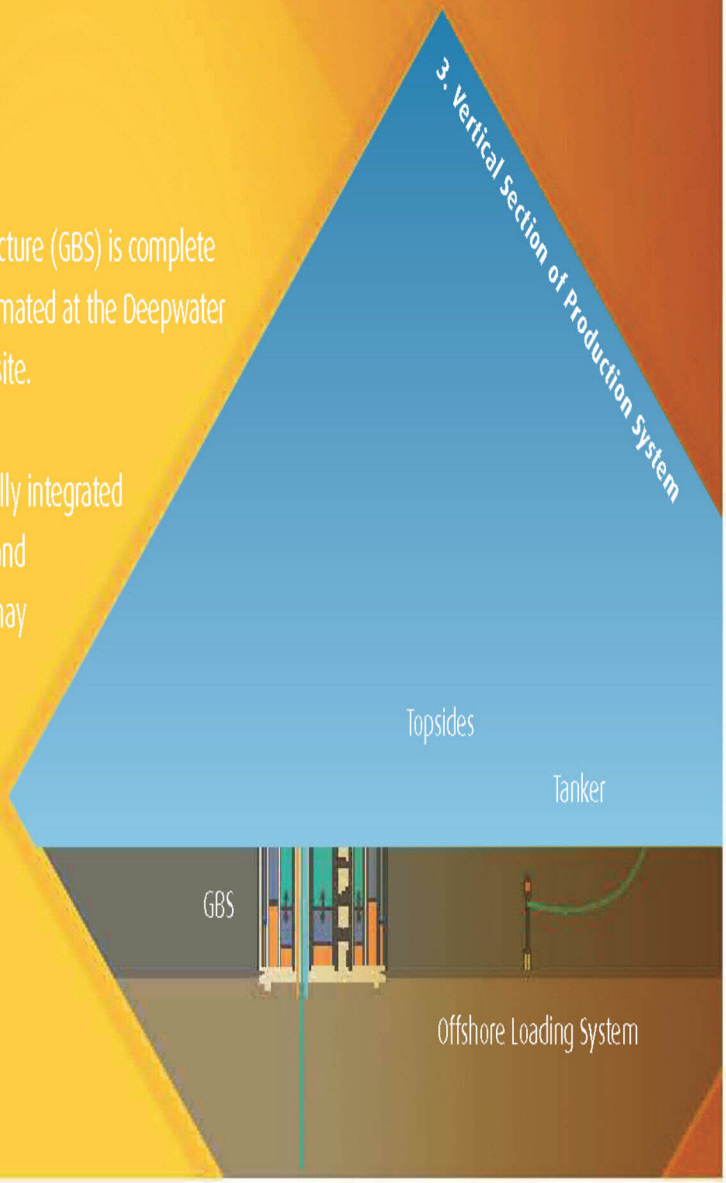
C0814-1011

Installation & Start-up

When construction of Hebron's gravity-based structure (GBS) is complete and the topsides are assembled, the two will be mated at the Deepwater GBS Construction site at the Bull Arm Fabrication site.

Hook-up and commissioning activities with the fully integrated topsides will begin at the pier prior to float over and mating with the GBS at the deepwater site and may continue after mating.

The mated structure will then be towed to the permanent offshore site and installed. Drilling from the platform rig will commence after installation of the GBS. Final commissioning and production start-up will follow.



