BASE Project - Implementation of the Baltic Sea Action Plan in Russia

HELCOM

Final report: Support for development of a

Salmon management plan in the Luga River

BASE

Pilot Activity	'Support for development of a salmon management plan in the Luga River'
Implemented by (Main Consultant)	All-Russian Social Organisation "All-Russian Society of Nature Protection", Leningrad Region office (ARSoNP)
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Executive Summary

Under the HELCOM BASE project, the All-Russian Society of Nature Protection in Leningrad Region carried out a pilot project "Support for development of a salmon management plan in the River Luga". The project's significance is increased by the fact that the population of Atlantic salmon in the River Luga is currently the only salmon population in the Russian part of the Baltic Sea that is reproducing naturally; however, according to existing data, a clear decline in their population numbers is observed. In order to maintain and restore the small population of wild salmon in the River Luga a workable management plan must be developed. The first step in implementing this strategy under the above-mentioned project is to conduct a comprehensive study of the current state of the Luga salmon and its habitat in order to develop evidence-based recommendations for its restoration.

The main reason for the decline of wild salmon numbers in the River Luga is their unreported catch, mainly occurring in the lower courses of the river and close to major settlements. 'Unreported fishing' includes illegal fishing (poaching) and overfishing for the needs of the Luga hatchery. Poaching and concealing catches by professional fishermen is encouraged by the high market cost of salmon and the lack of sufficient control by law enforcement authorities.

The available literature shows that until recently, the population of the Luga salmon remained one of the least studied in the Baltic Sea basin. Only few publications from 19th - 20th centuries examined the biology of the Luga salmon, fishing techniques and the reasons why the numbers were declining. Over the years, the authors proposed various restoration measures aimed at preserving the Luga salmon.

In the course of the studies carried out under the project, spring downstream migration of salmon smolts was studied using a floating trap in the mouth of the River Luga, which determined migration timing and dynamics depending on the water temperature. Also, the ratio of hatchery grown and wild salmon was estimated, the size and weight characteristics of migratory fish were defined and the age composition of migrating smolts was studied. An unstable condition of the Luga salmon population was indicated by the low number of migrating individuals estimated in 2013 (below the average annual values) and the significant predominance of the yearlings over the other age classes when compared to the data from previous years of observations.

A study of salmon spawning grounds and nursery areas in the River Luga basin and the assessment of their condition showed that the main spawning grounds are located at three rapids in the main course of the river (Sabskie, Storonskie and Kingiseppskie) and at the lower course of its right tributary - the River Vruda. Unfortunately, a significant part of the spawning grounds and nursery areas in the main stream of the River Luga (730,000 m^2) cannot currently be used by salmon because of the anthropogenic

wasting of the bottom, its 'cementation' and biofouling with water vegetation. The only way to solve this problem is to recultivate the spawning grounds.

The total area of the spawning grounds and nursery areas that are currently available is estimated at 350,000 m^2. These areas can provide habitats and foraging resources for more than 170,000 individuals of juvenile salmon of different age classes.

The analysis of the fish fauna of salmon spawning grounds and nursery areas showed that, under current densities, salmon associated species are unable to cause severe food competition or exercise significant predation pressure on parr. Nevertheless, the results of controlled fishing demonstrated extremely low densities of wild juvenile salmon in the Kingiseppskie rapids and the lower course of the River Vruda, and the complete absence of wild salmon in the Sabskie and Storonskie rapids. This highlights the distressful situation of the natural reproduction of salmon in the River Luga during recent years.

This negative trend is confirmed by a general decline in the level of genetic diversity that was observed in the wild salmon population of the River Luga over a ten-year period. Genetic drift revealed itself in the form of a 'washout' of rare gene haplotypes from the population, which is caused by the limited number of breeders participating in the annual spawning. As a result, the viability of the Luga salmon population delicately adapted to heterogeneous environment of the River Luga seems to be decreasing.

An important, common factor limiting the number of salmonid fishes in rivers is the level of food availability. The results of our study showed that there is no reason to assume the presence of foraging limitations for salmon (including an anthropogenic one) in its traditional spawning grounds. The presence of certain reliable bioindicators at the studied sites of the River Luga indicates a medium or high condition of the water environment and corresponding level of food supplies.

The results of our study of the Luga salmon spawning stock showed that it is represented by fish of different age classes, including repeatedly spawning breeders. Salmon spawning stock is dominated by wild individuals, which indirectly indicates a reduced viability of juvenile salmon released by the Luga hatchery.

Thus, the results of the comprehensive study indicate that there are now all the components - good quality of the water environment, sufficient potential areas of spawning and nursery grounds and easily available food resources - essential for the existence of a wild salmon population of up to 170,000 individuals of juveniles of different age classes in the River Luga. The salmon potential of the River Luga can be increased to 360,000 juveniles by means of the melioration of that part of the spawning grounds currently not used by salmon, as well as the elimination or attenuation of unreported (illegal) fishing.

1. Introduction

The Leningrad Region office of the All-Russian Social Organization "All-Russian Society of Nature Protection" (ARSoNP) has implemented the pilot project "Support for development of a salmon management plan in the River Luga" under the Agreement with HELCOM within the scope of the BASE project.

The activities in the BASE project will help to achieve the commitments made under the HELCOM Baltic Sea Action Plan (BSAP), such as the follow-up of the preparation of an inventory of Baltic Sea rivers with salmon and sea trout populations within the Russian Federation. The SALAR report provides a basis for implementing the BSAP and its measures pertaining to salmon and sea trout. These specifically concern identifying and prioritising the populations for recovery or restoration measures. The SALAR project has identified wild original salmon populations to be prioritized for recovery measures and potential populations/rivers to be prioritised for re-establishment or restoration measures.

The River Luga that empties into the Gulf of Finland is one of the identified rivers that hold an original salmon population in need of recovery. Luga is also listed by IBFSC as an index salmon river.

In order to promote and ensure that the recommendations of the SALAR project and the HELCOM BSAP would also materialize in the Russian Federation, it is important that a specific action in the Gulf of Finland catchment for the restoration of rivers, such as the River Luga and recovery of its salmon population, take place. The River Luga holds an original salmon population and is free of migration barriers for ascending salmon. The salmon may hence reach the reproduction areas of the river. Artificial rearing of salmon and sea trout is currently carried out at the Luzhskiy hatchery to sustain the local population of salmonids.

In order to accomplish the tasks of the pilot project, good information exchange and communication established with respective Russian authorities will be utilized to ensure the coordination of the project's activities in St. Petersburg and in Leningrad and Kaliningrad Regions. A link will also be ensured between the pilot project and activities at the Federal level for the development of national programmes for the implementation of the BSAP. This will secure the project's sustainability in terms of ownership of its outcomes. It is crucial that the dialogue and information activities with the local communities (incl. local organisations, inhabitants, fishermen) will be established. It is also important to ensure the wide dissemination and accessibility of the project's findings to stakeholders and relevant actors within the scientific and policy-making communities.

The tasks of the project were to: 1) analyse available material concerning salmon in the Luga River; 2) carry out research work; 3) promote activities to ensure that the recommendations of the SALAR project and the HELCOM BSAP would also materialize in the Russian Federation; and 4) cooperate with relevant stakeholders in order to pave the way for the approval of a management plan by the authorities and, as a parallel process, to pave the way for public awareness and better commitment by local by understanding/acknowledging the importance of the actions that will be taken for the benefit of the communities.

The reported project activities were carried out by the expert team of the Laboratory of Monitoring Salmonid Fish Populations at the State Research Institute on Lake and River Fisheries (GosNIORKh): Sergey Titov (managing expert); Sergey Mikhelson (ichthyologist); Margarita Barabanova (ichthyologist); Dmirty Sendek (ichthyologist/geneticist); Anton Uspensky (hydrobiologist); and Olga Semenova (geneticist).

Sergey Rezvyi (ARSoNP/St. Petersburg State University) acted as Project Manager. All project activities were also controlled and coordinated by Veronica Tarbaeva (Vice-president of ARSoNP).

2. Assessment of information and data produced by previous projects and programs and available in national information sources

At present, in the Baltic Sea basin the reproduction of Atlantic salmon remains in general at low level, due to longstanding and intensive anthropogenic impact (damming of rivers, destruction of juvenile salmonid fishes habitat, river pollution by industrial and domestic sewage, intensive fishing in rivers and sea). There are only three salmon populations that live in the rivers Neva, Narva and Luga remained in Russia (Kazakov, Veselov, 1998). To maintain salmon populations in all three rivers the hatcheries are built, however, spawning in the wild maintains only in the Luga River.

The Luga River is the most important salmon river in the Russian part of the Baltic Sea catchment basin. It springs from about 1 km South-East of Lake Samino, runs through the Novgorod and Leningrad regions and flows into Luga Bay of the Gulf of Finland. The river is 359 km long, and its catchment area is 13600 km^2. The width of the river at the mouth part is approximately 400 m (Resource…, 1972a, 1972b, State ..., 1978).

Until recently, the Luga salmon population was the least studied in the Baltic Sea basin. The first scientific reference on the salmon of this river is found in a publication by K.M. Baer, who visited the mouth of the Luga River back in 1851, but in his "Study of Fisheries in Russia" the author mentioned only the blockage of salmon passage by the fishing gear (cited by Grimm, 1889). Also among the few literature references we should mention a work written by N.I. Lieberich in which the author suggests a number of measures to protect salmonid fishes of the Luga River (among which he emphasized protection of the salmon, sea trout and grayling) from extirpation; cited by Grimm, 1889).

Study by O. Grimm "Fish and fishing in the Luga River" was mostly devoted to the description of the biology of the Luga salmon, fishing methods and analysis of the factors causing decline of the population. O. Grimm stated that the salmon is the main commercial fish species in the Luga River, but by the time of finishing his work, the author had found a tendency of catch reduction down to 2-5 thousand individuals per year. At the same time the salmon potential of the river, according to O. Grimm's opinion, is 20-30 times higher. There is a spring-summer and autumn period when salmon enters the river. Spawning begins around September 15 and lasts until the first frost, i.e. until mid-October. The author first described salmon spawning in the basin of the Luga, namely in the Luga River itself in Yamburg (currently- Kingisepp) on the rapids, and in the tributaries of the Luga River: Lemovzha, Vruda, Khrevitsa, Oredezh and Azika.

Among the methods of salmon fishing in the Luga River O. Grimm distinguishes harvesting using various trap-nets and seines, fixed nets, fish-forks, partition off part of the river by means of so-called "goats." The author draws attention to the illegality of many fishing gear used at the time, and suggests to regulate and legitimize the use of relatively harmless fishing methods for the rational management of the population of the Luga salmon. According to the article by O. Grimm, even in the nineteenth century the issue of the Luga salmon population preservation was very acute.

As an important cause of the depletion of the fish fauna of the Luga River, the author shows malignancy of timber and firewood rafting on the river. Particularly, he justifies the hazard of sunken timber as a source of emissions of substances harmful to fish such as salmon, sea trout, and whitefish.
To restore fish stocks of the Luga River O. Grimm suggests a number of measures, among which he specifically points out restrictions on fishing areas and fishing methods, as well as the proposal on the releases of artificially grown salmon young fishes into the river.

The first experiments on artificial breeding of salmon in the Luga River took place in the second half of the XIX-th century and, according to O. Grimm, showed their prospectivity. Special salmon hatchery with 1.5 million egg capacity was built in the mouth part of the Luga in 1897. Apparently because of a bad location and structure of the hatchery, and also due to the fact that predominantly the spawners from the Neva River were used, the hatchery was liquidated in 1912 (Zhukovsky, 1939). Since then, works on the artificial breeding of salmon in the Luga River were not conducted until the end of the second half of the XXth century.

The results of the Luga salmon research in 1930s were summarized in a publication by E.S. Kuchina (1939). The author showed that the commercial fishing of salmon was carried out in the Luga, Narva and Koporskaya bays and the salmon approaching the spawning rivers was fished. The largest catches of salmon were in Luga Bay (in 1934, 343.6 cwt of salmon and sea trout were caught in Luga Bay, 48.7 cwt in Koporskaya Bay, and 6.4 cwt in Narva Bay). The main salmon fishing was taking place in May and June. The majority of salmon was moving in Luga Bay along the East coast; to much less extent migration took place along the West coast and the central part of the bay. In Narva Bay salmon was heading to the Narova River and was coming from the northern and southern sides. In Koporskaya Bay the first individuals appeared near the West coast (Krivoruchie settlement and Staroe Gorkolovo).

According to the estimates by E.S. Kuchina, in the 1930s, about 3000 - 3500 individuals of salmon were caught in the Luga River and Luga Bay. About 250 fishes were caught above Kingisepp in 1934. As a result of fishing on spawning grounds, there is very few breeding salmon left in the wild. Young fishes are ruthlessly harvested on the spawning grounds with seines. According to the author of the work, the salmon spawns in the most rapid parts of the Luga River and its tributaries, with the major spawning grounds located in the rapids near Kingisepp. Spawning takes place in October and early November.

Describing features of the Luga salmon biology, E.S. Kuchina writes that large salmon enters the Luga River. For instance, the average size characteristics of salmon in the catches in 1934 were: length - 93.3 cm and weight - 9.92 kg. 75.4 % of all fish had length of 85 to 105 cm and 74.8 % had weight of 7 to 13 kg.

The author of the study found that prior to downstream migration young salmons live in the river for 2 to 3 years, with the majority of 93.9% migrating downstream at the age of three young fishes performing downstream migration after two years of life had a length of 11.1-12.9 cm, after three years – 15.9-16.8 cm. Mass downstream migration of young fishes occurred in the second half of May. Having migrated out of the river, some salmon continued to the sea, and the majority (69.5%) remained in the brackish environment of the Gulf of Finland. The latter had one or two rings on their scale corresponding to two winters spent in brackish waters. Their growth rate during this period is lower than that of fish migrating straight into the Main Basin.

According to E.S. Kuchina's data the majority of fish (78.4 %) went to their first spawning in to the river having spent three winters in the sea. In 1934 only 3.9 % of all fish entered the Luga River for their second spawning. In the river low growth rate of salmon was observed. So, by the end of the first winter fish length was on average 4.8-5.5 cm, after two winters - 15.3-17.3 cm; for the first winter in the brackish environment, fish had a length of 20.2 to 23.8 cm. Whereas at the sea salmon grew faster and by the end of the first winter it had a length of 38,5-42,5 cm. The growth rate for the second winter in the brackish environment was close to the one for the first year at sea. By the end of two years of life at sea salmon reached 70-75 cm length, by the end of the third winter – 94.3 cm. The salmon which spent one winter in the brackish areas had similar size but it was slightly smaller having spent there two winters.

The author of the study concludes that for the proper salmon management it was necessary to take a number of measures, namely, to give salmon an access to natural spawning grounds. For this matter, it was essential to build a fish-pass in Kingisepp, and prohibit over-fishing of young fish and breeding adults on the spawning grounds.

Due to the continued decline of salmon population number during the years which followed E.S. Kuchina's study, in late 1980s on the Khrevitsa River (a tributary of the Luga River) the Luga fish hatchery was built. First release of hatchery young fish was done in 1989, right away after putting the hatchery into operation. During the first 10 years, until 1998, there was no any clear scheme in the hatchery working. Young fish was released in different age. In 1989 dominated one-summer old salmons (0+), in other years – one-year old (1) (1990-1993, 1996, 1997), two-summer old (1+) (1995, 1998, 1999) or two-year old (2) (1994). The numbers of released young fish were rather low in that period: not more than 20 000 until the year 1996 and in some years even less than 5 000 (Table 2.1).

Table 2.1. Numbers (thousands of individuals) and age of young salmons released by Luga hatchery. Reference data of North-Western basin directorate on fishery and conservation of water biological resources (Sevzaprybvod)

Years	Age of release			
	one-summer old (0+)	one-year old (1)	two-summer old (1+)	two-year old (2)
1989	15,0			
1990		2,8		
1991		2,5		
1992		1,2		
1993		20,4		
1994				1,8
1995			5,9	2,9
1996		16,2		
1997		44,6	0,1	
1998	8,1	5,5	53,9	
1999		55,9	44,5	
2000		76,9		3,0
2001		96,4		1,6
2002	125,4	121,0		1,0
2003		86,2		2,5
2004	24,9	106,1		1,7
2005		99,1		2,0
2006		91,7		
2007		108,1		1,0
2008		96,4		0,5
2009		93,7	15,8	0,5
2010		31,2		0,1
2011		119,7		
2012		116,4		
2013		109,6		0,8

Starting from 1999 until now mainly the one-year old salmons having body mass of 20 grams are released in the river, and they are regarded as the smolts that are ready to catadromous migration. Releasing of one-summer old fish (0+) in some years was not planned in advance but resulted from force majeure events in the hatchery. The amount of one-year old salmons released by the hatchery during the last 14 years has been rather stable averaging 100 thousand individuals (76,9 - 121,0 thousand). The only exclusion was the year 2010 (a little more than 30 thousand) because of enlarged mortality of fish in the hatchery.

Until the year 1997 releasing of hatchery young fish was carried out mainly in the river Khrevitsa were the hatchery is located, or directly in the Luga River close to the mouth of Khrevitsa in the areas poorly suited young salmons. Quite often the releases were done in June-September, i.e. after finishing downstream migration of wild salmon in the river. On our opinion the factors mentioned above negatively affected the productivity of Luga hatchery.

Starting from thew year 1998 and following the GosNIORKh's recommendations the releases became carried out exclusively in the area of Kingiseppskie and Sabskie rapids in the main streambed of Luga River where key potential salmon spawning grounds and nursery areas are located. After the year 2000, also according to the GosNIORKh's recommendations, the smolts started to be released in April-May, 2-3 weeks before the beginning of catadromous migratrion of salmonids.

These changes in the hatchery operations were quite positive on our view. Nevertheless, the results of monitoring studies of downstream migration of young salmons carried out by the GosNIORKh from the year 2001 until now shows that the effectiveness of the hatchery young fish releases still remains low.

In 1999, the Laboratory of monitoring salmonid fish populations of GosNIORKh initiated comprehensive studies in the basin of the Luga River. The results of these studies are reflected in a number of internal reports of the Institute (Report GosNIORKh, 2000, 2003, 2005, 2007, 2008). According to these reports, during the first surveys on Sabskie and Kingiseppskie rapids of the Luga River young salmons of various age classes were found and identified, based on characteristic morphological features, as "wild" young fish, and it was in contradiction with traditional for that time views that the population of salmon in the Luga River, as well as in two other salmon rivers - the Neva and Narova – was supported entirely by artificial breeding (Khristoforov, Murza, 2003). This was the first direct evidence of the current occurrence of natural reproduction of salmon in the Luga River. Confirmation of this fact was obtained in the spring of 2000 when, in the course of control fishing of adult salmon in the mouth of the river, dozens of spawners belonging to natural population were caught.

In the following years the Luga salmon population research by the Laboratory of monitoring salmonid fish populations of GosNIORKh has expanded, and the results of the studies have been published, including the report, prepared for the Coalition Clean Baltic (Titov, Sendek, 2008). According to the data provided in this report, in order to obtain more tangible evidence of the existence of natural population of salmon and estimation of its number, GosNIORKh for the first time in the Russian part of the Baltic Sea started to study downstream migration of salmon smolts. Every year since 2001, in 12 km from the mouth of the Luga River trap-nets were set to study the downstream migration of juvenile salmon from the river into the sea. It became possible to obtain direct and accurate data not only on the timing of young fish migration, but on the size of "wild" population. It was found out that during the period of downstream migration to the sea for foraging from 2500 to 8000 salmon smolts from the natural population migrate annually (Mikhelson, Titov, 2013). As an average for 5 years of research, this value was about 5000 individuals per year (Fig.2.1).

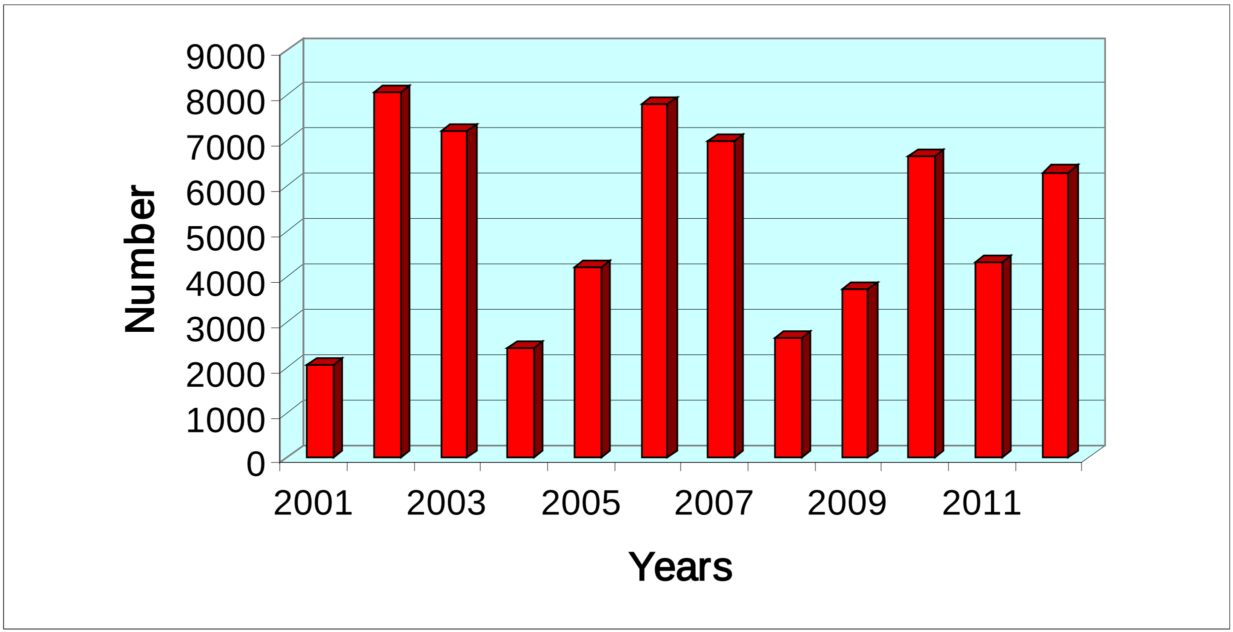

Figure 2.1. Numbers of salmon smolts of natural origin migrating annually from Luga River to marine nursery areas.

Given that the return of adult salmon from wild smolts is about 10% (Smirnov, 1971; Mills et al., 2005), the size of modern natural salmon population was estimated to be 500 spawning individuals. By the data of 11-years research, average number of hatchery salmons migrating annually from the river to Main Basin is less than 16 thousand individuals (from 3,1 to 42,5 thousand). Thus, not more than 17% of young salmons released from the hatchery to the Luga rapids reach their destination area (Fig. 2.2). The only exclusion was the year 2003 when 47% of released hatchery smolts has successfully migrated downstreams. Much more often the “failed” years happened, when not more than 10% of released catadromous salmons reached the Main Basin (2002, 2004, 2009). Moreover, in the year 2011 their share was even less than 3%.

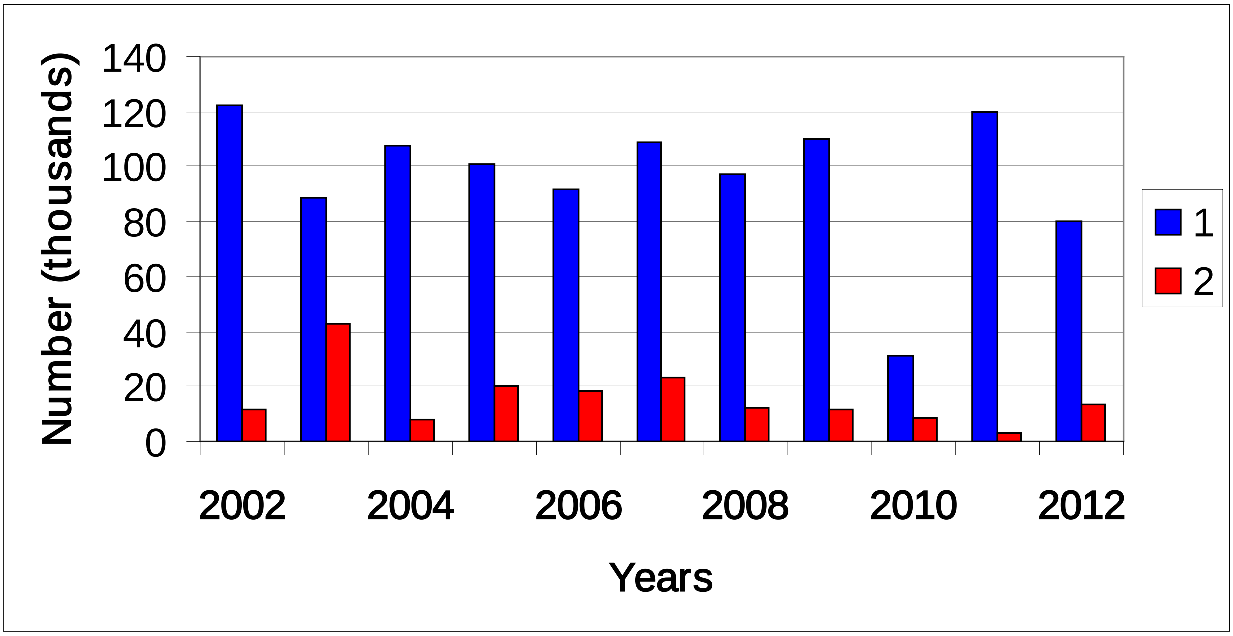

Figure 2.2. Numbers of hathery salmons released (1) and counted with the trap during downstream migration (2).

The main reason of low effectiveness of Luga hatchery operations, on our opinion, is relatively poore adaptiveness of hatchery youngs (to be compared with wild ones) for living in natural environment. It leads to heightened mortality of released young fish and inability of their considerable part to the catadromous migration in the year of release. Not more than 1-2% of those fish that stay in the river until next year survive before downstream migration (Report GosNIORKh, 2007, 2008).

According to the opinion of the scientists from the Institute, it has to ensure the return of 600 to 2000 (on average - 1-1.2 thousand) hatchery-grown breeding individuals to the river which is a very low value for the Luga River capacity (Report GosNIORKh, 2007, 2008).

In order to assess the potential the Luga River, the specialists from the Laboratory of monitoring salmonid fish populations of GosNIORKh conducted a survey of spawning grounds and spawning-hatching areas (SHA). The main spawning and nursery grounds were located in 3 main river rapids - Sabskie, Storonskie and Kingiseppskie. The total area of these sites is about 700 000 m². Spawning grounds are located in this area and Sabskie and Storonskie rapids are in good condition and can be used by salmon for spawning in full. Situation is somewhat different from the spawning grounds in Kingiseppskie rapids. The proximity of a large town, Kingisepp, has led to pollution of a significant part of the rapids. Stones and gravel in the rapids are covered with vegetation. The bottom of the spawning grounds is polluted by domestic waste and metal, which makes them largely unsuitable for spawning.

However, the area of the remaining spawning grounds including Sabskie and Storonskie rapids is not less than 400-450 thousand m². This may ensure existence of salmon population of not less than 20-30 thousand breeding individuals in the Luga River.

In addition, according to the reports mentioned above, the research results obtained by the specialists from GosNIORKh at beginning of the XXIst century fully confirm the existence of two peaks in entering the Luga River by mature salmon. The first peak of the adult individuals entering the river is in May - June. At this time, the river is entered only by salmon (sea trout almost never enters the river in spring). For this peak it is typical that the river is entered mostly by large individuals of salmon (average weight is 8-10 kg) from the natural population.

The second peak of the spawning migration occurs at the end of August - October. At this time, both salmon and sea trout enter the river. The adult individuals of salmon have significantly smaller size (average weight is 4-5 kg); a substantial part of mature salmon migrating at this time is now represented by hatchery-grown fish.

In the abovementioned reports several factors that negatively affect the state of the Luga salmon population are defined. The most important of these factors is poaching, as during the spawning migration of salmon in Luga Bay and the lower course of the river a huge amount of illegal fishing gear is set. The legislative basis for bringing the poachers to justice is far from perfect, and the fisheries authorities are unable to control the river throughout the salmon spawning migration because of the small number of officers and lack of technical means. Moreover, the lack of environmental education of the local population leads to the fact that a large percentage of young salmon, released in the rapids near Kingissepp, gets caught by recreational fishermen with fishing rods.

The spawning-hatching areas (SHA) in Sabskie and Storonskie rapids in the Luga River are in good condition, whereas the spawning grounds near the Kingiseppskie rapids are located directly within the town of Kingisepp and are far from optimal conditions. As it follows from the report conclusions, at present no more than one-third of Kingiseppskie rapids can be used as spawning grounds, which certainly reduces the potential of the river for the maintenance of natural salmon spawning.

During the last decade, active construction of harbour facilities was launched on the shore of Luga Bay inevitably associated with dredging, construction of new vessel channels and a general change in the underwater (and not only) relief. Large-scale industrial construction carried out almost all year round, results in a degradation of the Luga salmon habitat: during their downstream migration the smolts are forced to change the traditional, i.e. optimal for the population, migration routes; noise and muddiness caused by working machinery deter the mature individuals coming to spawn. Thus, the "industrial" factor is defined which also negatively affects the overall salmon population in the Luga River (Titov, Sendek, 2008).

Finally, it is stated in the reports that the large number of smolts migrating in the spring from the river into the sea is caught as by-catch in fishing gear set in Luga Bay for fishing for smelt and sprat.

In the list of activities developed to preserve the populations of the Luga salmon it is suggested to conduct reclamation/restoration works on Kingiseppskie rapids involving advanced experience of foreign experts; to ensure unconditional compliance with science-based recommendations on the timing of construction works in Luga Bay; to establish effective conservation measures in the places where the hatchery-grown young fishes are released into the river; to raise the level of environmental awareness of the local population; to reduce poaching press.

3. Research of downstream migration of salmon smolts*

This part of the project activities has been done by means and funds of All-Russian Society of Nature Protection and State Research Institute for Lake and River Fisheries during May – early June, 2013.

In order to examine the current status of natural and hatchery-grown salmon a variety of methods can be used. One of the most effective approaches is to study the downstream migration of young salmons from the rivers into the sea. Until recently, the study of the downstream migration of salmon in the Leningrad region through direct observation has not been conducted. Timing of migration, the number, size and age of smolts were determined on the basis of various indirect evidences. Meanwhile, these data are of great value for the assessment of natural reproduction of salmon and development of optimal release regimes for hatchery-grown young.

The main objectives of the study within the framework of the current project were to:

- Determine the timing of downstream migration of young salmons in the Luga River;
- Estimate the number of smolts migrating through the mouth of the Luga River;
- Determine the ratio of the number of natural and hatchery-grown smolts migrating from
- the Luga River into the Gulf of Finland;
- Determine size and age characteristics of smolts.

