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Problems and Prospects of Atlantic Salmon Mariculture Development in the Russian Arctic*

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Abstract. The authors present the volume of Atlantic salmon farming in the world and in the Russian Arctic. It shows the reasons that hamper the development of salmonid mariculture in the Russian Arctic: the lack of own planting material adapted to Arctic waters, high-quality fodder, fish diseases and others. Objectives of the article: to show the peculiarities of natural and socio-economic conditions of mariculture development in the Russian Arctic and the impact of Atlantic salmon mariculture on import substitution. Relevance stems from the need to substantiate the sources of import substitution of salmon products. The most important results: the main factors that reduce the economic efficiency of growing and selling products were found; the possible causes of salmon diseases in the Russian Arctic and their impact on production processes were systematized, the possible impact of caged fish farming on the environment and on the population of salmon in the Arctic zone was shown. Practical significance: the article shows the influence of possible escapes of farmed salmon on the socio-economic conditions of the population of the Terskiy coast of the Murmansk region and the White Sea basin. It is proposed to introduce Atlantic GM salmon into the composition of genetically modified products. It is shown that import substitution is fully provided by Atlantic salmon mariculture and the supply of wild salmon from the Far East to the European part of Russia.
Keywords: *Russia, Arctic, Atlantic salmon, commercial farming, import substitution, prospects, problems.*

Introduction

World's population growth, improvements in living standards, primarily in the developing countries of Asia, have become the main factors in increased demand for food of animal origin, including fish. Since lots of natural reserves of fish and seafood were depleted by the end of the XX century and did not allow a significant increase in catches, the governments of many countries and investors turned their attention to aquaculture, which made it possible to use feed resources 4.5 times more efficiently than growing beef and 2.8 times — than pork.

The main production of commercial farming of fish and other objects of aquatic biological resources is concentrated in countries with large population in Southeast Asia [1]. These countries have a huge population of 57% (according to 2017), which, given the low level of fisheries devel-

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[1] Ezhegodnik FAO po statistike rybolovstva i akvakul'tury [FAO Fisheries and Aquaculture Statistics Yearbook]. URL: http://www.fao.org/fishery/statistics/yearbook/en (accessed 03 January 2021).

opment, needs providing food of animal origin. The share of this region in the total aquaculture production in 2018 is 88.69%, including China — 57.9% (Table 1).

Table 1

Fish production in aquaculture by major producer (thousand tons, % of the world volume) [2]

Regions / countries	2000	2005	2010	2015	2018
Asia (excluding Cyprus)	28420.6 87.67%	39185.9 88.46%	51228.8 88.72%	64591.8 88.76%	72812.2 88.69%
China (continental)	21522.1 66.39%	28120.7 63.48%	35513.4 61.50%	43748.2 60.12%	47559.1 57.93%
India	1942.5 5.99%	2967.4 6.70%	3785.8 6.56%	5262.0 7.23%	7066.0 8.61%
Indonesia	788.5 2.43%	1197.1 2.70%	2304.8 3.99%	4342.5 5.97%	5426.9 6.61%
Asia, rest of the countries	4167.4 12.86%	6600.8 15.57%	9624.7 16.68%	11241.2 15.45%	12760.1 15.55%
North and South America	1423.4 4.39%	2176.9 4.91%	2514.6 4.35%	3274.7 4.50%	3799.2 4.63%
Chile	391.6 1.21%	723.9 1.63%	701.1 1.21%	1045.8 1.44%	1266.1 1.54%
Latin America and the Caribbean, rest of the countries	447.4 1.38%	784.5 1.77%	1154.5 2.00%	1615.5 2.22%	1873.6 2.28%
North America	584.5 1.80%	668.5 1.51%	659.0 1.14%	613.4 0.84%	659.6 0.80%
Africa	399.6 1.23%	646.4 1.46%	1285.8 2.23%	1777.6 2.44%	2195.9 2.67%
Europe (including Cyprus)	2052.6 6.33%	2137.3 4.82%	2527.0 4.38%	2948.6 4.05%	3082.6 3.75%
Norway	491.3 1.52%	661.9 1.49%	1019.8 1.77%	1380.8 1.90%	1354.9 1.65%
Countries — EU members	1402.5 4.33%	1272.4 2.87%	1263.3 2.19%	1263.7 1.74%	1364.4 1.66%
Europe, rest of the countries	158.7 4.33%	203.1 0.46%	243.9 0.42%	304.0 0.42%	363.2 0.44%
Oceania	121.5 0.37%	151.5 0.34%	187.8 0.33%	178.5 0.25%	205.3 0.25%
The whole world	**32417.7**	**44298.0**	**57743.9**	**72771.3**	**82095.1**

