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Plastic pollution tendencies of the Barents Sea and adjacent waters under the climate change*

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Abstract. The article represents the analysis of the plastic pollution of water areas and coasts of the Barents Sea and adjacent waters based on foreign and Russian studies. The authors consider the influence of various factors, including climate change in the Arctic. The threat to various types of marine activities and the marine ecosystem from plastic pollution is evaluated. The emphasis is on the existing and potential damage to industrial fisheries in the Barents Sea and adjacent waters. An analysis of the regulatory and organizational and economic mechanisms for preventing plastic pollution of the Arctic seas and coasts of the Arctic Council member states and practices of their application is carried out. Particular attention is paid to the control and supervision over litter collection onboard and the efficiency of its disposal after delivery to the land. To improve the legal regulation of handling waste of production and consumption, it is justified to adopt the draft federal law "On secondary material resources"; to create a financial platform for the circular economy in analogy with the European Union and to develop technologies to increase the life cycle and reuse of goods made of plastic. To supplement to the activities of the "State Program Social and Economic Development of the Arctic zone of the Russian Federation" and the state programs for social and economic development of the Arctic, it is proposed to include various types of plastic in the list of hazardous pollutants of water areas and coasts of the Russian Arctic and to build facilities for processing of plastic wastes from fishing enterprises in the Arctic. Also, the regional authorities should encourage volunteering for cleaning coasts of the Barents Sea from garbage, incl. plastic.
Keywords: *The Barents Sea, plastic pollution, climate change, maritime activities, ecological and economic damage, circular economy*.

Introduction

The problem of plastic pollution of the oceans and seas was recognized by the world community and at the international level, in particular, by the UN, even before it had become one of the most important environmental problems of the world. In our opinion, the preseason for that is the fact that UNESCO included the issue marine resource use in the list of global problems, while the handling of plastic waste on land still has the status of a regional or local problem and, less commonly, a national problem.

The first international conventions on the rational use of the marine resources and the protection of waters from pollution were adopted in 1960[1].

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In the1950s-1960s, the industrial production of the most common types of plastic used to produce disposable tableware, packaging, bottles, containers, bags, etc., was not developed (polypropylene, polystyrene) or they had not been created by science (polyethene terephthalate).

It was during these years that the threat of not only the more intensive use of the oceans as a dumping ground for industrial and household waste for the economies of the world, quickly recovering after World War II, but also turning it into a nuclear repository, increased.

It must be admitted that today one of the largest repositories of radioactive waste, chemical weapons and the site of nuclear submarine accidents is the bottom of the most developed sections of the World Ocean. This fully applies to the Barents Sea, its adjacent waters and shores. As we know, in the 20th century, the Soviet Union conducted ground, underground and underwater tests of atomic and hydrogen weapons on the islands of the Novaya Zemlya Archipelago, flooded nuclear reactors of icebreakers and submarines in the Kara Sea. Russia, like the USSR's successor in the "nuclear club", flooded containers with radioactive waste into the sea until 1991. Monitoring containers with radioactive waste and submerged nuclear reactors showed that they are “time bombs” since they are metallic containers stored in a chemically aggressive marine environment for no more than 15 years. Some of them are about 25 years old. However, if they were embedded in lead and plastic, they will be safe for at least 500 years.

Each plastic bottle trapped in seas also represents a “time bomb”, since the useful properties of the plastic are resistance to the effects of many environmental factors (ultraviolet, low and high temperatures, solvents, etc.) i.e., durability. According to experts, plastic products decompose 100 - 500 and sometimes even 1000 years. If the influence of ultraviolet radiation, mechanical and other factors fasten the destruction of plastic, it will turn into a microplastic, even more, destructive for all living beings in the oceans.

Of course, it is difficult to change people's opinion about the power of the ocean, its vastness, its ability to absorb ships and islands, destroy settlements and civilizations that had taken shape over thousands of years, as well as the fear of mankind over the ocean. The idea of the ocean's power was based on the persistent belief that using its waters to bury various wastes would not cause significant harm to the ocean, and it had not yet been eradicated in the minds of individuals and governments engaged in its pollution. E.g., during a sea voyage, an aircraft carrying cruiser, such as the "Admiral Kuznetsov" leaves several hundred thousand plastic bottles and other containers from under fresh water that is legally thrown overboard in those areas of the ocean where the international law allows to do it. It is obvious that a fire on a military vessel should not be allowed, also because of its cluttering up with garbage, and saving the life of a sailor or fisherman is a priority for the maritime activity. However, with reference to this priority, sometimes an elementary and thoughtless economy is concealed, political differences between coastal states

[1] UN Convention “On the Open Sea”, April 29, 1958, International Convention for the Safety of Life at Sea (SOLAS). 1960.

and an archaic idea of the unlimited resources of the ocean, incl. for the disposal of waste, garbage, etc.

Of course, plastic pollution of the ocean by two dozen aircraft carriers can, figuratively speaking, be called "a drop in the sea". But it should be noted that today the geopolitical situation in the world and in the Arctic becomes similar to the “cold war” years: the countries of the Arctic Union form the Arctic troops and create the infrastructure for their arrangement, modernize weapons in the “polar version” ice-class ships, airfields, etc. Political scientists are discussing the possibility of a new round of nuclear threats and, as a result, an increase in the radioactive contamination of the Arctic. In other words, the anthropogenic load on the ecosystem of the Barents Sea from strengthening the military and defense complexes of the Arctic Union increases markedly.

It should be noted that in recent years, the peaceful development of marine economic activities in the Barents Sea has been significantly developed. First of all, this is the development of the merchant fleet, which uses the ice-free port of Murmansk to transport, e.g., Kuzbass coal, minerals and other goods. A further increase in the volume of cargo transshipment in the port of Murmansk is planned, transshipment terminals and the corresponding land transport system are planned and partly built. Murmansk has a base of atomic icebreakers, used to escort vessels, incl. foreign ones, along the Northern Sea Route to the eastern areas of the Russian Arctic, where several ports are modernized and built, and then to the Bering Strait.

Despite the complex of organizational, economic, technical and political problems of the fishing industry of the North during the entire period of market economy transformation, its fishing fleet remained. It lost more than third ships compared to the Soviet period. Today it consists of 197 sea fishing vessels and 60 small size vessels of coastal fishing. As of January 1, 2018, 166 organizations were engaged in sea fishing. In the Murmansk Oblast — 33[2].

