

# Details of artificial reproduction of Atlantic salmon (Semga) at the Umba fish hatchery

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**Abstract.** The world's demand for fish products for food and industrial purposes has already significantly exceeded the reproduction capacity of wild fish. Further increasing exploitation of natural fish populations leads to a sharp reduction in their numbers and degradation of population biodiversity. The only way to solve the problem is to develop artificial reproduction of fish. This applies primarily to salmon, which are the most valuable and popular types of fish. In the Murmansk region, there are three fish hatcheries that carry out artificial reproduction of Atlantic salmon. Factory reproduction at the Umba Fish Hatchery (URZ) is currently an important and necessary process, since the plant is the only fish hatchery for reproductive purposes in the Tersk district. The article reveals the peculiarities of reproduction of Atlantic salmon (salmon) in the URZ. A brief description of the Umba River is given. The main fish-breeding activities are covered: catching and keeping of producers, collection of sexual products and fertilization, incubation of eggs, keeping of larvae and their transfer to external nutrition, factory tagging of juveniles, release of juveniles in the Umba River and its tributaries. The peculiarity of the Umba plant in contrast to the other two fish hatcheries of the Kola Peninsula is shown. The question of the necessity of the existence of the Umba fish hatchery and the prospects for its development is highlighted. The reasons for the decline in the number of salmon in Umba are listed. Recommendations for restoring the abundance and preserving the intraspecific biodiversity of the Umba River salmon are provided.

## 1 Introduction

Fish products are known to be highly delicious and dietary. They are an essential source of animal proteins. Fish also has therapeutic and disease-prevention properties. It contains all essential compounds necessary for a human, including amino acids, unsaturated fatty acids that inhibit development of atherosclerosis, vitamins and trace elements. In terms of vitamins, except for vitamin C, fish surpasses fruit and vegetables. Thus, the importance of fish is not limited to its nutritional value only. That is the reason why the need for fish products will increase even if consumption of meat and dairy products in Russia increases at some point of time [1].

As the demand for fish products goes up, so does the pressure on natural fish populations, which leads to their reduction and the depletion of populational biological diversity. Artificial reproduction of aquatic bioresources provides an opportunity to solve the problem described above.

Salmon fish and red caviar extracted from it are highly valued and considered a delicacy. Restrictions imposed upon catching of salmon in seas and rivers and constantly growing demand necessitated artificial breeding of salmon which became a very profitable line of business.

In the Murmansk region three fish-farming factories – Umba, Kandalaksha, Knyazheguba – are engaged in young salmon breeding for reproduction purposes.

The Umba fish hatchery (UFH) is a subdivision of FGU “Murmanrybvod”. UFH mostly deals with artificial reproduction of Atlantic salmon of the Umba River of the White Sea basin.

The Umba River is one of the five most productive rivers of the Kola Peninsula. The length of the river is 125 km. The catchment area is 6248.5 km<sup>2</sup>. There are 599 rivers of different sizes in the basin. The total water area of all the lakes located within the Umba River basin is 807.3 km<sup>2</sup>. The lakes quotient is 12.9%. Potentially, the number of smolts living in the Umba River can be up to 700 000 specimens. The potential number of spawners, at 5% come-back rate, is 35 000 [2].

The first phase of facility evolution (1932–1959) was characterized by a sharp decrease in the number of salmon fished in specific years, increased quantities of timber rafted down spawning rivers of the White Sea basin, considerable immigration of new people, construction of river infrastructure.

In 1932, fish hatcheries were built on the Varzuga and Umba rivers, the technology was based upon “salmon eggs and larvae field incubation method” proposed for use by I. L. Zhukovsky.

Today, the UFH, despite its more than 89-year history, continues to deal with artificial reproduction of

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the Umba River population of Atlantic salmon (semga).

## 2 Materials and methods

Fish breeding methodology utilized at the fish hatchery is based upon “Atlantic salmon breeding procedure” [3] that has been originally customized to suit physical and climatic conditions of the Umba River.

