Technical and economic indicators calculation for rainbow trout juveniles growing nursery in Murmansk region

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Abstract. The paper describes characteristic features of rainbow trout fish seed material market in Murmansk region and in Russia, gives the description of the main elements of the organizational and production plans of the farm enterprise, presents the fish-breeding calculation of the proposed farm as well as the main technical and economic indicators. The urgency of creating a nursery for growing rainbow trout juveniles in Murmansk region is justified.

1 Introduction

Industrial aquaculture is of particular importance in the northern regions of our country, which have significant reserves of water and energy resources on their territories. Important prerequisites for this are the vulnerability of the ecosystems in these regions and the intensive use of some fish resources, leading to their depletion and the prospect of long-term recovery. Ensuring the food security of the northern regions of the Russian Federation and the country as a whole is based on the complexly integrated economic relations of the Russian Federation subjects with each other and with neighboring states.

The rainbow trout, *Oncorhynchus mykiss*, is one of the most common aquaculture objects. According to the FAO, in 2018, more than 35 thousand tons of rainbow trout were grown in the Russian Federation, which accounted for 12% of the rainbow trout production in Europe. The popularity of this type of trout as an object of aquaculture in Russia is due to the well-developed biotechnology of cultivation, consistently high demand from the buyer and other reasons. These prerequisites create a demand for fish planting material for part-time farms engaged in trout rearing.

Trout farms of Murmansk region mainly buy fish seed material (FSM) in other regions of the Russian Federation. The organization of the farm for the young fish breeding (fish hatchery) on Murmansk region territory is promising, as it will eliminate long-distance transportation and offer commercial farms young rainbow trout at affordable prices.

According to preliminary data from Rosrybolovstvo (Russian Fishery Ministry), in the first quarter of year 2020, the production of fish seed material in the Russian Federation increased by 29.7% and amounted to about 9.2 thousand tons.

The work is relevant due to the need to create an economy that can provide commercial trout producers with seed material at an affordable price on Murmansk region territory.

Objective is to calculate the main technical and economic indicators of a nursery establishment for rainbow trout juveniles breeding and to assess the relevance of this project implementation in Murmansk region. The research materials can be used in a real fish farm projecting.

2 Rainbow trout Oncorhynchus mykiss as an object of cultivation

Rainbow trout is native to the Pacific coast of North America. It is the most eurythermal among salmonids, characterized by a maximum latitudinal distribution.

The migratory form of *O. mykiss* spends the early part of its life in the river, growing and feeding in the sea or in the ocean, after which it returns to rivers and streams to spawn. The living form spends its entire life in fresh water [1]. Anadromous trout are known for their rapid growth and can reach a weight of 7–10 kg in three years, while lake trout can gain up to 4.5 kg in the same period.

2.1 Current state of trout farming

In Russia, in recent years, there has been a rapid growth in trout production, which is currently estimated at 33 thousand tons. Trout farming is carried out in Leningrad Region, Karelia, Altai Territory, Krasnoyarsk Territory, Krasnodar Territory (Adler trout farm), Stavropol Territory (Kislovodsk trout farm) and in other areas. Most trout farms have a small capacity of up to 10 tons of marketable products [2].

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In the Russian Federation, there are breeding trout farms located in the south of the country, in particular, the Federal State Unitary Enterprise "Trout Breeding Plant 'Adler'" (Krasnodar Territory). Caviar is produced from September to March and is supplied to the farms of the Russian Federation and the CIS countries. "Adler trout" can be found in Irkutsk region, Krasnodar Territory, the Urals, Karelia, Kazakhstan and Belarus [3].

"'Forelevy'Agricultural Breeding Plant" JSC has been operating in Kislovodsk since 1935. In addition to caviar, the 'Forelevy' plant sells seed material, its cultivation volume is 800 thousand fingerlings and about 100 tons of commercial trout per year.

In general, according to the FAS, more than 30 economic entities in the Russian Federation produce and sell fish seed material of various breeds of rainbow trout. The leaders in the market of trout seed material are: "Trout Breeding Plant 'Adler'", Federal Selection and Genetic Center of Fish Farming "Ropsha", "'Forelevy' Agricultural breeding plant" JSC, "Virta" JSC, "Chistye Prudy" LLC. Fish farms "Lapland" LLC and "Primorskoe" LLC, located in Leningrad region also play an important role for Murmansk region, due to economic and geographical reasons.

