Strategic Environmental Assessment of proposals to close fishing for sandeel in all Scottish waters

Environmental Report

July 2023

Scottish Government
Riaghaltas na h-Alba

Non-Technical Summary

Introduction

The seas around Scotland have a wide variety of marine wildlife and varied habitats that support a diverse abundance of marine organisms. Sandeel form a particularly important component of the North Sea ecosystem and a link between different levels of the marine food chain[1] from plankton up to commercial fish species, seabirds, and marine mammals. As an island-based society, the sea around Scotland has always had an important role to play, offering a source of food and recreation.

The Scottish Government has national and international commitments to protect marine biodiversity, and to take necessary measures to protect and conserve the marine ecosystem. The Scottish Government is also committed to the sustainable management of fisheries, which includes taking account of the protection of biodiversity and healthy functioning ecosystems.

Taking these commitments into account, the Scottish Government is consulting on proposals to close fishing for sandeel in all Scottish waters. The consultation, which will seek views on these proposals, is being undertaken with the purpose of bringing about wider environmental and ecosystem benefits. These include potential benefits to sandeel, seabirds, marine mammals, and other fish species.

What is a Strategic Environmental Assessment?

This Environmental Report summarises the findings from the Strategic Environmental Assessment (SEA) of the proposals to close fishing for sandeel in all Scottish waters. An SEA of the proposals is required by the Environmental Assessment (Scotland) Act 2005 ('the 2005 Act').

SEA identifies the likely significant environmental impacts of plans and policies, and proposed reasonable alternatives to them. SEA also identifies mitigation measures that are required to avoid or minimise any significant adverse effects and highlights opportunities for enhancements of beneficial effects. Taking place at an early stage in the plan or policy preparation process, it ensures that decision-making is informed by relevant environmental information. SEA provides opportunities for the public to consider this information and use it to inform their views on the draft plan or policy.

A screening and scoping exercise on the proposed sandeel fishery closure was undertaken by the Marine Directorate, in accordance with the requirements of the 2005 Act. In response to the screening, Consultation Authorities[2] confirmed the need for a SEA due to the potential for significant environmental effects to occur. They also provided comment on the proposed scope and methodology of the assessment and the proposed consultation period for the Environmental Report. Their views are taken into account in this Environmental Report, as per the requirements of the 2005 Act.

[1] Sandeel | NatureScot
[2] Historic Environment Scotland (HES), Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH).

What are the proposals?

The Scottish Government has national and international commitments to protect marine biodiversity, and to take necessary measures to protect and conserve the marine ecosystem. The Scottish Government is also committed to the sustainable management of fisheries that takes account for the protection of biodiversity and healthy functioning ecosystems.

Given the importance of sandeel to the wider ecosystem and the subsequent benefit provided by the species in aiding long-term sustainability and resilience of the marine environment, it remains an over-arching and long-held Scottish Government position not to support fishing for sandeel in Scottish waters, which is reflected in Scotland's Future Fisheries Management Strategy[3]. A sandeel closure in sandeel management area 4 has also been in place since 2000 (Figure 1) and the UK has not allocated sandeel quota to UK vessels since 2021.

Taking these commitments into account alongside the key role that sandeel play in the marine environment, the Scottish Government is consulting on proposals to extend the existing closure in Sandeel Area 4 to all Scottish waters. As part of the process to determine whether this measure should be taken, the Scottish Government is now inviting views on the findings of the SEA.

How was the Strategic Environmental Assessment undertaken?

The SEA provides a high-level and qualitative assessment of the potential environmental effects that are likely to result from the extension of the sandeel closure to all Scottish waters. In addition, the potential effects that may arise from reasonable alternatives are also assessed (see below).

The assessment identifies the effects of the proposed closure extension that are scoped into the assessment, specifically Biodiversity, Flora and Fauna; and Water Quality, Resources, and Ecological Status. The assessment also considers the effects of the proposed closure extension on a series of key statements ('SEA objectives'). These SEA objectives reflect the scope of the assessment as well as the environmental protection objectives from relevant legislation. The assessment also considers the interaction of this proposal with existing and developing projects, plans and strategies that have similar objectives.

Economic impacts, including those on other users of the marine environment, are assessed in a Business and Regulatory Impact Assessment (BRIA).

[3] Scottish Government. Future fisheries: management strategy – 2020 to 2030. 17 December 2020, URL: Future fisheries: management strategy - 2020 to 2030 - gov.scot (www.gov.scot) (last accessed: 20/06/23).

Which reasonable alternatives have been assessed?

The scoping exercise identified some alternative management strategies that could be taken that might achieve the same outcomes, as well as the alternative of taking no action. The alternatives assessed were:

- Extension of the existing closure to all of Sandeel Area 4 only
- Seasonal closure of the sandeel fishery
- Voluntary closure of the sandeel fishery
- No action taken

It was assessed that none of the identified reasonable alternatives were likely to result in additional benefits compared to the proposed closure of all Scottish waters, and each carries additional risk when compared to the proposed closure. Extension of the existing closure to sandeel area 4 only risks displacement of fishing effort into novel sandeel fishing grounds in Scottish waters with potential for detrimental environmental effects. Seasonal closure of the sandeel fishery has the risk of being an ineffective measure if the timing of sandeel availability were to change in the future due to changes in environmental or biological drivers. Voluntary closure of the sandeel fishery was assessed as risking a potential shorter fishery closure due to the need for annual agreement to the measure from all fishing nations, and also incurred an increased management cost.

Taking no action was assessed as not providing sufficient benefits to meet the policy objectives. Additionally, potential detrimental effects were also identified due to potential displacement of fishing effort into Scottish waters under the UK Government's preferred option of closure of English Waters within the North Sea.

What is the current state of the marine environment?

Scotland's marine environment supports a diverse complex of different habitats, which in turn support a wide range of marine plants and animals. Sandeel are a key component of the ecosystem of Scotland's seas due to their role in marine foodwebs as a prey source for a range of species including seabirds, seals, cetaceans (whales, dolphins and porpoises), and predatory fish. Progress towards Good Environmental Status (GES) for elements including biodiversity and commercial fish is monitored and measured under commitments in the UK Marine Strategy[4].

Sandeel stocks are influenced by environmental factors such as temperature, and biological factors including the availability of their zooplankton prey, mortality from predation, and mortality due to fishing. The sandeel stock experienced a decline between 1992 and the early 2000s and has remained relatively stable since although fluctuations occur between years (Figure 2).

Scotland holds internationally important numbers of breeding seabirds, many of which include sandeel in their diet during the breeding season. Species that include sandeel in their diet include black-legged kittiwake, Atlantic puffin, Razorbill,

[4] Department for Environment Food & Rural Affairs. Marine Strategy Part Two: UK updated monitoring programmes. UK Government, 19 December 2022, URL: updated UK Marine Strategy Part Two (publishing.service.gov.uk) (last accessed: 20/06/23).

European shag, Black and Common guillemot, Artic and Sandwich tern, and Northern gannet. The conservation status of the majority of these species has been assessed as unfavourable with only Northern gannet carrying a favourable conservation status in the UK. Scottish seabirds were heavily affected by the 2021-22 Highly Pathogenic Avian Influenza outbreak[5] and it has not yet been possible to fully assess the effects of this outbreak on population status. The conservation status of these seabird species may therefore have changed since last assessed.

Scotland has two native species of seal; grey seals and harbour seals; that are found in Scottish waters year-round. Both of these include sandeel in their diet. Grey seals occur around the entire Scottish coastline where their distribution is driven by proximity to suitable haulout sites. Harbour seals are also distributed around Scotland's coastline with highest densities occurring throughout the Inner Hebrides, Orkney, Shetland, and the Inner Moray Firth. The grey seal population is showing overall growth, which is mainly limited to the North Sea colonies along the east coast of Scotland and England, with slight declines occurring in the Inner and Outer Hebrides and Orkney[6]. Harbour seal populations also show regional trends with significant population declines occurring in some regions [6]. GES has been achieved for grey seals but has not been achieved for harbour seals.

Eleven species of cetacean are regularly sighted around Scottish seas. Of these, harbour porpoise, minke whale, and white-beaked dolphin include sandeel in their diet. The long-term population trends of these species are classed either as 'unknown' or 'uncertain' as not enough survey data is available to establish a trend. Estimates of harbour porpoise and minke whale in the North Sea suggest that their numbers are stable.

Several species of commercially important fish species include sandeel in their diet, including Atlantic cod *Gadus morhua*, haddock *Melanogrammus aeglefinus* and whiting *Merlangius merlangus*. Atlantic cod biomass declined between 1980 and 2005 followed by a slight increase in biomass since 2005. Biomass of haddock in Scottish waters showed an initial decrease in the mid-80's followed by relatively low biomass levels except for a peak between 2000 and 2003. Biomass has shown recent increases since 2020. Biomass of whiting has been relatively stable since the mid-80's. As mentioned above, GES has been achieved for some species of commercially important fish[7].

What are the likely significant environmental effects of the proposed sandeel fishery closure?

The proposed sandeel fishery closure are expected to provide *potential* environmental benefits for a range of marine species that eat sandeel, including

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[5] NatureScot. Avian influenza (bird flu). URL: [Avian influenza (bird flu) | NatureScot](#) (last accessed: 20/06/23).

[6] Natural Environment Research Council, Special Committee on Seals. Scientific Advice on Matters Related to the Management of Seal Populations: 2021. http://www.smru.st-andrews.ac.uk/files/2022/08/SCOS-2021.pdf (last accessed 21/06/2023).

[7] Department for Environment Food & Rural Affairs. Marine Strategy Part Two: UK updated monitoring programmes. UK Government, 19 December 2022, URL: [updated UK Marine Strategy Part Two (publishing.service.gov.uk)](#) (last accessed: 20/06/23).

seabirds, seals, cetaceans, and predatory fish, as well as the direct benefits to sandeel stocks. This is due to evidenced linkages between predator success and prey abundance as has been observed particularly for black-legged kittiwake, harbour seals, and harbour porpoise.

However, there is also evidence that other drivers may play a greater role in population dynamics of marine species that include sandeel in their diet. These are varied and include disease outbreaks, climate change, mismatch between prey availability and key life stages, as well as various anthropogenic stressors. Benefits may be difficult to evidence due to the challenge of identifying the influence of individual factors. However, having access to ample prey resources can help marine species cope with other stressors, for example good body condition may incur greater resilience to thermal stress and disease.

It is expected therefore that increasing the abundance and availability of sandeel in the marine environment may bring wide environmental benefits through increased population resilience to the range of pressures faced by marine species.

What are the cumulative effects of the proposals to close fishing for sandeel in all Scottish waters?

As the proposal is for a single measure, there is no scope for cumulative effects of this proposal. The cumulative effects of this measure were considered in combination with other existing or developing plans, programmes and/or strategies that have similar objectives, but that fall outside the scope of this proposal.
It is assessed that the proposed extension of the sandeel closure to all Scottish waters will potentially support the outcomes of existing measures to protect seabirds, and marine mammals including Special Areas of Conservation (SACs), Special Protected Areas (SPAs) and Marine Protected Areas (MPAs) in which seabirds and marine mammals are a protected feature. It is also assessed that the proposed extension will potentially support Scotland’s Highly Pathogenic Avian Influenza in wild birds response plan, Scotland’s Future Fisheries Management Strategy, Scotland’s National Marine Plan, and the developing Scottish Seabird Conservation and UK Dolphin and Porpoise Strategies. Complimentary benefits to these plans, programmes and strategies will likely arise through increasing the resilience of sandeel and the species they support to the range of other pressures that they face.

How do I respond to the consultation?

The consultation on the SEA Environmental Report is now open. Views and opinions on this are now invited and should be provided by 13 October 2023.

Please respond to the consultation online at: https://consult.gov.scot/marine-scotland/consultation-on-proposals-to-close-fishing

If you have any enquiries please contact: sandeelconsultation@gov.scot

Or send your inquiry by post to:

Sandeel Fishery Closure Consultation
Scottish Government
Area 1B North
Victoria Quay
Edinburgh
EH6 6QQ

What happens next?

Following the consultation period, the responses received will be analysed, and a Post-Adoption Statement will be prepared. The Post-Adoption Statement will explain how issues raised in the SEA, and associated views in response to the consultation, have been addressed.

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1.1.1 The Scottish Government has commitments under the UK Marine Strategy to collaborate with the other UK administrations to assess, monitor and publish a programme of measure the UK will use to support progress towards achieving Good Environmental Status. This includes descriptors for biodiversity and commercial fish[8,9]. The Scottish Government's key regional platform for collaboration with neighbouring countries on marine biodiversity is OSPAR (the Convention for the Protection of the Marine Environment in the North-East Atlantic), where we participate as part of the UK and take action developed under this forum to protect and conserve the marine ecosystems and biodiversity. Under the Joint Fishery Statement of the Fisheries Act 2020 the Scottish Government is committed to delivering sustainable management of fisheries that takes account for the protection of biodiversity and healthy functioning marine ecosystems[10].

1.1.2 Given the importance of sandeel to the wider ecosystem and the subsequent benefit provided by the species in aiding long-term sustainability and resilience of the marine environment, it remains an over-arching and long-held Scottish Government position not to support fishing for sandeel in Scottish waters, which is reflected in Scotland’s Future Fisheries Management Strategy[11]. This position was emphasised in June 2021 when the Cabinet Secretary for Rural Affairs and Islands committed in Parliament to considering what management measures could be put in place to better manage the North Sea sandeel fisheries in Scottish waters.

1.1.3 There are currently several measures in place for the protection of sandeel stocks, through the network of Marine Protected Areas. A sandeel closure in sandeel management area 4 has also been in place since 2000 and the UK has not allocated sandeel quota to UK vessels since 2021.

1.1.4 The Scottish Government wishes to consult on proposals to close fishing for sandeel in Scottish waters that would meet as far as possible the following aims:

a) To seek effective protection of sandeel, as a contribution to the wider marine ecosystem.

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[8] Department for Environment Food & Rural Affairs. Marine Strategy Part Two: UK updated monitoring programmes. UK Government, 19 December 2022, URL: updated UK Marine Strategy Part Two (publishing.service.gov.uk) (last accessed: 20/06/23).
[9] OSPAR. Convention for the protection of the marine environment of the north-east Atlantic. 18 May 2006, URL: Convention Text | OSPAR Commission (last accessed: 20/06/23).
[10] Department for Environment, Food & Rural Affairs, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), The Scottish Government, and Welsh Government. Joint Fisheries Statement (JFS). 6 December 2022, URL: https://www.gov.uk/government/publications/joint-fisheries-statement-jfs (last accessed: 20/06/23).
[11] Scottish Government. Future fisheries: management strategy – 2020 to 2030. 17 December 2020, URL: Future fisheries: management strategy - 2020 to 2030 - gov.scot (www.gov.scot) (last accessed: 20/06/23).

b) To provide the opportunity for wider ecosystem benefits to a range of species, including commercial fish species, seabirds and marine mammals, that will also improve resilience to changes in the marine environment.
c) To complement, as far as possible, existing sandeel management measures.

1.2 Strategic Environmental Assessment

1.2.1 The Environmental Assessment (Scotland) Act 2005 ('the 2005 Act') requires that certain public plans, programmes and strategies be assessed for their potential effects on the environment[12]. Strategic Environmental Assessment (SEA) is the process used to fulfil this requirement and includes consultation with both the public and the Consultation Authorities[13]. The 2005 Act also sets out the information that is required to be provided in this Environmental Report.

1.2.2 A screening and scoping exercise on the proposed extension of the existing sandeel closure to all Scottish waters was undertaken by Scottish Government , in accordance with the requirements of the 2005 Act. A combined Screening and Scoping Report was published in May 2023, setting out the proposed approach to the SEA, including the proposed scope and level of detail. Comments were invited from the Scottish Consultation Authorities.

1.2.3 The outcome of the screening exercise and the consultation responses confirmed the need for an SEA due to the likelihood for significant environmental effects to arise. The proposed scope of the assessment and methodology was broadly accepted by the Scottish Consultation Authorities (see Section 3).

1.3 Purpose and structure of this report

1.3.1 The purpose of this Environmental Report is to document the findings of the SEA on the proposed extension of the existing sandeel closure to all Scottish waters.

1.3.2 The views of the public and the Consultation Authorities on the proposed extension of the existing sandeel closure to all Scottish waters and the findings of this Environmental Report are now being sought.

1.3.3 The remainder of this Environmental Report is structured as follows:

- Section 2 provides information on existing sandeel management measures, the proposed closure, and their policy context;
- Section 3 presents the approach to the SEA and the methods used;
- Section 4 describes the relevant components of the environment that could be affected by proposals to close fishing for sandeel in all Scottish waters;
- Section 5 sets out the results of the assessment; and
- Section 6 considers the next steps in the implementation of sandeel management measures and the SEA process.

[12] The Environmental Assessment (Scotland) Act 2005. HMSO, 2005. URL: Environmental Assessment (Scotland) Act 2005 (legislation.gov.uk) (last accessed: 20/06/23).
[13] Historic Environment Scotland (HES), Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH).

1.3.4 The Non-Technical Summary precedes Section 1.

2. Sandeel management measures

2.1 Background

2.1.1 Sandeel represent the most abundant species group in the North Sea and play a key role in North Atlantic marine food webs[14]. Variations in the abundance and availability of sandeel can have important effects on both ends of marine food web[15] (top-down regulation of lower trophic levels and bottom-up effects on marine predators). This background section provides an overview of trends and drivers of sandeel abundance as well as placing sandeel in the context of the wider marine environment. Further detail can be found in the report 'Review of Scientific Evidence on the Potential Effects of Sandeel Fisheries Management on the Marine Environment' which can be found in the consultation package.

2.1.2 Sandeel fisheries in European waters are currently assessed and managed in the North Sea only (Figure 2). Due to the lack of data and the current absence of a fishery, sandeel on the west coast of Scotland are not assessed. The largest of the sandeel stocks in Scottish waters is Sandeel Area 4 (SA4), and this is the only one with an active fishery.

2.1.3 Since 2008, the Scottish Government Marine Directorate has conducted an annual winter dredge survey at grounds off the Firth of Forth and Turbot Bank in SA4. Data from this survey as well as earlier sampling efforts dating back to 1993 show a high degree of fluctuation in standing stock biomass (SSB) with SSB dropping below the precautionary spawning biomass level in some years (Figure 2).

2.1.4 Causes of variation in sandeel abundance are numerous and are driven by natural mortality, which is influenced by factors such as environmental change (temperature effects, regime shifts) and top-down processes (trophic regulation by marine predators), in addition to fishing mortality.

2.1.5 Several species of seabird are dependent on sandeel as a prey source during the breeding season, including black-legged kittiwake *Rissa tridactyla*, common guillemot *Uria aalge*, black guillemot *Cepphus grille*, Atlantic puffin *Fratercula arctica*, and Northern gannet *Morus bassanus*[16] and declining populations of sandeel and other small fish may be a contributing factor to the decline of seabirds. For example, in 1993 there was a measurable, negative effect of the

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[14] Sparholt, H. An estimate of the total biomass of fish in the North Sea. ICES Journal of Marine Science, Volume 46, Issue 2, 1990: 200-210. https://doi.org/10.1093/icesjms/46.2.200 (last accessed 21/06/2023).

[15] Eliasen, K., Reinert, J., Gaard, E., Hansen, B., Jacobsen, J., Grønkjær P., Christensen, J. Sandeel as a link between primary production and higher trophic levels on the Faroe shelf. Inter-Research Science Publisher, MEPS, Volume 438, 2011: 185-194. https://www.int-res.com/abstracts/meps/v438/p185-194/ (last accessed 21/06/2023).

[16] Thaxter, C., Lascelles, B., Sugar, K., Cook, A., Roos, S., Bolton, M., Langston, R., Burton, N. Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. Science Direct, Biological Conservation, Volume 156, 2012: 53-61. https://www.sciencedirect.com/science/article/abs/pii/S0006320711004721?via%3Dihub (last accessed 21/06/2023).

fishery on the sandeel stock (local depletion) in the western part of Area 3, which coincided with a reduction in breeding success of seabirds, especially kittiwakes[17]. The ability of seabirds to predate upon sandeel will depend on both the absolute numbers of sandeel (stock biomass) and the availability of sandeel to seabirds. Seabirds are constrained in both the distance from nest sites that they can forage and the depth in the water column that they can reach.

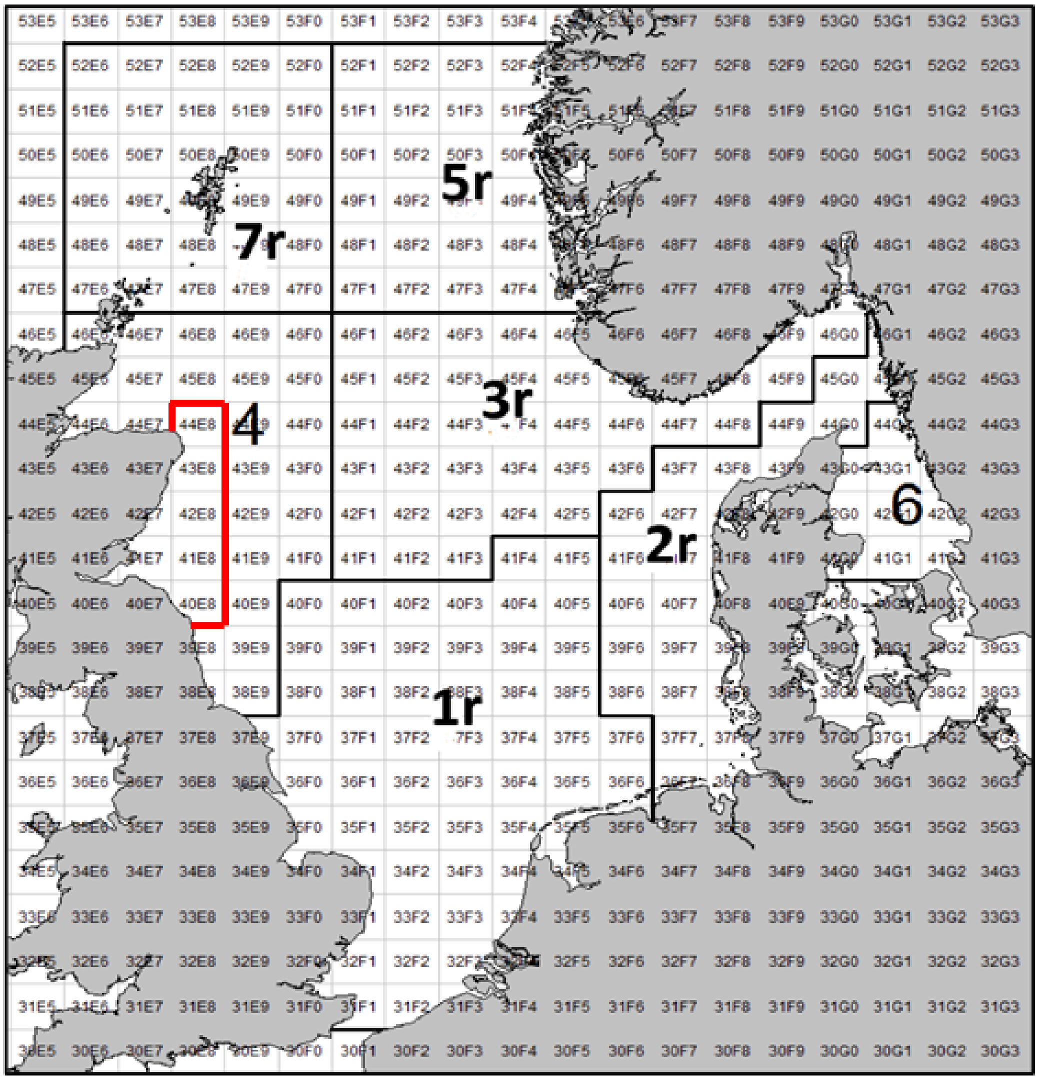

Figure 1: Map of sandeel areas (SAs) in the North Sea and Skagerrack with the existing closure in SA4 shown in red.

[17] ICES. Report of the ICES Advisory Committee on the Marine Environment, 1999. Cooperative Research Report 239, 01 January 2020, URL: [Report of the ICES Advisory Committee on the Marine Environment, 1999 (figshare.com)] (last accessed: 22/06/23).

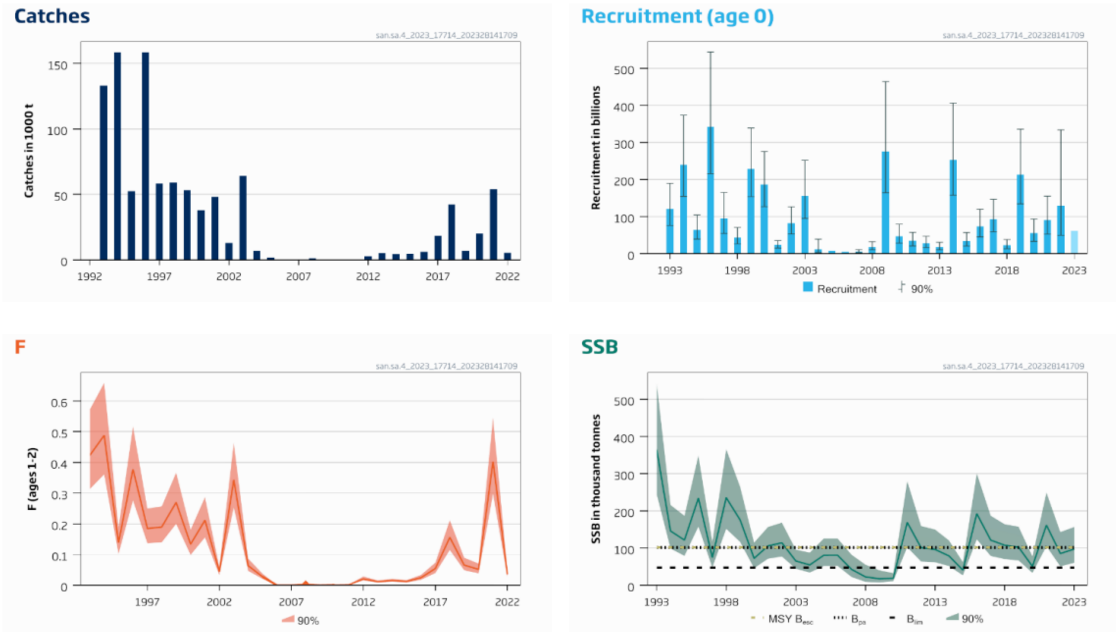

Figure 2: Summary of the stock assessment for Sandeel Area 4 in 2021. The 'Catches' panel shows catches of sandeel in 1000 tonnes per year. The'Recruitment (age 0) panel shows the number of age 0 recruits that enter the fishery per year, with error bars depicting the 90% confidence intervals. In this panel the 2023 value corresponds to the geometric mean for the period 2012-2021 as this assessment is incomplete. The 'F' panel shows fishing mean mortality (F) of sandeel aged 1 and 2 per year. 90% confidence intervals are depicted by the shaded region around the mean. Panel 'SSB' shows the mean spawning stock biomass (SSB i.e. the biomass of all available sandeel) in Sandeel Area A4 in thousand tonnes. The shaded region depicts the 90% confidence interval around this mean. The dotted black line shows the precautionary biomass level (Bpa), below which stocks levels are at risk. The dotted yellow line shows the rate of fishing mortality consistent with achieving Maximum Sustainable Yield (MSY). The dashed black line shows the biomass limit (Blim) below which stocks rae considered to suffer from impaired recruitment. (ICES, 2023).

Sandeel also comprise a key component of the diets of marine mammals including grey seals *Halichoerus grypus* and harbour seals *Phocu vitulina*, as well as cetaceans such as minke whale *Balaenoptera acutorostrata*[18] and harbour porpoise *Phocoena phocoena*[19]. Harbour seals are experiencing regional population declines and one potential contributing factor is a reduction in the availability of prey species, including sandeel in regions where they are experiencing decline[20]. Lower availability of sandeel has been linked with increased risk of starvation in harbour porpoise[18].

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[18] Macleod, K., Fairbairns, R., Gill, A., Fairbairns, B., Gordon, J., Blair-Myres, C., Edward, C., Parsons, M. Seasonal distribution of minke whales, *Balaenoptera acutorostrata,* in relation to physiography and prey off the Isle of Mull, Scotland. Inter Research Science Publisher, MEPS, Volume 277, 2004: 263 – 274. https://www.int-res.com/abstracts/meps/v277/p263-274/ (last accessed 21/06/2023).
[19] MacLeod, C., Begoña Santos, M., Reid, R., Scott, B., Pierce, G. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? The Royal Society Publishing, Biology Letters, Volume 3, Issue 2, 2007. https://royalsocietypublishing.org/doi/abs/10.1098/rsbl.2006.0588 (last accessed 21/06/2023).
[20] Wilson, L., Hammond, P. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Wiley Online Library, Aquatic Conservation:

2.1.6 Sandeel is also a prey species for some predatory fish species (Atlantic cod *Gadus morhua*, whiting *Merlangius merlangus*, haddock *Melanogrammus aeglefinus* and saithe *Pollachius virens*) [21,22]. In addition to trophic interactions with sandeel, other marine fish may interact with the sandeel fishery via catching patterns. Whiting and mackerel *Scomber scombrus* are caught as bycatches in the sandeel fishery and whiting aggregate at sites of high sandeel abundance[23].

2.2 Effects of sandeel management measures to date

2.2.1 North Sea sandeel is jointly managed stock between the UK and the EU. Under the UK/EU Trade and Cooperation Agreement (TCA), the UK has a 2.97% share and the EU a 97.03% share of the Parties' combined sandeel quota in 2023. The Total Allowable Catch (TAC) is set during the in-year consultations, followed by the ICES advice release. As a result of the negotiations this year, the TAC has been set at 194,367 tonnes[24] which is 3% lower for areas 1r and 4[25] (UK waters) than the ICES advice.

2.2.2 Under the UK/EU Trade and Cooperation Agreement (TCA)[26], and during a transition period lasting until 30 June 2026, the UK and the EU have full mutual access to their respective EEZs (i.e., 12 – 200 nautical miles); as well as access to specific English, Welsh and Channel Island waters in the 6-12 nautical mile area. Sandeel is an important fishery to some EU member states, in particular Denmark, who regularly fish the stock in UK waters.

Marine and Freshwater Ecosystems, Volume 29, Issue S1, 2019: 71 – 85. https://onlinelibrary.wiley.com/doi/abs/10.1002/aqc.3131 (last accessed 21/06/2023).

[21] Temming, A et al. Predation of whiting and haddock on sandeel: aggregative response, competition and diel periodicity. Wiley Online Library, Journal of Fish Biology, Volume 64, Issue 5: 1351 – 1372. https://onlinelibrary.wiley.com/doi/10.1111/j.0022-1112.2004.00400.x (last accessed 21/06/2023).

[22] Reilly, T et al. Interpreting variation in fish-based food web indicators: the importance of "bottom-up limitation" and "top-down control" processes. ICES Journal of Marine Science, Volume 71, Issue 2, 2014: 406 – 416. https://academic.oup.com/icesjms/article/71/2/406/784513 (last accessed 21/06/2023).

[23] Temming, A., Götz, S., Mergardt, N., Ehrich, S. Predation of whiting and haddock on sandeel: aggregative response, competition and diel periodicity. Wiley Online Library, Journal of Fish Biology, Volume 64, Issue 5: 1351 – 1372. https://onlinelibrary.wiley.com/doi/10.1111/j.0022-1112.2004.00400.x (last accessed 21/06/2023).

[24] Scottish Government. European Union and the United Kingdom – sandeel fisheries consultations: written record for 2023. 23 March 2023. https://www.gov.scot/publications/european-union-and-the-united-kingdom-sandeel-fisheries-consultations-written-record-for-2023/ (last accessed 21/06/2023).

[25] ICES. Sandeel *(Ammodytes spp.)* in divisions 4,v-c, Sandeel Area 1r (central and southern North Sea, Dogger Bank). ICES Advice on fishing opportunities, catch and effort, 2022. https://ices-library.figshare.com/articles/report/Sandeel_Ammodytes_spp_in_divisions_4_b_c_Sandeel_Area_1r_central_and_southern_North_Sea_Dogger_Bank_/19248998/1 (last accessed 21/06/2023)

[26] Brussels and London. Trade and Cooperation Agreement. 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/982648/TS_8.2021_UK_EU_EAEC_Trade_and_Cooperation_Agreement.pdf (last accessed 21/06/2023).

2.2.3 Due to their ecosystem importance, sandeel were made a Scottish priority marine feature[27] and given their limited movements, various Nature Conservation (NC) MPAs have been designated with sandeel as a key conservation target (Figure 3). In 2014, following two public consultation exercises, the North West Orkney, the Mousa to Boddam and the Turbot Bank NC MPAs were designated under the Marine (Scotland) Act 2010 and Marine and Coastal Access Act 2009 to protect sandeel. Designations were based primarily on assessment of peer-reviewed scientific evidence, using the process as set out in the Scottish MPA Selection Guidelines. These areas demonstrated a regular presence of sandeel and were particularly important to adult aggregations (Turbot Bank), recruitment (Shetland) and/or larval export (NW Orkney, Turbot Bank), and had geophysical attributes supportive to sandeel populations, based on evidence from historic trawl, dredge and continuous plankton recorder (CPR) surveys, particle size analysis (PSA) and oceanographic modelling.

