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Contemporary Issues of Commercial Invertebrates' Harvesting in the Russian Sector of the Barents Sea

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Abstract

The Russian fishery for invertebrate hydrobionts in the Barents Sea includes the list of a dozen species of crustaceans, mollusks, and echinoderms. This type of fishery is characterized by great diversity in relation to the status of exploited stocks, catch size, and economic efficiency of the fishery. The list of up-to-date problems of this industry is long and includes biological, scientific, commercial, socio-economical, and market issues. Among the main problems of the Russian invertebrate fishery in the Barents Sea, overfishing, underutilization of a number of stocks, and significant emissions from fishing waste are considered. The causes of these problems, possible solutions and the priorities of such a solution are analyzed.

Keywords: Barents Sea, Russian sector, commercial invertebrates, fishery, problems

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1. Introduction

The Russian invertebrate fishery is performed mainly in the Northwestern Pacific (Bering, Okhotsk and Japan Seas, and oceanic waters) exclusive economic zone of Russia (EEZ), where 35 commercial invertebrate species are exploited, while the list for the Northeastern Atlantic EEZ (Barents, White and Baltic Seas) comprises only 13 species. These are two species of large crustaceans introduced from the Pacific region: the red king crab *Paralithodes camtschaticus* and the snow crab *Chionoecetes opilio*. The other crustacean commercial species are the northern prawn *Pandalus borealis* and sculptured (Bering) shrimp (*Sclerocrangon* genus), the mollusks are presented by the Iceland scallop *Chlamys islandica*, whelks (*Buccinum* genus), blue mussel *Mytilus edulis* and clams (*Serripes groenlandicus, Clinocardium ciliatum, Arctica islandica*), echinoderms, by the green sea urchin *Strongylocentrotus droebachiensis* and orange-footed sea cucumber *Cucumaria frondosa*. By now, red king crab, snow crab, northern prawn, Iceland scallop, and green sea urchin are the main objects [1, 2].

In the Russian sector of the Barents Sea, the northern prawn is harvested since 1980s (until 1991, the USSR sector), Iceland scallop, since 1997, red king crab, since 2004, snow crab, since 2014 [3--6]. Other listed invertebrates are caught occasionally, mostly as by-catch. Despite a relatively short history and a small number of the commercial species harvested in this region, the problems characteristic of the Russian invertebrate fishery in the Barents Sea are partly global, partly unique for various reasons.

The study aims to identify the current problems of the Russian invertebrate industry in the Barents Sea and to search for the reasons and possible solutions.

2. Materials

The data of the Russian official fishery statistics provided by Federal Agency for Fishery (Rosrybolovstvo) for the Barents Sea and adjacent waters have been used a primary source [7]. For comparison, the data on the catches of commercial invertebrates in the Northwestern Pacific EEZ of Russia have been analyzed. We also refer to FAO reports [8].

3. Results and Discussion

The problems of the Russian invertebrate fishery in the Barents Sea and adjacent waters are complex due to various reasons. Here we consider a wide range of them based on the particular examples.

The Iceland scallop is an example of a depressed stock. Commercial exploitation of this species in 1998--2001 with an annual catch of about 11 thousand tons led to a long-term depression of the stock and, as a result, to the total termination of the fishing in 2018 (Figure 1). The situation was aggravated by the epizootic of the Iceland scallop, which has manifested itself since the mid-1990s. In 1998--2013, at some areas of accumulation of this mollusk, more than 5% of animals had the signs of an infectious disease that impaired motor activity and inhibited reproductive processes. For this reason, in 1997---2013, from 10 to 45 thousand tons of Iceland scallop perished annually [9]. At present, a decrease in the intensity of the disease has been noted, which, together with a temporary ban on fishing, gives hope for the restoration of Iceland scallop population and biomass.