2.2 Trout farming in Murmansk region

Trout farming in the Kola North has been going on for more than 30 years. Rainbow trout are imported to the north-western region from farms in the central and southern parts of Russia, as well as from Finland. The first cage farms were created in the warm waters of nuclear power plants, thermal power plants and in natural fresh water bodies in the 60–70 years of the last century. Their turnover was small and ranged from 5 to 10 tons.

In Murmansk region, the development of trout farming was due to the launch of the Kola nuclear power plant, which discharges heated water into Imandra Lake.

In the mid-80s of the twentieth century, the possibility of keeping trout in the coastal zone of the northern seas was proved [4,5]. Currently, this industry is developing quite intensively in the northern region, and commercial trout farms are being created in the coastal zone of the Barents and White Seas.

Fish production was constrained by the need for annual seed material import from other regions. Thanks to the creation of a brood trout herd with a capacity of 4 million spawn at the Imandra fish hatchery, 350 tons of trout were raised in 1991 [4]. In the early 90s, a new plant for the seed material production – the Arctic Salmon plant – was created in Murmansk region. The plant is located on the territory of Verkhnetulomskaya HPP, it contains a breeding and repair herd, incubates caviar and raises young trout. The farm uses warm water from the cooling system of HPP generators.

Other closest suppliers in the Russian Federation are located in Karelia, where several companies grow rainbow trout for sale: "Virta" JSC (part of "Kala-Ranta" JSC group), "Karelproducts" LLC, "Kala ya maryapoyat" LLC, "Kintizma" LLC, "Yanisjarvi" LLC. In St. Petersburg and Leningrad region, trout fry is supplied by "Volna" LLC, "Rybstandart" LLC, Federal Selection and Genetic Center of Fish Farming "Ropsha", "Lapland" LLC and "Primorskoe" LLC. In Novgorod region, "Yazhelbitsky Fish Farm" LLC, "RIF" LLC grow trout seed material for sale.

Fish seed material is divided into two main categories:

1. Fertilized spawn at the stage of eye pigmentation
2. Young fish divided into the following categories depending on the age: fry (1–100 grams), fingerlings (50–300 grams), yearling (100–700 grams).

The average prices for young rainbow trout (females) from Russian producers depend on the weight and are presented in Table 1. Prices are taken from open sources, the values are indicated with VAT and without delivery, and are relevant at the beginning of 2020.

Table 1. Average prices for young rainbow trout (female) from Russian producers (including VAT).

Fish weight, g	Price per piece, rub.	Price per kg, rub.
1	10	10000
5	18	3600
10	23	2300
20	30	1500
50	47.5	950
70	51	730
100	77	770

In Murmansk region, commodity farms are mainly stocked in late spring – early summer and in the autumn before the ice period. The greatest demand is for fry weighing 5 grams. Commercial farms prefer fish-planting material, the batches of which are 95% or more are represented by females, who spend less energy on spawning changes in the body, and have better growth rates. In addition, breeding females provides an additional opportunity to obtain spawn.

It is less advisable to order the delivery of juveniles from regions remote from Murmansk region, since it is recommended to deliver fry and fingerlings within a day because it is necessary to control the water temperature and its oxygen saturation. This fact determines the

importance of having some own fry farms in Murmansk region, even if they work on imported fertilized spawn. If the rules of transportation are followed, the caviar at the eye stage can tolerate the road for up to five days.

Prices for fertilized rainbow trout spawn for the final buyer will depend on the purchased batch volume, transportation containers and the transportation distance. Some idea of the cost of fertilized spawn can be made according to Table 2, prices are relevant at the beginning of 2020.

Table 2. Prices for fertilized rainbow trout spawn at the eye-stage from Russian producers.

Batch size	Price per piece, rub
"FORELEVY" CLOSED JOINT-STOCK COMPANY, AGRICULTURAL BREEDING PLANT	
The cost of delivery – from 48 rubles/km and up to 63 rubles/km, depending on the volume of containers transported. The calculation is for the full there and back trip	
Up to 50 thousand items	1.9
From 50 thousand items	1.6
'Adler' Breeding plant JSC	
Prices including delivery to the airport, nearest to the buyer (Russia)	
Monoecious spawn (females)	
Up to 50 thousand items	1.8
From 50 thousand items to 100 thousand items	1.6
From 100 thousand items to 500 thousand items	1.5
From 500 thousand items	1.2
Double-gender spawn	
Up to 50 thousand items	1.6
From 50 thousand items to 100 thousand items	1.5
From 100 thousand items to 500 thousand items	1.3
From 500 thousand items	1.2
'Lapland' Group of Companies: "Lapland" LLC and "Primorskoe" LLC Regardless of the volume of the batch, excluding delivery	2

In Murmansk region, there are currently 13 commercial trout farming enterprises, two of which are focused on commercial mariculture and purchase imported seed material, while the volume of commercial trout produced is steadily growing mainly due to large firms. Thus, there is practically no competition in the market of rainbow trout seed material in Murmansk region.

