

Development of commercial trout breeding in southern Russia in the context of the import substitution strategy

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Abstract. Aquaculture is the main promising direction for the development of the fisheries industry. Analysis of the general condition of fish breeding enterprises and the potential for expanding production shows that the growth trend of traditional for the southern regions pond fish breeding is weak. A significant problem for the development of aquaculture is the high price of fish products and, accordingly, low demand. A substantial reduction in the cost of fish production is currently unlikely to be achieved, so switching to more valuable fish varieties can stimulate consumption. To ensure the development of the fish products market and increase demand, entrepreneurs in southern Russia are improving technologies for growing such valuable fish varieties as salmonoids, in particular, rainbow trout. Studying the activities of trout farms requires taking into account which area of activity is prioritized. A farm can produce marketable fish or fish planting material, as well as execute both types of production. The work observes the organizational features of trout farms and promising directions of their development. Solving such key issues as the provision of qualified personnel, high-quality feed of domestic, preferably regional production, and provision of logistically affordable and high-quality planting material is the basis for achieving the goals of import substitution for high-quality fish products in Russia.

1 Introduction

For the effective functioning of the agricultural sector, it is necessary to develop all its areas, taking into account the most profound development of those sectors that are most profitable for specific natural and climatic conditions. The development of the fisheries industry is vital for achieving the food security of the Russian Federation, since fish products are the most accessible source of animal protein and microelements. Despite the difficulties accompanying the production of commercial fish and aquatic organisms, the development of this industry is necessary to improve the life quality of the population.

For a long time, a significant share of fish products in the Russian market was imported. Modern economic and political realities require substitution of all possible groups of fish and seafood products with Russian-made goods. The stated development goals require a

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constructive approach to the reorganization of already existing enterprises and the organization of new enterprises producing fish products [1].

An important indicator of the level of development of the sector and of consumer demand's meeting is the amount of annually consumed product per person [2]. According to the board materials based on the results of the activities of the Federal Agency for Fisheries (hereinafter referred to as the FAF) during 2022, in 2021, the consumer accounted for 21.7 kg per year, and in 2022 - 22.6 kg. However, the production of processed fish and seafood decreased by 6% in 2022. The volume of imports of fish products decreased by 22%, which indicates, in general, a decrease in its availability to the consumer.

It must be remembered that the fishing industry is an economic sector that contributes to social stability and provides employment in a number of constituent entities of the Russian Federation. The state program for the development of the fishery complex No. 314, adopted by the Decree of the Government of the Russian Federation dated April 15, 2014, reflects the economic and social indicators that must be achieved. For the Far Eastern fishery basin, fishery enterprises that extract, process or reproduce fish resources using aquaculture technologies can be an important part of the social structure, often settlement-forming, determining employment, income and social integration of residents of specific settlements [3].

Due to the temperature condition, the southern regions of Russia are favorable for the development of aquaculture and belong to zones with historically established fishing traditions.

The south of Russia belongs to the fifth and sixth fish-breeding zones, which causes both a significant increase in the cultivation of commercial fish using the least expensive technologies, as well as the most popular fish farming facilities, characterized by natural or acquired as a result of acclimatization adaptation to the temperature and hydrochemical characteristics of the region [4]. However, currently it is difficult to say that the biological and economic potential of aquatic biological resources, both on a national scale and in the South of Russia, is used quite effectively.

Industrial fishing in the South of Russia is largely limited by the depletion of populations of commercial facilities, both as a result of economic activity and due to adverse climatic factors, as well as high anthropogenic pressure. According to the materials of the FAF board, in 2022 for the Azov-Black Sea basin, the catch amounted to 38 thousand tons, which is 32% less compared to 2021. Almost 30 thousand tons of extracted aquatic biological resources were sprat, anchovy and kilka, species that are not too valuable as food and have a low market value [5]. The trend towards a constant decrease in catch is currently intensified by the fact that a number of areas of the Azov and Black Seas' waters are designated as prohibited and temporarily dangerous and closed to fishing.

Therefore, the main promising direction for the development of the fisheries industry is aquaculture. A significant amount of commercial production of aquatic biological resources is carp and herbivorous fish, for example, silver carp. The traditional object of fish farming is sturgeon. However, recently, the range of fish breeding facilities begins to expand, in particular due to the urgent need to replace the supply of imported fish products. Such objects as rainbow trout and channel catfish appear in it [5].