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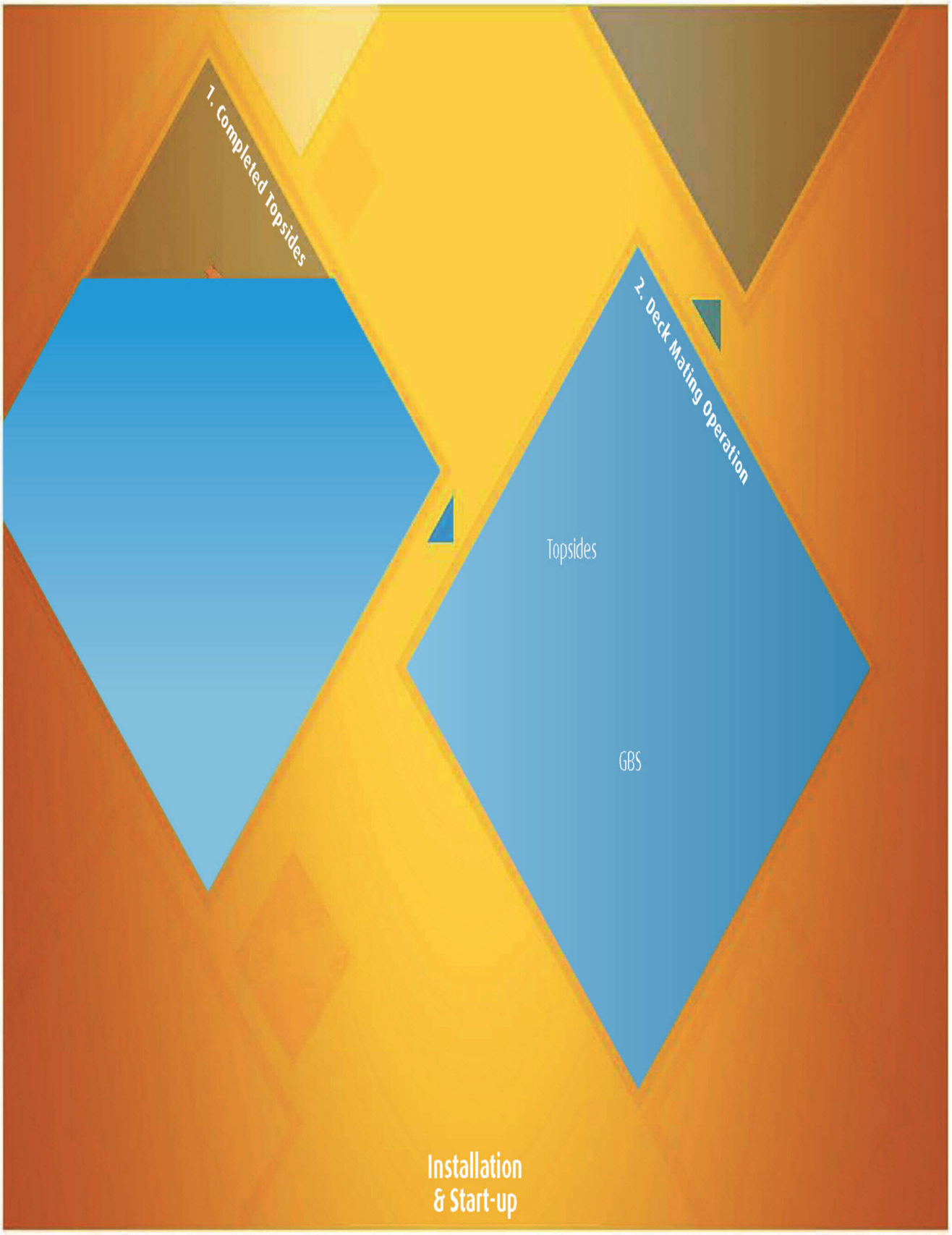
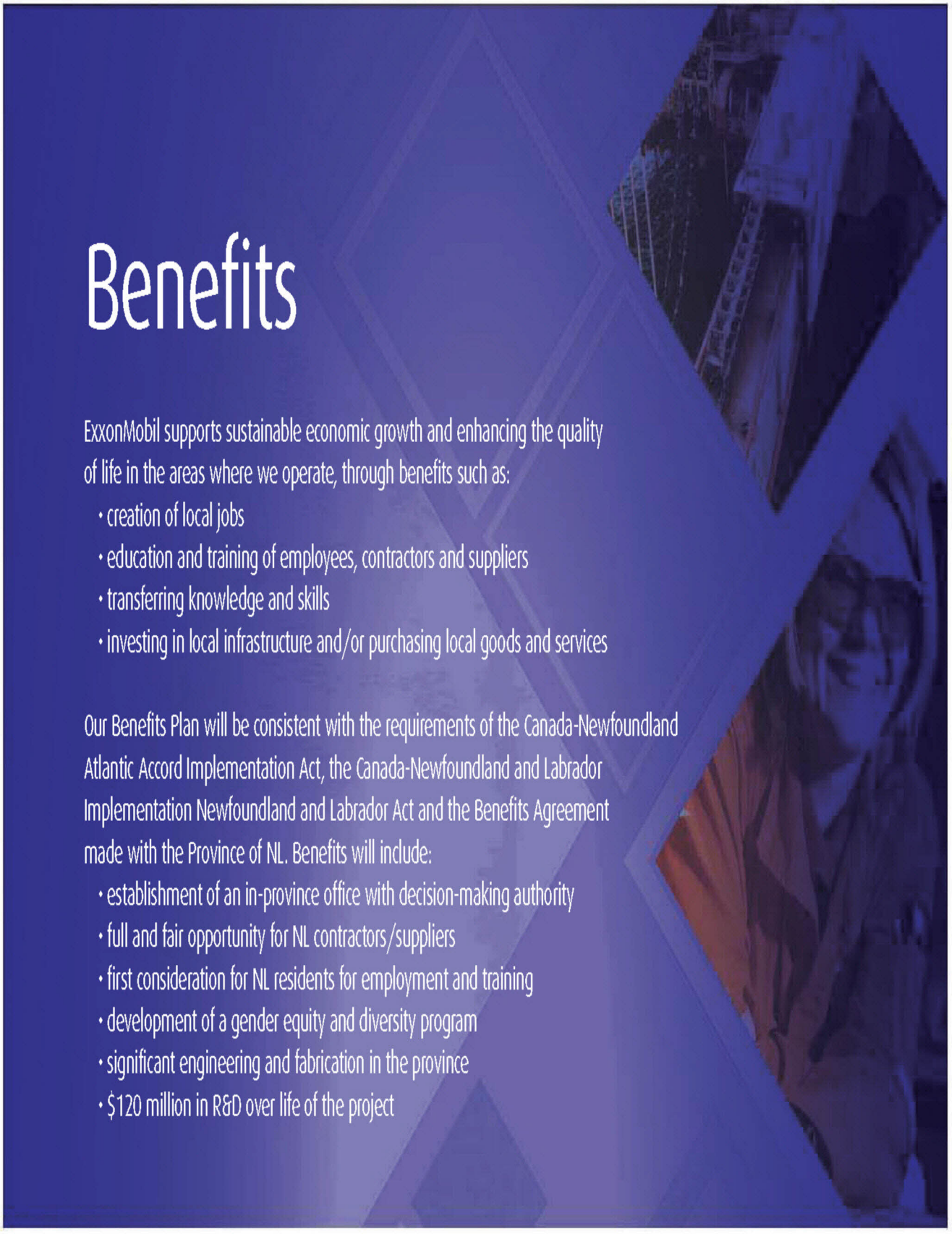