Aquaculture in Europe accounts for about 1.2% of world production by volume and about 3% by value. In 2017, the EU grew about 1.4 million tons of fish and seafood worth 4.6 billion euros. This is significantly less than world production. Moreover, production in the EU has declined from a moderate annual growth rate of 3.4% during the period 1990–2000 to negative growth rates of –0.2% in the period 2000–2017 [3].

The volume of aquaculture in North America is negligible. In 2000, it amounted to 584.5 thousand tons (1.8%), in 2018 — 659.6 thousand tons (0.8%). The countries of this continent — the USA and Canada, — like Russia, have large natural resources of fish and seafood; authorities and society pay great attention to environmental issues and their impact on public health. So, until

[2] Compiled by the authors. Source: Ezhegodnik FAO po statistike rybolovstva i akvakul'tury [FAO Fisheries and Aquaculture Statistics Yearbook]. URL: http://www.fao.org/fishery/statistics/yearbook/en (accessed 03 January 2021).

[3] Akvakul'tura v Evrope: ekonomicheskiy obzor [Aquaculture in Europe: an economic overview]. URL: https://fishretail.ru/news/akvakultura-v-evrope-ekonomicheskiy-obzor-401293 (accessed 25 December 2020).

recently, the cultivation and consumption of genetically modified fish was prohibited in the United States.

Main section

The Government of the Russian Federation pays great attention to the aquaculture development, planning to increase the participation of fishing industry in the Food Security Doctrine implementation and to reduce the problem of high prices for fish products. The total volume of fish farming production in Russia in 2018 amounted to 238.7 thousand tons, which is only 41 thousand tons (14.6%) less than in 1990. The value of fish farming in the total volume of marketable fish products was 3.7%. At the same time, carp fish accounted for 61.0% of the total growth volume, salmonids — 28.0% [4]. Compared to 2012, the volume of salmon production increased in 2018 by 6.6%, while carp production decreased by 13.0% [1]. The above data show that Russia lags significantly behind the world level of fish farming and that was to be expected, since the country does not develop commercial reserves of wild fish.

In terms of fish farming in 2018 — 78.7 and 37.8 thousand tons (48.8%) — the Southern and Central Federal Districts are in first place. There are good conditions for aquaculture of cyprinids and other non-predatory fish, as well as great demand for them. The territories are far from the main fishing regions — the Far East and the North.

In the Northwestern Federal District, mainly in Karelia and the Murmansk region, 59.5 thousand tons of commercial mariculture products were produced in 2018 (24.9% of the total volume of cultivation). Trout is mainly grown in Karelia. The Murmansk region is the only region in the Russian Arctic where genetically modified Atlantic salmon (genetically modified salmon) is grown for import substitution. The production volumes are shown in table 2.

In the Far Eastern Federal District, mainly in the Primorskiy Krai, there are difficulties with the production and sale of wild salmon. Mariculture has been developed there and 13.0 thousand tons of marketable products were already grown in 2018. Seafood is grown in small quantities and mainly for export. Aqua and mariculture are also developing in other territories of Russia [5].

Table 2

Mariculture of Atlantic salmon, thousand tons [6]

Country	2013	2014	2015	2016	2017	2018
Norway	1168.3	1258.4	1303.3	1233.6	1236.3	1282.0
Chile	492.3	644.5	608.5	532.2	614.2	661.1

[4] Karabut T. Osobennosti natsional'noy akvakul'tury. Chto meshaet investoram uvelichivat' proizvodstvo ryby [Peculiarities of National Aquaculture. What Prevents Investors from Increasing Fish Production]. URL: https://www.agroinvestor.ru/markets/article/31489-osobennosti-natsionalnoy-akvakultury/ (accessed 25 December 2020).

[5] Dinamika proizvodstva produktsii tovarnoy akvakul'tury v Rossiyskoy Federatsii [Dynamics of Production of Commercial Aquaculture Products in the Russian Federation]. URL: http://fish.gov.ru/files/documents/otraslevaya_deyatelnost/akvakultura/proizvodstvo_akvakultury/statistika/dinamika_proizvodstva_produkcii.pdf (accessed 25 December 2020).