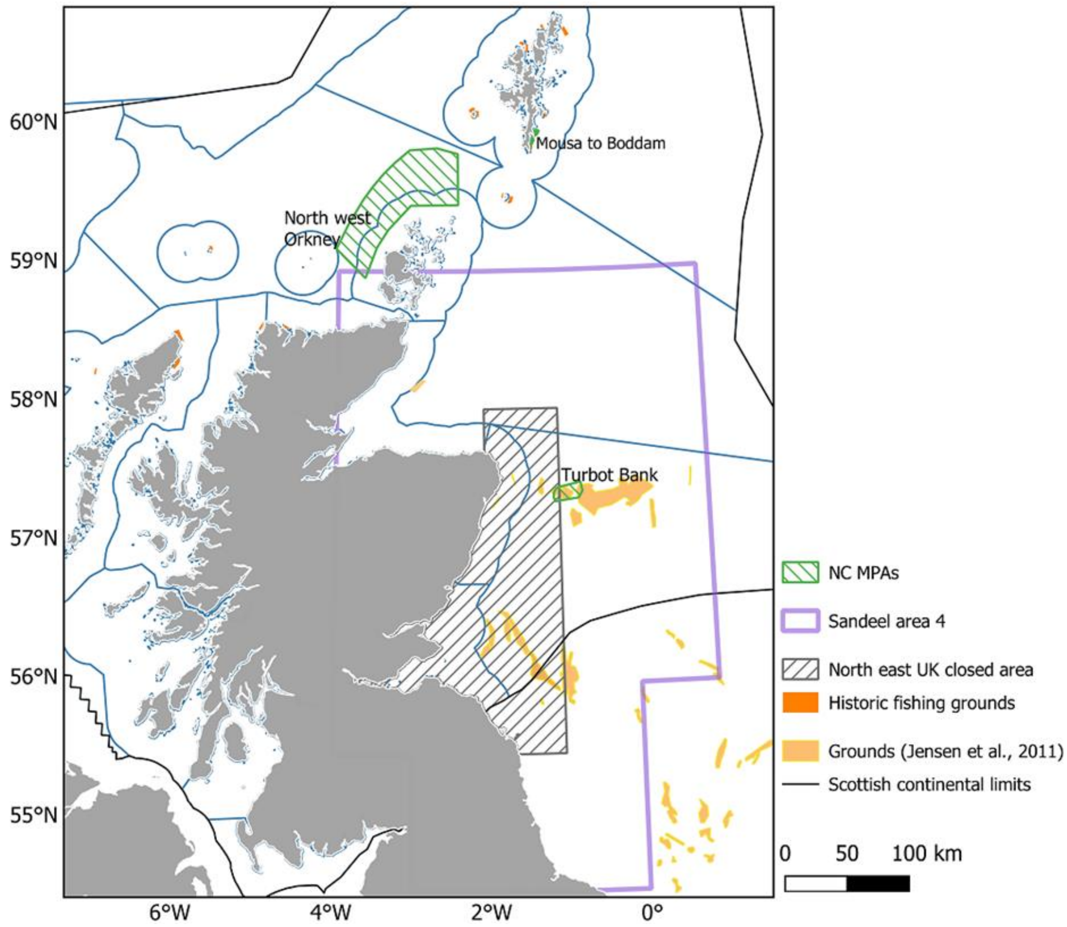

Figure 3: Map of SA4 and the various spatial measures for sandeel within Scottish waters. Blue lines show Scottish Marine and Offshore Regions for context.

2.2.4 As a precautionary measure to safeguard marine top predators, particularly seabirds at internationally important colonies in and around the Firth of Forth, an area off the east coast of Scotland, from Rattray Head to St Abbs, was closed to

[27] Marine Scotland Directorate. Priority Marine Features. Scottish Government. https://www.gov.scot/policies/marine-environment/priority-marine-features/ (last accessed 21/06/2023).

industrial fishing for sandeel in 2000. The extent of the area is indicated in Figure 3 and covers about 27% of SA4 fishing grounds historically targeted by the fishery[28].

2.2.5 Evidence establishing the effect of the fishery closure is limited. The Marine Directorate led studies that compared measures of sandeel abundance before and during the closure[29,30], relying on sandeel sampled during the summer months using a variety of gears (demersal trawls, pelagic trawls, acoustic surveys, dredges, and grabs). A substantial increase in sandeel biomass was observed in the Firth of Forth in 2000 and 2001 (i.e., the first years following the closure). This increase was found to be associated with high levels of recruitment in 1999 and 2000, combined with the lack of fishing pressure. However, the cause of the 2000 increase in sandeel biomass (high recruitment in 1999 and 2000) is unclear as it preceded any increase in the local spawning stock, so cannot be attributed to the closure. Since 2001, sandeel biomass has declined to reach levels in 2008-2009 that were similar to those observed in 1997 and 1998 when the sandeel fishery in the area was active[31] (Figure 4).

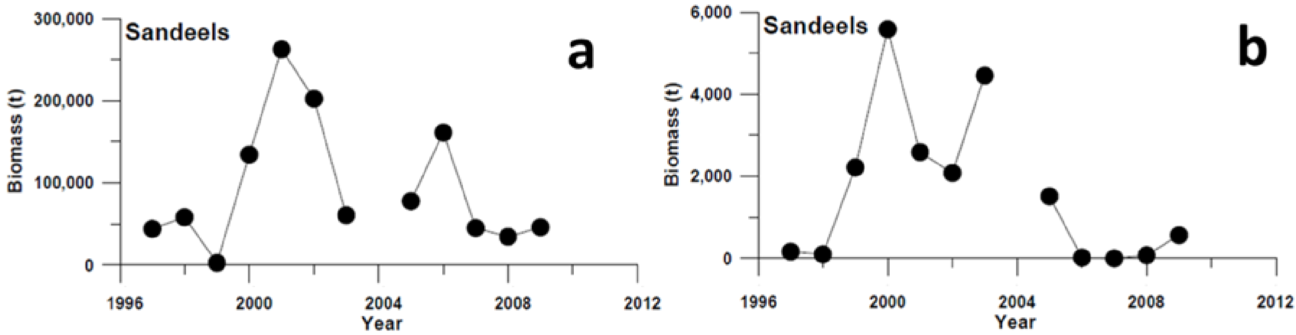

Figure 4: Sandeel abundance estimates in the Firth of Forth from a) fisheries acoustic surveys or b) demersal trawls (Trade Cooperation Agreement, 2020).

2.2.6 Evidence shows that causes of variation in natural mortality played a more prominent role than fishing mortality in shaping sandeel abundance in Scottish

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[28] Jensen, H., Rindorf, A., Wright, P.J. & Mosegaard, H. Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science, Volume 68, Issue 1, 2011: 43 - 51. https://academic.oup.com/icesjms/article/68/1/43/631084 (last accessed 21/06/2023).

[29] Greenstreet, S. P. R., Armstrong, E., Mosegaard, E., Jensen, H., Gibb, I. M., Fraser, H. M., Scott, B. E., Holland, G. J., & Sharples, J. (2006). Variation in the abundance of sandeel Ammodytes marinus off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. ICES Journal of Marine Science, 63: 1530 - 1550. https://academic.oup.com/icesjms/article/63/8/1530/714676 (last accessed 21/06/2023).

[30] Greenstreet, S.P., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M. & Gibb, I.M. Combining hydroacoustic seabed survey and grab sampling techniques to assess “local” sandeel population abundance. ICES Journal of Marine Science, Volume 67, Issue 5, 2010: 971 – 984. https://academic.oup.com/icesjms/article/67/5/971/608540 (last accessed 21/06/2023).

[31] Brussels and London. Trade and Cooperation Agreement. 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/982648/TS_8.2021_UK_EU_EAEC_Trade_and_Cooperation_Agreement.pdf (last accessed 21/06/2023).

waters and as these causes of variation are rarely accounted for, an effect of fishing pressure on sandeel abundance is rarely observed. However, while results should be considered with caution, age 1 sandeel seem to have a higher survival rate in the current fishery closure.

2.2.7 While the effect of a fishery closure may be difficult to observe in a changing environment, sandeel are likely to benefit from spatial management measures aimed at reducing fishing mortality due to their life-long attachment to particular sand banks and limited dispersal and movements. As represented in Figure 5, variations in Spawning Stock Biomass (SSB) are mainly driven by variability in recruitment.

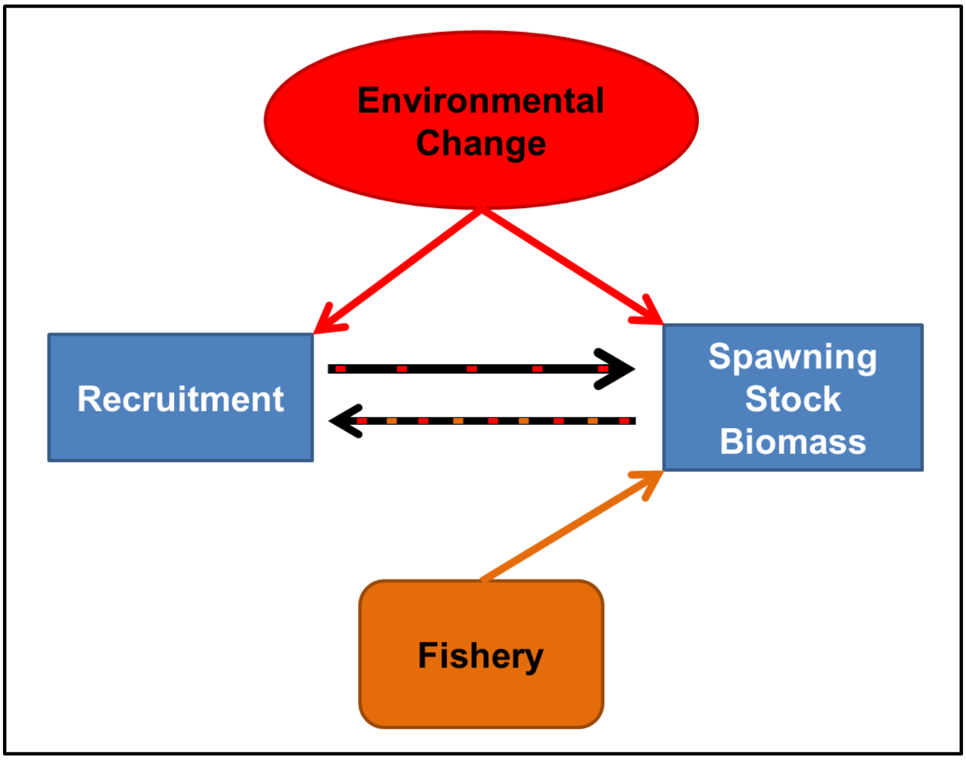

Figure 5: Diagram representing the pressures affecting sandeel biomass.

2.2.8 Here recruitment, to a certain extent, is contingent on the size of the reproductive population (SSB). Environmental change has a multitude of effects (direct and indirect) and can affect SSB through the maturation process (see section 3.2.1 of the report 'Review of Scientific Evidence on the Potential Effects of Sandeel Fisheries Management on the Marine Environment'); recruitment through the effects on phenology (spawning date, incubation time, hatching date); and trophic mismatch between sandeel hatching and the availability of their copepod prey. The fishery can directly affect SSB through fishing mortality and there is some evidence that it may also indirectly affect recruitment by decreasing SSB (through mortality) or by reducing the abundance of large individuals which have a higher fecundity and may spawn earlier (which in turn may affect trophic mismatch and interact with climate change effects). A fishery closure may therefore promote sandeel resilience to climate change by limiting variation in SSB that might affect recruitment and ensuring that sufficient large, early spawning individuals are present in the population. In accordance, a modelling study found that population collapse was more likely under exploitation[32].

2.3 Proposals to close fishing for sandeel in all Scottish waters

2.3.1 The Scottish Government has committed to considering what measures could be introduced to better manage fishing for sandeel in Scottish waters, with an aim to benefit both North Sea sandeel stocks, and the wider ecosystem.

2.3.2 Based on the scientific evidence available there is evidence that extending the existing closure to all Scottish waters may benefit the stock and wider ecosystem.

2.3.3 Taking into consideration the pressures facing key predator species such as seabirds, marine mammals and predatory fish stocks, the Scottish Government therefore proposes to consult on proposals to extend the existing sandeel area closure to all Scottish waters. This proposal is informed by the potential benefits to the wider marine ecosystem that such a measure could bring. These include benefits to sandeel, seabirds, marine mammals, and other fish species. The extension of the current closed area to all Scottish waters would also benefit several of Scotland's Marine Protected Areas (MPAs) for which sandeel are a protected feature, and would contribute to achievement of GES for seabirds and marine mammals[33].

2.3.4 Sandeel in area 4 is a single stock. The TAC for sandeel area 4 covers the whole area, without taking into account the existing closure within the area, therefore some fishing effort is currently displaced without regard to the potential effects on local depletion.

2.3.5 Consideration was given to possible further displacement of fishing effort as a result of an extension to the closed area. It is possible that closure of the sandeel fishery in all Scottish waters would mean that some activity is displaced into the portion of sandeel area 4 that extends into English waters. However, it is difficult to quantify to what extent fishing patterns in the area will change as a result of displacement, or if fishing will simply decrease. Displacement can be assessed using VMS data which is already available for all vessels in the fishery. Furthermore, the UK government launched a consultation on the management of sandeel in English waters on 7 March 2023. This proposes a closure of sandeel fishing in English waters within the North Sea. If this proceeds, then this would mitigate the risk of displacement of activity into English waters. On the other hand, closure of the

[32] Poloczanska, E.S., Cook, R.M., Ruxton, G.D. &Wright, P.J. Fishing vs. natural recruitment variation in sandeel as a cause of seabird breeding failure at Shetland: a modelling approach. ICES Journal of Marine Science, Volume 61, Issue 5, 2004: 788 - 797. https://academic.oup.com/icesjms/article/61/5/788/866027 (last accessed 21/06/2023).
[33] Department for Environment Food & Rural Affairs. Marine Strategy Part Two: UK updated monitoring programmes. UK Government, 19 December 2022: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1125641/uk-marine-strategy-part-two-monitoring-programmes-2021.pdf (last accessed: 20/06/23).

sandeel fishery in English waters may risk displacement of fishing activity into Scottish waters if the option to close the sandeel fishery in Scottish waters is not pursued. Catching levels are set in line with the agreed TAC level flowing from the UK-EU Bilateral Agreement, meaning that there will be no increased fishing pressure in the area as a whole.

2.3.6 Sandeel play a key role in North Atlantic marine food webs and variations in their abundance and availability can have important effects across the marine food web. Sandeel are an important food source for globally important Scottish seabird populations that are currently facing a range of pressures. Some species, such as black-legged kittiwake and Arctic skua *Stercorarius parasiticus*, are considered highly sensitive to sandeel availability[34]. Sandeel are also an important food source for fish species and marine mammals, including locally declining harbour seal populations[35]. The total stock biomass of sandeel has shown an overall decline over the last three decades. Climate change has the potential to further affect sandeel abundance and their availability to marine predators.

2.3.7 We propose extension of the closure to cover all Scottish waters, due to the potential benefits that it may bring to sandeel stocks (which continue to be depleted) as well as the wider marine environment[36]. We propose that the closure is effective year-round, and that it should be permanent until revoked. Full consideration to all options will be given following the consultation.

2.4 Policy context overview of the proposals to close fishing for sandeel in all Scottish waters

2.4.1 The Scottish Government has commitments under the UK Marine Strategy to collaborate with the other UK administrations to assess, monitor and measure progress towards Good Environmental Status. This includes descriptors for biodiversity and commercial fish[37]. The Scottish Government's key regional platform for collaboration with neighbouring countries on marine biodiversity is OSPAR (the Convention for the Protection of the Marine Environment in the North-East Atlantic), where we participate as part of the UK and take action developed under this forum to

[34]Furness, R., Tasker, M. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Inter-Research Science Publisher, MEPS, Volume 202: 253 – 264. https://www.int-res.com/abstracts/meps/v202/p253-264/ (last accessed 21/06/2023).
[35] Wilson, L., Hammond, P. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Wiley Online Library, Aquatic Conservation: Marine and Freshwater Ecosystems, Volume 29, Issue S1, 2019: 71 – 85. https://onlinelibrary.wiley.com/doi/abs/10.1002/aqc.3131 (last accessed 21/06/2023).
[36]Dunn, E. Revie our Seas: The case for stronger regulation of sandeel fisheries in UK waters. RSPB, 2021. https://www.rspb.org.uk/globalassets/downloads/documents/campaigning-for-nature/rspb2021_the-case-for-stronger-regulation-of-sandeel-fisheries-in-uk-waters.pdf (last accessed 21/06/2023).
[37]UK Government. Marine strategy part one: UK updated assessment and Good Environmental Status. 2019. https://www.gov.uk/government/publications/marine-strategy-part-one-uk-updated-assessment-and-good-environmental-status (last accessed 21/06/2023).

protect and conserve the marine ecosystem and biodiversity[38]. Under the Joint Fishery Statement of the Fisheries Act 2020 the Scottish Government is committed to delivering sustainable management of fisheries that takes account for the protection of biodiversity and healthy functioning marine ecosystems[39].

2.4.2 Given the importance of sandeel to the wider ecosystem and the subsequent benefit provided by the species in aiding long-term sustainability and resilience of the marine environment, it remains an over-arching and long-held Scottish Government position not to support fishing for sandeel in Scottish waters, which is reflected in Scotland's Future Fisheries Management Strategy[40]. This position was emphasised in June 2021 when the Cabinet Secretary for Rural Affairs and Islands committed in Parliament to considering what management measures could be put in place to better manage the North Sea sandeel fishery in Scottish waters.

[38]OSPAR. Convention Text. 1992. https://www.ospar.org/convention/text (last accessed 21/06/2023).
[39]Department for Environment, Food and Rural Affairs., Department of Agriculture., Environment and Rural Affairs (Northern Ireland)., The Scottish Government., The Welsh Government. Joint Fisheries Statement (JFS). 2022. https://www.gov.uk/government/publications/joint-fisheries-statement-jfs (last accessed 21/06/2023).
[40]Scottish Government. Future fisheries: management strategy – 2020 to 2030. 17 December 2020. Future fisheries: management strategy - 2020 to 2030 - gov.scot (www.gov.scot) (last accessed: 20/06/23).

3. Approach to the Assessment

3.1 Purpose of the assessment

3.1.1 The purpose of this SEA is to assess the potential for likely significant environmental effects to arise from the extension of the existing sandeel closure in Sandeel Area 4 to all Scottish waters. This will allow corresponding mitigation measures to be identified where necessary and highlight opportunities for enhancement in cases where beneficial effects are likely.

3.2 Scope of the proposals

3.2.1 It is not considered within the scope of this SEA to evaluate the evidence base underlying the decision to extend the existing sandeel closure in Sandeel Area 4 to all Scottish waters. This evidence base is presented in the report 'Review of Scientific Evidence on the Potential Effects of Sandeel Fisheries Management on the Marine Environment' and summarised in the consultation document which was published as part of the consultation package.

3.2.2 The potential economic and social impacts that may result from the implementation of the proposals do not form part of the scope of this SEA. A Business and Regulatory Impact Assessment (BRIA) will also be undertaken to assess the economic impacts of this proposal.

3.3 Scope of the assessment

3.3.1 The scope of any potentially significant environmental effects is largely limited to the beneficial effects for species that fall within the proposed closure area or regularly use this area; spill-over benefits beyond area boundaries; and potential adverse effects outside the proposed closure area as a result of the displacement of fishing activity and the intensification of activity in areas where sandeel fishing already occurs.

3.3.2 An initial review of the related assessment work (see Section 3.5) suggests that potentially significant environmental effects are likely to fall under the SEA topic of Biodiversity, Flora and Fauna. This could also include relevant aspects of Water quality, resources, and ecological status (the status of marine resources i.e. the sandeel stock and other marine fish stocks). The rationale for scoping in and out each of the SEA topics is provided in Table 1.

Table 1: Proposed scoping in/out of SEA topics.

SEA Topic	In/out	Reasons for inclusion / exclusion
Biodiversity, flora and fauna	In	The proposals are considered to be beneficial to sandeel stocks, seabirds, predatory fish and marine mammals and therefore this topic will be scoped in.

SEA Topic	In/out	Reasons for inclusion / exclusion
Population	Out	The proposal would not result in significant increases and/or decreases in human population numbers, changes to in- or out-migration, etc. These topics are scoped out of the SEA. Social and economic effects will be considered by the BRIA.
Human health	Out	The proposal would not result in any significant human health issues. This topic is scoped out of the SEA.
Soil, geology and hydrodynamic processes	Out	The proposals are unlikely to have a significant impact on soil, geology, or hydrodynamic processes. Sandeel fishing is focussed on sandy grounds with a moderate current so there has never been concern about sediment disturbance from sandeel trawls. This topic has therefore been scoped out of the SEA.
Water quality, resources, ecological status	In	The proposal may have an impact on resources (fish stocks) therefore this topic will be scoped in.
Air	Out	The proposal would be unlikely to result in emissions to air, other than those from vessel use. It is unlikely that the extension would make a significant difference to existing vessel emissions. This fishery currently takes place in offshore waters and therefore doesn't impact Scottish air quality. Any displacement of vessels caused by closing all Scottish waters would move vessels further from Scotland therefore the proposed extension will have no positive or negative impact on Scottish air quality. This topic is scoped out of the SEA.
Climatic factors	Out	The proposal is unlikely to result in significant increased/ decreased emissions of greenhouse gases although a change in fishing effort may result in a change in vessel emissions. The UK has not allocated sandeel quota since 2021 therefore no UK vessels hold quota for sandeel. The only vessels that currently fish in the area are Danish. Extending the closure will therefore have no impact on Scottish carbon emissions. Although there may be an impact on emissions from Danish vessels as a result of displacement to other grounds, this is a trans-boundary issue that is disproportionate to a SEA. As Scottish sandeel fishing grounds are furthest geographically from Denmark any affect would be a reduction in emissions. Any reduction in their emissions is not likely to be significant. This is scoped out of the SEA.
Material assets	Out	The proposal will not intrinsically impact built assets or natural assets as defined in SEPA guidance.
Cultural heritage	Out	Fishing practices will remain largely unchanged at the methodological level. Any impacts to cultural heritage will

SEA Topic	In/out	Reasons for inclusion / exclusion
		remain as before. Depending on future spatial measures, there may be less impact in some areas (due to closures) and more in others (due to displacement) but for the purposes of the extension of existing closure in sandeel area 4 to all Scottish waters assessment this can be scoped out.
Landscape/ seascape	Out	The proposal is unlikely to have effects on landscape and/or seascape over or below what effects the industry currently has. These issues are therefore scoped out of the SEA.

3.4 Reasonable alternatives

3.4.1 The SEA has identified some reasonable alternatives to the proposals to close fishing for sandeel in all Scottish waters that might achieve the same wider environmental benefits. These alternatives include smaller closures and alternative measures to support the wider ecosystem and are summarised in Table 2.

Table 2: Alterative measures to achieve wider environmental benefits.

Measure	Scope
Option 0: Do nothing.	Objectives of the proposed closure will not be met.
Option 1: Complete closure of all Scottish waters to sandeel fishing (preferred option).	To achieve all objectives of the proposed closure.
Option 2: Extension of existing closure to all of sandeel management area 4 only.	To achieve all objectives of the proposed closure.
Option 3: Seasonal closure of the sandeel fishery.	To achieve all objectives of the proposed closure.
Option 4: Voluntary closure of the sandeel fishery	To achieve all objectives of the proposed closure.

3.5 Assessment methodology

3.5.1 The SEA has presented a high level and qualitative account of the potential environmental effects that might be expected to arise from the proposal. The SEA has also assessed the potential effects that could arise from the measures that have been developed as reasonable alternatives (see Section 3.4).

3.5.2 The assessment has been informed by a desk-based review of available information on the existing environment within the current sandeel closed area within Sandeel Area 4 , and in wider Scottish waters to which we propose to extend the closure (environmental baseline). This baseline review is presented in Section 4.

3.5.3 The assessment has then considered the sensitivity (tolerance/recoverability) of sandeel and sandeel-dependent species identified as part of the baseline review to the removal of fishing pressure as a result of the proposed measure, and to measures outlined as reasonable alternatives. This assessment is based on the latest understanding of the relative impact of fishing pressure on sandeel in comparison to other population drivers; the dependence of identified species on sandeel; the distribution of identified species in relation to sandeel, and the extent of other pressures faced by each identified species.

3.5.4 For the purpose of this assessment, the indicative criteria set out in Table 3 were used to help determine the type (beneficial or adverse) and magnitude (negligible, very minor, minor, moderate or major) of potential effects that may result from the proposed measure. The potential for future effects has also been identified, however the magnitude of potential future effects was impossible to predict based on available information.

Table 3: Indicative criteria of potential effects.

Type	Magnitude	Indicative criteria
Adverse/Beneficial	Major	Large spatial scale (size/number); Long-term (duration/frequency); High sensitivity to management measure; and/or Low tolerance/reversibility of features.
	Moderate	Medium spatial scale; Medium-term; Moderate sensitivity to management measure; and/or Moderate tolerance/reversibility of features.
	Minor	Small spatial scale; Short-term; Low sensitivity to management measure; and/or High tolerance/reversibility of features.
	Negligible	There is likely to be a change, but the level will be indiscernible from baseline conditions.
Neutral	None	No change from baseline conditions.

3.5.5 The potential implications of the proposed measures were then assessed against the SEA objectives. The SEA objectives that we applied in the assessment are presented in Table 4.

Table 4: SEA objectives.

SEA Topic	SEA Objective
Biodiversity, Flora and Fauna	• To safeguard and enhance marine and coastal ecosystems, including species, habitats and their interactions; • To maintain or work towards achieving 'Good Environmental Status' for biodiversity; • To maintain or work towards achieving 'Good Environmental Status' for relevant commercial fish; • To protect and conserve the ecosystems and the biological diversity of UK territorial seas; • To deliver sustainable management of fisheries that takes account of the protection of biodiversity and healthy functioning marine ecosystems.
Water quality, resources, ecological status	• See Biodiversity, Flora and Fauna

4. Environmental Baseline

4.1 Introduction

4.1.1 This section of the Environmental Report describes the character of the environment which may be affected by the proposed extension of the existing closure in SA4 to all Scottish waters. The focus of this baseline information is therefore on Biodiversity, Flora and Fauna; and Water quality, resources, and ecological status (the ecological status of sandeel and other commercially fished species that interact with sandeel), reflecting the scope of the assessment as described in Section 3.3.

4.2 Biodiversity, flora and fauna

4.2.1 Sandeel represent the most abundant species group in the North Sea and play a key role in North Atlantic marine food webs[41]. Species that interact with sandeel include several species of seabird[42], grey and harbour seals[43], cetaceans such as minke whale[44] and harbour porpoise[45], and several species of commercially important fish (see Section 4.3).

Seabirds

4.2.2 Scotland holds internationally important numbers of breeding seabirds, with 24 species regularly breeding in Scotland[46]. A large proportion of these species include sandeel in their diet during the breeding season.

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[41] Sparholt, H. An estimate of the total biomass of fish in the North Sea. ICES Journal of Marine Science, Volume 46, Issue 2, 1990: 200 – 210. https://academic.oup.com/icesjms/article/46/2/200/645388

[42] Thaxter, C., Lascelles, B., Sugar, K., Cook, A., Roos, S., Bolton, M., Langston, R., Burnton, N. Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. Science Direct, Biological Conservation, Volume 156, 2012: 53-61. https://www.sciencedirect.com/science/article/abs/pii/S0006320711004721?via%3Dihub (last accessed 21/06/2023).

[43] Wilson, L., Hammond, P. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Wiley Online Library, Aquatic Conservation: Marine and Freshwater Ecosystems, Volume 29, Issue S1, 2019: 71 – 85. https://onlinelibrary.wiley.com/doi/abs/10.1002/aqc.3131 (last accessed 21/06/2023).

[44] Macleod, K., Fairbairns, R., Gill, A., Fairbairns, B., Gordon, J., Blair-Myres, C., Edward, C., Parsons, M. Seasonal distribution of minke whales, *Balaenoptera acutorostrata,* in relation to physiography and prey off the Isle of Mull, Scotland. Inter Research Science Publisher, MEPS, Volume 277, 2004: 263 – 274. https://www.int-res.com/abstracts/meps/v277/p263-274/ (last accessed 21/06/2023).

[45] MacLeod, C., Begoña Santos, M., Reid, R., Scott, B., Pierce, G. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? The Royal Society Publishing, Biology Letters, Volume 3, Issue 2, 2007. https://royalsocietypublishing.org/doi/abs/10.1098/rsbl.2006.0588 (last accessed 21/06/2023).

[46] Mitchell, I., Newtom, S., Ratcliffe, N., Dunn, T. Seabird Populations of Britain and Ireland: results of the Seabird 2000 census (1998 – 2002). 2011: https://data.jncc.gov.uk/data/1dae7357-350c-483f-b14d-7513254433a5/S2000-seabird-pop-exec-summary.pdf (last accessed 21/06/2023).

4.2.3 Several seabird species include sandeel as a major component of their diet and so are a focus of the baseline and SEA:

- Black-legged kittiwake *Rissa tridactyla*
- Atlantic puffin *Fratercula arctica*
- Razorbill *Alca torda*
- European shag *Gulosus aristotelis*
- Black guillemot *Cepphus grille*
- Common guillemot *Uria aalge*
- Arctic tern *Sterna paradisaea*
- Sandwich tern *Thalasseus sandvicensis*

4.2.4 Black-legged kittiwake are broadly distributed in Scottish waters with breeding colonies distributed across the whole Scottish coastline (Figure 6). Most recent surveys have estimated that there are 367,000 breeding pairs in the UK and during the non-breeding season 1,319,000-1,742,000 birds are estimated to be present in UK waters, although there is a high degree of uncertainty around this estimate[47]. The UK Kittiwake breeding population constitutes 12.3-14.8% of their North Atlantic biogeographic population. Seventy-seven percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable. They are an OSPAR red-listed species.

4.2.5 Atlantic puffin are broadly distributed in Scottish waters, with breeding colonies concentrated on Northwest Scotland, the Western Isles, the Northern coast, Orkney and Shetland, and Southeast Scotland (Figure 7 **Error! Bookmark not defined.**). Most recent surveys have estimated that there are 580,000 breeding pairs in the UK with 537,000 individuals estimated to occur in UK waters during the non-breeding season [47]. The breeding population of Atlantic puffin in the UK make up 9-11% of their Atlantic biogeographic population. Eighty-five percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

4.2.6 Razorbill are broadly distributed in Scottish waters with breeding colonies distributed across the whole Scottish coastline. Most recent surveys have estimated that there are 110,000 breeding pairs in the UK, 560,000 individuals estimated to be present during the non-breeding season[47]. The UK breeding population of razorbill constitutes 21% of their Northwest Europe biogeographic population. Eighty-five percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

4.2.7 Black guillemot are distributed very close inshore around the coast of West, North and North East Scotland. The number of breeding pairs in the UK is estimated to be 26,000 at the most recent count[47]. There are estimated to be 120,000 individuals present in UK waters during the non-breeding season. Black guillemot in

[47] Waggit, J. J. et al. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 2019; 57(2): 253-269. https://doi.org/10.1111/1365-2664.13525 (last accessed 21/06/2023).

UK waters make up 18-36% of their northern North Atlantic biogeographic population. Eighty-eight percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

4.2.8 Common guillemot are broadly distributed throughout Scottish waters with breeding colonies distributed around the whole Scottish coastline (Figure 8). Most recent surveys have estimated that there are 890,000 breeding pairs in the UK, with 2,577,000 individuals present in UK waters during the non-breeding season, although there is a high degree of uncertainty around this estimate[48]. Common guillemot in UK waters make up 31-32% of their North Atlantic biogeographic population. Eighty-eight percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

4.2.9 European shag are broadly distributed around the Scottish coast with breeding colonies distributed across the whole Scottish coastline (Figure 9). Most recent surveys have estimated that there are 28,000 breeding pairs in the UK and 96,000 individuals present during the non-breeding birds[48]. Shag in UK waters make up 40-44% of their coastal northern Europe biogeographic population. Seventy-eight percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

4.2.10 Arctic tern are distributed around the Scottish coast with high concentrations of breeding colonies in Shetland, Orkney and the Western Isles and lower abundances found around the rest of the Scottish coast (Figure 10). Most recent surveys have estimated that there are 52,600 breeding pairs in the UK, all of which migrate to the South Atlantic or Antarctica for the Austral summer[48]. Arctic tern in UK waters make up 2.9-3.5% of their European and North Atlantic biogeographic population. Ninety percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

4.2.11 Sandwich tern are present around the coast of Scotland, (Figure 11). Most recent surveys have estimated that there are 10,540 breeding pairs in the UK, all of which migrate out of Scottish waters during the non-breeding season, predominantly to West Africa[48]. Sandwich tern in UK waters make up 14-16% of their Western Europe and West Africa biogeographic population. Ten percent of the UK breeding population reside in Scotland. Their conservation status in UK waters is unfavourable.