A noticeable recovery in the Russian Arctic was received by sea tourism. This was largely due to the visa-free regime of visiting the town of Murmansk by ocean liners and the establishment of the Russian Arctic National Park — a unique tourist site. Also, we observed a rapid growth of recreational marine fisheries. Its center in the Murmansk Oblast is the settlement of Teriberka. An increase in the scale of recreational fishing of the Atlantic salmon carried out by foreign tourists on the Kola Peninsula rivers was also visible.

The objectives of our study are to determine the contribution of each type of marine activity to plastic pollution of the Barents Sea, adjacent waters and coasts. In addition, one of the goals of our work is to determine, at least as a first approximation, the magnitude of the damage from the current level of plastic pollution for various types of marine activities.

Most of the plastic that pollutes the seas and oceans get there from land, where it is produced and used. The main routes of plastic pollution are rivers and bays flowing into the sea, as

[2] Ministerstvo ekonomicheskogo razvitiya Murmanskoy oblasti. Buklet. Rybopromyshlennyy kompleks Murman-skoy oblasti. 2016 g. [Ministry of Economic Development of the Murmansk Oblast. Booklet. Fishing complex of the Murmansk Oblast. 2016]. [In Russian]

well as the flow of plastic debris from the coastlines. Then ocean currents and winds carry plastic trash around the waters of the seas and oceans, or again “throw” it onto the coast. The rivers of the Arctic Ocean seas basins have significant differences from the rivers that flow into the southern seas. First of all, their shores are much less populated and often a large part of the catchment area of the northern rivers falls on completely deserted territories. Therefore, the statement that the northern rivers are the main source of plastic pollution of the Barents Sea needs further confirmation.

However, it does not require any proof of the fact that the largest settlements on the Arctic Circle are located on the coast of the Barents Sea and the nearby part of the Norwegian Sea. In Russia, it is Murmansk, Severomorsk and Polyarny; in Norway — Vadso, Kirkenes, Vardo and Hammerfest. Like all coastal cities and towns, the polar ones also have problems with sewage treatment. Some of them are still being dumped into the nearby bays either directly into the sea without any cleaning or only after mechanical cleaning, during which only large and heavy fractions of garbage are trapped. Utilization of large objects accumulated on the grids of the treatment facilities cause problems for water utilities in the northern settlements: no shot-locks, debris that is not subject to fragmentation has no place to be taken or it is not profitable to do, etc. In small settlements on the coast of the Barents Sea, landfills for waste that meet environmental requirements have never been created. Landfills are found almost everywhere, incl. unauthorized ones. Even if landfills are far from the coast, the strong winds of the Barents Sea and streams of melt water spread the garbage and a part of it falls into the sea.

One of the directions of the recent Russian state environmental policy is the problem of handling production and consumption waste, incl. the Arctic territories of the Federation. The latest regulatory act of the government was adopted in January 2018 — “Strategy for the Development of Industry in the Treatment and Disposal of Production and Consumption Wastes until 2030”[3].

To identify the trends of plastic pollution in water areas and the coast of the Barents Sea and adjacent waters, it is logical to rely on the forecast for the development of production of plastics and its use in the world and in our country.

Only 155 years have passed since the invention and first commercial use of plastics by Alexander Parks. During this relatively short period for the history of mankind, plastics have spread throughout the world and have been used in every field of human activity. It took about the same amount of years for aluminum to become the main construction material. Currently, plastic is also the main structural material, and according to some forecasts, plastics may be ahead aluminum in the near future.

[3] Rasporyazheniye Pravitel'stva RF ot 25 yanvarya 2018 goda № 84-r “Ob utverzhdenii Strategii razvitiya promyshlennosti po obrabotke, utilizatsii i obezvrezhivaniyu otkhodov proizvodstva i potrebleniya”. [Order of the Government of the Russian Federation of January 25, 2018 No. 84-p “On Approval of the Industry Development Strategy for the Treatment and Disposal of Production and Consumption Wastes”]. URL: http://government.ru/docs/31184/ (Accessed: 01 September 2018). [In Russian]

Today plastics are used in mechanical engineering, in all sectors of transport, in construction, in electrical and radio engineering, in agriculture, in medicine and in everyday life. Modern tools for the extraction of aquatic organisms, unlike those used in fisheries half a century ago, are usually composed of plastic and metal. And the cheapest types of plastic are used for packaging, dishes, clothing and cosmetics, i.e. for the production of goods used once or relatively quickly turn into waste.

Several hundred types of plastics have been created, and their invention continues. Since the mid-1990s, attempts to create a bioplastic are going on, e.g., from starch, vegetable fats, sugarcane and other types of reproducible raw materials. They can decompose from polymers to monomers under the influence of various microorganisms or only sunlight. Several types of bioplastic have already been obtained, but its mass production has high cost-effectiveness and is opposed by oil, gas and coal companies that produce raw materials for the traditional plastics production.

It should also be noted that a possible transition to the use of bioplastics will not affect those industries where plastics are replacing metal today, or where plastic has more properties than natural materials, e.g., in the production of modern fishing gear (networks, traps, trawls, longlines, etc.). However, their mass use will allow reducing the volume of plastic garbage from households, tourism industry and from everywhere where one-time packaging or dishes are used.

In 2015, the volume of polymers consumption in the world exceeded 235 million tons. Polyethene accounts for the largest share of consumption (about 38%), polypropylene takes the second place (about 26%), polyvinyl chloride takes the third place (about 18%)[4]. By 2030, the world may expect a further increase of the specific consumption of polymer products per capita. It will lead to an increase in consumption to $ 140 per person instead of $ 61 per person in 2013.