[6] Compiled by the authors. Source: Ezhegodnik FAO po statistike rybolovstva i akvakul'tury [FAO Fisheries and Aquaculture Statistics Yearbook]. URL: http://www.fao.org/fishery/statistics/yearbook/en (accessed 03 January 2021).

Great Britain	163.5	179.4	172.1	163.1	189.7	166.0
Canada	97.6	86.3	121.9	123.5	120.5	123.5
Faroe islands	75.8	86.4	80.6	83.3	86.8	78.9
Australia	42.8	41.6	48.3	56.1	52.6	61.2
Russia	22.5	18.7	10.8	12.9	13.0	20.6
USA	18.9	18.7	18.7	16.2	14.7	16.1
Iceland	3.0	4.0	3.3	8.4	11.3	13.4
Ireland	9.1	9.4	13.1	16.3	18.3	12.0
Other	0.025	0.72	0.73	1.61	1.16	1.09
TOTAL	2093.8	2348.1	2381.3	2247.2	2358.6	2435.9

Table 2 shows that the world's main producer of Atlantic genetically modified salmon is Norway. Its share in the total volume of cultivation in 2018 was 52.6%, and together with Chile — 79.8%. Norway sells genetically modified salmon around the world, using price dumping to capture markets.

Two companies are involved in cultivation of genetically modified Atlantic salmon in the Russian Arctic: "Russian Salmon" and "Russian Aquaculture". They increased production until 2015, when the second company suffered a total fish disease and hundreds of tons of salmon were destroyed. The volume of salmon mariculture reached the pre-crisis level only by 2018. The companies import 100% of the fry from Norway, including the Norwegian factory they have already bought. The conditions of the Murmansk region are suitable for the cultivation of Atlantic salmon in the Russian Arctic. There are a significant number of bays, the water temperature there is insignificantly below the optimum. In the Kara Sea and other seas of the Arctic Ocean, the conditions for mariculture of genetically modified salmon, according to experts, are not suitable.

The most important reason for investors' attention to commercial farming of GM salmonids in the world and in Russia is the high level of economic efficiency. Thus, according to the Norwegian Fisheries Administration, the operating profitability of the cage system for growing Atlantic salmon is ~ 40%, the return on investment is ~ 18%, and the payback period is 5.6 years [7].

The second stimulating factor for the development of mariculture in Russia, primarily salmon fish, is the policy of import substitution and state assistance. The strategy for the national fishery complex development provides an increase in the volume of aquaculture production by almost three times by 2030 — up to 618 thousand tons. The state provides a set of measures for this. In 2018, the Ministry of Agriculture of Russia and the Federal Agency for Fishery allocated 653 million rubles to support aquaculture. In addition, the issue of reimbursement of capital costs for commercial aquaculture in the amount of 25% to 30% of the estimated cost and a number of other measures are being discussed [8].

[7] Sravnenie ekonomiki i ekologichnosti modeley s ustanovkoy zamknutogo vodosnabzheniya (UZV) i sadkovoy sistemy dlya vyrashchivaniya atlanticheskogo lososya [Comparison of the Economics and Environmental Friendliness of Models with a Recirculated Water Supply (RWS) and Cage System for Growing Atlantic Salmon]. URL: https://aquavitro.org/2016/04/23/sravnenie-ekonomiki-i-ekologichnosti-modelej-uzv-i-sadkovoj-sistemy-dlya-vyrashhivaniya-atlanticheskogo-lososya/ (accessed 25 December 2020).

[8] Strategiya razvitiya rybokhozyaystvennogo kompleksa Rossiyskoy Federatsii na period do 2030 goda (utv. Rasporyazheniem Pravitel'stva Rossiyskoy Federatsii ot 26.11.2020 g. № 2798-r) [Strategy for the Development of the Fishery Sector of the Russian Federation for the Period up to 2030 (approved by the Order of the Government of the

The third factor is high feed efficiency. The feed coefficient for growing genetically modified salmon, depending on the type of feed and a number of other reasons, varies from 0.6 to 1.4. In trout aquaculture, it is 1.5–2.0, in pig farming — 3.0, and in cattle breeding — 6.8 [9].

