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This article presents a description of the background material, and analyses used by UNEP-GIWA for the assessment of the Russian seas. It gives an overview of the development of fisheries over the last 100 years in the 2 Russian seas, the Barents and the Azov Sea. The major stages of fisheries development in the Barents and in the Azov Seas and the main reasons for their decreasing productivity are discussed. These 2 seas, with very different physical and geographical characteristics, both show similar trends in fish-catch dynamics. The natural fluctuations of marine ecosystems and anthropogenic interference with natural ecosystems functions have led to significant negative impact on ecosystem health and have resulted in a negative change in both the structure and the amounts of catches. The decreasing fish catch in the Russian seas has become a concern for the Russian Federation, and revised policies for the management of the Russian fisheries have been introduced. This policy document *Concept of the Fishery Development in the Russian Federation for the Period up to the Year 2020* is presented and discussed.

INTRODUCTION

Fisheries in the North Atlantic, southeast Atlantic, and eastern central Atlantic reached their maximum production levels one or two decades ago and are now showing a declining trend in total catches (1). The declining catches are consistent with observations that these areas have the highest incidence of overexploited stocks, depleted stocks or slowly recovering stocks that have been depleted by overfishing. Excessive fishing pressure has resulted not only in a loss in total production, but has also had a significant social and economic impact. A recent study suggested that 80 – 90% of the worldwide large marine fish predators have been lost due to exploitation (2, 3). Freshwater and marine habitats are also being destroyed by pollution, infrastructure development, and human settlements. There is therefore, growing public concern regarding the declining condition of the world's aquatic environment as a consequence of the impact of human activities. This concern has resulted in increasing pressure on decision makers to establish new and innovative policies that can be deployed in order to reverse those negative trends.

The management of marine resources is a very complex task, and the scientific knowledge required for a cross-sectorial approach that integrates environmental, socioeconomic, and developmental requirements is often lacking or unavailable to policy makers. The United Nations Environmental Program, UNEP, recognized this deficiency and, to fill the current gap in scientific knowledge of the aquatic ecosystem, initiated the Global International Waters Assessment, (GIWA). A cooperation agreement was established between UNEP-GIWA and the Russian Academy of Science, (RAS), and, with the Murmansk Marine Biology Institute as the leading institution of the project. Overexploitation of aquatic living resources is one of the main concerns of the GIWA. This article presents background material together with a historical assessment of fish resources of the main Russian seas, Barents and Azov Seas, assembled within the GIWA project.

THE BARENTS SEA

The Barents Sea is part of the marginal continental seas of the Arctic Ocean (Fig. 1). The area is 1424 thousand km^2 with an average depth of about 200 m. Although the whole Barents Sea is located above the Polar Circle, it is never completely ice covered. Biological productivity is rather high due to favorable climatic conditions, characterized by a significant warm winter anomaly. Due to the large latitudinal extension of the Barents Sea, the duration of daylight over the entire area differs significantly, and this fact determines the duration of the biological seasons. Atlantic waters entering with the Nord Cap current from the west, form the warmest (4 – 12°C) and the most saline (35 psu) water mass in the southwestern part of the Barents Sea. High levels of bacteria and phyto-zooplankton production characterize this area of the Barents Sea. Proceeding to the north and the east, the impact of the saline and warm Atlantic waters diminishes with a subsequent decrease in species richness. The major feature of the Barents Sea ecosystems is the distinct seasonal variability of the abiotic conditions that affect the life cycle of the organisms. The marine community constitutes only a small number of species, and the impact of the abiotic factors prevails over the biotic ones.