In terms of production and consumption key indicators for chemical products, Russia lags significantly behind world leaders (Japan, Germany, France, Italy, Great Britain, etc.) and even from the People's Republic of China, which is not among the world leaders. Home consumption of the chemical products in Russia dependents on imports, whose share in 2014 was 40%. The same year was marked by the adoption of the “Strategy for the Development of the Chemical and Petrochemical Complex of the Russian Federation for the Period up to 2030”, which includes 2 development scenarios: with and without state support[5]. If the state does not have the means to support the industry, the growth in consumption of plastic products will still be observed. It will reach 79.4 kg/person by 2030 compared with 30.2 kg/person in 2012. However, it will be signifi-

[4] Rynok krupnotonnazhnykh polimerov. Chast' II. [Market of large-capacity polymers. Part II]URL: https://dcenter.hse.ru/data/2017/01/31/1114339135/(Accessed: 01 September 2018). [In Russian]

[5] Prikaz Ministerstva promyshlennosti i torgovli RF ot 8 aprelya 2014 goda № 651/172 “Ob utverzhdenii Stra-tegii razvitiya khimicheskogo i neftekhimicheskogo kompleksa na period do 2030 goda” (s izmeneniyami na 14 yan-varya 2016 goda). [Order of the Ministry of Industry and Trade of the Russian Federation of April 8, 2014 No. 651/172 On approval of the Strategy for the development of the chemical and petrochemical complex for the period up to 2030” (as amended on January 14, 2016)]. URL: http://docs.cntd.ru/document/420245722 (Accessed: 01 September 2018). [In Russian]

cantly lower than the predicted level of plastic products consumption in the world (140 kg/person in 2030). With the state support of the industry and favorable macroeconomic factors (high oil prices, etc.), the average per capita for consumption of plastic products in Russia will rise to the level of developed countries by 2030. The highest rates of consumption growth will be observed in construction, primarily road construction, in housing and utilities, in the automotive and food industries. According to the developers of the Strategy, “plastic products will smoothly push out paper and foil from food packaging”. The outpacing rates of growth in the production of polymers will reduce the share of their imports in home consumption to 5–10%.

As we know, all types of modern traditional plastics are created from non-reproducible natural resources — oil, coal and gas, and they are also used as necessary additives in the production of bioplastics. A purely theoretical relationship has been proven between the production of hydrocarbons and plastics in the country: the greater the resources and hydrocarbons production, the greater the opportunities for the development of home polymers production. On the other hand, it is possible to import plastic from other countries using the income from the sale of hydrocarbons.

But we would like to draw attention to the problem of hydrocarbon pollution of the seas of the Arctic Ocean and the object of our study — the Barents Sea. This problem is urgent today, as it was evidenced by the ongoing protests of international public environmental organizations (Bellona and Greenpeace) and their Russian divisions against the development of hydrocarbon deposits in the Arctic and, above all, in its Russian part.

The explored reserves on the Arctic shelf make up 25% of the world reserves of hydrocarbons materials or a quarter of Russian oil reserves and half of the gas reserves. The potential reserves in the Barents Sea and Kara Sea (more than 80% of oil and gas) are estimated at 140–180 billion tons of conditional fuel. The Barents Sea accounts for 49% of the total reserves at the Artic shelf.[6] The strategy for the development of hydrocarbon deposits in the Arctic is well known. It is the basis of the State program for its social and economic recovery. But not only Russia implements such a strategy. In 2016, Norway began operating the "Goliath", an oil field in the Norwegian sector of the Barents Sea, 88 km North-West of Hammerfest. After the Russian-Norwegian Treaty on the Delimitation of Maritime Spaces and Cooperation in the Barents Sea and the Arctic Ocean in 2010, oil companies stepped up their exploration of hydrocarbon resources in the Norwegian sector.

In other words, today we are facing a real threat of damage to the Barents Sea eco-system from pollution by hydrocarbons, which are comparable in force to and even exceeds the threat of radioactive contamination.

Not only the public environmental organizations, but also many environmental scientists have no doubt that as the investment projects of Russia and Norway are implemented to develop

[6] Osadchiy A. Neft' i gaz rossiyskogo shel'fa: otsenki i prognozy [Oil and gas of the Russian shelf: estimates and forecasts]. URL: https://www.nkj.ru/archive/articles/6334/ (Accessed: 01 September 2018). [In Russian]

new fields, build large-scale offshore facilities and terminals on artificial islands for transporting oil and gas, the threat of pollution will only increase.

Mining companies fear that in case of accidents, leaks, collisions of platforms with icebergs, they will pay heavy fines and incur serious losses. In this regard, all technologies of extraction and transportation of hydrocarbons in high latitudes, as well as methods of preventing environmental damage, are constantly and actively improved, and huge financial resources are allocated for this. E.g., in recent years, special attention has been paid to the study of the impact of the Arctic climate change on the oil and gas industries on the shelf of the Arctic Ocean and on the safety of transportation of hydrocarbons in the Arctic seas.

In our opinion, the study of the plastic contamination degree of the Barents Sea and its adjacent waters is the first and necessary step for a further comprehensive study of the factors that contribute to it and technical and technological methods of its prevention and elimination.

Methods and results of assessing the plastic contamination level by in the Barents Sea and the damage it causes to ecosystem and major marine activities

The first international agreement on the prevention of pollution from seas and oceans with plastic from ships — MARPOL 73/83 — was adopted under the auspices of the International Maritime Organization (IMO) in 1978 as an annex to the International Convention for the Prevention of Pollution from Ships by Oil of 1973. Today, every Russian ship must strictly comply with the rules of MARPOL 73/83, since our country is a member of IMO and ratified this convention in 1983. There is no doubt that the IMO would accept the application to the international convention on plastics MARPOL 73/83. But, as in the case of oil pollution, it reflects the economic problems of ocean resources.

Also, in the 1970s — 1980s, there was a rapid growth of scientific attention to oceanology around the world. E.g., Alfred Wegener's research institute for polar and marine studies (Germany) was established in 1978. Also, during this period, the material and technical base of marine research increased noticeably. In 1978, the first satellite was launched to solve the problems of oceanographic research centers.

All maritime powers actively developed the network of their national marine fishery research institutes. The network of basin applied research institutes exists in Russia today. It has 13 organizations of the fishery industry, and it was also most actively formed in 1970–1980.

Today, it is believed that Charles Moore, who was a participant of the Trans-Pacific Yachting Race in 1997, accidentally “discovered” a large Pacific garbage cans, drew the attention of the public of the world to the ecological side of the plastic pollution of the seas and oceans. Of course, it is difficult to believe that in the age of space flights, these big “trash spots” were not known before Charles Moore. But he earned the worldwide discovery of it only because he gave 20 years of his life for investigating plastic pollution in the Pacific; created the Algalita Foundation, whose mission is to deal with plastic pollution through training and equipping everyone who wants to save

the ocean[7]. In our opinion, Charles Moore is a living moral example for contemporaries, since the education of people with such a responsible attitude to nature is the goal of an expensive system of environmental education today.