The stock status of most of the other commercial invertebrates in the Barents Sea is much better. Thus, the commercial stocks of the most valuable crustaceans --- the red king crab and the snow crab --- are used almost fully in regard to the annual total

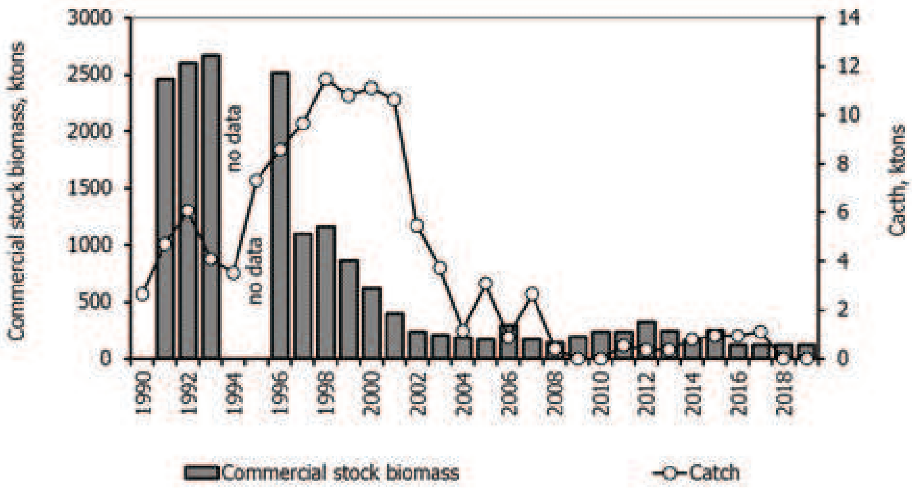

Figure 1: Annual commercial stock biomass index and Russian catch of Iceland scallop in the Barents Sea in 1990---2019, `000 t.

allowable catch (TAC). The biomass of the commercial stock of the red king crab in the Barents Sea has stabilized over the past five years at about 90 thousand tons (Figure 2), which allows receiving about 9 thousand tons of catch annually. However, it is reported that stock trends in red king crab appear to be related to decadal climate shifts, so these parameters must be taken into account when forecasting the TAC.

The catch and processing the red king crab and snow crab on the fish-factory ship is accompanied by a significant biomass waste. Due to the fact that only the limbs of these crustaceans are used, the cephalothorax and internal organs are simply thrown into the sea after processing the catch. About 58% of the total biomass of red king crab and about 39% of the biomass of snow crab are thus wasted [10]. According to our estimates, the average annual loss of the biomass of large crustaceans in the Russian fishery is about 4.2 thousand tons, this waste contains valuable substances such as chitin, proteins, and enzymes. The main markets for Russian products from red king crab and snow crab are the United States and countries of the Southeast Asia (Japan, South Korea, and China). The American market for red king crab in recent years shows an increase in the flow of products from Russia. From January to April 2019, 1.8 thousand tons more of red king crab were exported to the United States than during the same period of 2018. At the same time, about half of this growth was achieved due to red king crab caught in the Barents Sea [11]. Significant demand and high cost of production, as well as good condition of commercial stocks allow considering this object as having high fishing potential.

Unlike large crustaceans of the Barents Sea, the commercial stocks of a number of invertebrates have remained unclaimed for many years (Table 1). Moreover, the reasons