1. Completed Topsides
2. Deck Mating Operation
Topsides
GBS
Installation
& Start-up

022865



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C0814-1014

We are committed to:

- maximizing local benefits while maintaining the highest levels of safety, efficiency and integrity of our operations
- selecting contractors and suppliers that will work diligently with us to deliver benefits to the people of the province
- promoting the development of local skills and industry capability which leaves a lasting legacy for the communities in which we operate and for the province
- delivering execution certainty to ensure that the project delivers best-in-class return on investment for stakeholders, including the Province of NL

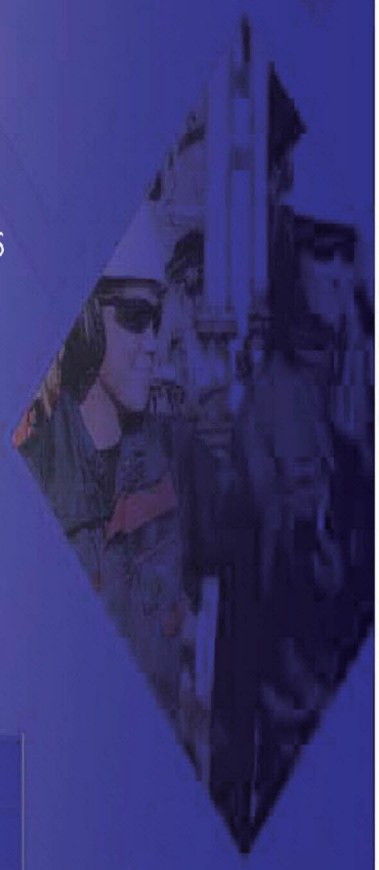
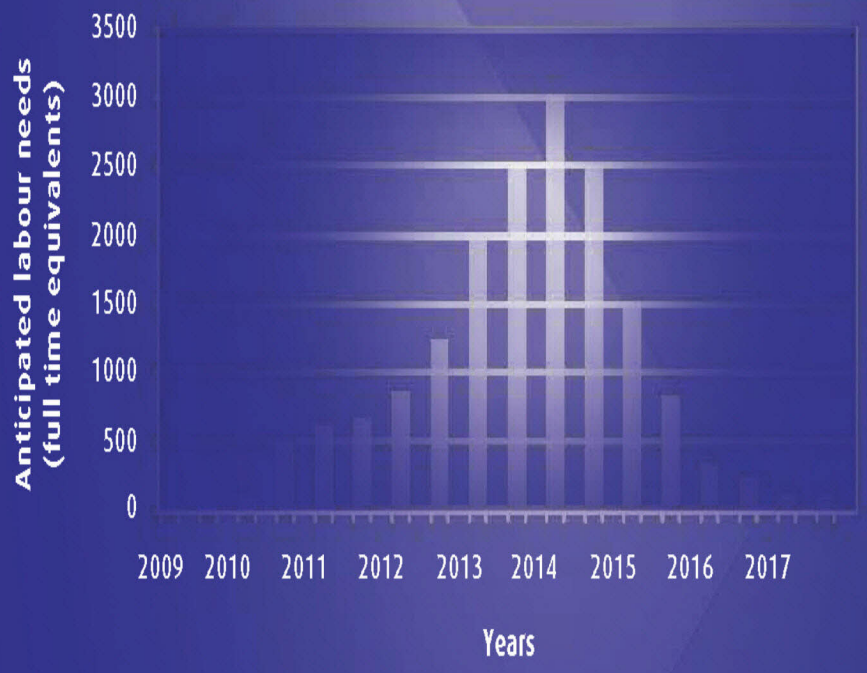


Diagram: Anticipated Employment Requirements 2009-2017



Benefits

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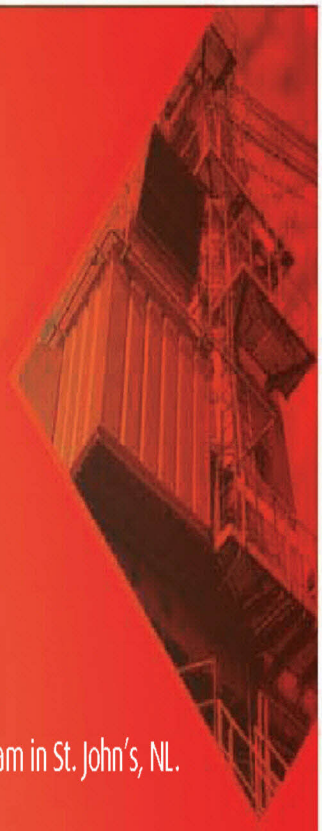

Procurement & Contracting

The Hebron Project procurement and contracting process is managed by the Hebron Project Team in St. John's, NL.

