

Development of safety system in salmon fish farms of the Murmansk region

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Abstract. The study presents the development of a biosafety system in aquaculture activities on the territory of the Murmansk region, accounting for the existing scientific developments and recommendations. The authors' scientific and practical experience in cultivating the hydrobionts in the conditions of the Polar region is the core of the study. The materials for the development of the regional biosafety program of salmon cages farms were the longstanding epizootic and ichthyopathological studies of the department of fish physiology and diseases, aquaculture objects of the Murmansk Regional Animal Disease Control Center (2013–2019). The most significant risks for salmon net farms of the Murmansk region are: carrying out activities in the zone of risky fish farming; lack (or scarcity) of high-quality nursery material of domestic origin, absence of the center for research and prevention of fish diseases; the absence of the specialized enterprise for aquaculture waste disposal. The developed system of practical safety of aquaculture enterprises in the region will allow managing the risks through certain efforts and events. The principles of biosafety system development in accordance with the environmental requirements and associated conditions for maintaining the epizootic and ichthyopathological safety in the commercial cultivation of fish are considered. Preventive measures to maintain epizootic safety in fish farms have been developed. Suggestions and recommendations are formulated to conduct safe aquaculture activities in the conditions of the Murmansk region. An integrated approach to biosafety through certain risk management activities is aimed at solving the problems of preserving the health of cultivated objects resulting in the maximal feasibility of the enterprise and maintaining the biodiversity of natural communities and environmental sustainability in the region.

1 Introduction

Biosafety is a widely used term in relation to the technology of food production, human habitat and agricultural animals and plants used to manufacture the food products. As for the aquaculture, high quality foods can be obtained only from healthy hydrobionts grown in healthy water environment. Biosafety in aquaculture involves three main components: 1) biosafety of food from hydrobionts produced in aquaculture (food safety); 2) biosafety of cultivated hydrobionts (safety of fish farms); 3) biosafety of the environment (environmental safety) in which aquacultural activity is performed.

Biosafety Program System is one of the methods for reducing the conflicts between aquaculture, the environment and other users of water resources. One of the modern approaches to the solution of biosafety issues is the use of risk analysis [1, 2]. Using an integrated approach, with certain activities, it is possible to solve the problems of preserving the health of cultured hydrobionts, protect the wild populations biodiversity, promote environmental sustainability and ultimately

ensure the food safety. An integrated management strategy for commercial, environmental and social risks is aimed at sustainable growth in the Aquaculture sector [3]. The prevention of hydrobiont diseases, the main focus of aquaculture, is a sign of the developing industry, but prevention requires state support and innovation. Diseases remain an economic and social problem. Understanding the economic consequences of hydrobiont diseases is necessary for the financial assessment of the alternative options and finding potential solutions, which can be provided by the concept of biosafety and preventive measures, and shed light on how to share the limited financial resources, and on the investment opportunities.

In the Murmansk region, as the results of integrated social, economic and environmental research in the northern seas show, aquaculture can be considered as one of the most sustainable types of man-made activities on the inland reservoirs of the Kola Peninsula and in the coastal zone of the White and Barents Seas. The development of aquaculture leads to the creation of new jobs, stabilizes the food situation in the region.

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The objective of the study is to develop a biosafety system and measures for its implementation in economic entities engaged in the activities of aquaculture on the territory of the Murmansk region, considering the existing scientific developments and recommendations. The main tasks are: to carry out a detailed risk analysis in terms of the occurring possible pathological phenomena and reducing the volume of ichthyomass; develop a number of preventive measures to preserve epizootic safety; devise a technological scheme for arranging the biosafety system in the fish farm. The development of the practical biosafety system of an individual enterprise in this region will allow to manage risks through certain efforts and events.

2 Materials and methods

This study is based on the authors' scientific and practical experience in cultivating the hydrobionts - trout and Atlantic salmon, mussels, laminaria in the conditions of the Murmansk region.

The materials necessary for arranging the biosafety system in fish farms in the North-West region of Russia were analyzed. A survey of legal documentation regulating the activities in aquaculture, aquaculture farms use in their activities, was conducted.