[48] Waggit, J. J. et al. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 2019; 57(2): 253-269. https://doi.org/10.1111/1365-2664.13525 (last accessed 21/06/2023).

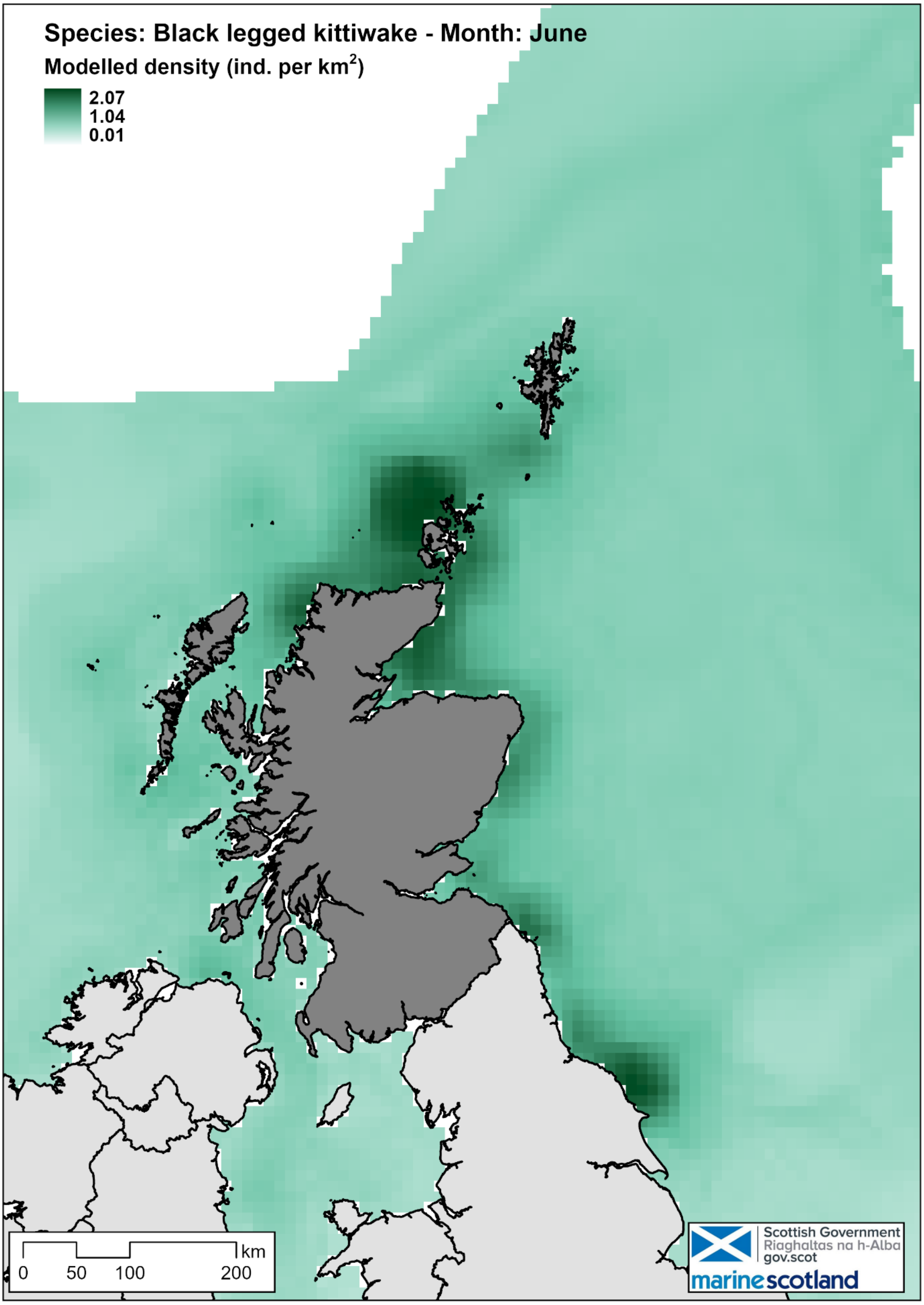

Figure 6: Estimated density of black-legged kittiwake, *Rissa tridactyla,* in Scottish waters. (Waggit et al. 2019)

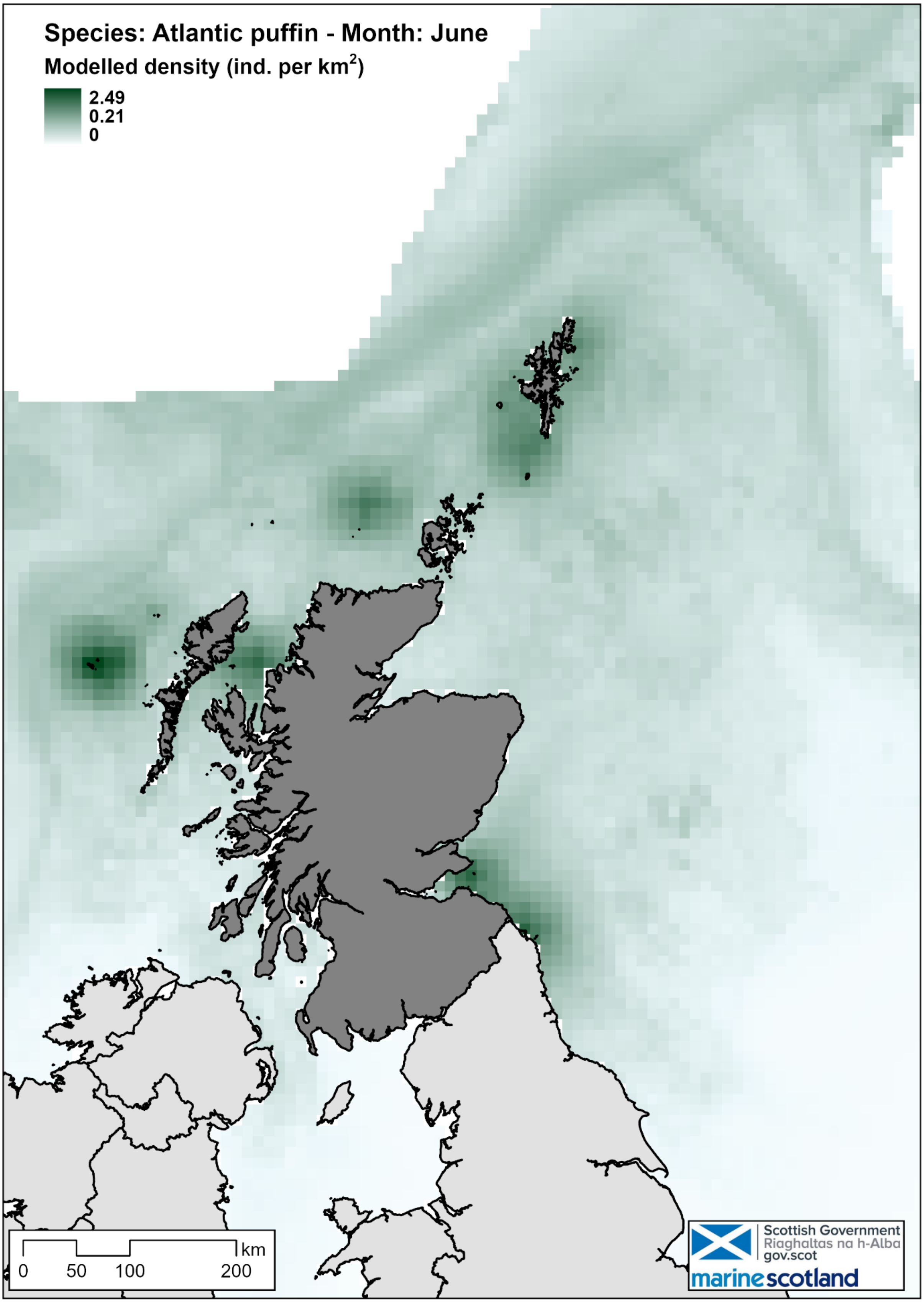

Figure 7: Estimated density of Atlantic puffin, *Fratercula arctica,* in Scottish waters. (Waggit et al. 2019)

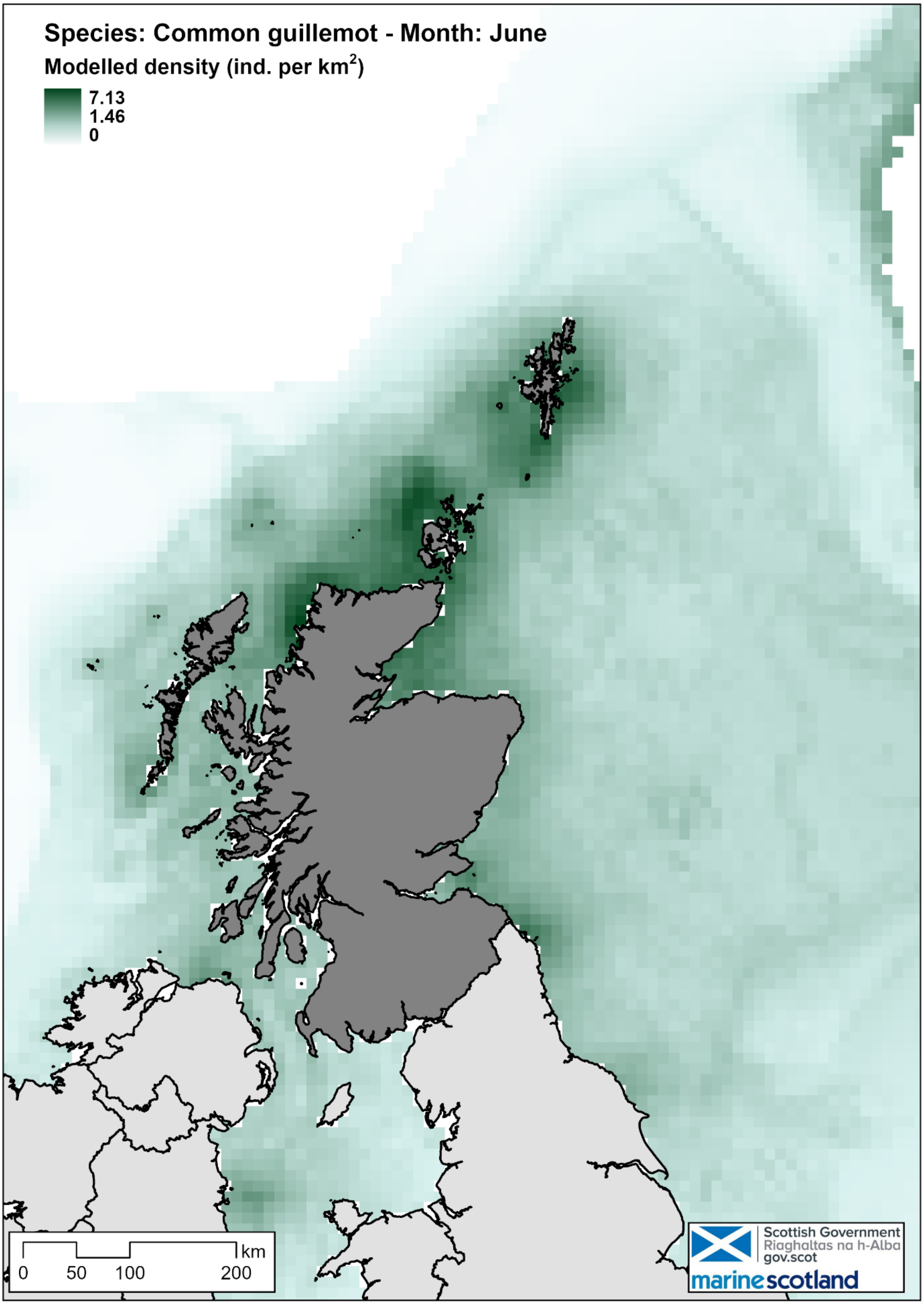

Figure 8: Estimated density of common guillemot, *Uria aalge,* in Scottish waters. (Waggit et al. 2019)

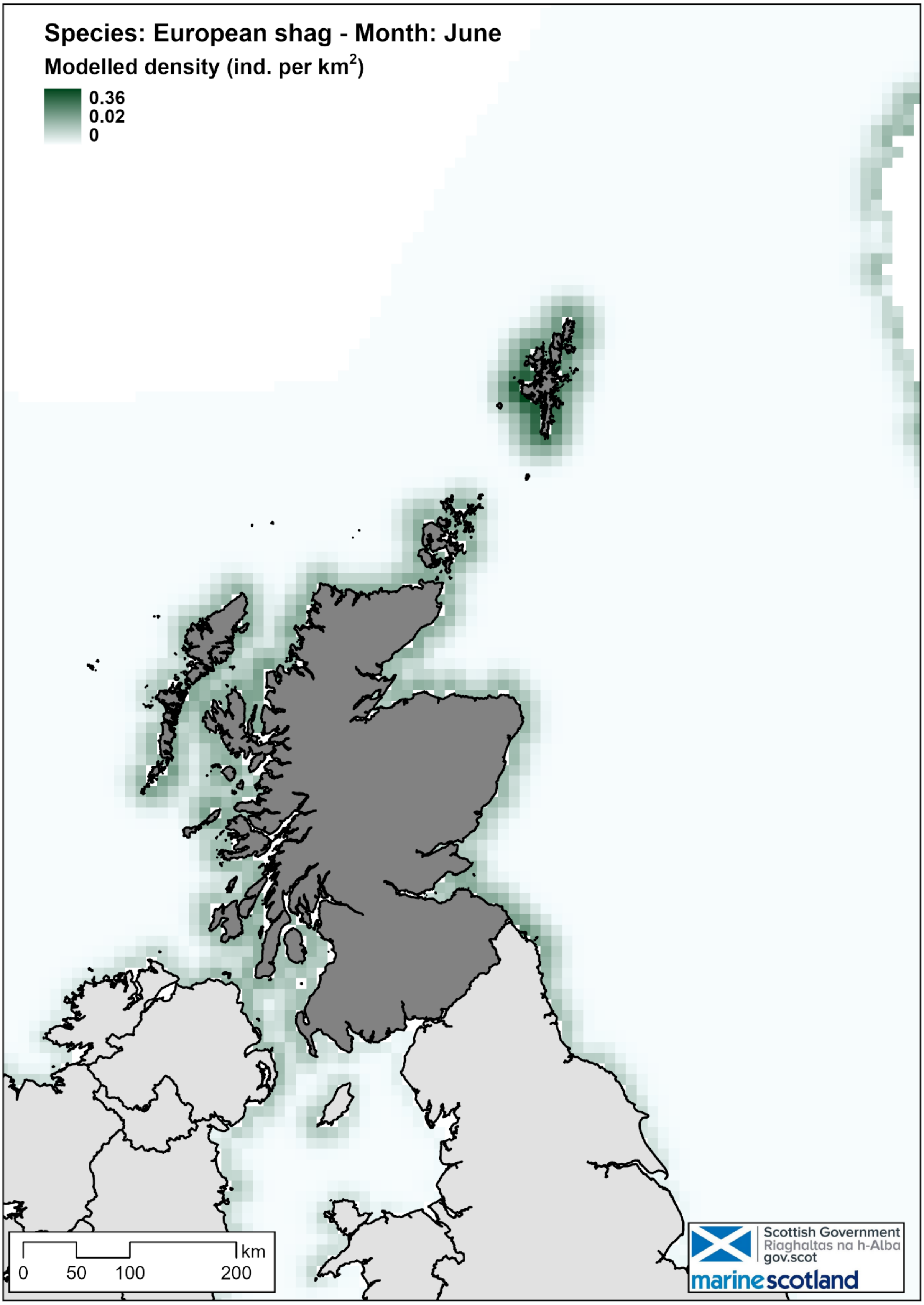

Figure 9: Estimated density of European shag, *Gulosus aristotelis,* in Scottish waters. (Waggit et al. 2019)

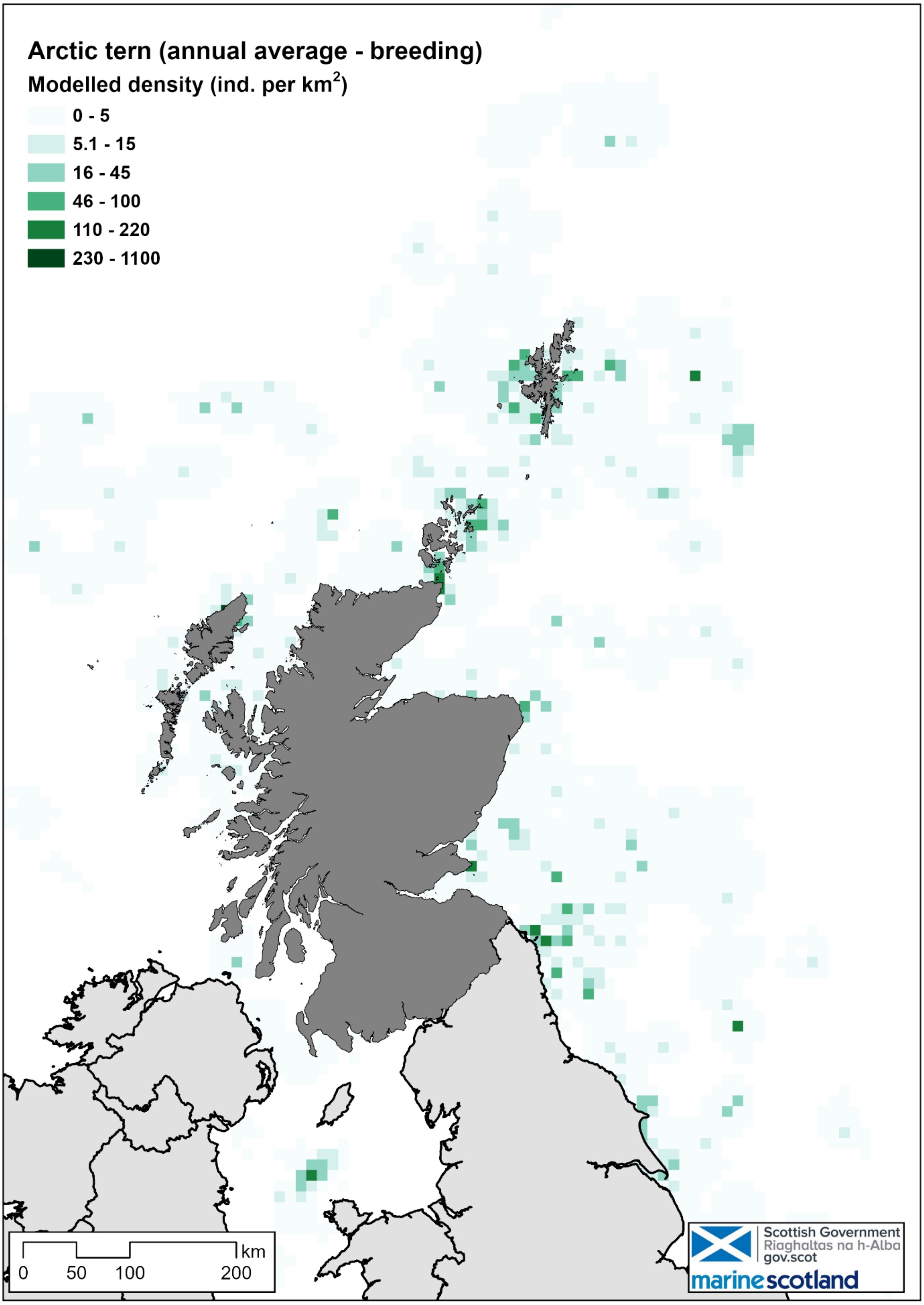

Figure 10: Estimated density of arctic tern, *Sterna paradisaea*, in Scottish waters during the breeding season. (Waggit et al. 2019)

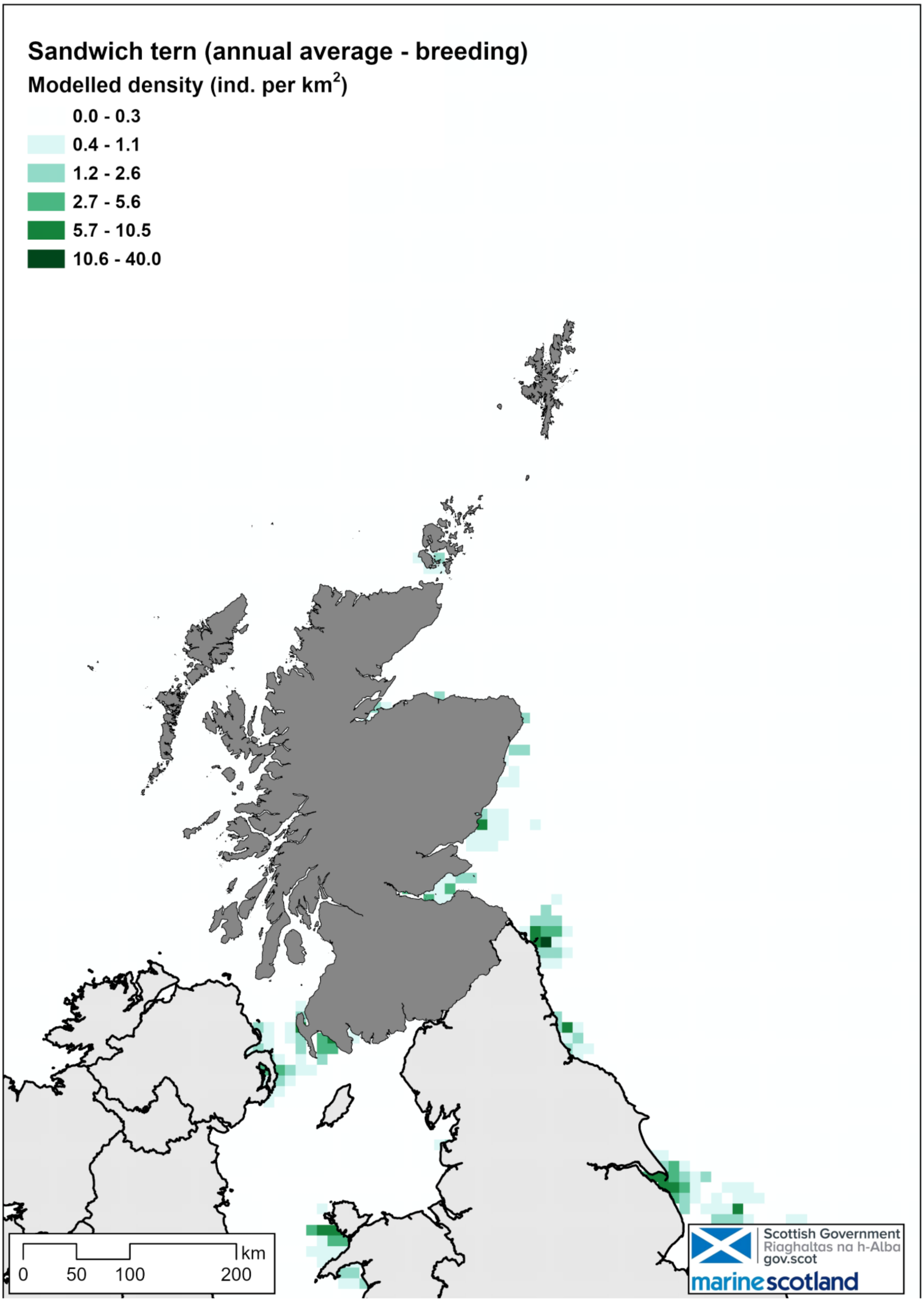

Figure 11: Estimated density of sandwich tern, *Thalasseus sandvicensis*, in Scottish waters during the breeding season. (Waggit et al. 2019)

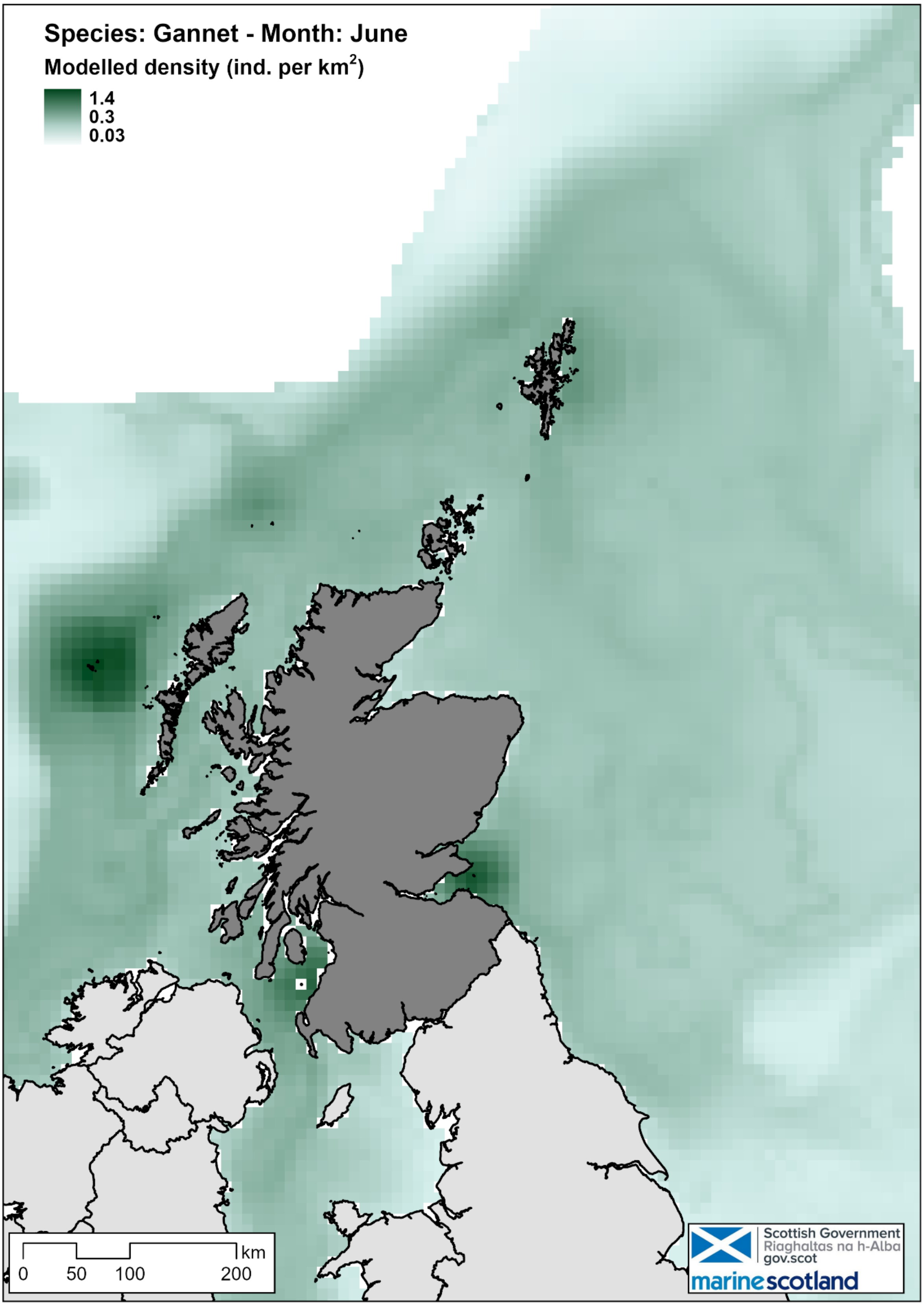

Figure 12: Estimated density of northern gannet, *Morus bassanus*, in Scottish waters. (Waggit et al. 2019)

Marine mammals (cetaceans and seals)

4.2.12 Marine mammals are widely distributed around the Scottish coastline. Species distributions are a function of prey availability and habitat distribution. Eleven species of cetacean are regularly sighted around Scottish seas. These comprise species with important resident populations, such as bottlenose dolphin, alongside more migratory species passing through Scottish seas, such as sperm whale. Key marine mammal species in Scottish seas include:

- Grey seal *Halichoerus grypus*;
- Harbour seal *Phoca vitulina*;
- Harbour porpoise *Phocoena phocoena*;
- Bottlenose dolphin *Tursiops truncatus*;
- White beaked dolphin *Lagenorhynchus albirostris*;
- Fin whale *Balaenoptera physalus*;
- Minke whale *Balaenoptera acutorostrata*;
- Short-beaked common dolphin *Delphinus delphis*;
- Atlantic white-sided dolphin *Lagenorhynchus acutus*;
- Risso's dolphin *Grampus griseus*;
- Long-finned pilot whale *Globicephala melas*;
- Killer whale *Orcinus orca*;
- Sperm whale *Physeter macrocephalus*; and
- Eurasian otter *Lutra lutra*.

4.2.13 Of these, several species include sandeel as a major component of their diet and so are a focus of the baseline and SEA:

- Grey seal;
- Harbour seal;
- Harbour porpoise;
- White beaked dolphin; and
- Minke whale

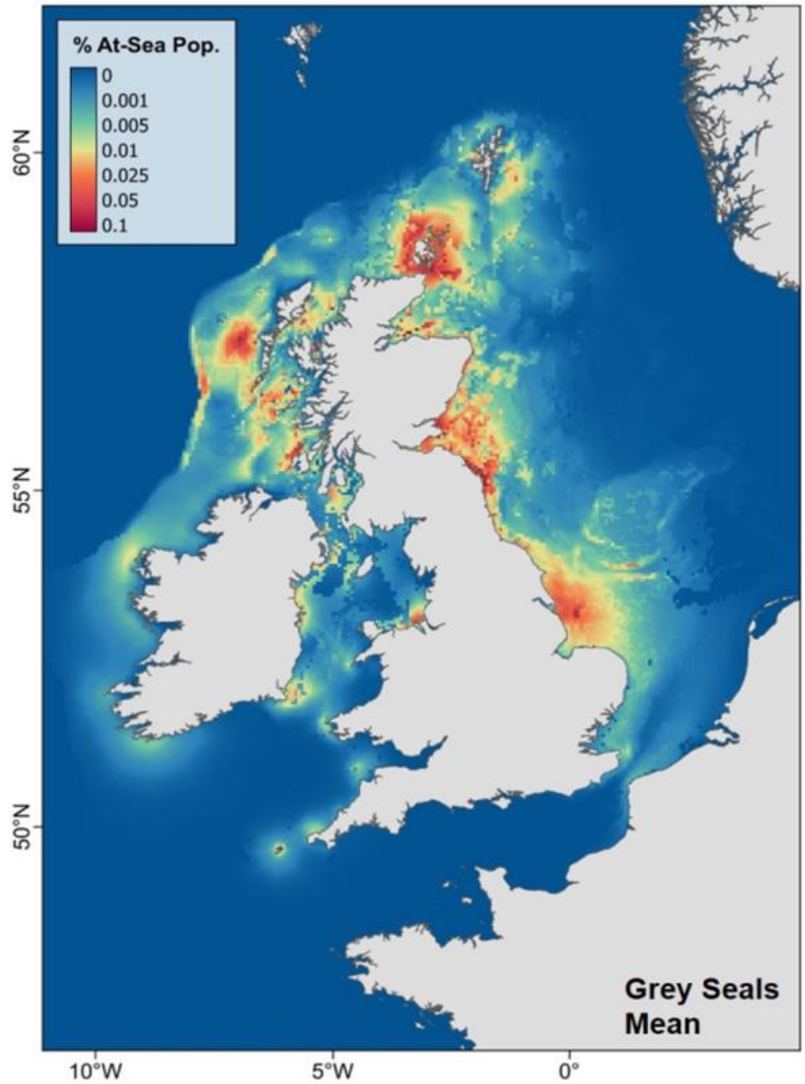

Figure 13: Predicted at-sea densities of grey seals *Halichoerus grypus* in the UK (Carter et al. 2020).

4.2.14 Grey seals occur around the entire Scottish coastline and are known to undertake long foraging trips to areas further offshore (Figure 13). In Scottish waters, grey seal at sea distribution is predominantly driven by the proximity to suitable haulout sites, with density scaling inversely with increasing distance from haulouts[49,50]. However, grey seals often undertake foraging trips of hundreds of

[49] Jones, E.L., McConnell, B.J., Smout, S., Hammond, P.S., Duck, C.D., Morris, C.D., Thompson, D., Russell, D.J., Vincent, C., Cronin, M. & Sharples, R.J., Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series, 534: 235-249. https://www.int-res.com/abstracts/meps/v534/p235-249/ (last accessed 21/06/2023).

[50] Carter, M.I.D., Boehme, L., Duck, C.D., Grecian, W.J., Hastie, G.D., McConnell, B. J., Miller, D.L., Morris, C.D., Moss, S.E.W., Thompson, D., Thompson, P.M. & Russell, D.J.F. Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959723/SMRU_2020_Habitat-based_predictions_of_at-sea_distribution_for_grey_and_harbour_seals_in_the_British_Isles.pdf (last accessed 21/06/2023).

kilometres[51]. Further to haulout affinity, grey seal distribution has been statistically correlated with several other environmental covariates, however these vary regionally both in importance and in direction. For example, grey seal density in all regions apart from the Western Isles has been shown to be driven, to varying degrees, by sediment type, with most regions showing higher affinities for coarser sand and rocky sediments than finer sands and silt-based substrates. This also mimics reported habitat preferences of sandeel in these regions[52]. Contrastingly around the Western Isles, grey seals appear to be driven by a-biotic oceanographic processes such as sea-surface temperature, stratification and proximity to the shelf edge (Carter *et al* 2020). Additionally, the at-sea distribution of grey seals suggests particularly high use of offshore sandbanks in some areas [53,54].