Fish breeding activities at the UFH can be divided into the following phases: catching and holding of spawners, collection of eggs and sperm and fertilization, incubation of eggs, holding of larvae and their switch to external nutrition model, followed by summer and winter rearing until they become yearlings, release of juveniles into the Umba River and its tributaries.

New biotechnical requirements that regulate breeding practices of young (larvae) of Atlantic salmon (semga), that were reared at fish farms of the Murmansk region, became effective January 30, 2015 [6].

Every year, the Umba fish hatchery has been ensuring successful compliance with all biological requirements that regulate salmon farming.

Spawners are caught for fish-breeding purposes at the following fish-counting fences (FCF): “Rybovodny zavod” (June-October) and “Maly Krivets” (June-August). Every year, FGU “Murmanrybvod” obtains a license allowing it to catch Atlantic salmon spawners at the Umba River. Within the period from September 1 through September 20, Atlantic salmon (semga) spawners are transported from fish counting fence “Maly Krivets” in a “wooden fish-transportation-boat” to fish hatchery where they are subsequently held in plastic cages.

As required by “Atlantic salmon breeding procedure”, only those Umba salmon spawners that are in good health and have specified average size-and-weight characteristics are allowed to be put into cages for long-term holding of Atlantic salmon [3].

Spawners are accounted for on an yearly basis – Table 1.

Table 1. Atlantic salmon spawners accountability [4].

	Year 2017	Year 2018	Year 2019	Year 2020
Total spawners caught (each)	1147	360	98	13
Including females (each)	52	198	61	6
Females used (each)	46	198	Within the 2019–2020 period, due to disease of unknown origin that has affected spawners in the Umba River of the White Sea basin, no eggs and sperm were collected and no eggs were put into incubators.	

When water temperature drops to 7-8° and spawning period is about to come, females and males are moved into separate holding areas. Once that happens, all the spawners get tested for maturity individually every 4 or 5 days.

In order to preserve the genetically established structure of Atlantic salmon populations, eggs should be collected from those spawners that represent all spawning periods and caught throughout the entire spawning period. Due to compliance with research recommendations of FGUP "PINRO", the Umba fish hatchery has been a success in caging autumn race Atlantic salmon spawners since 2008.

A sign of males' maturity is the emergence of a drop of roe when light pressure is applied near its anus.

The maturity degree of a female fish is assessed by lifting a female fish by its tail to see how soft and sagged its abdominal cavity walls are at the rear part of the body. This condition occurs because part of mature eggs, that have fallen out of the ovary, have moved to the front part of body cavity. As a rule, males mature earlier and at faster rate than females.

Salmon specimens that participated in autumn and summer runs are kept in different cages at the Umba fish hatchery.

Eggs and sperm are collected in October-November at the hatchery by straining them off. Atlantic salmon spawners are released back into the Umba River once their eggs and sperm have been collected and fish has gone through recuperation process for one full day (24 hours).

Eggs and sperm are only collected from those spawners that are in good health and whose eggs and sperm are mature (fluid).



Fig. 1. Eggs fertilization.

In order to reduce influence of individual males, each batch of eggs must be fertilized using sperm pre-mix collected from two or three males. Pre-mixing must be done right before the use of pre-mix. Pre-mix can be used only after it has been tested for quality (Figure 1) [1].

Far-east-type troughs with Zhukovsky machines installed inside are utilized for incubation at the Umba fish hatchery.

Total amount of eggs obtained: in 2017 – 319.4 thousand eggs, in 2018 – 1721 thousand eggs. Eggs incubation periods: 2017 – 218 days, 2018 – 223 days. Survival rate during incubation period: 2017 – 110.824 (98%), 2018 – 431.52495 (95%) [4]. The number of eggs placed for incubation and transferred to other fish hatcheries in 2018 is shown in Figure 2.

*Holding and rearing of larvae, summer and winter holding of Atlantic salmon juveniles.*

Young salmon fish were fed with pelleted fish food: Biomar (Denmark); EWOS Micro (Great Britain). Food consumption and average water temperature by month at the URZ are shown in Figure 3.