Analysis of the general condition of fish breeding enterprises and the potential for expanding production shows that the growth trend of traditional pond fish farming for the southern regions is weak.

In the Krasnodar Territory, the area of fresh and slightly saline reservoirs suitable for fish farming is more than 500 ha, area of reservoirs for intensive cultivation is 50 thousand ha, while the operation of reservoirs for intensive cultivation is carried out by no more than 60%, and only half of the territories are used for the production of fish-planting material (5 thousand ha).

The general fund of fishery reservoirs of the Stavropol Territory and the Republic of Kalmykia is represented by large rivers, such as the Kuban, Terek, which, together with the territories of comprehensive use reservoirs, is more than 70 thousand ha). Less than half used. The Astrakhan Region has significant natural potential for the development of the fisheries industry, but growth is hampered by infrastructure problems.

In recent years, aquaculture in the Rostov region has been developing most intensively, compared to other southern regions. The total area of reservoirs suitable for various types of fishery activities is exploited by 80%, fish productivity reaches 15–16 centners per hectare. In the Rostov region, both farmed fish breeding and large organizations focused on the production of more than a thousand tons of products annually are developing rapidly.

According to the FAF board, in 2022, the total volume of aquaculture production in Russia amounted to 384 thousand tons what is 7,5% more than it was previous year, taking into account that, growing 82 thousand tons of fish, the Southern Federal District ranks second in terms of production after the Northwestern. However, it must be admitted that production increase in the Southern Federal District was achieved mainly by the means of carp production (output 73,8 thousand tons, which is 1,4% more compared to 2021). Salmon production has also increased, but it is only 2,5 thousand tons, what compared to carp production is more than modest (figure 1).

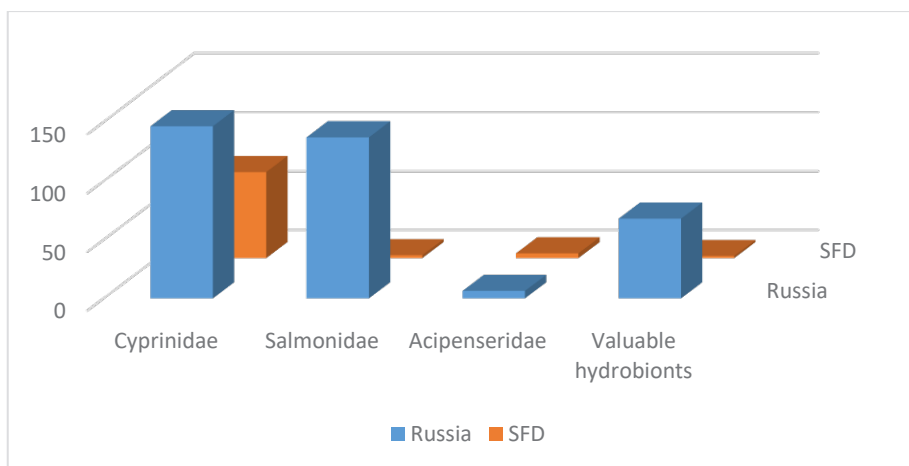


Fig. 1. production of commercial aquaculture in Russia and in the Southern Federal District (the materials of the FAF board according to the results of 2022)

Meanwhile, a significant problem for the development of aquaculture is the high price of fish products and, accordingly, low demand. A substantial reduction in the cost of fish production is currently unlikely to be achieved, so switching to more valuable fish varieties can stimulate consumption. To ensure the development of the fish products market and increase demand, entrepreneurs in the south of Russia are developing technologies for growing such valuable fish varieties as salmonoids, in particular, rainbow trout. In the report on the production of aquaculture products The Federal Agency for Fisheries, data on the production of fish products for 2021 are following: carp fish - 146,4 thousand tons, salmon - 137 thousand tons, valuable aquatic organisms - about 58,7 thousand tons (figure 1).