THE AZOV SEA

The Azov Sea is connected with the Black Sea by the narrow Kerch Strait (Fig. 1). The area is 38 000 km^2, and the average depth is 8 m, with a maximum depth of 14 m. In contrast to the Barents Sea, the Azov Sea receives a large amount of fluvial waters (up to 12% from the total amount of the seawater). The ratio of fluvial runoff to sea volume is the largest, when compared to all the seas of the world. Thus, the seasonal variation in the runoff, and its anthropogenic regulation, are the major factors affecting both water salinity and the amount of nutrients in the Azov Sea. The increase in salinity levels, due to the compensatory flow of the more saline waters from the Black Sea, greatly determines the environmental conditions of the Azov Sea. In general, this

Figure 1. Geographic location of the Azov Sea and Barents Sea.

allows the Azov Sea to be termed "a basin of the estuarine type". However, the Azov Sea is a typical marine basin, which is in constant connection to the Atlantic and Mediterranean water masses (4). The major part of the fluvial waters (approximately 94%) enter the Taganrog Gulf with the Don River runoff (63%) and into the southeastern part of the Azov Sea with the Kuban River runoff (31%). Water salinity in the eastern part of the sea is 9 – 10 psu, near the mouth areas it is 2 – 4 psu, and in the south it is about 11 psu.

HISTORICAL DEVELOPMENT OF THE FISHERY IN THE BARENTS AND AZOV SEAS

Barents Sea

In spite of large differences in geography and in major hydrological characteristics, the Barents and the Azov Seas present common features such as the high natural variability of the abiotic conditions that impacts the functioning of the ecosystem. Moreover, the fish fauna of the Barents and the Azov Seas include species belonging to rather different faunistic complexes, whose existence is highly dependent on the environmental conditions. In the Barents Sea, the main commercial fish species inhabit the cold waters of the Arctic and boreal areas while in the Azov Sea they are distributed in the relatively warm waters of the boreal area. The major commercial fish species in the Barents Sea are Atlantic cod, haddock, cat-fishes, red-fishes, Greenland black halibut, Atlantic halibut, plaice, long rough dab, capelin, Atlantic herring, and Polar cod. Catches of these species represent up to 95 – 99% of total catch in the Barents Sea and in the adjacent waters. In the Azov Sea, the catch of the sea species does not exceed 38% of the total catch (5). The majority of the commercial fish species (i.e. sturgeon, sander, carp, bream, vimber) are semi-anadromous and anadromous. In comparison to other areas of the northeast Atlantic, a regular and intensive fishery in the Barents Sea started in a relatively recent period although it existed in the area already in the 15th century (6). Until the end of the 19th century, the fishery was conducted only in the summer-autumnal period in the narrow 25 miles zone of Murman coastal waters and gears used were long-lines, gillnets and hand-lines. The targets of the fishery depended greatly on the direction and strength of the coastal current, which together with the warm Atlantic waters regulates the distribution of the boreal and Arctic fish fauna in the Barents Sea. The fish productivity of the cold Arctic waters seldom exceeds 0.1 tonne (t) km^{-2}, whereas in the moderate warm boreal waters, this index is 30 – 35 times higher (7). Total catch of Atlantic cod in the Murman coastal zone did not exceed 6.9 – 12.8 000 t by the beginning of the 20th century (8), and for the Barents Sea as a whole, catches were around 30 – 50 000 t (9). Cod catches were more than 90% of the total catch with haddock, halibuts, catfishes, plaice, and pollock representing the other main commercial species. From 1927 to 1933, the number of Russian vessels in the Barents Sea increased from 17 to 60, and the amount of fish caught from 33 to 61 000 t (10). After 1933, an increment in catches took place due to the improvement of the fishing technique and exploitation of new fishing grounds of the Barents Sea. In 1936, the catches of the Russian fleet reached 206 000 t and in 1937 – 1938 they amounted to 249 000 – 255 000 t (8), the major part of the catches consisting of cod. During World War II the fishery was episodic and conducted in the local coastal areas only. During the postwar period the catches of the 11 major commercial species (cod, haddock, common red fish, beaked red-fish, Greenland black halibut, Atlantic halibut, northern, common, spotted cat-fishes, plaice, long rough dab) grew rapidly to 1.0 million t and in 1974 the catch reached a record of 1.8 million t for the Barents Sea and adjacent waters (Fig. 2). The most common species was the Arcto- Norwegian population of Atlantic cod (Fig. 3). In the 1950 – 1970s the cod stock in the Barents Sea and in the adjacent waters was on average 2.8 million t and the annual total allowable catch (TAC) was around 780 000 t (11). Subsequently, in 1980 – 1986 due to a combination of