ExxonMobil Canada uses procedures that award business to contractors and suppliers that:

- operate safely
- are cost competitive
- deliver requirements on schedule
- provide the specified quality
- provide opportunity for involvement of Newfoundland and Labrador/Canadian businesses and people consistent with the Atlantic Accord and Benefits Agreement
- have proven performance

Vendor Registration Database

ExxonMobil Canada and our main contractors will make use of a database of suppliers and contractors to identify possible suppliers and subcontractors to participate in the project. Register your company at **hebronproject.com**.

022868

C0814-1016

Contracting process includes the following steps:

1. Expressions of Interest are issued for various project requirements. Major contracting opportunities can be found at:
   - www.hebronproject.com
   - www.bids.ca
   - www.noianet.com
2. Pre-qualification of bidders. The operator conducts assessments of the interested bidders to determine contractor capabilities.
3. Qualified contractors/suppliers are invited to tender.
4. Bids are assessed using pre-determined evaluation plan.
5. Contract is awarded to successful bidder.

Contractor Procurement Information Session

Procurement & Contracting

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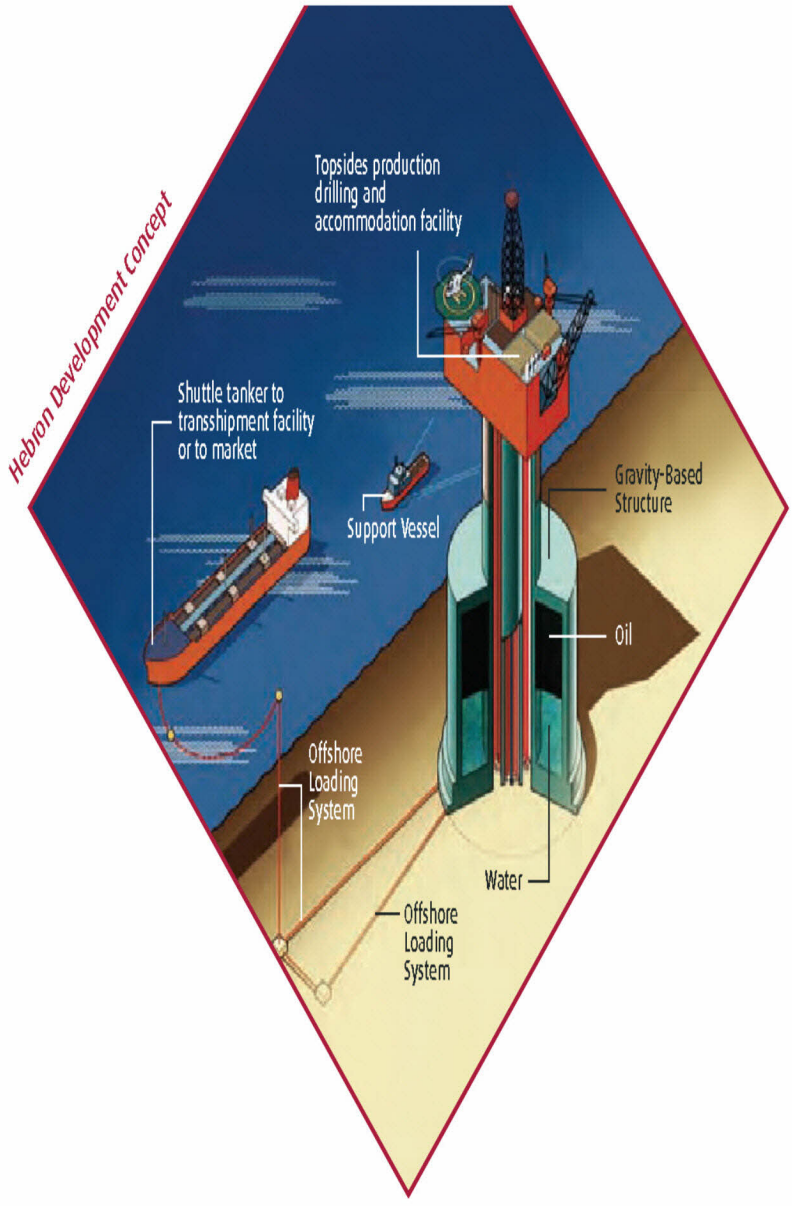

ExxonMobil Chevron SUNCOR ENERGY StatoilHydro nalcor energy

Hebron Project Office
Suite 701, 215 Water Street, St. John's, NL A1C 5K4
T 709.752.6444