2.3 Biological and fish-breeding characteristics of rainbow trout

The average life expectancy of rainbow trout is 6-8 years, the maximum is about 11–12 years, and sexual maturity is reached in females by 2–4 years, in males– by 1–3 years.

There are seven stages of rainbow trout embryogenesis: from the blastodisk formation and crushing to the eyes' pigmentation and, then, hatching [6]. The duration of the embryogenesis stages depends on the temperature. In the range of 6–12^{0}C, the period between insemination and hatching can take from 26 to 50 days [7].

The postembryonic development of trout includes the stages of pre-larvae, larvae afloat, fry, fingerlings and sexually mature fish. The duration of development of different age groups depends not only on the water temperature and its oxygen content, but also on the quality and quantity of feed consumed. The fry development from the larva afloat takes 1.5–3 months. The development of fingerlings from fry takes 3–4.5 months. The development of commercial fish from a fingerling takes 4–6.5 months.

When breeding different age groups of rainbow trout, it is necessary to ensure optimal or close to optimal growing conditions for them. The optimal pH range for embryos and fry is 6.5–8.0; in older age groups, both the optimal (6–8.5) and acceptable (4–11) pH ranges are wider [8]. The water temperature ranges for caviar and fry are optimal between 6–12°C, acceptable from 4 to 16°C; for older age groups of trout, the optimal temperature range is 7–20°C, acceptable is 0–25°C.

The appetite of rainbow trout increases when the temperature rises in the optimal range of 7–18 °C. If the water temperature is too low or too high, the fish stops eating [8]. The best increase due to the feed consumed and the optimal efficiency of feed use are observed in the range from 13°C to 15°C [9].

During the spawn incubation and at the first stages of fry ontogenesis, the optimal and acceptable concentrations of O_2 are 5–6 mg/l. In older age groups, the minimum acceptable oxygen content in water can be about 4–5 mg/l. It is important to know that during and after feeding, the oxygen consumption of fish increases significantly [8].

The required amount of water supply depends on the age and number of developing fish in the fish tank, which is determined by the O_2 content in the supplied water. Thus, the actual volume of water required to contain the same number of developing embryos, fry, and fish will vary. At low water temperatures, the volume of water supplied may be less, at higher temperatures – more. It is obvious that the best opportunities to control the environmental parameters at different young trout development stages are provided by the technology of growing in recirculating aquaculture systems.

3 Designing a trout nursery

These calculations are indicative in nature and are intended only to show the general structure of technical and economic indicators in the business planning. The legal support of the project and the time spent on it have not been considered. The calculations are carried out for the creation of a fish hatchery, which provides three production cycles per year. In one cycle, the nursery will produce ~ 330 thousand pieces or 1.65 tons of fry with a weight of 5 g. Thus, the capacity of the projected nursery is 1 million pieces or 5 tons of fish planting material per year. In the end, such a number of juveniles can ensure the production of up to 1.5 thousand tons of commercial trout weighing 1.5 kg.

Table 3. Main characteristics of the project.

The project aim	Creation of an industrial fish hatchery for the cultivation of rainbow trout juveniles in a recirculating aquaculture system
Organizational and legal form of the project initiator	Common household farming
Project location	Murmansk region, Murmansk city
Main types of economic activity under All-Russian classifier of economic activity types	03.2 “Fish farming” 03.22 “Freshwater fish farming” 03.22.1 “Industrial freshwater fish farming”
Planned number of jobs	6 people (including the founder)
Investments	13 mln. rubles

The planned nursery for rearing young rainbow trout *Oncorhynchus mykiss* is a type of cold-water (trout) industrial nurseries.

The nursery will be organized by the principle of closed water supply. Recirculation is based on mechanical filtration, biological purification, aeration and degassing. Taking into account the modular nature of the recirculating aquaculture system, it is possible to add modules for UV disinfection, heat exchange [10], ozonation, and water treatment at the stage of water intake.