To count the number of young fishes migrating downstream we used a floating trap-net having a similar design with a seine (Fig.3.1; 3.2) with the following characteristics: the length of the wings - 15 m, height - 1.5 m, mesh size from 10 mm to 24 mm.

The trap operated by professional ichthyologists was set near the village Strupovo, 12 km from the mouth of the Luga River. River width at that site is 200 m, the depth in the area of maximum flow velocity (in the zone where salmonid fishes migrate) is about 4 m. The trap was installed in the zone of maximum flow velocity using four concrete sinkers weighing about 100 kg each, and 2 anchors.

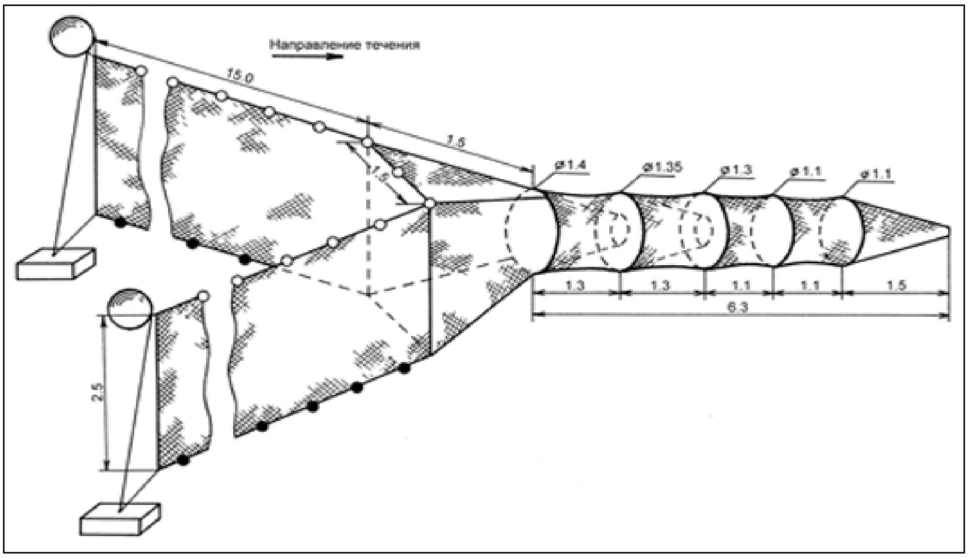

Figure 3.1. Scheme of trap-net of a floating type structure for catching smolts. Arrow defines the direction of river flow.

The trap was functioning continuously in the period from May 3 to June 2, and was checked depending on the number of young fishes migrating downstream either once at 9.00 am or twice a day, at 9.00 am and 9:00 pm. All smolts were measured, weighed and released into the wild. From the majority of wild smolts and all smolts of unclear origin scale samples were taken for age determination. The control skale sampes of hatchery salmons were taken just before their releasing in Luga River. The accuracy of method of visual differenciation of wild and hatchery smolts from the mixed flock of catradromous migrants has been tested earlier by the analysis of their skale samples. The smolts of knowingly hatchery origin marked by cutting off the fat fin before releasing in the river have, besides of abnormalities of central parts of scales, peculiar uderdeveloped gill covers and contorted rays of dorsal fins. These peculiarities permit to distinguish reliably the hatchery young fish from the smolts of natural origin having normal development of scale, dill coverts and fins, and the accuracy of identification is close to 100%. The hatchery salmons staying in the river one or two years more generally keep the abnormalities (Fig. 3.2 -3.3). According to our estimation, the exactness of visual diagnostic (by morphological signs) of hatchery salmons lingered in the river is about 96% (unpublished data).

Figure 3.2. Hatchery smolt with uderdeveloped gill covers.

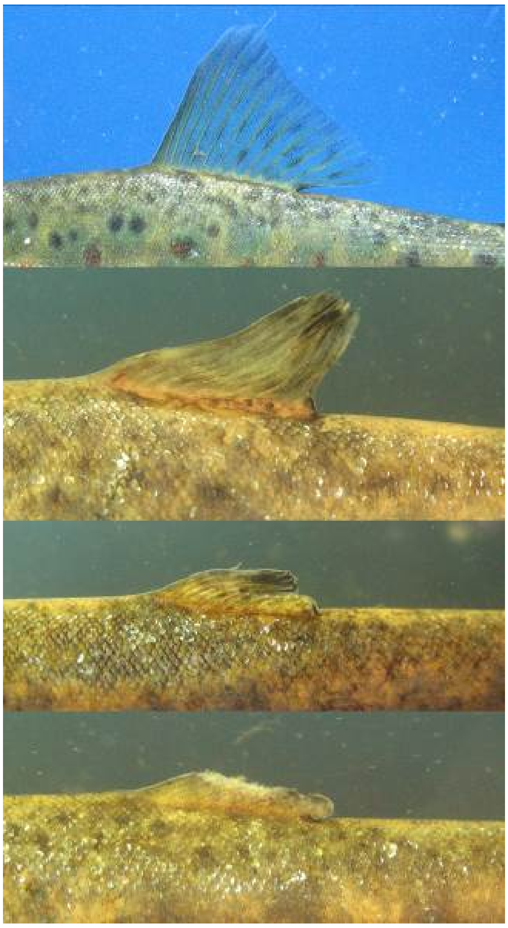

Figure 3.3. Wild smolt with normal dorsal fin (on top) and hatchery smolts with contorted rays of dorsal fins.

Catching capacity of the trap was determined using standard methodology: on a daily basis some of the fish caught (from 10 to 65 individuals) were marked by cutting off part of the tail fin, then transported to a distance of 1 km upstream and released into the river. Based on the number of individuals recaptured we estimated the percentage of catching capacity. To increase the accuracy of the estimations we marked 15 batches of juveniles (over 250 individuals). For each batch we repeatedly calculated the proportion of fish recaptured. On the basis of these data, we estimated mean percentage of catch efficiency.

Fugure 3.4. Working with the trap-net.

During the entire period of the trap functioning 151 salmon smolts of natural origin and 1025 hatchery-grown smolts were caught. Thus, using the percentage of trap's catching capacity (6.2%), the number of smolts, which has migrated downstream thought the mouth of the Luga River during the survey period can be estimated as 2430 salmon smolts of natural origin and 16500 hatchery-grown smolts. Almost 96% of trapped catadromous migrants of hatchery origin were reprrsented by smolts released in 2013, the rest 4% - by fishes of earlier years of release. It should be noted that the number of juvenile salmon of natural origin annually migrating downstream in the Luga River can vary three or four-fold and the parameters obtained in 2013 were significantly below the average annual values (see Fig.2.1 for reference). This may indicate that natural population Luga salmon is in unstable condition.

Size and weight characteristics of salmon smolts of natural origin, which migrated from the Luga River in 2013, are presented in Table 3.1.

Table 3.1. Size and weight characteristics of salmon smolts.

Age	N, individ.	Weight, g			Length, cm		
		min	max	mean	min	max	mean
1	117	6,5	25,1	15,3±0,36	8,5	13,6	11,6±0,11
2	24	25,7	43,7	33,0±1,16	13,7	17,2	15,5±0,20
3	4	53,4	88,0	64,4±8,13	18,0	20,1	19,1±0,47

According to the literature, the total duration of downstream migration of Atlantic salmon is usually 3-4 weeks, and its peak - is from 3 to 7 days. Typically, the rate of migration varies irregularly - in the first several days, it increases slowly, then rapidly reaches its maximum and two weeks later begins to decline gradually. This smolt migration pattern is described for salmon rivers both in the Baltic Sea region and in more northern basins, such as the White Sea (Mitans, 1967; Yakovenko, 1977; Bagliniere, 1993; Veselov et al, 1998; Veselov, Kalyuzhin 2001, Monitoring .. . 2002).

As a result of our studies it was found that the timing of migration correlates with the water temperature in the river. Start of migration and achievement of its peak in all years occur at similar values of the water temperature. So, the beginning of downstream migration of Atlantic salmon is observed at 8-10° C, the peak - at 12-17° C. Downstream migration of salmon in the Luga River usually ends in late May or early June. Sometimes these terms are shifted to the end of the first decade of June, which is associated with uncharacteristic temperature conditions in the river due to late spring. The total duration of downstream migration of juvenile salmon in the Luga River is usually less than 1.5 months. A graph representing the dynamics of smolt migration through the mouth of the Luga River is shown on Fig.3.5.

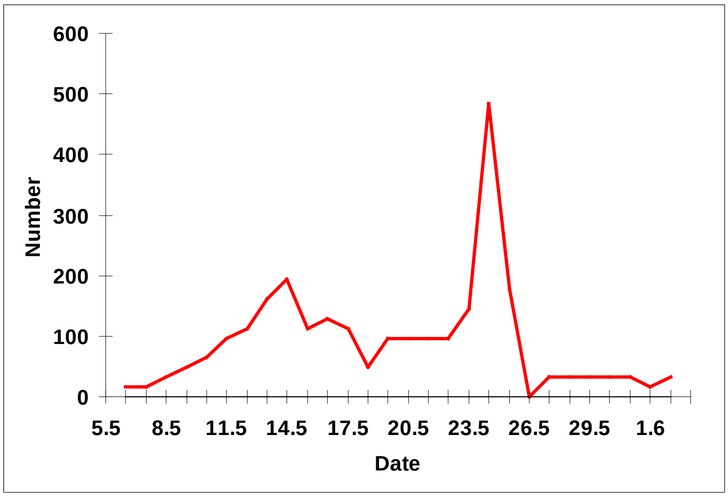

Figure 3.5. Dynamics of Atlantic salmon smolt migration in the mouth part of the Luga River.

Migration of the Atlantic salmon smolts of natural origin in 2013 began on May 6 continued for at least 30 days. Number of smolts caught in the trap for the entire observation period ranged from 1 to 30 individuals per day. Migration peaks were registered in the period from 12 to 18 May at average water temperature of about 14°C and from 23 to 25 May at average temperature of about 18°C. Probably, two migration peaks in 2013 were related not only to water temperature dynamics but also to hydrological regime of the river.

Scale samples were taken from 145 salmon smolts of natural origin. According to the results of scale analysis it was found that 81% of youngs in 2013 migrated downstream at the age of 1 year, 16% - at 2 years and 4% - at 3 years (Fig.3.6).

In studies conducted in previous years it was found out that the age structure of wild salmon smolts in the Luga River can vary significantly from year to year. So, the proportion of wild salmon yearlings in the total sample from migrating fish may vary in the range of 0-90%, a two-year old - in the range of 10-100%. Significant changes in the age structure of the smolts in different years of observations likely suggest small size of natural salmon population inhabiting the Luga River, and, for example, a small number of migrating yearlings is explained by low efficiency of natural spawning in previous years (Mikhelson, Titov, 2013).

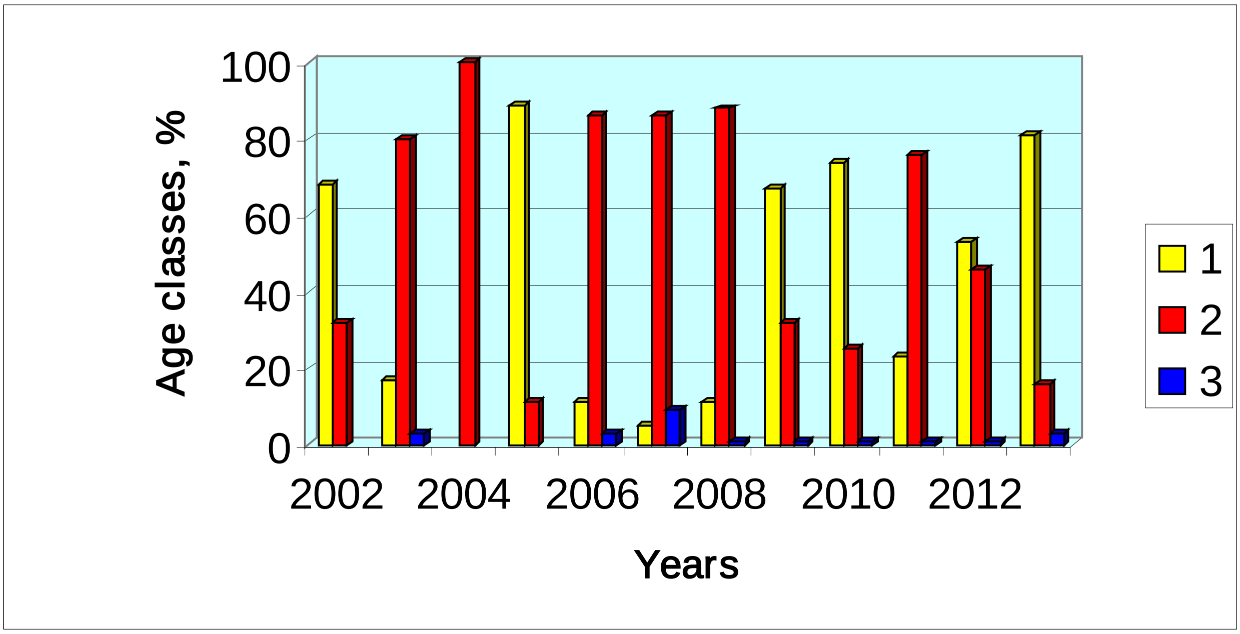

Figure 3.6. Distribution of age classes of “wild” Atlantic salmon smolts. 1 – one-year; 2 – two-year; 3 – three-year.

In addition to salmon and sea trout the following species of fish and fish-shaped were found in the catches: perch (Perca fluviatilis), roach (Rutilus rutilus), silver bleak (Blicca bjoerkna), bream (Abramis brama), common bleak (Alburnus alburnus), rudd (Scardinius erythrophthalmus), three-spine stickleback (Gasterosteus aculeatus), smelt (Osmerus eperlanus), lamprey (Lampetra fluviatilis), pike (Esox lucius), ruffe (Gymnocephalus cernuus), tench (Tinca tinca), crucian carp (Carassius carassius), sabrefish (Pelecus cultratus), cubb (Leuciscus cephalus), dace (Leuciscus leuciscus), vimba (Vimba vimba).

4. Iichthyological and hydrobiological research in the Luga River and its tributaries

In order to achieve our study goal, i.e. to study modern state of natural reproduction of the Atlantic salmon and its environmental conditions in the Luga River basin in July-September 2013, we conducted field surveys which allowed us to complete the following tasks:

- Description of the current state of Luga River and its tributaries;
- Description and mapping of spawning grounds and nursery areas in the Luga River and assessment of their current status;
- Detection and abundance estimation of young salmons (parrs) in these areas (density estimation by means of electrofishing);
- Description of the ichthyofauna composition at spawning grounds and in nursery areas.

4.1. Description of the current state of Luga River and its tributaries

In July 2013 we conducted the first ichthyological survey encompassing the entire Luga River - from the sources located in the Novgorod region, to the mouth of the river, near its influx into Luga Bay of the Gulf of Finland. The length of the route traveled by boat was more than 300 km. During the expedition we were describing the characteristics of the river (width, depth, flow velocity, type of the coastline, presence of various obstacles, etc.). For practical reasons the river was subdivided in 9 parts (sites) (Fig.4.1) in accordance with their physiographic and ecological features.

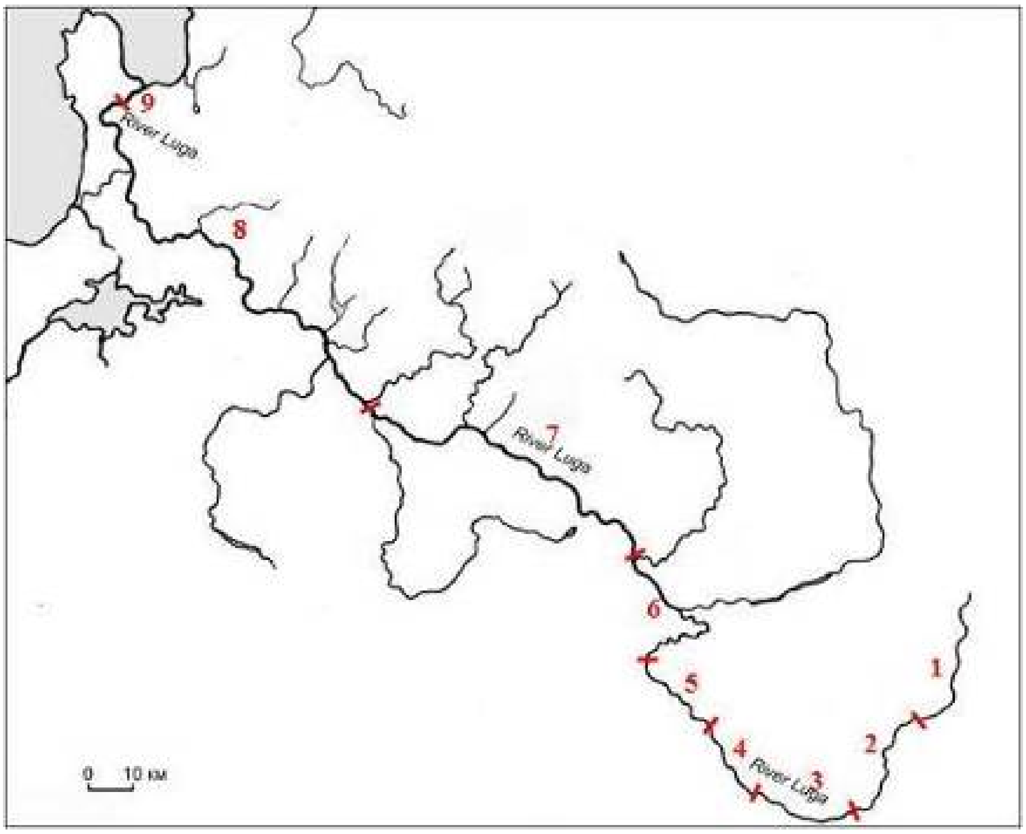

Figure 4.1. Sites of the Luga River inspected and drescribed during field survey.

Site № 1 (From the source to the Chernaya River inflow)

The source of the Luga River is considered to be located at the beginning of the head channel from Tesovo-Netylskoe swamp, in 1 km South-East of the Samina Lake. The Luga River

from the village Vol'naya Gorka to the place of its right-bank tributary inflow - the Chernaya River, is a narrow watercourse from 1 m to 3 m wide (Fig.4.2). Water flow velocity reaches 10-20 cm/sec, the bottom is sandy, and water has peaty dark color. The river makes no sharp bends and has no meanders. Its banks are steep, 1-2 m high, densely overgrown by semi-aquatic herbs, shrubs (willow, alder), trees (birch, aspen), which projective coverage is 75-100%. River valley is represented by meadows with mixed forest, growing mainly on the left bank, the width of the valley is 100-300 m.

Figure 4.2.The Luga River near Vol'naya Gorka village

Site № 2 (From the Cheraya River mouth to Kositskoe village)

Below the confluence with the Chernaya River the Luga River has a width of 5-10 m. The river meanders strongly, forms oxbows, sometimes splits into two streams, connecting again in 100-400 m. The banks are represented by floodplain meadows, overgrown by meadow grasses and semi-aquatic vegetation, with abundant willow thickets. Height of the banks is 1-2 m, slopes - 45°.
From the village Torchinovo to the village Kositskoe the width of the Luga River is about 10-20 m (Fig.4.3), the river forms local floodplains up to 30 m wide, with backflow and considerable depth. Flow velocity is 10-20 cm/sec. Water is transparent enough (1.5-2 m), has amber color. The river meanders strongly.

The river main course is adjoined by a large number of oxbow lakes, flood waterbodies and streams, with estuaries densely overgrown with partly submerged vegetation (bulrush, horsetail and sedge).
Often the entire width of the river is covered with thickets of potbelly, lilies and pondweed, thickets length is up to 50 m. In the river bed and banks there is a large number of fallen trees. At the bottom large stones can sometimes be found. The river often forms long chutes with flow velocity of up to 25 cm/sec, where the river bed may get as narrow as 1.5 m, such sites are typical for low floodplain banks. In such areas pondweed and sedges are common. Height of the banks varies from 0.2 to 3 m with bank slope of 30-50°, near the villages (Pogost-Sable, Tereboni) banks often have very steep slopes with an angle of 75-90°. The river banks are mostly forested (birch, willow, aspen, alder, fir, pine), rarely represented by meadows. Width of the valley of the river is about 100 m.

Figure 4.3. The Luga River near Torchinovo village

Site № 3 (From Kositskoe village to Podgor'e village)

Downstream from Kositskoe village (Fig.4.4), the river flows mostly in the meadow and floodplain shores (height - 0.2-1.5 m), covered with meadow grasses, shrubs and semi-aquatic plants. River bed meanders significantly less and forms almost no oxbows. The width of the river increases to 20-25 m. This part of the river is characterized by overgrowth of the entire width of watercourse with submerged and floating hydrophytes (potbelly, water lily, pondweed), length of the thickets is 30-200 m. There are thickets of cane, sedge and reed everywhere along the shore. The width of the river valley is 100-300 m.

From Zapol'e village to Podgor'e village (Fig. 4.5) the river has a width of 20 - 50 m in floodplain and the junction of oxbows. Height of the river banks is 1.5-3 m. Places along the banks and across the entire width of the river for over the 50-200 m are overgrown with thickets of submerged and floating hydrophytes - lilies, potbelly, pondweed, as well as sedges, reeds and horsetail. The river flows through the meadow floodplain 200-400 m wide. The banks of the valley are up to 30 m high, the slope angle is about 30°.

Figure 4.4. The Luga River near Kositskoe village

Figure 4.5. The Luga River near Zapol'e village

Site № 4 (From Podgor'e village to Rusynya village)

From Podgor'e village to Rusynya village the river is represented by a completely overgrown submerged floodplain with significantly meandering and narrow river bed (Fig.4.6) with a width of 0.5-5 m, numerous oxbows and partition of the watercourse. The floodplain is completely overgrown with cones, reeds, sedges, horsetails, density projective coverage of the thickets is 75-90%, often reaching 100%. Floodplain width is 300-500 m. Banks of the river valley are meadow, with height of 50-60 m, slope angle - 10-40°.

Figure 4.6. The Luga River near Novoe Selo village

Site № 5 (From Rusynya village to the town of Luga)

From Rusynya village to Petrovskie Baby village (the Leningrad region), the width of the river is about 20-30 m (Fig.4.7), sometimes it increases to up to 50 m. Water flow velocity is on average 10 cm/s, on river bars - 15-25 cm/sec. Water is dark, muddy. Hydrophytes are less common and their abundance is low, sometimes on the river bars formed by narrowing of the river bed (width up to 15 m) there are thickets of arrowhead and pondweed. River banks and river bed covered with large number of fallen trees. River banks are forested, steep, 5-10 m high. The edges of the banks are overgrown with shrubs (willow, alder, currant). Closer to Petrovskie Baby village along the river there is a plowed field. One can smell resistant organic fertilizers over a large area around. Old weirs (zakols) and remains of destroyed wooden bridges can sometimes be found on the river bed.

In the town of Luga and even a bit upstream (Fig.4.8) the river has a width of 25-30 m. The water flow velocity is low - 2-5cm/sec, but the river bars 0.5-2 m deep and with flow velocity over 20 cm/s often occur. Water has dark color. In the water, along the banks, one can find many fallen trees and thickets of potbelly. The left bank of the river is represented by meadow, with a height of 3-4 m, tree vegetation consists of shrubs (willow, alder) and poplars. Right bank 3-4 m high, mostly overgrown with shrubs (willow, alder) and forest (pine), with occasional meadows. The river banks are steep, slope angle - 45-90°. Flat sandy beaches covered with sedges or with no vegetation at all are often found along both banks of the river.

Figure 4.7. The Luga River downstream from Rusynya village

Figure 4.8. The Luga River near the town of Luga

Site № 6 (From the town of Luga to the mouth of the Yaschera River)

From the town of Luga downstream to Posol'skiy Island (near the camp "Molodezhniy"), the river flows through a swampy meadow floodplain. Right bank is forested at many sites. A large number of oxbows and small lakes are adjacent to the river. Width of the river is about 20 m, in some narrow places - less than 15 m. The water flow velocity is low; the river forms the riffles with flow velocity over to 15cm/sec. The banks are steep; angle of the slopes is 60-90°, height - 1.5-3m. Floodplain width is 200-300 m, on the banks of the river valley there is a mixed pine forest. Sometimes valley bank gets very close to the river, forming steep sandy banks up to 30 m high. Willow, alder, pine, floodplain and meadow grasses mainly grow along the banks of the river.

In the area near Posol'skiy Island close to the Merevo Lake the river gets as narrow as 10m and transitions into a long river riffle about 1 km long with flow velocity over 20cm/sec (Fig.4.9). There are rocky sites on this riffle mainly with large stones. Island is formed by the main and secondary course of the river. The banks at this site are floodplain meadow, sometimes swampy. Narrow strips of shrub (willow) grow along the river. The width of the river valley is 300-500 m. There is a pine mixed forest on the slopes of the valley.

Upstream and downstream from the camp "Mayak" width of the river is 15-20 m (Fig.4.10). Water flow is weak - up to 5 cm/sec. Occasionally, the river forms rapids (flow velocity increases up to 10 cm/s) and areas with backflow. Water has sandy color; transparency is medium (about 1 m). The banks are forested, steep (sometimes sandy), height is 1.5-3 m. On the banks there are pine, birch, aspen, alder, oak and shrubs. Sometimes there are meadows on both sides of the river. At this site there is a channel that connects the river and the Beloye Lake. The mouth of the channel is about 1m wide, barely visible, swampy, overgrown with cones, reeds and sedges.

In the vicinity of the village Ploskoe after confluence with the Oredezh River the width of the Luga River increases to 30 m. Flow velocity is 5-10cm/sec. River flows through meadow floodplain 200-300 m wide. The floodplain vegetation is dominated by sedges and shrubs, on the sandy slopes of the valley there is a pure pine forest. Height of the river banks is about 1m, slope is about 90°. In the areas where the slopes of the valley are closely adjacent to the river, they form high sand banks.

In the vicinity of the village Tolmachyevo the river flows in low meadow banks (about 0.5 m height, slope angle 90°) and partially in submerged floodplain, overgrown with sedges, reeds, horsetail, arrowhead. The width of the river is 30 m, the flow velocity - 5-10 cm/sec. River bed is nearly clean from water vegetation, narrow bands of potbelly thickets occur only close to the shores. Along the banks of the river there are thickets of willow. Floodplain width varies from 100 to 500 m. Pine, birch, aspen, spruce, oak and elm grow on the slopes of the valley.

Downstream from the village Sitenka and up to the mouth of the Yaschera River floodplain width gradually decreases to 50-100 m, and the river acquires high forested banks.

Figure 4.9. Long river bar on the Luga River near Posol'skiy Island

Figure 4.10. The Luga River near the camp "Mayak"

Site № 7 (From the mouth of the Yaschera River to Bol'shoy Sabsk)

Downstream from the Yaschera River mouth the width of the Luga River is about 30 m. Flow velocity is 5cm/sec, sometimes stronger water jets (10 cm/sec) with whirlpools and backflow on uneven bottom are visible. Left bank is mostly forested, about 5 m high (slope angle is about 60°), covered with spruce, oak, birch and willow. Right bank is flat, meadow with a sand band overgrown with willow and birch along the shoreline. Aquatic vegetation is represented by sparse areas of potbelly and arrowhead thickets along the coastline.

In 2.5 km upstream from the mouth of the Kemko River the width of the Luga River is about 30 m. Water flow velocity is less than 5 cm/sec. The banks are forested, steep, at least 4-6 m high (slope angle is 60-70°). The main tree species are elm, birch, pine, spruce. In some parts of the river the banks are represented by meadows with narrow bands of shrubs (willow, currant). Sometimes one can find narrow bands of partly submerged (horsetail, arrowhead) and submerged (Potamogeton) aquatic vegetation. There are narrow sandy beaches up to 100 m long, overgrown with willows and sedges.

In the area near Bezhany village, Muraveyno village and downstream to Tverdyat' village the Luga River is 40 m wide (Fig.4.11). Flow velocity is 2-3 cm/sec. Water is dark brown, muddy. There are no river bands or chutes. Along the shore there are many submerged trees. The banks are mostly high - 3-6 m, with a band of forest (willow, birch, oak, elm, linden, pine), beyond which meadows begin. On the left bank there are sometimes sloping forested areas, with a height of up to 1m. Sometimes there are steep sandy banks up to 15 m high. The area is characterized by a large number of streams inflowing the Luga River; all streams have sandy bottom, are shallow (up to 1 m wide) and often have mouth overgrown with semi-aquatic vegetation.

From Tverdyat' village to the Vidon' River mouth the width of the Luga River is about 40 m (Fig.4.12). In the river bed the islands 2-10 m in diameter and covered with sedges often occur. The water flow velocity between the islands and the coast in the sites with braiding of river channels increases up to 10-15 cm/sec. Along the coastline of the main channel of the river and in oxbows there are potbelly and arrowhead thickets. The river banks are mostly high (up to 3 m high, slope angle - 30-80°), forested (pine, spruce, birch, aspen, willow), but floodplain areas with oxbow lakes and small adjacent ponds often appear. In the floodplain there are thickets of horsetail, sedges, willow. The banks often form sloping sandy beaches, overgrown with shrubs.

From the Vidon’ River to Radezha village the river banks are mostly high (up to 3 m high, slope angle 30-80°), forested (pine, spruce, birch, aspen, willow) and overgrown with shrubs. The river width is 60-80 m. In the river bed sometimes there are small islands covered with sedges. The water flow is calm. In this area the Lemovzha River inflows to the Luga River.

From Radezha village to Sabskie rapids the banks of the river are mostly open meadows, often floodplains. In the river bed there are numerous islands with grass and shrubs. There are many surrounding flood waterbodies and oxbows. Width of the river is 80-100 m. The water flow is from moderate to fast on the river bars between the islands. Near Bol’shoy Sabsk the number of islands and sites with braiding of river channels is particularly high.

Figure 4.11. The Luga River upstream the Staritsa village

Figure 4.12. The Luga River downstream from Tverdyat' village

Site № 8 (From Bol'shoy Sabsk to Ust'-Luga)

From Bol'shoy Sabsk to the mouth part of the river near Ust'-Luga settlement the width of the river gradually increases from 80 to 300 m, the maximum width of the river (up to 400 m) is observed here near Strupovo village. The banks are mostly high, represented by meadows either overgrown with sparse forest and shrubs, or forested. Height of the banks is 3-5 m, slope - 30-45º. Slopes are composed of bouldery loams, sometimes - sandy loams. Often there are extensive floodplains, covered with sedges, reeds and coastal grasses. The bands of cane appear more and more frequently. In this area many islands and oxbows are formed in the river bed, also a large number of flood watersbodies adjoins the river. The largest island, measuring about 900 m in length, is located downstream from Strupovo village. Vegetation on the islands is mainly grassy and shrubby. In this part of the Luga River the following tributaries inflow: Peleda, Vruda, Chebazhir, Lychenka, Dolgaya, Lubenka, Vertsa, Hrevitsa, Azika, Gorodenka, Vaguy, Kaskolovka, Solka, Notica, Or'evka, Chernaya, Rosson', Mertvitsa.