Currently, many intergovernmental and governmental organizations have been created to deal with plastic pollution of water and land, as well as funds that finance various public associations: from environmental to youth (German Heinrich Böll or Ellen MacArthur foundations and others).

One of the most well-known intergovernmental organizations in the world, the OSPAR Commission, established by the Convention on the Protection of the Marine Environment of the North-East Atlantic in 1992. It brings together 16 countries, incl. 5 countries of the Arctic Council, except Russia, Canada and the USA[8]. The OSPAR Commission attracts local people to data collection on pollution of sea coasts by filling in a specially designed questionnaire that lists all possible types of garbage, incl. plastic. A completed application form must be sent to a specific address. Recently, some other organizations, incl. Russian ones have begun to use this method for obtaining data on coastal pollution.

Surveys of coastal residents, fishermen, tourists or volunteers, and garbage collection in sea waters and on the coasts are an empirical method of observation, which is mainly practiced by various scientific institutions. Scientific institutions, of course, go further and apply methods of description and comparison. Also, the methods of observation as the development of special devices and other technical means are becoming more complex, and the analysis of their results can be done only by scientists or specially trained people.

The predominant use of observation, description and comparison is due to the huge gap in information about the volume and composition of plastic garbage in the oceans, their parts and seas. It should also be noted that to obtain data on the amount of plastic contamination, its migration routes and the impact on ocean biodiversity, it is impossible to apply the experimental methods due to the impossibility of isolating the studied object from the influence of adverse circumstances and external factors. E.g., the experiment of a German scientist Georg von Neumayer's on throwing bottles overboard into the sea to explore global ocean currents and open more efficient shipping routes is perceived a joke. The experiment of the German Maritime Observatory began in 1876 and lasted 69 years. Over the years, several thousand bottles thrown overboard, less than

[7] Algalita is a nonprofit organization committed to solving the plastic pollution crisis in our oceans through research and education. URL: http://www.algalita.org/ (Accessed: 01 September 2018).

[8] Pros'ba Komissii OSPAR o predostavlenii statusa nablyudatelya v sootvetstvii s punktom 1(d) pravila 82 Pravil protsedury Assamblei. [Request by the OSPAR Commission for observer status in accordance with Rule 82, paragraph 1 (d) of the Rules of Procedure for the Assembly] URL: https://www.isa.org.jm/sites/default/files/files/documents/isba-16a-inf2_1_1.pdf (Accessed: 01 September 2018). [In Russian]

one thousand were caught and returned to the address found in the note. The last bottle was caught in 2018. It was in the water 134 years[9].

Thus, now, the joint efforts of scientific institutions, environmental organizations and ocean protection enthusiasts are going on to accumulate knowledge in three main areas:

- determination of the contamination degree of various types of plastic and microplastic of specific parts of the ocean and its coasts;
- determining the impact of plastic pollution on ocean biodiversity, its inhabitants, and ecosystems;
- determination of economic damage to various types of marine activities.

In addition, today, almost all studies of ocean pollution are related to the determination of the global climate change impact. Many scientific research institutes are moving from the studies of the effects and consequences of climate change to complex studies.

In our opinion, researching ocean pollution with plastic won't take a long time that humanity needed to discover, map, and get a general idea of the World Ocean geography and its main characteristics. First, the UN's firm determination, which was again demonstrated at the World Summit on the World Ocean (Bali, February 2017) and the Ocean Conference (New York, June 2017), will contribute to the achievement of the goal of sustainable development No 14 "Conservation and rational use of the oceans, seas and marine resources in the interests of sustainable development" and the measures taken to find and to solve the problem of preventing the plastic pollution of the World Ocean and its recovery[10,11].

Secondly, the important factors for obtaining results are the sharply increased scientific and technical level of the equipment of scientific research and marine scientific expeditions and the degree of safety of navigation.

These factors are of particular importance for studies of the Arctic Ocean, which, although it is the smallest and shallow among the oceans of the Earth and surrounded on all sides by the continents but surpasses all other oceans with the severity of climate and the dangers of polar ice and water (below 5 degrees of heat), icebergs, tidal currents and even such a representative fauna as a polar bear. Therefore, the entire history of geographical discoveries in the NLO, scientific research and development of the islands and its coasts is undoubtedly recognized as heroic, since it was created on the verge of human capabilities and often due to the lives of pioneers and travelers.

Despite the fact that the safety of navigation in the Barents Sea and in adjacent waters has increased significantly, there are other factors that impede scientific research. Among them, first

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[9] Drevneysheye poslaniye v butylke pribilo k beregu. [The oldest message in the bottle washed ashore].URL: https://weekend.rambler.ru/items/39304233/?utm_content=rweekend&utm_medium=read_more&utm_source=copylink (Accessed: 01 September 2018). [In Russian]

[10] OON namerena borot'sya s plastikovymi otkhodami v Mirovom okeane. [UN intends to fight with plastic waste in the oceans]. URL: https://news.un.org/ru/story/2017/06/1305751 (Accessed: 01 September 2018). [In Russian]

[11] Nashi okeany — nashe budushcheye: partnerstvo v interesakh dostizheniya tseli 14 v oblasti ustoychivogo razvitiya. [Our oceans are our future: partnership to achieve sustainable development goal 14] URL: http://www.un.org/ru/conf/ocean/index.shtml (Accessed: 01 September 2018). [In Russian]

of all, one should point out the remaining bans for their implementation for political reasons, including the need to ensure the military security of coastal states.

A review of research into the problem of plastic pollution of the Barents Sea and adjacent waters showed that, as of today, the greatest contribution to its solution belongs to scientists of the Alfred Wegener Institute (Germany). Its research vessels conduct expeditionary research in all oceans, and the accumulated information has already enabled them to create LITTERBASE — a database of ocean pollution and its map[12].