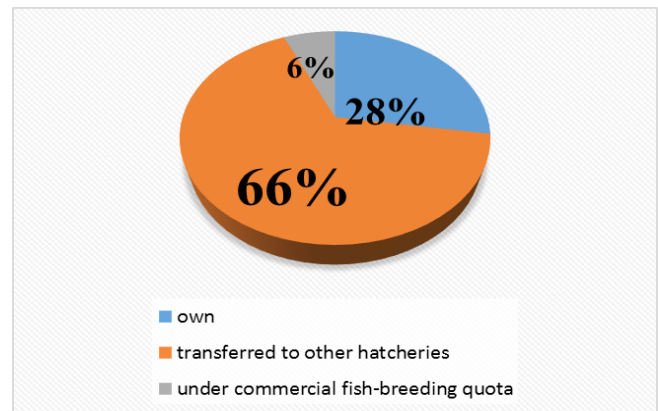


Fig. 2. Number of eggs placed for incubation.

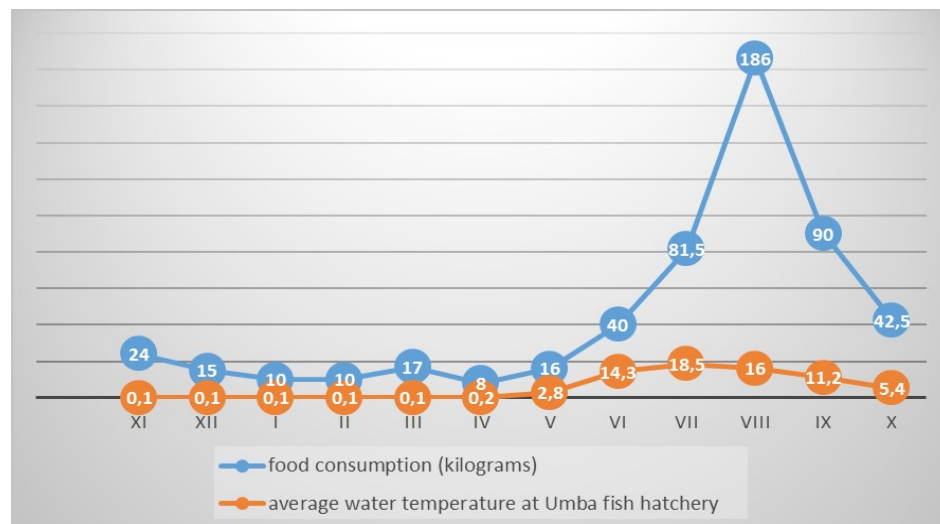


Fig. 3. Fish food consumption rates and average water temperature at UFH.

Based upon food tables, food consumption rates go up as water temperature goes up.

In order to be able to determine how many fish have come back to hatchery, juveniles to be released are tagged at the hatchery by amputating their fat fin (Figure 4.).



Fig. 4. Tagging of juveniles.

### 3 Results and discussion

Since January 03 through February 24 2020, 202 842 thousand fish that had been born that year were tagged; the average weight of each specimen was 1.5 grams. Under a government contract, 187 thousand of young salmon have been tagged; 15 842 thousand young salmon have been tagged above that number [4].

The term “release of juveniles” is interpreted as “purposeful introduction of Atlantic salmon into its natural habitat at any phase of its life cycle in order to increase, improve, replenish, restore or breed the species”[5]. During release of juveniles held in the hatchery, juveniles were accounted for by total accounting method.

In 2020, the number of fish returned to hatchery were accounted for at the “Maly Krivets” fish counting fence within the period since 22 July 2020 through 07 August 2020 with river completely fenced up (Table 2). Fishing

mode: daily accounting and caging of Atlantic salmon (Semga) spawners for fish-breeding purposes [4].

Fish counting fence “Rybovodny zavod” has been in the shut-down status in 2020.

Data on how many eggs and juveniles have perished during rearing process are presented in Table 3 [4].