4.2.15 The foraging ranges of grey seals vary greatly depending on the time of year. Individuals may remain close to haulouts during the breeding season (October-December), and as they are capital breeders (animals that use energy stores built up before reproduction to breed), the females do not forage during the lactation period.

4.2.16 Areas of high at-sea usage predicted by Carter *et al*. (2020 [53]) for grey seals include Orkney, areas of the east coast (particularly those around the Firth of Forth and Firth of Tay), and those along the shelf edge to the west of the Western Isles. The outer sandbanks in the Firth of Tay and the Moray Firth also appear to be favoured foraging grounds. Based on the probability of sandeel occurrence predicted by Langton *et al*. (2021[55]), there will be significant spatial overlap in the waters around Orkney, the east coast, the Inner Moray Firth and the Inner Hebrides (particularly the waters north west of Islay).

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[51] Thompson, P. M., Mcconnell, B. J., Tollit, D. J., Mackay, A., Hunter, C., & Racey, P. A. Comparative Distribution, Movements and Diet of Harbour and Grey Seals from Moray Firth, N. E. Scotland. Journal of Applied Ecology, Volume 33, Number 6: 1572–1584. https://www.jstor.org/stable/2404795 (last accessed 21/06/2023).

[52] Holland, G.J., Greenstreet, S.P., Gibb, I.M., Fraser, H.M. & Robertson, M.R. Identifying sandeel Ammodytes marinus sediment habitat preferences in the marine environment. Marine Ecology Progress Series, Volume 303, 2005: 269-282. https://www.int-res.com/articles/meps2005/303/m303p269.pdf (last accessed 21/06/2023).

[53] Carter, M.I.D., Boehme, L., Duck, C.D., Grecian, W.J., Hastie, G.D., McConnell, B. J., Miller, D.L., Morris, C.D., Moss, S.E.W., Thompson, D., Thompson, P.M. & Russell, D.J.F. Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78, 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959723/SMRU_2020_Habitat-based_predictions_of_at-sea_distribution_for_grey_and_harbour_seals_in_the_British_Isles.pdf (last accessed 21/06/2023).

[54] Jones, E.L., McConnell, B.J., Smout, S., Hammond, P.S., Duck, C.D., Morris, C.D., Thompson, D., Russell, D.J., Vincent, C., Cronin, M. & Sharples, R.J. Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series, 534, 235-249: 2015. https://risweb.st-andrews.ac.uk/portal/en/researchoutput/patterns-of-space-use-in-sympatric-marine-colonial-predators-reveals-scales-of-spatial-partitioning(58af22c6-0f96-4107-a881-bf027856cc5c).html (last accessed 21/06/2023).

[55] Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. Mar. Ecol. Prog. Ser. 667: 145-159: 2021. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

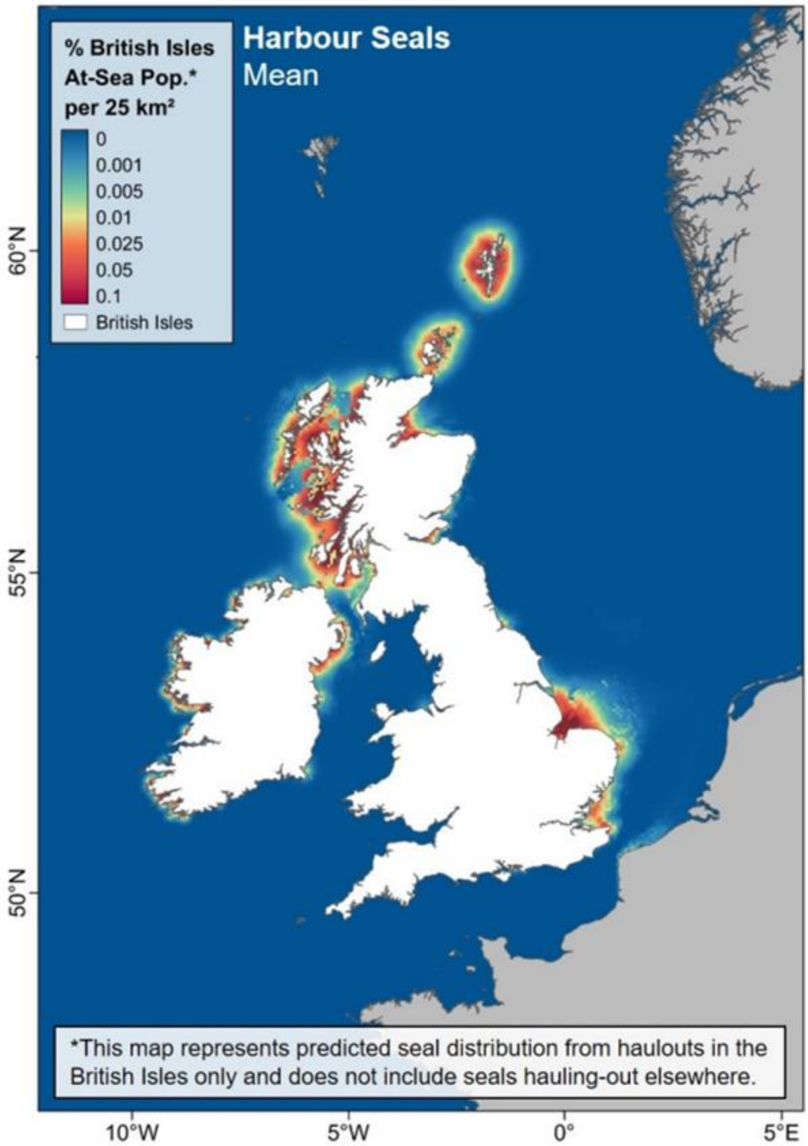

Figure 14: Predicted at-sea densities of harbour seal *Phoca vitulina* in the UK (Carter et al. 2020).

4.2.17 Harbour seals usually remain closer to the coastline than grey seals[56], typically undertaking foraging trips of up to 50km from their haulout sites[57,58] (Figure 14). However, foraging range can vary regionally and individuals from some

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[56] Jones, E.L., McConnell, B.J., Smout, S., Hammond, P.S., Duck, C.D., Morris, C.D., Thompson, D., Russell, D.J., Vincent, C., Cronin, M. & Sharples, R.J. Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series, 2005, Volume 534: 235-249. https://risweb.st-andrews.ac.uk/portal/en/researchoutput/patterns-of-space-use-in-sympatric-marine-colonial-predators-reveals-scales-of-spatial-partitioning(58af22c6-0f96-4107-a881-bf027856cc5c).html (last accessed 21/06/2023).

[57] Thompson, P. M., & Miller, D. Summer Foraging Activity and Movements of Radio-Tagged Common Seals (Phoca vitulina. L.) in the Moray Firth, Scotland. Journal of Applied Ecology, 1990, Volume 27, Number 2: 492–501. https://www.jstor.org/stable/2404296 (last accessed 21/06/2023).

[58] Thompson, P. M., Mcconnell, B. J., Tollit, D. J., Mackay, A., Hunter, C., & Racey, P. A. Comparative Distribution, Movements and Diet of Harbour and Grey Seals from Moray Firth, N. E. Scotland. Journal of Applied Ecology, 1996, Volume 33, Number 6: 1572–1584. https://www.jstor.org/stable/2404795 (last accessed 21/06/2023).

populations are known to make longer trips offshore[59,60]. Harbour seals are occasional income breeders (i.e., females will sometimes continue to forage during lactation), undertaking sporadic foraging trips throughout the lactation period. This means that throughout their breeding season (June-July) harbour seals will still be predating sandeel.

4.2.18 The areas of overlap between sandeel and harbour seal populations in Scottish waters are primarily off the west coast. Harbour seal populations on the east and north coasts of Scotland have experienced severe declines in the last few decades. The highest predicted at-sea densities (and therefore, number of foraging individuals) of harbour seals occur throughout the Inner Hebrides, Orkney, Shetland and the Inner Moray Firth[61]. The areas of high probability of sandeel occurrence that are therefore most relevant to harbour seal are the waters of the Sea of the Hebrides, the Western Isles and Orkney[62].

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[59] Cunningham, L., Baxter, J. M., Boyd, I. L., Duck, C. D., Lonergan, M., Moss, S. E., & McConnell, B. Harbour seal movements and haul-out patterns: implications for monitoring and management. Aquatic Conservation: Marine and Freshwater Ecosystems, 2005, Volume 19, Issue 4: 398-407. https://onlinelibrary.wiley.com/doi/10.1002/aqc.983 (last accessed 21/06/2023).

[60] Sharples, R. J., Moss, S. E., Patterson, T. A., & Hammond, P. S. Spatial variation in foraging behaviour of a marine top predator (Phoca vitulina) determined by a large-scale satellite tagging program. PLoS one, 2012, Volume 7(5), e37216. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0037216 (last accessed 21/06/2023).

[61] Carter, M.I.D., Boehme, L., Duck, C.D., Grecian, W.J., Hastie, G.D., McConnell, B. J., Miller, D.L., Morris, C.D., Moss, S.E.W., Thompson, D., Thompson, P.M. & Russell, D.J.F. Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, 2020, Report to BEIS, OESEA-16-76/OESEA-17-78. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959723/SMRU_2020_Habitat-based_predictions_of_at-sea_distribution_for_grey_and_harbour_seals_in_the_British_Isles.pdf (last accessed 21/06/2023).

[62] Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145-159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

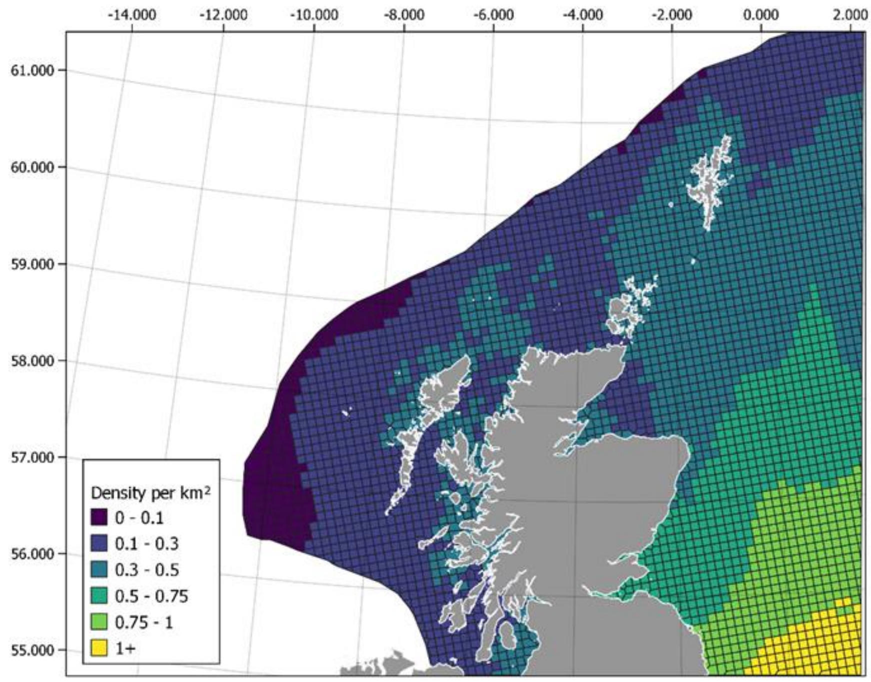

Figure 15: Predicted surface of estimated density for harbour porpoise *Phocoena phocoena* in Scottish waters in 2016. Density surface downloaded from the SCANS report and reproduced using density bins following Lacey et al. (2021).

4.2.19 Harbour porpoises are resident and abundant year-round in all regions of Scottish waters[63] (Figure 15). Predictive habitat modelling based on data collected on the west coast shows a distinctly inshore distribution, with a preference for areas within 15km of the shore and depths between 50-150m[64,65]. Harbour porpoise distribution is also thought to vary with season in some areas across the UK, with animals predicted to move into the innermost North Sea during winter months from offshore areas[66] (Figures 16 and 17).

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[63] Hague, E.L., Sinclair, R.R. & Sparling, C.E. Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters. Scottish Marine and Freshwater Science, 2020, Volume 11, Number 12. Appendix 3 SCANS Surveys. https://data.marine.gov.scot/dataset/regional-baselines-marine-mammal-knowledge-across-north-sea-and-atlantic-areas-scottish (last accessed 21/06/2023).

[64] Booth, C. G., Embling, C., Gordon, J., Calderan, S. V., & Hammond, P. S. Habitat preferences and distribution of the harbour porpoise Phocoena phocoena west of Scotland. Marine Ecology Progress Series, 2023, Volume 478: 273-285. https://porpoise.org/library/habitat-preferences-distribution-harbour-porpoise-phocoena-phocoena-west-scotland/ (last accessed 21/06/2023).

[65] Marubini, F., Gimona, A., Evans, P. G., Wright, P. J., & Pierce, G. J. Habitat preferences and interannual variability in occurrence of the harbour porpoise Phocoena phocoena off northwest Scotland. Marine Ecology Progress Series, 2009, Volume 381: 297-310. https://abdn.pure.elsevier.com/en/publications/habitat-preferences-and-interannual-variability-in-occurrence-of- (last accessed 21/06/2023).

[66] Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. & Felce, T. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 2019, Volume 57, Issue 2: 253-

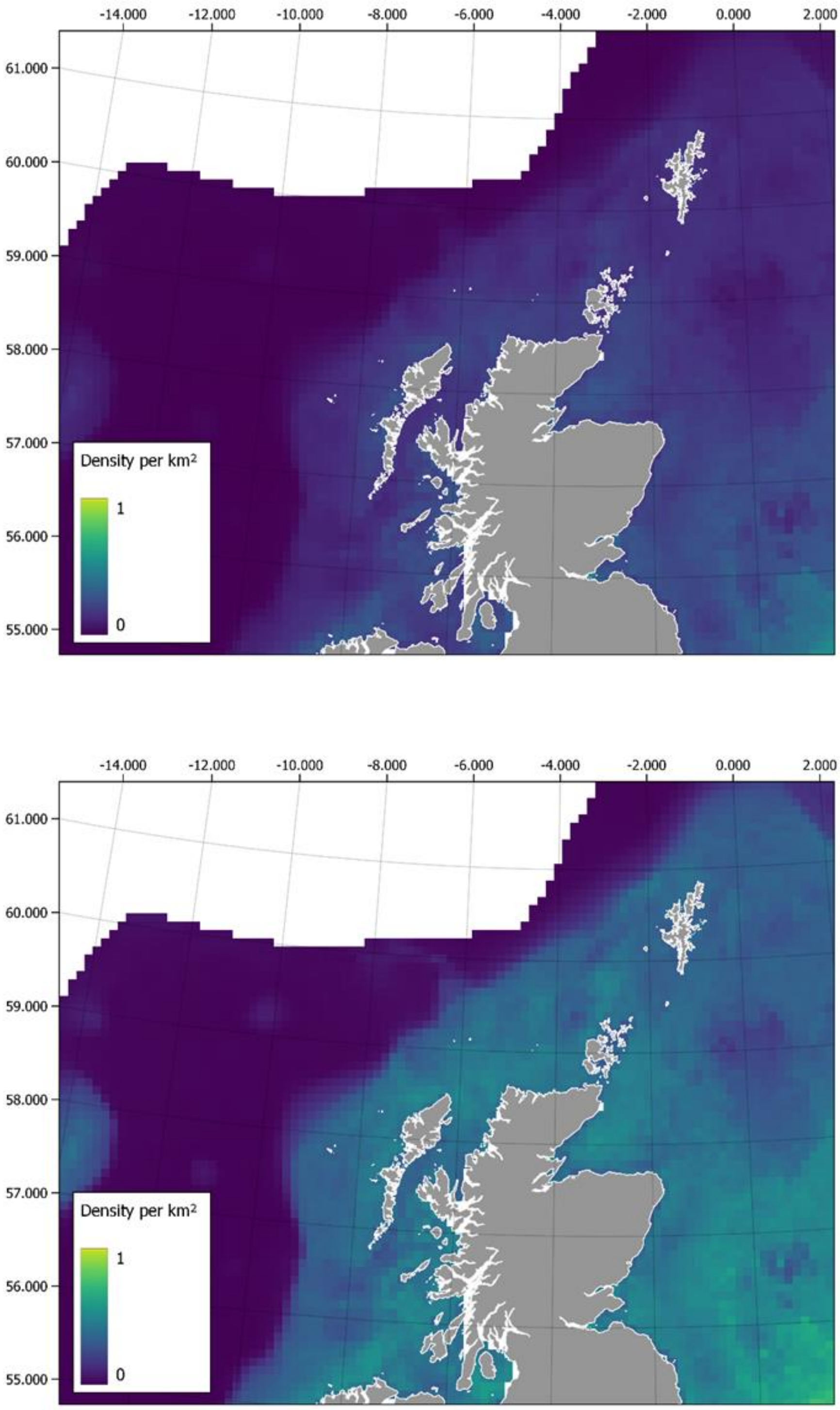

Figure 16: Predicted densities (animals per km^2 of harbour porpoise *Phocoena phocoena* in (above) January and (below) July in the North-East Atlantic (reproduced using density estimates from Waggitt et al. 2020).

269. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13525 (last accessed 21/06/2023).

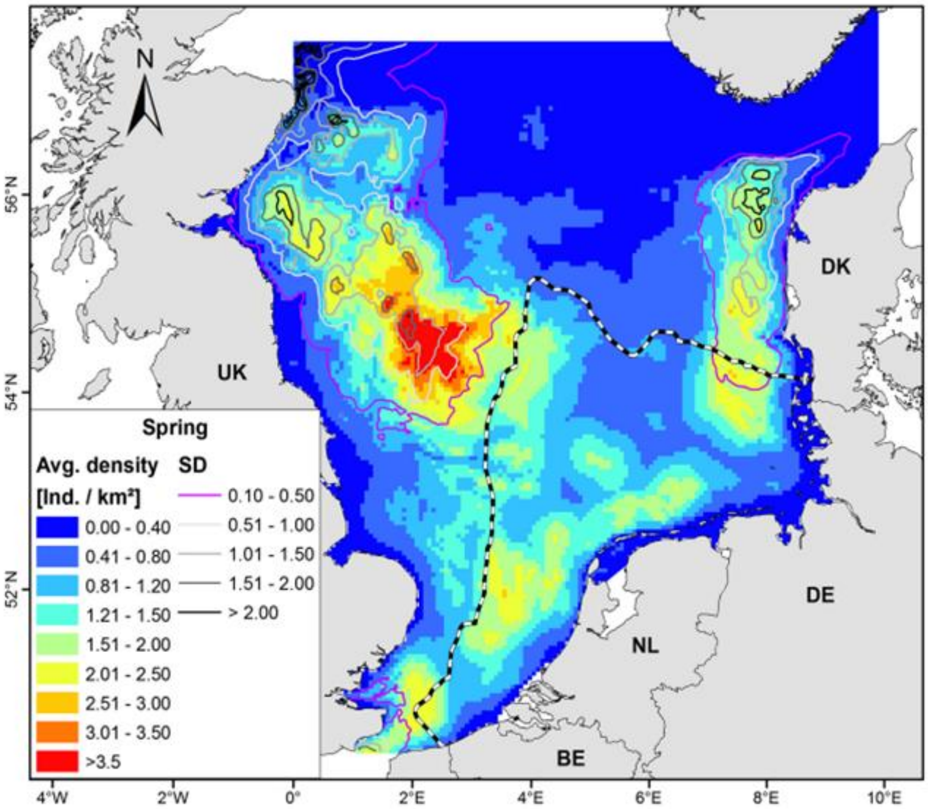

Figure 17: Predicted harbour porpoise *Phocoena phocoena* densities in the North Sea in spring (March - May; Gilles et al. 2016).

4.2.20 The highest observed densities of harbour porpoise in Scotland are generally in the North Sea[67], where porpoises seem to prefer similar depth ranges as on the west, as well as sandy habitats that are typically favoured by sandeels, such as the gravelly sand seabed area of Smith Bank in the middle of the Moray Firth[68,69]. It should be noted that the Inner Hebrides and Minches SAC on the west coast is designated for harbour porpoise, which coincides with areas identified as high probability of sandeel occurrence[70]. In terms of spatial overlap, the areas of high probability of sandeel occurrence that coincide with areas of high area usage by

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[67] Lacey, C., Hammond, P.S., Gilles, A., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J., Viquerat, S. & Øien, N. Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. 2021 https://scans3.wp.st-andrews.ac.uk/files/2022/08/SCANS-III_density_surface_modelling_report_final_20220815.pdf (last accessed 21/06/2023).

[68] Brookes, K.L., Bailey, H. & Thompson, P.M. Predictions from harbor porpoise habitat association models are confirmed by long-term passive acoustic monitoring. Journal of the Acoustical Society of America, 2013, Volume 134: 2523-2533. https://www.abdn.ac.uk/sbs/documents/JASMAN13432523_1.pdf (last accessed 21/06/2023).

[69] Williamson, L.D., Brookes, K.L., Scott, B.E., Graham, I.M., Bradbury, G., Hammond, P.S. and Thompson, P.M. Echolocation detections and digital video surveys provide reliable estimates of the relative density of harbour porpoises. Methods in Ecology and Evolution, 2016, Volume 7, Issue 7: 762-769. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12538 (last accessed 21/06/2023).

[70] Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145-159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

porpoise are the east coast, particularly the offshore regions adjacent to the Firths of Forth and Tay such as Scalp Bank, the waters to the north east of Islay. However, sandeel spatial overlap with porpoises should be expected in any areas of shallow, coastal water and for most areas of the North Sea wherever sandeel are present. Additionally, for most coastal areas in Scotland, harbour porpoise abundance may increase during the summer months which is coincident with the seasonal increase in sandeel in the water column suggesting a possible link with seasonal movement of porpoises and availability of sandeel.

4.2.21 Minke whale distribution in Scottish waters is not well understood. Different studies, using different survey methods, suggest different high usage areas. In some areas there appears to be year-round occurrence, whereas for most areas minke whales are present only in the summer months[71] (Figures 18 and 19[72]). Minke whale occurrence is associated with sea surface temperatures and chlorophyll concentrations (Figure 20). As such, temporal and spatial variations in minke whale distribution are to be expected both within and between years.

4.2.22 In summer, high use minke whale areas appear to be the Moray Firth, the waters north of Shetland and the entire west coast of Scotland. This is spatially coincident with identified sandeel hotspots in Scottish waters[73] and may reflect movement of minke whales targeting sandeel as they become more abundant in the water column during the summer months. This relationship would be particularly important for filter and lunge feeders such as minke whales given their foraging behaviour predominantly and generally targets small actively swimming (nektonic) species. As density of a pelagic prey species increases it would follow that density of filter and lunge feeding species would also increase. The Minches, the Sea of the Hebrides and off the west coast of the Western Isles are also known to experience seasonally varying hotspots of minke whales (Figure 18). While the identified hotspots are not coincident with relatively high sandeel abundances on the west coast [73] this may indicate variation in diet between spatially discrete populations of Minke whales; a pattern seen in other, more studied marine mammals, as described above.

[71] Hague, E.L., Sinclair, R.R. & Sparling, C.E. Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters. Scottish Marine and Freshwater Science, 2020, Vol 11, No 12. Appendix 3 SCANS Surveys. https://data.marine.gov.scot/dataset/regional-baselines-marine-mammal-knowledge-across-north-sea-and-atlantic-areas-scottish (last accessed 21/06/2023).
[72] Paxton, C.G., Scott-Hayward, L.A.S. & Rexstad, E.A. Statistical approaches to aid the identification of Marine Protected Areas for minke whale, Risso's dolphin, white-beaked dolphin and basking shark. Scottish Natural Heritage, 2014, Policy and Advice Directorate. https://www.nature.scot/doc/naturescot-commissioned-report-594-statistical-approaches-aid-identification-marine-protected-areas (last accessed 21/06/2023).
[73] Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145-159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

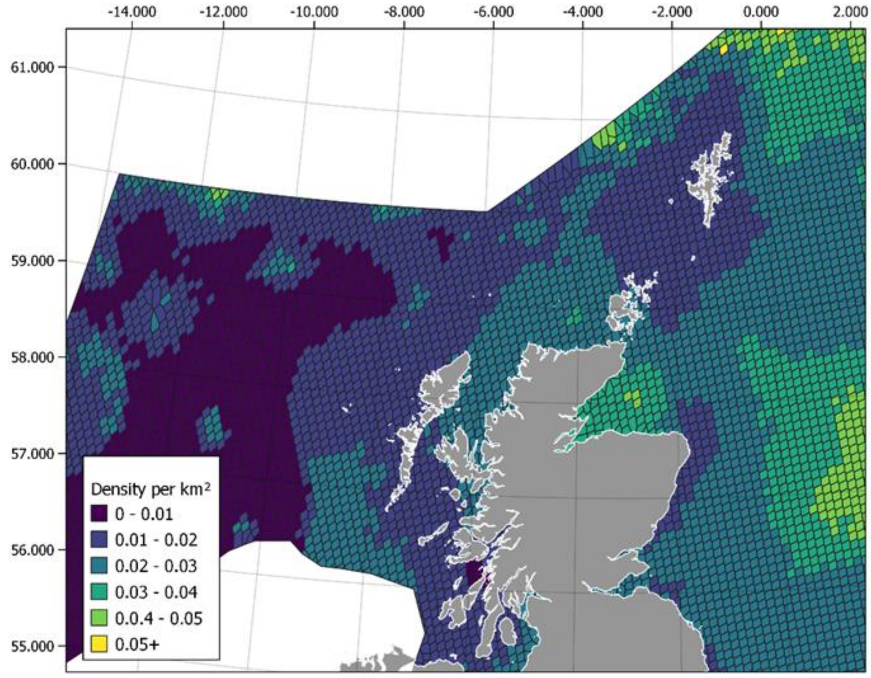

Figure 18: Predicted surface of estimated density for minke whale *Balaenoptera acutorostrata* in Scottish waters in 2016. Density surface downloaded from the [SCANS report] and reproduced using density bins following Lacey et al. 2021.

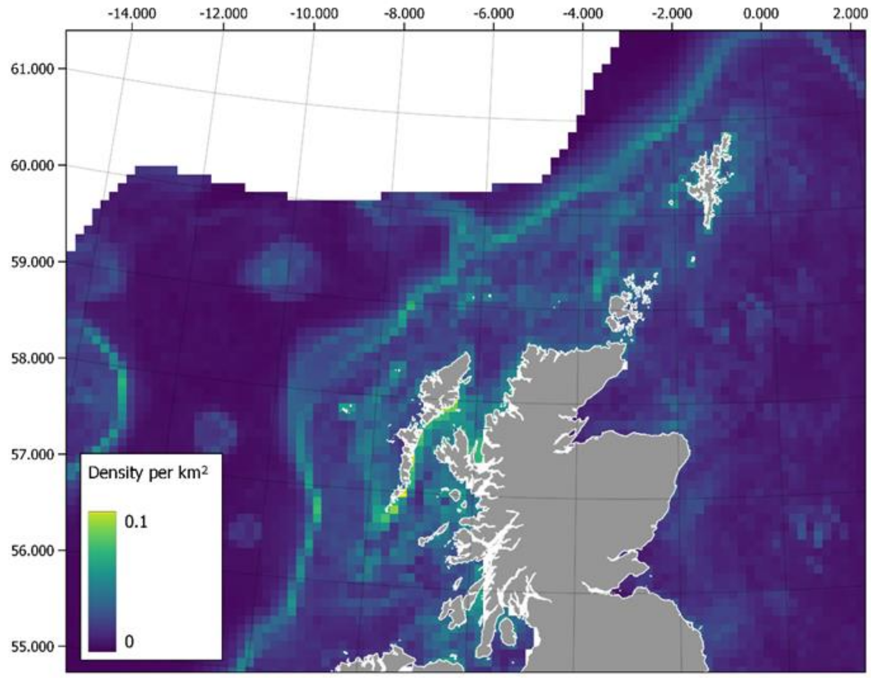

Figure 19: Predicted densities (animals per km ^{2}) of minke whale *Balaenoptera acutorostrata* in January (above) and July (below) in the North-East Atlantic (reproduced using density estimates from Waggitt et al 2020).

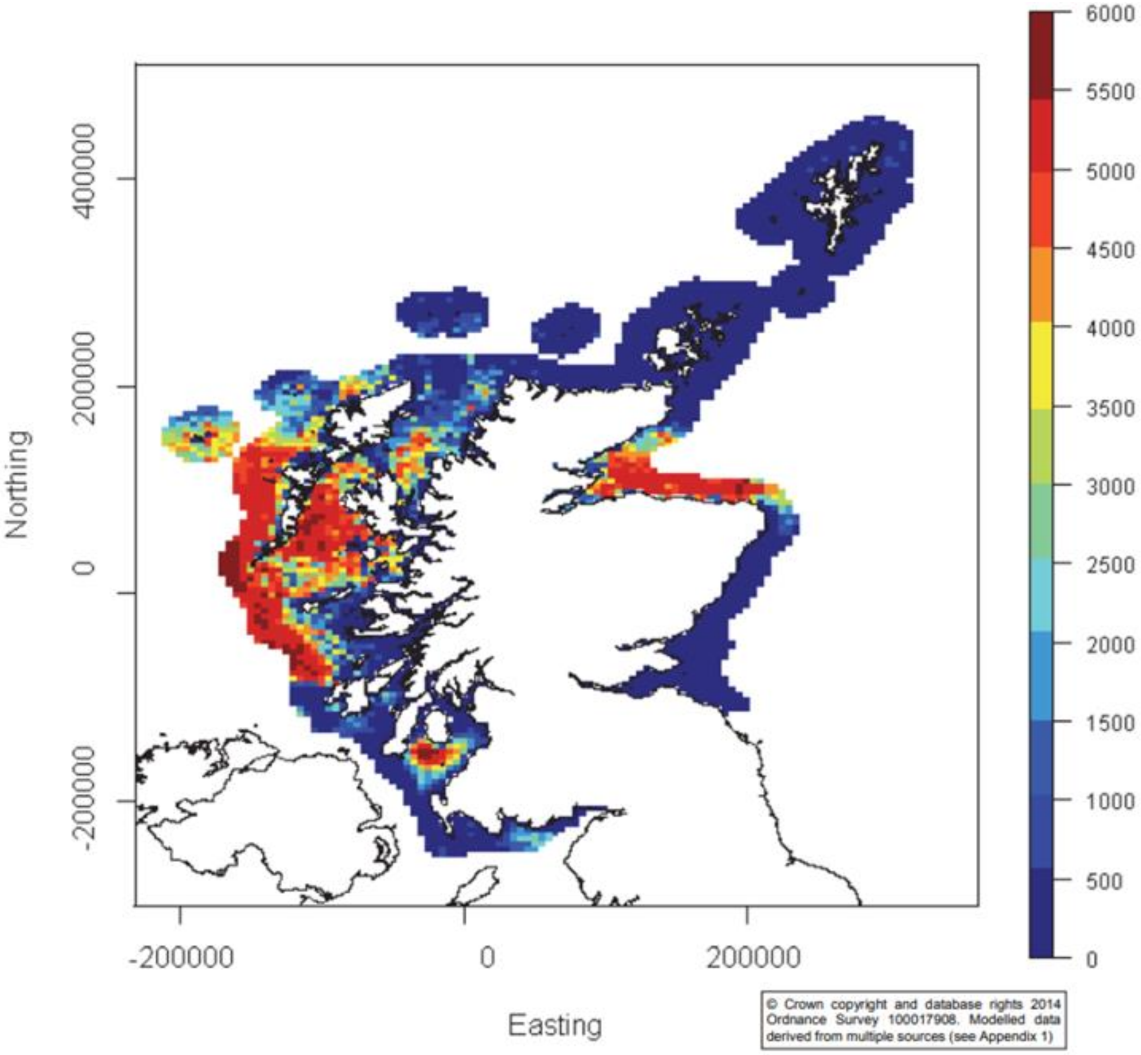

Figure 20: Index of predicted minke whale *Balaenoptera acutorostrata* persistence-certainty (summer only) between 2001 - 2021 (Paxton et al. 2014).

4.2.23 White-beaked dolphins are present in Scottish waters year-round, with a wide distribution that favours both offshore and nearshore areas depending on the region (Figure 21[74] and sections of coast adjacent to deeper water[75]. The abundance of this species in nearshore waters appears to vary seasonally [75], with numbers increasing in the summer months as more individuals move into the area from offshore[76].

4.2.24 White-beaked dolphins appear to be present in reasonably high numbers in all regions of Scotland except the south west and south east of Scotland[77] (Figure 21 and 22). Distribution of white-beaked dolphin appears to change seasonally, with an apparent shift eastwards between winter and summer months, with densities in the North Sea peaking in June and July (Figure 22) The main areas of white-beaked dolphin overlap with high probability of sandeel occurrence is the offshore waters of the east coast, concurrent with increased sandeel availability in the water column during summer months where seasonal white-beaked dolphin density is also highest.