Trout breeding in Russia began in the 18th century. It was a delicacy intended for the royal table. The discovery by V. P. Vrassky of the "Russian" method of fertilization of caviar formed the basis for the development of work on trout reproduction in the middle of the 19th century, when a factory was built in Valday. The advantages of rainbow trout as an object of

cultivation are its adaptive abilities and growth rate. The high ecological plasticity of rainbow trout assumes existence in the temperature range from zero to 25-28 ° C, the fish can withstand an alkaline environment, high mineralization [6,7].

Rainbow trout is a popular cultivation object, it is bred in South America, Europe, Scandinavian countries. In the countries which actively develop trout-breeding, 1 ha the pond area allows to breed up to 400 tons of fish.

Thus, both in developed and developing economies, it is possible to organize highly productive trout breeding farms that bring profit and stimulate the development of the fisheries sector. The comparison of various forms of trout farms' organization is aimed at identifying the most effective strategies for the development of salmon farming enterprises. The purpose of this work is to study the experience of trout breeding farms and to analyze the opportunities and risks that emerge by the development of trout breeding in the southern Russia.

2 Materials and methods

Studying the activities of trout farms requires taking into account which area of activity is prioritized. A farm can produce marketable fish or fish planting material, as well as execute both types of production. The work observes the organizational features of trout farms and promising directions of their development. The analysis of several clusters of data on the development of the fishing industry in the Southern Federal District allows us to talk about the potential for the development of the industry, and, in the future, about the possibility of developing successful strategic projects on import substitution and the development of regional salmonoids production.

The analysis of the activities of fisheries enterprises is possible highlighting key indicators that will provide quantitative characteristics of the industry development effectiveness. For any economic component of the agricultural sector, social, economic and environmental performance indicators can be distinguished. The social efficiency of an enterprise depends on such parameters as the average number of jobs and wages. This data is available for most enterprises and can be analyzed. The level of industry stability is harder to assess, but indirectly, it can be judged according to the duration of the company's existence. According to Russian Federal State Statistics Service, the length of the working day in the agricultural sector is the longest and is 7.5 hours. But in 2023, the fishing and fish farming sector is leading in this parameter, where the average working day is 8.21 hours.

Environmental efficiency can be assessed by the average level of emissions and waste from the company's activities entering the water basin. It is rather hard to get this data. However, it is possible to assess the degree of waste-free production, the introduction of closed technological cycles at the enterprise, quantitative indicators of waste recycling of hydrobiont production activities.

However, despite the importance of the above characteristics of the industry, the most interesting is the economic efficiency of the fish farming enterprise. The strategy in the company's activities can be aimed at achieving maximum profit at a stable, predetermined cost level, or ensuring some economic effect at minimal cost. So far, in order to assess the economic potential of trout farming enterprises, it is only possible to analyze the effectiveness of individual technical or organizational measures carried out in the fish production.

3 Results

Joint Stock Company "Tribal trout farming "Adler" plant" founded in 1964 is one of the largest fish breeding enterprises in Russia. The total area of the enterprise is 81 ha. The

company has a collection of rainbow trout breeds (mikizha) with altering spawning periods (Babiy, 1997). The collection includes three breeds of mikizha (*Parasalmo mykiss*) of foreign selection – Kamloops, Donaldson and steelhead trout, as well as two own breeds – Adler trout and Adler amber and offsets (Augustine and late steelhead trout).

Breeding works on trout breeding Augustine were aimed at the formation of a sign of early spawning and selection according to the quality of spawn and offspring. Pubescence begins at the age of two years, spawning lasts from August to October. Selection of late spawning steelhead trout is aimed at securing spawning in April-May, i.e. one and a half to two months later than the main group, and the ripening age of 3-4 years, for the supply of planting material to farms growing large-sized trout of 3-4 kg.

The selection of breeding lines allows the production of fish spawn for 9 months from September to May, in total the plant produces up to 6 million pcs. of fish planting material of different ages annually. In addition, the farm produces up to 800 tons of commercial fish per year. The producers' collection is 30 thousand individuals and its maintenance requires significant costs.