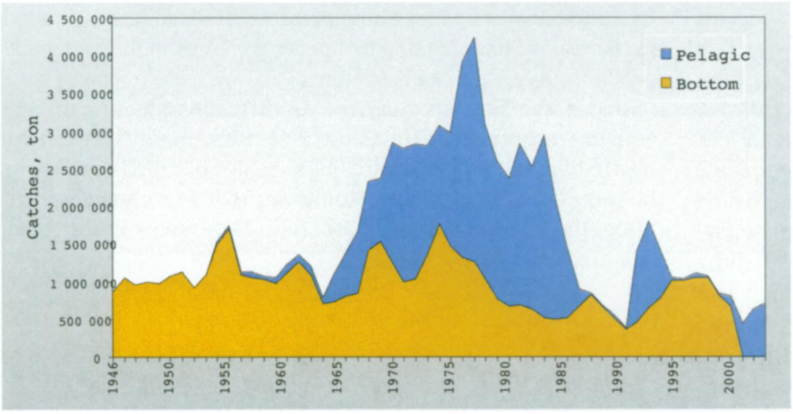

Figure 2. Dynamics of the major commercial bottom and pelagic fish species catches in the Barents Sea and adjacent waters.

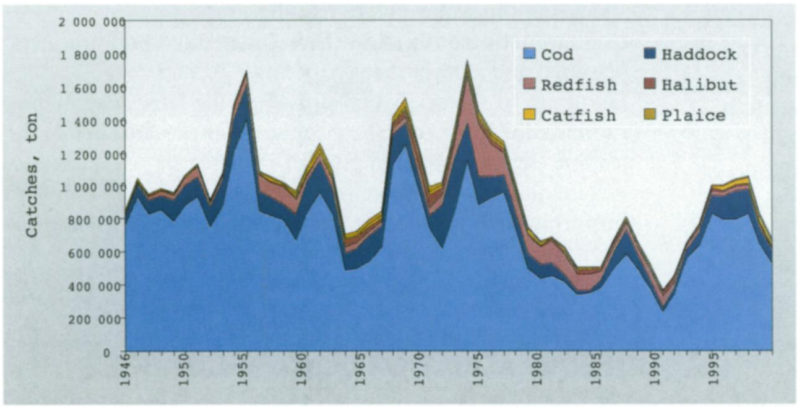

Figure 3. Dynamics of the major commercial bottom fish species catches in the Barents Sea and adjacent waters.

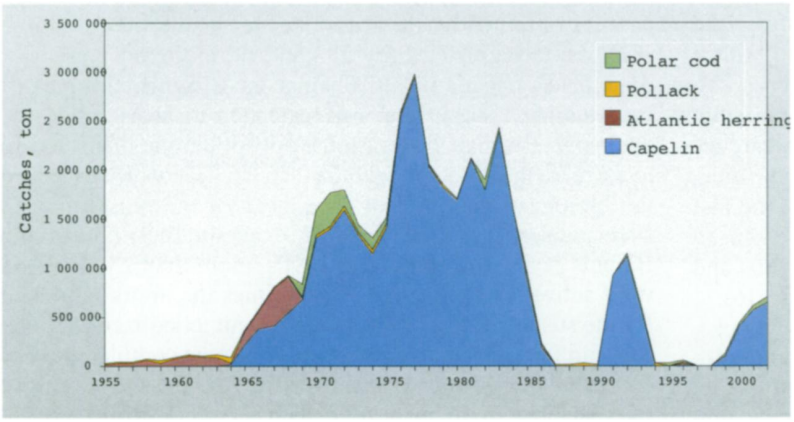

Figure 4. Dynamics of the major commercial pelagic fish species catches in the Barents Sea and adjacent waters.