In the area near Bol'shoy Sabsk, Bol'shoy Klenno and Porkhovo the width of the river floodplain reaches 1000 m, downstream from the mouth of the Koskolovka River it increases to 2000 - 3000 m, near the villages Zhabino and Koshkino reaches 4000 - 5000 m. The floodplains are particularly large between the villages Keikino and Bol'shoe Kuzemkino, where the waters of the rivers Luga, Rosson' and Narva joint. At high water overflow of Luga waters to the Narva River via the Rosson channel is observed. Floodplain is flooded with 1-2 m of water, occasionally up to 4 - 6 m; duration of flooding is 2 - 3 weeks, in some years downstream from the Koskolovka River - up to 1 month.

Near the town of Kingisepp there is a large floodplain area with numerous large and small islands, overgrown with cones, sedges, reeds. Slopes of the valley of the river consist of limestone, covered by loam. The valley slopes are very steep, 10 - 20 m high, the width of the floodplain in some places reaches 500 – 600 m. Within the town, the river forms a few sharp bends. Minimum depth is 0.5 m (Kingisepp), maximum - up to 10 m. Prevailing depths - 1.5 - 2.0 m.

In the area of Preobrazhenka village there are pillars of the old railway bridge in the river bed. Downstream from Preobrazhenka village and to the mouth of the river the islands in the river bed practically do not occur.

Figure 4.13. The Luga River in the settlement of Bol'shoy Sabsk

In this part of the Luga River there are several rapids important for salmonid fishes: Sabskie rapids, Storonskie rapids, Ivanovskie rapids, rapids near Klenno village, and Kingiseppskie rapids.

Sabskie rapids (Fig.4.14) are located near Bol'shoy Sabsk village (110 km from the river mouth). The length of the rapids (excluding alluvial areas between them) is 1800 m. the width of the river bed is 60 - 135 m, depth - 0.4 - 1.2 m, flow velocity - 0.5 - 1.5 m/sec. Area of potential spawning and nursery grounds is 161 750 m^2. The bottom is uneven, formed by boulders and slabs of limestone.

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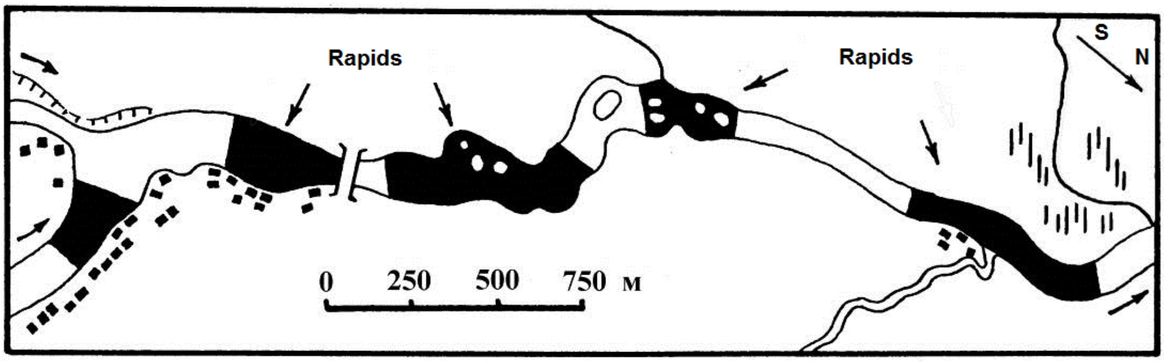

Figure 4.14. Sabskie rapids

Storonskie rapids (Fig.4.15) are located in the area of Bol'shoe Storon'e stow (urochische) in 95 km from the river mouth. The length of the rapids (excluding alluvial areas between them) is 1700 m. The width of the river bed is 105 - 125 m, depth - 0.5 - 1.5 m, flow velocity - 0.5 - 1.5 m/sec. Area of potential spawning and nursery grounds is 192 500 m^2. The bottom is uneven, formed by boulders and slabs of limestone.

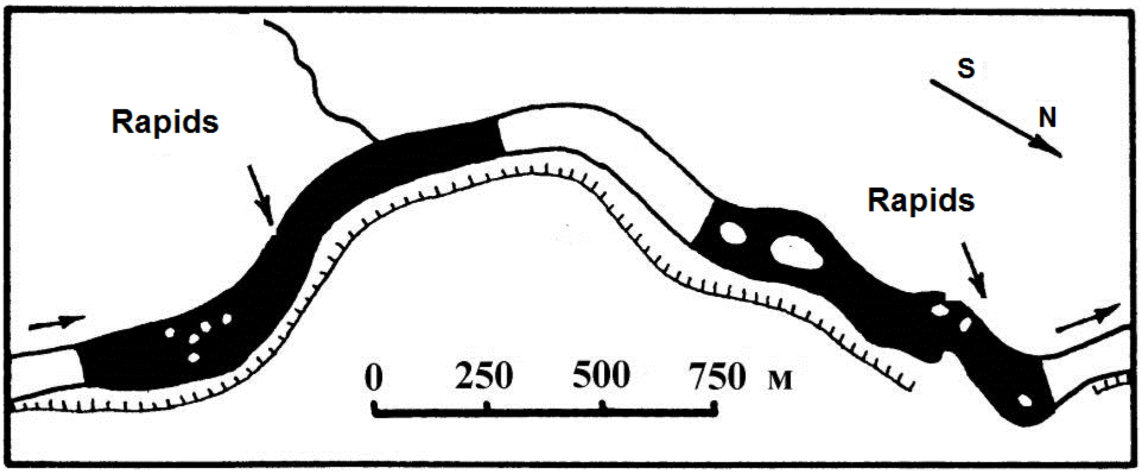

Figure 4.15. Storonskie rapids

Ivanovskie rapids are located near Porech'e village (87 km from the river mouth). Length of the rapids (excluding alluvial areas between them) is 1300 m, river bed width - 100 m, depth - 0.4 m, flow velocity -

0.5 - 1.7 m/sec. Area of potential spawning and nursery grounds is 130 000 m^2. The bottom is even, formed by slabs of limestone.

Rapids near Klenno village are located in 77 km from the mouth of the river (Fig.4.16). The length of the rapids is 80 m, river bed width - 40 m, depth - 0.5 - 1.5 m, flow velocity - 0.5 - 1.0 m/sec. Area of potential spawning and nursery grounds is 3 200 m^2. The bottom is uneven, formed by boulders and slabs of limestone.

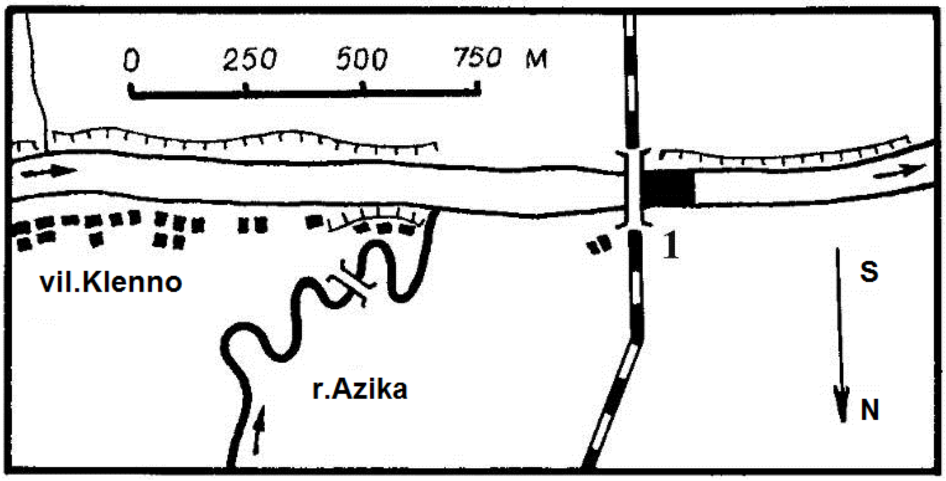

Figure 4.16. Rapids near Klenno village

Kingiseppskye rapids (Fig.4.17) are located in the town of Kingisepp (61 km from the river mouth). The length of the rapids (excluding alluvial areas between them) is 2500 m. The river bed width - 100 - 200 m, depth - 0.3 - 1.2 m, flow velocity - 0.5 - 1.2 m/sec. Area of potential spawning and nursery grounds is 375 000 m^2. The bottom is uneven, formed by boulders and slabs of limestone.

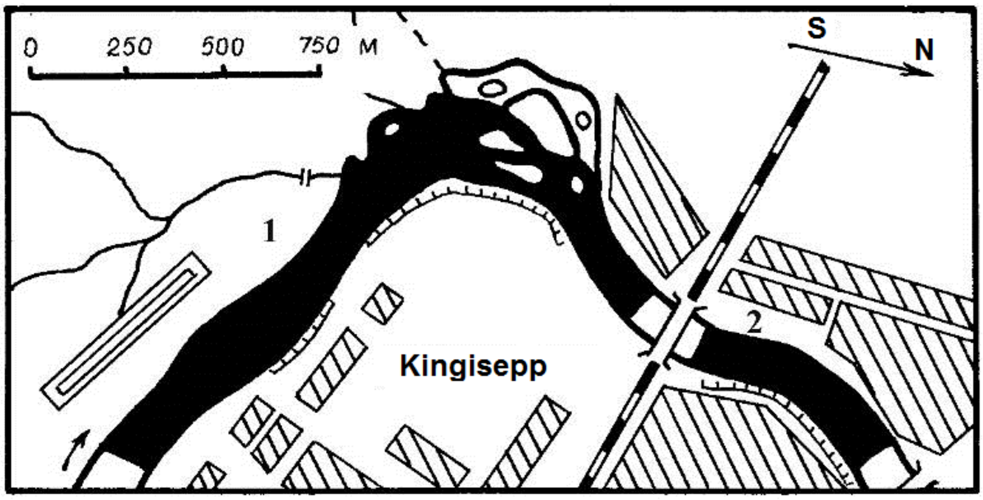

Figure 4.17. Kingiseppskie rapids

Site № 9 (River mouth area - the last 1000 m)

The Luga River in the lower course is characterized by weak currents, frequent and abrupt bends, shoals and river bars. The mouth area is straightened. Depth is about 2 m, in the river bed part - 5 - 6 m. The river bed has a trough-shaped form with steep banks, a relatively rapid decline of the bottom near the water edge and smooth slope in the middle.

At the mouth part of the Luga River over the last kilometer of its course the width increases sharply from 300 to 900 m. There is a bar which juts out to Luga Bay in a fan shape for 1.5 km and is characterized by depth of 0.8 - 1.8 m. The watershed line watershed is better expressed in the western part.

Description of the Luga River tributaries

The Yaschera River

It is a right tributary of the Luga River. It is formed by the confluence of the rivers Sosnovka and Kamchatka and flows into the Luga River in 177 km from the mouth. The river length is 78 km, the average slope is 0.77%, catchment area is 655 km^2.

The width of the river is from 7 to 20 m, depth on the river bars - about 0.3-0.5 m and on reaches - much deeper. The Yaschera River flows mainly through a forest (spruce, alder, birch). Flow velocity does not exceed 0.4 m/sec. The banks of the river over considerable distance are high, in some places - up to 10 m. In 19 km from the mouth, in the village Dolgovka, the river is regulated with a dam, which represents an obstacle for fish migration.

Downstream from the dam there are rapids areas 9-10 km long. They vary in length (from 5 to 300 m), but similar in the basic parameters. Depth at the rapids is about 0.5 m, flow velocity – up to 0.8 m/sec. The composition of soil includes gravel with 2.5-7.5 cm diameter, stones up to 30 cm in diameter and large boulders. On some riffles there is considerable amount of sand in the soil.
Area of spawning and nursery grounds of the Yaschera River suitable for juvenile sea trout, is very small - about 7700 m^2.

Fugure 4.18. The Yaschera River

The Vidon' River

It is a right tributary of the Luga River. It originates from the swamp Gusiniy Mokh in 8 km North-East of the village Lemovzha. It flows into the Luga River in 124 km from the mouth. The river length is 7 km.

Character of the river throughout its length is almost the same: no pronounced bars or deep swampy reaches. Width of the river varies from 3 to 5 m, depth - about 0.5 m, the flow velocity is 0.2-0.4 m/sec. There is a spruce forest with birches and alders growing along the banks of the river. Projective coverage is significant, up to 80%.

All sites suitable for habitat for juvenile sea trout are concentrated within 2 km from the mouth of the river. Pronounced riffles in these areas were detected, the nature of the river is about the same throughout its length: depths reaches 0.3-0.4 m, the flow velocity does not exceed 0.4 m/sec. Soil consists of sand and gravel, in some places is rocky.

Area of spawning and nursery grounds suitable habitat for juvenile sea trout in the Vidon' River is very small and is approximately 8,000 m^2.

Figure 4.19. The Vidon' River.

The Lemovzha River

It is a right tributary of the Luga River formed by the confluence of the Chernaya and Izvarka rivers in Chernaya village and it flows into the Luga River in 128 km from the mouth of the latter (1 km upstream from Lemovzha village). The river is 48 km long, its catchment area is 839 km^2. The river has 64 tributaries with total length of 129 km.

The width of the river varies from 7 to 40 m, depth is from 0.3 to 1.5-2.0 m. The banks in the upper course are from 1 to 9 m high, in the middle course - up to 20-26 m, and at the lower course - up to 44 m. The rapids and riffles are mainly located in the upper and lower thirds of the river, reach sites - in the middle course.

The length of the rapids varies from 30-50 m to 500-1000 meters. The width ranges from 15-20 m in the upper course to 35m at the lower. Throughout the length of the river the depth is about 0.5 m, flow velocity - 1.0-1.2 m/sec, in the mouth part - about 0.6 m/sec. River bed consists of sand and gravel, it is stony, sometimes littered with driftwood and snags, the bottom is rocky on rapids, with jumbles of boulders up to 1.5 m in diameter. Bottom of the river in some places is covered with fieldstone.

Area of spawning and nursery grounds of the Lemovzha River suitable for juvenile sea trout, is significant - about 160,000 m^2.

Figure 4.20. The Lemovzha River, source

The Vruda River

The river is a right tributary of the Luga River. It originates from the Lake Smerdovitskoe (Bol'shoe Vruda village), inflows into the Luga River in the 105 km from the mouth of the latter (2.5 km downstream from the village Bol'shoy Sabsk). The river is 60 km long, its catchment area is 526 km^2. The river has 47 tributaries with total length of 97 km.

The width of the river in the part from the mouth to the confluence with the Sumka River reaches 30-34 m, then upstream declines sharply to 15-17 m in most places (in some places – 9-10 m). In the area of Ust'e village (20 km from the mouth) the Vruda River is blocked by a destroyed dam, which does not represent a barrier to fish passage. Depth of the river in most parts of the river bed is 0.3-0.5 m and only in some places reaches 0.7-1.5 m. River bed consists of vast reaches alternating with riffles and rapids. On reaches the bottom is sandy. Rapids and riffles are fairly evenly distributed, most of reaches are located the first and last thirds of the river.

The length of rapids varies from 50 to 500 m (only one rapid 1500 m long was found in the middle course of the river). The width of almost all the rapids in about 20 m, depth ranges from 0.3 to 0.6 m, flow velocity - 0.6-0.7 m/sec, sometimes up to 1.0 m/sec. Soil on the rapids consists of gravel 2.5-7.5 cm in diameter, stones 30 cm in diameter and large boulders. In the last third part of the river there is a significant amount of sand in the soil. Rapids of the mouth of the river can be considered as spawning and nursery grounds suitable for salmon because here juvenile salmon was found.

Among all the tributaries of the Luga River the Vruda River has the largest spawning grounds and nursery areas suitable primarily for juvenile sea trout. Out of all spawning grounds and nursery areas of the river suitable for trout and constituting according to our estimate about 220,000 m^2, no more than 2-5% can be used by salmon in the lower course of the river.

Figure 4.21. The Vruda River, upper course

Figure 4.22. The Vruda River, lower course

The Dolgaya River

It is a left tributary of the Luga River, originating from the Lake Spas-Kotorskoe, inflows into the Luga River in 93 km from the mouth. The river length is 91 km, its catchment area is 830 km^2.
Most of the basin is covered with mixed forests, the largest marshes are located in the middle part of the catchment area; lakes are concentrated in the southern part of the basin.

In 15 km from the mouth, near the village Zagorje, the river is regulated with a dam, which represents an obstacle for the passage of fish. Throughout the area reaches alternate with rapids.

Length of the river bars is mostly small: about 20-50 m. A couple of riffles 600 m long was found. Width - 10-15 m. Depth almost everywhere is 0.4 m. Only on long riffles it increases to 0.8-1.0 m. Flow velocity - 0.8 m/sec, increases to 1.0 - 1.2 m/sec. on long riffles. Soil on the riffles consists of gravel 2.5-7.5 cm in diameter, stones (sometimes with sharp edges) up to 30 cm in diameter and large boulders. Lots of higher aquatic vegetation is observed. Among dominating trees along the banks are alder, willow pine and spruce.

Figure 4.23. The Dolgaya River

The Lubenka River

It is a right tributary of the Luga River, its length is 16 km. It originates in 1.5 km to the southeast of Jyrki village. It inflows into the Luga River in 2.5 km upstream from Porech'e village (85 km from the mouth). Width of the river is 3-5 m, at the mouth it is up to 6 m. The depth of reaches is up to 0.8-1.0 m, flow velocity is mostly 0.2-0.3 m/sec, higher on the river bars. River flows through the forest (spruce, aspen, alder). The banks are mostly flat, covered with grass and shrubs. River bed for most parts is represented by reaches, alternating with small bar.

The length of the riffles is small - about 20-50 m, depth is 0.3-0.7 m, flow velocity - 0.4-0.5 m/sec. Soil on the riffles is mostly sandy, muddy, sometimes with small size pebbles and single boulders 1.0 m in diameter. Higher aquatic vegetation is found.

Area of spawning and nursery grounds of the Lubenka River suitable for juvenile sea trout, is not significant and is about 14,000 m^2.

Figure 4.24. The Lubenka River

The Azika River

It is a right tributary of the Luga River, 17 km long. It originates from streams near the villages Veimarn and Bryumbel'. It inflows into the Luga River near the village Klenno (77 km from the mouth). Throughout its length the river varies in width from 4 to 6 m, in depth - from 0.3 to 1.0 m The first third of the river has a lot of reaches, beaver dams often occur. River riffles are located in the middle and lower courses of the river.

The length of the riffles is small, mostly from 10 to 30 m. Only one riffle located near the mouth of the river has a length of 200 m. Within this riffle four rapids from 7 to 10 m long can be identified (with 2 rapids of artificial origin: the river bed is partitioned by smooth ridges of boulders). Depths are 0.2-0.3 m, flow velocity - 0.4-0.5 m/sec (on a riffle in the mouth area it reaches 1.3 m/sec). Soil is pebbly and sandy with small stones, and usually with several large boulders 0.5-1.0 m in diameter. The banks are grassy, with shrubs, alders and willows. There is a spruce forest with aspen, alder, sometimes - birch.

Area of spawning and nursery grounds of the Azika River suitable for juvenile sea trout is small and based on our estimation is less than 3000 m^2.

Figure 4.25. The Azika River

The Solka River

The Solka River is a right tributary of the Luga River. It originates from the swamps in 1 km south of Gurlevo settlement and inflows in the Luga River near Bol'shoy Luts settlement (54 km from the mouth). The river is 33.5 km long, its catchment area is 206 km^2. In Killi village (21.5 km from the mouth) the river is crossed by a dam, which is a barrier to anadromous salmonids.

The width of the river varies from 3 to 8 m, depth is from 0.3 to 1.0 m. Almost the entire river has reaches with flow velocity of up to 0.2 m/sec. The soil is predominantly sandy, silty, covered with aquatic vegetation.

Considerably large rapids are found in Killi village in 21.5 km from the mouth, where the river falls from the dam dividing into two sleeves, and further downstream. Their total length is 400 m. The width of the river is highly variable, depths range from 0.4 to 0.7 m, flow velocity - 0.6-1.0 m/sec. The composition of the soil includes sand, gravel 2.5-7.5 cm in diameter, numerous stones 30 cm in diameter and large boulders.

Downstream, after a small reach there are sites with river riffles over about 5 km. These sections alternate with reaches in a proportion of about 1:1 and end with a small rapid. The total length of reaches together with a rapid is approximately 2.6 km.

Area of spawning grounds and nursery area of the Solka River suitable for juvenile sea trout according to our estimate is about 19,000 m^2

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Fugure 4.26. The Solka River, dam

Figure 4.27. The Solka River, site downstream from dam

4.2. Description and mapping of spawning places and nursery areas of Luga River and an assessment of their current status

During the field survey we have identified and described all the sites of the river, potentially suitable for spawning of the breeding Atlantic salmon and nursing of young fishes. We recorded the coordinates of these sites, which will allow to map them accurately in the future. As a result of the survey it was found out that all potential salmon spawning grounds in the Luga River are located within the three key rapids - Sabskie, Storonskie and Kingiseppskie (Fig. 4.28 – 4.31).

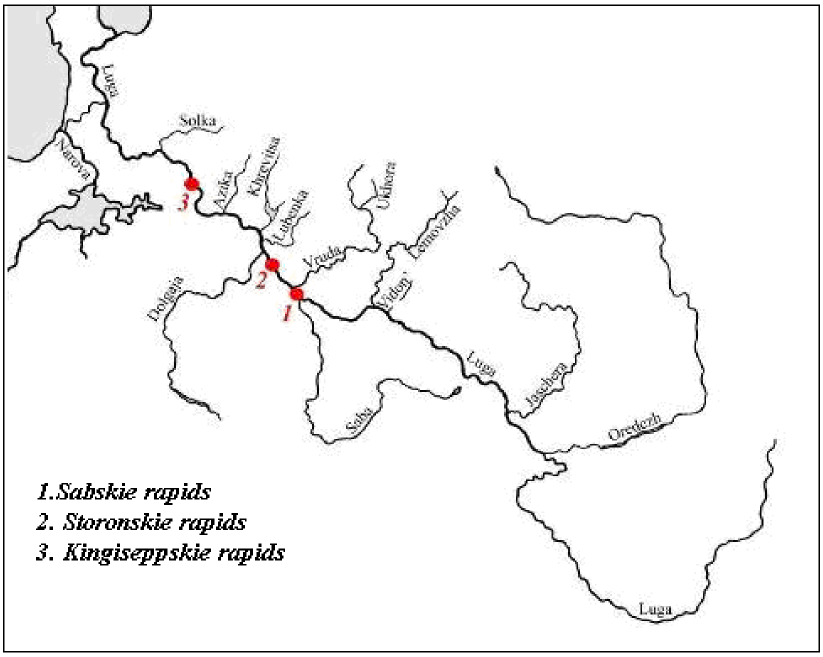

Figure 4.28. Major spawning grounds of salmon in the Luga River.

Figure 4.29. The Luga River, Sabskie rapids.

Figure 4.30. The Luga River, Storonskie rapids

Figire 4.31. The Luga River, Kingiseppskie rapids

Our survey allows assessing location and size of these areas (Table.4.1). As a part of the study we examined the bottom characteristics of these sites and the extent of their coverage with underwater vegetation. Preliminary results indicate that, at present, only a small portion of these rapids can be effectively used for the reproduction of the Atlantic salmon.

Table 4.1. Characteristics of main rapids and river bars suitable for salmon in the Luga River

Name of rapids or tributary	Coordinates		Length, m	Wigth, m	Area, m^2	Depth, m	Max flow velocity, m/sec	Bottom characteristics
	Start (upstream)	End (downstream)						
Sabbskie	59° 07' 57,1" 29° 00' 49,1"	59° 08' 12,3" 28° 59' 57,5"	1800	60–130	160 000	0.3	1.5	uneven, consists of slabs of limestone and boulders
Storonskie	59° 11' 43,1" 28° 53' 25,0"	59° 12' 48,5" 28° 52' 11,4"	1700	60–150	190 000	0.5	1.4	same
Kingiseppskie	59° 21' 30,6" 28° 35' 46,9"	59° 22' 23,8" 28° 35' 10,4"	2500	100–200	360 000	0.3	2.0	same
Vruda river	59° 09' 31,4" 29° 00' 16,1"	59° 09' 31,7" 28° 58' 46,5"	1500	15	22 500	0.3	0.7	same

Out of the five rapids in the Luda River (see the description of Site № 8 in the previous chapter) only three can be considered as salmon spawning grounds and nursery areas since on Ivanovskie rapids and on rapids in the area of Klenno village salmon breeders or smolts have never been observed.

The total area of spawning grounds and nursery areas of Sabskie, Storonskie and Kingiseppskie rapids is estimated by us at 730 000 m^2, but now the amount of suitable habitat for juvenile salmon is estimated at only 350 000 m^2. More than twofold decline of spawning grounds and nursery areas compared with potentially available areas in the main course of the Luga River is caused by their significant overgrowth with aquatic vegetation, their repeated underutilization as spawning substrates by mature salmon with inevitable subsequent "cementing" of the bottom, littering with municipal and industrial waste (especially in the area of Kingisepp).

Assuming that development of foraging base in the river corresponds to the medium level according to adopted scales and can support the maximum density of juvenile salmonids of up to 0.5 ind./m^2, then remaining in circulation rapids of the Luga Rive provide necessary conditions and foraging habitat for more than 170 000 of young salmon of different age classes.

4.3. Detection and abundance estimation of juvenile salmons (parrs) on nursery areas (an assessment of density by means of electrofishing)

A standard technique of electrofishing was applied in order to identify juvenile Atlantic salmon, estimate its density distribution, and determine the species composition of fish fauna on the spawning grounds and nursery areas of the Luga River and its spawning tributaries (Method review..., 2000).
Electrofishing was conducted at control stations located on the rapids and river bars of the Luga River and its tributaries - rivers Lemovzha, Vruda, Vidon’, Yaschera, Solgaya, Lubenka, Azika and Salka.

For fishing we used backpack type of electrofishing with a battery and a net with an anode attached to its ring. 3 people participated in fishing (Fig.4.32).


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Figure 4.32. Fish catches using electrofishing.

Throughout the river we visually selected areas with similar bottom topography, aquatic vegetation and fractional composition of the soil, with depths ranging from 5 to 50 cm and flow velocity of 0.5-1.5 m/sec. An area of each studied site was chosen individually for each river and ranged from 50 to 800 m^2.

Fishing on each site was conducted consecutively - three times with 10 minutes intervals, which allowed to withdraw more than 90% of the fish, and to determine with sufficient accuracy the density distribution of juvenile salmon in the area. Movement of specialists across the site was carried out upstream along imaginary contours from edge to edge of the site with a step of 1.5 m. Caught live fish (Fig.4.33) was weighed, measured and released into the river 50 m downstream from the site fished .

Figure 4.33. Young salmons caught using electrofishing in the Luga River.

At the end of electrofishing, description of fished area was made indicating the nature of the river, presence of coastal and littoral vegetation, fractional composition of soil, level of overgrowth, abundance of vascular aquatic vegetation.

When electrofishing the records on associated fish species being possible food competitors for young salmon or environment status indicators were made.

In the course of control fishing conducted in August – September, 2013 juvenile salmon was found in the Luga River and in the lower course of its most significant spawning tributary - the Vruda River. Juveniles of this species were absent on the potential spawning and nursery grounds of other tributaries of the Luga River, but at the same time in some parts of the rivers Lemovzha, Vidon', Solka, Azika, Lubenka we found juvenile sea trout in significant numbers. This fully confirms our earlier data that most of the spawning tributaries in terms of their hydrological characteristics are more suitable habitat for reproduction not for Atlantic salmon but another species of salmonids - migratory form of sea trout (Salmo trutta L.).

Spawning grounds and nursery areas of Atlantic salmon in the basin of the Luga River are almost entirely concentrated in the main course of the river (here we can distinguish at least 8 rapids). The most important spawning grounds and nursery areas for salmon in the Luga River are located on Sabskie, Storonskie and Kingiseppskie rapids (Fig.4.28, Table 4.1).

Fishing conducted in the Luga River on the rapids in the town of Kingisepp allowed to estimate the density distribution of juvenile salmon on these spawning grounds and nursery areas in 2013 which amounted to more than 8 individuals per 100 m^2, but the majority of juveniles has been identified as reared and released to the rapids by the Luga salmon hatchery (Table 4.2).

Table 4.2. Density distribution of wild and reared juvenile salmon on spawning grounds and nursery areas of the Luga River (based of electrofishing data).

River	Location of spawning ground	Number of sites fished	Total site area m^2	Number of fish caught		Density distribution, ind./100 m^2	
				reared	wild	reared	wild
Luga	Sabskie rapids	4	1380	—	—	—	—
	Storonskie rapids	5	1070	—	—	—	—
	Kingiseppskie rapids	6	1280	92	13	7.2	1.0
Vruda	Lower course	4	2820	—	13	—	0.5

As it was mentioned above, during last years Luga hatchery releases in the river (on Kingiseppskie rapids) some weeks before the beginning of downstream migration mainly one-year old fishes that are regarded as smolts. Nevetherless, only part of released salmons migrate in the sea. Some of them stay in the river during one year (more rare two years) keeping the characteristic signs of artificially reared fish (underdeveloped gill covers and contorted rays of dorsal fins. These features together with deformed pattern of sclerites in their central part permit to tell the hatchery salmons from the wild ones quite reliably.

Density of wild juveniles on Kingiseppskie rapids is less than 1 individual per 100 m^2. On Sabskie and Storonskie rapids no juvenile salmon was caught in 2013. The spawning ground located in the mouth of the Vruda River was characterized by density distribution of juvenile salmon of less than 1 individual per 100 m2 in 2013 (Table 4.2).

Both on Kingiseppskie rapids and in the lower course of the Vruda River wild juvenile salmon was represented by different age classes (Table 4.3; 4.4). It indicates that on this spawning grounds salmon spawning occur annually.

Table 4.3. Size and age characteristics of wild juvenile salmon on spawning grounds and nursery areas of the Luga River (Kingiseppskie rapids).

Age	n	Length, cm			Weight, g		
		min	max	X ± m	min	max	X ± m
0+	4	8.3	8.7	8.5±0,20	5.3	7.9	6.6±0.39
1+	9	9.9	15.7	12.4±0.93	8.9	37.0	24.1±2.12

Table 4.4. Size and age characteristics of wild juvenile salmon on spawning grounds and nursery areas of the lower course of the Vruda River.

Age	n	Length, cm			Weight, g		
		min	max	X±m	min	max	X±m
0+	10	6,6	8,5	7,3±0,26	3,4	7,1	4,6±0,38
1+	3	10,5	13,0	11,9±0,80	16,2	24,4	20,2±1,43

Among the fish on Kingiseppskie rapids we have studied the sample of 29 individuals that were represented by two age classes: the salmons of the age class 1+ prevailed, the group 2+ occurred in less numbers (Table 4.5).