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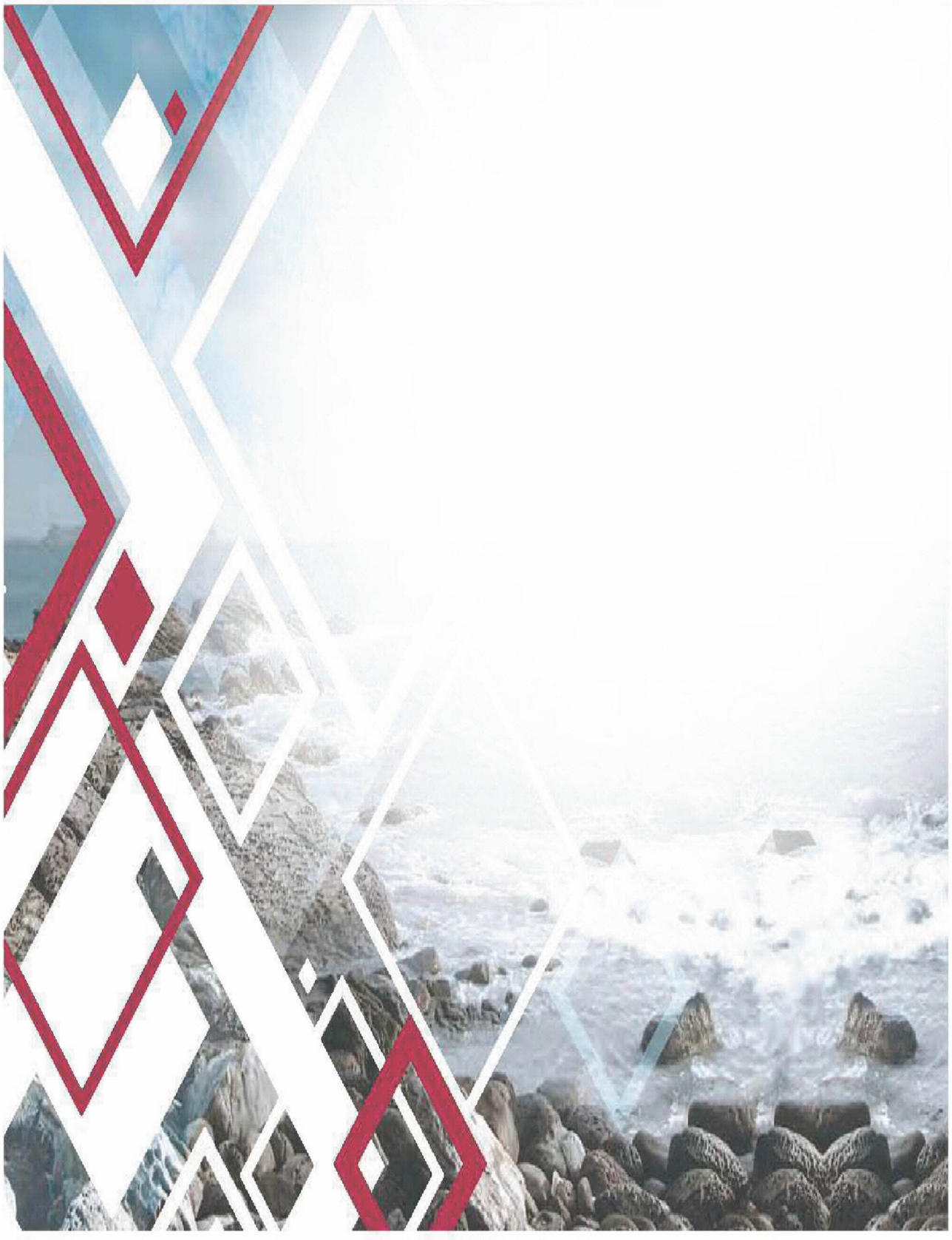


022871

APPENDIX D

Feedback Boards

022872

Community Feedback Survey

Please take a few minutes during the course of the Public Information Session to complete the following evaluation and return to the Registration Table before you leave.

How did you hear about the Hebron Public Information Session?

◇ Newspaper ◇ Radio ◇ Word of Mouth ◇ Invitation ◇ Other _____

On a scale of 1 to 5, with 1 meaning the quality was poor and 5 meaning the quality was excellent, how would you rate this Public Information Session?

1 2 3 4 5

How easy to understand/clear and concise was the information provided at the Public Information Session?

1 2 3 4 5

Specifically, what did you like about the Public Information Session? _____

Specifically, what could we improve on? _____

How would you rate the follow areas of the Public Information Session on a scale of 1-5 with a one meaning poor and a 5 meaning excellent?

Meeting Hebron staff 1 2 3 4 5

Employment / training information 1 2 3 4 5

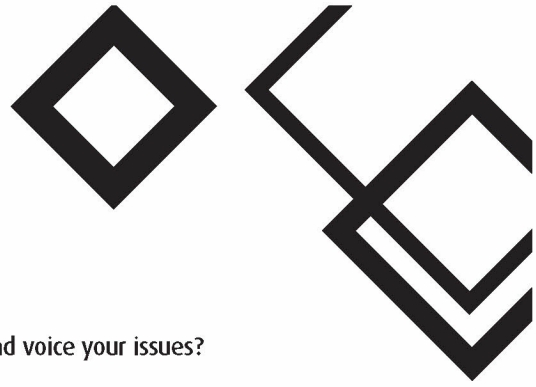
General learning about the Hebron project 1 2 3 4 5

Environmental information 1 2 3 4 5

Ability to discuss any concern(s) 1 2 3 4 5

022874

C0814-1021



Did the Public Information Session provide you with a chance to ask questions and voice your issues?

◇ Yes ◇ Somewhat ◇ No

Please describe any comments or concerns about the Hebron Project with respect to the following topics:

a. Employment _____

b. Opportunities for NL businesses _____

c. Environment _____

d. Research & Development _____

e. Gender equity & diversity _____

Would you like to receive additional information regarding the Hebron project?