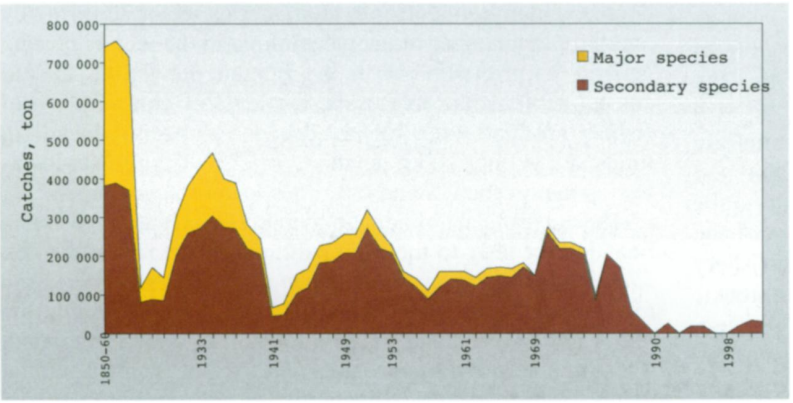

Figure 5. Dynamics of the major and secondary fish species catches in the Azov Sea.

unfavorable climatic conditions and intense overexploitation, the cod stock decreased to 1.0 million t, and TACs were around 370 000 t. At the beginning of the 1990s, several rich year classes of cod appeared, which led to an increase in the stock biomass to 1.9 million t. Thus, TACs in 1994 – 1995 were again increased to 740 000 t (11), although climatic and ecological conditions showed a tendency to a new worsening of the situation. As a result, by the beginning of the 21th century, TACs were again lowered to 414 000 t, although the level of exploitation of the Arcto-Norwegian population of Atlantic cod was still very high. According to ICES estimations, since 1998 stock spawning biomass (SSB) and fishing mortality are outside safe biological limits and these tendencies are nowadays confirmed (12).

An intensive fishery of pelagic fish species (Polar cod, coal-fish, Atlantic herring, capelin) started in the Barents Sea later compared to demersal species, reaching the highest catch of around 3.0 million t in 1977 (Fig. 4). Catches of the pelagic species in the Barents Sea were characterized by a sharp increase and thereafter the level of the stocks diminished significantly, no longer allowing exploitation on the former scale. Maximal catches of Atlantic herring in the Barents Sea were noted between 1965 and 1968 (123 000 – 381 000 t) and for Polar cod in 1969 – 1974 (134 000 – 348 000 t). The period of high capelin catches was more prolonged and lasted from 1970 to 1984 (1147 – 2940 thousand t), but the consequences of this over exploitation were harmful to the persistence of the stock. The fishery was prohibited in 1987 – 1991 and the stock is currently in a poor state.

In the second half of the 1980s, with the moratorium for herring, capelin and Polar cod fishery, the total catches were significantly reduced, constituting less than 0.4 million t in 1990 (Fig. 2). During the last decade of the 20th century, total catches of demersal and pelagic fish species varied between 0.8 – 1.8 million t, in 1991 – 1992 the major part consisted of pelagic species (67.2 and 63.5%, respectively), while in 1993 – 1999 demersal species dominated.

The evolution of the fishing gears impacted significantly on the intensity and effectiveness of the fishery in the Barents Sea. During the early period of the trawl fishery, only steam side-trawlers were used, while since 1931 the fishing fleet began to be replenished with diesel ships (13). Since the beginning of the 1950s large stern trawlers appeared and they were capable of freezing and processing the catch directly on board. However, because of their large processing capacity, this part of the fleet was unable to obtain sufficient catch capacity inside the Barents Sea. Thus, starting from the latter half of the 1970s, they began to fish in distant areas. From the 1990s onwards, the major type of ship was medium tonnage freezing trawlers, and vessels for long-line fishery appeared.