Materials on biotechniques of rainbow trout and Atlantic salmon cultivation in the northern reservoirs, were thoroughly examined taking into account the Norwegian experience and the experience of Murmansk researchers, practitioners dealing with cultivation in the fish farms of various ownership types in the Murmansk region [4, 5, 6].

The basis for the development of the integrated regional program regional program for biosafety on salmon farms were the longlasting materials (2013-2019) on epizootic and ichthyopathological studies of salmon fish grown in the fish farms of the Murmansk region, collected by the employees of the department of fish physiology and diseases, aquaculture facilities of the Murmansk Regional Animal Disease Control Center (MRADCC).

The materials of international agreements on the prevention of the spread of fish diseases in the northern fish-farms and water bodies of Scandinavia and other European countries were analyzed. Instructions and guidelines for assessing the epizootic situation, methods of diagnostics and prevention of invasive and infectious diseases of salmonids in the conditions of the North-Western region were studied [7, 8, 9]. The veterinary regulations of European countries with intensive development of aquaculture have also been examined.

3 Results and discussion

In recent years aquaculture is quite a dynamically developing direction of the Murmansk region's fishery complex activities. A promising direction of aquaculture

in the region is the trout culturing in the freshwater sea water and coastal fish farms and the cultivation of Atlantic salmon in marine farms. Currently, the production activities on the territory of the Murmansk region are performed on 32 territorially isolated fish farms of industrial type: fry farms, sea and freshwater cages fish farms, the pilot experimental mussels cultivation farm.

3.1 Developing the safety system is the legal regulation in aquaculture

Aquaculture is in direct conflict with the economic, environmental and social interests of other consumers of the fresh and sea water resources. A more efficient biosafety program is one of the tools for reducing the conflicts. To overcome the conflicts, the most important step is the formation of a rigid legal basis of the coast use, in particular, the definitions of legal rights to water, land, biological resources. In general, key issues include environment and consumers safety, sustainable use of the resources and production development. The rapid expansion of the aquaculture sector has generated a diverse set of international, regional, national and local regulations on veterinary, environmental protection, regulatory functions of various agencies, which reflects the historically established approach to regulation in this area.

Russian aquaculture enterprises rely on their activities are based on the fundamental environmental legislation of the Russian Federation (RF), on the acts regulating the work activities on the preservation of water biological resources and their habitats, and the main documents in the field of veterinary medicine. The legislative framework in the field of aquaculture in the Russian Federation is currently ambiguous and contradictory, there is a permanent process of making changes, and the question of bringing it to the integrated unity is still unresolved.

It is necessary to better coordinate with the legislation at the European and national levels. When developing the safety system, it is necessary to consider the experts' views who works directly with the fish farms and to actualize the existing regulatory framework to the realities of life. It is required to speed up the process of formation and adoption of both regional rules and federal laws.

Despite the development and introduction of regulatory subordinate acts to the fundamental framework in the field of fisheries and preservation of water biological resources, aquaculture, environmental legislation, however the number, complexity and seriousness of the risks of aquaculture activities are not reduced. Therefore, the development of a biosafety system for each economic entity, taking into account considering certain features, first of all, primarily the aquatic object, where the fishing farm is located, the biotechnics of breeding and maintenance of the breeding

biotechniques and aquaculture object's maintenance is relevant and justified.

The issue of preserving the Atlantic salmon gene pool in the rivers of the Murmansk region arises in terms of progressive anthropogenic press on fisheries water bodies, including the activities in the aquaculture sector. In this regard, it is important to actualize the system of state control over the habitat of this valuable species of commercial fish in accordance with the current regulatory basis.

At the regional level, problems and trends are determined, including interregional importance, requiring measures taken by the subject of the Russian Federation for the sustainable development of aquaculture in a particular region; programs and recommendations for adopting the measures aimed at solving aquaculture problems of are being developed.