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[74] Canning, S., Santos, M., Reid, R., Evans, P., Sabin, R., Bailey, N., & Pierce, G. Seasonal distribution of white-beaked dolphins (Lagenorhynchus albirostris) in UK waters with new information on diet and habitat use. Journal of the Marine Biological Association of the United Kingdom, 2008, Volume 88, Issue 6, 1159-1166: https://seawatchfoundation.org.uk/wp-content/uploads/2012/08/Canning-et-al-2008.pdf (last accessed 21/06/2023).

[75] Weir, C. R., Stockin, K. A., & Pierce, G. J. Spatial and temporal trends in the distribution of harbour porpoises, white-beaked dolphins and minke whales off Aberdeenshire (UK), north-western North Sea. Journal of the Marine Biological Association of the United Kingdom, 2007, Volume 87, Issue 1, 327-338 https://www.researchgate.net/publication/231807063_Spatial_and_temporal_trends_in_the_distribution_of_harbour_porpoises_white-beaked_dolphins_and_minke_whales_off_Aberdeenshire_UK_north-western_North_Sea (last accessed 21/06/2023).

[76] Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. & Felce, T. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 2020, Volume 57, Issue 2: 253-269 https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13525 (last accessed 21/06/2023).

[77] Lacey, C., Hammond, P.S., Gilles, A., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J., Viquerat, S. & Øien, N. Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. 2021. https://scans3.wp.st-andrews.ac.uk/files/2022/08/SCANS-III_density_surface_modelling_report_final_20220815.pdf (last accessed 21/06/2023).

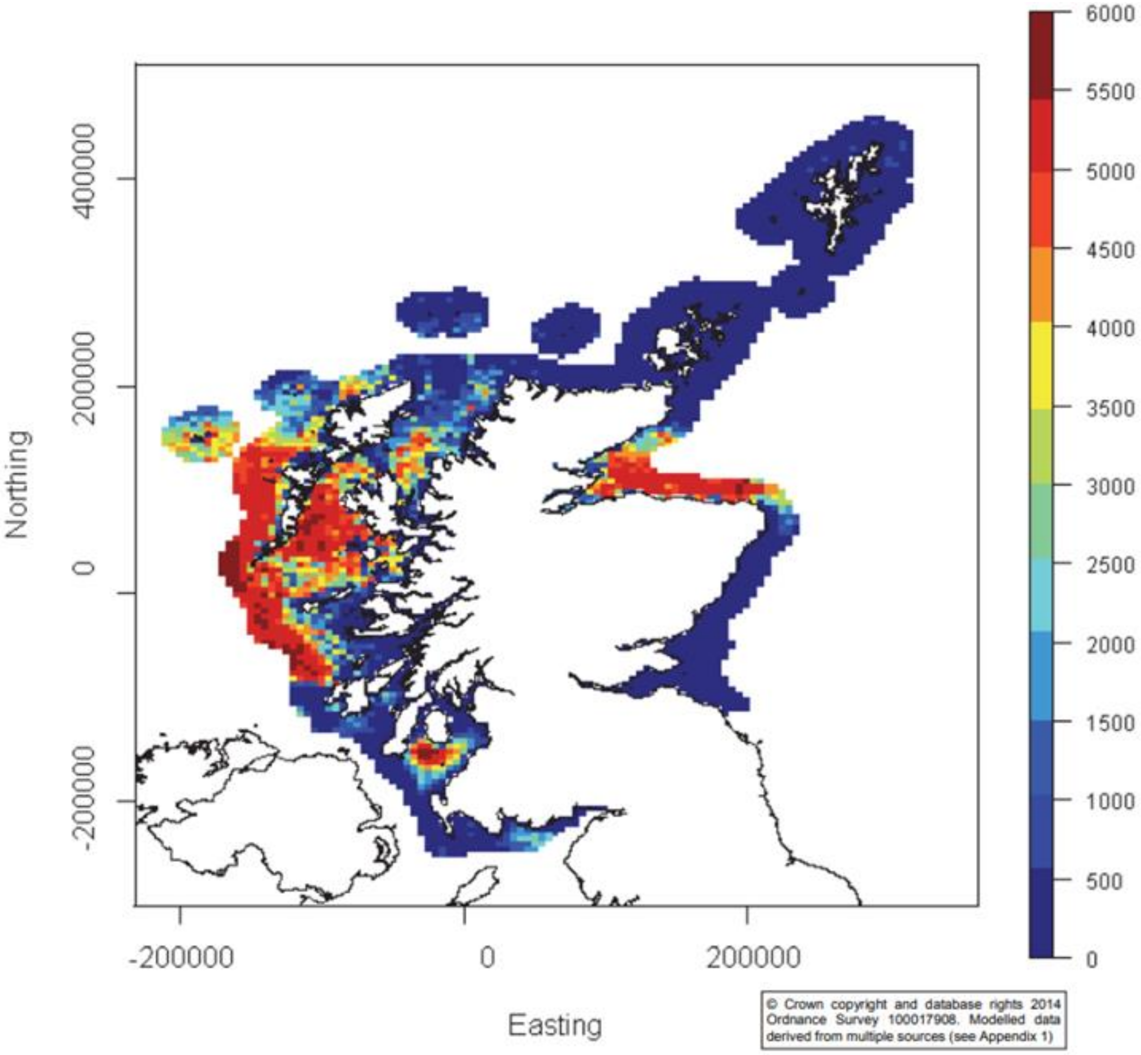

Figure 21: Predicted surface of estimated density for white-beaked dolphin *Lagenorhynchus albirostris* in Scottish waters in 2016. Density surface downloaded from the SCANS report and reproduced using density bins following Lacey et al. (2021).

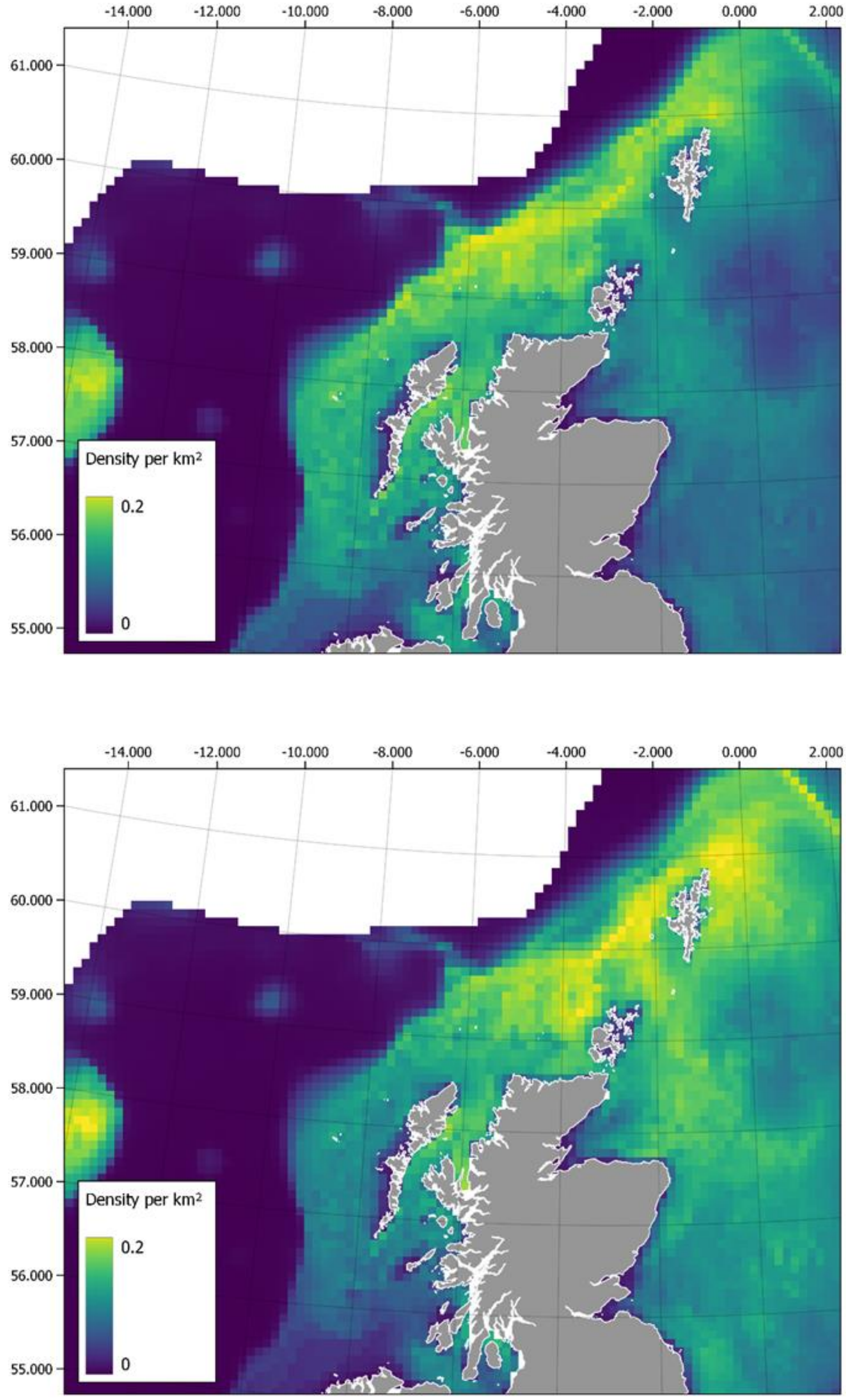

Figure 22: Predicted densities (animals per km^2) of white-beaked dolphin *Lagenorhynchus albirostris* in January (above) and July (below) in the North-East Atlantic (reproduced using density estimates from Waggitt et al 2020).

Trends and pressures

<u>Seabirds</u>

4.2.25 At their most recent assessment the Scottish breeding abundances of black-legged kittiwake, Atlantic puffin, European shag, common guillemot and tern species were in decline. The Scottish breeding abundances of Northern gannet and razorbill were increasing. The Scottish breeding abundance of black guillemot was stable. The 2021/2022 outbreak of Highly Pathogenic Avian Influenza (HPAI) affected wild bird populations, including seabird populations[78]. It is important to note that seabird populations have not been reassessed since the 2021/22 HPAI outbreak and may have changed in light of the impact of the outbreak.

4.2.26 The threats to seabirds in Scotland, the pressures that drive that pressure, and the human activities that result in that pressure are provided in Table 5. As well as these direct anthropogenically influenced pressures, seabirds are threatened by indirect pressures resulting from climate change, including changes to habitat availability, prey availability and physiological stress[79]. Seabirds are also threatened by disease outbreaks including HPAI[80].

Table 5: Impacts and threats to seabirds from widespread pressures.

*Pressures and activities are taken from the Marine Pressures-Activities Database (PAD) v1.3[81].

Impact/Threat	Pressure*	Activity*
Bycatch mortality	Removal of non-target species	Demersal trawling, Pelagic trawls and purse, Hooks and lines, Static nets, Aquaculture
Wind turbine collision	Death or injury by collision – above water	Energy generation – Offshore wind: Operation and maintenance
Displacement by wind turbines	Physical loss	
Wind turbines as a barrier to species movement	Barrier to species movement	
Mortality by collision with underwater turbines etc.	Death or injury by collision – below water	Energy generation – Tidal stream: Operation and maintenance Wave energy generation

[78] NatureScot. Avian influenza (bird flu). https://www.nature.scot/doc/avian-influenza-bird-flu (last accessed: 21/06/2023).
[79] Grémillet, D., Boulinier, T. Spatial ecology and conservation of seabirds facing global climate change: a review. MEPS, 2009, Volume 391: 121 – 137. https://www.int-res.com/abstracts/meps/v391/p121-137/ (last accessed: 21/06/2023).
[80] Banyard, A., Lean, F., Robinson, C., et al. Detection of Highly Pathogenic Avian Influenza Virus H5N1 Clade 2.3.4.4b in Great Skuas: A Species of Conservation Concern in Great Britain. Viruses, 2022, Volume 14, Issue 2: 212. https://www.mdpi.com/1999-4915/14/2/212 (last accessed: 21/06/2023).
[81] JNCC (2018). Marine Pressures-Activities Database (PAD) v1.3. URL: Marine Pressures-Activities Database (PAD) v1.5 | JNCC Resource Hub (last accessed: 14/10/19)

Habitat loss from coastal infrastructure	Physical loss (to land or freshwater habitat) / Reduction in prey	Coastal Infrastructure – Reclaim and land take (e.g. the footprint of coastal defences)
Marine litter	Marine litter	Multiple and non-specific
Habitat loss & mortality from invasive predatory mammals	Introduction or spread of non-indigenous species & translocations (competition)	Multiple and non-specific
Reduction in prey by fishing	Reduction in prey	Set (fixed) net fishing, Pelagic fishing (or fishing activities that do not interact with sea-bed) Demersal/benthic fishing
Disturbance from recreation, tourism and transport	Visual Disturbance[82]	Recreation and leisure: Powerboating or sailing with an engine Non-motorised land craft (e.g. sand yacht, kite buggy) Non-motorised water craft (e.g. kayaks, windsurfing, dinghies) Unmanned Aerial Vehicle (UAV e.g. drones) Dog walking Wildlife tour operators Transport: Vessel movements
Intentional taking of adults/eggs	Removal of target species (lethal)	Egg harvesting – human consumption Non-specific – control
Mortality or sub-lethal impacts of synthetic compounds (e.g. pesticides, antifoulants)	Synthetic compound contamination (including pesticides, antifoulants, pharmaceuticals)	Multiple and non-specific
Mortality from oil contamination	Hydrocarbon and PAH contamination	Energy generation – Oil spills including oil spill response
Mortality or sub-lethal impacts of non-synthetic compounds (e.g. heavy metals)	Non-synthetic compound contamination (inc. heavy metals, produced water)	Multiple and non-specific

[82] The FEAST pressure of 'Visual Disturbance' includes three separate pressures referred to in the PAD: Visual disturbance, Introduction of light, Above water noise.

Grey and harbour seals

4.2.27 Grey seal populations trends vary by region. Overall, UK pup production increased by <1.5% per annum between 2016 and 2019. Growth was mainly limited to the North Sea colonies along the east coast of Scotland and England. Pup production in the Inner and Outer Hebrides and Orkney on the other hand showed a slight decline from 2016[83].

4.2.28 Harbour seal populations are showing regional trends with populations declining in some regions and increasing in others. Populations in the West Scotland and Southwest Scotland Seal Management Units (SMUs) have increased continuously since the 1990s. The Western Isles population declined in the late 1990s but has been increasing since approximately 2005. Shetland and the Moray Firth SMUs are apparently stable after a large, rapid decline in the early 2000s, but Moray Firth counts may now be increasing. North Coast and Orkney SMU is declining, and in the East Coast SMU the population in the Tay and Eden Special Area of Conservation (SAC) has declined rapidly since 2002 and is apparently continuing. Less frequent counts in the Firth of Forth indicate that the whole South East Scotland SMU population may be declining[84].

4.2.29 The causal mechanisms of harbour seal declines have not been identified, but several factors have been rejected as primary causes of the decline, although these may remain as potential secondary factors. Critical factors have been identified for further research including reduction in prey availability, competition with grey seals for prey resources, predation by grey seals and by killer whales, and exposure to toxins from harmful algal blooms [84]. Declining sandeel stocks have been linked to declines in harbour seal populations[85].

Cetaceans

4.2.30 The long-term population trends of key cetacean species are summarised in Table 6 and are either classed as ‘unknown’ or ‘uncertain’. Although there are two robust estimates of abundance for harbour porpoise, minke whale, and white-beaked dolphin covering the UK EEZ over a period of 11 years, two data points do not enable confidence in population trends therefore the UK population trend is unknown. Estimates of abundance of harbour porpoise and minke whale in the North Sea suggest that their numbers are stable[86].

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[83] Natural Environment Research Council, Special Committee on Seals. Scientific Advice on Matters Related to the Management of Seal Populations: 2021. http://www.smru.st-andrews.ac.uk/files/2022/08/SCOS-2021.pdf (last accessed: 21/06/2023).
[84] Natural Environment Research Council, Special Committee on Seals. Scientific Advice on Matters Related to the Management of Seal Populations: 2021. http://www.smru.st-andrews.ac.uk/files/2022/08/SCOS-2021.pdf (last accessed: 21/06/2023).
[85] Wilson, L., Hammond, P. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Wiley Online Library, Aquatic Conservation: Marine and Freshwater Ecosystems, Volume 29, Issue S1, 2019: 71 – 85. https://onlinelibrary.wiley.com/doi/abs/10.1002/aqc.3131 (last accessed 21/06/2023).
[86] OSPAR. Abundance and Distribution of Cetaceans. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/abundance-distribution-cetaceans/ (last accessed: 21/06/2023).

4.2.31 Pressures that can affect cetaceans as identified in the UK dolphin and porpoise conservation strategy technical report[87] are summarised in table 7. The most recent estimate of abundance of cetaceans in each of their management units is also shown[88].

Table 6: Population trends and abundance estimates key cetacean species in UK waters.

Species	Population Trend	Management Unit	Abundance of animals in the UK portion of Management Unit	95% Confidence interval for UK portion of Management Unit	Source
Harbour porpoise	Uncertain	North Sea	159,632	127,442 – 199,954	Hammond *et al.* 2021[89]; Rogan *et al.* 2018[90]
		West Scotland	24,305	17,121 – 34,505	Hammond *et al.* 2021 [89]; Rogan *et al.* 2018 [90]
		Celtic and Irish Seas	16,777	11,216 – 25,096	Hammond *et al.* 2021 [89]; Rogan *et al.* 2018 [90]
Minke whale	Unknown	Celtic and Greater North Seas	10,288	6,210 – 17,042	Hammond *et al.* 2021 [89]; Rogan *et al.* 2018 [90]

[87] Scottish Government. UK dolphin and porpoise conservation strategy: technical report. 22 March 2021. https://www.gov.scot/publications/uk-dolphin-porpoise-conservation-strategy-technical-report/ (last accessed 21/06/2023).
[88] JNCC. Updated abundance estimates for cetacean Management Units in UK waters. JNCC Report, 2022, No. 680. https://data.jncc.gov.uk/data/3a401204-aa46-43c8-85b8-5ae42cdd7ff3/jncc-report-680-revised-202203.pdf (last accessed 21/06/2023).
[89] Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J., Øien, N. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys, 2021. https://scans3.wp.st-andrews.ac.uk/files/2022/08/SCANS-III_density_surface_modelling_report_final_20220815.pdf (last accessed 21/06/2023).
[90] Rogan, E., Breen, P., Mackey, M., Cañadas, A., Scheidat, M., Geelhoed, S. & Jessopp, M. Aerial surveys of cetaceans and seabirds in Irish waters: Occurrence, distribution and abundance in 2015-2017. Department of Communications, Climate Action & Environment and National Parks and Wildlife Service (NPWS), Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland, 2018. https://research.wur.nl/en/publications/aerial-surveys-of-cetaceans-and-seabirds-in-irish-waters-occurren (last accessed: 21/06/2023).

White-beaked dolphin	Unknown in the North Sea	Celtic and Greater North Seas	34,025	20,026 – 57,807	Hammond *et al.* 2021 [89]; Rogan *et al.* 2018 [90]

Table 7: Pressures that can affect cetacean populations.

Pressure	Description
Bycatch/entanglement	Entanglement in fishing gear, including pots and creels; drift nets; trawling and purse seine; and set (fixed) nets.
Acoustic disturbance	Including cumulative impacts of acoustic disturbance; seismic/geophysical surveys; underwater explosions; pile driving; operational offshore windfarms; operational oil and gas platforms; acoustic deterrent devices; fish finders and depth sounders; pingers; mining and dredging activities; vessel noise; military activity and sonar.
Physical disturbance	Including scientific studies (e.g. tagging, photo ID, biopsy); recreation and wildlife tourism.
Change to habitat	Including barriers to movement; change/removal of supporting habitat; reduction in availability of prey; localised temperature change
Physical injuries/mortalities	Including vessel strikes; collision with renewable energy devices; high energy acoustic events (e.g. removal of unexploded ordnance)
Marine pollution	Including oil pollution; chemical pollution (e.g. PCBs, Butyl tins, PAHs, Radionuclides, heavy metals); plastic pollution (ingestion); entanglements in marine litter and ghost nets; eutrophication, sewage pathogens

4.3 Water quality, resources, and ecological status

Sandeel

4.3.1 Sandeel are distributed broadly in Scottish waters where they are highly reliant upon the availability of suitable sandy substrates[91,92,93,94]. A study by the Scottish Government's Marine Directorate on sandeel distribution in sediment grab samples collected in the Firth of Forth found that sandeel preferred medium to coarse sand, presumably as this offers greater permeability and thus higher oxygen concentrations, and avoided fine sediment[95], confirming previous results of an experimental test of sediment preference conducted by the Marine Directorate[96]. Sandeel were also found to prefer water depths of around 50 m [96].

4.3.2 These sediment preferences, along with other environmental variables, have been used by the Marine Directorate to map sandeel habitat suitability and predict sandeel distributions around Scotland, eastern English waters and the Celtic Seas[97]. The resultant Species Distribution Models (SDM) highlighted an avoidance of fine sediment, a preference of depths around 40 m and a high patchiness of suitable habitat [94]. The key output of the model was a prediction of sandeel distribution within and beyond the limits of Scottish waters (Figure 23). The model predicts the highest probability of sandeel occurrence on Dogger Bank (North Sea, sandeel management area 1, eastern English waters) and also identifies sandeel grounds in the Firth of

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[91] Wright P.J., Jensen H. & Tuck I. The influence of sediment type on the distribution of the Lesser Sandeel, Ammodytes marinus. Journal of Sea Research, 2000, Volume 44, Issues 3-4: 243 – 256. https://www.sciencedirect.com/science/article/abs/pii/S1385110100000502 (last accessed 21/06/20230.

[92] Holland, G.J., Greenstreet, S.P., Gibb, I.M., Fraser, H.M. & Robertson, M.R. Identifying sandeel Ammodytes marinus sediment habitat preferences in the marine environment. Marine Ecology Progress Series, 2005, Volume 303: 269-282. https://www.researchgate.net/publication/242697259_Identifying_sandeel_Ammodytes_marinus_sediment_habitat_preferences_in_the_marine_environment (last accessed 21/06/2023).

[93] Tien N.S.H., Craeymeersch J., van Damme C., Couperus A.S., Adema J. &Tulp I. Burrow distribution of three sandeel species relates to beam trawl fishing, sediment composition and water velocity, in Dutch coastal waters. Journal of Sea Research, 2017, Volume 127: 194 – 202. https://www.sciencedirect.com/science/article/abs/pii/S1385110117301223 (last accessed 21/06/2023).

[94] Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145 - 159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

[95] Holland, G.J., Greenstreet, S.P., Gibb, I.M., Fraser, H.M. & Robertson, M.R. Identifying sandeel Ammodytes marinus sediment habitat preferences in the marine environment. Marine Ecology Progress Series, 2005, Volume 303: 269-282. https://www.researchgate.net/publication/242697259_Identifying_sandeel_Ammodytes_marinus_sediment_habitat_preferences_in_the_marine_environment (last accessed 21/06/2023).

[96] Wright P.J., Jensen H. & Tuck I. The influence of sediment type on the distribution of the Lesser Sandeel, Ammodytes marinus. Journal of Sea Research, 2000, Volume 44, Issues 3-4: 243 – 256. https://www.sciencedirect.com/science/article/abs/pii/S1385110100000502 (last accessed 21/06/20230.

[97] Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145 - 159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

Forth (consistent with historic sandeel fishing grounds[98]), the Moray Firth, the east coast of Orkney, east of Dublin, north east coast of Donegal, north and west of Islay, and to the north and west of Lewis. Model predictions were validated against the east coast sandeel dredge survey and both the North Sea and West of Scotland International Bottom Trawl Surveys[99].

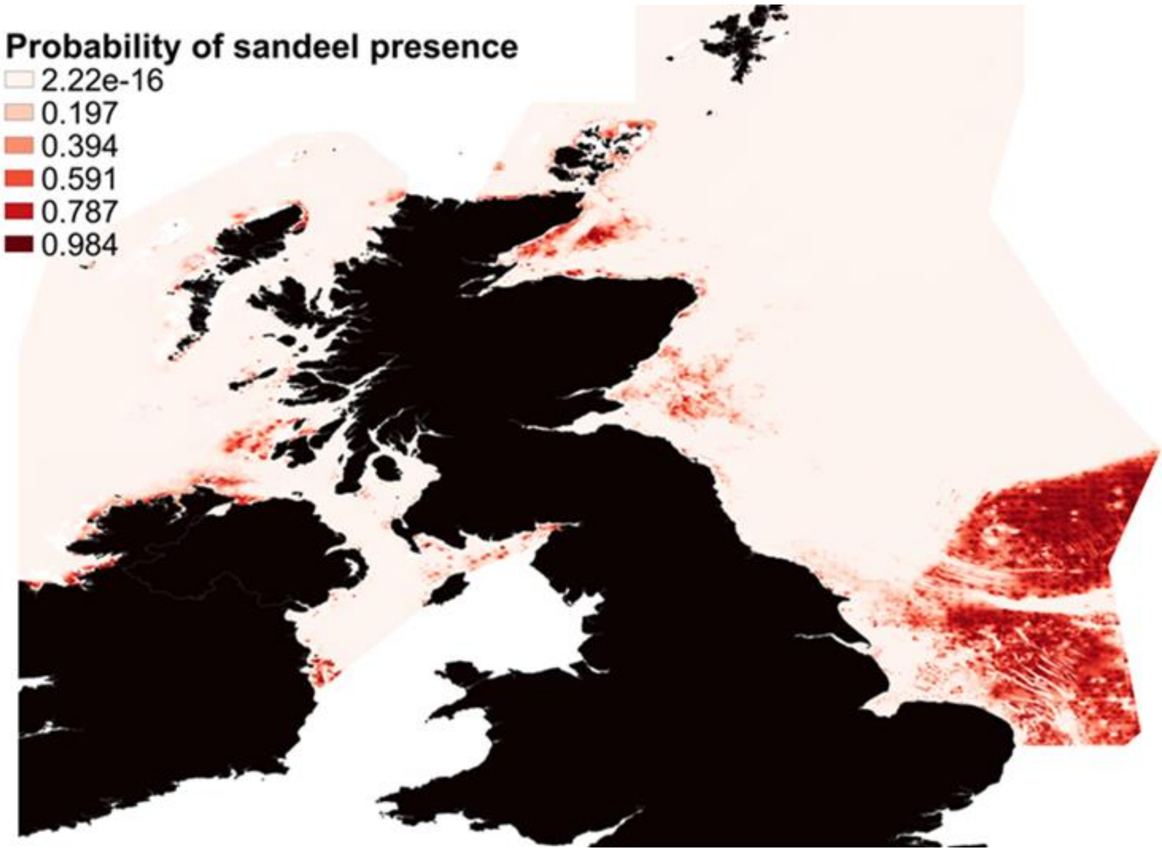

Figure 23: Predicted probability of occurrence of sandeel in UK waters. Reproduced from Langton et al. (2021).

4.3.3 The lack of a sandeel assessment on the west coast of Scotland (there are no recent data on sandeel status in this area) and the designation of several Marine Protected Areas (MPAs) in these areas protecting sandeel directly or indirectly (e.g., sandeel reliant predators), resulted in the Marine Directorate conducting a sandeel survey to the west coast of Scotland in 2019. The observed occurrence of sandeel in grab and dredge samples at various sites on the west coast of Scotland was in good agreement with the Langton *et al*. (2021) predictions[100].

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98 Jensen, H., Rindorf, A., Wright, P.J. & Mosegaard, H. Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science, 2010, Volume 68 Issue 1: 43 – 51. https://academic.oup.com/icesjms/article/68/1/43/631084 (last accessed 21/06/2023).

99 Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145 - 159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

100 Langton R., Boulcott P., Wright P.J. A verified distribution model for the lesser sandeel Ammodytes marinus. MEPS, 2021, Volume 667: 145 - 159. https://www.int-res.com/abstracts/meps/v667/p145-159 (last accessed 21/06/2023).

4.3.4 Sandeel movement at the adult stage is limited and connectivity between sandeel grounds results from larval dispersal, mostly driven by oceanographic processes.

Predatory fish

4.3.5 There are approximately 100 species of fish that live in Scottish waters with varying characteristics that fill a variety of ecological niches[101]. Sandeel forms a significant component of the diet of the following commercially important species:

- Atlantic cod *Gadus morhua*;
- Haddock *Melanogrammus aeglefinus*;
- Whiting *Merlangius merlangus*; and
- Saithe *Pollachius virens.*

4.3.6 Atlantic cod is a species of demersal fish that is distributed broadly across North Atlantic waters[102]. In Scottish waters significant aggregations are found off the Moray Firth, the Northern Isles as well as areas off Rattray head and Buchan Deep[103]. In the North Sea, Atlantic cod abundance is estimated by the International Bottom Trawl Survey (IBTS) taking place in quarter 1 and quarter 3. The biomass of cod measured in Catch Per Unit Effort (CPUE) in quarter 1 is presented in Figure 24 [103] An estimation of the distribution of cod spawning grounds highlights the presence of a number of recurrent and occasional cod spawning grounds in Scottish waters[104] (Figure 25).

4.3.7 Haddock is a species of demersal fish that is distributed broadly across North Atlantic waters. In Scottish waters, significant aggregations are found off the Moray Firth and generally along the East coast of Scotland and to the West of the Hebrides particularly for age 3 and older [105] (Figure 26). An estimation of the distribution of haddock spawning grounds highlights the presence of a number of recurrent and occasional haddock spawning grounds in Scottish waters[105] (Figure 27).

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[101] Daan, N. (2006). Spatial and temporal trends in species richness and abundance for southerly and northerly components of the North Sea fish community separately, based on IBTS data 197702005. Paper presented at ICES Annual Science Conference 2006, Maastricht, 19-23 September 2006. https://edepot.wur.nl/22490 (last accessed: 21/06/2023).

[102] Rose, G. A. (Ed.). Atlantic cod: a bio-ecology. John Wiley & Sons; 2019 Feb 26.

[103] ICES. 2022. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).ICES Scientific Reports. 4:43. 1367 pp. http://doi.org/10.17895/ices.pub.19786285

[104] Gonzalez-Irusta, J. M., and Wright, P. J. Spawning grounds of Atlantic cod (Gadus morhua) in the North Sea. ICES Journal of Marine Science, 2016, Volume 73, Issue 2: 304 – 315. https://academic.oup.com/icesjms/article/73/2/304/2614292 (last accessed: 21/06/2023).

[105] Gonzalez-Irusta, J. M., and Wright, P. J. Spawning grounds of haddock (Melanogrammus aeglefinus) in the North Sea and West of Scotland. Fisheries Research, 2016, Volume 183: 180 – 191. https://www.sciencedirect.com/science/article/abs/pii/S0165783616301771 (last accessed: 21/06/2023).

4.3.8 Whiting is a species of demersal fish that is predominantly found in the North Sea. In Scottish waters, significant aggregations are found off the Moray Firth and generally along the East coast of Scotland[106] (Figure 28). An estimation of the distribution of whiting spawning grounds highlights the presence of a number of persistent and occasional whiting spawning grounds in Scottish waters, particularly around the Northern Isles and off the East coast of Scotland[107] (Figure 29).

4.3.9 Saithe is a species of demersal fish that is distributed broadly across North Atlantic waters. Juveniles are found in inshore nursery grounds along the coast of Norway, Scotland and Shetland Islands, while adults are highly migratory[108].

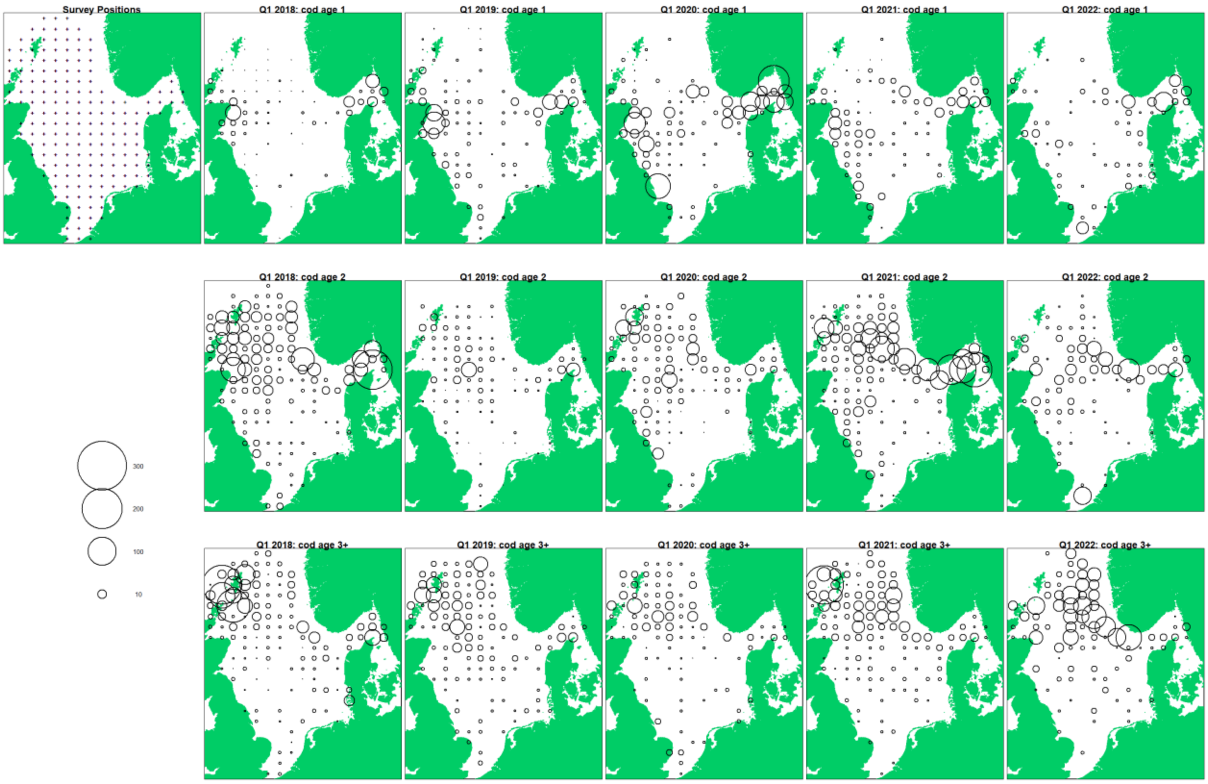

Figure 24: Atlantic cod *Gadus morhua* abundance in the North Sea IBTS Q1 survey 2018-2022. Circles indicate Catch per Unit Effort (ICES, 2022).