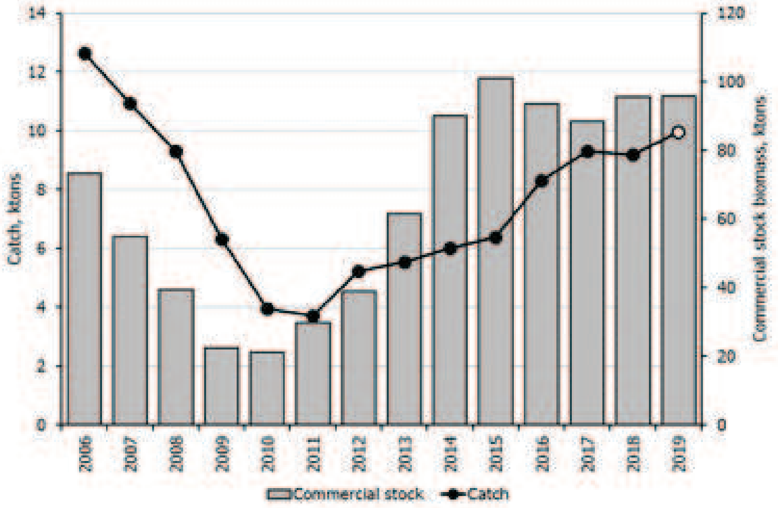

Figure 2: Annual commercial stock biomass index and Russian catch of the red king crab in the Barents Sea in 2006--2019, `000 t (data for 2019 are preliminary catch).

for this under-exploitation are very different. For example, orange-footed sea cucumber is distributed over a wide area of the sea, but does not form dense aggregations; it is usually harvested only as by-catch when performing the dredging fishery of the Iceland scallop [9]. The main reason is the ban of fishing for this echinoderm. The only case of fishing by Russian fishermen in the southeast of the Barents Sea occurred in 2000, when about 150 tons of the orange-footed sea cucumber were harvested (in average, it was about 7 tons per day). Despite Iceland scallop fishing were carried out until 2018, the lack of processing of this species in subsequent years is due to several reasons: this commercial object did not find its consumer in Russia, and the fishermen could not find logistic accessible and profitable foreign markets; vessels harvesting the scallop had neither possibility for additional processing of the echinoderm by-catch, nor production capacities and holding areas for their storage.

The bivalves, horse mussel *Modiolus modiolus* and blue mussel *Mytilus edulis*, inhabiting the sublittoral coastal waters of the southern part of the Barents Sea may potentially contribute about 2,000 tons of total annual catches. Their fishing stocks are in a state close to pristine, they are usually presented as by-catch when performing other species fisheries (bottom trawling and dragging), after sorting the live catches, they are released back to the habitat (personal communication, anonymous fishermen, 2018), although their survival rate after such release is unknown. There is no commercial production performed by Russian fishery in the Barents Sea using these species. According to official Russian fishing statistics, there are no commercial catches of these bivalves.

The reasons for the under-exploitation of these species lie in the fact that they form only small clusters that vary from year to year both in biomass and spatial position. Their

Table 1: Total allowable catch (numerator) and practical catch (denominator) by Russian fishermen in the exclusive economic zone of Russia in the Barents Sea and adjacent waters in 2016--2018, tons.

Species	2016	2017	2018
Red king crab	8,510/8,300	9,940/9,285	9,940/9,187
Snow crab	1,600/1,500	7,840/7,840	9,840/9,728
Northern prawn	25,000/2,460	25,000/3,849	25,000/12,561
Iceland scallop*	2,200/2,024	1,100/952	110/0
Green sea urchin	6,000/0,3	6,000/321	6,000/213
Orange-footed sea cucumber	1,000/0	1,000/0	1,000/0
Horse mussel	1,000/0	1,000/0	1,000/0
Whelk	25/0	25/0	25/0
Blue mussel	was not announced	was not announced	1,950/0
Clams	60/0	60/0	60/0
Bering shrimp	10/0	10/0	10/0

* -- total for the White Sea and the Barents Sea

coastal habitat is greatly affected by adverse hydrological conditions (winter cooling of the waters and the abrasive effects of coastal ice in the inlets and bays). Years, when high local biomass of these mollusks is observed, are followed by the periods of their almost complete absence in the areas where they formed dense clusters [12]. Based on the fact that manual collection by SCUBA diving is most effective harvesting method for mussels in shallow waters, their successful fishing in the southern part of the Barents Sea can only be carried out in a relatively short period of the polar day, which about 70 days from mid-May to early August. In the autumn-winter period characterized by lack/absence of natural light, storms and negative air temperatures, diving is almost impossible here. The low economic efficiency of such seasonal fishing also negatively affects the organization possibilities, since its cost significantly exceeds the possible income from production [13].