The period of Atlantic salmon rearing is 16–18 months and is divided into three periods: rearing fry, juveniles and growing up to a certain size or weight, taking into account buyers' preferences. There are feeds with certain qualities for each period: for fry — starting feeds, for juveniles — transitional ones and at the final stage — production feeds.

The feed is based on high quality fish-flour containing about 70% protein, as well as wheat gluten and fish oil. The domestic industry has developed production of various feeds for all age groups. However, quality and prices do not satisfy the fish farmers, and they often prefer to buy foreign feed. This is especially true for predatory fish, such as trout, Atlantic salmon and sturgeon. According to the estimation of "Rosrybkhoz" association, the dependence of fish feed on imports is 69% [2].

Considering the economic efficiency of genetically modified salmon farming, it is more profitable to use extruded feed. They have a feed ratio in the range of 0.6-0.8, and granulated ones — 1.2-1.4. In addition, extruded feed is more environmentally friendly — crumbling and sifting is about 1.0%, and granulated feed has the range of 5.0% to 10.0%. Therefore, when using extruded feed, water and bottom are less polluted [10].

Salmon feeding does not stop at low temperatures (1–2° C), and when the temperature rises above 20° C (beyond the optimum), their feeding activity gradually decreases.

Salmonids, including the Atlantic salmon, are quite demanding for an oxygen regime (oxygen content of at least 7 mg/l). With a decrease in oxygen level, fish growth deteriorates, and food consumption decreases. The optimal water temperature for raising salmon fish is 14–18° C. The sea water temperature of the Russian coast of the Western Arctic in certain periods of the year does not correspond to these parameters, which reduces the consumption of feed and the growth of fish adapted to the water temperature of the Norwegian coast [11].

It is necessary to adjust the daily ration when the oxygen level in the reservoir or fish tanks fluctuates. At high stocking densities in cages and pools, technological errors and miscalculations in fresh water supply affect oxygen levels. It should also be taken into account that with active feeding, the intensity of oxygen consumption of salmonids increases by 50–200%. Many researchers have proven that even short-term, but frequent reductions in oxygen levels in fish tanks negatively affect the growth of fish [12].

Russian Federation dated November 26, 2020, No. 2798-r)]. URL: https://www.garant.ru/products/ipo/prime/doc/72972854/ (accessed 25 December 2020).

[9] Osnovnye strany-proizvoditeli atlanticheskogo lososya [Major Producing Countries of Atlantic Salmon]. URL: https://uifsa.ua/news/world-news/the-main-producing-countries-of-atlantic-salmon (accessed 17 December 2020).

[10] Korma dlya ryby: sovremennye resheniya [Fish Feed: Modern Solutions]. URL: https://www.fishnet.ru/news/aquaculture_news/49525.html (accessed 04 January 2021).

[11] Ibid.

[12] Ibid.

Consumers are accustomed to the fact that salmon meat has a specific pink tint of varying intensity. In order to achieve the desired color of fish meat, feed suppliers add dyes to their products — natural or artificial. Astaxanthin, which colors fish meat in pink color of varying intensity, is one of them [13].

As shown above, cost-effective farming of Atlantic salmon is achieved under many conditions, the main of them are high quality fishmeal and oil based feed. In 2019, Russia produced 126.0 thousand tons of fish flour [14], and its production will increase rapidly in the coming years due to the commissioning of about 40 fishing vessels equipped with fishmeal plants. This amount of flour is sufficient for the production of aquaculture feed. But since most of the fishmeal in Russia is produced from wastes from fish cutting, it is not suitable for salmon mariculture due to its low protein content. Whole fish meal is prohibited in Russia.

World fishmeal is produced in the amount of 4.0 to 7.0 million tons [15].There is a shortage of it during periods of poor condition of Peruvian anchovy commercial stocks, which leads to an increase in the cost of aquaculture production and prices for fish products. Other fish suitable for flour production are used, such as herring, menheden, sardines and others [16].

The cultivation of Atlantic salmon on the Kola Peninsula has potentially serious competitors in the marketing of wild salmon harvested in the Pacific Ocean in the Far East. In future, when the embargo on fish products supply from Norway and Finland is lifted, they will also become competitors.

The annual salmon production in the Far East ranges from 300 to 650 thousand tons. Their massive deliveries to the Russian market are constrained by the unavailability of technical equipment and the underdevelopment of transportation along the Northern Sea Route (NSR). But the Government of the Russian Federation is taking serious measures to organize the transportation of fish along the NSR. A specialized hub “Seroglazka” is being built in Kamchatka, which will be ready in 2021. Test passages with fish in refrigerated containers have been made, including ones assisted by the nuclear-powered lash lighter carrier “Sevmorput”. The issues of return loading of ships are being resolved [17].