The use of a water recirculation system allows to save water and energy resources. For the normal juveniles’ development in the direct-flow water supply system, it is necessary to ensure water exchange every 15 minutes at least and the temperature of at least 6 °C. In the conditions of Murmansk region, this will require high costs for water heating. In general cases, the recirculating aquaculture system requires a daily supply of fresh water in the amount of up to 10 % of the total volume of water in the pools.

The use of the recirculating aquaculture system provides the following advantages:

- no need to place the farm near the reservoir;
- lower volumes of water used and discharged;
- the ability to provide stable conditions, minimizing the impact of external factors, including pathogenic ones;

The disadvantages include the general high cost of operation and high requirements for the personnel qualification.

Monitoring of production parameters allows to grow trout throughout the year. The advantage in the growth rate of fish makes it possible to conduct more production cycles per year, get more profit and compensate for the higher initial investment in the construction of a closed water supply farm compared to a flow-through farm.

3.1 Elements of the organizational plan

The fish hatchery will be registered as a common household farm, the head of which is an individual entrepreneur (IE). The simplified tax system, with a tax rate of 6% of income, will be used. Such farms can receive land acquisition benefits, land lease benefits, and participate in a competition for a business development grant through federal or regional programs to support domestic agricultural producers. The project budget includes an amount of 100,000 rubles for all the costs connected with registering the company, obtaining all the necessary permits and approvals.

To organize a fish hatchery, one will need to rent a plot or a room with an area of 1,000 m^2 with connected utilities: electricity and/or gas supply, water and sewerage, access roads. Staff with appropriate qualifications and work experience will be required to carry out work in the nursery (Table 4).

3.2 Elements of the production plan

The main source of water supply for the fish hatchery will be an artesian well; 250 000 rubles are budgeted for its drilling and a water intake node construction. With such a water supply of the recirculating aquaculture system, it will be necessary to install modules for

aeration and de-ironization of artesian water in the water treatment system. Water well licensing is carried out for 4 years, repeated for 25 years. Approximately 250 000 rubles are included in the project budget for licensing.

Table 4. Fishery staff.

Position	Number	Shift	Salary, rub
Leading fish breeder	1	from 9 to 17 o' clock, 5/2 schedule	60 000
Fish breeder-worker	4	12 hours day time, 12 hours night time, 2/3 schedule	28 500

3.2.1. Construction of insulated hangar room

In order to create a fish hatchery with the use of such a technology, this project involves the construction of an insulated hangar - type room, an arched or a straight-walled one, on the leased site. The hangar will have an effective area of 700 m^2, accommodating the main fish-breeding and hatching shops, a zone for technological equipment, a household area, a laboratory and a "cold" annex for storing feed. The hangar walls shall be made of sandwich panels, overlappings that allow it to maintain the necessary positive temperature of at least 15–18 °C.

3.2.2. Equipment purchases and installation

Equipment for the fish hatchery can be purchased from one of the companies that specialize in closed water supply systems: these companies also install equipment and offer the engineering services for the technical projects development, recirculating aquaculture systems' launch and configuration.

The recirculation system consists of fish-breeding pools, incubators, water treatment section, pumps, pipelines and trays for water supply and discharge (Figure 1).

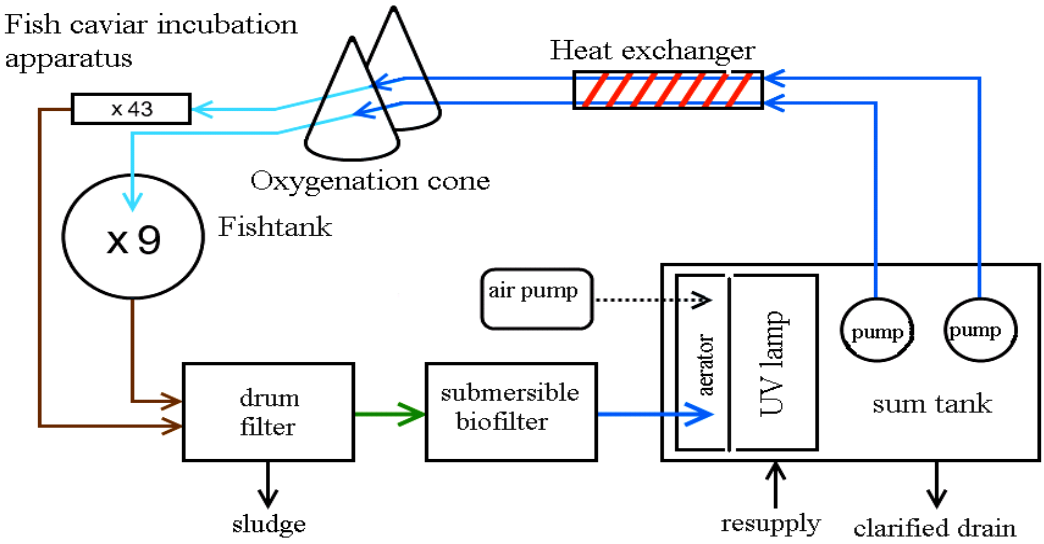

Fig. 1. Closed water supply system.