It is especially important for the adjacent regions, where hydraulic connection of the fisheries water objects

is observed. In order to plan and implement joint activities, in terms of conservation of the Atlantic salmon habitats and information and experience exchange, interdepartmental agreements are concluded, task teams and commissions working on a regular basis are created. To address the biosafety issues of fish cultivating and processing, it is necessary to improve management in the aquaculture sector.

3.2 Basic environmental risks in salmon fish farms

When developing an integrated aquaculture biosafety program, the analysis and classification of the main environmental risks, occurring in the salmon cages farms of the Murmansk region has been done. The most significant risks in the implementation of commercial fish farming and for the purposes of artificial reproduction are presented in the table.

Table 1. Environmental risks and solutions in the implementation of commodity fish farming in the Murmansk region.

Risks	Solutions	Events in fish farms
Implementation of activities in the risky fish farming zone	Creation of regional scientifically based fish farms, considering the climatic conditions of the Murmansk region, the characteristics of water bodies and aquaculture objects	Implementation of activities in accordance with fish-breeding and biological recommendations or approved instructions, taking into account the adaptation of acceptable methods to polar conditions
Absence (or lack) of high-quality cultivation material of domestic origin	Construction of fish farms on the territory of the Murmansk region. Developing salmon species repair and brood stock. Construction of modern incubatories	The use of high-quality selection cultivation material. Compliance with quarantine measures when importing the cultivation material.
Lack of a center (laboratory) of research and prevention of fish diseases	Creating an interdepartmental center for the research and implementation of methods for fish diseases control and prevention. Development of express methods for diagnosing the diseases. Development of therapeutic feed and vaccines of domestic origin. Immediate informing about monitoring the infectious and especially dangerous fish diseases; outbreaks of new diseases not registered in the region previously	Veterinary control throughout the cycle of cultivation. Compliance with the principles of responsible fish farming. Long-term contracts work with specialized accredited laboratories and conducting production activities under scientific supervision of specialized fishery bodies
Lack of a specialized enterprise for the disposal of aquaculture waste products	Developing a system and the specialized enterprise for the disposal of infected fish and wastes from aquaculture products processing	Instructions for the collection and processing of wastes from aquaculture products processing to ensure epizootic and epidemiological safety on the territory of fish farm

The risks considered for the Murmansk region are generally relevant to other regions of Russia [10].

3.3 Formation of biosafety conditions is the compliance with the environmental principles of safety

The development of commodity fish farming will be successful if the fish farm produces the commodity fish

in compliance with the principles of environmental safety and focuses on the preservation of the ecosystem in the location area [11, 12, 13]. Following the environmental principles is necessary to obtain high-quality and safe aquaculture products. Biosafety of salmon fish farms is based on the principles of the so-called precautional approach.

The specification of these principles is reflected in the "biosafety system" of an aquaculture enterprise,

which is developed taking into account the characteristics of a particular fish farm, is approved by the enterprise's authority and is obligate for strict execution by the staff. According to the current legislation of the Russian Federation in the design and implementation of works in fishing areas intended for the placement of net modules in a water facility, in fish-water sections and coastal structures owned by the enterprise, measures are also provided for the maximum prevention of the adverse effects of aquaculture facilities on water biological resources, conditions of the habitat and reproduction.

Aquaculture activities are carried out in accordance with the recommendations of the fish-breeding and biological substantiation or approved instructions, considering the adaptation of the methods applied to the northern climatic zone. When implementing the projects related to commodity fish farming in the Murmansk region, it is necessary to consider the following:

1. It is recommended to distribute the objects and the execution of fish-breeding works in places, time and methods that have a minimum unfavorable effect on the aquatic ecosystems.

2. When designing a fish farm in general and, in particular for each fishing area (net complex), scientific studies are conducted to assess the impact of commercial fish farms on the water biological resources of the water body, taking into account other fishery reservoirs included in the hydrological system as a whole.

3. The specific "Plan for a fish farm production activity" contains the section devoted to environmental safety, its essential component being the maximum reduction of anthropogenic load in the area of the aquaculture activities and processing the cultivated production.