Table 4.5. Age and characteristics of the juvenile salmons of hatchery origin

Age	n	Length, cm			Weight, g		
		min	max	X ± m	min	max	X ± m
1+	24	11.0	14.0	13.0±0,19	12.7	35.5	27.2±0,51
2+	5	14.2	15.0	14.5±0.28	35.4	41.6	39.1±0.83

4.4. Assessment of juvenile salmon fodder base (hydrobiological research)

Parallel to ichthyological research on the rivers of basin of the Luga River hydrobiological researches on estimation forage base of salmonid fish were made. Index-map of sampling places is presented on the Figure 4.34.

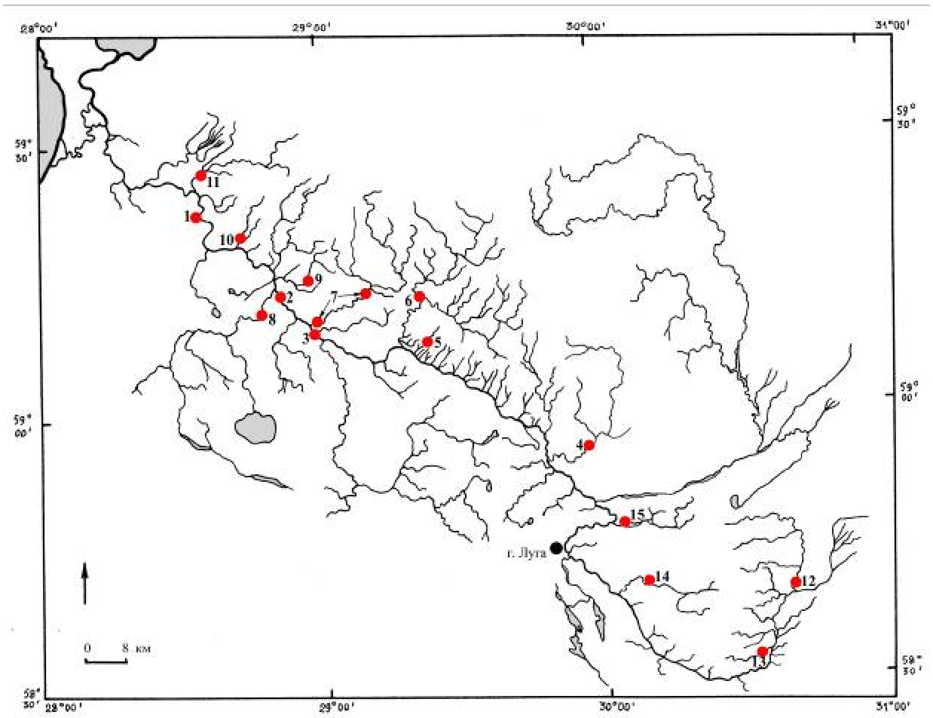

Figure 4.34. Hydrobiological and ichthyological sampling places in basin of the Luga River. Legend: 1. Kingiseppskie rapids of the river Luga; 2. Storonskie rapids of the river Luga; 3. Sabskie rapids of the river Luga; 4. River Yaschera; 5. River Vidon'; 6. River Lemovzha; 7. River Vruda; 8. River Dolgaya; 9. River Lubenka; 10. River Azika; 11. River Solka; 12. River Chernaya; 13. River Luzno; 14. River Udrajka; 15.River Kemka.

In the investigation of macrozoobenthos and drift on river station we studied macro invertebrates having bottom life pattern and involved to the drift in water column and on surface. Water temperature during sampling period in water bodies varied insignificantly, and substratum characteristics, meanings of depth and current velocity were equitable.

The macrozoobenthos was studied by standard methods of Zoological Institute RAS and GosNIORKh (Methodical recommendations…,, 1983) and Biological Institute of Karelian Research Centre RAS (Komulainen et al., 1981).

For macrozoobenthos sampling on sites with soft and medium sediments (sand, small gravel) the modified Petersen grab with capture area 0,025 m^2 (with using equipment details providing unitary size of samples for different bottom types and preventing fluviraption of upper sediment lay during grab's closing) was implemented. On bottom sites with more coarse substrates analogue of frame called "Surber" (Slack et al., 1973) with capture area 0,04 m^2 has been used.

Study of macrozoobenthic organisms involving to the drift was carried out in few ways: in water column by gauze sieve № 23 with square frame 860 cm^2 in area that being placed vertical to water flow; on water surface by modified Elliot trap (Elliot, 1967; Shustov, Shirokov, 1980) with capture area 280 cm^2, that also being installed vertical to water flow. The equipment for drift sampling was being exposed during 15 minutes on sites with depth meanings close to average depths on section lines of river station. Cameral analysis was carried out in laboratories with standard methods. Besides, larvae of Chironomidae and Simuliidae were separately fixed with mixture of ethanol and glacial acetic acid for further verification of species features using karyosystematic methods (Karyotypes and morphology ..., 1991).

Water quality assessment using macrozoobenthos was based on results of analysis of bottom communities' structural and functional characteristics (Alimov, Teslenko, 1988; GOST 17.1.3.07-82; Kukharev, 1991; Alimov, 1994; Shuisky, 1997; Shuisky et al., 2000, 2001, Shuisky et al., 2001).
Estimating of quantitative development of macrozoobenthos is given according scales of S.P. Kitaev (1984) and Y.A. Shustov (1987). The S.P. Kitaev's scale includes 8 gradation of freshwater benthos – from "very low" grade (less than 1,25 g/m^2) to "very high" grade (more than 40 g/m^2). The Y.A. Shustov's scale contains only 3 gradations and takes into account dietary requirements of salmonid fish relying on following description.

As it known (Shustov, 1983; Shustov, 1987; Kruglova et al., 1985; Pervozvansky et al., 1988) that after escape from redds and distribution along nursery area juvenile salmon feed on small benthic organisms (preferably on chironomids' and mayflies' larvae and nymphs). Large aerial and terrestrial insects commonly occur in feeding habits of the parrs at age 1+ and older. Feeding of fingerlings and older parrs maximally activated in summer time. At this time in salmonid river ecosystem which are undisturbed by anthropogenic impact benthos commonly capable to provide fulfillment of maximum population density of salmonid fish (~1 ind./m^2). Wherein there are three gradations of benthos development as forage base for salmonid fish by reference on biomass of obtainable organisms (Shustov, 1987):

1. low benthos development rate – biomass less than 2 g/m^2;
2. average benthos development rate – biomass 2-10 g/m^2;
3. high benthos development rate – biomass equal to 10 g/m^2 and more.

It was shown that mentioned above maximum density of the juvenile salmonid fish can be achieved by high benthos development rate; in particular, biomass of available benthos with meaning 8 g/m^2 provides individual area for 1 juvenile salmonid fish about 2 m^2.

Results of forage base analysis on three main spawning grounds and nursery areas in mainstream of the Luga River are presented in the Table 4.6.

Following filamentous algae are dominated in phytobenthos of the river Luga: Mougeotia sp., Oscillatoria sp., Zygnema sp., Spyrogira sp., Ulothrix sp., Cladophora sp., Tribonema sp., Pinnularia sp., Navicula sp., Synedra sp., Gomphonema sp., Fragillaria capucina and F. crotonensis. Such microphytobenthos content corresponds to oligo-betamesosaprobian conditions ("moderately polluted" – according to saprobian scale).

Phytoplankton is characterized by relatively rich species diversity (up to 45 species in sample) and by quantitative poorness.

Dominant taxa in macrozoobenthos composition of the Luga River:

- on rapids – stoneflies and mayflies;
- on flatwater sites – large bivalve, caddisflies and chironomid larvae;
- on riffles and sites with moderate velocity (up to 0,2 m/sec) all mentioned benthos taxa occur approximately in equal biomass proportion and also bivalve mollusks Euglesiidae, gastropods, Simuliidae, Heleidae, Hydrachnidae, larvae of dragonflies and beetles play significant role in bottom communities.

During research unessential part of macroinvertebrates has being involved into the drift. Total biomass of macrozoobenthos (in an amount of water column above 1 m^2 of bottom square) having bottom life way and involving into drift, also with counting of organisms drifting on river surface, is defined mainly by benthos input. The river benthos from particular sites corresponds to conditions of “high” (□□eutrophic) trophicity. However on the river stations near town Kingisepp benthos was suppressed in qualitative and quantitative characteristics. It appears that water pollution with toxicants takes place on this station. Indicator of resulting anthropogenic load Y has a high meaning – 2.3, so anthropogenic impact already changed biota significantly having exceeded safety coefficient more than twice.

According to received results macrozoobenthos development rate (taking into account the drift) at the average (8.7 g/m^2) corresponds to rate of □□□mesotrophic water bodies (average grade of benthos biomass) (Kitaev, 1984), although on particular sites it can reach even □□□eutrophic rate (high grade of benthos biomass). Based on classification of Y.A. Shustov (1987), benthos development rate are evaluated also as “average” on studied river site. Some trophic limitations of salmonid fish numerosity are expected. Community species richness is more or less high or average indicating moderate anthropogenic impact.

Table 4.6. Characteristic of macrozoobenthos and drift on three studied spawning grounds and nursery areas in the Luga River and assessment of fish food supply.

Characteristic	Meaning on sites*		
	1	2	3
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	34	30	38
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	2.2□0.7	2.1□0.7	2.6□0.8
Macrozoobenthos biomass (g/m^2)	8.2□5.3	8.5□3.3	17.4□2.8
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	7.3	7.9	15.0
Drift in stream, in 1 m^3 (g/m^3)	0.035	0.032	0.037
Drift on surface, on 1 m^2 (g/m^2)	0.025	0.026	0.028
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	8.2	8.0	8.3
Trophicity (ref.: Kitaev, 1984)	□- mesotrophicity	□- mesotrophicity	□-eutrophicity
Biomass grade (ref.: Kitaev, 1984)	"average"	"average"	"high"
Benthos development rate (ref.: Shustov, 1987)	"average"	"average"	"high"

**Sites: 1- Kingiseppskie rapids, 2- Storonskie rapids, 3 – Sabskie rapids.*

Results of forage base analysis in the river Yaschera are demonstrated in the Table 4.7. In macrozoobenthos composition insect larvae dominate in density and biomass (predominantly larvae of caddis flies and beetles, also of butterflies, mayflies, stoneflies, chironomids, tabanid’s flies, black flies, water bugs, dragonflies, snipe flies). Amphipods play significant role in bottom communities also. It is less essential role of leeches, bivalves and gastropods and oligochaetes. Thus, reference to composition macrozoobenthos is “forage” or “soft” (82 – 97 % of biomass), i.e. it is almost completely accessible for fish.

Table 4.7. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the river Yaschera and assessment of fish food supply.

Characteristic	Meaning
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	30
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	2.5±0.6
Macrozoobenthos biomass (g/m^2)	14.7±1.7
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	12.2±1.2
Drift in stream, in 1 m^3 (g/m^3)	0.032
Drift on surface, on 1 m^2 (g/m^2)	0.014
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	14.70
Trophicity (ref.: Kitaev, 1984)	□ eutrophicity
Biomass grade (ref.: Kitaev, 1984)	"excessive"
Benthos development rate (ref.: Shustov, 1987)	"high"

Macrozoobenthos on spawning grounds and nursery areas are characterized with relatively high diversity, abundance and productivity. Indicators of clean water occur in all studied biotopes, such as larvae of caddis fly Odontocerum albicorne, mayflies, stoneflies, chironomids from subfamily Orthocladiinae. On set of all counted bioindicator features water mass in the river Yaschera should be evaluated as “very clean” (I grade), oligosaprobian. In this way, results of bioindication based on macrozoobenthos state do not afford ground for suggestion of essential limitation of the salmonid rivers in studied water bodies by any anthropogenic impact.

In the analyzed samples of drift insignificant part of macrozoobenthos was observed. Total biomass (in counting for water column above 1 m^2 bottom square) of macrozoobenthos having bottom life pattern and involving into the drift, also with counting of organisms drifting on river surface almost completely defined by input of bottom invertebrates (percentage of drift not less than 1 %).

Referring to given results, macrozoobenthos on spawning grounds and nursery areas of the river Yaschera coincides to “excessive” benthos biomass grade (□eutrophicity) (Kitaev, 1984). Considering that biomass of bottom communities have exceeded meaning 10 g/m^2, in reference to scale of Y.A. Shustov (1987), rate of quantitative development of macrozoobenthos on spawning grounds and nursery areas are characterized as “high”, i.e. practically not limitating salmonid fish abundance.

Therefore, ecological conditions in the river Yaschera should be recognized as favourable conditions as by means quality of water environment and salmonid fishes forage base state.

Results of forage base analysis in the river Vidon’ are demonstrated in the Table 4.8. Total number of macroinvertebrates species, identified in bottom communities and in the drift in the river Vidon’ was equal to 14. In composition of macrozoobenthos insect larvae have significant role (mayflies, caddis flies, chironomids, black flies, beetles and etc.). In this way, macrozoobenthos considering species content is “forage” or ‘soft” and wholly accessible for fish.

On set of all counted characteristics water mass of the river Vidon’ might be described as “very clean” (I grade), oligosaprobian. Therefore, results of bioindication based on macrozoobenthos state do not afford ground for suggestion of essential limitation of the salmonid rivers in studied water bodies by any anthropogenic impact.

Table 4.8. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the river Vidon’ and assessment of fish food supply.

Characteristic	Meaning
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	9
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	0.8±0.2
Macrozoobenthos biomass (g/m^2)	1.5±0.2
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	1.5
Drift in stream, in 1 m^3 (g/m^3)	0.014
Drift on surface, on 1 m^2 (g/m^2)	0.008
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	1.5
Trophicity (ref.: Kitaev, 1984)	⊟ oligotrophicity
Biomass grade (ref.: Kitaev, 1984)	"low"
Benthos development rate (ref.: Shustov, 1987)	"low"

During investigation unessential part of macroinvertebrates was involving in the drift. Total biomass (in counting for water column above 1 m^2 bottom square) of macrozoobenthos having bottom habit of life and involving into the drift, also with counting of organisms drifting on river surface almost completely defined by input of bottom invertebrates (percentage of drift not less than 1 %).

Macrozoobenthos of the river Vidon’ are relatively poor: it corresponds to rate of oligotrophicity or “low” biomass grade in accordance with two classifications, and it limits salmonid fishes abundance obviously.

Results of forage base analysis in the river Lemovzha are demonstrated in the Table 4.9. There are 45 species observed in phytoplankton composition: 1 chrysophyceae algae, 32 diatoms, 1 cryptophytae algae, 2 Euglenophyta, 9 green algae (4 Volvocaeans, 4 Chlorococcales, 1 Desmids). Number and biomass of phytoplankton comprised 408 thousand cells/L and 0.599 g/m^3; diatoms were absolute dominants with percentage 78 % and 79 % adequately. Green algae subdominated: Chlorococcales by numerosity (11%), Desmids by biomass (16%). According to numerosity phytoplankton community was polydominant. Diatoms were prevailing such as Melosira varians (□), Cocconeis pediculus (□), Synedra ulna (□), Nitzschia acicularis (□), Synedra vaucheriae etc. Melosira varians (□), Cocconeis pediculus (□), Navicula radiosa (o-□), Surirella linearis (□) и десмидиевая Closterium moniliferum (□) were dominating by biomass.

Among dominating species by numerosity and biomass in the river Lemovzha □-mesosaprobian species were dominant, one of dominants related to o-□-saprobes and only one from mentioned species (with low quantitative characteristics) related to □-mesosaprobes. Species composition of phytoplankton and its quantitative characteristics also indicate absence of significant organic pollution (high species diversity of diatoms, low development of cryptophytae algae, Euglenophyta, □-mesosaprobian Volvocaeans).

Table 4.9. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the river Lemovzha' and assessment of fish food supply.

Characteristic	Meaning
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	30
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	2.5□0.8
Macrozoobenthos biomass (g/m^2)	23.2□14.5
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	22.0
Drift in stream, in 1 m^3 (g/m^3)	0.094
Drift on surface, on 1 m^2 (g/m^2)	0.141
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	23.3
Trophicity (ref.: Kitaev, 1984)	□- eutrophicity
Biomass grade (ref.: Kitaev, 1984)	"high"
Benthos development rate (ref.: Shustov, 1987)	"high"

In the summary, the state the river Lemovzha according to phytoplankton development data preferably can be designated as state in the border between oligotrophicity and mesotrophicity. In accordance to productivity features of zooplankton the river Lemovzha belongs to "average" trophicity grade (□-□-mesotrophicity), so zooplankton development does not limit plankton feeder requirements in this tributary.

The results of the Vruda River fodder base analysis are shown in Table 4.10. There were 33 phytoplankton species identified on spawning grounds and nursery areas near Ust'e village including 1 species of cyanobacteriae, 27 species of diatoms, 1 species of yellow-green algae, 4 species of green algae (2 Volvocales and 2 Chlorococcales).

The abundance and biomass of phytoplankton achieved 328 000 cell/litre and 0.443 g/m^3. Diatom species dominated comprising 73% of total abundance and 96% of total biomass. The most numerous species were Navicula sp., Amphora veneta, Cocconeis pediculus (□), Navicula vulpina. Among algae species the highest abundance was reported for cyanobacteriae species - a very small cell colonial form of Merismopedia tenuissima ("□-□"-mesosaprobic form), which biomass was, however, very low due to small size of cells — 0.0001 g/m^3. Diatom species Cocconeis pediculus had the highest biomass (49%), whereas Amphora veneta and Navicula vulpina were subdominant species.

Table 4.10. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the Vruda River and assessment of fish fodder base.

Characteristic	Value
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	33
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	2.7□0.5
Macrozoobenthos biomass (g/m^2)	42.8□10.5
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	35.4
Drift in stream, in 1 m^3 (g/m^3)	0.0019
Drift on surface, on 1 m^2 (g/m^2)	0.0013
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	43
Trophicity (ref.: Kitaev, 1984)	□- eutrophicity hypertrophicity
Biomass class (ref.: Kitaev, 1984)	“high”
Benthos development rate (ref.: Shustov, 1987)	"high"

In the samples collected from spawning grounds and nursery areas near Volna village only 9 phytoplankton species were found, including 4 diatom species and 5 green alga species. The abundance was 368 000 cell/litre, biomass — 0.11 g/m^3. Unicellular volvocales algae dominated (among green algae) — Chlamydomonas globosa — 320 000 cell/litre and 0.10 g/m^3. Among other species the most numerous one was Chlamydomonas reinchardii — 5% of total abundance.

Based on the composition of dominants the Vruda River in that site should be classified as the □-mesosaprobic zone, but due to the low quantitative indicators of phytoplankton and its structure (absolute dominance of diatoms and their high species diversity, which is typical for clean water) it is necessary to have additional indicators in order to objectively assess the degree of organic pollution of this watercourse (e.g., information about other aquatic organisms). It should be noted that among the species prevailing in cell number, one □-□-mesosaprobic species was found - a colonial cyanobacteria with very small cells - Merismopedia tenuissima, but its extremely low biomass (0.0001 g/m^3) allows to exclude this species from the overall assessment of this reservoir saprobity level.

Thus, according to early summer phytoplankton development data, the Vruda River can be referred to the oligotrophic type of watercourses only with some mesotrophic traits.

Zooplankton features of the watercourses characterize their conditions as oligo - betamesosaprobic. Based on productivity properties of the zooplankton the Vruda River refers to the "middle" class trophic level (□-□-mesotrophic). Thus, the development of zooplankton does not limit plankton-eating organism needs in this water basin.

Total biomass of macrozoobenthos and drift corresponds, on average, to "high" and even "very high" biomass classes (Kitaev, 1984) (as in □□-eutrophic and hypertrophic water basins and watercourses), "high" level of benthos development (Shustov, 1987). Trophic limitation of the salmonid fishes number is unlikely. Species diversity is medium, which may indicate the limited resources in the studied biotopes or anthropogenic impact.

The results of the fodder base analysis of the Dolgaya River are shown in Table 4.11. In macrozoobenthos community the insect larvae dominate in both density and biomass (mainly caddis flies and beetles, as well as butterflies, mayflies, stoneflies, chironomids, horseflies, simuliids, beetles, bugs, dragonflies, snipe flies). Amphipods also play a significant role. The proportion of leeches, bivalves, gastropods and oligochaetes is less significant. Thus, the composition of macrozoobenthos is, primarily, "foraging" or "soft" (82-97% of the biomass), which is almost completely accessible for fish.

Macrozoobenthos on spawning grounds and nursery areas is characterized by relatively high diversity, abundance and productivity (Table 4.11). In all studied biotopes indicators of clean water are present, including caddis fly larvae Odontocerum albicorne, mayflies, stoneflies and chironomids from subfamily Orthocladiinae. According to all recorded biological indicators of the Dolgaya River, its water should be characterized as "very clean" (I class), oligosaprobic. Thus, the results of bioindication based on macrozoobenthos status do not suggest a significant limitation of salmonid fishes in the studied watercourses by any anthropogenic impact.

Table 4.11. Characteristics of macrozoobenthos and drift on studied spawning grounds and nursery areas in the Dolgaya River and assessment of fish fodder base.

Characteristic	Value
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	38
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	2.9±0.5
Macrozoobenthos biomass (g/m^2)	12.5±1.9
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	10.7
Drift in stream, in 1 m^3 (g/m^3)	0.025
Drift on surface, on 1 m^2 (g/m^2)	0.012
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	12.5
Trophicity (ref.: Kitaev, 1984)	□- eutrophicity
Biomass class (ref.: Kitaev, 1984)	"increased"
Benthos development rate (ref.: Shustov, 1987)	"high"

In the studied samples in drift a small portion of macroinvertebrates was found. The total biomass (calculated for the water column above the bottom area of 1 m^2) of macrozoobenthic with a bottom lifestyle involved in the drift, as well as the organisms drifting on the river surface, is almost completely determined by the contribution of benthic invertebrates (the proportion of drift - less than 1%).

Judging by the results described here, macrozoobenthos of spawning ground and nursery area of the Dolgaya River refers to "high" class of benthic biomass (□-eutrophic) (Kitaev, 1984). Since the biomass of benthic communities exceeded the value of 10 g/m^2, on a scale of Yu. A. Shustov (1987) rate of quantitative development of macrozoobenthos of spawning grounds and nursery area is characterized as "high", i.e. practically not limiting the abundance of salmonids.

Thus, environmental conditions in the Dolgaya River should be recognized as quite beneficial in terms of both quality of the aquatic environment and salmon fodder base.

Analysis results of the Lubenka River fodder base are shown in Table 4.12.
Judging by the results obtained, drift macrozoobenthos characteristics correspond to the "low" level of oligotrophic watercourse (Kitaev, 1984), and based on classification by Yu. A. Shustov (1987) correspond to the lower boundary of the "medium level of development" (close to the "low level"). Obviously, salmon in the Lubenka River experiences trophic limitation. Low species diversity suggests the limited resources in the studied biotopes or anthropogenic impact.

Table 4.12. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the Lubenka River and assessment of fish fodder base.

Characteristic	Value
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	15
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	1.5 □0.5
Macrozoobenthos biomass (g/m^2)	3.4 □2.4
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	3.0
Drift in stream, in 1 m^3 (g/m^3)	0.10
Drift on surface, on 1 m^2 (g/m^2)	0.05
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	3.5
Trophicity (ref.: Kitaev, 1984)	□ eutrophicity
Biomass class (ref.: Kitaev, 1984)	" low "
Benthos development rate (ref.: Shustov, 1987)	"near low"

Analysis results of the Azika River fodder base are shown in Table 4.13.

Judging by the results of the survey, the quantitative development of macrozoobenthos corresponds to □mesotrophic reservoir level - "medium" class of biomass (Kitaev, 1984) and the medium level of development of benthos (Shustov, 1987).

Probably some trophic limitations of the number of salmonids are taking place here. Species diversity is medium, which may indicate the limited resources in the studied biotopes or the anthropogenic impact.

Table 4.13. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the Azika River and assessment of fish fodder base.

Characteristic	Value
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	34
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	1.9 □0.5
Macrozoobenthos biomass (g/m^2)	6.2 □3.8
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	5.9
Drift in stream, in 1 m^3 (g/m^3)	0.050
Drift on surface, on 1 m^2 (g/m^2)	0.075
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	6.3
Trophicity (ref.: Kitaev, 1984)	□mesotropicity
Biomass class (ref.: Kitaev, 1984)	"medium"
Benthos development rate (ref.: Shustov, 1987)	"medium"

Analysis of the fodder base status of the Salka River suggests that the water basin is a quite favorable habitat for salmonids. Some characteristics of macrozoobenthos which are important for assessing the quality of the aquatic environment are rendered in Table 4.14.

Table 4.14. Characteristic of macrozoobenthos and drift on studied spawning grounds and nursery areas in the Solka Riber and assessment of fish fodder base.

Characteristic	Value
Number of species (macrozoobenthos and macroinvertebrates involved in drift)	33
Index of species richness of Shannon-Weaver based on biomass (bit/ind.)	2.6±0.5
Macrozoobenthos biomass (g/m^2)	25.4±2.3
Macrozoobenthos biomass, accessible for fish ("soft" benthos) (g/m^2)	24.3
Drift in stream, in 1 m^3 (g/m^3)	0.014
Drift on surface, on 1 m^2 (g/m^2)	0.005
Macrozoobenthos + drift, on 1 m^2 (g/m^2)	25.4
Trophicity (ref.: Kitaev, 1984)	□- eutrophicity
Biomass class (ref.: Kitaev, 1984)	"high"
Benthos development rate (ref.: Shustov, 1987)	"high"

Judging by the results of the research conducted in the Salka River it has a good foraging base - it is □-eutrophic, or belongs to "high" class of benthic biomass (Kitaev, 1984). Since the biomass of benthic communities is greater than 10 g/m^2, on a scale of Yu. A. Shustov (1987) the rate of quantitative development of macrozoobenthos on spawning grounds and nursing areas is characterized as "high", i.e. practically not limiting the abundance of salmon.

Conclusion of hydrobiological research

An important factor limiting the number of salmonid fishes in the rivers is the level of food avalability. In the course of spawning grounds and nursery area studies we analyzed species and quantitative composition of zoobenthos and drift, which are the main food sources for juvenile salmon and brown trout. It is important to note that in all studied biotopes certain very reliable indicators of clean water occur - caddisflies, various species of chironomids (subfamily Orthocladiinae), mayflies, stoneflies. Levels of species richness and species diversity of the communities support the conclusion about medium or high quality of the environment. All this allows us to assess studied watercourses as "oligosaprobic" - "oligo -□□- saprobic", with "clean" or "moderately polluted" water. Thus, judging by the bioindication results (macrozoobenthos status), there is no reason to assume significant limitation of the number of salmonids due to anthropogenic impacts.

The species composition of macrozoobenthos and macroinvertebrates involved in the drift was quite similar. Macrozoobenthos in dominated by insect larvae both in terms of density and biomass, leeches play a significant role along with bivalves, gastropods and oligochaetes. Spawning grounds and nursery areas in all rivers are characterized by medium or relatively high species diversity, abundance and productivity of invertebrates.

These indicators make it possible to assess the status of fodder base of the rivers and the degree of salmonid population limitation by foraging resources availability (Table 4.15). It should be noted that macrozoobenthos in the studied rivers is mostly represented by the so-called "soft" macrozoobenthos that is an accessible food items for fish. According to our study results there is no reason to assume any food limitation of the number of salmonids in studied watercourses, probably with the exception of the rivers Vidon' and Lubenka. The rivers Vruda, Lemovzha and Salk are characterized by the best fodder base.

Table 4.15. Characteristics of fodder base of the studied watercourses

River Name	Biomass of benthos and drift (g/m^2)	Trophic level (ref.: Kitaev, 1984)	Biomass class (ref.: Kitaev, 1984)	Rate of benthos development (ref.: Shistov, 1987)
Luga	8.7	□mesotrophic	medium	medium
Yaschera	12.2	□ eutrophic	higher than medium	high
Vidon'	1.5	□oligotrophic	low	low
Lemovzha	23.3	□ eutrophic	high	high
Vruda	43.0	□ eutrophic, hypertrophic	high	high
Dolgaya	10.7	□ eutrophic	higher than medium	high
Lubenka	3.4	-	low	Close to low
Azika	6.3	□ mesotrophic	medium	higher than medium
Solka	25.4	□eutrophic	high	high

The results of the conducted analysis suggest that the studied rivers have all the components - good water quality, sufficient areas of spawning grounds and nursery sites, highly developed fodder base - that are necessary for the salmonid fishes.

4.5. Description of the ichthyofauna composition at spawning places and nursery areas

Along with the work on the detection of juvenile salmon on potential spawning grounds and nursery areas in the Luga River basin, we investigated species composition of fish fauna at fished sites.

Descriptions of the species composition at three sites of the main course of the river are given in Tables 4.16 – 4.18. In total in the main course of the river on Sabskie, Storonskie and Kingiseppskie rapids 13 fish species belonging to the families Salmonidae (1), Esocidae (1), Cyprinidae (6), Balitoridae (1), Cottidae (1), Percidae (1), Lotidae (1), Siluridae (1) were found. Ichthyocenosis core at all three stations of the main course of the river was represented by carp fish, comprising 60% of the species composition (on Kingiseppskie rapids). One of the representatives of Cyprinidae - bleak - formed sparse density clusters at fished sites; its density on Storonskie rapids reached 11.6 ind./100 m². Bearded stone loach was relatively numerous on spawning grounds and nursery areas: its density on Sabskiy rapids reached 10.0 ind./100 m². All other species of fish in the catch were represented by single individuals; most frequently encountered species were bullhead, minnow, sometimes dace, perch, chub.

Under the existing densities all associated fish species are not able to create food competition for juvenile salmon on spawning grounds and nursery areas or exercise significant influence as a predator on parrs. So there is no reason to assume the existence of limiting effect on juvenile salmon from the associated species on spawning grounds and nursery areas of the main course of the Luga River.

Table 4.16. Ichthyofauna species composition on fished sites of the Luga River (Kingiseppskie rapids). 6 sites (total area 1280 m^2) were fished.

Species	Total, individuals	Density in the site, ind./100 m²
Atlantic salmon *(Salmo salar)*	105	8,2
Roach *(Rutilus rutilus)*	7	0,5
Stone loach *(Barbatula barbatula)*	103	8,0
Common bleak *(Alburnus alburnus)*	32	2,5
Bullhead *(Cottus gobio)*	12	0,9
Gudgeon *(Gobio gobio)*	9	0,7
Ide *(Leuciscus idus)*	1	0,1
Perch *(Perca fluviatilis)*	6	0,5
Dace *(Leuciscus leuciscus)*	14	1,1
Chub *(Leuciscus cephalus)*	1	0,1

Table 4.17. Ichthyofauna species composition on fished sites of the Luga River (Sabskie rapids). 4 sites (total area 1380 m^2) were fished.