106 ICES. 2023. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports.

107 González-Irusta, J. M., and Wright, P. J. Spawning grounds of whiting (Merlangius merlangus). Fisheries Research, 2017, Volume 195: 141 - 151. https://www.sciencedirect.com/science/article/abs/pii/S0165783617301790 (last accessed 21/06/2023).

108 Myksvoll, Mari & Devine, J & Quintela, María & Geffen, Audrey & Nash, RDM & Sandvik, A & Besnier, Francois & Saha, Atal & Dahle, Geir & Jansson, Eeva & Nedreaas, K & Johansen, Torild. (2021). Linking dispersal connectivity to population structure and management boundaries for saithe in the Northeast Atlantic. Marine Ecology Progress Series, 2021, Volume 680: 177 – 191. https://www.int-res.com/abstracts/meps/v680/p177-191/ (last accessed 21/06/2023).

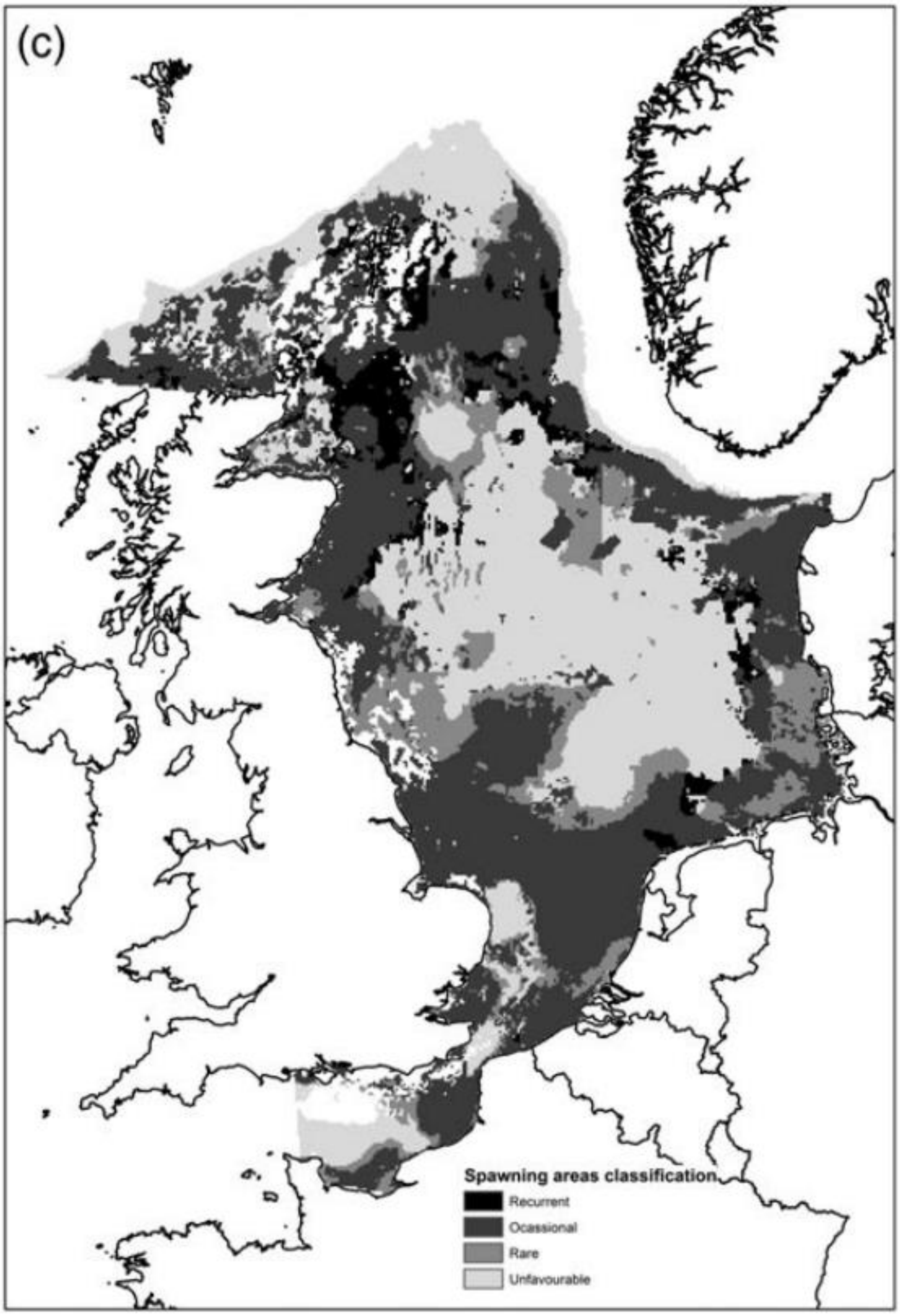

Figure 25: Classification of Atlantic cod *Gadus morhua* spawning habitat by recurrence. Recurrence categories are recurrent (dark grey), occasional, rare, and unfavourable (light grey) (Gonzalez-Irusta et al. 2016).

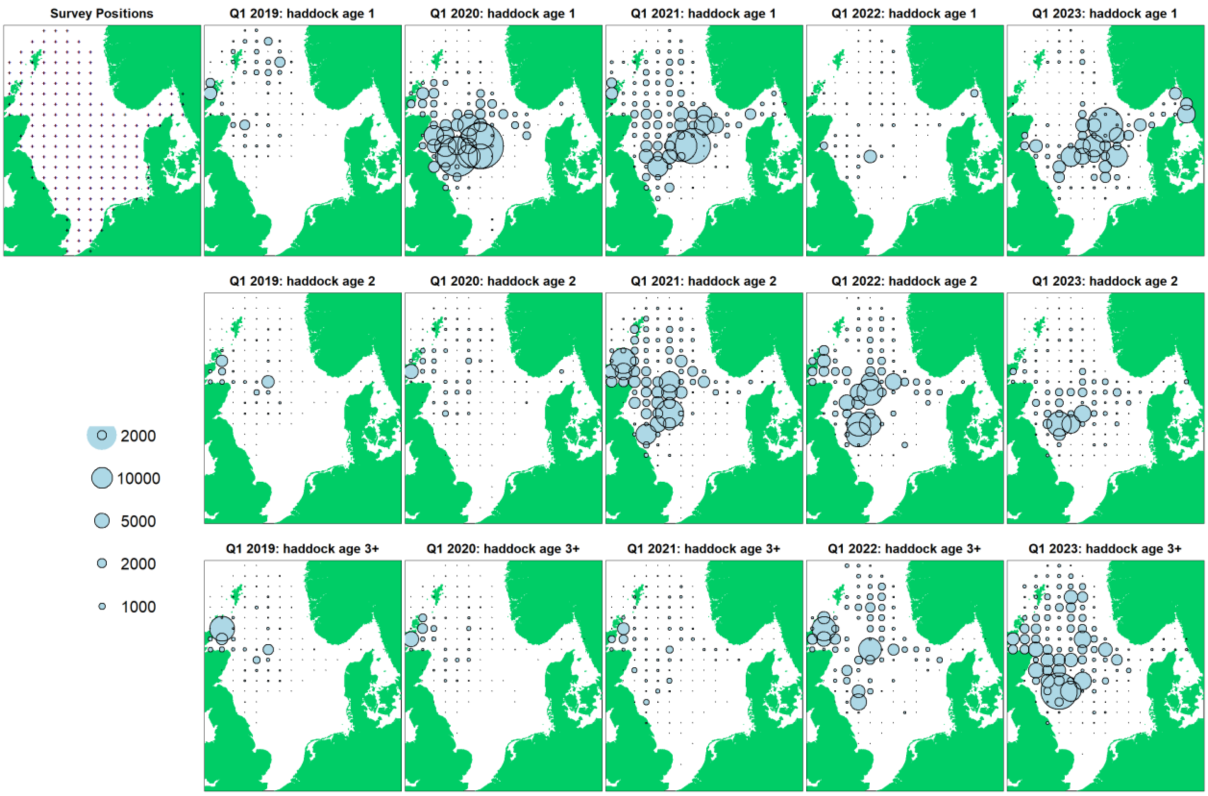

Figure 26: Haddock *Melanogrammus aeglefinus* abundance in quarter 1 of the North Sea IBTS Q1 survey 2018-2023. Circles indicate Catch per Unit Effort (ICES, 2022).

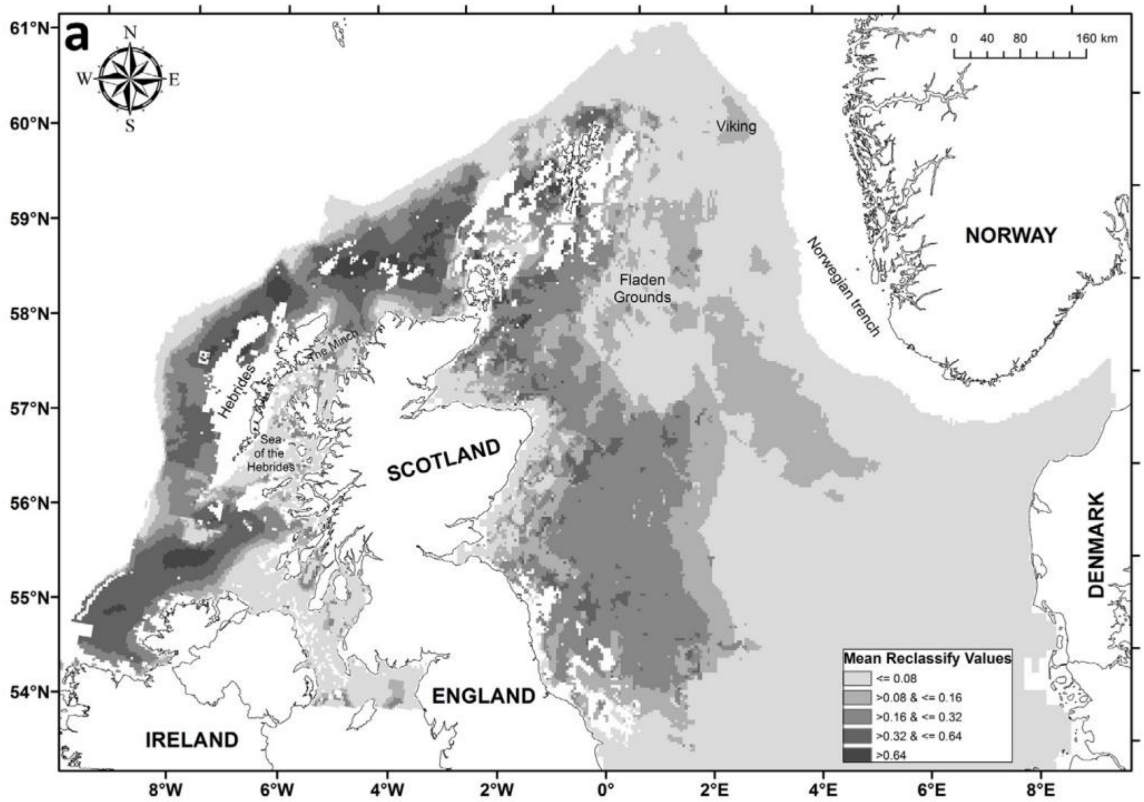

Figure 27: Classification of haddock *Melanogrammus aeglefinus* spawning by recurrence (Gonzalez-Irusta et al. 2016b).

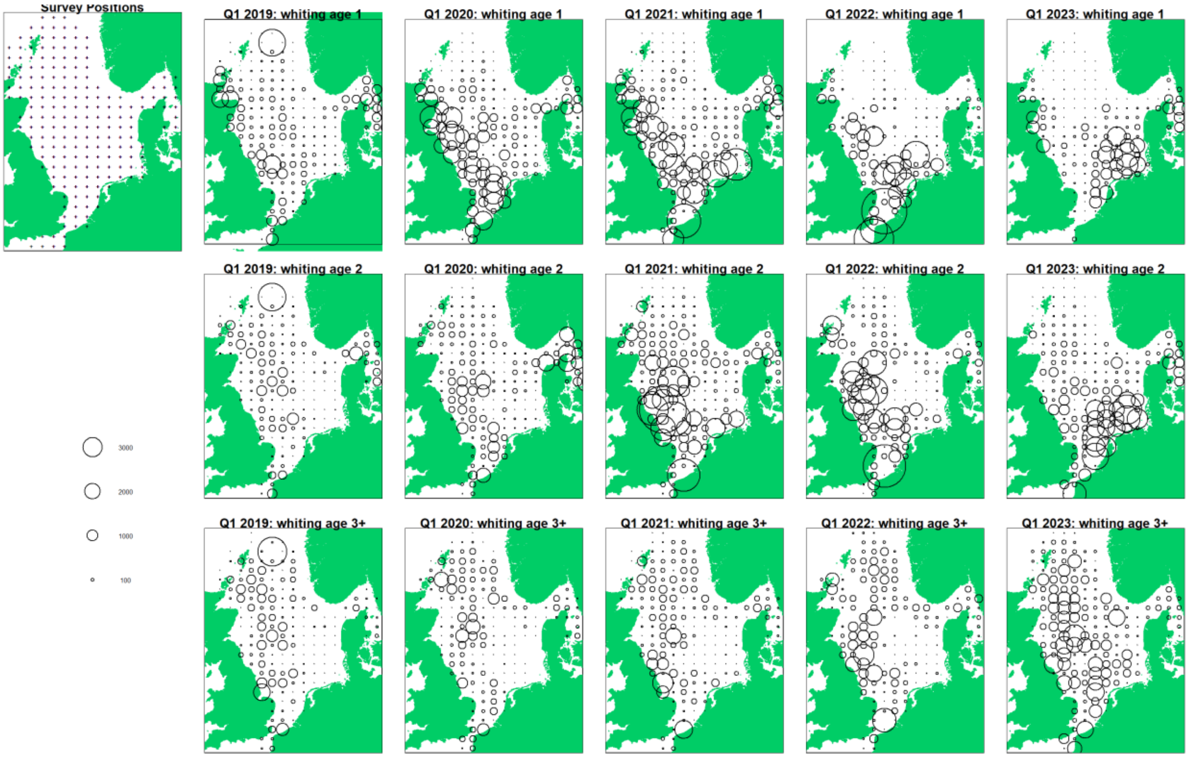

Figure 28: Whiting *Merlangius merlangus* abundance in the North Sea IBTS Q1 survey 2018-2023. Circles indicate Catch per Unit Effort (ICES, 2023).

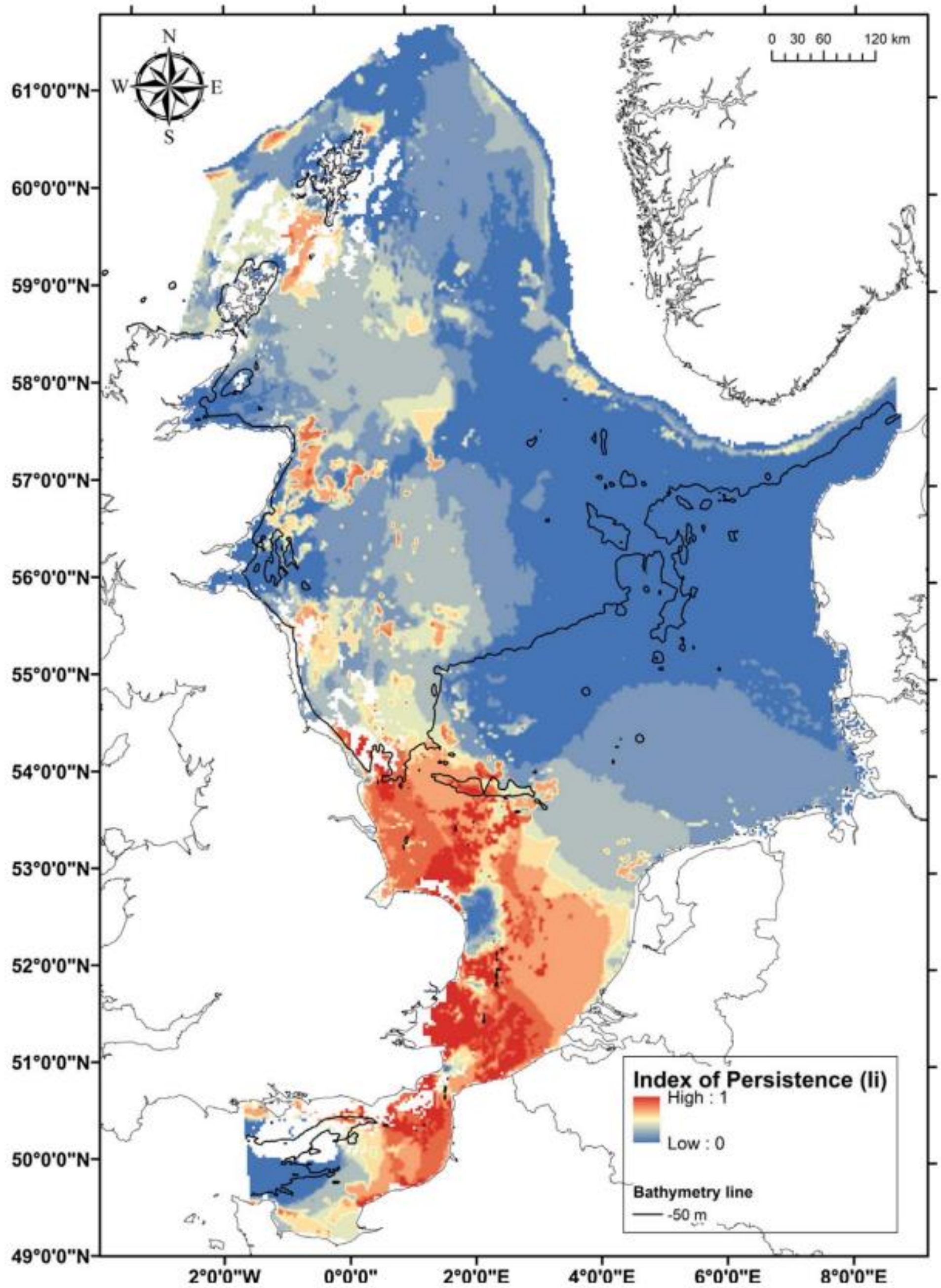

Figure 29: Classification of whiting *Merlangius merlangus* spawning habitat by recurrence (González-Irusta et al. 2017).

Trends and pressures

<u>Sandeel</u>

4.3.10 Recruitment in 2014, 2016, 2017, 2019, 2021 and 2022 was above the geometric mean for the period 2012-2021, while the remaining years after 2010 were below (Figure 31). Fishing mortality (F) has been low since 2005, apart from 2018 and 2021 (Figure 31). The low level of F, together with high recruitment in 2014 and 2019, has resulted in Spawning Stock Biomass (SSB) above the precautionary spawning biomass level (Bpa) between 2016 and 2019 and in 2021. Spawning Stock Biomass (SSB) was between the Limit reference point for spawning stock biomass (Blim) and the precautionary spawning biomass level (Bpa) in 2020 and 2022[109] (see Figure 2).

4.3.11 Causes of variation in sandeel abundance are numerous and are driven by fishing mortality and (principally) natural mortality, the latter being influenced by factors such as environmental change (temperature effects, regime shifts) and top-down processes (trophic regulation by marine predators). Aside from fishing pressure, a major pressure facing sandeel is climate change which has direct effects on sandeel physiology as well as indirect effects on the availability of their prey.

4.3.12 Climate change and changes in sea temperature, particularly, have the potential to affect sandeel abundance and their availability to marine predators through a variety of mechanisms. Two key characteristics of sandeel biology make them particularly sensitive to a temperature increase during winter: (i) the long overwintering period during which sandeel remain inactive and buried in the sand and (ii) the requirement to build up energy reserves at times when food is abundant due to investment in reproduction at a time of low prey availability (sandeel are capital breeders). As sandeel rest (do not feed) throughout winter, the increased metabolic rate and maintenance costs associated with climate change may result in an increase in overwinter mortality (i.e. if the maintenance costs cannot be met by the finite energy stores acquired during the growing season) and a delay in maturation[110]. (i.e. energetic commitment to maturation is constrained by increasing maintenance costs). These temperature related delays in ovarian development and spawning dates[111,112], and changes to egg development[113] may in turn result in a mismatch between sandeel hatching and the availability of their copepod prey[114].

[109] ICES (2023) Sandeel (Ammodytes spp.) in divisions 4.a-b, Sandeel Area 4 (northern and central North). In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, san.sa.4. https://ices-library.figshare.com/articles/report/Sandeel_Ammodytes_spp_in_divisions_4_a_b_Sandeel_Area_4_northern_and_central_North_Sea_/21815193 (last accessed: 21/06/2023).

[110] Wright, P.J., Pinnegar, J.K. and Fox, C. Impacts of climate change on fish, relevant to the coastal and marine environment around the UK. MCCIP Science Review 2020,354–381. https://www.mccip.org.uk/sites/default/files/2021-07/16_fish_2020.pdf (last accessed: 21/06/2023).

[111] Enzor, L.A., Zippay, M.L. and Place, S.P. High latitude fish in a high CO2 world: synergistic effects of elevated temperature and carbon dioxide on the metabolic rates of Antarctic notothenioids. Comparative Biochemistry and Physiology, 2013, Part A: Molecular and Integrative Physiology, 164: 154–161. https://pubmed.ncbi.nlm.nih.gov/22884997/ (last accessed: 21/06/2023).

[112] Couturier, C.S., Stecyk, J.A., Rummer, J.L., Munday, P.L. and Nilsson, G.E. Species-specific effects of near-future CO2 on the respiratory performance of two tropical prey fish and their predator. Comparative Biochemistry and Physiology, 2013 Part A: Molecular and Integrative Physiology, Volume 166: 482–489. https://pubmed.ncbi.nlm.nih.gov/23916817/ (last accessed: 22/06/2023).

[113] Regnier, T., Gibb, F.M. and Wright, P.J. Temperature effects on egg development and larval condition in the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research, 2018; 134: 34-41. https://doi.org/10.1016/j.seares.2018.01.003

[114] Régnier, T., Gibb, F.M. and Wright, P.J. Understanding temperature effects on recruitment in the context of trophic mismatch. Scientific Reports, 2019; 9: 15179. https://doi.org/10.1038/s41598-019-51296-5

4.3.13 Climate change is also predicted to affect the marine environment through an increase in ocean acidification resulting from increased CO_2 levels as well as a decrease in dissolved oxygen[115]. While no empirical evidence of the effects of ocean acidification on sandeel is available, effects have been documented in other fish, with potential impacts on metabolic rate[116] and respiratory performance[117] which may ultimately impact survival and abundance. Ocean acidification may also impact sandeel through bottom-up processes as effects have been documented on both phytoplankton and zooplankton communities[118,119]. Oxygen levels are predicted to decrease further with climate change[120] and may impose further restrictions on fish distributions. Sandeel spend a considerable proportion of their life cycle buried in the sediment, in anoxic or near anoxic conditions. Experimental work revealed that decreasing oxygen affected the depth at which sandeel buried in the substrate and that they emerged at very low dissolved oxygen levels[121]. A decrease in oxygen levels may therefore indirectly impact sandeel survival and abundance through an increase in sandeel exposure to predators, in addition to potential direct effects on fish physiology. While most studies of the impacts of climate change on sandeel have focussed on temperature, other effects such as ocean acidification and low dissolved oxygen levels are likely to play an important role and their cumulative effects may result significant impacts on sandeel abundance and availability to marine predators.

Predatory fish

4.3.14 Atlantic cod biomass exhibited a decline between 1980 and 2005 followed by a slight increase in biomass since 2005[122] (Figure 30). Biomass of haddock in Scottish waters showed an initial decrease in the mid-80's followed by relatively low biomass levels except for a peak between 2000 and 2003. Biomass has shown recent increases since 2020 (Figure 31). Biomass of whiting has been relatively stable since the mid-80's[123] (Figure 32).

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[115] Wright, P.J., Pinnegar, J.K. and Fox, C. Impacts of climate change on fish, relevant to the coastal and marine environment around the UK. MCCIP Science Review, 2020: 354–381.

[116] Enzor, L.A., Zippay, M.L. and Place, S.P. High latitude fish in a high CO_2 world: synergistic effects of elevated temperature and carbon dioxide on the metabolic rates of Antarctic notothenioids. Comparative Biochemistry and Physiology Part A: Molecular and Integrative Physiology, 2013; 164: 154–161. https://doi.org/10.1016/j.cbpa.2012.07.016

[117] Couturier, C.S. et al. Species-specific effects of near-future CO_2 on the respiratory performance of two tropical prey fish and their predator. Comparative Biochemistry and Physiology Part A: Molecular and Integrative Physiology, 2013; 166: 482-489. https://doi.org/10.1016/j.cbpa.2013.07.025

[118] Dutkiewicz, S. et al. Impact of ocean acidification on the structure of future phytoplankton communities. Nature Climate Change, 2015; 5: 1002-1006. https://doi.org/10.1038/nclimate2722

[119] Hammill, et al. Ocean acidification alters zooplankton communities and increases top-down pressure of a cubozoan predator. Global Change Biology, 2018; 24: e128–e138. https://doi.org/10.1111/gcb.13849

[120] Townhill, B.L. et al. Consequences of climate-induced low oxygen conditions for commercially important fish. Marine Ecology Progress Series, 2017; 580: 191-204. https://doi.org/10.3354/meps12291

[121] Behrens, J.W. et al. Oxygen dynamics around buried lesser sandeels *Ammodytes tobianus* (Linnaeus 1785): mode of ventilation and oxygen requirements. Journal of Experimental Biology, 2007; 210(6): 1006-1014. https://doi.org/10.1242/jeb.000570

[122] ICES. 2022. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).ICES Scientific Reports. 4:43. 1367 pp.

[123] ICES. 2023. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).ICES Scientific Reports.

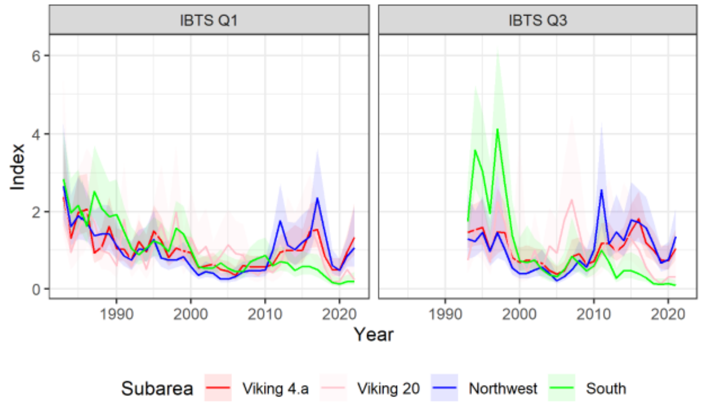

Figure 30: Atlantic cod *Gadus morhua* biomass indices estimated by subregion (ICES, 2022).

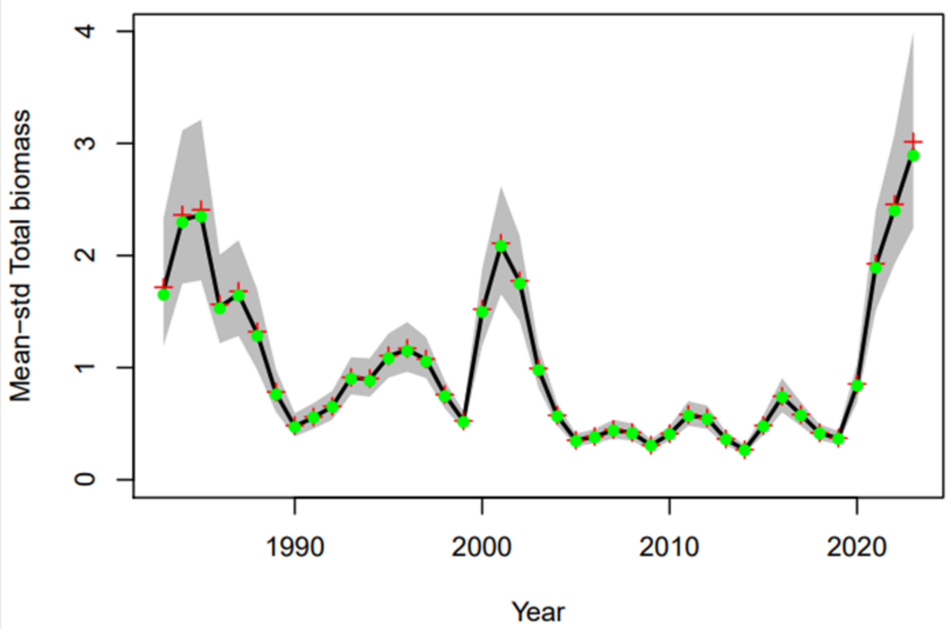

Figure 31: Relative total biomass of haddock *Melanogrammus aeglefinus* in Subarea 4, Division 6.a, and Subdivision 20. Summary plots from an exploratory SURBAR assessment using both available survey derived indices (delta-GAM NS-WC Q1 and delta-GAM NS-WC Q3+Q4) (ICES, 2022).

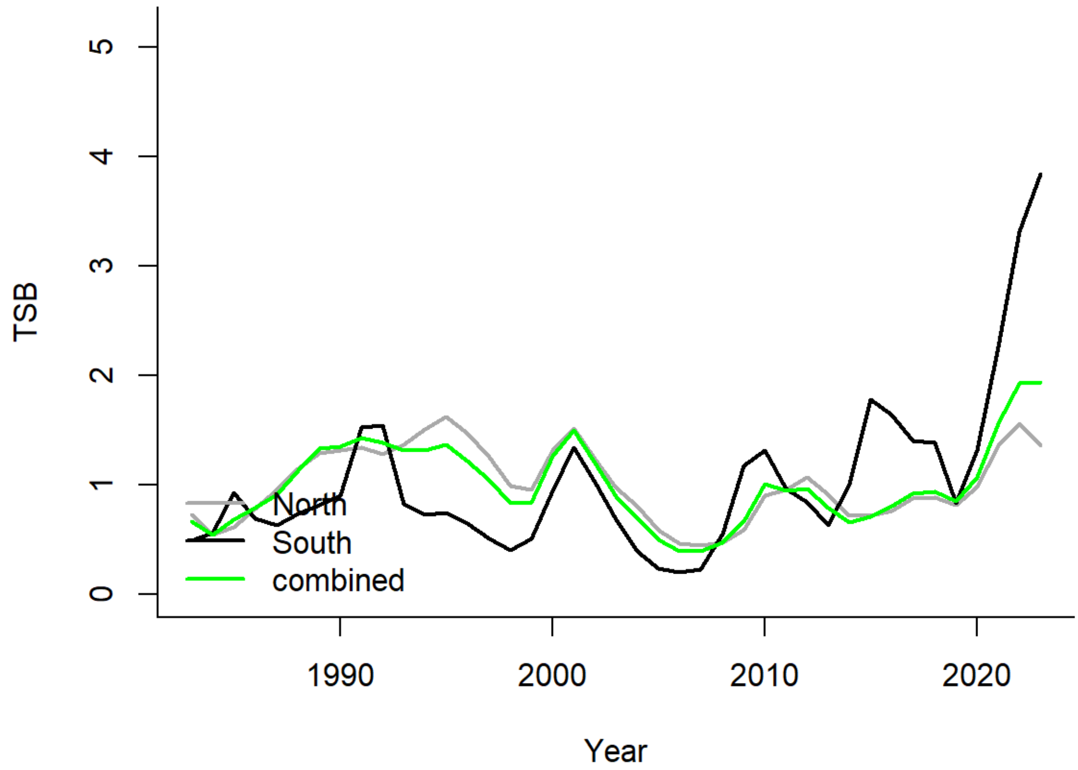

Figure 32: Whiting *Merlangius merlangus* relative total stock biomass (TSB) indices estimated by subregion using an exploratory SURBAR assessment (ICES, 2023).