The analysis of the organizational features of the "Adler" breeding plant showed, first of all, a significant resource of material funds that have been preserved and constantly modernized since the establishment of the enterprise in 1964. The area of ponds and pools containing spawning schools and commercial fish is 3489 ha. The water supply is carried out from 39 artesian wells with a depth of 35-40 meters, water is pumped at a speed of 0.7-0.9 m/sec. One of the significant costs of the enterprise is the increase in the cost of electricity consumed by pumping units, as well as the current consumption of the enterprise, from 8.5 to 10.3 million kV/h annually. An isolated water supply source ensures the absence of suspensions, water impurities and pathogens of dangerous parasitic and infectious diseases in the water, however, the enterprise carries out constant monitoring of the water condition.

To assess the effectiveness of the technologies used at the enterprise, the change in the mass of juveniles at some areas during its import and export, as well as the intermediate sample weight was studied (table). For these periods, the increase in the average juveniles weight was from 31 g up to 67 g, waste in each of the ponds is not more than 10% (table 1).

Table 1. Change in the weight gain of trout juveniles at the production areas of JSC "Tribal trout farming "Adler" plant"

	<i>Delivery</i>	<i>Intermediate sample weight</i>	<i>Outflow</i>
<i>812 (RAS)</i>			
<i>Date</i>	<i>28.05.21</i>	<i>29.06.21</i>	<i>30.07.21</i>
<i>Sample weight, g</i>	<i>29,5</i>	<i>44,3</i>	<i>80,7</i>
<i>Number, ths. pcs.</i>	<i>10,5</i>	<i>–</i>	<i>9,7</i>
<i>802 (RAS)</i>			
<i>Date</i>	<i>17.06.21</i>	<i>29.06.21</i>	<i>30.07.21</i>
<i>Sample weight, g</i>	<i>37,4</i>	<i>41</i>	<i>88</i>
<i>Number, ths. pcs.</i>	<i>10</i>	<i>–</i>	<i>9,5</i>
<i>214 (Pond)</i>			
<i>Date</i>	<i>20.05.21</i>	<i>19.06.21</i>	<i>29.07.21</i>

<i>Sample weight, g</i>	30	57,7	97
<i>Number, ths. pcs.</i>	11,9	–	11
206 (Pond)			
<i>Date</i>	19.03.21	29.04.21	22.05.21
<i>Sample weight, g</i>	44	52	75
<i>Number, ths. pcs.</i>	17,6	–	16,5

Reproductive characteristics of females of breeds grown at the enterprise exceed regulatory requirements by 1.2-2.2 times. The highest fertility has Donaldson trout and Adler trout. The largest spawn is produced by female steelhead trout, and the smallest by the Kamloops trout. The fish growth rate of different breeds in the first months of their rearing is the same, which indicates similar growth potentials of individuals in the early stages of development.

Another enterprise considered as promising is trout farming is LLC "EcoDon" located in the small village Volochensky, Kamensky District, Rostov region. The enterprise was opened in 2022. The complex farm is designed to grow trout up to a maximum sample weight of 1.85 kg with a capacity of up to 200,000 kg per year. Fertilized eggs in the amount of 300,000 pieces in each stocking cycle are used as planting material. Fish farming is carried out in recirculating aquaculture system, the production process is automated. Monitoring of the water condition is carried out using an automated control system, monitoring the condition of hydrobionts requires the participation of qualified personnel.

4 Discussion

Analyzing the data obtained as a result of the study of the activities of fish farms of various directions, it was possible to identify the main difficulties that fish farms have to face. Since the main direction of development of fisheries in general and trout farming in particular is import substitution, it is assumed that planting material, feed and equipment of domestic production will be used. The domestic market provides with a sufficient number of RAS equipment. But most farms depend on the import of planting material. Trout farming companies in Karelia, Alanya and Ossetia grow 95% of their products from imported spawn. The fish farming LLC "EcoDon" which is observed in this work imports fertilized eggs from Denmark, South Africa and Italy. The import of planting material requires veterinary control, additional customs clearance and competent logistics, which leads to a significant increase in production costs.