Species	Total, individuals.	Density in the site, ind../100 m²
Roach *(Rutilus rutilus)*	7	0,5
Stone loach *(Barbatula barbatula)*	137	9,9
Common bleak *(Alburnus alburnus)*	96	6,9
Bullhead *(Cottus gobio)*	10	0,7
Gudgeon *(Gobio gobio)*	13	0,9
Perch *(Perca fluviatilis)*	17	1,2
Pike *(Esox lucius)*	4	0,3
Burbot *(Lota lota)*	1	0,1

Table 4.18. Ichthyofauna species composition on fished sites of the Luga River (Storonskie rapids). 5 sites (total area 1070 m^2) were fished.

Species	Total, individuals	Density in the site, ind./100 m²
Cat-fish (*Silurus glanis*)	1	0,1
Roach *(Rutilus rutilus)*	2	0,2
Stone loach *(Barbatula barbatula)*	43	4,0
Common bleak *(Alburnus alburnus)*	124	11,6
Bullhead *(Cottus gobio)*	5	0,5
Gudgeon *(Gobio gobio)*	17	1,6
Ide *(Leuciscus idus)*	4	0,4
Chub *(Leuciscus cephalus)*	16	1,5
Pike *(Esox lucius)*	1	0,1

Tables 4.19 - 4.25 contain data on the species composition and density distribution of fish in the tributaries of the middle course of the Luga River, where salmon was detected. Note that all these rivers are right tributaries of the Luga River, originating on the slopes of Izhora eminence. All together in the rivers Vruda (lower and upper courses), Lemovzha, Solka, Vidon', Azika, Lubenka we registered 17 species belonging to the following families: Salmonidae (2), Thymallidae (1), Balitoridae (1), Cottidae (1), Esocidae (1), Percidae (1), Lotidae (1), Cobitidae (1), Gasterosteidae (1), Cyprinidae (7).

Out of the six rivers that we surveyed both species of salmonids belonging to genus Salmo inhabit together only in the lower course of the Vruda River. However, the densities of both salmon and sea trout in the lower spawning grounds of the Vruda River are low (Table 4.19 – 4.20). In the upper parts of the Vruda River juvenile salmon was not registered, but the density of sea trout distribution increased to 2.9 ind./100 m². Salmon was found in none of other surveyed tributaries of the Luga River. Grayling belonging to the suborder of salmonids Salmonoidei, was extremely low in numbers in all these rivers.

Density of sea trout on the river bars of Vidon', Azika, Lubenka is low, 1.1-1.8 ind./100 m² (Table 4.21 - 4.25), but the same parameter in the rivers Lemovzha and Solka reaches 9.9 ind./100m² and 19.2 ind./100 m², respectively (Table 4.21 - 4.22). It should be noted that on the sites fished in the latter two rivers sea trout dominated in numbers over all other species.

Predominance of sea trout over other species is observed also in the Vidon' River, where relatively small sample size of sea trout exceeded the total number of all other species. Apparently, in the rivers Azika and Lubenka more complete filling of the available ecological niches on spawning grounds by sea trout is not possible due to competition with other fish species, and primarily with carp fish, which total density in the two rivers exceeds the density of sea trout in 4.8 and 13.5 times, respectively.

Low numbers of pike, burbot and perch on spawning grounds of surveyed rivers confirms the hypothesis of lack of significant predation press on juvenile salmonids. In five of the six studied rivers a minnow, which is an indicator of high water quality, was found in catches. This fact may indicate indirectly relatively good condition of the watercourses and absence of significant anthropogenic impact on the fish populations in terms of water pollution.

Table 4.19. Ichthyofauna species composition on fished sites of the Vruda River (Mouth area). 4 sites (total area 2820 m^2) were fished..

Species	Total, individuals.	Density in the site, ind./100 m²
Atlantic salmon *(Salmo salar)*	13	0,5
Sea trout (*Salmo trutta)*	1	0,1
Grayling *(Thymallus thymallus)*	2	0,1
Stone loach *(Barbatula barbatula)*	32	1,1
Gudgeon *(Gobio gobio)*	5	0,2
Minnow *(Phoxinus phoxinus)*	22	0,8
Perch *(Perca fluviatilis)*	3	0,1
Chub *(Leuciscus cephalus)*	1	0,1
Burbot *(Lota lota)*	3	0,1
Pike *(Esox lucius)*	2	0,1
Spined loach *(Cobitis taenia)*	1	0,1
Bullhead *(Cottus gobio)*	7	0,2

Table 4.20. Ichthyofauna species composition on fished sites of the Vruda River (middle and upper course). 2 sites (total area 940 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m²
Sea trout (*Salmo trutta)*	27	2,9
Grayling *(Thymallus thymallus)*	8	0,8
Minnow (*Phoxinus phoxinus)*	17	1,8
Burbot (*Lota lota)*	2	0,2
Pike (Esox lucius)	9	0,9
Stone loach *(Barbatula barbatula)*	50	5,3
Bullhead *(Cottus gobio)*	4	0,4

Table 4.21. Ichthyofauna species composition on fished sites of the Lemovzha River.
4 sites (total area 900 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m²
Sea trout (*Salmo trutta)*	89	9,9
Stone loach *(Barbatula barbatula)*	21	2,3
Bullhead *(Cottus gobio)*	19	2,1
Minnow (*Phoxinus phoxinus)*	91	10,1
Pike (Esox lucius)	4	0,4

Table 4.22. Ichthyofauna species composition on fished sites of the Solka River.
4 sites (total area 1204 m^2) were fished.

Species	Total, individuals	Density in the site, ind./100 m²
Sea trout (*Salmo trutta)*	231	19,2
Grayling *(Thymallus thymallus)*	1	0,1
Bullhead *(Cottus gobio)*	14	1,2
Minnow (*Phoxinus phoxinus)*	2	0,2
Three-spine stekleback *(Gasterosteus aculeatus)*	7	0,6

Table 4.23. Ichthyofauna species composition on fished sites of the Vidon' River.
3 sites (total area 1060 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m²
Sea trout (*Salmo trutta)*	19	1,8
Grayling *(Thymallus thymallus)*	2	0,2
Dace (*Leuciscus leuciscus)*	9	0,8
Burbot (*Lota lota)*	5	0,5

Table 4.24. Ichthyofauna species composition on fished sites of the Azika River.
3 sites (total area 1120 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m²
Sea trout (*Salmo trutta)*	14	1,3
Grayling *(Thymallus thymallus)*	1	0,1

Stone loach *(Barbatula barbatula)*	4	0,4
Gudgeon *(Gobio gobio)*	12	1,1
Minnow (*Phoxinus phoxinus)*	37	3,3
Perch (Perca fluviatilis)	4	0,4
Bullhead *(Cottus gobio)*	7	0,6
Dace (*Leuciscus leuciscus)*	13	1,2
Ide (*Leuciscus idus)*	6	0,5
Roach (*Rutilus rutilus)*	1	0,1

Table 4.25. Ichthyofauna species composition on fished sites of the Lubenka River.
2 sites (total area 1200 m^2) were fished.

Species	Total, individuals	Density in the site, ind./100 m²
Sea trout (*Salmo trutta)*	13	1,1
Grayling *(Thymallus thymallus)*	2	0,2
Stone loach *(Barbatula barbatula)*	14	1,2
Gudgeon *(Gobio gobio)*	1	0,1
Minnow (*Phoxinus phoxinus)*	112	9,3
Common bleak *(Alburnus alburnus)*	65	5,4
Bullhead *(Cottus gobio)*	1	0,1
Pike *(Esox lucius)*	1	0,1

Tables 4.26 – 4.31 contain data on the fish species composition in the Luga River tributaries, where juvenile salmonids were not found. In the list of fish fauna of rivers Dolgaya, Yaschera, Kemka, Chernaya, Luzno and Udrayka fishes belonging to family Cyprinidae (6), there were also representatives of the families Balitoridae (1), Cottidae (1), Esocidae (1), Percidae (1), Lotidae (1), Cobitidae (1) dominated.

There may be a variety of reasons why salmon do not live in these rivers. Tributaries of the upper course of the Luga River located in the Novgorod region and on the border with the Leningrad region (Kemka, Chernaya, and Luzno, Udrayka) have significant inflow of acidificated waters coming from surrounding bogs, rapids areas there are scarce or non-existent. Water quality and hydrological regime of the Dolgaya River (left tributary of the Luga River in the lower part of its basin) are also unfavorable for salmon and trout. In the Yaschera River occurrence of salmonids is limited by a dam located in 11 km from the mouth and cutting off the potential spawning grounds and nursery areas from the mainstream of the Luga main course.

The largest tributary of the Luga River – the Oredezh River (192 km long, was not surveyed) is regulated by a cascade of dams as well. According to existing reports salmon used to occur in that river (Grimm, 1889) and was abundant, but after the construction of a cascade of hydropower stations in 1948 spawning grounds and nursery areas of the upper course of the river were cut off from the mainstream of Luga and salmon disappeared from the river. It is assumed that the salmon of the Oredezh River could be immortalized on the coat of arms of the town of Luga, located in relative proximity to the Oredezh upstream the Liga River.

In the description of the coat of arms of the town of Luga made in 1781 it is said that its upper part is a coat of the Pskovskya region, and the bottom is "in golden field put in tub salmon fish, which in the Luga River, washing the walls of this city, is abundantly caught." Given the fact that we found lack of salmonid spawning grounds in the upper basin of the Luga River (as well as near the town of Luga), this assumption does not seem implausible and requires separate study.

Table 4.26. Ichthyofauna species composition on fished sites of the Dolgaya River.
3 sites (total area 520 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m^2
Stone loach *(Barbatula barbatula)*	98	18,8
Gudgeon *(Gobio gobio)*	4	0,8
Perch *(Perca fluviatilis)*	32	6,2
Bullhead *(Cottus gobio)*	43	8,3
Dace (*Leuciscus leuciscus)*	3	0,6
Burbot (*Lota lota)*	2	0,4
Minnow (*Phoxinus phoxinus)*	34	6,5

Table 4.27. Ichthyofauna species composition on fished sites of the Yaschera River.
3 sites (total area 516 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m^2
Stone loach *(Barbatula barbatula)*	117	22,7
Gudgeon (Gobio gobio)	7	1,4
Burbot (*Lota lota)*	4	0,8
Perch *(Perca fluviatilis)*	56	10,9
Bullhead *(Cottus gobio)*	29	5,6
Dace (*Leuciscus leuciscus)*	6	1,2
Vimba bream *(Vimba vimba)*	1	0,2
Roach (*Rutilus rutilus)*	31	6,0

Table 4.28. Ichthyofauna species composition on fished sites of the Kemka River.
2 sites (total area 310 m^2) were fished.

Species	Total, individuals	Density in the site, ind./100 m^2
Dace (*Leuciscus leuciscus*)	28	9,0
Ide (*Leuciscus idus*)	3	1,0
Common bleak (*Alburnus alburnus*)	23	7,4
Gudgeon (*Gobio gobio*)	2	0,6

Table 4.29. Ichthyofauna species composition on fished sites of the Chernaya River.
3 sites (total area 340 m^2) were fished.

Species	Total, individuals	Density in the site, ind./100 m^2
Pike (*Esox lucius*)	20	5,9
Perch (*Perca fluviatus*)	14	4,2
Roach (*Rutilus rutilus*)	27	7,9
Ide (*Leuciscus idus*)	17	5,0
Stone loach (*Barbatula barbatula*)	4	1,2
Spined loach (*Cobitis taenia*)	10	2,9
Burbot (*Lota lota*)	3	0,9

Table 4.30. Ichthyofauna species composition on fished sites of the Luzno River.
2 sites (total area 210 m^2) were fished.

Species	Total, individuals	Density in the site, ind../100 m^2
Stone loach (*Barbatula barbatula*)	18	8,6
Burbot (*Lota lota*)	3	1,4

Table 4.31. Ichthyofauna species composition on fished sites of the Udrayka River.
3 sites (total area 280 m^2) were fished.

Species	Total, individuals.	Density in the site, ind./100 m^2
Perch (*Perca fluviatus*)	9	3,2
Roach (*Rutilus rutilus*)	41	14,6
Ide (*Leuciscus idus*)	14	5,0
Gudgeon (*Gobio gobio*)	13	4,6

Thus, we can conclude that the species composition of fish fauna in the sites studied in the mainstream of the Luga River and some of its tributaries comprise of 19 fish species belonging to 11 families: Salmonidae (2), Thymallidae (1), Balitoridae (1), Cottidae (1), Esocidae (1), Percidae (1), Lotidae (1), Cobitidae (1), Gasterosteidae (1), Siluridae (1), Cyprinidae (8). In the surveyed spawning grounds and nursery areas of the main course and the lower course of the Vruda associated fish species do not limit salmon population as food competitors or predators. The same conclusion holds for sea trout of the rivers Vruda, Lemovzha, Solka, Vidon' when considering its competitive relationship with the associated species of other families.

Absence of salmon in the majority of investigated tributaries of the Luga River is explained by several reasons, the most significant among which is adverse environmental conditions due to the quality of water (Dolgaya, Kemka, Chernaya, Luzno and Udrayka), lack of spawning ground of certain quality (Vidon', Lemovzha, Lubenka, Azika, Solka), regulation of rivers by dams (Yaschera, Oredezh).

5. Research of salmon spawning migration

Control fishing works on the salmons migrating to spawning to the Luga River were carried out on two stations situated in the Luga Bay of the Gulf of Finland and also directly in the Luga River in 1 km down along river from site where spring works took place on observation of the salmonid fishes downstream migration near village Strupovo (Fig.5.1). For control fishing off works the nets with mesh size from 70 to 110 mm were used. Fishing was being carried out from end of August till November 2013.

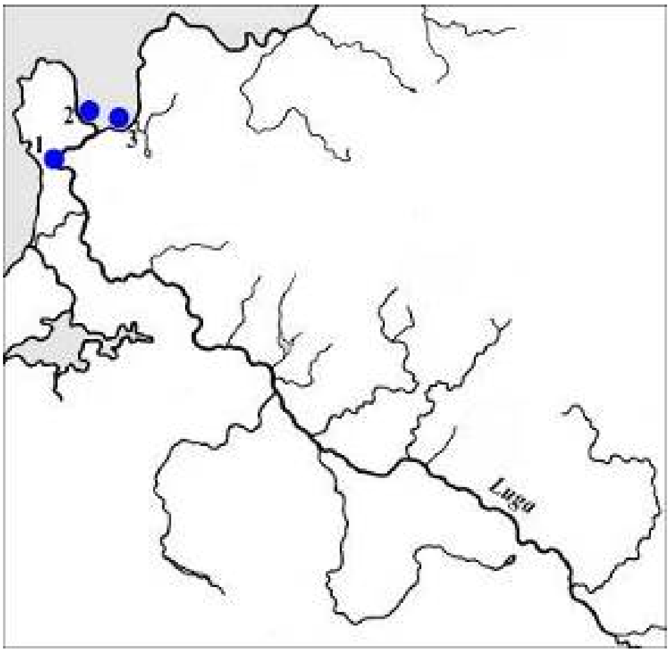

Figure 5.1. Sites of control fishing works of salmons in area of village Strupovo (1) and on two stations in the Luga Bay (2, 3).

Right on the place of fishing partial biological analysis of caught salmons was carried out, that included length and body mass measurements and also collecting of scale samples for fish age definition (Chugunova, 1959; Pravdin, 1966). After conduction of morphometric measurements all viable fishes extracted from nets were released back to environment (Fig. 5.2).

Figure 5.2. Releasing of viable salmon back to natural environment.

Besides, data of salmon breeding stock, which were caught by team of fishermen for needs of Luga hatchery with using of trapnet partly overlapping the river directly in the village Strupovo was added to current research. In addition to standard fish measurements, weighing and age definition using scale samples, gender of fish were also defined (Fig. 5.3).

Figure 5.3. Measuring of the trapped salmon.

Identification of salmon juveniles from breeding stock of hatchery origin was made on base of fish external morphometric features analysis. As it was described in the Chapter 3, identification of hatchery fish did not cause difficulties considering that almost all fish produced by hatcheries had the signs of artificial growing - fins and gill covers damage, distortions of sclerites scales drawing which were brightly expressed. The most visible features were fins' damage, especially on the dorsal fin (Fig.5.4 - 5.5).

Some fish had underdeveloped gill covers (See the Fig. 3.2). As additional diagnostic characteristic scale structure features of all fish was used because hatchery fish differs from the wild fish by character of growth and often has disorders of the correct figure on scale's sclerites (Fig. 5.6). An experience of GosNIORKh's experts on identification of fish origin (caught to be used by Luga hatchery) according to their external morphological features has shown that the accuracy of hatchery salmon identification by the character of fins and gill covers (even independently of scale samples) is not less than 94%.

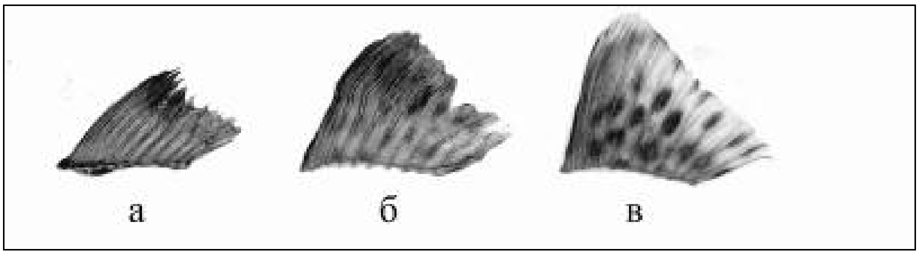

Figure 5.4. Dorsal fins of salmon's juveniles: а, б — hatchery origin; в — wild origin.

Figure 5.5. Contorted rays of dorsal fins of breeding salmons of hathery origin.

Figure 5.6. Salmon scale's samples: а — hatchery origin; в, б — wild origin.

During fish off works in time of salmon migration to spawning we caught 59 fish and among them 56 individuals were diagnosed as wild origin fish, and 3 fish had features of hatchery origin. The migration peak was observed in the second half of September: during this period 48 individuals were caught whereas from the end of August till mid-September we caught only 4 individuals and then in October – 7 more. In November no salmon was caught. In spawning population of Luga salmon from autumn 2013 we registered fish of different year classes which spent 2-3 years in the river before downstream migration and 1-3 years in sea feeding period. Among wild salmons mature fishes were dominating at the age of 3 years from which they were spending for 2 years in the river and one year in the sea (2.1+).

Fish at this age were characterized with low-level age-length parameters: so with a length of 37-62 cm the body mass was 600 -2500 g. It should be mentioned that 3 individuals of the smallest fishes of this age in our catch (less than 1000 g) could be immature, but it was impossible to verify it because all salmons were released in the river after measuring and taking the scale samples. The larger fish of older age (2.3+ and 3.3+) reached length of more than 100 cm and weight of more than 10000 g. Mean age-length parameters of wild salmon spawning population from autumn 2013 which were identified by the investigated sample comprised L = 67,4 cm and P = 4796 g (Table 5.1).

Five salmons of natural origin had spawning tags observed on scale that indicates participation of these fishes in spawning earlier. In our opinion, the character for the location of sclerites on the scales to the periphery of the "spawning ring" refers to the fact that three of the five natural origin fish, after catadromous migration to the sea in the first half of calendar year following autumn's spawning period, spent on feeding grounds of the Main Basin one full year, and two other fish spent two full years. One of these salmons who came to spawning for the second time achieved maximal size among all analyzed fish with natural origin: with length of 110 cm it's weigh comprised of 13 700 g.

Table 5.1. Age groups and size-weight parameters of spawning wild salmon from our own catches.

Age	N*	min P, g.	max P, g.	mean P, g.	min L, cm.	max L, cm.	mean L, cm.
2.1+	24 (1**)	600	2500	1652,5±102,8	37	62	51,3±1,3
2.2+	4	3200	6500	4925,0±705,2	68	81	74,8±3,4
3.1+	5	1200	3000	1860,0±321,0	45	64	52,4±3,3
3.2+	4 (1***)	5500	6500	5950,0±210,2	80	83	81,3±0,8
2.3+	10 (1**)	9000	13000	10600,0±452.5	80	104	93,8±2,3
3.3+	4	8500	11000	9625,0±515,4	80	93	85,3±2,8
3.2sm2+	1	13700		13700,0	110		110,0
2.1sm1+	2	2200	2200	2200,0	52	55	53,5±1,5
3.1sm2+	1 (1**)	4000		4000,0	70		70,0
3.3sm1+	1	9500		9500,0	90		90,0
Mean	56	600	13700	4795,7±530,9	37	110	67,4±2,6

N* - total number of caught fish in three stations. In brackets – number of fish caught in the stations 2** and 3*** located in Luga Bay.

Description: in the age of salmon the first digit shows number of full years spent in the river before downstream migration, the second digit shows number of full years spent in feeding in the sea, sign "+" means incomplete year in fish life cycle from birth till catch. Letters "sm" and number following letters show spawning marks availability on the fish scale and number of full years spent after spawning in repeated feeding in the sea.

From 31 salmons that were caught by fishermen team for needs of Luga hatchery 30 individuals had natural origin and only one salmon had features of hatchery origin. As in the case with analyzed salmons from our own catches among fish of wild origin individuals from the age group 2.1+ have dominated.

However, compare to our data in fishermen's catches the second group by numerosity was two-year fishes, which spent for one year in the river and one year in the sea (1.1+). Small fish from this age group (mean parameters of length and weigh amounted to L = 51.9 cm and P = 1320 g respectively), which were absent in our own catches, comprised 27 % among other age groups in catches of fishermen team.

It was only few large fish belonging to salmons of older age feeding in the sea for 2-3 years delivered to hatchery (Table 5.2). In this context the average size of salmon caught by fishermen team in fishing season 2013 (L = 57,3 cm and P = 2329 g), were much lower than similar parameters from our catches (Table 5.1). We also note a significant higher proportion of males over females in the studied total catch of wild salmon than in the catches of fishermen professionals: the predominance of males is expressed by proportion 24 ♂♂: 6 ♀♀.

Table 5.2. Age groups and size-weight parameters of spawning wild salmon from catches of fishermen for Luga hatchery.

Age	Gender	N	min P, g.	max P, g.	mean P, g.	min L, cm.	max L, cm.	mean L, cm.
2.1+	♀	2	1200	2050	1625,5±426,2	47	61	54,0±7,0
	♂	15	1200	2800	1860,0±126,9	49	65	55,2±1,4
2.1+ Sum		17	1200	2800	1832,4±118,8	47	65	55,1±1,4
2.2+	♀	1	5000		5000,0	84		84,0
	♂	2	3600	4170	3885,0±287,3	70	74	72,0±2,0
2.2+ Sum		3	3600	5000	4256,7±406,9	70	84	76,0±4,2
2.3+	♀	1	7000		7000,0	82		82,0
2.3+ Sum		1	7000		7000,0	82		82,0
3.3+	♀	1	8400		8400,0	98		98,0
3.3+ Sum		1	8400		8400,0	98		98,0
1.1+	♀	1	1260		1260,0	60		60,0
	♂	7	1100	1700	1328,6±103,8	46	56	50,7±1,4
1.1+ Sum		8	1100	1700	1320,0±90,4	46	60	51,9±1,6
Mean		30	1100	8400	2329,3±317,5	42	98	57,3±2,2

Total sample set of 4 hatchery fish that were caught by our and fishermen team (for Luga hatchery) joint efforts was characterized by relatively large size of individuals (L = 80.0 – 108.0 cm and P = 5200 – 14 500 g). All first time spawning fish belonged to different age groups in range of 4-5 years of overall life time. One hatchery-grown salmon had spawning marks on the scale that demonstrate participation of this fish in spawning before (Table 5.3).

Table 5.3. Age groups and size-weight parameters of spawning hatchery salmon from our own catches and catches of fishermen for Luga hatchery.

Age	Gender	N	min P, g.	max P, g.	mean P, g.	min L,cm.	max L, cm.	mean L, cm.
2.2+	♀	1*	5200		-	80		-
3.2+	-	1*	6500		-	83		-
2.3+	-	1*	14500		-	108		-
3.3 cm1+	-	1**	7000		-	89		-
Mean		4	5200	14500	8300,0±2101,2	80	108	90,0±6,3

Notes: 1* - salmon from our catches; 1** - salmon that caught by fishermen team for needs of hatchery.

The results of our studies showed that spawning stock of the Luga salmon is represented by fish belonging different age classes, including repeatedly spawning individuals. However, it should be mentioned that the serious changes in the age composition of breeders going to nursery in Luga river have happened after 1930-s. As well as in other salmon rives of the region, the rejuvenation of the flock is observed, i.e. increase of share of fish coming back from the sea in the age of 1-2 years. (Report of GosNIORKh, 2010). The reasons of this tendency could be both the changes in marine environment (food availability etc.), and selective fishing – withdrawal of largest individuals in the first place. For the detailed analysis of the processes taking place in Luga salmon population regular monitoring is required.

The peak of spawning migration in the lower course of the Luga River occurs in the second half of September, which agrees well with the available literature data. The spawning stock is dominated by salmon of natural origin, which indirectly indicates the reduced viability of juvenile salmon released by the Luga hatchery. Low percentage of recovery of hatchery salmons can be be conditioned by small numbers of hatchery smolts in previous years.

Thus, during the years 2007 - 2011 gradual decrease in the numbers of smolts of hatchery origin has been observed at downstream migration, and the year 2011 was mostly unfavorable (less than 3% of released salmons migrated in the Main Basin; see the Fig. 3.6) for the category of fish that could represent (taking into account the current tendencies) an essential part of the nursery flock in the year 2013. Meanwhile, among the 4 fishes of hatchery origin caught in 2013 only two individuals aged 2.2+ и 3.2+ may correspond to downstream migration of 2011, whereas 11 natural individuals of the same age groups were caught by fishing teams (see the Tables 5.1 – 5.3).

Mean size characteristics of wild salmon we caught were: P = 4795.7 g. and L = 67.4 cm. Corresponding parameters measured by professional fishermen serving the Luga hatchery, were: P = 2329.3 g and L = 57.3 cm. Significant mismatch in morphometric parameters of fish from a single herd in the catches of two teams of fishermen fished at the same time within the distance of several hundred meters from one another (in the Luga Bay we caught only 4 salmons of total 59), and predominance of males of younger age classes over other fish in the catches of professionals can be considered as indirect evidence that not all salmons caught for the needs of the Luga hatchery are transferred to the facilities by fishermen.

It is doubtful whether this fact can be explained by the trap selectivity because our stationary nets with a mesh size of 70-110 mm trapped the salmons of different size/weight groups, and the trap (weir) of professional fishermen (being rather complicated engineering construction; Fig 5.7) is also intended for trapping the breeders of all size groups.

Figure 5.7. Stationary trap blocking the Luga River set annually for trapping salmon breeders for the hatchery needs.

6. Description of hindrances and narrow passages of rivers as well as focal c ontrol points (places where poachers can put illegal nets)

As it was mentioned above, salmon spawning grounds in the Luga River are located on three rapids in the main course of the river, as well as in the lower course of its tributary – the Vruda River. Throughout its migration route from the sea to the spawning grounds salmon is at risk to be caught in illegal fishing gear which are numerous in the river during autumn migration. In the lower courses of the river, including all three major rapids, the Luga River retains considerable width, which makes it difficult for poachers to set illegal fishing gear in the narrow parts of the river because of their almost complete absence. Therefore, the main poaching sites are concentrated in the vicinity of large settlements along the banks of the river rapids (Kingisepp, Bol'shoy Sabsk village), as well as in the lower course of the river and in its mouth area. In this regard, particularly unfavorable for salmon part of the river is 15-km section from the village Bol'shoe Kuzemkino to Ust'-Luga settlement (Fig.6.1).

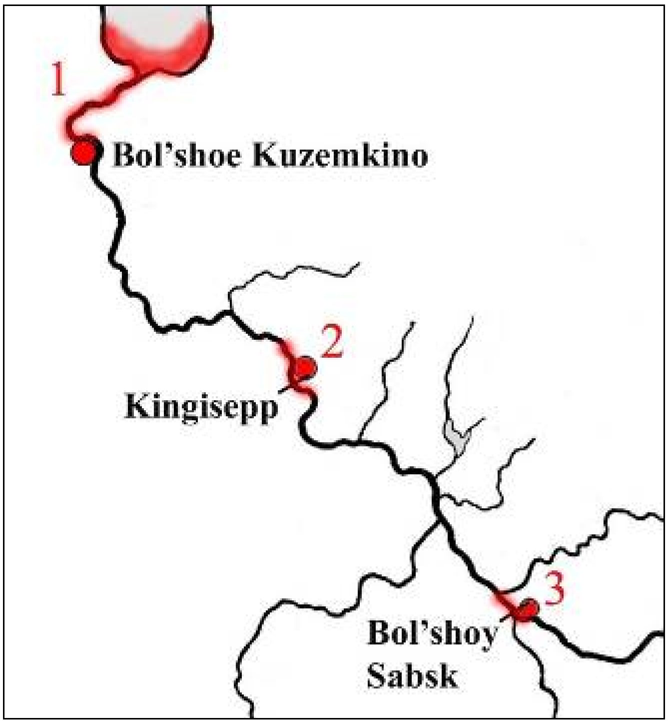

Figure 6.1. The main poaching sites at the Luga River.

For a long time this section of the river has been attracting the attention of fishermen because here salmon spawning stock begins its upstream migration from the sea to the spawning grounds; it is very rough with plenty of holes in the bottom where the salmon stays after entering the river.

According to an article by A. Grimm (1889), even in the nineteenth century, the question of maintaining Luga salmon population was very acute due to its intense fishing. Types of salmon fishing in the Luga River according to Grimm included usage of all sorts of weirs and seines, gill nets, leisters, partition off part of the river with the help of so-called "goat" (koza) Here is how the author describes salmon fishing during the spawning migration: "... having acquainted with all types of gear used in the Luga River, lets take a look at the movement of “loch” (<male salmon in spawning condition>) as the main commercial fish. Having escaped the seines in Luga Bay, it gets to 7 weirs and fyke nets (Kochnev’s and 1 peasant’s), located at the mouth of the river; certainly some “loch” will pass them, but then will get caught into one of Kochnev’s seines set nearby. It goes without saying that here at the mouth about 80% of all incoming “lochs” are caught, the remaining 20% should avoid roughly about 2 dozen of peasant weirs and an unknown number of fixed nets, and, that lucky one who is be able to break through all those barriers, will approach the nearest spawning grounds on Yamburgskie (<Kingiseppskie>) rapids. But, alas! Here, if he avoids one goat, so will get to another. But the share of goats, as we saw above, is a worthless catch, and therefore only very few producers remain for spawning, and you have to wonder how “loch” in the Luga River has not yet become the same pleasant memory as whitefish. But the matter does not end there; poor “loch” who took the fight with as many as 30 fortresses and passed the nets and everything else, already on the most spawning grounds at the time of spawning, gets stubbed by a leister and caught by portage, despite the fact that at this time its meat is white, flabby and valued very cheaply, and caviar ca not be used for food.”