In the Barents Sea, the Institute had only 14 expeditions out of the total number (1,249), the LITTERBASE data does not reflect the situation with plastic pollution in this area. However, research methods used at the Alfred Wegener Institute are the most developed and widely borrowed by other scientific institutes, universities, and even environmental organizations [1, Geyer R., Jambeck J.R. et al.].

Marine debris is distributed to the most common types (wood, glass/ceramics, metal, plastic, etc.), and plastic garbage is separately divided into its types: plastic fibre, plastic film, plastic in granules, foam polystyrene, etc. Catch and garbage collection is carried out, as far as possible, on the surface of the sea, at a depth (in the water column), at the bottom and on the coasts.

Data analysis allows us to draw the following conclusions: plastic absolutely dominates in all studied environments of the sea. Its share varies from 47% at the bottom and up to 77% at the surface (Table 1). The largest proportion is accounted for plastic used for fishing (nets, longlines, trawls, fish crates, product packaging, buoys, etc.). It should be noted that these types of large plastic are mainly found not on the surface, but in the water column or on the bottom (see Table 1).

Table 1

*Shares of various waste (>= 5mm) in its total composition, in the water column, on the bottom, on the surface and on the beaches, %**

Type of sea waste	Global composition of marine, %	Litter types in the water column, %	Litter types on the seafloor, %	Litter types at the sea surface, %	Beached litter types, %
Biotic	1.3				
Fisheries (metal)	1.3				
Fish stocks	3.1		10.74		
Glass ceramics	3.2	5.63			4.02
Metal	3.71	9.59	8.77		
Different types	4.8			6.58	5.71
Paper/cardboard	1.7				
Rope	1.5		3.7		
Textiles/fabrics	1.2				
Wood	2.3			3.57	
Cigarette packs	2.9				
Plastic, total	**59.74**	**51.75**	**47.06**	**76.87**	**57.67**
Incl.: fishing (plastic)	8.03	22.93	11.97	3.21	8.29

[12] Online Portal for Marine Litter. URL: http://litterbase.awi.de/ (Accessed: 01 September 2018).

Plastic fiber	7.05				
Polyethylene film	8.4				
Plastic granules	1.3				
Styrofoam	4.6			3.0	7.05
Other	4.0				

Source: LITTERBASE. URL: http://litterbase.awi.de/ (Accessed: 01 September 2018).
* An empty cell means that the proportion of this garbage type is extremely small in this column.

Particles with a size 0.5-5 mm are micro-waste (even smaller particles are called nano-waste). The ranking of micro-waste types largely coincides with the findings of large debris (more than 5 mm): microplastic predominates, except for beaches (Table 2). The prevailing types of microplastics: plastic fibre occupy the first place (everywhere except beaches), followed by plastic granules and foam plastic. It should be noted that scientists still do not have complete clarity on how plastic turns into microplastic and how it migrates over the ocean. Also, many of its types have not yet been identified or their content in water has not been determined [2, Lusher A.M.].

Table 2

*Shares of various micro-waste (>= 5mm) in its total composition, in the water column, on the bottom, on the surface and on the beaches, %**

Types of micro-waste	***Litter types in the water column, %***	***Litter types on the seafloor, %***	***Litter types at the sea surface, %***	***Beached litter types,%***
Different types	15.63			0.51
Plastic fiber	14.21	19.91	10.01	27.05
Polyethylene film		2.42	0.82	0.47
Plastic granules	1.93	2.5	2.43	38.12
Plastic total	**77.8**	**72.89**	**82.03**	**28.25**
Fishing (plastic)				0.39
Styrofoam	1.55	1.01	3.27	4.74
Biotic		0.62		
Rope		0.33		
Glass ceramics				0.31

Source: LITTERBASE. URL: http://litterbase.awi.de/ (Accessed: 01 September 2018)..
* An empty cell means that the proportion of this garbage type is extremely small in this column.

Therefore, generalizations on its content in sea waters and on the coast or even the results obtained in specific areas, still are the first approximation. E.g., scientists from the RAS Institute of Oceanology named after P.P. Shirshov hypothesized that microplastic migrates in the ocean like amber which has the same density as the majority of the plastic types. Observations of amber migration have been carried out for hundreds of years, scientists believe that it is possible to assume how microplastic particles will migrate [3, Chubarenko I., Stepanova N.].

Scientists from Russia and Norway, who study the ecosystems in the Barents Sea and adjacent waters and their reserves of aquatic organisms, also observe the garbage in the aquatic environment.

The results of observations of the Polar Scientific Research Institute of Marine Fisheries and Oceanography (PINRO, Russia) and the Marine Biological Institute (BIMI, Norway) showed that the main components of the floating garbage on the surface of the Barents Sea and in its depths in

2011–2016 were objects made of paper, plastic, metal, rubber, glass, textiles and wood, incl. their various combinations (Table 3) [4, Krivosheya P., Prokhorova T. et al.].

That time, garbage was observed everywhere in the entire water area of the annual Russian-Norwegian trawl survey aimed at studying fish stocks and covering the geographical limits of the Barents Sea and some parts of the Norwegian and Greenland Seas limited to the west by the continental slope.

Objects of garbage were observed both on the surface, in the depth and at the bottom. Objects on the surface often included floating parts of logs, trees and plastic. Bottom trawling brought metal, wooden and rubber-made objects..

Table 3

The frequency of anthropogenic debris in the Barents Sea and adjacent waters noted by the Russian-Norwegian ecosystem surveys in 2011–2016.

Years	Type of debris		
	Metal	Wood	Plastic
2011	0.4	1.8	12.0
2012	0.1	1.8	20.6
2013	0.7	3.7	14.0
2014	0.2	-	5.4
2015	0.4	1.5	18.8
2016	0.7	3.0	12.7

In most cases, the plastic noted in the trawl catches was represented by pieces of fishing gear, parts of equipment used in aquaculture and various packaging. The second, less common component of garbage was wood. It could be assumed that this garbage came to the Barents Sea from the eastern Arctic seas. It entered these seas with the runoff of Siberian rivers. Even more rare component of pollution is metal.

The frequency peaks of plastic debris in catches in the Barents Sea and adjacent waters were observed in 2012 and 2015. Now, it is not possible to be confident about the reasons for the observed maxima. Potentially they may be the commercial activity, which coincided with stormy days, increased wind activity over the northeast Atlantic and others. [5, Grøsvik B.E., Prokhorova T.].