4.3.15 The main pressures facing predatory fish include environmental change and fishing pressure. Cod, haddock and saithe are considered boreal species (cold-favouring) and are likely to be negatively impacted by warming waters[124,125]. Atlantic cod populations are more abundant in the northern portion of the North Sea compared to the southern portion where temperatures are warmer (Figure 32). A combination of fishing pressure and climate change has affected growth and resulted in a decrease in the length and age at maturation for gadid stocks[125,126,127]. This in

[124] Serpetti, N. et al. Impact of ocean warming on sustainable fisheries management informs the Ecosystem Approach to Fisheries. Scientific Reports, 2017; 7: 13438. https://doi.org/10.1038/s41598-017-13220-7

[125] Ter Hofstede, R. and Rijnsdorp, A. D. Comparing demersal fish assemblages between periods of contrasting climate and fishing pressure. ICES Journal of Marine Science, 2011; 68(6) 1189-1198. https://doi.org/10.1093/icesjms/fsr053

[126] Marty, L., Rochet, M-J. and Ernande, B. Temporal trends in age and size at maturation of four North Sea gadid species: Cod, haddock, whiting and Norway pout. Marine Ecology Progress Series, 2014; 497: 179-197. https://doi.org/10.3354/meps10580

[127] Ikpewe, I. E. et al. Bigger juveniles and smaller adults: Changes in fish size correlate with warming seas. Journal of Applied Ecology, 2021; 58: 847– 856. https://doi.org/10.1111/1365-2664.13807

turn affects their recruitment, as well as the timing of spawning[128,129,130]. Whiting on the other hand are considered a Lusitanian (warm-favouring) species and so may be less affected by climate change[131]. Stock dynamics of whiting are driven by recruitment and a high level of natural mortality[132]. Haddock abundance is driven by a high level of recruitment variability meaning that environmental conditions, including climate, are a key driver of population changes in this species[133,134]. Fishing mortality of cod, whiting and haddock has been declining in recent years due to restricted fishing effort in the whitefish fishery caused by the low cod TAC in this fishery[132].

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[128] Marshall, D. J., Barneche, D. R. and White, C. R. How does spawning frequency scale with body size in marine fishes? Fish and Fisheries, 2022; 23(2): 316-323. https://doi.org/10.1111/faf.12617

[129] Marty, L., Rochet, M-J. and Ernande, B. Temporal trends in age and size at maturation of four North Sea gadid species: Cod, haddock, whiting and Norway pout. Marine Ecology Progress Series, 2014; 497: 179-197. https://doi.org/10.3354/meps10580

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[131] Comparing demersal fish assemblages between periods of contrasting climate and fishing pressure | ICES Journal of Marine Science | Oxford Academic (oup.com)

[132] ICES. 2023. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).ICES Scientific Reports.

[133] Fogarty. M. J., Myers, R. A. and Bowen, K. G. Recruitment of cod and haddock in the North Atlantic: a comparative analysis. ICES Journal of Marine Science, 2001; 58(5): 952–961. https://doi.org/10.1006/jmsc.2001.1108

[134] Edda Johannesen and others, Persistent differences in recruitment variability among co-occurring North Atlantic groundfish species, *ICES Journal of Marine Science*, Volume 79, Issue 9, November 2022, Pages 2430–2441, https://doi.org/10.1093/icesjms/fsac181

5. Results of SEA

5.1 Overview

5.1.1 The purpose of this section is to report the results of the SEA.

5.1.2 It is considered that the extension of the sandeel closure to all Scottish waters has the potential to lead to significant beneficial environmental effects.

5.1.3 An overview of the implications of the extended closure on the environment, namely the Biodiversity, Flora and Fauna headline topic and component topics, and the Water quality, Resources, and Ecological Status headline topic and component topics (see Section 3.3) and SEA objectives, is provided in this section. Further detail and supporting evidence can be found in the paper 'Review of Scientific Evidence on the Potential Effects of Sandeel Fisheries Management on the Marine Environment' which supports this consultation.

5.2 Environmental effects

Potential effects on seabirds

5.2.1 A large proportion of seabird species in Scotland include sandeel in their diet during the breeding season.

5.2.2 A consistent pattern in the way seabird breeding success changes with forage fish abundance has been reported for many seabird-forage fish interactions around the globe. Known as 'one-third for birds', seabird breeding success has been shown to vary little or not at all at intermediate and high forage fish abundance, but once forage fish abundance dropped below a threshold of one-third of maximum biomass, seabird breeding success rapidly declined[135]. This relationship has also been found for seabirds feeding on sandeel, e.g., for breeding success of Arctic skua, great skua and black-legged kittiwake on Foula in relation to the Shetland sandeel total stock biomass[136,137]. A similar relationship has also been found for a proxy of adult survival at the Isle of May for kittiwakes [137].

5.2.3 Seabird breeding success is influenced not only by sandeel biomass, abundance, and quality but also by their availability. Assessing sandeel availability to seabirds, especially surface feeders, is difficult as availability varies as sandeel move between the water column and the sediment, and their depth within the water column. Temporal availability of sandeel also influences seabird breeding success. The peak in sandeel abundance, and sandeel of the appropriate age and size, needs

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[135] Cury, P.M. et al. Global seabird response to forage fish depletion – one-third for the birds. Science, 2011; 334: 1703–1706. https://doi.org/10.1126/science.1212928

[136] Frederiksen, M., Furness, R. and Wanless, S. Regional variation in the role of bottom-up processes in controlling sandeel abundance in the North Sea. Marine Ecology Progress Series, 2007; 337: 279-286. https://doi.org/10.3354/meps337279

[137] MacArthur Green (2021). HRA Derogation Scope B - Review of seabird strategic compensation options. Report to Crown Estate Scotland and SOWEC. URL: hra-derogation-scope-b-report.pdf (offshorewindscotland.org.uk) (last accessed: 29/06/23).

to coincide with the seabird breeding season. Breeding success of three seabird species on the Isle of May was greatest when the sandeel fishery Catch Per Unit Effort (CPUE in June was high and the May/June CPUE ratio (an index of the timing of the onset of sandeel burying behaviour) was low, implying a peak abundance in May is too early to benefit seabird chicks[138].

5.2.4 The extent to which seabirds can dive down into the water column to obtain sandeel at different depths varies greatly among species. Surface feeding seabirds, such as terns and black-legged kittiwake, can only take fish very close to the surface whereas other species such as common guillemot, razorbill and Atlantic puffin can dive to considerable depths. Guillemot and European shag can also extract fish from the sediment on the seafloor and so can feed on sandeel even when they are not in the water column.

5.2.5 The extent to which seabirds are dependent on sandeel varies among species. For example, guillemot species have been shown to have greater capability to switch to foraging on sprat and small herring when sandeel are unavailable compared to black-legged kittiwake [138]. During breeding many Scottish seabird populations exploit seasonal peaks in sandeel abundance, feeding on both adult (1+ year group) and juvenile (young-of-the-year; age 0) age classes[139,140].

5.2.6 When the Shetland sandeel stock collapsed in the 1990s, many seabird species exhibited reduced breeding success[141,142,143,144] and survival [141,142,145,146]. The extent to which sandeel populations drive patterns in kittiwake breeding success among colonies appears to be stronger in Shetland and Orkney than further south, due to the absence of alternative prey[147].

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[138] Rindorf, A., Wanless, S. and Harris, M.P. Effects of changes in sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series, 2000; 202: 241-252. https://doi.org/10.3354/meps202241
[139] Newell, M. et al. 2013. Isle of May seabird studies in 2011. JNCC Report, No. 475g. URL: Isle of May seabird studies (2005–2015) | JNCC Resource Hub (last accessed: 22/06/23).
[140] Swann, R.L, Harris, M.P, and Aiton, D.G. The diet of European shag *Phalacrocorax aristotelis*, black-legged kittiwake *Rissa tridactyla* and common guillemot *Uria aalge* on Canna during the chick-rearing period 1981-2007. Seabird, 2008; 21: 44-54. Layout 1 (seabirdgroup.org.uk)
[141] Davis, S.E., Nager, R.G. and Furness, R.W. Food availability affects adult survival as well as breeding success of parasitic jaegers. Ecology, 2005; 86: 1047-1056. https://doi.org/10.1890/04-0989
[142] Furness, R.W. Responses of seabirds to depletion of food fish stocks. Journal of Ornithology, 2007; 148(Suppl 2): 247–252 https://doi.org/10.1007/s10336-007-0152-2
[143] Frederiksen, M., Furness, R. and Wanless, S. Regional variation in the role of bottom-up processes in controlling sandeel abundance in the North Sea. Marine Ecology Progress Series, 2007; 337: 279-286. https://doi.org/10.3354/meps337279
[144] Phillips, R.A. et al. Diet of the northern fulmar *Fulmarus glacialis*: reliance on commercial fisheries? Marine Biology, 1999; 135:159–170. https://doi.org/10.1007/s002270050613
[145] Oro, D. and Furness, R. W. Influences of food availability and predation on survival of kittiwakes. Ecology, 2002; 83(9): 2516-2528. https://doi.org/10.2307/3071811
[146] Ratcliffe, N. et al. The effect of age and year on the survival of breeding adult Great Skuas *Catharacta skua* in Shetland, Ibis, 2002; 144(3): 384-392. https://doi.org/10.1046/j.1474-919X.2002.00066.x
[147] Olin A.B. et al. Spatial synchrony of breeding success in the blacklegged kittiwake *Rissa tridactyla* reflects the spatial dynamics of its sandeel prey. Marine Ecology Progress Series, 2020; 638: 177-190. https://doi.org/10.3354/meps13252

5.2.7 Due to the challenges of studying seabird diet in the non-breeding season, when birds are at sea and away from their colonies, less is known about the importance of sandeel in seabird diet during this period[148]. Despite this, the limited information that exists suggests that seabirds forage on a wider variety of prey during the non-breeding season, but still include sandeel to some extent[149,150].

5.2.8 While sandeel have traditionally been considered one of the most abundant and energy rich prey for seabirds in Scotland[151,152,153] the availability, size and calorific content of this species has declined in recent decades[154,155,156,157] . As a result, many seabird populations now appear to have a reduced dependency on

[148] Barrett, R.T. et al. Diet studies of seabirds: a review and recommendations. ICES Journal of Marine Science, 2007; 64(9): 1675-1691. https://doi.org/10.1093/icesjms/fsm152
[149] Blake, B. et al. Seasonal changes in the feeding ecology of guillemots (*Uria aalge*) off north and east Scotland. Estuarine, Coastal and Shelf Science, 1985; 20: 559−568. https://doi.org/10.1016/0272-7714(85)90107-6
[150] Howells, R.J. et al. Pronounced long-term trends in year-round diet composition of the European shag *Phalacrocorax aristotelis* . Marine Biology, 2018; 165: 188. https://doi.org/10.1007/s00227-018-3433-9
[151] Dunnet, G. M. et al. Seabird ecology in the North Sea. Netherlands Journal of Sea Research, 1990; 26: 387–425. https://doi.org/10.1016/0077-7579(90)90097-Z
[152] Hislop, J. R. G., Harris, M. P. and Smith, J. G. M. Variation in the calorific value and total energy content of the lesser sandeel (*Ammodytes marinus*) and other fish preyed on by seabirds. Journal of Zoology, 1991; 224(3): 501–517. https://doi.org/10.1111/j.1469-7998.1991.tb06039.x
[153] Furness, RW, and Tasker, M.L. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series, 2000; 202: 253-264. https://doi.org/10.3354/meps202253
[154] Wanless, S. et al. Evidence for decrease in size of lesser sandeel *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Marine Ecology Progress Series, 2004; 279: 237-246. http://www.jstor.org/stable/24867841
[155] Wanless, S. et al. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Marine Ecology Progress Series, 2005; 294: 1-8. https://doi.org/10.3354/MEPS294001
[156] Frederiksen, M. et al. Climate, copepods and seabirds in the boreal Northeast Atlantic – current state and future outlook. Global Change Biology, 2013; 19: 364-372. https://doi.org/10.1111/gcb.12072
[157] Wanless, S. et al. A community wide decline in the importance of lesser sandeels *Ammodytes marinus* in seabird chick diet at a North Sea colony. Marine Ecology Progress Series, 2018; 600, 193–206. https://doi.org/10.3354/meps12679

sandeel, although this can be highly variable among years and colonies[158,159,160,161,162,163].

5.2.8 Obtaining measures of how a sandeel fishery changes the abundance or availability of sandeel to seabirds, and hence seabird demography, is not straightforward. Figure 33 illustrates the multiple complexity of linking changes to a sandeel fishery to seabird population size.

5.2.9 On two separate occasions, industrial sandeel fisheries have been closed due to concerns about their impacts on the breeding success of seabirds [162]. During the mid to late 1990s, a small sandeel fishery off Shetland was closed following declines in breeding success of seabirds including Arctic tern[164], great skua[165] and black-legged kittiwake[166]. More recently, an industrial sandeel fishery on the Wee Bankie, Scalp Bank and Marr Bank that opened in 1990 was closed in 2000 due to concerns about the fishery impacting breeding success of seabirds nesting around the Firth of Forth, including guillemot species, razorbill, black-legged kittiwake and, to some extent Atlantic puffin, were known to use the fished area for foraging during the breeding season[167].

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158 Wanless, S. et al. Evidence for decrease in size of lesser sandeel *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Marine Ecology Progress Series, 2004; 279: 237–246. http://www.jstor.org/stable/24867841

159 Wanless, S. et al. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Marine Ecology Progress Series, 2005; 294: 1-8. https://doi.org/10.3354/MEPS294001

160 Heubeck, M. Common guillemot *Uria aalge* chick diet and breeding performance at Sumburgh Head, Shetland in 2007-09, compared to 1990-91. Seabird, 2009; 22: 9-18.

161 Howells, R.J. et al. From days to decades: short- and long-term variation in environmental conditions affect offspring diet composition of a marine top predator. Marine Ecology Progress Series, 2017; 583: 227-242. https://doi.org/10.3354/meps12343

162 Howells, R.J. et al. Pronounced long-term trends in year-round diet composition of the European shag *Phalacrocorax aristotelis* . Marine Biology, 2018; 165: 188. https://doi.org/10.1007/s00227-018-3433-9

163 Anderson, H. B. et al. The diet of Common Guillemot *Uria aalge* chicks provides evidence of changing prey communities in the North Sea. Ibis, 2014; 156: 23–34. https://doi.org/10.1111/ibi.12099

164 Monaghan, P. et al. The relationship between food supply, reproductive effort, and breeding success in Arctic terns, *Sterna paradisaea*. Journal of Animal Ecology, 1989; 58: 261e274. https://doi.org/10.2307/4999

165 Hamer, K. C., Furness, R. W., and Caldow, R. W. G. The effects of changes in food availability on the breeding ecology of great skuas in Shetland. Journal of Zoology, 1991; 223: 175e188. https://doi.org/10.1111/j.1469-7998.1991.tb04758.x

166 Hamer, K. C. et al. The influence of food supply on the breeding ecology of kittiwakes *Rissa tridactyla* in Shetland. Ibis, 1993; 135: 255e263. https://doi.org/10.1111/j.1474-919X.1993.tb02842.x

167 Wanless, S., Harris, M. P., & Greenstreet, S. P. R. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. ICES Journal of Marine Science, 1998; 55: 1141–1151. https://doi.org/10.1006/jmsc.1998.0372

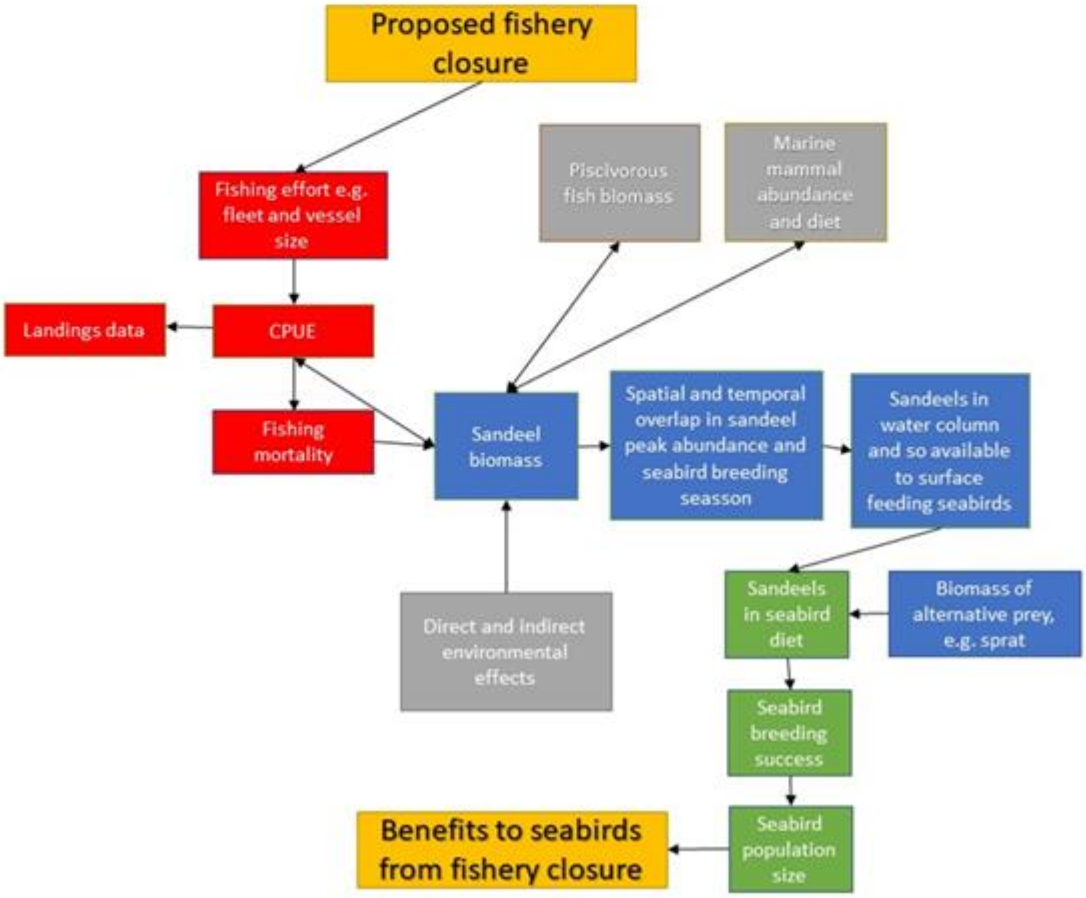

Figure 33: Diagram illustrating the complex relationship between sandeel fisheries measures and seabird breeding success.

5.2.10 The evidence for the fishery reducing breeding success, particularly for kittiwake, was so strong that ICES recommended using '*the criterion of kittiwake breeding success falling below 0.5 fledged chicks per well-built nest for three successive seasons as the threshold to close sandeel fisheries in areas important for foraging by the kittiwake colonies being monitored*'[168].

5.2.11 Following closure of the Wee Bankie sandeel fishery in 2000, sandeel abundance initially increased, as did black-legged kittiwake breeding success. Consumption rates of age 0 sandeel were higher after the fishery closure, despite the fishery not targeting age 0 sandeel[169]. However, no significant relationship

[168] ICES. Report of the ICES Advisory Committee on the Marine Environment, 1999. Cooperative Research Report 239, 01 January 2020, URL: [Report of the ICES Advisory Committee on the Marine Environment, 1999 (figshare.com)](https://ices-library.figshare.com) (last accessed: 22/06/23).
[169] Daunt, F. et al. The impact of the sandeel fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Canadian Journal of Fisheries and Aquatic Sciences, 2008; 65(3): 362-381. https://doi.org/10.1139/F07-164

between sandeel abundance and breeding success was found in European shag, guillemot species, razorbill, Atlantic puffin, common tern or Arctic tern[170,171].

5.2.12 While the breeding success of kittiwakes differed following the Wee Bankie sandeel fishery, it is difficult to distinguish the driver of population dynamics in the natural environment. Pressures such as disease, climate change and weather can all also play a role in population dynamics. The effects of the sandeel fishery may be additive on top of wider environmental processes, particularly climate change, that are reducing sandeel availability to seabirds[172]. Therefore, fisheries closures can provide benefits but environmental processes will also strongly determine seabird breeding success [170,173].

5.2.13 The positive benefits to seabird productivity and populations of a sandeel fishery closure are difficult to quantify because of the complex relationships between prey and seabird demography, ongoing climate-mediated changes in sandeel population (including from climate change) and the numerous other pressures that seabirds face. There is also considerable variation across seabird species in their dependence upon sandeel and their ability to switch to alternative prey. However, despite these uncertainties, maximising abundance and availability of sandeel stocks as prey for seabirds in Scotland remains a key mechanism by which resilience in seabird populations might be achieved.

Potential effects on marine mammals

5.2.14 Sandeel are a key prey species for marine mammals in Scottish waters, comprising a large proportion of the diet of seals and some cetaceans[174],[175],[176]. However, the importance of sandeel to marine mammal diet varies considerably with species and season.

5.2.15 Grey seals and harbour seals are largely sympatric within the UK, occupying similar ecological niches with some degree of regional spatial partitioning.

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[170] Daunt, F. et al. The impact of the sandeel fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Canadian Journal of Fisheries and Aquatic Sciences, 2008; 65(3): 362-381. https://doi.org/10.1139/F07-164
[171] Frederiksen, M., Jensen, H., Daunt, F., Mavor, R.A. & Wanless, S. (2008), differential effects of a local industrial sand lance fishery on seabird breeding performance. Ecological Applications, 18: 701-710. https://doi.org/10.1890/07-0797.1
[172] Rindorf, A., Wanless, S. and Harris, M.P. Effects of changes in sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series, 2000; 202: 241-252. https://doi.org/10.3354/meps202241
[173] Cook A.S.C.P. et al. Indicators of seabird reproductive performance demonstrate the impact of commercial fisheries on seabird populations in the North Sea. Ecological Indicators, 2014; 38: 1-11. https://doi.org/10.1016/j.ecolind.2013.10.027
[174] Pierce, G. et al. Diet of minke whales *Balaenoptera acutorostrata* in Scottish (UK) waters with notes on strandings of this species in Scotland 1992–2002. Journal of the Marine Biological Association of the UK, 2004; 84(6): 1241-1244. https://doi.org/10.1017/S0025315404010732h
[175] Santos, M.B. et al. Variability in the diet of harbor porpoises (*Phocoena phocoena*) in Scottish waters 1992–2003. Marine Mammal Science, 2004; 20: 1-27. https://doi.org/10.1111/j.1748-7692.2004.tb01138.x
[176] Wilson, L. J. and Hammond, P.S. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Aquatic Conservation, Marine and Freshwater Ecosystems, 2019; 29(1): 71-85. https://doi.org/10.1002/aqc.3131

This is marked by a notable overlap in diet throughout the UK populations where sandeel and large gadids are proportionally the most represented prey groups by weight, in both species[177,178,179,180,181].

5.2.16 Scat analysis studies have concluded that sandeel dominate the diet of grey seals in all regions during autumn and winter except for the Inner Hebrides where gadids predominated [182]. However, this dominance shifts to gadids and other benthic species during the spring and summer in Orkney and Shetland, and drops from 22.2% to 8% of the diet of grey seals in the inner Hebrides. For harbour seals, sandeel were also dominant but with regional variation. In the Moray Firth, sandeel were dominant in harbour seal scats across all seasons. However, the data suggested that sandeel became less important in more southerly regions with flatfish and gadids predominating in south-east Scotland, the southern North Sea and the Inner Hebrides. In addition, harbour seals from the Outer Hebrides and Shetland preferred pelagic species with sandeel only representing 13.1% and 23.7% of the diet in these regions during the spring and summer months. This prevalence does increase during autumn and winter in Shetland where sandeel become the preferred prey of harbour seals, representing 31.5% of their diet [182].

5.2.17 It has been suggested that the decline in harbour seal abundance in the North Sea may be linked to a reduction in sandeel stocks. Specifically, there appears to be a correlation between regional declines of sandeel stocks (northern and eastern Scotland) and the declining populations of harbour seals in eastern Scotland and Orkney, where sandeel dominate the diet of harbour seals. This relationship with sandeel stock levels was supported by findings that the diet of harbour seals appeared more diverse in areas where harbour seals are not in decline (West of Scotland). If sandeel are in short supply, it has been proposed that grey seals may out compete harbour seals thereby contributing to their decline given grey seal preference for sandeel in these regions [182].

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[177] Brown, E. G. et al. Interannual variation in the summer diets of harbour seals *Phoca vitulina* at Mousa, Shetland (UK). Journal of the Marine Biological Association of the United Kingdom, 2001; 81(2): 325-337. https://doi.org/10.1017/S0025315401003812

[178] Hall, A. J., Watkins, J., and Hammond, P. S. Seasonal variation in the diet of harbour seals in the south-western North Sea. Marine Ecology Progress Series, 1998; 170: 269-281. https://doi.org/10.3354/meps170269

[179] Pierce, G. J., and Santos, M. B. Diet of harbour seals (*Phoca vitulina*) in Mull and Skye (Inner Hebrides, western Scotland). Journal of the Marine Biological Association of the United Kingdom, 2003; 83(3): 647-650.

[180] Sharples, R. J., Arrizabalaga, B. and Hammond, P. S. Seals, sandeels and salmon: diet of harbour seals in St. Andrews Bay and the Tay Estuary, southeast Scotland. Marine Ecology Progress Series, 2009; 390: 265-276. https://doi.org/10.3354/meps08232

[181] Tollit, D. J. & Thompson, P. M. (1996). Seasonal and between-year variations in the diet of harbour seals in the Moray Firth, Scotland. Canadian Journal of Zoology, 74, 1110-1121. https://doi.org/10.1017/S00253154030007604h

[182] Wilson, L. J. and Hammond, P.S. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Aquatic Conservation, Marine and Freshwater Ecosystems, 2019; 29(1): 71-85. https://doi.org/10.1002/aqc.3131

5.2.18 Harbour porpoises (*Phocoena phocoena*) in Scottish waters have been found to feed predominately on whiting and sandeel[183,184] with sandeel being particularly important during the spring and summer 184.

5.2.19 A diet study on stomach contents of ten stranded minke whales (*Balaenoptera acutorostrata*) in Scotland showed that sandeel were the most important prey. species and contributed two-thirds of the individual diet, by weight diet[185]. These findings have been supported by other studies in the wider North Sea region. For example, sandeel were found to comprise 86.7% of the weight of the prey species found in the stomach contents of minke whales caught by Norwegian whalers in 1999[186] and were also found to dominate the diet of minke whales caught in the North Sea[187]. However, the proportion of sandeel dominance appeared to change between years, with one year showing a complete absence of sandeel in favour of a dominance of mackerel. Further, the importance of sandeel appeared to diminish through the sampling years, which was suggested to be linked to the poorer availability of sandeel in contemporary years 187.

5.2.20 Sandeel were present in a diet study of a small number of white beaked dolphins (*Lagenorhynchus albirostris)*[188], but gadids are thought to be the predominant prey items in the North Sea[189,190]. Sandeel are not thought to be a major component of the diet of bottlenose dolphins (*Tursiops truncatus*)[191].

5.2.21 Sandeel are an abundant, but declining food source in much of the distributional ranges of the marine mammal species described above. However, the reliance on sandeel and subsequent susceptibility to fluctuations in sandeel abundance and distribution differ among marine mammal species, owing to variations in their ecological niches and dietary plasticity. Furthermore, the varying vulnerability of marine mammals to declines in sandeel abundance is a complex and

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[183] Santos, M.B. and Pierce, G.J. The diet of harbour porpoise (*Phocoena phocoena*) in the northeast Atlantic. Oceanography and Marine Biology: an Annual Review, 2003; 41: 355-390.

[184] Santos, M.B. et al. Variability in the diet of harbor porpoises (*Phocoena phocoena*) in Scottish waters 1992–2003. Marine Mammal Science, 2004; 20: 1-27. https://doi.org/10.1111/j.1748-7692.2004.tb01138.x

[185] Pierce, G. et al. Diet of minke whales *Balaenoptera acutorostrata* in Scottish (UK) waters with notes on strandings of this species in Scotland 1992–2002. Journal of the Marine Biological Association of the UK, 2004; 84(6): 1241-1244. https://doi.org/10.1017/S0025315404010732h

[186] Olsen, E. and Holst, J.C. A note on common minke whale (*Balaenoptera acutorostrata*) diets in the Norwegian Sea and the North Sea. Journal of Cetacean Research and Management, 2001; 3(2): 179-184. https://doi.org/10.47536/jcrm.v3i2.888

[187] Windsland, K. et al. Relative abundance and size composition of prey in the common minke whale diet in selected areas of the northeastern Atlantic during 2000-04. Journal of Cetacean Research and Management, 2007; 9(3): 167-178. https://doi.org/10.47536/jcrm.v9i3.665

[188] Santos, M. B. et al. Diets of small cetaceans from the Scottish coast. Copenhagen: ICES, 1994.

[189] Canning, S. et al. Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. Journal of the Marine Biological Association of the United Kingdom, 2008; 88(6): 1159-1166. https://doi.org/10.1017/S0025315408000076

[190] Jansen, O. et al. Are white-beaked dolphins *Lagenorhynchus albirostris* food specialists? Their diet in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom, 2010; 90(8): 1501-1508. https://doi.org/10.1017/S0025315410001190

[191] Santos, M. et al. Stomach contents of bottlenose dolphins (*Tursiops truncatus*) in Scottish waters. Journal of the Marine Biological Association of the United Kingdom, 2001; 81(5): 873-878. https://doi.org/10.1017/S0025315401004714

stochastic interaction between prey distributions, diet, predator and prey demography, and predator foraging distributions and behaviour[192] so predictions are subject to considerable uncertainty.

5.2.22 Sandeel are a high-quality, lipid-rich prey source[193] and improved body condition in marine mammals is linked to the proportion of sandeel in their diet. For example, a correlation was found between harbour porpoises in better body condition and higher amounts of fatty fish in their diet[194]. Links between consumption of sandeel and health status of porpoises also suggested that a decrease in sandeel availability could have negative effects on porpoise populations [193]. The predicted consumption of sandeel is high in porpoise diets, despite an abundance of other available prey species. Further, consumption of sandeel is significantly greater than all other prey types even when abundances are roughly equal[195]. Multi-species functional responses have been published, describing the relationship between harbour porpoise and their prey species in the North Sea. These have indicated that when energy rich prey-species (i.e., sandeel) are scarce, porpoises must increase the total biomass consumed to avoid shortfalls in energy intake [195] and by extension, poor body condition. As a result, minor differences in overall biomass and energetic intake were predicted between 2011 and 2022 (a period of pronounced sandeel decline in abundance across their range). Porpoise may subsequently travel greater distances or shift their ranges in search of a higher biomass of prey or increased densities of other high energy prey, partially explaining the southward distributional shifts of porpoise in the North Sea between 1994 and 2005 when sandeel in the SA4 region also showed pronounced declines[196,197].

5.2.23 Declines in sandeel stocks could have implications on inter-specific competition between marine mammal species in situations where sandeel are the primary food source. If sandeel are scarce, the considerable overlap in diet between grey and harbour seals [192] could result in exploitative competition which could impact one or both species. With harbour seals noted to be in significant decline in certain regions of Scotland, a depletion in sandeel stocks could be a factor in the further decline of harbour seals as indicated by the continuing decline in areas where seals show high preference for sandeel and little plasticity in diet [192]. The compounded

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[192] Wilson, L. J. and Hammond, P.S. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Aquatic Conservation, Marine and Freshwater Ecosystems, 2019; 29(1): 71-85. https://doi.org/10.1002/aqc.3131
[193] MacLeod, C.D. et al. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biology Letters, 2007; 3(2): 185-188. https://doi.org/10.1098/rsbl.2006.0588
[194] Leopold, M. F. Eat and be eaten, Porpoise diet studies. Doctoral Thesis – Wageningen: Wageningen University, 2015. https://edepot.wur.nl/361729
[195] Ransijn, J.M. et al. Integrating disparate datasets to model the functional response of a marine predator: A case study of harbour porpoises in the southern North Sea. Ecology and Evolution, 2021; 11(23): 17458-17470. https://doi.org/10.1002/ece3.8380
[196] Mahfouz, C. et al. Multi-approach analysis to assess diet of harbour porpoises *Phocoena phocoena* in the southern North Sea. Marine Ecology Progress Series, 2017; 563: 249-259. https://doi.org/10.3354/meps11952
[197] Hammond, P. S. et al. Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation, 2013; 164: 107-122. https://doi.org/10.1016/j.biocon.2013.04.010

effects could hasten the decline in certain populations, rendering conservation effort increasingly challenging[198].

5.2.24 Identifying an effect of the sandeel fishery or a reduction in fishing pressure is difficult as it involves complex interactions between multiple drivers of both sandeel and predator dynamics. Further, data on the effects of sandeel abundance on marine mammal population sizes, foraging ecology and distribution are limited, with few studies able to garner sufficient statistical power to identify significant relationships. However, it seems a reasonable assumption that any increase in sandeel abundance that might result from a reduction in fisheries pressure might be beneficial to several populations of marine mammals given their dependence on sandeel as a prey source.