Obviously, during the period since the end of the XIX century Luga salmon population status has only got worse due to overfishing. Currently seines, portages, leisters and goats are not used for Luga salmon fishing, but the number of fixed nets set during spawning migration is beyond counting. This is facilitated by, first of all, significant cheapening of netting gear and their availability on the open market to anyone, and secondly, insufficient staff of fisheries control service and lack of technical and financial means of control.

Significant negative role in the depletion of Luga salmon populations, in our opinion, is played by blocking the Luga River using fixed nets (weirs), set for the needs of the hatchery. This weir operates annually from late July - early August to mid-November, blocking the river during this period in the regime of "five days of complete coverage - five days covering 2/3 of the width of the river." (see the Fig.5.6). In the absence of proper control by the law enforcement agencies at this site near Struppovo village salmon, such fishing here is related to obvious violations both in terms of schedule of weir operations, and in terms of concealment of the fish caught by fishermen. The last assertion is confirmed by comparing the size and weight characteristics of salmon caught at the same time and almost in the same place by for the needs of hatchery and by us in the frames of BASE project (see the Chapter 5).

7. Research of the genetic structure of natural and reared salmon populations from the Luga River

Analysis of the genetic structure of the Luga salmon population is one of the most important tasks in the research part of the implemented BASE project. Genetic diversity assessment of the population studied allows to draw conclusions on its origin, current status (whether the population is in good condition or depressed), whereas the comparison with the previous years study results gives an opportunity to reveal major evolution factors influencing the population over time. Besides, it is of interest to compare the analyzed genetic parameters of natural and reared samples of the Luga salmon in order to determine the genetic relations between these nominal groups.

The obtained results have to be taken into consideration in the process of the development of the Luga salmon restoration program as one of the main goals of this program is conservation of the natural viable population and prevention of loss of part of its valuable gene pool.

The last decade of the 20th century should be considered as starting point for intensive population genetic studies of Atlantic salmon. Based on allozyme data R.V. Kazakov and S.F. Titov (Kazakov, Titov, 1991) first suggested that salmon inhabiting the proglacial lakes could spread throughout Northern Europe. Subsequently, M.-L. Koljonen et al (Koljonen et al., 1999) confirmed that the origin of salmon of the southern Baltic Sea is indeed proglacial lakes

As it was shown, for phylogeographic studies of freshwater and anadromous forms of fishes polymorphism analysis of the mitochondrial genome is well applicable (Bernatchez, Wilson, 1998). Mitochondrial markers are widely used in such matters due to maternal inheritance form and the absence of recombination, which allows to identify various maternal lines and measure their proximity to each other. For instance, it was shown that Atlantic (Nielsen et al., 1996) and the Baltic salmon populations (Nilsson, 1997) have differences in the gene encoding a subunit of NADH-dehydrogenase-1 (ND1) of mitochondrial genome, which suggests a long reproductive isolation of phylogenetic lines of salmon that originated populations from different ocean basins.

E. Verspoor et al. (Verspoor et al., 1999) described nine haplotypes of Atlantic salmon on the basis of restriction fragment length polymorphism (RFLP) of the gene ND1, showing that this region of mtDNA in salmon is the most variable.

To elucidate the origin of the Baltic population of Atlantic salmon population structure and phylogenetic relationship between genealogical lineages of Atlantic salmon from the North Sea, the Baltic Sea and the

White Sea was investigated. RFLP analysis of mitochondrial gene ND1, as well as subunits 3 and 4 (ND3/4), 5 and 6 (ND5/6) of NADH-dehydrogenase (Nilsson et al., 2001) was used. It was shown that all haplotypes from the Baltic Sea are also common in the Atlantic, however, the frequency distribution of these haplotypes has significant differences. For example, out of 15 combined haplotypes of European salmon populations (Fig. 7.1), only three haplotypes were detected by ND1 in the Baltic Sea. At the same time in genes ND3/4 and ND5/6 there was no variability in the Baltic populations. Thus, in the Baltic salmon populations level of genetic variation was lower than the variability of the Atlantic populations, indicating the effect of the "bottleneck" which took place in the process of formation of the Baltic salmon populations (Fig. 7.2).

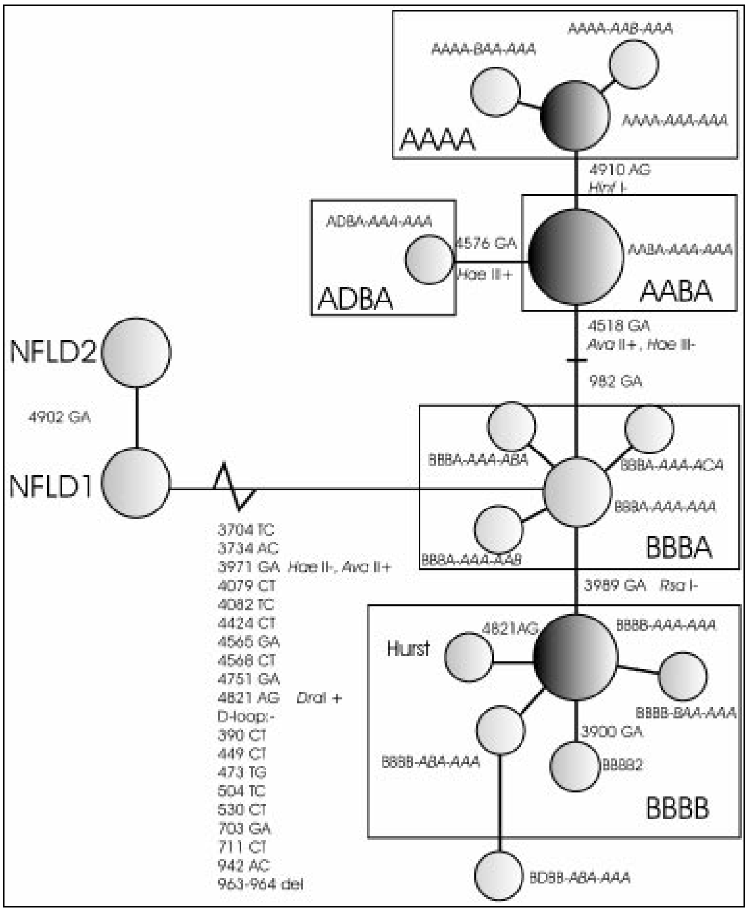

Figure 7.1. Web of combined salmon haplotypes (Nilsson *et al*., 2001). The Baltic salmon population haplotypes are brighter.

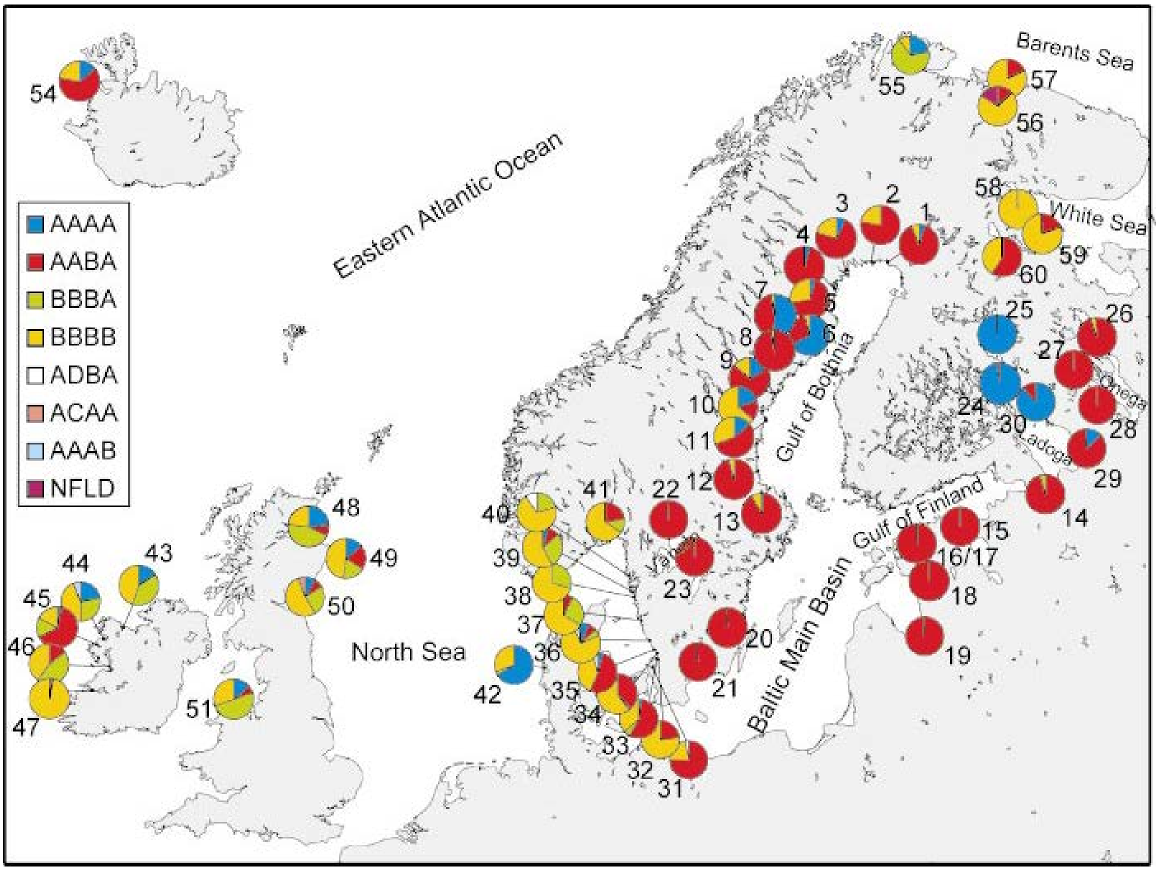

Figure 7.2 Map of sampling locations with pie diagrams showing the distribution of haplotype frequencies among studied Atlantic salmon populations (Nilsson et al., 2001).

Our study of Atlantic salmon in the Luga River was conducted in accordance with the methods and on the basis of molecular genetic markers described by J. Nilsson et al. (Nilsson et al., 2001). This allowed to fully reproduce the PCR-RFLP analysis of the most informative gene of mtDNA of Atlantic salmon and to compare our data with data from previous surveys.

Samples from the salmon population of the Luga River (in total 103 wild and reared specimens) were used for polymerase chain reaction (PCR) –RFLP analysis of the mitochondrial ND1 region. Tissue samples (heart, muscles, fin), from each individual fish were fixed with 96% ethanol.
Total DNA was isolated by the standard method (Sambrook *et al*., 1989).
Pieces of tissue were homogenized in 0.5 ml lysis buffer containing 100 mM Tris -HCl, pH 7.4, 100 mM NaCl, 50 mM EDTA , pH 8.0, 1 % SDS and 25 ug proteinase K and incubated at 37^{0}C for 15 hours. Ribonuclease A was added at concentration of 50 ug / ml and incubated at 37^{0}C for 30 min then double deproteinized with an equal volume of chloroform for 10-15 min, and then centrifuged at about 10 000 rpm during 15 minutes. The upper layer was separated, and then precipitated with two volumes of ethanol. The DNA precipitate was centrifuged for 10 min at 10 000 rpm, and dissolved in TE- buffer containing 10 mM Tris -HCl, pH 7.5 and 1 mM EDTA, pH 8.0.

Primers designed by Nilsson et al. (Nilsson et al., 2001) were used for PCR-RFLP analysis of the mitochondrial ND1 region of Atlantic salmon:

5'-CCCGCCTGTTTACCAAAAAC-3 ‘(forward) and 5'-GGTATGAGCCCGAAAGC-3'(reverse).

The PCR mixture (25 µl) contained 1 units of *Taq*DNA polymerase, 2,5 µl of a 10x *Taq* buffer (SibEnzyme), 0.2 mM each dNTP, 0.25 µM each primer, and approximately 10 ng of total DNA. Amplification included initial denaturation at 95°C for 5 min; 30 cycles of denaturation at 95°C for 1 min, primer annealing at 55°C for 1 min, and elongation at 72°C for 1 min; and final synthesis at 72°C for 10 min. The amplified fragments were electrophoretically separated in 1% agarose gel in 50 mM Tris–borate buffer. Gels were stained with ethidium bromide, and DNA was visualized in transmitted UV light.

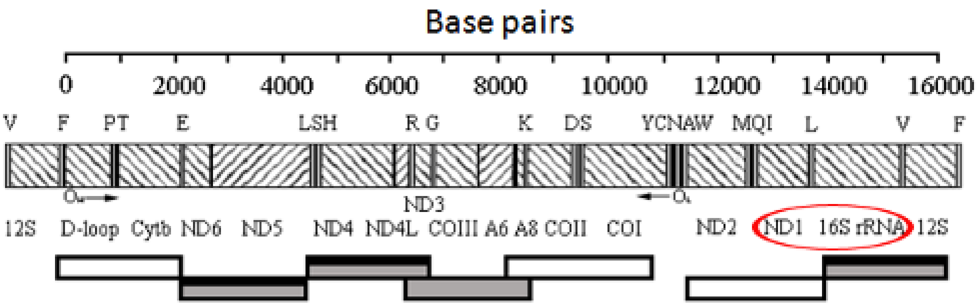

Fig. 7.3. mtDNA genes on the linear gene map of the mitochondrial genome of vertebrates.

We conducted electrophoretic analysis of restriction fragment length polymorphism of the amplified gene ND1 of mitochondrial DNA to study the population genetic structure of Atlantic salmon. Aliquots of the amplified ND1 were treated by set of restriction enzymes under conditions specified by the manufacturer (Fermentas, Lithuania; SibEnzyme, Russia) (Table 7.1).

Table 7.1. The set of restriction enzymes

name	restriction site
*Ava*II	G↓GWCC
*Hae*III	GG↓CC
*Hinf*I	G↓ANTC
*Rsa*I	GT↓AC

Note: W = A or T, N = G,A, T or C

After digestion, the samples were electrophoretically separated in 1.8% agarose gel in 50 mM Tris–borate buffer [28]. The DNA fragments were stained with ethidium bromide and photographed in transmitted UV light. The molecular weight of the fragments was estimated against a 100_bp DNA ladder (Gibco, Grand NY) and phage λ DNA digested with *Pst*I.

Based on the linear arrangement of the restriction fragments, a restriction map was constructed for each of the restriction enzymes of the amplified mtDNA region according to the size of resulting restriction fragments (Table 7.2). The maps were used to establish the presence or absence of particular sites. Variants differing by the presence or absence of a restriction site as a result of mutations were designated with letters for each region and each restriction enzyme (Fig. 7.4, 7.5, 7.6, 7.7).

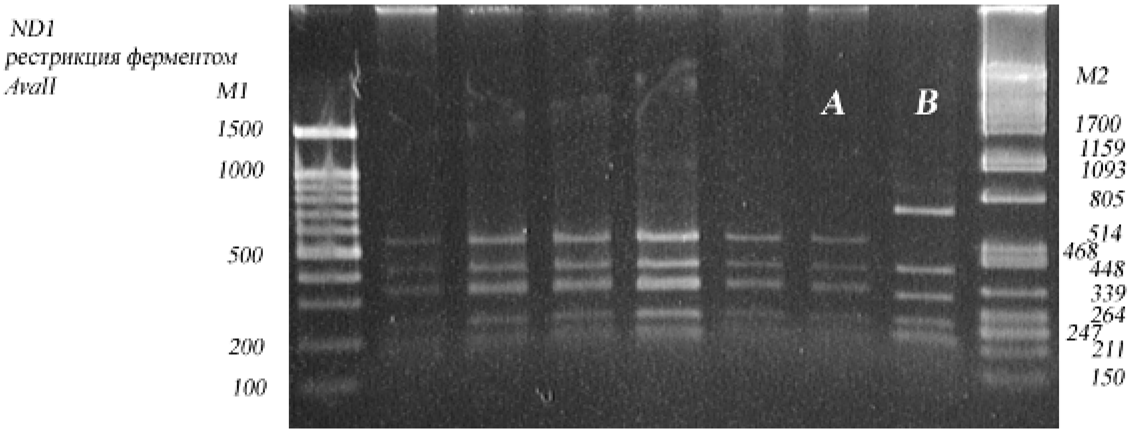

Figure 7.4. Pattern of gene ND1 cleavage by restriction enzyme AvaII. A - haplotype of *Salmo salar*, B – haplotype of *Salmo trutta*

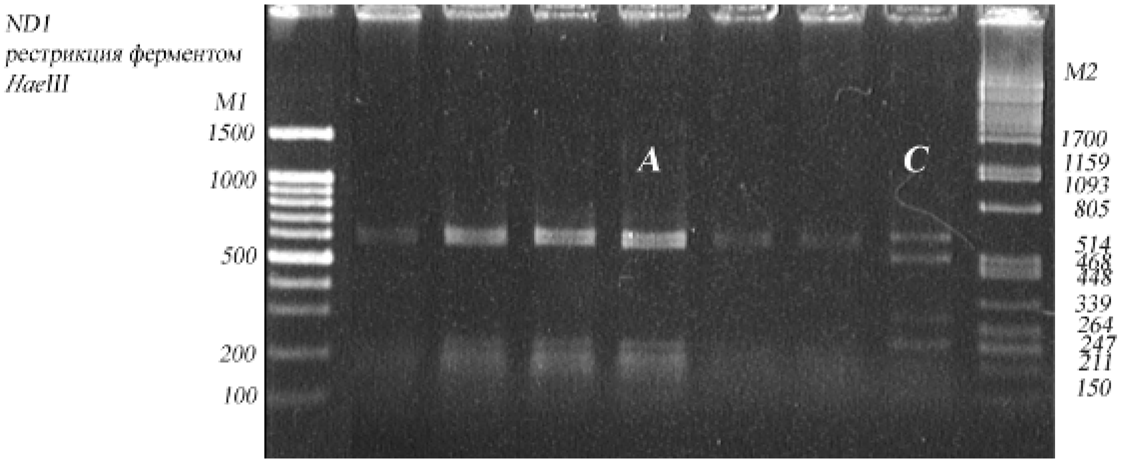

Figure 7.5. Pattern of gene ND1 cleavage by restriction enzyme *Hae*III. A - haplotype of *Salmo salar*, C – haplotype of *Salmo trutta*

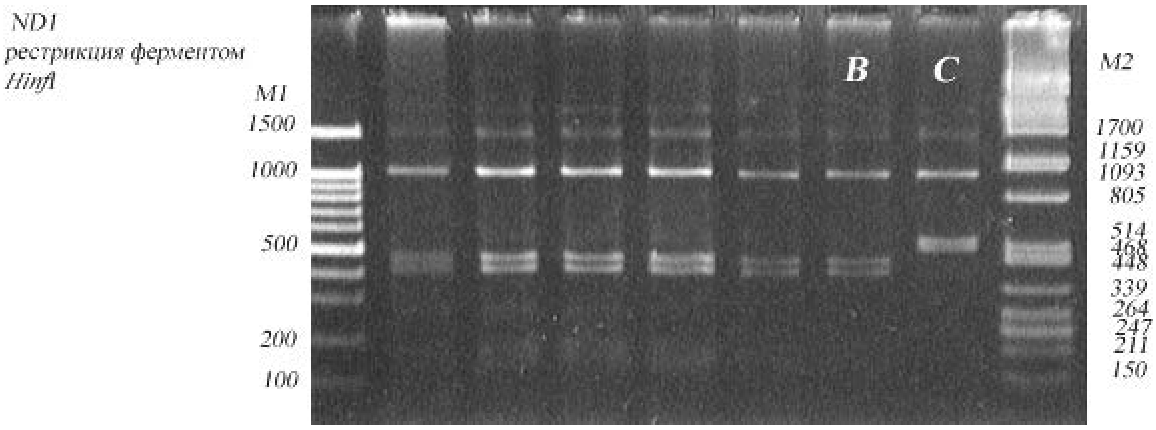

Figure 7.6. Pattern of gene ND1 cleavage by restriction enzyme *Hinf*I. B - haplotype of *Salmo salar*, C– haplotype of *Salmo trutta*

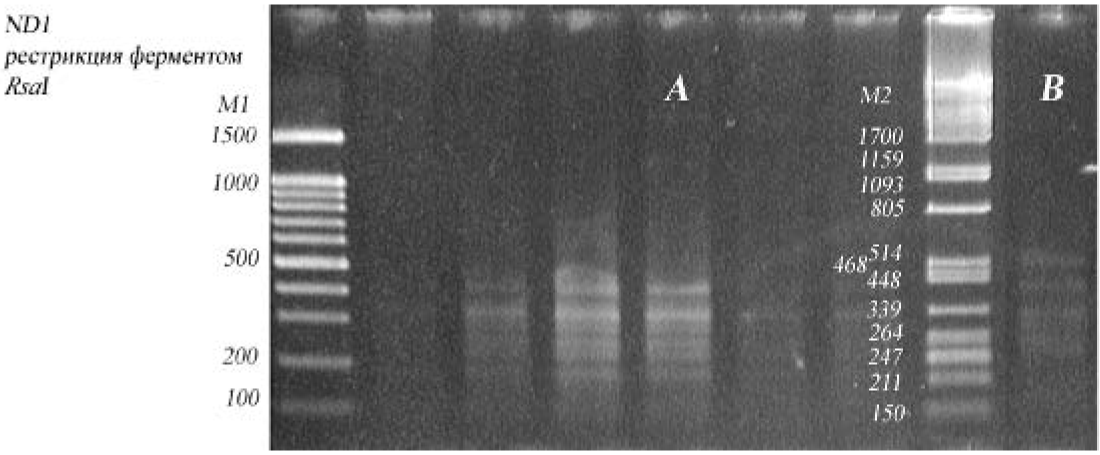

Figure 7.7. Pattern of gene ND1 cleavage by restriction enzyme *Rsa*I. A - haplotype of *Salmo salar*, B – haplotype of *Salmo trutta*

Table 7.2. Restriction fragment sizes (bp), obtained by treating of ND1 mtDNA of Atlantic salmon and brown trout by each of the four restriction endonucleases.

ND1

*Ava*II		*Hae*III				*Hinf*I			*Rsa*I	
A	B	A	B	C	D	A	B	C	A	B
	866				632	982	982	982		510
530		604		604				539	411	411
406	406	560				529			331	
336			499	499				488	321	321
319	319			290			436		291	291
215	215	193	193	193	193	395	395		254	254
152	152	168	168		168	103	103		222	222
51	51	151	151	151	151		93		179	
		122	122		122					
		84	84	84	84					
		72	72	72						
			61	61						

Note. **Red** – Atlantic salmon haplotypes, **blue** - brown trout haplotypes in the r.Luga sample.

Table 7.3. Haplotyping data of wild (W) and hatchery (R) specimens of Salmo salar and Salmo trutta in the Luga River.

№	Probe	R/W	*Ava*I	*Hae*III	*Hinf*I	*Rsa*I
1	533	W	A	A	B	A
2	537	W	A	A	B	A
3	559	R	A	A	B	A
4	560	W	A	A	B	A
5	561	R	A	A	B	A
6	562	R	A	A	B	A
7	563	R	A	A	B	A
8	564	W	A	A	B	A
9	575	R	A	A	B	A
10	576	R	A	A	B	A

11	588	R	A	A	B	A
12	589	R	A	A	B	A
13	590	R	A	A	B	A
14	591	R	A	A	B	A
15	592	R	A	A	B	A
16	593	R	A	A	B	A
17	594	W	A	A	B	A
18	595	R	A	A	B	A
19	596	R	A	A	B	A
20	597	R	A	A	B	A
21	598	R	A	A	B	A
22	599	R	A	A	B	A
23	600	W	A	A	B	A
24	601	W	A	A	B	A
25	602	W	A	A	B	A
26	603	R	A	A	B	A
27	604	W	A	A	B	A
28	605	W	A	A	B	A
29	606	R	A	A	B	A
30	607	R	A	A	B	A
31	608	R	A	A	B	A
32	609	R	A	A	B	A
33	610	W	A	A	B	A
34	611	R	A	A	B	A
35	612	W	A	A	B	A
36	613	*S.trutta*	B	C	C	B
37	614	R	A	A	B	A
38	615	R	A	A	B	A
39	616	R	A	A	B	A
40	617	W	A	A	B	A
41	618	W	A	A	B	A
42	619	W	A	A	B	A
43	620	-	A	A	B	A
44	621	-	A	A	B	A
45	622	W	A	A	B	A
46	623	-	A	A	B	A
47	624	-	A	A	B	A
48	625	-	A	A	B	A
49	626	-	A	A	B	A
50	627	-	A	A	B	A
51	628	-	A	A	B	A
52	629	-	A	A	B	A
53	630	W	A	A	B	A
54	631	W	A	A	B	A

55	632	W	A	A	B	A
56	633	W	A	A	B	A
57	634	W	A	A	B	A
58	635	-	A	A	B	A
59	636	-	A	A	B	A
60	637	-	A	A	B	A
61	638	W	A	A	B	A
62	639	*S.trutta*	B	C	C	B
63	640	-	A	A	B	A
64	641	-	A	A	B	A
65	642	-	A	A	B	A
66	643	W	A	A	B	A
67	644	-	A	A	B	A
68	645	-	A	A	B	A
69	646	-	A	A	B	A
70	647	W	A	A	B	A
71	648	W	A	A	B	A
72	649	-	A	A	B	A
73	650	W	A	A	B	A
74	652	-	A	A	B	A
75	653	-	A	A	B	A
76	654	-	A	A	B	A
77	655	-	A	A	B	A
78	656	-	A	A	B	A
79	657	-	A	A	B	A
80	658	-	A	A	B	A
81	659	-	A	A	B	A
82	660	W	A	A	B	A
83	661	W	A	A	B	A
84	662	-	A	A	B	A
85	663	W	A	A	B	A
86	664	-	A	A	B	A
87	665	W	A	A	B	A
88	666	-	A	A	B	A
89	667	W	A	A	B	A
90	669	W	A	A	B	A
91	670	W	A	A	B	A
92	671	W	A	A	B	A
93	672	W	A	A	B	A
94	673	W	A	A	B	A
95	674	W	A	A	B	A
96	676	-	A	A	B	A
97	677	-	A	A	B	A
98	678	-	A	A	B	A

99	679	-	A	A	B	A
100	680	-	A	A	B	A
101	681	-	A	A	B	A
102	682	-	A	A	B	A
103	683	-	A	A	B	A

Thus, Atlantic salmon, both wild and reared, is represented in the Luga River by a single haplotype AABA (Table 7.3). Detection in the studied sample of salmon of two haplotypes of sea trout may indicate the possible existence of interspecific hybrids of salmon and sea trout, which are hard to distinguish from pure species morphologically. It is known that the presence of interspecific hybrids in the water basin indirectly indicates the adverse environmental conditions and/or bad condition of one of the species populations, in particular, low number.

We estimated how much data we obtained using PCR-RFLP analysis of the mitochondrial ND1 gene are consistent with those of Nilsson et al. on haplotyping of natural populations of Atlantic salmon (Nilsson et al., 2001). For instance, the mean frequency of the haplotype AABA is: 0.81 - for the Baltic Sea as a whole, 0.64 - for the Gulf of Bothnia, 0.99 - for the southern Baltic Sea (including the Baltic states). Thus, our findings, according to which the frequency of the haplotype AABA in the studied sample of salmon is 1.00, confirm that the Luga salmon belongs to the pool of the Baltic populations of Atlantic salmon. Absence of mtDNA haplotypes other than AABA in the Luga salmon genome proves its reproductive isolation from salmon populations from other regions. Another method used for studying population genetic structure of the Luga salmon during the execution of the project was allozyme (isoenzyme) analysis.

For the purpose of this analysis conducted in the framework of the study of salmonid downstream migration from the Luga River to the Gulf of Finland in spring 2013 we collected tissue samples from juvenile Atlantic salmon *Salmo salar* L. The fish was caught using trap net in 12 km from the river mouth. The sample size was: 100 samples of juvenile salmon (smolts) of natural origin ("wild" population) and 100 samples of juvenile hatchery grown (reared) salmon. Reared salmon was represented by juveniles at the age of 1 year (fish reared in the Luga hatchery and released into the Luga River in 2013). Salmon smolts from the natural population were represented by fish aged 1–3 years (modal class — yearlings).

After biological examination (measurements, weighing, scale sampling for age determination, determination of sex) tissue samples were collected from each fish’s heart, liver, eyes, and white skeletal muscles. The tissue samples were frozen, transported to the laboratory GosNIORKH and stored in liquid nitrogen until further genetic treatment (Fig.7.8, 7.9).

Figure 7.8, 7.9. GosNIORKH's experts making laboratory treatment of genetic samples.

Standard techniques were applied for electrophoresis on polyacrylamide gel (Davis, 1964; Peacock et al., 1965). In total, 32 gene loci encoding 12 enzyme systems were studied using electrophoresis on polyacrylamide gel (Table 7.4). Names of proteins and loci, their notations and abbreviations are provided in accordance with the latest recommendations (Shaklee et al., 1990).

Table 7.4. Protein loci studied in the Atlantic salmon samples from the Luga River

Enzyme	Locus
Aspartate aminotransferase	*AAT–1,2,3,4**
Alcogl dehydrogenase	*ADH**
Esterase D	*ESTD–1,2**
Glycerol-3-phosphate dehydrogenase	*G3PDH–1,2**
L-Iditol dehydrogenase	*IDDH–1,2**
Isocitrate dehydrogenase	*IDHP–1,2,3**
L-Lactate dehydrogenase	*LDH–1,2,3,4,5**
Malic enzyme	*MEP–1,2,3**
Malate dehydrogenase	*MDH–1,2,3,4**
Peroxidase	*PX–1,2**
Superoxide dismutase	*SOD–1,2**
Phosphoglucomutase	*PGM–1,2**

For each of the polymorphic loci with co-dominant inheritance system, the empirical and theoretical (expected) phenotype frequencies were compared. Compliance with the Hardy-Weinberg-Castle principle was assessed using χ^2-test. Tests for homogeneity of allele frequencies of polymorphic protein loci in the samples were carried out also using χ^2-test. Statistical processing of the data was done using the software package "BIOSYS-1" (Swofford, Selander, 1989).

In order to monitor changes in population genetic structure of the Luga salmon that have occurred over the past 10 years, previously obtained data on the genetic features of reared and wild juvenile salmon from the Luga River were included in the analysis (data from 2002).

Out of 32 polymorphic protein loci analyzed in 2013 three loci were found in the samples from both natural Atlantic salmon and the reared one: *AAT–4**, *IDDH–2**, *MEP–2**.
In the previously studied (in 2002) similar samples of the Luga salmon there were five of such loci: *AAT–4**, *IDDH–1**, *IDDH–2**, *IDHP–3**, *MEP–2**.