Our international research project MARP (Marine Aggregate Resources and Processes) “Plastic Pollution of the Arctic Waters: Origin, Status, Costs and Incentives for Prevention” (2016–2018) was implemented together with the Norut Research Institute (Norway), the Arctic University of Norway, UiT (Norway), the Plymouth Marine Laboratory (UK), the Norwegian Polar Institute (Norway) and the Institute of Economic Problems of the RAS Kola Scientific Center (Russia). The goal of the project was to provide data on the pollution of the Barents Sea and adjacent waters. The determination of plastic pollution in adjacent waters, e.g., the waters around the Spitsbergen (Svalbard) Archipelago, is very important for the Norwegian project participants. This is so not only due to Norway’s well-known political claims to sole management of the archipelago, but also due to the increase in plastic pollution of this area [6, Jambeck J.R., Geyer R. et al.].

An evidence of the plastic contamination is trash caught in the water adjacent to the Svalbard archipelago and stored at the waste disposal station in the Norwegian village of Longyearbyen

(Fig. 1). In September 2016, the project participants sorted this marine litter using the OSPAR methodology.

Fig. 1. The waste disposal station in the village of Longyearbyen.

As a result, the most common types of garbage were identified. Fishing plastic (nets, buoys, fish crates) was in the first place — 92%. Shares of other types of garbage ranged from 1% and less and were distributed (to reduce the share in the total volume of garbage) as follows: fabrics, ceramics/glass, rubber, cardboard, etc.

As a supplement to the research method based on the level of plastic contamination, our project addressed the problem of determining the source of plastic waste, i.e., the country of its production. It is clear that a reliable determination of the vessel's origin or the coast from which this garbage got into the sea is practically impossible. It was also not possible to identify the country-producer of the largest amount of plastic but judging by the remaining labelling of the manufacturers on some types of garbage, the largest contribution was made by the Nordic countries. Unfortunately, the time period during which the Norwegians caught sea garbage and stored it at the waste sorting station was unknown. Among the items were, e.g., builders' plastic helmets with inscription "Glory to the CPSU" or plastic bottles for drinks of famous world brands existed for decades. Also, the participation of experts from the fishermen unions and associations of Russia and Norway made it possible to establish that fishing plastic, e.g., nets, ropes or floats, was produced and used in different years.

In our opinion, the identification of the country-producer of the plastic found at sea is not enough to compile a hierarchy of countries that are guilty of plastic pollution. It is impossible to ob-

tain reliable information about the primary cause of pollution by one or another country, production and sales of plastic products around the world, pollution of sea waters from vessels or their transfer by sea currents in the water area and to the shores of other countries. All available conclusions on this issue are political or speculative.

One of the project's objectives is to assess the threats to various types of marine activities and, above all, the existing and possible damage to the fishing activities in the Barents Sea and adjacent waters. At the initial stage of the study, a survey of Russian and Norwegian fishing companies was completed in November 2017 -February 2018. In the online questionnaire, there were 25 questions. They could be answered by that the owner of the vessel, its captain or other employees of the fishing company. To answer the question on a type of garbage found in catches, it was possible to choose among the most common types of marine garbage.

Much attention was paid to the fishermen's proposals to improve the management of plastic waste handling on the vessels and in the ports and to reduce the amount of waste produced on the vessel. It was also proposed to agree (fully or partially) or not with several statements related to the plastic pollution, assessing its threat to fishing, and responsibility for the pollution of the sea of a particular vessel or a certain country.

The Russian side was able to give answers from 26 fishing companies through the Union of Fishermen of the North. The Norwegian side also faced low activity of fishing companies. The most common answers by representatives of Russian companies are in Table 4.

Table 4

Preliminary survey results of the fishing companies on the plastic pollution of the Barents Sea and adjacent waters

Questions	The most common answers
What type of waste did you encounter in the catches?	*Household waste; waste associated with fishing.*
What items most often fall into the sea from your vessel?	*Home waste (e.g. food containers, bottles, detergent containers); fishing nets (parts of fishing nets); floats, reels, buoys, trawls; packaging materials related to industrial production.*
How can you reduce the amount of waste produced on your vessel?	*To take less packaging from goods used in everyday life on board ; products are pre-packaged, so it's not possible to reduce waste.*
Do you agree with the following statements?	*I completely agree:* *I throw plastic garbage overboard, because a small amount of plastic garbage thrown into the sea does not matter.* *Sea litter probably will not cause lasting damage.* *In general, Russian fishermen do not dump plastic waste into the sea.* *Most of the garbage in Russian waters comes from afar.* *I am concerned about the reputation of Russian fish due to pollution of the ocean.*

Only one Russian company indicated the presence of economic damage from plastic garbage, although most of the surveyed companies answered affirmatively to questions that garbage caught along with the catch negatively affects the working environment, reduces the quality of the catch, etc. In addition, cleaning fishing gear from debris for one fishing day by Russian fishermen spends an average of 15 to 30 minutes and has to be cleaned at least once a month.

According to preliminary data from a survey of Norwegian companies, 54% of them admitted that they are losing working time to clean fishing gear; 48% noted that garbage spoils nets and other fishing gear. 31% of Norwegian fishing companies have losses from plastic pollution, an average of 10,000 US dollars. Norwegian fishermen believe that other countries are suppliers of marine litter. As well as Russian fishermen, they are worried about the reputation of the home seafood industry due to pollution by sea garbage.

After a complete processing of the survey results and their comparison, the most common answers will be clarified, and the necessary conclusions will be drawn in order to apply direct and indirect methods of assessing the economic damage from plastic pollution to the fishing industry.

Trends in plastic pollution of the Barents Sea and adjacent waters and initial measures for its prevention and elimination

Today, data of scientific and simple visual observation no longer leaves the opinion that the waters of the Barents Sea, its islands, archipelagoes and coasts are polluted with plastic and, despite the measures taken, to control and monitor garbage collection and disposal on vessels, the negative trends prevail.

The main factors contributing to the increase in pollution in the Russian part of the Arctic are:

• development of the plastics industry by home chemical and petrochemical industries, which leads to the expansion of plastic consumption in all sectors of the economy, incl. households;

• active implementation of the national strategy for the economic revival of the Arctic and, above all, the development of new hydrocarbon deposits on the shelf of the Arctic Ocean and the necessary infrastructure and an increase in traffic along the Northern Sea Route.