Comparison of retail prices for salmon in Murmansk stores shows that they are significantly lower for comparable types of Far Eastern products than for Atlantic salmon of local mariculture production. The main reasons for this are differences in the assortment and cost of products. In addition, salmon from local farms is usually sold fresh and therefore requires a

[13] Ibid.
[14] V 2019 g. v Rossii vyroslo proizvodstvo rybnoy muki [In 2019, the Production of Fishmeal Increased in Russia]. URL: https://www.fishnet.ru/news/novosti_otrasli/89495.html (accessed 26 December 2020).
[15] Ekspert: rybnaya muka, kak produkt bezotkhodnogo proizvodstva [Expert: Fishmeal as a Waste-Free Product]. URL: https://finance.rambler.ru/economics/35341624-ekspert-rybnaya-muka-kak-produkt-bezothodnogo-proizvodstva/?article_index=1 (accessed 04 January 2021).
[16] Ibid.
[17] Rybnaya muka — ugroza rybnym resursam [Fishmeal is a Threat to Fish Resources]. URL: fishnet.ru›news/novosti_otrasli/69565.html (accessed 26 December 2020).

quick sale, forcing producers to lower prices. The seasonality of mariculture salmon production and restricted sales times are also factors limiting sales prices.

Another reason for decline in effectiveness of mariculture in the Russian Arctic, primarily in the European North, is competition with products from Norway and Finland after the resumption of their import to Russia. These countries use the latest technology in salmon farming, and most production processes are automated. Significant progress has been achieved in reducing the feed ratio, preventing and treating fish diseases. They use their own feed and smolt adapted to the sea water temperature. The water temperature off the coast of Norway is slightly higher than in Russia, and therefore the fish grows faster and the return on feed is higher.

Before the import ban, Norway and Finland supplied more than 200 thousand tons of mariculture products to Russia. With its resumption, fish from Norway and Finland will again appear on the Russian market in large volumes and, as evidenced by experience, prices will be lower than of Russian producers. It can have serious consequences, including bankruptcy, which has already occured in the Russian North and in Finland [3]. Moreover, the Russian competitive factor — low wages — plays an increasingly small role.

Fish diseases, which are usually treated with antibiotics, are a major reason for the decline in the economic efficiency of genetically modified salmon farming. Literary sources claim that, for example, Norway has managed to minimize this damage to mariculture and products are sold with minimal antibiotics in fish meat.

In Russia, the development of cage culture for salmonids is at an early stage, and so far it has not been possible to avoid serious losses. According to Vorob'eva V.V. and Proskura D.Yu., in Russia over the past two decades, mariculture has not received the planned development due to the presence of numerous problems, including the lack of safe feed and fight against diseases of cultivated aquatic organisms [4]. In the Murmansk region, as shown above, hundreds of tons of Atlantic genetically modified salmon were destroyed due to the disease, and a loss of hundreds of millions of rubles was inflicted. During the same period, a salmon disease was observed in the Kola River. Currently, the state of affairs with diseases in this industry is carefully hidden through the secrecy of information.

The problem of benefits and harms of eating farmed salmon should also be kept in mind. The founder of the Norwegian Conservation Union, Kurt Oddekalv, claims that fish farmers pour strong pesticides that have neurotoxic effects into the water to fight fish parasites. As a result, various chemicals can be found in fish and it cannot be eaten. French toxicologist Jérôme Rüsgen, confirming the results of K. Oddekalv's research, said: "Indeed, the degree of contamination of farmed salmon is very high. It is 5 times more harmful and toxic than any other food.

These toxins must be avoided, and by consuming foods containing them, we run the risk of experiencing their effects." [18]

Fish feed is no less serious concern. Scientists have assessed the level of polychlorinated biphenyls (PCBs) in salmon. Farmed salmon had significantly higher PCB levels than wild salmon. These toxic substances can accumulate in the body over time. It is believed that some of them can disrupt the normal functioning of the nervous, immune and reproductive systems [5].

To give salmon meat a natural color, they are fed with dyes of both natural and synthetic origin (canthaxanthin), which affect human vision [6].