The project budget includes 400 000 rubles for the equipment installation; 500 000 rubles for the technical project (according to 'FISH-AGRO' LLC at the beginning of 2020).

3.2.3. Production assurance

The production cycle of growing fry in the projected nursery begins with the purchase of caviar at the stage of eye pigmentation. To start one production cycle of the nursery, it is necessary to purchase 500 thousand spawns at this stage.

The supplier of the spawn was selected to be the breeding trout breeding plant "Adler", the leader in the Russian market of rainbow trout, which offers a choice of seed material of various breeds. The contract for the spawn supply is concluded 3 months before incubation.

To those purchasing a batch of 500 thousand pieces, this plant offers spawn at a price of 1 200 rubles for 1 thousand pieces of same-sex (only female) spawn at the stage of eye pigmentation. The cost of 500 thousand spawn will be 600 thousand rubles.

The nursery will use starter feeds from the 'Biomar' manufacturer, the INICIO line for different age groups.

3.2.4. Production cycle

In the projected fish hatchery, it is planned to grow 330 thousand pieces of fry weighing 5 g in one production cycle, including: spawn purchase (3 months before the start of incubation), spawn pre-incubation (10–15 days),

obtaining larvae weighing 0.5 g (about 30 days), obtaining fry weighing 5 grams (50–60 days), sale.

The nursery will carry out three cycles per year. The first cycle begins with the laying of spawn in February and ends with the implementation of the 5-gram fry at the end of May. The second cycle lasts from the second half of April to mid-August. The third cycle begins in July, the fry is sold in the second half of October.

From November to February, the nursery does not contain fish, repairs, adjustment and cleaning of equipment are carried out.

4 Fish farming calculations

4.1 Calculation of the number of different age groups of juveniles grown on the farm

The trout nursery under consideration is designed to carry out three production cycles per year (capacity – 5 tons per year). When purchasing a batch of 500 thousand spawn, we predict the following waste: up to the hatching stage – 10 %, up to an average weight of 0.5 g – 15 %, up to a weight of 5 g – 20 % [7]. In one cycle, the farm grows 330 thousand fries with a weight of 5 g.

4.2 Calculation of the area, volume and number of fish tanks

The spawn at the eye stage in the amount of 500 thousand are planned to be placed in the incubation devices of the IL-4 “Trout” tray type. The useful area of the incubator is 0.84 m^2, places up to 42 thousand spawns. After hatching, the larvae are kept in pallets filled with water up to a level of 15 cm, until they reach an average weight of 0.5 g and rise to float. The number of devices is calculated in accordance with the requirements for the placement of pre-plates (10 thousand pieces/m^2). Taking into account the spawn waste, 40 m^2 of free space will be required for 400 thousand pre-larvae. Taking into account the area of the pallet (0.93 m^2), it is easy to calculate that 43 incubation devices will be needed for the maintenance of larvae. One incubation tray of spawn will contain 2900–3000 eggs. The larvae, after being raised on the float, are transplanted into round pools with the following parameters d = 2.8 m; h = 1.3 m; V_{aqua} = 6.2 m^3, where they will be kept until an average weight of 5 g is reached. Based on the planting rate of 30 kg/m^3, the required volume of pools for the content of 330 thousand fry with a weight of 5 g is calculated the following way:

$$\sum V_{tank} = (330\,000 \cdot 5 : 1\,000) : 30 = 55\ m^3$$

Let's calculate the required number of fish-breeding pools:

$$N_{tank} = 55 : 6{,}2 = 9\ \text{pools}$$

4.3 Calculation of feed consumption

The daily norms of juveniles feeding are taken from the manufacturer's website, the values are recommended in order to achieve the lowest feed coefficient, which is especially important in the RAS to reduce the amount of waste and the load on the biofilter.

Feeding of the larvae begins on average 20 days after their hatching at a temperature of 10°C. When switching to external nutrition (about 10 days), the larvae are fed with starter feed with granules of the smallest size – 0.2 mm. Then you can transfer the larvae to the starter feed with granules of 0.8 mm and 1.1 mm. Table 5 shows the daily feeding rates of juveniles in accordance with the manufacturer's recommendations. Trout feeding rates depend on the body weight of the fish and on the water temperature.