With the accumulation of knowledge on the impact of gear selectivity on the structure and abundance of the fish populations, minimum mesh size allowed in the bottom trawls was changed. From 1946 to 1983 it increased from 90 mm to 125 mm in the Russian economic zone and to 135 mm in the Norwegian zone. Mesh-size changes were directed to decrease the by-catch of young fish, but it did not affect the general level of biomass removal for the major commercial fish species. Technical improvements of the gear and fishing activities led to a large increase in catchability, which is a crucial parameter in the estimation of fish population abundance and the total allowable catch (TAC). However, a rational exploitation of marine biological resources has to take into account not only official catches, but also the amount of discards from the fisheries. In 1993 – 1995, the amount of discards of different commercial species were not included in official statistics, but were estimated to be as high as 5.3 – 12.6% of the total catch (14). This is a conservative estimate since catches from poaching fishery are not taken into consideration. Unfortunately, current TAC, mesh-size regulation, and temporary closure of certain sea areas are the main management measures used for the preservation of threatened fish stocks. However, a drastic reduction in the TAC or a moratorium for those species outside safe biological limits should also be considered in order to avoid irrational exploitation of the fish populations of the Barents Sea.

Azov Sea

The history of fishery in the Azov Sea is longer than that in the Barents Sea, and thus the impact of fisheries on the abundance of the stocks was noticeable much earlier than in the Barents Sea. Already by the mid-19th century the amounts of fish caught reached historical maxima, with a tendency to a significant decrease thereafter (15). Nevertheless, even in the 1830 – 1850s, the annual catch exceeded 300 000 t, or about 8.5 t km^{-2}. Moreover, catches consisted mainly of species with high commercial value, such as sturgeon, sander and vimba (Fig. 5). Over the last 50 years, fish catches from the Azov Sea have decreased steadily, with 150 000 – 220 000 t in the 1960 – 1980s and only 15 000 – 20 000 t at the end of the 20th century (16).

Besides a decrease in total abundance of fish stocks, changes in the structure of the Azov Sea species communities were also observed. Several important commercial fish species decreased significantly, while since the 1950 – 1960s gobid species increased, and from the 1970 – 1980s, Azov anchovy and the common kilka also showed an increasing trend (Fig. 5). Moreover, the relative number of fish species such as sander, carp, bream and vimba in the catches diminished from 86.3% in the 1960s to 15.0% at the beginning of the 21th century (17).

Thus, although the characteristics of the 2 basins are quite different, the development of the fishery and the evolution of the fish communities in the Barents and in the Azov Seas showed a common trend over the whole of the period considered. However, we should recognize that fishery is not the only factor affecting the status of fish stocks. Regulation of the fluvial runoff, chemical contamination, exploration and exploitation of the hydrocarbon fields on the shelf, and the accidental introduction of exotic species, are also important factors that affect the abundance of fish species and the structure of marine communities in the Russian seas. Undoubtedly however, fishing pressure needs to be considered as the major factor leading to a general change in the biological productivity of these ecosystems.

As in the Barents Sea, the significant reduction of the aquatic resources in the Azov Sea was mainly caused by overfishing, although other causes cannot be ruled out. Major factors, other than overexploitation, that are considered to affect the abundance of aquatic living resources in the Azov Sea are listed below (16).

- Lack of access to the spawning grounds for anadromous fish species.
- Changes in the runoff distribution of the Don River which caused the disruption of spawning periods and grounds for several fish species.
- Mass mortality of juveniles of several commercial fish species at the water intake installations.
- Contamination of the Azov Sea waters due to oil products, phenols, and salts of heavy metals.
- Dumping of materials that provoked the loss of spawning grounds for the Azov Sea gobies, an important link in the trophic nets of the Azov Sea.
- Accidental introduction of exotic species which led to important changes in the marine ecosystem with serious economical consequences.

TOWARDS SUSTAINABILITY OF THE RUSSIAN AQUATIC LIVING RESOURCES

The amounts of total fish caught by Russian fishermen between 1990 and 2002 diminished by 52.5% (from 6.93 million t to 3.29 million t). There was a reduction of fish catches obtained by the Russian fleet inside the economic zones of foreign states (by 58.5%) and in the open areas of the world's oceans (by 67.0%). Thus, a significant part of the Russian fishery fleet was relocated to areas inside the exclusive Russian Federation economic zone. This led to an increase in the catch capabilities of the fleet, which exceeded the biological potential of the stocks of the most valuable fish species, i.e. cod, haddock, capelin, herring. In the Barents Sea at the end of the 1990s, more than 250 trawlers were active, exceeding by 2.5 – 3 times the limits estimated for the sustainability of the stocks. Commercialization of the Russian fisheries in the 1990s led to almost complete loss of control by the former USSR over the fishery, and economic interests began to take precedance over a strategy of a sustainable exploitation.