**Table 2.** Number of salmon entered “Maly Krivets” fish counting fence in 2020 [4].

Period:	Total:	Fish hatchery’s	
		Specimen	% of total quantity
22 July 20 – 31 July 20	275	2	0.7
01 Aug 20 – 07 Aug 20	97	2	2.1
Grand total:	372	4	1.1

**Table 3.** Salmon eggs and juveniles perished during rearing, by periods (%).

Age	Period	Requirement	Umba fish hatchery
eggs	01 November 2018 – 01 June 2019 (generation year 2018)	10	5.4
0+	01 June 2019 – 01 November 2019 (generation year 2018)	53	28
	01 November 2018 – 01 June 2019 (generation year 2017)	20	5.6
	01 November 2019 – 01 June 2020 (Generation year 2018)	20	5.2

All fish-breeding activities associated with release of young salmon are subject to coordination with experts of the Polar branch of FGBNU “VNIRO” (“PINRO” named after N.M. Knipovich) and the Murmansk branch of “Glavrybvod”. Release of fish was made in April - August 2020.

Atlantic salmon generation-2018 release plan is 100% fulfilled: 187.0 thousand yearlings have been released; average weight of each specimen is 1.5 grams. All juveniles were placed in locations recommended by the Polar branch of FGBNU “VNIRO” (“PINRO” named after N.M. Knipovich) [4]. Fish release data is presented in Table 4.

**Table 4.** Release (transfer) of fish in 2020 [4].

Item #	Name of species	Fish age	Number of juveniles		Average mass, kg	Released (transferred) within	Release location or entity-transferee
			Total, thousand each	Including downstreams, thousand each			
1	2	3	4	5	6	7	8
1	Atlantic salmon (Semga), generation year 2018	1	187,00	–	1.5	01 Apr – 02 Apr 2020	Umba river, Kanozero rapid – 102 thousand specimens, Karelskiy rapid – 85 thousand specimens
2	Atlantic salmon (Semga), generation year 2018	1	26,151	–	1.5	28 Apr – 17 Aug 20	<u>Vyala tributary (distance from dam to mouth)</u> – 2 650 thousand specimens; 3 036 thousand specimens; 4 000 thousand specimen; 1 000 thousand specimens; <u>Nyizma channel, Kryvoy porog</u> – 9 362 thousand specimens; 2 428 thousand specimens; 3 493 thousand specimens; 0 182 thousand specimens.

In summer, research is conducted in young fish habitats to see how well they have managed to get accustomed to natural conditions. Based on research results, adjustments are made associated with release of juveniles in subsequent years.

Spawners that entered the trap of the “Maly Krivets” fish counting fence had the signs of being affected by ulcerative dermal necrosis disease, that is why only a little number of them have been caged. On August 11, 2020, 13 spawners were transported to a cage installed at the Umba fish hatchery so that possible scenarios of pathological process could be monitored. Out of these, 3 specimens were transferred to the aquaculture, fish physiology and disease sector laboratory “Murmansk region’s animal disease control station”. The remaining spawners perished over the time period August 28, 2020 – September 25, 2020 and were disposed of at the cremation facility at Knyazhegubsky fish hatchery [4].

## 4 Conclusion

The difference between UFH and other FGU “Murmanrybvod” fish hatcheries is that the former is located right on the Umba River. This provides an opportunity to release juveniles right at the location where eggs have been collected, thus the need to transport the fry is obviated.

Autumn-race spawners are caged and held at the hatchery.

In the future, UFH can also handle reproduction of other valuable fish species (whitefish, kumza, trout).

The main reason why the number of salmon in the Umba River has decreased are the aftermath of timber downstream rafting and illegal fishing (poaching). At present, there are as few as two pay-roll water-bailiffs providing fish conservation activities out in the field.

In 2020, the captured producers died as a result of the disease ulcerative dermal necrosis.

In order to replenish the number of salmon quantities and preserve intra-species biological diversity of the Umba River, the following needs to be provided: artificial reproduction of aquatic biological resources; reclamation of spawning-and-rearing areas; technical (retrieval of sunken wood) and biological (catching of predator fish) reclamation; fish-preservation activities.

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