Table 5. The amount of feed a trout nursery needs at different stages of the cycle

Mass, g	Period, 10°C, 24 h	Day norm % from the mass	Feed need		Cost, rub/kg
			kg/day	per growing period, kg	
0.3–0,5	~ 10	2.76	4.5	45	560
0.5–1,5	~ 15	2.41	9.3	140	360
1.5–5	~ 45	2.11	22.3	1 000	360

The cost of feed, necessary for the production cycle – 435 600 rubles; for one year – 1 306 800 rubles.

5 Technical and economic indicators of the fish hatchery

The cost of one fry (5 gram) is equal to the cost of its production. Dividing the cost of production by the number of fry obtained for the year, we get the cost of one fry weighing 5 g, which is equal to 5.5 rubles. The selling price will be set equal to the average price in Russia for fry weighing 5 g – 18 rubles/one.

Table 7 shows how the price of products is formed for the consumer.

The economic efficiency indicators of the projected fish hatchery are shown in Table 8.

Table 6. The main technical and economic indicators of the projected fish hatchery.

Indicator	Measurement unit	Value

1. Production output in kind (per year)	pieces	1 000 000
	kg	5 000
2. The cost of products per piece/ per kg (with VAT 20%)	Rub.	18/3 600
3. Production cost per piece/ kg	Rub.	5.5/1 100
4. Number of employees (including the founder)	people	6
5. Staff Salary Fund	Rub.	171 000/2 052 000
6. Accruals for labor remuneration (contributions to the FIU, Social Insurance Fund, Federal Compulsory Health Insurance Fund, the total amount of contributions - 30%) month/year	Rub.	51 300/615 600
7. Amount of initial investment	Rub.	13 000 000
8. Revenue (per year)	Rub.	18 000 000
9. Costs (per year)	Rub.	11 167 600
10. Income (per year)	Rub.	6 832 400
11. Taxes (Simplified tax system 6%, per year)	Rub.	1 080 000
12. Net profit (per year)	Rub.	5 752 400
13. Payback period	months	28

Table 7. Price structure for nursery products.

Indicator	Measurement unit	Value
Unit cost/kg of production	Rub.	5.5/1100
Price per unit/kg of products without VAT	Rub.	15/3000
Unit price/kg of products for the consumer (with VAT 20%)	Rub.	18/3600
Extra charge	%	63
Profit from 1 unit of production	Rub.	9.5

Table 8. Indicators of economic efficiency of the projected fish hatchery.

Indicator	Measurement unit	Value
Project profitability ratio	%	88.50
Return on sales	%	31.96
Profitability of production	%	62.04
Costs per 1 rub of products sold	Rub.	0.31
Average annual cost of fixed assets	Rub.	12 000 000
Return on funds	Rub.	1.5
Capital intensity	Rub.	0.67

6 Conclusion

1. The profitability ratio of the project with the initial indicators laid down in this work is quite high (88.50%). However, this amount will be significantly adjusted when preparing a specific project, taking into account the full structure of its costs.
2. Return on sales. According to Rosstat (Russian Statistics Department), for the "Fishing and fish farming" activity in 2018, the return on sales was 31.96%. Thus, the activities of the projected fish hatchery will bring profit, which is typical for the fishing industry of the last decade.
3. The profitability of production (62.04%) can be estimated as high. It's necessary to note that this value will also change when production costs are fully accounted for.
4. The calculation of the fund return indicator showed that the unit cost of fixed assets of the fish hatchery accounts for 1.5 rubles of revenue, which shows the economic efficiency of this project.
5. The calculation of the capital intensity index showed that 1 ruble of the revenue received by the nursery accounts for 0.67 rubles of the company's fixed assets. This indicator is normal for a fish-breeding enterprise, since fish farming is a fund-intensive industry.
6. The foundation of such a farm will require large investments. However, the calculated technical and economic indicators of the nursery for the cultivation of rainbow trout juveniles indicate the feasibility of implementing such a project in Murmansk region. The nursery, designed to produce about 1 million fry weighing 5 g for three production cycles per year, is able to generate high profits. The payback period for the initial investment can be 28 months. The creation and operation of a new economic entity in

Murmansk region will help increase tax revenues to the regional budget system, increase and accelerate cash flows between economic entities in the sphere of aquaculture.

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