4. To ensure the execution of the "Plan for a fish farm production activity" specialized scientific organizations develop a fish-breeding and biological substantiation on the request of the enterprise. It includes the following tasks: determining the hydrology and -hydrochemical conditions of water systems for the net farms purposes; assessing the biodiversity of natural communities in the area of net fish farm's location; evaluation of the environmental consequences of man-made impact on commodity fishing; the proposals of optimal methods of fish-breeding and obtaining high-quality and safe aquaculture products; development of environmental and compensatory events.

Based on the studies conducted and the tasks' solutions proposed, the possible volumes of commercial production are determined, which can later be corrected depending on the degree of influence of the fish farming on the ecological condition of the water used.

In this regard, the obligatory principle of the fish farm is to monitor the breeding conditions of the total volume of the fish cultivated and the pollution level of the water biological resources' habitat. The most effective way to implement such control measures is the

work on long-term agreements with specialized accredited laboratories and conducting production activities under scientific support of specialized fishery scientific institutions (Table 1).

The encouraging factor in the development and execution of the biosafety system at aquaculture enterprise is the authority's and manager's understanding of necessity to execute the environmental laws when working with biological objects. Saving the habitat for aquatic bioresources (populations of hydrobionts in the natural environment) and the creation of habitats for salmon species in accordance with their physiological requirements is an essential aspect of the overall biosafety system.

Environmental parameters must be fully integrated into all types of activities in the Arctic zone, by the regional countries accepting the common environmental criteria for the use of natural resources and pollution prevention.

Thus, the implementation of activities in the zone of risky fish farming in the conditions of the Polar region puts the task of creating a unified system in the aquaculture management, which would allow promptly and prospectively, in accordance with the feasibility studies and the objectives of the enterprise's activities, solve the issues from the cultivation of aquaculture objects to the sales in accordance with the market requirements.

3.4 Quality cultivation material of domestic origin is the basis of the fish farm biosafety

Spreading of the diseases dangerous for commercial cultivation facilities and for wild species of valuable associated with the delivery of cultivation materials and fish from abroad and neighboring regions of the Russian Federation cause certain danger. Invasive animals and pathogenic organisms can be carried with living fry and even in the water. International and interregional trade - of live fish trade (larvae, fry, adult) is associated not only with the risk to fish health due to the possibility of transferring pathogens, but also to the risk of breeding material death, for being not adapted to the temperatures of the Kola Peninsula reservoirs during the period of stocking in a fish farm. The physiological non-availability of cultivation material will lead to the death of large amounts of fish, which will cause not only economic losses, but will also lead to negative environmental consequences, primarily in the area of commodity farms [14].

Mandatory measures to verify the safety and health of cultivation material imported to the fish farm are based on the principles and provisions of the current environmental and veterinary regulations of the Russian Federation, as well as harmonized with international standards and requirements of the International Epizootic Bureau (World Animal Health Organization) in the field of aquaculture [15].

There are a few specialists having profound practical experience in the field of commercial cultivation of the Atlantic salmon in Russia, therefore, for the fish farms beginners, simple, affordable and integrated methods of quality control of the acquired cultivation material, harmonized with generally accepted international norms, should be put into practice of the Russian marine fish farming. In Russia, there are no incubators and plants for the production of the Atlantic salmon juvenile for marine commercial farms. In this regard, fish farms are forced to buy fry (smolt) adapted for living in seawater, in Norway, Scotland and other countries with developed industrial fish farming. Considering the longstanding and multifaceted experience of neighboring countries, in particular Norway, attention should be paid to the problems associated with marine fish farming in terms of fish diseases [3, 16]. The scientific studies of Norwegian institutions, both of specialized fisheries and of veterinary, are aimed at developing the sustainable development programs of aquaculture and the national biosafety system in aquaculture.

Thus, one of the first principles of biosafety is the use of high-quality cultivation material.

The system of epizootic safety in the fish farms is arranged through the active implementation of international standards and strengthening the precaution approach "One health for all" based on the association of state and non-state enterprises. It involves strengthening the efforts for the disease's prevention at the level of fish farm, due to responsible fish farming and the expansion of understanding of the necessity to ensure ichthyopathological safety (lack of diseases).