The decrease in the most valuable fish stocks led to a decrease in investments into the fisheries sector, lowering by one-third the number of people working in the sector, causing general impoverishment in the human population and in coastal settlements. In Russia, the level of consumption of fishery products over the past decade has been reduced 1.6 times and is only 10 kg person^{-1} yr^{-1}. This figure is twice as low as that in the US and 6.5 times lower than in Japan.

The current state of aquatic living resources in the Russian Seas led recently to the establishment of the following act: *Concept of the fishery development in the Russian Federation for the period up to the year 2020.* In this document, the major fishery problems in the Russian seas were formulated. These are: lack of the conceptual approach of the management of the fishery sector conducted by the government; lack of the necessary normative and mechanisms for the sustainable

management of the aquatic resources; a weak organization of the coastal fishery and aquaculture; and underdevelopment of adequate market mechanisms including financial and credit opportunities.

The first stage of implementing the Act (2003 – 2005) is to develop a mechanism for the governmental management of fisheries and rules for the commercial quotas distribution. A very important problem to be solved is to carry out a clear division of the power of decision making between the federal and the executive authority of the Russian Federation. The rights for aquatic living resources catch will be given to the coastal states of the Russian Federation on a long-term basis — i.e. not less than 5 years — as a fraction of the total allowable catch, which is based on the official catch obtained over the past 5 years. At the same time, TAC has to be based on sound scientific advice on the state of the stocks and correct and transparent fishery statistics.

Before the beginning of the 1970s, several aquaculture farms conducted successful commercial fishery on the Barents Sea coast. Later, under pressure from centralized economic policies and administrative rigidities, populations in the coastal settlements abandoned fisheries activities on these farms. However, possible and beneficial returns to exploitation of coastal resources in the Russian part of the Barents Sea will probably face difficulties for coastal populations due to a lack of financial resources and competition for the available biological resources with fisheries in distant sea regions. The existence of a coastal fishery zone within the 12 mile limit for territorial waters, is not conducive to effective year round fishery for the most valuable fish and invertebrate species, due to the migration of the major commercial species. Nevertheless, the restoration of a coastal fishery which is practical on the basis of the use of ecologically sound fishing gear is considered as one of the main priorities, in this first stage of the Act.

The second stage of the Act (2006 – 2010) will be devoted to widening Russian participation in international fisheries, i.e. fishery in the oceans and, on a contractual basis, in the economic zones of foreign states. This stage will also include the development of the domestic base for fish processing and establishment of the financial conditions for the restoration of the fish stocks.

The third stage (2011 – 2020) entails that Russian fishery will follow a path of sustainable exploitation. By this stage many of the problems put forward in this paper, concerning the overexploitation of marine biological resources, must be solved. To this end, considerable knowledge on the functioning of the marine ecosystems subject to exploitation needs to be collected and analyzed. Without fundamental knowledge of the marine ecosystems and the ecology of marine species, a correct estimate of the status of the stocks is impossible. This is a fundamental prerequisite for rational planning and exploitation of aquatic living resources, as described in the Russian fisheries act. Another important consequence of the planned reforms must be a large reduction in fleet capacity. Establishing a balance between fishery effort and resources will reduce the risk of overexploitation. This is an important step towards the implementation of a precautionary principle for fisheries (18) accepted by the international community as the basis for the sustainable development and exploitation of marine resources.

Participation in the GIWA project, cooperation with UNEP and GEF, thereby achieved, and participation in the global network of other collaborating institutions involved in the GIWA project have been of great value for the understanding of these complex processes in the Russian seas, and will benefit the development of sustainable exploitation of Russian aquatic resources in the future.

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