In 2017, the volume of shipping along the NSR amounted to almost 10 million tons. By 2025 it is planned to increase shipping to 80 million tons per year (excluding the transit of foreign shipping companies). The bulk cargo will be oil, liquefied gas and raw materials for dry cargo vessels. In this regard, the demand for new icebreakers will grow. According to specialists, only in the European sector of the Northern Sea Route, at least four icebreakers will be required by 2025.

As you know, one of the priorities of the State “Strategy for the Social and Economic Development of the Arctic until 2025” is to increase the living standards of northerners and create a comfortable environment for them. The implementation of this complex task is likely to reduce the desertion rate of the Arctic territories observed now. In the conservative version, i.e., the population will remain at the current level or slightly decrease without breakthroughs and cardinal changes for the better. However, even with this option, the growth of plastic consumption in households will increase the volume of plastic waste.

It is also necessary to mention the strategic plans of the fishing industry of the Northern Fishery Basin [7, Kuranov Yu.F.; 8, Vasilyev A.M., Kuranov Yu.F.; 9, Vasiliev A.M.]. The fulfilment of intentions to radically improve the system of taxation of fishing enterprises to reduce its burden

by the government of the country will be a powerful incentive for the modernization and development of the fleet, incl. coastal one, and processing factories. Moreover, the existing tax system makes incomes of fishing and processing companies constantly growing. So, this sector of the economy remains attractive to businesses.

A subjective factor contributing to the strengthening of the negative trend of pollution of the Arctic Ocean with plastic waste today is the absence even mention of the threat of pollution of the seas and, as a result, measures to prevent it in all legal regulations on the development of the Russian part of the Arctic. The recognized priority for ensuring the environmental safety of the Arctic is the protection of its waters from hydrocarbons' pollution and from the negative effects of climate change, and its islands and coasts — from historically accumulated garbage, or containers from fuel mostly.

Meanwhile, today it is possible to justify *the factors that will contribute to the turn of the situation with plastic pollution of the Barents Sea and other areas of the Arctic Ocean*.

First of all, *it is the strengthening of the international protection of the resources and ecosystems of the oceans, outlined in the latest UN documents, which imply the adoption of similar actions by national governments*. Russia will not be an exception among the UN member states in joining the solution of the problem.

At the national level, an important factor in the prevention of plastic pollution will be *the implementation of two interrelated reforms of the state environmental management and environmental protection: 1) handling production and consumption waste and 2) rationing and promoting environmental protection activities*. Both reforms started in 2014 and today it is possible to see a significant progress.

Fundamental changes were made in the Federal Law “On Production and Consumption Wastes”. In accordance with it, the development of territorial waste management schemes and regional programs, the creation of a regional operator for waste management, the responsibility of Russian producers and importers of certain goods, etc. were legally secured.

It would not be superfluous to conclude that today the country has developed the conditions for the transition to a new waste management system largely based on borrowing the provisions of the EU Directive 2008/98/EC on waste (Waste Framework Directive)[13]. “Prevention of the waste generation” is at the top of the waste management hierarchy, followed by reuse (and preparation for it), recycling, use and disposal.

It is easy to see that the Russian reforms were aimed at “preventing the generation of waste”. Since 2016, Russian producers of certain goods and their importers have been obliged to annually ensure the disposal of their waste in an amount of up to 30% (a recycling rate) of goods released into circulation in Russia in the previous year. The list of goods and their packages to be recycled after losing consumer properties, includes 54 groups of goods, except for food and raw

[13] The EU Directive 2008/98/EC on waste (Waste Framework Directive). URL: http://ec.europa.eu/environment/waste/framework/ (Accessed: 01 September 2018).

materials. In particular, the group No 21 “Plastic packaging products” includes bottles, vials and similar products made of plastic; ethylene polymer bags; bags made of other plastics masses; boxes, crates, baskets and similar plastic products; other plastic packages.[14]. The recycling rate for these goods is 10% in 2018 and will be 20% in 2020.[15] In fact, the list of goods to be recycled after losing consumer properties contains all types of packaging goods, incl. those made of various polymers. An environmental fee is established for businesses and organizations not willing to recycle waste. E.g., the fee for group No 21 “Plastic packaging products” is 3,844 rubles per ton.

At the beginning of 2018, the Government of the Russian Federation approved the “Strategy for the Development of the Industry for the Processing, Disposal and Recycling of Production and Consumption Wastes”. Its provisions are the foundations of the state program to be developed to create a recycling and disposal industry in Russia.

Such an industry has already been created in the EU countries, and therefore they are going further. Back in 2015, the European Commission adopted the program “Closing the loop - An EU Action Plan for the Circular Economy”, i.e., an economy that reduces, reuses and recycles waste within the production, circulation and consumption of goods.

Russia is an example of the transition to a circular economy. It is applied to the polymer industry. We are talking about the “State program for the Development of Biotechnology in the Russian Federation for the period up to 2020” or “BIO2020”[16]. In accordance with it, since 2014, a plan is being implemented to reduce the use of traditional polymers in the production of food packaging, which is not properly recycled by means of biodegradation, primarily plastic bags and disposable tableware. As a result of the program, bioplastics should take up 10% of the polymer market, incl. packaging — up to 25%.

Recycling of many types of plastics is a difficult problem, since their processing is only possible separately, and some types of plastic waste are not profitable to recycle into secondary raw materials. Currently, the industry is facing the problem of processing mixed plastics waste. Also, the problem of science is the search for new applications of plastic as a secondary raw material. Products made of recycled plastic are inferior in quality to those made of new plastic, therefore, they have a lower price, and their production is non-competitive and unprofitable. Today, recycled plastic is used mainly as a filler for various construction mixtures, facing products, insulation materials, technical structures, fuel, and even electricity items.