The emergence of genetically modified salmon, one of which is the Atlantic salmon, is also becoming a cause for concern. Typical salmon grows only in the warm season, and its cultivation takes 31–56 months, genetically modified salmon grows all year round due to the implanted growth hormone and reaches the required size in 16–18 months. It significantly reduces its cost. But research suggests that the use of recombinant hormone in living organisms can potentially contribute to cancer. There is also evidence that genetically modified food can cause problems with kidneys, liver and pancreas, cause reproductive problems, and negatively affect blood circulation and immunity [19] [7].

The debate around these issues is complex, and the information available in the media, on the Internet, in scientific publications is highly controversial. However, prices for wild salmon in Russia and in Western countries are currently 1.5–2.0 times higher, which, in our opinion, is one of the factors of poorer quality of farmed fish. It can be argued that with an increase in public awareness, the consumption of farmed genetically modified salmon will decrease. It can also be assumed that the quality of farmed salmon will decrease as a result of changes in the feed formulation due to the lack of high quality fish meal and to reduce costs.

Experts believe that salmon fish farming creates many serious environmental problems. It has been suggested that farming is the main reason for the decline in wild salmon populations. This is mainly due to the spread of diseases and parasites among cultivated fish and contamination of wild populations as a result of fish escaping from cages. According to the official statistics of the Norwegian Directorate of Fisheries, an average of 413 thousand specimens of fish per year escaped from fish farms in 2001–2011 [20].

A serious environmental problem is the contamination of the bottom with feed residues in places where the cages are located. In the world, it is solved by moving the cages to artificially cre-

[18] Regulyarnym perevozkam ryby po Sevmorputi pomogut subsidii i zagruzka obratnykh reysov [Regular Transport of Fish along the Northern Sea Route will be Helped by Subsidies and Loading of Return Voyages]. URL: tass.ru›Экономика и бизнес›8542475 (accessed 26 December 2020).

[19] Norvezhskiy losos' v 5 raz vrednee i toksichnee, chem lyubye drugie produkty, - utverzhdayut ekologi [According to Environmentalists, Norwegian Salmon is 5 Times More Harmful and Toxic than Any Other Food]. URL: https://roscontrol.com/journal/news/norvegskiy-losos-v-5-raz-vrednee-i-toksichnee-chem-lyubie-drugie-produkti-utvergdayut-ekologi/ (accessed 26 December 2020).

[20] Ryba s zapakhom skandala. Kakuyu pol'zu prinosit i kakoy vred nanosit vyrashchivanie lososya [Fish with the Smell of Scandal. What Benefits and what Harm Does Salmon Farming Do]. URL: https://www.kommersant.ru/doc/4067642 (accessed 03 January 2021).

ated reservoirs on the shore with closed water supply installations. The second option for solving the problem is the removal of cages into the open sea at great depths and currents. This kind of production is already being developed in Norway.

The above options for solving the problem of sea pollution require significant additional costs and, apparently, will not soon be in demand in the Arctic.

The development of mariculture of Atlantic genetically modified salmon does not contribute to solving the global problem of food shortage, since the production of feed requires catches of other fish, including those suitable for food purposes, exceeding production volumes by 3–4 times. In the European countries of the North-East Atlantic coast, 2/3 of the anchovy catch, half of the catch of capelin, sprat (40%), blue whiting (30%), horse mackerel (20%) are used for fish flour [8].

The main goal of breeding Atlantic genetically modified salmon in the Russian Arctic, from the point of state interests, is to replace ~200 thousand tons of Atlantic salmon imported from Norway before the embargo. PJSC "Russian Salmon" and PJSC "Russian Aquaculture" won all sea areas convenient for breeding on the coast of the Barents Sea and, according to the statement of the head of PJSC "Russian Aquaculture" to the newspaper "Kommersant" dated 09/30/2020, can grow, based on the water area, only 100 thousand tons of Atlantic salmon.

In order to produce feed for such a volume of cultivation, about 40 thousand tons of conditioned fishmeal will be required, which needs about 120 thousand tons of fish. Since such volumes of non-food fish do not exist in the 200-mile economic zone in the Arctic and adjacent waters [9], the construction of own factory for fish feed production is highly improbable.