Based on the primary data (genotype frequencies), frequency distribution of the alleles of polymorphic protein loci in the studied populations were estimated. The names of all polymorphic loci, their tissue localization and allele mobility are shown in Table 7.5. Table 7.6 demonstrates the distribution of allele frequencies of polymorphic protein loci in reared and natural salmon samples studied in 2002 and 2013. Mobility of the most frequent (common) allele was set at “100”, and the rest of the alleles acquired numerical values according to their electrophoretic mobility relative to the one of the common allele.

Table 7.5. Polymorphic protein loci studied (and commonly screened tissues are indicated) in the investigated Atlantic salmon samples from the Luga River

Enzymes	Locus	Allele	Tissue
Aspartate aminotransferase	*AAT–4**	100, 76, 57	L
L-Iditol dehydrogenase	*IDDH–1**	100, 85	L
L-Iditol dehydrogenase	*IDDH–2**	100, 28	L
Isocitrate dehydrogenase	*IDHP–3**	100, 116	L
Malic enzyme	*MEP–2**	100, 88	M

Note: L, liver; M, muscle.

Table 7.6. Allele frequencies in the Atlantic salmon populations (*Salmo salar* L.) from the Luga River

Locus	Allele	Population			
		wild		reared	
		2002 г.	2013 г.	2002 г.	2013 г.
*AAT–4**	100	0.714	0.750	0.798	0.790
	76	0.270	0.230	0.173	0.195
	57	0.016	0.020	0.029	0.015
*IDDH–1**	100	0.953	1.000	0.913	1.000
	85	0.047	0.000	0.087	0.000
*IDDH–2**	28	0.182	0.150	0.298	0.240
	100	0.818	0.850	0.702	0.760
*IDHP–3**	116	0.016	0.000	0.000	0.000
	100	0.984	1.000	1.000	1.000
*MEP–2**	100	0.068	0.055	0.010	0.065
	88	0.932	0.945	0.990	0.935

In order to determine the degree of genetic homogeneity of the material in each of the studied samples we used χ^2-criteria commonly applied in such cases to test the consistency of observed and theoretical frequencies of phenotypes. In all the juvenile groups studied we observed the compliance with the Hardy–Weinberg–Castle principle for all polymorphic loci analyzed. This suggests the presence of genetically homogeneous groups of fish within each of the investigated samples (populations).

When comparing the allele frequencies of polymorphic protein loci from the samples of natural and reared salmon analyzed in 2013, we detected significant differences in one of the three polymorphic loci - locus *IDDH–2** (Table 7.7) .

Such minor differences are explained by the fact that for breeding purposes the Luga hatchery annually catches dozens of salmon spawners from the Luga River and the catch includes fish of both natural and reared origin. This, in turn, causes the genetic affinity of juvenile salmon grown in the Luga hatchery and the fry obtained by natural reproduction.

The analysis of changes in the genetic structure of natural population of salmon in the Luga River which have been happening during the past decade, since 2002, is much more interesting.
Comparative analysis of the frequencies of genetic markers in the samples of juvenile salmon from natural population analyzed in 2002 and 2013 revealed highly statistically significant differences in locus *IDDH–1** (Table 7.8).

Table 7.7. Contingency chi-square analysis at all loci in the wild and reared samples from 2013

Locus	No. of. alleles	Chi-square	D.F.	P
*AAT–4**	3	0.927	2	0.62904
*IDDH–2**	2	5.160	1	0.02311
*MEP–2**	2	0.177	1	0.67372
Totals		6.264	4	0.18025

Table 7.8. Contingency chi-square analysis at all loci in the wild samples from 2002 and 2013

Locus	No. of. alleles	Chi-square	D.F.	P
*AAT–4**	3	0.936	2	0.62619
*IDDH–1**	2	9.595	1	0.00195
*IDDH–2**	2	0.738	1	0.39014
*IDHP–3**	2	1.925	1	0.16535
*MEP–2**	2	0.275	1	0.59981
Totals		13.470	6	0.03615

The revealed differences are mainly due to poor status of natural population of the Luga salmon. According to our data, the number of spawners of natural origin annually entering the Luga River does not exceed 200–800, while the number of fish involved in spawning in some years may be several dozen individuals only.

For description of the genetic features of certain fish populations the parameters characterizing the level of genetic diversity — the proportion of polymorphic loci, number of alleles per locus and mean heterozygosity — are very important. For the studied samples of the Luga salmon these parameters are presented in Table 7.9.

Table 7.9. Genetic diversity at 32 loci in all populations studied

Population	Mean no. of alleles per locus	Percentage of loci polymorphic**	Mean heterozygosity	
			Direct-count	HdyWbg expected**
Wild:				
2002	1.2±0.1	15.6	0.032±0.018	0.030±0.016
2013	1.1±0.1	9.4	0.023±0.014	0.023±0.014
Reared:				
2002	1.2±0.1	12.5	0.030±0.019	0.029±0.017
2013	1.1±0.1	9.4	0.023±0.014	0.026±0.016

* A locus is considered polymorphic if more than one allele was detected
** Unbiased estimate (see Nei, 1978)

It turned out that based on the main parameters of genetic diversity — the number of alleles per locus, proportion of polymorphic loci and the mean heterozygosity — natural and reared salmon samples almost did not differ from each other, both in 2002 and 2013.

However, it must be emphasized that in the last ten years significant reduction in genetic diversity has been observed: the values of all the parameters mentioned above were almost 25% lower in 2013 compared with 2002.

Genetic studies conducted in 2013 in the framework of the BASE Project revealed that over the ten years past since the previous genetic studies (in 2002) some changes, adverse in our opinion, in genetic structure of the Luga salmon have begun to appear.

Genetic markers frequency differences between the samples of salmon analyzed in 2002 and 2013 are quite understandable. Such phenomena are the result of so called "genetic drift" which is quite common for small populations of various species of animals. Our research findings suggest that the size of the Luga salmon natural population may vary considerably from year to year (the number of wild smolts migrating from the Luga River over the past 15 years has been ranging from 2000 to 8000 individuals).

The frequency changes of certain genetic markers are less significant than the change (usually, decline) in genetic diversity of the population that occurs as a result of this process. In 2013, the number of polymorphic loci identified in the analyzed sample of the wild salmon from the Luga River was considerably lower than in 2002 (3 and 5 loci respectively). There was a significant — about 25% — reduction over the years in such parameters as the mean level of genetic diversity and a number of alleles per locus. It must be emphasized that decline of the level of genetic diversity of a given population is often viewed from the standpoint of reduction of the potential adaptability of both the population and the species in general.

Based on these data (allele frequencies of protein and enzyme loci and genetic diversity parameters) "genetic IDs" for the salmon populations studied were developed (Table 7.10, 7.11).

Figures 7.10 – 7.12 are schematic diagrams illustrating inheritance for each of studied polymorphic genetic loci.

Table 7.10. Allele frequencies and genetic diversity measures of the wild salmon population of the Luga River

Locus	Sample size	Allele			Mean heterozygosity per locus*		
		A	B	C	H	H (unb)	H (D.C.)
*AAT–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*AAT–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*AAT–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*AAT–4**	100	1.750	0.230	0.020	0.384	0.386	0.380
*ADH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*ESTD–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*ESTD–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*G3PDH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*G3PDH–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDDH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDDH–2**	100	1.150	0.850	0.000	0.255	0.256	0.260
*IDHP–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDHP–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDHP–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–4**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–5**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MDH–1**	100	0.000	1.000	0.000	0.000	0.000	0.000
*MDH–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MDH–3**	100	0.000	1.000	0.000	0.000	0.000	0.000
*MDH–4**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MEP–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MEP–2**	100	0.055	0.945	0.000	0.104	0.104	0.110
*MEP–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PGM–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PGM–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PX–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PX–2**	100	0.000	1.000	0.000	0.000	0.000	0.000
*SOD–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*SOD–2**	100	1.000	0.000	0.000	0.000	0.000	0.000

Mean heterozygosity per locus (biased estimate) = 0.023 ± 0.014
Mean heterozygosity per locus (unbiased estimate) = 0.023 ± 0.014
Mean heterozygosity per locus (direct-count estimate) = 0.023 ± 0.014
Mean number of alleles per locus = 1.13 ± 0.07
Percentage of loci polymorphic (0.95 criterion) = 9.38
Percentage of loci polymorphic (0.99 criterion) = 9.38
Percentage of loci polymorphic (no criterion) = 9.38

Table 7.11. Allele frequencies and genetic diversity measures of the reared salmon population of the Luga River (2014)

Locus	Sample size	Allele			Mean heterozygosity per locus*		
		A	B	C	H	H (unb)	H (D.C.)
*AAT–1**		1.000	0.000	0.000	0.000	0.000	0.000
*AAT–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*AAT–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*AAT–4**	100	0.790	0.195	0.015	0.338	0.339	0.300
*ADH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*ESTD–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*ESTD–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*G3PDH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*G3PDH–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDDH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDDH–2**	100	1.240	0.760	0.000	0.365	0.367	0.320
*IDHP–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDHP–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*IDHP–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–4**	100	1.000	0.000	0.000	0.000	0.000	0.000
*LDH–5**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MDH–1**	100	0.000	1.000	0.000	0.000	0.000	0.000
*MDH–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MDH–3**	100	0.000	1.000	0.000	0.000	0.000	0.000
*MDH–4**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MEP–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*MEP–2**	100	0.065	0.935	0.000	0.122	0.122	0.130
*MEP–3**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PGM–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PGM–2**	100	1.000	0.000	0.000	0.000	0.000	0.000
*PX–1**	100	1.000	0.000	0.000	0.000	0.000	0.0*00
*PX–2**	100	0.000	1.000	0.000	0.000	0.000	0.000
*SOD–1**	100	1.000	0.000	0.000	0.000	0.000	0.000
*SOD–2**	100	1.000	0.000	0.000	0.000	0.000	0.000

Mean heterozygosity per locus (biased estimate) = 0.026 ± 0.016
Mean heterozygosity per locus (unbiased estimate) = 0.026 ± 0.016
Mean heterozygosity per locus (direct-count estimate) = 0.023 ± 0.014
Mean number of alleles per locus = 1.13 ± 0.07
Percentage of loci polymorphic (0.95 criterion) = 9.38
Percentage of loci polymorphic (0.99 criterion) = 9.38
Percentage of loci polymorphic (no criterion) = 9.38

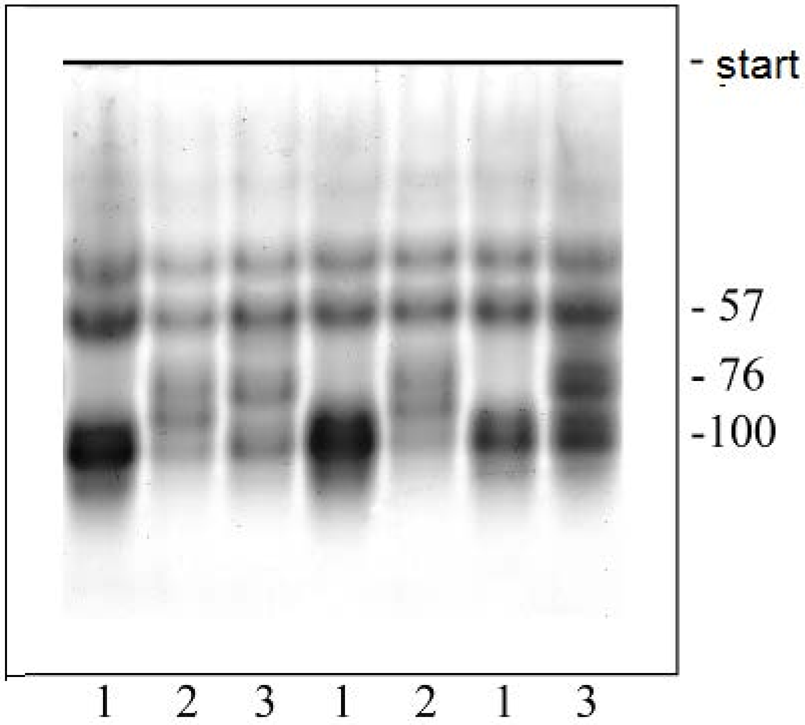

Figure 7.10. Electrophoretic phenotypes found in the studied sample of the Atlantic salmon for locus *AAT–4**: 1 — homozygote 100/100,
2 — heterozygote 76/100, 3 — heterozygote 57/100.

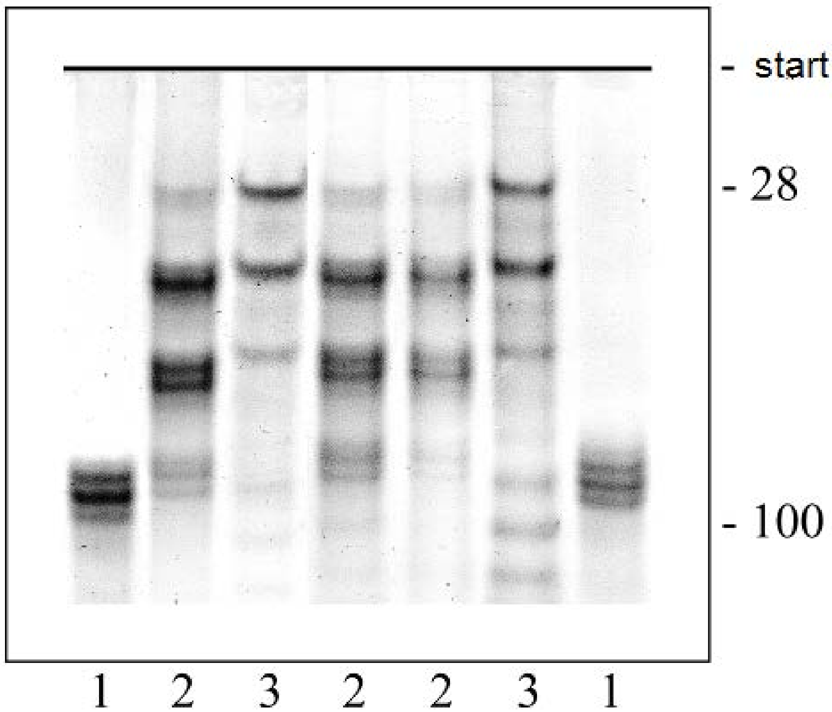

Figure 7.11. Electrophoretic phenotypes found in the studied sample of the Atlantic salmon for locus *IDDH–2**: 1 — homozygote 100/100,
2 — heterozygote 28/100, 3 — homozygote 28/28.

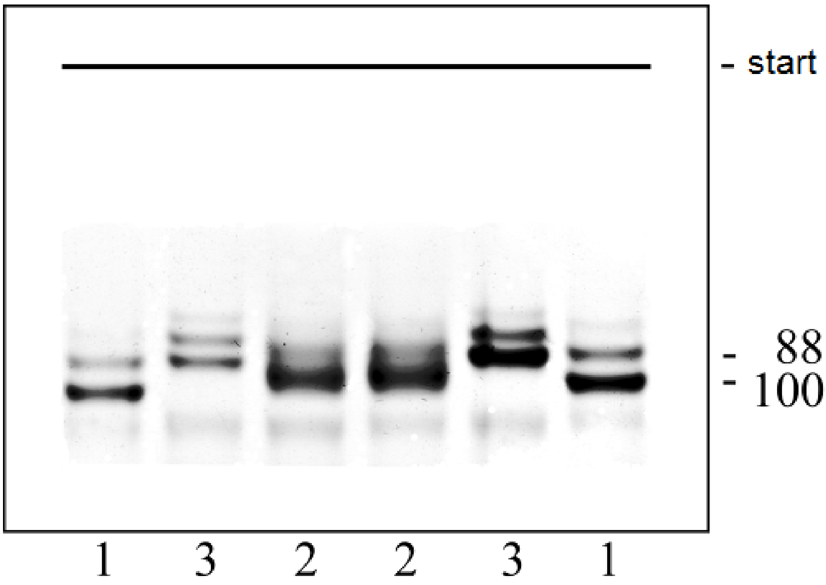

Figure 7.12. Electrophoretic phenotypes found in the studied sample of the Atlantic salmon for locus *MEP–2**: 1 — homozygote 100/100,
2 — heterozygote 88/100, 3 — homozygote 88/88.

Genetic study of the Luga salmon population using mitochondrial and allozyme methods for analysis suggests the following conclusions:

1. Luga salmon belongs to the southern (Baltic) group of the Baltic salmon populations, which differ from the populations of Atlantic (Western) origin. Like other populations of this pool, Luga salmon to large extend is reproductively isolated from populations from other parts of the Baltic Sea.

2. Currently, the population of Luga salmon is genetically consistent, which probably accounts for the lack of genetic differentiation to smaller units (subpopulations) associated with various biotopes (spawning grounds). A completely different structure is typical, for example, for another salmonid species in the River Luga - sea trout, which is represented by several local genetically distinct populations associated with separate spawning tributaries. This fact significantly simplifies the implementation of practical measures for the restoration of Luga salmon.

3. Insignificant genetic differences in polymorphic protein loci allele frequencies were found between the samples from natural and reared Luga salmon. The relative genetic proximity of the analysed samples is explained first of all by the implementation technique of the hatchery, which uses both natural and reared salmon breeders for breeding purposes. Since hatchery grown salmon is apparently able to spawn in the wild, hatchery-grown salmon should be considered as a viable donor material for restoration releases of young salmon of different age classes into the vacant spawning grounds of the River Luga.

4. An overall decline of the genetic diversity level observed in the wild salmon population of the River Luga over the past ten years is caused first of all by the genetic drift effect occurring in a low-number natural population. A permanent loss of rare gene alleles occurs due to a limited number of breeders annually taking part in spawning. As a result of such a negative tendency, the viability of the Luga salmon population - delicately adapted to the heterogeneous environment of the River Luga - is decreasing. Findings of sea trout genes in the salmon gene pool, which suggest the occurrence of interspecies hybrids, is indirect evidence of the genetic weakness of the Luga salmon population. In order to minimize the risk of the population genetic diversity loss, more efficient scheme of breeders trapping for the hatchery

(ensuring fish use not only from autumn but also from summer spawning run) should be suggested in the Program of the Luga salmon restoration

8. Activities to promote and ensure that the recommendations of the SALAR project and the HELCOM BSAP would materialize also in the Russian Federation

In the beginning of the project numerous negotiations and conversations were conducted with different stakeholders, both international (HELCOM, Finnish Game and Fisheries Institute, South East ELY/Finland, Inland Fishery Institute/Poland, CCB) and Russian (Federal Service for Supervision in the Use of Natural Resources/Rosprirodnadzor, Federal Fishery Agency/Rosrybolovstvo, Leningrad Region Administration, Neva-Ladoga Basin Directorate, Baltic Fund for Nature, SPBPO Ecology&Business, ANNPO "Center of the Baltic Salmon", CPO "Biologists for Nature Conservation"). As a result, information on the project was widely distributed, good preconditions for further cooperation were found and the Project Advisory Board was formed.

The first Advisory Board Meeting ("Kick-off Meeting") was held on September, 9 in St.Petersburg (see the meeting Minutes in Annex 2). The Minutes are available to the broad sections of stakeholders.

By the recommendation of the meeting, the official letter from the Project on the situation with Luzhskyi hatchery was sent to the Head of NW Board of Federal Fishery Agency Mr. Denis Belyaev. As a result, direct link and data exchange with the hatchery was established.
The information on the project was presented by Veronica Tarbayeva at the conference "Ecological safety of population" on 11-th of October 2013 in St.Petersburg.

BASE project experts participated at the international events - HELCOM workshop on Fisheries and Maritime Spatial Planning (MSP) "Fishing for space" which was held in on 14-th of November 2013 in Vilnius, Lithuania and the BASE project meeting which took place on 10 December 2013 in Helsinki, Finland.

Project experts took part in an international work meeting aimed at establishing cooperation regarding the Baltic Sea salmon (in relation to the Helcom/CCB program). The meeting was organized by Swedish Agriculture University (SLU), Salmo Lapland AB, Sweden, and Finnish Game and Fisheries Institute. It was held on 11-12 of February, 2014 in Umeå, Sweden.

Participants:

Hans Lundquist, Swedish Agriculture University, Umeå

Jan Nilsson, Swedish Agriculture University, Umeå

Kjell Leonarsson, Swedish Agriculture University, Umeå

Peter Funegard, International Coordination Unit, Swedish Agency for Marine and Water Management, Sweden
Greger Jonsson, Salmo Lapland AB, Sweden
Stig Westbergh, Swedish Agriculture University, Umeå
Lo Persson, Swedish Agriculture University, Umeå
Gunnar Norén, CCB/Sweden
Markku Kaukoranta, Finnish Game and Fisheries Institute
Sergey Titov, BASE Project Managing Expert, State Research Institute for Lake and River Fisheries (GosNIORKH)/Russia
Dmitry Sendek, BASE Project Expert, State Research Institute for Lake and River Fisheries (GosNIORKH)/Russia

The prospects of cooperation between Sweden, Finland and Russia on Atlantic salmon population management in the Baltic Sea have been discussed. Swedish and Finnish specialists made their presentations on conservation of Atlantic salmon populations, restoration of salmon rivers, population genetics and salmon breeding.

Special attention was paid to the natural salmon population in the Luga River and current results of the BASE Project which were presented by Sergey Titov. The participants gave some recommendations for preparation of the Luga salmon management plan. They concluded that all necessary data for elaboration of complex program for restoration and conservation of salmon population in the Luga River are obtained in the course of BASE Project.

Peter Funegard has informed the participants that he was planning to present the results of the work meeting at the conference at the Russian Ministry of Natural Resources and Environment (MNR) to be held in March 2014 in Moscow, and to discuss with MNR the issues of international cooperation on Luga salmon management.

During the reporting period good cooperation was established with the ENPI CBC Project SE-717 “Clean Rivers to Healthy Baltic Sea” (Luga-Balt; http://lugabalt.ru). The project tasks are quite similar to our BASE project:

1. To collect and analyze the information on the Luga River environmental condition and biology, to make the list of "hot spots” and to create the proved system of long-term objectives to improve the water quality and biodiversity status.
2. To assist both regional and municipal authorities and the enterprises in increasing their competence

in environmental management of rural territories and water objects.

3. To promote increasing of environmental literacy and responsibility of the people living in the area of the Luga River basin, to initiate and support nature conservation actions by forces of all groups of the population.

Project Partners:

- Luga county municipality administration
- North-West Research Institute of Agricultural Engineering and Electrification (SZNIIMESH) of the Russian Academy of Agricultural Sciences
- Saint Petersburg State Agrarian University (SPSAU)
- Regional Public Organization "Association for Assistance of Field Research and Development of Rural Territories" (AAFRDRT)
- MTT Agrifood Research Finland
- Mikkeli University of Applied Sciences
- Cattle farm "Partizan"
- Committee on Agriculture and Fishery of Leningrad Region.

The BASE project team members (Sergey Rezvyi, Sergey Titov and Sergey Mikhelson) had been invited to the Luga-Balt Round Table "Measures on improvement of water quality and restoration of natural biodiversity in the Luga River" that was held on 13 March 2014 in Luga city. More than 30 people representing key Luga-Balt project partners participated in this event (Fig. 8.1-8.3). The BASE project presentation including the proposals on Luga salmon management plan was given by Sergey Titov (Fig.7.4). Representatives of two related projects agreed on further cooperation.

Figure 8.1. Opening of the Round Table “Measures on improvement of water quality and restoration of natural biodiversity in the Luga River” (Luga-Balt project coordinator Vladislav Minin).

Figure 8.2. Presentation by Hanne Sounen, Mikkeli University of Applied Sciences.

Figure 8.3. Presentation on the Luga River hydrobiology by Prof. Nikolay Aladin, Zoological Institute RAS.

Figure 8.4. Presentation of the BASE project by Sergey Titov.

A linkage was also established with “ECO-FRIENDLY PORT”, the project financed by the ENPI programme “South-East Finland - Russia”. The wide objective of this project is improving the environmental status of the Eastern part of the Gulf of Finland by establishing close cooperation between citizens, Ust-Luga port actors and authorities on the base of green value, green economy and ecological mentality aimed at sustainable regional development (http://ecoport.rshu.ru/index_eng.html).

Project partners:

- Russian State Hydrometeorologcal University (Leader Partner)
- Ust-Luga Company JSC
- Kymenlaakso University of Applied Sciences
- University of Turku CMS
- Port of HaminaKotka
- Finnish Port Association
- Kotka City Authority
- Leningrad region Authority

Project activities include analyzing the environmental status of the region and developing compensatory measures, studying environmental regulations and establishing monitoring centre, cooperation with stakeholders and social project part called "Port in the city".

The executors of BASE and ECO-FRIENDLY PORT projects agreed on exchange data on environmental status of Luda Bay with special attention to Ust-Luga Port influence on migratory fish populations. On March 20, 2014, both projects were presented at the Round Table “Impact of human activities on marine biodiversity” within XV International Environmental Forum «Baltic Sea Day», which took place in St. Petersburg. The statement of importance of restoration of natural salmon population in Luga River was included in Round Table Resolution.

The final expanded meeting of the Project Advisory Board was organized to discuss the project results and developed recommendations on salmon management plan in the Luga river. The meeting took place on Tuesday, 27-th of May, 2014 at Sokos Hotel in St.Petersburg. Diverse stakeholders (representatives of federal, regional and municipal authorities, scientists, NGOs) were invited (See the meeting Minutes in Annex 3).

Thus, the information on Pilot project findings and results was widely distributed among the stakeholders both on international and Russian national (Federal, regional, municipal) levels. The established dialogue, information activities and fruitful discussions with respective Russian authorities, scientific community, NGOs and local inhabitants are useful for approval of developed plan of spawning areas restoration, realization of the management plan for Luga salmon and for the development of national programmes for the implementation of the BSAP.

9. Conclusion and recommendations

Detailed analysis of all available information (publications and departmental reports of various organizations) on the Luga River and the salmon population inhabiting this watercourse confirmed the relevance and necessity of the project aimed at a comprehensive study of the Luga salmon, which was conducted in the BASE Project.

In the course of the project all its goals and activities were successfully met. As a result, for the first time in ichthyological research in the region, the actual data were obtained on the current status and the number of "wild" salmon population in the Luga River, and an assessment of the potential of the watercourse was carried out.

Study of downstream migration of juvenile salmon from the river to the sea carried out in the lower course of the river using a trap, allowed to estimate the real size of the "wild" salmon population in the Luga River. From 2500 to 8000 "wild" salmon smolts (in 2013 the number of smolts in the area was the lowest - about 2500) migrate annually to the sea (Main Basin) for foraging. On average over the last ten years this value was about 5000 individuals per year. Given that the number of returning salmon breeders is about 10% of wild smolts having migrated downstream, the current number of wild salmon population can be estimated as no more than 500 individual breeders. Apart from the juveniles from wild population each year from 3000 to 23000 reared fish from the Luga hatchery migrates from the river into the sea. In the analogy of calculations done for the wild smolts, this can provide a return to the river of 300 to 2300 adults. However, due to low fitness of hatchery grown smolts the actual number of breeders would be lower.

Evidence of a low number of the Luga salmon was obtained also during ichthyological studies conducted on spawning grounds and nursery areas of the Luga River and its spawning tributaries. Juvenile "wild" salmon was detected on only one out of three spawning grounds in the main course of the Luga River and at a small site in its right tributary - the Vruda River. Density distribution of juveniles on fished areas was extremely low - less than 1 ind./100m^2. This means that the total number of juvenile salmon of different age classes which at the same time inhabit the Luga River basin, is less than 7000-10000 individuals.

The study of the migration of salmon breeders did not allow to estimate the real size of the Luga salmon spawning stock. However, according to expert estimates, in 2013 no more than 1-2 thousand salmon breeders entered the Luga River to spawn, and a large part of them was represented by fish from wild population. Obviously, for such rivers as Luga this estimated population size is extremely low.

To assess the potential of the Luga River, a survey of spawning grounds and nursery areas suitable for juveniles was conducted not only in the main course of the Luga River, but also in most of its spawning tributaries. For this purpose, for the first time we carried out route surveys along the entire length of the river - from its sources located in the Novgorod region, to its inflow into Luga Bay of the Gulf of Finland.

Relatively small size spawning grounds and nursery areas currently used for spawning by salmon were found in the lower course of the Vruda River. The area of these spawning grounds, according to our estimate, does not exceed 23 000 m^2, but very good condition of these areas which can provide high efficiency of salmon spawning taking place there should be noted.

The main spawning grounds for breeders and nursery areas for juveniles were located on 3 main river rapids - Sabskie, Storonskie and Kingiseppskie. The total area of these sites is about 730000 m^2, but now the amount of suitable habitat for juvenile salmon in these areas is estimated at only 350000 m^2. More than twofold decline in the area of functioning spawning grounds and nursery areas compared with potentially available areas in the main course of the Luga River is explained by their poor condition (especially in the area of Kingisepp). According to our estimates, currently functioning spawning grounds on the Luga River provide all necessary conditions for the habitat and foraging of more than 170 000 individuals of juvenile salmon of different age classes - the number which is approximately twenty times greater than the current population of this species.

High potential of the Luga River is explained not only by presence of significant spawning areas here, but by a number of other factors that can be evaluated as having positive influence on habitat and reproduction of salmon in the watercourse. As a result of the Project research it was found out that there are no barriers (dams, debris, beaver dams) throughout the course of the Luga River which might be obstacles to the migration of salmon. On the spawning grounds and nursery areas neither predatory fish species that can feed on juvenile salmon, nor species that may exercise serious competition for food.

It should be noted that the water quality in the Luga River can be generally characterized as "good"; at the moment in the Luga basin there are no large industrial facilities potentially threatening habitat and reproduction of salmon. Although the water quality in the river is in general rather acceptable for sulmon reproduction, it should be taken into account that some problems in this field can arise in nearest future. Potential threats for water quality can come from the livestock farms located in Luga river catcment area. Forest cuttings close to the river becoming more usual during last years may also negatevily affect the water regime that, in tern, will increase biogene leakage.

However, there are several factors that adversely affect (or may have such effects in the future) on the population status of the Luga River salmon. These include the already mentioned poor condition of spawning grounds and nursery areas, low effectiveness of the Luga hatchery, influence of hydrotechnological operations in the Luga River and Luga Bay of the Gulf of Finland. However, in our opinion, the main reason for decline of reproduction rate of wild salmon in the Luga River is a high level of illegal fishing (poaching).

The data obtained in the course of the Project indicate the need for development of recovery plan for salmon population in the Luga River which should include clear and realistic goals for the effective exploitation of the resources of this species in this watercourse. Such a document is relevant now and should be prepared as soon as possible.

The following recommendations for the implementation of activities aimed on improvement of the current situation can form the basis of the recovery plan for salmon population in the Luga River and preservation of its gene pool.