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[14] Rasporyazheniye Pravitel'stva RF ot 24.09.2015 N 1886-r “Ob utverzhdenii perechnya gotovykh tovarov, vklyuchaya upakovku, podlezhashchikh utilizatsii posle utraty imi potrebitel'skikh svoystv” [Order of the Government of the Russian Federation of September 24, 2015 No 1886-p “On approval of the list of finished goods, including packaging, to be recycled after they lose consumer properties”]. [In Russian]

[15] Rasporyazheniye Pravitel'stva RF ot 28 dekabrya 2017g. № 2971-r “O normativakh utilizatsii otkhodov ot ispol'zovaniya tovarov na 2018–2020 gg.” [Decree of the Government of the Russian Federation of December 28, 2017 No. 2971-p “On standards for the disposal of waste from the use of goods for 2018–2020.”]. [In Russian]

[16] Koordinatsionnaya programma razvitiya biotekhnologiy v Rossiyskoy Federatsii na period do 2020 g. (BIO2020), utv. Pravitel'stvom RF 24.04.2012 N 1853p-P8. [Coordination program for the development of biotechnology in the Russian Federation for the period up to 2020 (BIO2020), approved by the Government of the Russian Federation 24.04.2012 No 1853p-P8.]. URL: http://biotech2030.ru/platforma/strategii-2/ (Accessed: 01 September 2018).[In Russian]

The goal of the reformed state system of environmental regulation and incentives is to reduce emissions of pollutants into the environment through the introduction of a new type of standards (technological) that will stimulate enterprises to introduce the better environment-friendly technologies. The transition period has legally established time limits: the largest environmentally hazardous enterprises in the country will pass through a transition period in 2019–2022. The enterprises which will not meet the standards of the best available technologies for the industry are going to fall under the negative incentive measures, i.e. their fees for environmental pollution will increase by 100%[17].

The collection and recycling of wastewater in the part concerning wastewater treatment of centralized sewage systems (with a volume of 20 thousand m3 per day and more) is assigned to the first category of environmental damage, i.e., it is, for example, water utilities. The transition to better technologies for water utilities and sewage recycling plants of industrial enterprises will reduce the amount of plastic waste and microplastics that are transferred by sewage into rivers and bays.

To reduce the threat of plastic pollution on the Russian seas and land a lot remains to be done at all levels of government in a complex geopolitical and economic situation.

In our opinion, the first steps of the federal regulator should be the further improvement of the regulatory framework of production and consumption waste, namely the adoption of the draft federal law “On Secondary Resources” and the development of a national program to “prevent” the emergence of the waste. This program should include a set of measures to be taken before a product becomes waste. In other words, technologies should be developed to increase the life cycle of goods. These products and goods should primarily include plastics. Its negative impact on the environment and human health has been proven by science. E.g., in Norway, studies on the processing of waste plastic, fishing nets, ropes, and trawls are going on.

It is also necessary to adjust or increase the output of equipment for the processing and recycling of waste to replace the imported analogues, incl. those used on vessels of various types. The necessary technologies and equipment should be innovative and, therefore, their development requires significant financial resources. In this regard, it is advisable to create a financial platform for a circular economy, by analogy with the EU. The development of a circular economy in the EU today is supported by such a powerful financial institution as the European Investment Bank (EIB) and several other banks that support various projects, e.g., for the processing of municipal solid waste. By the end of 2016, the European Investment Program attracted € 164 billion[18].

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[17] Federal'nyy zakon “Ob okhrane okruzhayushchey sredy” ot 10.01.2002 N 7-FZ. [Federal Law “On Environmental Protection” January 10, 2002 No.7-FZ].URL: http://www.consultant.ru/document/cons_doc_LAW_34823/ (Accessed: 03 September 2018).[In Russian]

[18] Yevrokomissiya predstavila obzor programmy krugovoy ekonomiki i novoy platformy finansirovaniya. [The European Commission presented an overview of the circular economy program and the new funding platform]. URL: http://rus.delfi.ee/daily/euroopa/evrokomissiya-predstavila-obzor-programmy-krugovoj-ekonomiki-i-novoj-platformy-finansirovaniya?id=77044912 (Accessed: 03 September 2018).[In Russian]

The Arctic subjects of the Federation are actively involved in the work on the production and consumption waste law (they develop territorial schemes for handling waste; define a regional operator; search, or, as it is in the Murmansk region, have already found an investor for the construction of modern landfills for waste disposal). The subjects have no own funds for developing regional programs to “prevent” the emergence of waste.

In this regard, it is advisable to include actions to “prevent” the emergence of waste, incl. plastic, in the "State Program for the Social and Economic Development of the Arctic".

A social movement for the reuse of things and materials in everyday life does not require any additional investments since it is now widely deployed throughout the world. People are taught to reuse household items, sort garbage and participate in cleanings up in different areas through numerous Internet web pages. Volunteers in Norway helped to clean several thousand beaches polluted with plastic garbage.

We have such events in the Murmansk Oblast as well. In early 2018, the Federal Law "On Volunteering" was adopted. In our opinion, the capacity of regional authorities and public movements in the Arctic regions to clean the coasts of the Barents Sea from debris, incl. plastic is greatly expanded.

As the system develops passive garbage collection in seawater, volunteers can be attracted to clean the surfaces of seas.

Conclusion

Today, in the waters of the Barents Sea, its islands and archipelagoes, as well as the continental coast, there is a negative trend towards increasing pollution by plastic waste.

Scientific data on the pollution of the Barents Sea and adjacent waters by various types of plastics and the damage they cause to marine ecosystems and marine activities are insufficient: more comprehensive and international research is needed, primarily from Russia and Norway.

In the medium term, in the Russian part of the Arctic, there will be at the same time factors that contribute to the growth of plastic pollution and deter it.

Today, one of the subjective factors contributing to the strengthening of the negative tendency of contamination of SLOs with plastic waste is the absence in all legal documents on the development of the Russian part of the Arctic of measures to prevent their pollution of the Arctic seas, including the financing of scientific research.

It is advisable to include various types of plastic in the list of hazardous pollutants in the water area and coasts of the Russian Arctic, by analogy with radiation pollution and hydrocarbons.

The State program for the creation of the industry for the processing and disposal of waste should provide for the development of technologies for the processing and recycling of plastic industrial fishing waste (nets, longlines, trawls, boxes for fish, packaging of products, buoys).

Territorial schemes for the management of waste recycling in the Arctic subjects of the Federation should contain actions for the collection, recycling and disposal of marine debris on the coasts and in coastal waters.

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