According to the FAO and WHO report "The State of Food Security and Nutrition in the World 2018", the number of hungry people in the world is growing, reaching 821 million in 2017 [21]. In order to find additional sources of animal protein for nutrition, the world community may limit the use of edible fish for the production of fishmeal for growing relatively small quantities of gourmet fish until more suitable sources of raw materials are found. Moreover, salmon, as follows from the above materials, is harmful to daily nutrition. A decrease in the production of fishmeal or a change in the composition of fish feed substances can have negative consequences for fish farming in the Arctic.

Russia, having huge reserves of salmon fish, is in a special position. There are enough wild salmon to meet the demand for these species in the future. The issues of increasing fish products supply from the Far East to the European part of Russia are being resolved. It is assumed that increase in the volume of fish products transportation by sea will reduce tariffs, which will make it possible to reduce prices for fish products. The planned modernization of the Trans-Siberian railway will also affect the growth of fish supplies from the Far East.

[21] Global'nyy golod prodolzhaet rasti, govoritsya v novom doklade OON [Global Hunger Continues to Grow, According to a New UN Report]. URL: ru.wfp.org›news/globalnyy-golod…govoritsya-v…oon (accessed 26 December 2020).

Conclusion

Despite the risks of the cultivation and consumption of Atlantic genetically modified salmon noted in the article, there is a demand for it in the world and in Russia and there is a slight increase in production (see table 2). At the same time, there is a growing public protest in the world against cage farming of salmonids. So, in the United States in the state of Washington, it was planned to close all farms. In Canada, 17 farms will be closed by 2023 [22]. In Scotland, consumer organization SumOfus has collected 40.000 signatures asking the government to inspect salmon farms [23].

In the Murmansk region, specialists and the population were greatly alarmed by the significant destruction of genetically modified salmon in PJSC "Russian Salmon", which fell ill with lice in 2015. It was burned, buried in the ground, and thrown into the sea. Due to the fact that the cages are located on the west coast, which coincides with the migration routes of salmon, wild fish can become infected with parasites from escaped genetically modified salmon. This will cause irreparable damage to the local population of salmon, which is already in a depressed state [10].

Of particular concern is the traditional lifestyle of the Pomors living on the banks of the rivers of the Terskiy coast and in the basin of the White Sea, having a traditional way of life, as well as those serving wealthy tourists who annually come to salmon fishing from all over the world (this type of tourism is very expensive).

Developing Arctic tourism is a serious competitor for cage culture of Atlantic genetically modified salmon. So, tourism development plans to implement a large project in the Pechenga Bay by 2025, including the construction of berths for mooring cruise ships, as well as eco-hotels and other infrastructure [24]. At the same time, an enterprise for cage farming of genetically modified salmon with a developed infrastructure is already operating here. There is a high probability that they will not be able to develop together, and priority will be given to tourism, which will lead to a significant reduction in the volume of genetically modified salmon farming.

The study concluded that full import substitution of salmon products previously supplied from Norway can be provided by joint deliveries to the Russian market of salmon fish products grown at Arctic enterprises and delivered from the Far East by water transport via the NSR. The success of selling them to consumers, in our opinion, will mainly depend on pric-

[22] Kakuyu pol'zu prinosit i kakoy vred nanosit vyrashchivanie lososya [What are the Benefits and the Harms of Salmon Farming]. URL: fishnet.ru›news/aquaculture_news/86112.html (accessed 17 December 2020).

[23] Vovchenko E. Eksperty raskhodyatsya v otsenkakh perspektiv stroitel'stva lososevykh ryborazvodnykh zavodov na Sakhaline [Experts Differ in Their Assessments of the Prospects for the Construction of Salmon Hatcheries on Sakhalin]. URL: ecosakh.ru›…rashodyatsya…lososevyh-ryborazvodnyh… (accessed 17 December 2020).

[24] Nauchnye i prikladnye osnovy ustoychivogo razvitiya i modernizatsii morekhozyaystvennoy deyatel'nosti v zapadnoy chasti arkticheskoy zony Rossiyskoy Federatsii: otchet o NIR (promezhut.) [Scientific and Applied Foundations of Sustainable Development and Modernization of Marine Economic Activities in the Western Part of the Arctic Zone of the Russian Federation: report on research (inter.)]. Apatity, 2020, 128 p.

es, since Russians are not sufficiently informed about the advantages and disadvantages of these types of fish products. Rospotrebnadzor should carefully monitor GM salmon in various positions, including informing buyers that farmed salmon belongs to genetically modified products.

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