Recommendations:

1. Effective conservation program is the most important and powerful method to be used for restoration of the Luga salmon population as poaching has been and remains the most important factor resulting in low abundance of this species in the Luga River. In order to reduce the negative impact of poaching the following measures should be taken:

- Establishing effective protection: in the mouth part and the lower courses of the Luga River during spawning migration of salmon breeders; on the main spawning grounds of the Luga River during salmon spawning; in the areas of hatchery releases (within 3-5 days after release);
- Revival of the institution of public (voluntary) inspectors (joint action by local administrations and Federal Fishery Agency) with conducting special training of the volunteers;
- Involve police officers in protection / inspection actions.

2. To mitigate the effect of comercial and sport fishing on the population of Luga salmon:

- to develop proposals for the effective monitoring of commercial fishing in the waters of Luga;
- to ban commercial fishing in Luga mouth in spring time (from April 15 to June 15) to prevent bycatch of juvenile salmon. Develop recommendations to be included in the fishing regulations;
- to develope proposals on temporal limitations of fishing of other species of fish (using netting gear) on the migration routes of salmon in Luga Bay during mass spawning migration of breeders;
- to amend fishing rules for to ban fishing of hatchery salmon in the Rusian part of the Gulf of Finland.

3. In order to maintain the population of wild salmon in the Luga River and restore its numbers it is necessary to increase the efficiency of the Luga salmon hatchery.

For this purpose it is necessary, at least, to:

- create conditions at the facilities improving the natural environment (temperature, food, light, fish density, etc.) that will let smolts quickly and efficiently adapt themselves to living in natural watercourse after release;
- optimize the timing and location of hatchery salmon release, making them as close as possible to the places and dates of natural downstream migration of this species in the Luga River;
- before the release of hatchery juveniles to conduct reclamation for catch of predatory fish species on the sites of planned releases. (Especially that special funds are currently available in the budget of Rosrybolovstvo for this purpose;
- to organize permanent inspection for 3-5 days in the areas of hatchery salmon releases (in order to prevent its catch);

- to prevent a decline of genetic diversity in the population of Luga salmon and preserve its gene pool that is essential to follow these recommendations:
- salmon breeders fished throughout the spawning season in the Luga River should be used for the reproduction;
- when laying eggs on the Luga hatchery the number of breeders from "wild" population must be at least 50% of the total number of fish used annually;
- annually for breeding process at least 100-150 salmon breeders should be used; in the long term - 250-500 salmon breeders (about 10% of the total population of Luga salmon)

4. To improve the productive capacity of the Luga River it is necessary to restore most of the spawning grounds located in the main course of the river.

In the area of Kingiseppskie rapids restoration works can be carried out in stages. At the first stage these activities should include cleaning of the rapids from household waste and metal products. Then proper restoration of the spawning grounds and nursery areas should be started including change (where required) of rapid profile and banking of stones and pebbles.

On Sabskie and Storonskie rapids it is essential to conduct reclamation activities aimed at the removal of higher aquatic vegetation which grows on these rapids in high densities.

To conduct these activities, it is desirable to involve local residents, particularly residents of the town of Kingissepp. In our opinion, it is of great importance since local people will feel their responsibility for the recovery of salmon stocks in their "home" river. Form of their participation may be either paid or voluntary.

To improve the efficiency of natural spawning grounds use in the Luga River it would be helpful to use artificial "spawning nests" where the fecundated roe from hatchery breeders will put on numerous vacant sites of the Luga river, primarily on Sabskie and Storonskie rapids, as well as in some spawning tributaries of Luga (rivers Vruda, Lemovzha, Solka).

Currently, there is an experience of such works in the rivers of the Kola Peninsula and in Karelia. Results of the first years of research showed that the efficiency of egg development in such constructions greatly exceeds the percentage (up to 83-98%) of egg development in natural spawning nests tubercles (Lupandin et al., 2005; Veselov et al., 2007; Pavlov et al., 2014). The constructions themselves are inexpensive to manufacture and maintain.

For the maintenance and protection of artificial spawning nests ("tubercles") on the rapids of the Luga River it is possible to involve local people. It will have a double positive effect. First, it will provide jobs to several people in the region where there are problems with employment. Second, it will additionally stimulate the participation of local residents in the process of recovery of salmon stocks in the river.

5. Strict compliance with scientific recommendations on limitation of the construction of port facilities in Luga Bay should become one of the most efficient ways to reduce anthropogenic pressure on the Luga salmon population. Such measures are currently practised by GosNIORKh for Luga Harbour constructions and have a real positive effect. The activities should include:

Ban/termination of any economic activity in Luga Bay and mouth part of the Luga River during downstream migration of juvenile salmon (May 15-June 15);
Ban/ termination of any economic activity in Luga Bay and mouth part of the Luga River during mass spawning migration of salmon breeders (dates should be set in real time based on the result of annual monitoring of migration of salmonids).

6. For the control of the water quality in Luga River and preventing potential threats it is proposed:
    - Conducting annual monitoring of nutrient leakage in the river from agricultural farms by means of regular inspections.
    - Prevention of forest cutting in the water-protection zone of the river.

7. Iimplementation of measurs aimed on conservation of wild salon population of the Luga River and restoration of its numbers is impossible without conducting of ichthological monitoring having obligatory annual and long-term charcter. The monitoring program shoulg invclude the following activities:

- studying the downstream migration of young salmonids using the floating trap established in lower stream of the Luga River (as it was practiced earlier by GosNOIRKh;
- making control fishing (with electrofishing use) on spawning grounds and nursery areas of the main riverbed of Luga River and its spawning tributaries (this work started already by the GosNOIRKh’s experts);
- making control fishing of salmon breeders going for the spowning in Luga River for estimation of numbers of wild breeders;
- studying of the quality of Luga hatchery young fish releasing in the river and esmation of the effectiveness of release by hatcery;
- genetical monitoring of youngs and breeders of Luga salmon;
- detailed mapping of salmon nursery grounds and spawning areas in the basin of Luga River and control of their contition.

10.Annexes

ANNEX 1

References

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ANNEX 2

MINUTES

of the first Advisory Board Meeting ("Kick-off Meeting") on the Project

"Support for development of a salmon management plan in the Luga River"

TIME: 9-th of September, 2013, at 12.00 – 17.00

VENUE: Leningrad Region office of All-Russian Social Organisation "All-Russian Society of Nature Protection", (ARSoNP), Drovyanaya str., 9, Saint-Petersburg, RUSSIA

Next day (10.09.13) – field excursion to the Project area (Luga River)

Participants 9.09.2013:

Saija Vuola/Project Manager, (EU-BASE), HELCOM

Marta Plichta, Project Researcher (EU-BASE), HELCOM

Piotr Debowski, HELCOM/ Inland Fishery Institute/Poland

Rustam Sagitov, HELCOM Habitat /Baltic Fund for Nature/Russia

Gunnar Norén, CCB/Sweden

Markku Kaukoranta, Finnish Game and Fisheries Institute

Igor Bykulyak, Federal Fishery Agency (Rosrybolovstvo), NW Board/Russia

Vladimir Sergeyev, Department of fisheries, Committee for agricultural and fishery complex of Leningrad region/Russia

Alexander Fedorov, Deputy Head of Neva-Ladoga Basin Directorate/Russia

Veronica Tarbayeva, Vice-president of ARSoNP/Russia

Sergey Titov, Project Managing Expert, State Research Institute for Lake and River Fisheries (GosNIORKH)/Russia

Sergey Rezvyi, Project Manager, ARSoNP/Russia

Natalia Dinkelaker, Federal Service for Supervision in the Use of Natural Resources (Rosprirodnadzor)/ SPBPO Ecology&Business/Russia

Ekaterina Vorobyeva, SPBPO Ecology&Business/Russia

Mikhail Obzhigin, ANNPO "Center of the Baltic Salmon"/Russia

Valery Turetsky, ANNPO "Center of the Baltic Salmon"/Russia

Tatyana Trofimova, Interpreter, secretary, CPO "Biologists for Nature Conservation"/Russia

9-th of September, 2013

12.00. Opening of the meeting. Introduction of the participants.

• Welcoming speech **by Veronica Tarbayeva.**

• Welcome on behalf of HELCOM – **by Marta Plichta and Saija Vuola**. The activities in the BASE project will assist in achieving of the commitments made under the BSAP, such as follow-up of the preparation of an inventory of rivers with salmon and sea trout populations in the Baltic Sea rivers within Russia. River Luga is the most important Russian wild salmon river flowing to the Gulf of Finland. In order to promote and ensure that the recommendations of the SALAR project and the HELCOM BSAP would materialize in the Russian Federation it is important that a specific action for the restoration of Luga River and recovery of its salmon population take place. Results of completed projects carried out by RTKL (Finnish Game and Fishery Institute) and CCB recommendations for a Luga River salmon management plan should be taken into consideration. Establishing good cooperation of stakeholders on different levels (including Russian responsible authorities) is necessary.

• HELCOM HABITAT activities as a part of BSAP and its role in restoring the Luga River salmon population – **by Rustam Sagitov**. Biodiversity conservation is an essential component of BSAP. We expected that the Federal Target Program on enhancement of the Baltic Sea environment will be adopted by Russian Government, but unfortunately it does not work yet. This is why the BASE project is an important support for Russia as it helps to understand what we can and what we have to do in Russian Baltic sector. In spite of limited financial support we are able to make some pilot projects including the Luga River salmon project. Historically international researches of Luga salmon started in early 1990-s. That time the ratio of wild/hatchery-reared salmons in the rivers of Baltic basin was 1:9, and we were targeted to change this ratio to 1:1 by the year 2010. Unfortunately the situation has not improved yet, and HELCOM is worried about it because Luga is the only river with wild salmon population in Russian catchment area of the Gulf of Finland, and creation of its management plan is an important part of the program of salmon recovery in the Baltic Sea.

• The Luga river project tasks – **by Sergey Rezvyi**. Brief information on scope of services according to the Project Terms of Reference, and what is done already (analyzing previously obtained data, field research, purchasing equipment etc.).

• Current situation with Luga River salmon according to the field data obtained in summer, 2013 – **by Sergey Titov**. Although the project has started later than supposed (in July instead of mid-April), we made the planned spring activities (research of downstream migration of salmon smolts using the floating trap-net) by our own resources. This spring we have got the minimum index of smolt numbers (ca 2500), and 70% of them were 1-year old (normally should be 2 years). It means that the population is quite week. The share of wild smolts is estimated as 15%. In late July – August two field expeditions on Luga River were carried out by GosNIORKH expert team. During 3 weeks more than 350 km were passed along Luga and its tributaries. The following activities have been done: description and mapping of spawning places and nursery areas and assessment of their current status; detection and abundance estimation of juvenile salmons (parrs) on the rapids of Luga River and its tributaries (by electrofishing); description of the ichthyofauna composition. Main results of summer expeditions:

- No salmons were found in upper stream of Luga (higher than Sabskii rapids);

- Sabskii rapids are overgrowing with algae because of low pressure by salmons during spawning and nursing;

- Storonskii and Kingiseppskii rapids are still used as salmon spawning areas. Kingiseppskii rapids are the best place, but hatchery-reared individuals prevail there;

- The only spawning area in Luga tributaries was found in lower stream of the river Vruda (right tributary of Luga), with total area ca 1,5 ha. More than 20 young wild salmons were caught there by electrofishing;

- After spring downstream migration many smolts spend a summer in Luga Bay of the Gulf of Finland using it as a feeding area.

Sergey Titov's presentation has stimulated a series of questions and active general discussion.

The questions:

(Ekaterina Vorobyeva): what shall you do for elaboration and realization of the management plan?

– This is the mostly complicated part of our work. But now we have a good experience from parallel RIFCI project and understand much better what is realistic and what is problematic. Now we regard the earlier elaborated CCB proposals as a good draft to be corrected.

(Ekaterina Vorobyeva): it is important to transform scientific knowledge into the management-plan. Do you understand how the stakeholders (responsible administrative bodies) will work with it?

– Until now we had a problem with Federal Fishery Agency because it had not proper financial support from the Ministry for the activities we are interested in. But recently a good amount of federal money was allocated to Rosrybolovstvo for restoring salmon spawning rivers in Leningrad region, and hopefully this fact will solve the problem. We work in close contact with Neva-Ladoga Basin Directorate and Leningrad Region Administration.

(Alexander Fedorov): what is the main reason of poor condition of Luga salmon population?

– This is poaching! According to our estimation 80% of salmon breeders are poached during spawning migration in Narva and Luga Bays and in the mouth of Luga River and do not reach the spawning areas. And we suppose that unfortunately the Luzhski hatchery acts as a main poacher withdrawing much more salmon breeders than necessary for implementing their main task.

(Piotr Debowski): what is your estimation of current potential of Luga River to be compared with the HELCOM SALAR project? – Now it became worse.

(Vladimir Sergeyev): Is it necessary to increase a capacity of Luzhski hatchery?

– Now they produce 100 thousand smolts, and this is enough for supporting natural reproduction. Otherwise the hatchery will feed the poachers!

(Sergey Rezvyi): you noted that Luga Bay is important nursery area for salmon. Can the Ust-Luga harbor influence on it negatively? – Possibly yes, but special investigation is required.

(Alexander Fedorov): there is an information (available in the Internet) that the municipalities along Luga River together with Ust-Luga Company are planning to restore navigable waterway along the river for boat tourism development. But it means that the main spawning rapids will be destroyed. Do you know about it?

– I know nothing about this idea, but if it is really promoted we have to use all our possibilities (including HELCOM prestige) for to stop it!

Further discussion on Sergey Titov's presentation:

(Ekaterina Vorobyeva): it would be important to include the chapter on risks in the project report and widely distribute this information among the regional and federal authorities.

(Natalia Dinkelaker): if the new attendant circumstances arise which can create obstacles for the project, it should be discussed with responsible authorities.

(Markku Kaukoranta): it is extremely important that wild salmon population still exists in Luga River. It would be good to make further Russian-Finnish projects on restoring the salmon rivers within the continuation of ENPI program with participation of Finnish Game and Fisheries Institute. Regarding the boat tourism, let it be the small-scale salmon tourism. There is a good example of the river Kümi in Finland. And it should be estimated economically what is more profitable – to grow the salmon flock or to develop tourism?

The discussion continued during coffee-break.

• CCB proposals for a Luga River Salmon management plan - **by Gunnar Norén**. The River Luga is a salmon river number one for the Gulf of Finland. Because of this the following activities are required: to continue scientific monitoring; to organize the effective inspection of the river state (including public inspection, there is a good experience from Latvia); to strengthen environmental education and public awareness on Luga salmon; to control poaching in "hot spots".

General discussion

(proposals by Vladimir Sergeyev): to act via Federal Fishery Agency as a main responsible body for implementation of all practical measures on Luga River salmon; to make the independent audit of Luzhski hatchery (its current state including possible poaching, its further development etc.); to promote the activities against the idea of restoring navigable waterway on Luga River.

(Igor Bykulyak): if we want to get a proper reaction of Rosrybolovstvo on the situation with Luzhski hatchery we have to act as soon as possible, namely to send the official letter from the Project to the Head of NW Board of Federal Fishery Agency Mr. Denis Belyaev on organizing independent international/ interdepartmental inspection of the hatchery and getting the objective information on the numbers of salmon breeders withdrawing by the hatchery.

(Rustam Sagitov): we have to convince Russian authorities (both federal and regional) to increase investments in nature conservation including the Baltic Sea nature.

(Veronica Tarbayeva): currently the Strategy of development of the Leningrad region is under discussion, but the nature conservation section is still absent there. As for Luga salmon, it would be important to declare the year 2014 as a Salmon Year in the Leningrad region.

CONCLUSIONS, FOLLOW UP ACTIVITIES

• To continue the project scientific activities (studying spawning migration of salmon breeders, further analysis of samplings

• To strengthen cooperation of the stakeholders. To organize a Round Table with stakeholders including responsible authorities, NGOs, local activists etc., to be held in December 2013 – January 2014

• To organize the expanded Advisory Board Meeting at the end of the projects (in May 2014) for discussing the results

• To invite the project participants to the international events (HELCOM workshop on Fisheries and Maritime Spatial Planning (MSP) "Fishing for space" to be held in on 14-th of November 2013 in

Vilnius, Lithuania and the BASE project meeting which will take place on 10 December 2013 in Helsinki, Finland)

• To send the official letter from the Project to the Head of NW Board of Federal Fishery Agency Mr. Denis Belyaev on the situation with Luzhskyi hatchery

• To present the project at the conference "Ecological safety of population" to be held on 11-th of October 2013 in St.Petersburg (Veronica Tarbayeva, this is done already)

The field excursion to the Project area (Luga River) leaded by Sergey Titov took place on 10-th of September. Participants (Marta Plichta, Markku Kaukoranta and Gunnar Norén) visited the crucial spots on Luga River including the net-trap of Luzhskyi hatchery.

ANNEX 3

Baltic Marine Environment Protection Commission
BASE Project

MINUTES

of extended meeting of international Advisory Board of the project

«Support for the development of a management plan for the salmon population in the Luga River»

Venue: St Petersburg, Sokos Palace Bridge hotel, Birzhevoy per., 2-4.

Date: 24 December 2013 г.

From: 11: 00
Till: 14 : 30

Participants:

1. Marco Milardi, researcher, HELCOM BASE project
2. Marta Plichta, researcher, HELCOM BASE project
3. Markku Kaukoranta, Finnish Game and Fisheries Institute/Finland
4. Evgeniya Bespalova, North-West territorial authority of Federal Fishery Agency
5. Igor' Trenkler, head of the Central Laboratory of fish stocks restoration of FSBI "Sevzaprybvod"
6. Galina Shtanina, department of the development of fisheries of the Committee of agriculture and fisheries of the Leningrad region.
7. Irina Antishina, Committee of Natural Resources of the Leningrad region
8. Vitaliy Burov, head of the department of control in the sphere of game and protected areas, Federal Service for Supervision in the Use of Natural Resources (Rosprirodnadzor) of North-West Federal district
9. Vladislav Minin, project "Luga-Balt", Luga municipal district of the Leningrad region
10. Veronika Tarbaeva, Chair of expert consultative council of the Permanent commission on ecology and nature use of Legislative Assembly of the Leningrad region
11. Sergey Titov, Project Managing Expert, State Research Institute for Lake and River Fisheries (GosNIORKH)/ St Petersburg
12. Dmitry Sendek, Project Managing Expert, State Research Institute for Lake and River Fisheries (GosNIORKH)/ St Petersburg
13. Servey Rezviy, project manager, ARSoNP/SPSU/ CPO "Biologists for Nature Conservation"/ St Petersburg
14. Tatyana Trofimova, project assistant, CPO "Biologists for Nature Conservation"/ St Petersburg
15. Rustam Sagitov, SPSU/ CPO "Biologists for Nature Conservation"/ St Petersburg
16. Larisa Makarova "Ecology and Business"/ St Petersburg

17. Valery Turetskiy, “Centre of the Baltic salmon”, St Petersburg
18. Irina Trukhanova CPO “Biologists for Nature Conservation”/ St Petersburg
19. Marina Vilner, technical assisstent of the project ARSoNP /CPO “Biologists for Nature Conservation”/ St Petersburg

Welcoming words:

The chair of the meeting Veronika Tarbaeva opened the meeting. Marta Plihta welcomed the participants and briefly told about the HELCOM BASE project.

Presentations:

1) Project manager **Sergey Rezviy** gave an overview of the main activities implemented within the project «Support for the development of a management plan for the salmon population in the Luga River» in the frames of the HELCOM BASE project. He told about the main goals of this one year long project and noted that in the course of the project the cooperation has been established with various organizations, state authorities, local public and other similar international projects. All planned activities were successfully carried out. As a result the recommendations on the development of a management plan for salmon population of the Luga River were prepared and three interim reports were submitted. The project results were presented at the meetings, conferences and workshops.

No questions were addressed to Sergey Rezviy.

2) **Dmitry Sendek** "The results of complex scientific study of modern status of the salmon population and spawning grounds in the Luga River".

Dmitry Sendek told about the study results of the state of Atlantic salmon population in the Luga River system. The study revealed three main salmon spawning grounds in the upper and middle course of the Luga River: Sabskie, Kingiseppskie and Storonskie rapids.

Dmitry presented the results of the main project activities. Based on smolt downstream migration study it might be assumed that the modern population number is very low for such a large river system as Luga. Based on the spawning ground and nursery area survey in the study area the conclusion was made that in the upper course of the Luga River, and to be more precise in the Novgorod region, at present there are no sites potentially suitable for salmon spawning.

Spawning grounds and nursery areas near Sabskie and Storonskie rapids of the Luga River are in satisfactory condition, whereas near Kingiseppskie rapids they are far from optimal state which for sure decreases the river potential for natural salmon population support. However the total area of the remaining spawning grounds is at least 400-450 000 m^2, which can support the population of at least 20 000- 30 000 salmon breeders. The study of salmon parrs on spawning and nursery sites (using electrofishing) showed that their number is low, and at the moment the existing potential of the river is not fully used. Assessment of salmon fodder base revealed no foraging limitations for salmon development. Moreover bioindication method suggested medium and high water quality. The experts collected data on the Baltic salmon spawning migration to Luga Bay and the Luga River in summer and autumn 2013. The study of genetic structure of the salmon population was one of the main goals of the project and it was found out the Luga salmon population is genetically uniform. There are insignificant genetic differences between the samples of wild and reared salmon. This allows us to consider hatchery grown salmon to be valuable donor material which will be used for restoration releases of young salmon to empty spawning grounds of the Luga River. An overall decrease in genetic diversity of the wild salmon population observed in the Luga River during the last ten years is caused first of all by the effect of genetic drift which occurs in small populations. In order to mitigate the process of genetic diversity loss it is essential to propose in a Program of the Luga salmon restoration a new more efficient scheme of breeders catching ensuring usage of fish during the whole spawning period (both in spring and summer).

Questions:

Turetsky V.I. What was the percentage of wild and reared salmon in the traps in spring 2013?

Sendek D.N. On average 1:1.

Turetsky V.I. How do you assess the level of spawning ground favorability?

Sendek D.N. Based on presence of proper substrate: gravel, pebble etc.

3) **Sergey Titov** «Draft Plan (Program) of the Luga salmon population restoration"

Sergey announced that the main purpose of the project was to prepare this plan and named the main factors affecting the status of stocks (number) of the Luga salmon, namely poor state of spawning grounds and nursery areas, illegal fishing (poaching), ineffective protection of salmon spawning areas and spawning migration routes of breeders, large-scale hydrotechnological works in Luga Bay and the mouth of the Luga River, impact of industrial and recreational fishing (removal of breeders and especially salmon smolts as bycatch), insufficiently effective work of Luga salmon hatchery. Sergey noted that on Kingiseppskie rapids only one third of the spawning grounds are suitable for salmon, the rest of the area is polluted, overgrown and silted. To improve the state of the rapids it is necessary to carry out restoration works: remove vegetation, bring more gravel, etc. The most significant factor is poaching. Legislative basis to bring poachers to justice is far from perfect, and fisheries authorities are unable to control the river throughout the salmon spawning season because of the small number of employees and lack of technical means. The main part of the report was devoted to complex of activities aimed at conservation and restoration of salmon populations in the Luga River basin. First, we need to carry out the restoration of the spawning grounds and nursery areas and increase the effectiveness of the existing ones. Various restoration methods and examples of their successful implementation were described. Among other activities that contribute to restoration of salmon populations there are creation of artificial spawning tubercles, improvement of timing, methods and locations of annual releases of smolts into the river, protection of the salmon population in the river, logging prevention in water protection zone, monitoring of industrial and sport fishing, monitoring of indirect effects of other fish species catches (smelt and sprat), compliance with recommendations for the economic activity suspension in the Luga River during young salmon downstream migration to the sea.

Questions:

Sagitov R. There was information in the talk about the fact that Luga hatchery catches salmon from August to October – isn't it poaching? And shouldn't strict time restrictions be put on such fishing?

Titov S. It is not possible to give a decisive answer to this question. Nevertheless, the information on catches is regularly sent to "Sevzaprybvod".

Sagitov R. Asked who sets the terms of industrial trap setting.

Titov S.: Federal Service for Supervision in the Use of Natural Resources (Rosprirodnadzor) of North-West Federal district and North-West territorial authority of Federal Fishery Agency (because a red listed sea trout is caught as well).

Tarbaeva V.M. Asked if there were any guidelines prepared for breeders catching and its timing.

Titov S. No.

Turetskiy V.I. explained that the timing of industrial catches corresponds with the necessity to catch all age classes to ensure genetic diversity coverage.

Turetskiy V.I. asked whether some estimations were done concerning the area of spawning grounds needed and the funds required for their restoration.

Titov S. Responded that such estimations were not done. Territorial administration of Federal Fisheries Agency can allow to allocate money for restoration activities. The activities involving bottom alteration require specific project and more sophisticated assessment methodologies.

Turetskiy V.I. If the hatchery releases 100 000 yearlings per year, it means that they need 100 000 sq m to winter and create stations, it that correct?

Titov S. Not all 100 000 individuals stay in the river for the whole year, certain part die, since reared young salmon is not well adapted, some stay in the river but the mortality during the winter is also very high.

Turetskiy V.I. What should be a percentage of wild and reared salmon in the plan?

Titov S.: The percentage which we have now is sufficient.

Markku Kaukoranta added a few comments on the situation in Finland. In Finland, there is an experience of the so called "closed" factories, i.e. periodically hatcheries do not release the fish. He gave an example of two hatcheries in Finland, which managed to reach the 10% proportion of hatchery grown fish. Markku suggested that if the Luga River was in Finland, the Luga hatchery would have been shut down for the year. Markku also proposed the establishment of a broodstock at the factory. He noted that the course of the Luga River has never been cleaned for timber floating so it is quite easy and cheap to restore.

Titov S.F. It is not possible to shut the Luga hatchery down for a year plus it will not solve the poaching problem. Although, we can consider an option of factory conversion.

Titov S.F. mentioned that restoration activities on the Luga River would require a highly expensive project.

Tarbaeva V.M. Suggested to send the proposals concerning the amendments of the legislation to the Ministry of Environment of the Russian Federation. Besides, the experience of involving public rangers proved to be very effective.

Minin V.B. asked to clarify why salmon occurs only in the lower course of the Luga River

Titov S. Explained that there are no suitable spawning grounds in the upper course of the river. He also added that previously salmon used to enter the Oredezh River prior to its regulation.

4) **Marco Milardi** "Importance of the results of the Luga salmon project in the light of HELCOM Baltic Fisheries and Environment Forum"

Marco noted that such object as migratory fish species (FISH-M), appeared in the HELCOM programs only recently. In January 2014 an expert group was formed in the frames of the HELCOM Baltic Fisheries and Environment Forum, which will be working for three years. This group considers the activities related to migratory fish problems. The overall aim of the group is protection of the Baltic Sea environment and population status of migratory fish species. The main objectives of the group are to discuss conservation and restoration of rivers, share information and disseminate knowledge and experience, summarize the best practices, implement the Baltic Sea Action Plan for migratory fish, support the national recovery plan. The expert group has common goals with the International Union for the Exploration of the Sea (ICES) related to migratory species: salmon, sea trout, eel, sturgeon, whitefish, etc. Regarding salmon and sea trout expert group has the following objectives: to improve the quality of smolt releases, state of fish stocks, to develop recommendations for the management and conservation of stocks. Marco listed possible outcomes of the group activities: optimization of environmental actions at the political level, dissemination of information on best practices, recommendations for improvement of the minimum requirements for restoration works, preparation of a handbook on best methods of restoration, development of projects for migratory species in reality. Marco mentioned that reports of Luga salmon presented at various meetings and forums.

Questions:

Tarbaeva V.M. Asked whether the handbook will contain recommendations only or it might be considered as a methodology for fish stock management

Marko clarified that the group is still discussing this question. However, the handbook will contain methodologies of smolt release which could be used by the regional authorities and other responsible organizations.

Markku Kaukoranta suggested the idea to prepare a proposal for a project to restore four salmon rivers - Luga, Narva, Kemi and Neva. HELCOM is now working out a document on the Gulf of Finland (Declaration of the Gulf of Finland), and one position in this document might be devoted to this issue. If presidents sign the Declaration, it will be possible to begin the work on these rivers, and Forum – is a good occasion to discuss this issue once again.

The question was followed by joint discussion on the experience of work with companies that have a negative impact on the environment, and then compensate for these effects in different ways. Unfortunately, very often in Russia compensation is not done in full because this mechanism is not sufficiently established in the legal framework.

V.G. Burov explained why the Luga sea trout is caught more than salmon under the control by the inspectors of Rosprirodnadzor. Perhaps this is due to the fact that poachers are less interested in sea trout than in salmon, besides it is smaller and easier to passes the nets. Vitaly suggested that this year it will be necessary to strengthen the control on the river.

Tarbaeva V.M. offered to organize a separate meeting on the protection of salmon, where the inspection issues can be discussed.

The question was followed by joint discussion on the conservation of salmon populations through the development of public-private partnership where one company controls illegal fishing in its section of the river. Also it was noted that the effectiveness of protection is achieved by regulating the catch, but not by total ban. In world practice, there are cases of replacement of poaching by licensed fishing. One can try to implement such a system on the Narva River, where the population is only supported by hatchery grown salmon. Note that the effective control of illegal fishing is not sufficiently developed in administrative law. A system of fines and withdrawing of expensive gear from poachers can also lead to favorable results.

Sergey Rezviy noted that the main result of the project – development of a plan (program) to restore and maintain the salmon population in the Luga River and raised several questions on how the results of the project will be included in the plans of the executive authorities of the regions and documents should be prepared for this.

Tarbaeva V.M. clarified that it is necessary to prepare the Terms of Reference to the draft development plan, and then it can be submitted to Federal Fisheries Agency and then included in targeted federal programs 2015-2016. The issue should be discussed in more details with "Sevzaprybvod", Federal Fisheries Agency and Rosprirodnadzor in order to receive the assessment from these agencies in the form of official letters.

Titov S.F. mentioned that the main result of the project should be preparation of the Plan, while the program with TR - is beyond the scope of the project, and requires greater investment of effort and resources.

Sagitov R.A. noted that during the project a unique material was obtained and it helps to understand the current situation, and it is the basis for further action. The project raised many issues to be solved under Russian conditions.

March Plichta agreed with the speakers and noted that the preparation of the complete Management Plan for the population of salmon in the Luga River takes more than one year. She also said that a large number of questions raised is a positive feature of the project. It is possible that with the involvement of other stakeholders we will have new projects that will continue the work started. If the plan is implemented in reality this project might be considered as successful.

All participants agreed that the project is successful and a large amount of useful information was collected. Representatives of the Northwest Territorial office of Federal Fisheries Agency Rosrybolovstva, Committee of Natural Resources of the Leningrad Region, Committee of agriculture and fishery complex of the Leningrad region expressed that the agencies are willing to support the implementation of the project and also provided necessary recommendations for this: TR preparation, determination of co-financing amount, determination of specific purposes. All the participants agreed that we should not stop at this point, and the project has to be continued.

Chair of the meeting *Tarbaeva V.M.* closed the meeting at 14:30.

Chair Tarbaeva V.M. Secretary Trofimova T.A.

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