Clams may appear an additional source of commercial catches in the Barents Sea; their total stock is not large, and the potential catch may reach about 60 tons annually. These species form relatively low densities, are caught in insignificant quantities when harvested by bottom fishing gear and, as a rule, are released back to sea. As for the mussels, their survival rate after these procedures is unknown.

Whelks is another group of potential commercial invertebrate species in Russian waters of the Barents Sea; these mollusks are the gastropods of genus *Buccinum* and genus *Neptunea*. These mollusks are caught quite actively by Russian fishermen in the Sea of Okhotsk [14]. In 2010---2015, the biomass of the commercial stock here amounted to 35.5--47.7 thousand tons, the catch ranged from 3.4 to 5.5 thousand tons.

In recent years, the annual TAC for the whelks in the Sea of Okhotsk ranged from 6.0 to 6.5 thousand tons and was almost completely fulfilled. Specialized fishing for these mollusks is carried out by the bottom traps. Products from the Far Eastern whelks are marketed both in Russia and overseas (South Korea, China, and Japan). In the Norwegian Sea, whelks are harvested by Norwegian fishermen; here the commercial fishing has officially started in 2005, until 2012, the catch ranged from 20 to 70 tons per year with an increase in recent years to the values of about 350 tons [15]. At the end of the XX century, in the Barents Sea, Russian fishermen occasionally fished the whelks as by-catch in dredges when harvesting Iceland scallop [16] and collected by SCUBA diving [17]. At present, whelk fishing is absent in the Russian waters of the Barents Sea; its specimens are accidentally trapped by bottom fishing gear used for fishing other aquatic organisms and are released back into the sea.

The reasons for the absence of whelk fishing in the Barents Sea are the low density of its accumulations and thus small catches, as well as the low demand for the local market. In the Barents Sea, the potential area for whelk fishing is the sublittoral zone of the southern coast, where the biomass of these mollusks in local clusters may reach up to 100---200 g/m^2. Given the existing favorable, almost pristine state of its fishing stock, the annual Russian catch of whelks here may comprise 100---150 tons [18].

Bering shrimp, one of the large shrimp species with a length of 100---130 mm, also belongs to totally unused fishing objects in the coastal waters of the Barents Sea. Like whelks, this species is caught by Russian fishermen in the Sea of Okhotsk and the Bering Sea both in direct fishery and as by-catch. This species is demanded by the market in these areas, so the annual catch comprises about 130 tons. Bering shrimp is not harvested in the Barents Sea, despite the fact that its TAC here significantly exceeds the levels accepted for the Far Eastern seas of Russia. Formally, in recent years an annual TAC of 10 tons is recommended for the Barents Sea, taking into account the fact that it will be possible to obtain data for subsequent more reasonable adjustment (increase) of this value based on the pilot fishing data [19]. At the same time, it seems that there will be no Bering shrimp harvesting in the Barents Sea in the coming years due to the low concentrations of these crustaceans and the low level of development of fishing gear and processing facilities.

It should be noted that a number of under-exploited fishing objects begin to be harvested in recent years with increasing intensity, green sea urchin and northern prawn may serve as the examples.

After an almost complete absence of the fishing of green sea urchin for many years (with the exception of certain episodes when less than 5 tons were harvested per annum), in 2017---2018, Russian fishermen caught from 185 to 320 tons of this echinoderm species along the coast of the Kola Peninsula. These values are significantly lower than the annual TAC of 6,000 tons. Sea urchin is harvested in the Barents Sea by SCUBA divers whose work is largely limited by the weather conditions. Gonads, for which green sea urchin is harvested, reach the best quality during the winter and early spring [20], coinciding with the period of greatest storm activity. Additional reasons that negatively affect the harvesting of green sea urchin, as well as other under-utilized fishery of aquatic organisms that inhabit the Barents Sea along the Kola Peninsula coast, are the relative transport inaccessibility of many coastal areas, an underdeveloped road network, and a small number of coastal settlements.