◇ No ◇ Yes (if yes, what information) _____

If yes, how would you like to receive it?

◇ Hebron website

◇ Future public information sessions

◇ Through your town council

◇ Other community organization (if so, please list) _____

Do you have any other comments? _____

Personal Information (optional)

Name _____ Town/City _____

Phone No. _____ Email address _____

Thank you for attending and providing your feedback!

022875

C0814-1022

APPENDIX E

Contractor Safety, Security, Health and Environment (SSH&E)
Forum Advertisement

022876

Contractor Safety Forum

June 30th

ExxonMobil Canada's Hebron Project and the Hibernia Management and Development Company Ltd. will hold a joint Contractor Safety Forum on Tuesday, June 30th at the Delta Hotel in St. John's.

The purpose of the forum is to share and promote best practices in Safety, Security, Health and Environment (SSH&E) for the benefit of the broader community.

The theme will be **"Excellence through Partnership"**, and presenters will include ExxonMobil leadership as well as local regulatory, industry and community SSH&E professionals.

Oil and gas industry managers and others in the community with responsibility for SSH&E leadership are invited to attend. The ideal participant would be senior managers and/or SSH&E professionals in a position to lead improvements in SSH&E culture, philosophy, and behavior within their respective organizations.

Breakfast 7:30 a.m. - Forum 8:30 a.m. to 5:00 p.m. - Delta Hotel, St. John's.

Visit NOIA at www.noianet.com for more information and to register for the event.

We look forward to seeing you at the forum and working together to take SSH&E performance to the next level.

Hareesh Pillai
Senior Project Manager, Hebron Project

Glenn Scott
President, ExxonMobil Canada

Hebron
AN ExxonMobil OPERATED PROJECT

Hibernia

Safety Poster Contest

To promote an early appreciation for safety amongst youth in the community, ExxonMobil is working with the Eastern School District (ESD) to host a Safety Poster Contest for students from kindergarten to grade six. Contest details have been circulated to the schools by the ESD.

The deadline for entries is June 10th.

Awards will be given out at the June 30th Contractor Safety Forum to the top three entries within each Eastern School District Region, and the school from each Region with the top winner will also receive an award.

Honourable mentions will also be chosen and all posters will be produced in a book. The winning entries will have their posters framed and displayed at the Hebron Project offices in St. John's.

For contest details contact:
Elsie Colbourne
757-4634

APPENDIX F

Government, Community and Stakeholder Meetings

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Meetings with Government, Communities and Stakeholders

Group	Date	Location	Number of Participants
Towns of Arnold's Cove, Clarenville, Come By Chance – municipal reps	April 8, 2009		
Towns of Burin, St. Lawrence and Marystown – municipal reps	April 9, 2009		
Marystown Shipyard (Peter Kiewit & Sons)	Jan 28, 2009	Marystown	
Mayor Dennis O'Keefe, St John's	Jan 30, 2009	St John's	
One Ocean meeting	May 21, 2009	St. John's	
College of the North Atlantic – Oil and Gas Stakeholder Forum	Feb 25, 2009	St John's	
Memorial University of Newfoundland Deans Breakfast	May 12, 2009	St. John's	
Discovery Regional Economic Development Board	Feb 12, 2009	St. John's	
Schooner Regional Economic Development Board			
Corner Brook	May 13, 2009	Corner Brook	
Women in Resource Development Committee reps	May 19, 2009	St. John's	
NOIA AGM	Nov 2008	St. John's	
NOIA Conference	June 16, 2009	St. John's	
Newfoundland Transshipment Limited	Feb/March 2009		
Bull Arm (Nalcor)			
Premier Williams	April 29, 2009		
Minister and DM and ADM's of Natural Resources – NL	April 29, 2009		
Robert Thompson, DM, NL Dept Natural Resources	April 3, 2009	St. John's	
CNLOPB	April 3, 2009	St. John's	
Mike Edwards and another woman Natural Resources Canada	Feb 26, 2009	St. John's	
NL Building & Construction Trades Council	May 21	St. John's	30
Professional Engineers & Geoscientists NL	June 12, 2009	St. John's	200
Arnold's Cove and Area Chamber of commerce	June 2, 2009	Arnold's Cove	30-40
OTC mtgs w NL govt	May 3, 2009	Houston	
City of St John's	August 3, 2009	St John's	6 (incl mayor + 1 councillor)
Argentia Area of Chamber of Commerce	Sept 23, 2009	Placentia	200
Safety Services NL annual conference	Oct 30, 2009	St John's	200
Government of NL Executive Speaker Series (DMs, ADMs, and Exec Dirs)	Oct 31, 2009	St John's	75
Arnold's Cove area mayors	Sept 14, 2009	Arnold's Cove	8
College of the North Atlantic	Oct 26, 2009	Clarenville	75
Clarenville High School	Oct 26, 2009	Clarenville	60
College of the North Atlantic	Oct 27, 2009	Burin	200
Marystown High School	Oct 27, 2009	Marystown	4
APEC	Nov 12, 2009	St John's	210
NLBTC	Nov 12, 2009	St John's	18
NLBTC	Nov 19, 2009	St John's	60

Appendix G

Media Briefing and Newspaper Articles

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OIL AND GAS

ExxonMobil hosts info session on Hebron in Marystown

By Paul Herridge

TRANSCONTINENTAL MEDIA—MARYSTOWN

Hebron senior project manager Hareesh Pillai suggests there's reason for people in the Marystown area to be optimistic about future work from the development.