The presence in the Southern Federal District of such a large farm for growing planting material as the "Adler" breeding plant, it would seem, should solve the problem, but with the constant appearance of new small enterprises, the resource capacity of the plant is not enough. To create a high-capacity production and sufficient volumes of high-quality planting material, the resources of small and medium-sized businesses are not enough. Therefore, state support is needed for the development of trout farming. According to the Ministry of Agriculture, in 2023, 115.7 million rubles were allocated to support the fisheries industry in the Rostov Region, and only 35 million in the Krasnodar Territory, while a significant part of the support is intended not for business projects, but for enterprises for the artificial

reproduction of aquatic organisms, mainly sturgeon and other rare aquatic organisms. However, the strategic goals of import substitution for the fish industry are no less important, but without thoughtful support, the possibility of their implementation is doubtful.

A significant part of the costs of trout cultivation falls on the purchase of high-quality feed, since all farms use imported feed. As can be seen from the presented data, the most efficiently functioning farms use recirculating aquaculture systems or cement basins, therefore, the feed used must contain all the nutrients that a hydrobiont would receive in a natural environment. In addition, the degree of digestibility of the feed and its caloric content should ensure accelerated growth of the hydrobiont and, if possible, reduce the degree of stress caused by high planting density. Most trout farms use feed produced by "Coppens" (Netherlands). This is a high-quality feed, but its use is associated with logistical problems and high cost (from 7 to 10 thousand rubles per 20 kg).

Therefore, the main activity to reduce the share of imported components in domestic products should be the development of domestic feed formulations and the creation of production enterprises in the regions for the production of fish feed [8,9]. Biofortification, the enrichment of feed for commercial cultivation facilities with substances especially valuable for human nutrition, is a promising, but not yet sufficiently implemented direction in feed development in Russia. Experiments on biofortification of fish feeds by meal obtained from kelp have shown a significant increase in the amount of iodine in the tissues of rainbow trout. In Russia, it is possible to obtain a sufficient number of ingredients to create innovative formulations, the problem is the development and testing of the composition of feed for salmonoids [10,11]. Currently, there are developments of improved feed formulations, with probiotic additives [12], as well as vitamin and mineral supplements [13,14]. Additional research is needed to ensure that these formulations are adapted for trout.

The list of trout farms that we have analyzed shows that for the most part these are farms for the production of small batches of commercial fish, depending on the turnover rate of funds, and they are not able to allocate resources for joint activities with fish farming enterprises [15]. Therefore, the expansion of scientific research on the basis of research institutes and specialized universities could contribute to solving the issue of developing feed formulations, especially since there are 4 large agricultural universities and 5 branches of VNIRO in the Southern Federal District. However, the creation of feed production on an industrial basis remains a key problem for increasing the profitability of the trout farming business.

5 Conclusions

The conducted analysis of the efficiency of trout farming enterprises showed insignificant social efficiency of these companies. Most fish farming enterprises in the south of Russia face the problem of a shortage of qualified personnel. None of the large fish farming enterprises is city-forming and provides a significant number of jobs. Large enterprises, such as the "Adler" breeding plant, are still rarely found in the south of Russia, where trout is not a traditional object of cultivation.

Economic efficiency is more noticeable. A significant part of the material assets of this plant was acquired as a state investment, and it was breeding work, the foundations of which were laid as fundamental developments of the Soviet period of fish farming science. The main guarantee of the economic efficiency of this enterprise is its comprehensiveness. The production of both commercial fish and fish planting material allows the company to meet the changing market trends. In addition, the company carries out recreational activities,

providing opportunities for amateur fishing. The success of this activity is facilitated by the location of the enterprise in close proximity to large resort centers.

"EcoDon" LLC, as a young and developing enterprise, has not yet reached the full production capacities achievable for a high-level technological equipment enterprise, but already now the enterprise needs qualified personnel, both fish breeders and specialists in the field of software. Solving such key issues as the provision of qualified personnel, high-quality feed of domestic, preferably regional production, and provision of logistically affordable and high-quality planting material is the basis for achieving the goals of import substitution for high-quality fish products in Russia.

In conclusion, we can say that business projects aimed at creating profitable and strategically important fish production enterprises are constantly emerging. "The Black Sea Trout" company, which grows trout in marine cages, has been operating in Sochi for two years, a similar enterprise is planned to be opened in Gelendzhik. Industrial fish farming enterprises can be opened even in the low-water regions of the Southern Federal District. Therefore, the achievement of complete import substitution for the production of salmonids is possible with the real interaction of science, business and the availability of state support.

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