The Russian fishery of the northern prawn is increasing in the Russian waters of the Barents Sea in recent years. This species inhabits vast sea areas of the Barents, Greenland, and Norwegian seas, as well as in the adjacent waters of the Arctic Ocean, forming local concentrations of high population density [21]. Northern prawn is harvested by bottom trawls, the fishing is carried out mainly by Russian and Norwegian fishermen throughout its range. The history of its harvest is characterized by significant variability due to the stock biomass fluctuations. After the highest total catches in the first half of the 1980s (up to 128 thousand tons per year), the catch began to decline to a minimum of 38 thousand tons in 1987. By 1990, the catch of northern prawn increased again up to 80,000 tons, the harvesting was predominantly performed by the USSR and Norway. After that, the fishermen of the USSR (hereinafter, Russia), due to domestic economic transformations, reduced significantly their catches, switching to a more economical cod fishery [22]. In 2009---2013, Russia did not fish the northern prawn in the Barents Sea at all. Since 2015, Russian fishermen are again harvesting this crustacean, increasing the catch from 1,100 tons to 12,600 tons in 2018. It is expected that in the coming years the Russian catch of the northern prawn will increase.

The commercial stock of the northern prawn has not been overfished historically; its current good biological state allows potentially catching up to 100 thousand tons without significant risks [23]. The current problems of the northern prawn fishing are (1) the relative uncertainty of its stock, which complicates management [24], (2) the quickly changing spatial distribution of this species, associated with the continued increase in the heat content of the Barents Sea waters [23], as well as (3) high by-catch of juvenile commercial fish (cod, haddock, deep-sea redfish, and Greenland halibut) [23].

The listed problems of the Russian invertebrate fishery are of different severity. Firstly, low fishery activities on the potential objects lead to a decrease in employment and thus lower income from environmental management. The second most important issue is the impact of the fishing on the ecosystem. The existing potential of the Barents Sea ecosystem has to be evaluated in detail to perform sustainable use of the popular and potential objects [25, 26], taking into account the borealization of the fauna due to the recent warming [27]. Interannual variability in the size classes, difficulties in the age definition, complex spatial distribution, expressed seasonality in fishing, and hardly standardized fishing effort are the main issues have to be considered in evaluating the stock of commercial invertebrates especially [28--30]. If this step is missing, negative impacts of fishing are usually associated with overfishing (for example, Iceland scallops) [31], destructive effects of the fishing gear (dredges, bottom trawls) on the bottom ecosystems [32], by-catch of other objects [33], and waste emissions of processing the catch that pollute the sea with dead organic matter [10]. The third most acute group of problems is associated with the underutilization of the catch [34].

4. Conclusion

The complex of existing problems of the Russian invertebrate fishery in the Barents Sea has a number of sources of a biological nature (undermining of stocks, ecosystem effects of fishing, seasonality of fishing stocks), scientific and commercial nature (lack of knowledge about the distribution of animals, their migrations, lack of an accurate estimate of stocks, imperfection of the fishing gear, lack of technologies for processing and transportation of products, including those produced from industrial waste), of a socio-economic nature (relatively low cost of the products versus high cost to fish, poorly developed road network along the coast, a relatively small number of the coastal localities), as well as market-based (an insignificant domestic market for the product or the lack of it, ignorance of the foreign markets). Due to its complexity, the solution to these problems should also be comprehensive with the priority of resolving issues related to the conservation of the particular stock and ecosystems as a whole.

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Conflict of Interest

The authors have no conflict of interest to declare.

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