"I think it's pretty obvious by inspection a lot of the yard capability and capacities that are in the province are between Bull Arm and Marystown. So, I think, while we can't at this point tell you who's going to get what kinds of work, I think there's a fair chance that some work will obviously go to Marystown."

The town was the location for one of three information sessions ExxonMobil conducted for contractors, looking to learn more about contracting strategies the company will employ for the Hebron Project.

The first session took place in St. John's Tuesday, followed by another in Clarenville the next day. A fourth will take place in Corner Brook next month.

About three dozen people were present for the Marystown event.

HareeshPillai

Not just for big players

"I don't want you to read a lot more into that, but it's kind of obvious you've got a pretty large yard here. Also, I'll tell you the focus of what we're doing is really not just for the big players," Pillai said.

"There are opportunities for small and medium-sized companies to participate and that's probably the biggest focus that we have.

"The big boys know how to play this game and how to get involved. So, most of our focus is on the smaller companies."

Pillai said the main intent of the sessions was to help people to understand the project's status, give them a sense of the technical aspects of the project so they can understand how it will come together, and provide a timeline and a schedule relative to the end of the project.

He said perhaps, most importantly, the sessions provide a chance to explain what the opportunities will be available for provincial suppliers — both for service and materials — to participate in the project. Also outlined was what kinds of bid packages will become available and when, the process used to invite people to participate and how contracts will be evaluated.

"So, all in all, a lot of information — very early, but very focused to make sure provincial companies understand what it's going to take to compete and participate."

Pillai said the company has a commitment to start production by 2017, but indicated if all goes well the date may be earlier.

He acknowledged it's important to get in the game early.

"A lot of the devil is in the details, and so we're working through some of those details now, with some front-end engineering design contracts to be awarded next year. So, very early days, but very early days is also an important time to get the market ready for us."

Overall, he was "extremely pleased" with the Marystown session.

"Whether it's 30 people or 400 people, the community is important to us. We want to get the message going, and it won't be the last time we'll be out."

The Southern Gazette

Telegram April 15/09

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C0814-1028

ExxonMobil Canada takes on Hebron operatorship

ST. JOHN'S, NL (October 1, 2008) The Hebron project co-venturers confirm that the change in operatorship for the project has been approved by all owners and that effective October 1, 2008, ExxonMobil Canada is the project operator. This follows the successful negotiation of formal binding agreements with the Government of Newfoundland and Labrador , which were announced publicly on August 20, 2008.

"ExxonMobil is pleased to accept this responsibility for the Hebron project," said Glenn Scott, president of ExxonMobil Canada . "Given our experience with the Hibernia project and our arctic execution capability, we believe there are many opportunities for us to build on the foundation we have in place in terms of people and processes and find synergy opportunities for Hebron ." Scott added, "Chevron has successfully led the project up to this point, and with the continuing support of the Province, the co-venturers are committed to move the project forward."

Effective October 1, Hebron-related matters should be directed to ExxonMobil Canada at: Hebroninfo@exxonmobil.com or to ExxonMobil Canada 's offices in St. John's , Newfoundland and Labrador at 709-778-7000.

The Hebron project, located approximately 350 kilometres offshore the island portion of Newfoundland and Labrador, is a joint venture between ExxonMobil Canada (36% ownership share), Chevron Canada (26.7%), Petro-Canada (22.7%), StatoilHydro Canada (9.7%) and the Energy Corporation of Newfoundland and Labrador (4.9%).

Media contacts:

Margot Bruce-O'Connell, ExxonMobil (709) 778-7222

Opportunity knocks

Local people, businesses should benefit from Hebron, says management team

BARBARA DEAN-SIMMONS

There are tons of concrete to be poured, rebar and steel membranes to be installed and hundreds of kilometers of electrical wires and piping to be fitted as the Gravity Based System for the Hebron oil field begins to take shape.

There will be thousands of hungry mouths to feed and massive amounts of bed linen to be washed — not to mention truckloads of toilet paper to be used — as workers move into the work camp at Bull Arm to build the massive structure.

It all means business opportunities for Newfoundland and Labrador companies — from major construction contractors to suppliers of the goods and services that will be required during the building of the Gravity Based Structure for the Hebron oil field.

On Monday, local businesses owners had a chance to meet some of the managers of the Hebron project.

Hareesh Pillai, senior project manager for Hebron, says their aim is to have as many local people as possible working on the project.

"Growing local talent and using local workers and suppliers is beneficial for the community, and its beneficial for us," he says.

In fact, under the benefits agreement signed between the Hebron partners and the province earlier this year, first consideration has to be given to Newfoundland and Labrador contractors and suppliers.

In accordance with the agreement, the risers, flare boom, heli-deck, lifeboat stations, sub-sea template and docking mechanism for the GBS, have to be built in the province. The drilling module and living quarters also have to be constructed here.

And if local companies are competitive, the process and utilities modules — which will be awarded on an international competitive basis — could be built here.

Construction of the GBS is set to begin at Bull Arm in 2012 — 15 years after the province's first GBS was towed out to the Hibernia oil field.