Potential effects on sandeel

5.2.25 Causes of variation in sandeel abundance are numerous and are driven by fishing mortality and (principally) natural mortality, the latter being influenced by factors such as environmental change (temperature effects, regime shifts) and top-down processes (trophic regulation by marine predators). Evidence shows that causes of variation in natural mortality played a more prominent role than fishing mortality in shaping sandeel abundance in Scottish waters and as these causes of variation are rarely accounted for, an effect of fishing pressure on sandeel abundance is rarely observed. However, while results should be considered with caution due to limited data availability, age 1 sandeel seem to have a higher survival rate in the current fishery closure.

5.2.26 While the effect of a fishery closure may be difficult to observe in a changing environment, sandeel are likely to benefit from spatial management measures aimed at reducing fishing mortality due to their life-long attachment to particular sand banks and limited dispersal and movements.

5.2.27 Variations in Spawning Stock Biomass (SSB) are mainly driven by variability in recruitment. Recruitment, to a certain extent, is contingent on the size of the reproductive population (SSB). Environmental change has a multitude of effects (direct and indirect) and can affect SSB through the maturation process; recruitment through the effects on phenology (spawning date, incubation time, hatching date); and trophic mismatch between sandeel hatching and the availability of their copepod prey. The fishery can directly affect SSB through fishing mortality and there is some evidence that it may also indirectly affect recruitment by decreasing SSB (through mortality) or by reducing the abundance of large individuals which have a higher fecundity and may spawn earlier (which in turn may affect trophic mismatch and interact with climate change effects). A fishery closure may therefore promote sandeel resilience to climate change by limiting variation in SSB that might affect recruitment and ensuring that sufficient large, early spawning individuals are present

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[198] Hanson, N. et al. Harbour seal (*Phoca vitulina*) abundance within the Firth of Tay and Eden estuary, Scotland: recent trends and extrapolation to extinction. Aquatic Conservation: Marine and Freshwater Ecosystems, 2017; 27(1): 268-281. https://doi.org/10.1002/aqc.2609

in the population. In accordance, a modelling study found that population collapse was more likely under exploitation[199].

Potential effects on predatory fish

5.2.28 Predatory fish are often generalist feeders, where the diet typically consists of no more than 20% of any species,, as predators switch between prey species based on availability[200,201]. The importance of sandeel as a food source is more variable for predatory fish than for seabirds and mammals. Some fish species such as whiting, haddock, cod, plaice, lesser weever and grey gurnard have shown higher body condition indices or growth in years of high sandeel abundances[202,203]. Body condition relates to growth, survival and reproduction and can thereby affect fitness and abundance of predators.

Potential effects on other fish caught by the sandeel fishery

5.2.29 Whiting and mackerel are caught as bycatches in the sandeel fishery and whiting aggregate at sites of high sandeel abundance[204]. It is expected that any benefits realised to sandeel through the closure of the sandeel fishery may be realised for whiting and mackerel also, although it is expected that these benefits would be to a lesser extent than for sandeel as they are not the target species of this fishery.

Other benefits

5.2.30 Sandeel are a protected feature of the following Marine Protected Areas (MPAs) - Mousa to Boddam MPA, North-west Orkney MPA and Turbot Bank MPA[205]. Several MPAs also aim to conserve sandeel habitat to ensure the continued supply of young recruits to other sandeel grounds across Scotland and the rest of the UK. The increased protection that will result from the closure of the sandeel fishery will benefit these MPAs through assisting the delivery of their conservation objectives.

5.2.31 There are conservation measures in place for several species that rely on sandeel as a source of prey, including Special Areas of conservation (SACs) for grey and harbour seal, Special Protected Areas for seabird species, and MPAs for Black

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199 Poloczanska, E.S. et al. Fishing vs. natural recruitment variation in sandeel as a cause of seabird breeding failure at Shetland: a modelling approach. ICES Journal of Marine Science, 2004; 61(5): 788–797. https://doi.org/10.1016/j.icesjms.2004.03.030

200 Engelhard, G. H. et al. Forage fish, their fisheries, and their predators: who drives whom? ICES Journal of Marine Science, 2014; 71: 90–104. https://doi.org/10.1093/icesjms/fst087

201 Trenkel, V.M. et al. Spatial and temporal predation patterns in the Celtic Sea. Marine Ecology Progress Series, 2005; 299: 257-268. https://doi.org/10.3354/meps299257

202 Engelhard, G.H. et al. Body condition of predatory fishes linked to the availability of sandeels. Marine biology, 2013; 160(2): 299-308. https://doi.org/10.1007/s00227-012-2088-1

203 Rindorf, A, Jensen, H, and Schrum, C. Growth, temperature and density relationships of North Sea cod (Gadus morhua). Canadian Journal of Fisheries and Aquatic Sciences, 2008; 65(3): 456-470. https://doi.org/10.1139/F07-150

204 Temming, A. et al. Predation of whiting and haddock on sandeel: aggregative response, competition and diel periodicity. Journal of Fish Biology, 2004; 64(5): 1351-1372. https://doi.org/10.1111/j.0022-1112.2004.00400.x

205 NatureScot. Sandeel, URL: Sandeel | NatureScot (last accessed: 21/06/23).

guillemot species and minke whale (Figure 34[206]). The increased protection that will result from the closure of the sandeel fishery will help ensure that conditions within these sites are supportive of the conservation site objectives through supporting the availability of prey species.

5.2.32 Overall, the increased protection that will result from the extension of the closure of the sandeel fishery to all Scottish waters will provide potential environmental benefits for the overarching topics of Biodiversity, Flora and Fauna, and Water quality, Resources, and Ecological status (Table 8), and contribute to the achievement of the SEA objectives (Table 9).

5.2.33 The implementation of this management measure may also result in the potential displacement of sandeel fishing activity and its associated pressures outside the boundary of Scottish waters. The closest sandeel fishing waters are in Northeast English waters. The UK government is currently leading their own consultation on the closure of the sandeel fishery in all English waters[207]. If the results of the consultation support closure this would mitigate any displacement effects to English waters. Effects of displacement to the wider North Sea are harder to predict due to the transboundary nature of any displacement.

[206] Scottish Government. Marine Protected Areas (MPAs), URL: https://www.gov.scot/policies/marine-environment/marine-protected-areas (last accessed: 21/06/23).

[207] Department for Environment, Food & Rural Affairs. Consultation on spatial management Consultation on Spatial Management Measures for Industrial Sandeel Fishing - Defra - Citizen Space (last accessed: 21/06/23).

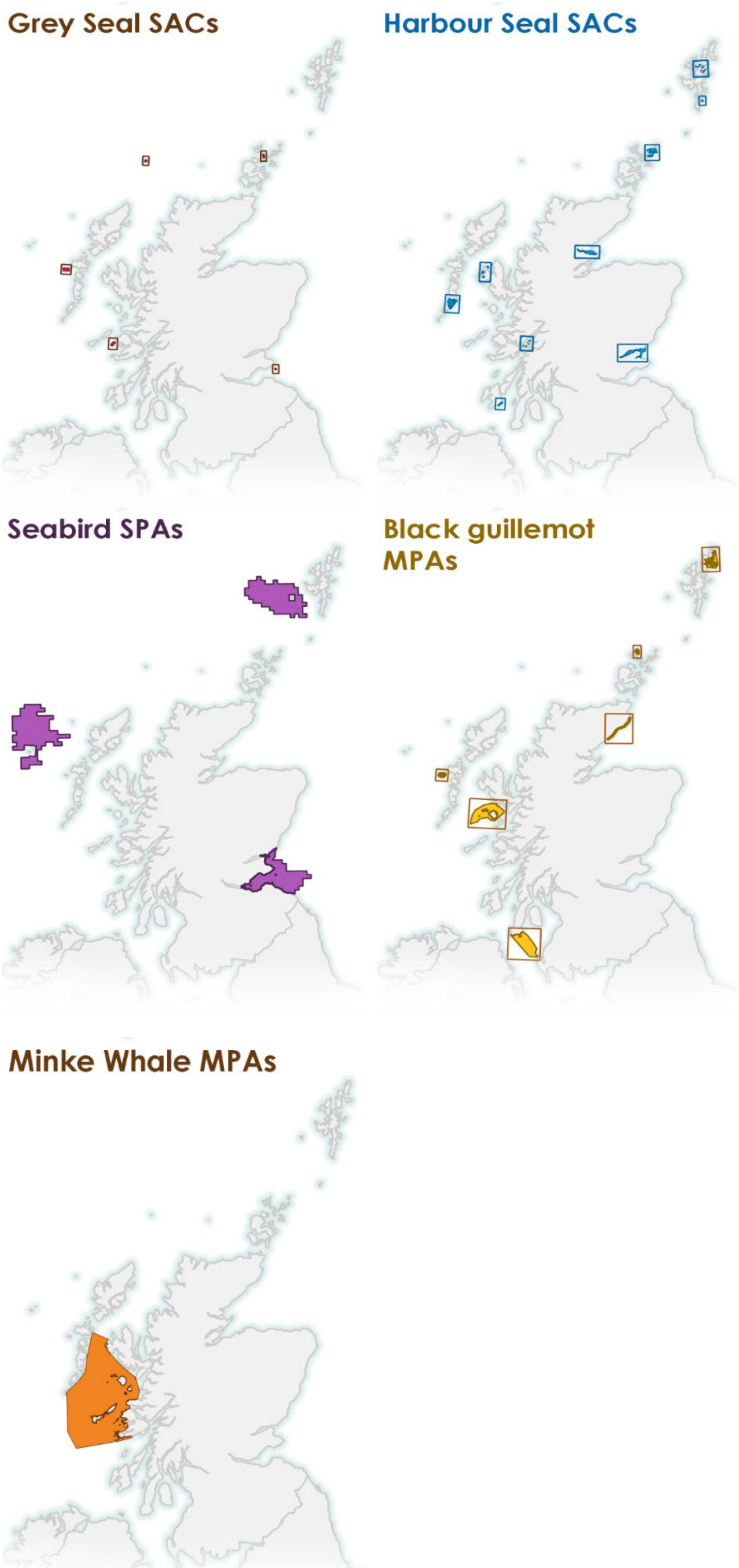

Figure 34: Locations of protected sites where a protected feature relies on sandeel as a prey source.

Table 8: Overall assessment of proposals to close fishing for sandeel in all Scottish waters

SEA Topic	Assessment
Biodiversity, Flora and Fauna	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **moderate beneficial effects** to marine biodiversity. This assessment takes into account the following factors: <u>Medium spatial scale</u> Fishing activity in Scottish waters is currently contained within Sandeel Area 4. Therefore, although the closure area proposed is all Scottish waters, the majority of benefits are expected to be delivered within the region of Sandeel Area 4. Extension to all of Scottish waters prevents the risk of adverse effects being realised via displacement of fishing effort to novel fishing grounds outside of Sandeel Area 4. <u>Long-term</u> The closure is expected to be permanent once in place, although this will be subject to views collected during consultation. Due to stochasticity of fish population dynamics it is expected that any increase in the sandeel population will not be immediate. It is expected therefore that benefits to species that include sandeel as a prey source will not become apparent upon closure but may become apparent several years post-closure. <u>Moderate sensitivity to management measure</u> An increased availability of sandeel may result in benefits to species that include them as a prey source. However, many of these species are sensitive to other pressures that may be a larger driver of their population dynamics than prey availability (see Section 4.2). While an increased prey availability may incur increased resilience to other pressures, the adverse effects of external pressures may outweigh the benefits of increased prey availability achieved through the proposed management measure. While increased prey availability is a likely outcome of the proposed management measure, other factors affecting sandeel population dynamics could outweigh the effects of fishery closure meaning that increased prey availability is not guaranteed.
Water Quality, Resources, and Ecological Status	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **moderate beneficial effects** to marine resources. This assessment takes into account the following factors: <u>Medium spatial scale</u> Fishing activity in Scottish waters is currently contained within Sandeel Area 4. Therefore, although the closure area proposed is all Scottish waters, the majority of benefits are expected to be delivered within the region of Sandeel Area 4. Extension to all of Scottish waters prevents the risk of adverse effects being realised via displacement of fishing effort to novel fishing grounds outside of Sandeel Area 4.

	Long-term The closure is expected to be permanent once in place. Due to stochasticity of fish population dynamics it is expected that benefits to sandeel and other commercially important fish will not become apparent upon closure but may become apparent over several years post-closure. Moderate sensitivity to management measure The closure will likely result in benefits to sandeel and other commercially important fish. However, these species are sensitive to other pressures including climate change which may be a larger driver of population dynamics than fishing pressure (see Section 4.2).

Table 9: Contribution of the proposed measure to SEA objectives.

SEA Objective	Met/not met	Rationale
1. To safeguard and enhance marine and coastal ecosystems, including species, habitats and their interactions	Yes	This measure will safeguard the sandeel population in Scottish waters and could potentially enhance populations of Scottish seabirds, marine mammals and other species of fish.
2. To maintain or work towards achieving ‘Good Environmental Status’ for biodiversity	Yes	This measure will potentially benefit a wide range of marine species including marine mammals, seabirds and fish species through alleviating fishing pressure on a species that forms the base of marine food webs.
3. To maintain or work towards achieving ‘Good Environmental Status’ for relevant commercial fish	Yes	This measure will directly benefit sandeel by alleviating fishing pressure and will potentially benefit other commercially fished species that predate on sandeel.
4. To protect and conserve the ecosystems and biological diversity of UK territorial seas	Yes	This measure will bring potential benefits for the sandeel population and the species which it supports.
5. To deliver sustainable management of fisheries that takes account of the protection of biodiversity and healthy functioning marine ecosystems	Yes	By stopping fishing for sandeel in Scottish waters this measure will alleviate pressure on a species that is a key prey source and is therefore vital to the healthy functioning of marine ecosystems.

5.3 Reasonable alternatives

5.3.1 Further to the potential benefits afforded by the extension of the existing sandeel closure to all Scottish waters described in Section 5.2, a detailed assessment of all the potential additional environmental effects that might arise from the scenarios that have been identified as reasonable alternatives (see Section 3.4) has been undertaken and is included in Appendix A. This has included an assessment of the contribution of each scenario to the achievement of individual SEA objectives.

5.3.2 In addition to the potential environmental benefits that will result from the extension of the existing sandeel fishery closure to all Scottish waters (see Section 5.2), Option 2 (extension of existing closure to all of Area 4; see Table 10) will provide no further positive impact to the area of the proposed closure when compared to the proposed closure of all Scottish waters and may have detrimental effects on the areas outside Sandeel Area 4a due to the potential for displaced fishing activity to these areas.

5.3.3 Option 3 (seasonal closures of all Scottish waters to sandeel fishing; see Table 11) will provide no further positive impacts to the area of the proposed closure, but also no negative impacts. This is because the sandeel closure is a seasonal fishery and so seasonal closures are not expected to have any different effect compared to the proposed all-year closure. A full-year closure is preferable in case fishing patterns change in the future.

5.3.4 Option 4 (Voluntary measure; see Table 12) may provide similar environmental benefits to the area of the proposed closure, however this has been considered to be a complex option that would require ongoing management costs of maintaining the voluntary closure agreement. The benefits provided by alternative 3 may be shorter term than the proposed closure, which provides a more permanent option.

5.3.5 Option 0 (do nothing; see Table 13) does not provide any additional benefits and therefore does not meet the objectives of the proposed closure. Alternative 4 may also result in detrimental effects due to displacement of fishing effort into Scottish waters if the UK Government decides to close their waters to sandeel fishing following the outcome of their consultation which took place earlier this year.

5.4 Mitigation and monitoring

5.4.1 No significant adverse environmental effects have been identified by the SEA and therefore no mitigation measures are proposed as part of the assessment process.

5.4.2 Existing environmental monitoring programmes will continue following the proposed closure of: the sandeel fishery in all Scottish waters:

- The abundance and distributions of marine mammals from, for example, the Small Cetaceans in European Atlantic Waters (SCANS) surveys and information made available through the Special Committee on Seals (SCOS) reports on populations estimates and trends.
- The abundance and distributions of seabirds, for example from the UK Seabird Monitoring Programme monitoring of breeding seabird species at coastal and inland colonies across the UK.
- The abundance of predatory fish species from information on the overall state of fish stocks made available through ICES annually.

5.4.3 It is important to acknowledge the complexity of marine ecosystems and their interactions with other drivers which may affect population status (such as climate change, weather events, offshore developments, disease outbreaks, etc.) which make it impossible in most cases to isolate any one driver of change.

5.5 Cumulative effects

5.5.1 The 2005 Act requires that the cumulative environmental effects of the extension of the current sandeel closure to all Scottish waters are identified and evaluated. As we are consulting on a single measure, there is no scope for cumulative effects of this proposal. The cumulative effects of this measure have been considered in combination with other existing or developing plans, programmes and/or strategies that fall outside the scope of this proposal.

5.5.2 The vision for Scotland's marine environment as set out in the Biodiversity strategy to 2045[208] is for 'clean, healthy, safe, productive and diverse seas; managed to meet the long term needs of nature and people'. The sandeel fishery closure proposed by this consultation supports this aim through potential benefits for marine biodiversity that may arise from the proposed closure.

5.5.3 There are a number of existing programmes and measures in place to protect Scottish seabirds. This includes a suite of SPAs and MPAs in which seabirds are a protected feature (Figure 26). The Scottish Government is developing the Scottish Seabird Conservation Strategy, which will aim to optimise the conservation prospects of seabirds in Scotland through effective management of existing and emerging threats. The Scottish Government has also developed a HPAI in wild birds response plan which sets out the approach that the Scottish Government and its agencies will take to respond to an outbreak of HPAI in wild birds in Scotland. The sandeel fishery closure proposed by this consultation will potentially support the outcomes of these existing and developing programmes through increasing seabird population resilience to the range of pressures that they face via an increased availability of an important prey species.

5.5.4 A number of existing programmes and measures are also in place to protect cetaceans in Scottish waters, including MPAs in which minke whales are a protected feature (Figure 26). It is an offence to deliberately or recklessly disturb any cetacean under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)[209]. The Scottish Government is leading on the development of the UK Dolphin and Porpoise Strategy, which aims to ensure that appropriate management is in place to respond to new and emerging pressures affecting cetaceans in UK waters and, in this way, help to maintain their favourable conservation status. Consultation on the

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[208] The Scottish Government. Biodiversity strategy to 2045: tackling the nature emergency. 27 March 2015, URL: Biodiversity strategy to 2045: tackling the nature emergency - gov.scot (www.gov.scot) (last accessed: 22/06/23).
[209] The Conservation (Natural Habitats, &c.) Regulations 1004, SI 1994 No. 2716. HMSO, 1994. URL: The Conservation (Natural Habitats, &c.) Regulations 1994 (legislation.gov.uk).

strategy concluded in summer 2021[210]. The proposals put forward by this consultation will potentially support the outcomes of these existing and developing programmes through increasing the resilience of cetaceans that consume sandeel to the range of pressures that they face.

5.5.5 A network of SACs are in place to protect both harbour and grey seals (Figure 26). Seals are also granted additional protection from intentional or reckless harassment at 194 designated haul-out sites under the Protection of Seals (Designated Seal Haul-out Sites) (Scotland) Order 2014[211], and are protected from intentional and reckless killing, taking and injury under the Marine (Scotland) Act 2010 Part 6[212]. The Scottish Government has funded research into the drivers of harbour seal decline [213] with the aim of identifying potential drivers of this decline. Potential drivers identified include competition for prey. The proposals put forward by this consultation will potentially support the conservation objectives of SACs by increasing prey availability to seals. Likewise, the proposed closure has the potential to reduce competition between harbour and grey seals by increasing the supply of prey to both species.

5.5.6 Given the importance of sandeel to the wider ecosystem and the subsequent benefit provided by the species in aiding long-term sustainability and resilience of the marine environment, it remains an over-arching and long-held Scottish Government position not to support fishing for sandeel in Scottish waters, which is reflected in Scotland's Future Fisheries Management Strategy. This position was emphasised in June 2021 when the Cabinet Secretary for Rural Affairs and Islands committed in Parliament to considering what management measures could be put in place to better manage the North Sea sandeel fisheries in Scottish waters.

5.5.7 Under the Fisheries Management Strategy 2020 to 2030, the Scottish Government is committed to work with our stakeholders to deliver an ecosystem-based approach to management, including considering additional protections for spawning and juvenile congregation areas and restricting fishing activity or prohibiting fishing for species which are integral components of the marine food web, such as sandeel[214]. The proposals to close fishing for sandeel in all Scottish waters directly support this aim.

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[210] Scottish Government. UK dolphin and porpoise conservation strategy: consultation. 22 March 2023, URL: [The UK Dolphin and Porpoise Conservation Strategy - UK dolphin and porpoise conservation strategy: consultation - gov.scot (www.gov.scot)] (last accessed: 21/06/23).
[211] The Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014, SSI 2014 No. 185. HMSO, 2014. URL: [The Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014 (legislation.gov.uk)].
[212] Marine (Scotland) Act 2010, Part 6. HMSO, 2010. URL: [Marine (Scotland) Act 2010 (legislation.gov.uk)].
[213] Scottish Government. Marine Mammal Scientific Support Research Programme, URL: [Marine Mammal Scientific Support Research Programme - Marine environment - gov.scot (www.gov.scot)] (last accessed: 21/06/23).
[214] Scottish Government. Future fisheries: management strategy – 2020 to 2030. 17 December 2020, URL: [Future fisheries: management strategy - 2020 to 2030 - gov.scot (www.gov.scot)] (last accessed: 20/06/23).

5.5.8 The Scottish Government is committed to a plan-led approach to the development of commercial scale offshore wind. The Sectoral Marine Plan for Offshore Wind Energy[215] (SMP-OWE) was adopted by Scottish Ministers in October 2020 and became the spatial footprint for the ScotWind leasing round, managed by Crown Estate Scotland. More recently, the Scottish Government is progressing the Sectoral Marine Plan for Offshore Wind Innovation and Targeted Oil and Gas (INTOG) decarbonisation alongside the Iterative Review of the SMP-OWE. Together, these planning processes will assess the potential impact of the Plan Options (INTOG) and the now know Option Agreements identified by the ScotWind leasing rounds.

5.5.9 Though effort has been taken in the planning process to avoid impact on key seabird species, the scale of potential development identified through ScotWind, in combination with existing developments, indicates that there are likely to be negative impacts on several seabirds species. Many of those seabirds are described above as potentially benefiting from the proposed closure.

5.5.10 The UK Government published their consultation on spatial management measures of industrial sandeel fishing in March 2023 and are currently analysing the responses to this consultation[216]. If the UK Government decides to close English waters in the North Sea to sandeel fishing following the outcome of their consultation then the combination of any measures in English waters and the proposed sandeel closure in all Scottish waters presented here will result in closure of all UK waters to sandeel fishing, if Ministers are minded to pursue the proposed closure. The combined measures will prevent displacement of fishing activity from Scottish into English waters and vice versa, and are expected to result in complimentary environmental benefits.

5.6 Conclusion

5.6.1 Overall, this assessment considers that the increased protection that will result from the extension of the existing sandeel fishery closure to all Scottish waters will potentially provide environmental benefits for the overarching topics ‘Biodiversity, Flora and Fauna’ and ‘Water quality, Resources, and Ecological Status’, and will contribute to the achievement of the SEA objectives. This is because the proposed extension has the potential to result in environmental benefits for a range of marine species including sandeel, seabirds, marine mammals and predatory fish.

5.6.2 Consideration of reasonable alternatives showed that several scenarios could result in some of the benefits of full closure being realised, but that the proposed full closure was the most likely scenario to bring about long-term benefits across the themes of Flora, Fauna and Biodiversity and Water Quality, Resources, and Ecological Status. Consideration of alternatives also showed that taking no

[215] Scottish Government. Sectoral marine plan for offshore wind energy. 28 October 2020, URL: https://www.gov.scot/publications/sectoral-marine-plan-offshore-wind-energy/ (last accessed: 21/06/23).
[216] Consultation on spatial management measures for industrial sandeel fishing - GOV.UK (www.gov.uk)

action poses a risk of adverse environmental effects through the potential for increased fishing effort in Scottish waters as a result of the closure of English waters.

5.6.3 The proposed extension of the sandeel closure to all Scottish waters will likely bring about synergistic benefits to a range of existing and developing policies and programmes including existing protected areas, Future Fisheries Management, and the developing Scottish Seabird Conservation and Dolphin and Porpoise Strategies.

6. Next Steps

6.1.1 The consultation on the SEA Environmental Report is now open, along with the accompanying Business and Regulatory Impact Assessment. Views and opinions on this are now invited and should be provided by 13 October 2023.

6.1.2 Please respond to the consultation online at: https://consult.gov.scot/marine-scotland/consultation-on-proposals-to-close-fishing

6.1.3 Following the consultation period, the responses received will be analysed, and a Post-Adoption Statement will be prepared. The Post-Adoption Statement will explain how issues raised in the assessments, and associated views in response to the consultation, have been addressed.

6.1.4 If you have any enquires please contact: sandeelconsultation@gov.scot

6.1.5 Or send your inquiry by post to:

Sandeel Fishery Closure Consultation
Scottish Government
Area 1B North
Victoria Quay
Edinburgh
EH6 6QQ

7. Appendix A: Assessment tables for scenarios identified as reasonable alternatives

Table 10: Assessment of Option 2: Extension of existing closure to all of SA4.

SEA Topic	Assessment
Biodiversity, Flora and Fauna	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **moderate beneficial effects** to marine biodiversity within the closure area and **minor/moderate detrimental effects** to marine biodiversity in other areas that support sandeel within Scottish waters. This assessment takes into account the following factors: <u>Medium spatial scale</u> Benefits of this option are expected to be delivered within the region of Sandeel Area 4. Sandeel are distributed broadly in Scottish waters (see Figure 25) although fishing effort is currently concentrated in Sandeel Area 4. If this area were to be closed to fishing, fishing effort may be displaced to novel fishing grounds outside of SA4. Sandeel provide a suitable prey source for marine species in some of these currently unexploited regions, for example regions in the North Sea outside of SA4 where a reduction in sandeel abundance has been linked to harbour seal decline. Displacement of fishing effort into novel regions therefore poses a risk to currently unexploited sandeel populations and their predators. <u>Long-term</u> The closure is expected to be permanent once in place. Due to stochasticity of fish population dynamics it is expected that any increase in the sandeel population will not be immediate. It is expected therefore that benefits to species that include sandeel as a prey source will not become apparent upon closure but may become apparent several years post-closure. <u>Moderate sensitivity to management measure</u> An increased availability of sandeel may result in benefits to species that include them as a prey source. However, many of these species are sensitive to other pressures that may be a larger driver of their population dynamics than prey availability (see Section 4.2). While an increased prey availability may incur increased resilience to other pressures, the adverse effects of external pressures may outweigh the benefits of increased prey availability achieved through the proposed management measure. While increased prey availability is a likely outcome of the proposed management measure, other factors affecting sandeel population dynamics could outweigh the effects of fishery closure meaning that increased prey availability is not guaranteed.
Water Quality, Resources,	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **moderate**

and Ecological Status	**beneficial effects** to marine resources within the closure area and **minor/moderate detrimental effects** to marine resources in other areas that support sandeel within Scottish waters. This assessment takes into account the following factors: Medium spatial scale Benefits of this option are expected to be delivered within the region of Sandeel Area 4. Sandeel are distributed broadly in Scottish waters (see Figure 25) although fishing effort is currently concentrated in Sandeel Area 4. If this area were to be closed to fishing, fishing effort may be displaced to novel fishing grounds outside of SA4 which may result in depletion of sandeel and other commercially important fish stocks that predate upon sandeel in these novel grounds. Long-term The closure is expected to be permanent once in place, although this will be subject to views collected during consultation. Due to stochasticity of fish population dynamics it is expected that benefits to sandeel and other commercially important fish will not become apparent upon closure but may become apparent over several years post-closure. Moderate sensitivity to management measure The closure will likely result in benefits to sandeel and other commercially important fish. However, these species are sensitive to other pressures including climate change which may be a larger driver of population dynamics than fishing pressure (see Section 4.2).

Table 11: Assessment of Option 3: Seasonal closure of all Scottish waters.

SEA Topic	Assessment
Biodiversity, Flora and Fauna	It is assessed that extending the closure of the sandeel fishery will bring about no additional benefits when compared to those described for the proposed management measure (see Table 8). This is because the sandeel fishery is a seasonal fishery that only takes place during the spring and summer, therefore closing it on a seasonal basis will not result in any additional benefits when compared to closing the fishery on a year-round basis. Closing the fishery on a seasonal basis could result in **moderate detrimental effects** should the timing of sandeel availability to the fishery shift to outside the current fishing season, allowing sandeel to still be targeted outside the closure period.
Water Quality, Resources, and Ecological Status	See ‘biodiversity, flora and fauna’

Table 12: Assessment of Option 4: Voluntary closure of all Scottish waters.

SEA Topic	Assessment
Biodiversity, Flora and Fauna	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **minor beneficial effects** to marine biodiversity. This assessment takes into account the following factors: <u>Medium spatial scale</u> Fishing activity in Scottish waters is currently contained within Sandeel Area 4. Therefore, although the closure area proposed is all Scottish waters, the majority of benefits are expected to be delivered within the region of Sandeel Area 4. Extension to all of Scottish waters prevents the risk of adverse effects being realised via displacement of fishing effort to novel fishing grounds outside of Sandeel Area 4. <u>Medium-term</u> Using a voluntary measure to bring about closure of the sandeel fishery would likely rely on agreement of the continuation of this measure during annual negotiations. This means that in comparison to the proposed measure there is not as strong a guarantee of a long-term closure. Due to stochasticity of fish population dynamics it is expected that any increase in the sandeel population will not be immediate. It is expected therefore that benefits to species that include sandeel as a prey source will not become apparent upon closure but may become apparent several years post-closure and may not become apparent if the closure is not implemented in the long-term. <u>Moderate sensitivity to management measure</u> An increased availability of sandeel may result in benefits to species that include them as a prey source. However, many of these species are sensitive to other pressures that may be a larger driver of their population dynamics than prey availability (see Section 4.2). While an increased prey availability may incur increased resilience to other pressures, the adverse effects of external pressures may outweigh the benefits of increased prey availability achieved through the proposed management measure. While increased prey availability is a likely outcome of the proposed management measure, other factors affecting sandeel population dynamics could outweigh the effects of fishery closure meaning that increased prey availability is not guaranteed.
Water Quality, Resources, and Ecological Status	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **minor beneficial effects** to marine resources. This assessment takes into account the following factors: <u>Medium spatial scale</u> Fishing activity in Scottish waters is currently contained within Sandeel Area 4. Therefore, although the closure area proposed is all Scottish waters, the majority of benefits are expected to be

	delivered within the region of Sandeel Area 4. Extension to all of Scottish waters prevents the risk of adverse effects being realised via displacement of fishing effort to novel fishing grounds outside of Sandeel Area 4. Long-term Using a voluntary measure to bring about closure of the sandeel fishery would likely rely on agreement of the continuation of this measure during annual negotiations. This means that in comparison to the proposed measure there is not as strong a guarantee of a long-term closure. Due to stochasticity of fish population dynamics it is expected that benefits to sandeel and other commercially important fish will not become apparent upon closure but may become apparent over several years post-closure and may not become apparent if the closure is not implemented in the long-term. Moderate sensitivity to management measure The closure will likely result in benefits to sandeel and other commercially important fish. However, these species are sensitive to other pressures including climate change which may be a larger driver of population dynamics than fishing pressure (see Section 4.2).

Table 13: Assessment of Option 0: No action taken.

SEA Topic	Assessment
Biodiversity, Flora and Fauna	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **no beneficial effects** to marine biodiversity and has the potential to bring about **moderate/major detrimental effects**. This assessment takes into account the following factors: Medium spatial scale Fishing activity in Scottish waters is currently contained within Sandeel Area 4, which also extends into English waters. The UK government have consulted on closure of their waters to sandeel fishing. If this is agreed following consultation, then not taking measures in Scottish waters risks displacement of fishing effort into the portion of SA4 that is in Scottish waters. Major sensitivity to management measure A decreased availability of sandeel may result in detrimental effects to species that include them as a prey source. Many of these species are sensitive to other pressures that may be a larger driver of their population dynamics than prey availability (see Section 4.2). Decreasing prey availability has the potential to reduce the resilience of marine species to other pressures, and the combined effects may result in a larger risk than any single pressure. While decreased prey availability is a likely outcome of taking no measure, other factors affecting sandeel population dynamics

	could outweigh the effects of fishery closure meaning that a decrease in prey availability could be minor.
Water Quality, Resources, and Ecological Status	It is assessed that extending the closure of the sandeel fishery to all Scottish waters has the potential to bring about **no beneficial effects** to marine resources and has the potential to bring about **moderate detrimental effects**. This assessment takes into account the following factors: Medium spatial scale As above, fishing effort is likely to be displaced into the Scottish portion of Sandeel Area 4 should the UK proceed with closing all English waters to sandeel fishing. Major sensitivity to management measure Displacement of fishing effort into the Scottish portion of Sandeel Area 4 would result in high fishing pressure in this region, which may result in a reduction in sandeel abundance within Scottish waters.

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Any enquiries regarding this publication should be sent to us at

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-83521-126-7 (web only)

Published by The Scottish Government, July 2023

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS1325382 (07/23)