The more intensive the cultivation of salmon and the higher the density of cultivated fish in the cages, the more carefully preventive measures should be carried out, they should become an integral part of all fish-breeding operations [9, 14].

Veterinary observation of aquaculture objects throughout the technological cultivation cycle is the basis for the sustainable development of aquaculture and its safety (Table). Fish of all age groups, including breeders and fish from repair groups, are examined when transferred from one reservoir to another, as well as while test seining in the cultivation season (no less frequency - once a month). If the infectious disease is suspected, fish pathological material from is sent to the veterinary laboratory, simultaneously measures to prevent the spreading of the disease are taken.

3.5 Veterinary and sanitary proposals and recommendations for conducting the activity in salmon fish farming include:

1. Compliance with the requirements of the current environmental and veterinary legislation of the Russian Federation.
2. Considering compulsory, the prevention and control measures to prevent the infection and

- invasion, as well as precaution measures to prevent the fish loss.
3. Excluding the use of antibiotics and stimulants in cultivation of fish.
4. Using medical drugs and disinfectants for the prevention of diseases and infections caused by parasites only in accordance with the manufacturers' instructions and manuals.
5. Using certified in Russia, standard, granulated salmon feed. Aquafeed is supplied to the farm with the corresponding veterinary accompanying documents.
6. Slaughtering and bleeding of fish in the waters of inlets and bays is prohibited. Slaughtering is done in compliance with sanitary standards and rules, as well as the requirements of environmental legislation in terms of environmental protection against biological and other pollutions.

When implementing the project of cultivating the salmon species, a compulsory condition is the observance of environmental activities and recommendations of state specialized fisheries agencies to preserve water bioresources and habitats. Compliance with the following requirements is supposed:

1. Transportation and movement of salmon fish species should be carried out under the control of veterinary service specialists and in the way to reduce the possibility of pathogens transferring of infectious and invasive diseases and parasites, as well as genetic and other biological interactions. Mechanisms for monitoring the movement of fish should be developed and implemented in the fish farm activities.
2. Implementing the scheme of the escapement catch. This scheme should be coordinated with the veterinary service and the fishery protection bodies in order this catch not to have a negative impact on the stocks of wild salmon.
3. Implementing a specially developed emergency plan in case of an accident, causing great fish escapement.
4. Carrying out the works at all stages of the production process from the delivery of the cultivation material to harvesting from the fish cages, including the transportation of live fish, in accordance with the established veterinary and hygienic standards.
5. Careful applying the appropriate cultivation methods in order to minimize the risk of diseases in the cultivated fish. It involves: ensuring the optimal cultivation densities, careful management, frequent inspection of fish, proper diet and feeding mode, excluding stress, disinfection of equipment used during farm transportation and fish farm maintenance.

6. When clinical signs of diseases appear, it is necessary to inform the state veterinary service immediately. The infected, dead or dying fish should be withdrawn from the cages and disposed, together with production waste, according to the measures agreed on with the veterinary service.
7. Fish farm capacity must correspond to the selected site, and cultivation density should not exceed the level established on the basis of breeding practices. The mode of "fallowing" should be used as a means of reducing the biological burden on the water area and for the prevention of diseases and parasitic invasions outbreaks.

For biologically safe and sustainable aquaculture development on the territory of the Murmansk region the integrated, ecosystem approach should be further improved.

4 Conclusion

The integrated approach to biological safety in fish farms through certain activities is intended to solve problems of preserving the health of cultivated hydrobionts, to protect the biodiversity of wild populations, to promote environmental sustainability and ensure food safety through certain activities. The most significant environmental and epizootological risks for salmon cages farms of the Murmansk region are: carrying out activities in the risky fish farming zone; absence (or lack) of high-quality cultivation material of domestic origin; lack of a specialized center for research and prevention of fish diseases; lack of the system and a specialized enterprise for the disposal of aquaculture wastes. A technological scheme for developing an aquaculture biosafety system allowing to manage the risks through certain efforts and events has been developed.

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