Pillai notes there are many similarities between the Hibernia GBS and the one for Hebron — in terms of skills required for construction and the materials and supplies required during the pre-construction and construction phase.

The Hibernia GBS employed 5,000 people during peak construction. During the Hebron GBS construction, employment will peak at 3,000-3,500.

To get ready for the GBS project, the Bull Arm site itself will see some work. Many of the workers will live on site, in the bunkhouses that were used by the Hibernia GBS workers. Because they have not been used for about 15 years, they require renovations to get ready for the next wave of workers.

Although the Hebron project has yet to clear all the environmental assessment hurdles — the federal assessment should be completed next year — work is being done to ensure the construction phase can begin as soon as the federal approval is granted.

"We've already awarded $11-$13 million worth of contracts," says Pillai, noting engineering work is progressing.

And two major contracts will be awarded before the end of the year — one for the construction of the GBS and the other for the topsides fabrication.

Once those contractors are in place, the process of hiring subcontractors and suppliers will begin.

"Those two large contractors will hire many subcontractors, and those contracts will, we hope, flow to many Newfoundland and Labrador companies," says Pillai. He adds the Hebron website, hebron.com, includes a 'procurement' link whereby local companies can be ask to be included on the list of potential suppliers and to watch for tender calls for supplies and services.

From start — site preparation, engineering and design — in 2010, until tow out of the GBS sometime in 2016, there should be many opportunities for local workers and companies.

It's one of the reasons the Hebron management team is holding public information sessions; to get a sense of what's available in terms of local goods and services and to ensure local people know how to get involved in the building of the mega project.

editor@thepacket.ca

23 in

Photo: Barb hareesh pillai.jpg

Hareesh Pillai, senior project manager for Hebron, was in Clarenville on Monday to explain the business and work opportunities for local people and companies during the construction of the GBS and topsides drilling platform.

Barbara Dean-Simmons photo

0.08	0.01	95
6.08	-0.02	27,550
26.74	-0.07	180,696
0.13	-0.005	370,760
0.06	0	28,500
0.035	0	2,797,177
0.2458	-0.0054	426,125
4.74	-0.02	170,791
26.74	-0.16	348,654
30.47	-0.28	738,801
6.83	-0.04	390,490
4.37	-0.03	101,006
37.75	-1.30	65,199
21.25	0	6,350
0.0771	-0.0029	79,000
0.08	-0.005	25,000
0.11	0	7,000
0.45	0.05	34,500
0.09	0	165,645
0.10	-0.005	7,000
0.075	0	109,325
0.72	0.02	136,305

0.08	0.01	95
685.59	-3.10	92,196
11,424.61	-21.34	478,469
1,265.00	16.00	228,890

0.08	95
$1,000/oz	$1,010/oz
$16.70/oz	$17.05/oz
$16,700/t	$17,300/t
$6,088/t	$6,230/t
$68.69	$71.32
$69.85	$72.04

OIL AND GAS

Hebron officials discuss project with public

Groups in Corner Brook impressed with plans

By Cliff Wells
TRANSCONTINENTAL MEDIA—CORNER BROOK

Arne Helgeland liked what he heard at the Hebron project information session Monday afternoon.

Hareesh Pillai, senior project manager and vice-president of ExxonMobil Canada, and a group of project staff held two information sessions in Corner Brook Monday.

They explained to those in attendance the project's plan to date. Steel will be cut and concrete will be poured for the gravity-based structure in 2011, with first oil scheduled for 2017 or before.

Helgeland, a Corner Brook resident, attended the session out of curiosity and he was pleased with the discussions around safety.

He was in the oil business for 15 years, working on offshore oil rigs in Norway and Nova Scotia. One thing that always bothered him about the process was waste.

"I saw the waste of burning of gas on the rigs," Helgeland said. "Here,they're going to recover the gas. There's a lot of waste of energy with a flare boom where they burn off all the gas. Here, they're going to recover it and pump it back into the wells. That's important."

Arne Helgeland (left) speaks to Hareesh Pillai, senior project manager for the Hebron project, after a public information session Monday afternoon in Corner Brook. Helgeland liked the fact that Hebron planners expect to release very little natural gas on the platform's flare boom. — Photo by Cliff Wells/The Western Star

Helgeland said flare booms burning day and night is a lot of wasted energy, probably enough to heat the city of St. John's.

At the Hebron structure, the plan is to use some of the gas on the platform and inject the remainder back in the well to help pump oil out.

There will be a flare boom on the platform, but Pillai said it's more for safety and won't be continuously burning.

Danny Cull, safety officer for J. Ray McDermott, was also excited about what he heard at the afternoon session.

Cull said it's a big project and he'd like to get his company, a specialty engineering and project management firm, in on the ground floor, rather than try to break in once the project's established.

He said the project's big commitment to safety impressed him. Pillai told the groups the job is not a success unless no one's hurt.

"To say the least, it excited me," Cull said of the project's commitment to safety.

"It's good that they're focused on safety. Everyone should be focused on safety. Safety should be everyone's number one priority. Everyone wants a job, and everyone wants a paycheque, but at the end of the day you've got to come home to your family.

"Working offshore, everyone around here knows the difficulties that lie with that."

The Western Star

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