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Report on the joint research on *Gyrodactylus salaris* in the northern region of Norway and Russia

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Abstract

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Concerns about parasites and diseases among salmon in Russia and Norway, especially *G. salaris* in the White Sea basin, have necessitated this project.

Atlantic salmon presently spawn in 16 rivers along the Karelian White Sea coast. Reliable data on the conditions of these rivers and their spawning statistics is required in order to solve the problem of restoration and conservation. In 1990, the Karelian Research Centre began an examination of the salmon rivers. By 1998, the rivers Pulonga, Keret, Kem, Vyg (lower part) and Kuzreka had been examined fully, and the rivers Vonga, Pongoma, Kuzema, Gridina, Kalga, Suma and Shuya examined partially. The data available definitely indicates a constant decrease in fish caught along the Karelian coast of the White Sea. Recommendations on solving these problems are discussed.

Today, two hatcheries in Karelia are engaged in salmon breeding. Hatchery-reared parr are released at 2 years of age. The total number of parr released has not exceeded 200 000–250 000 individuals. The return makes up less than 1 %.

Investigations on the parasites of salmon parr in the White Sea basin were reported by several authors from 1935 to 1985. Their analyses showed significant quantitative and qualitative differences in fauna in various areas of the region. In the River Keret investigations have continued every year since 1992. In 1992, *G. salaris* was found infecting fins, skin and gills of salmon parr. The parasite had not been recorded previously on salmon parr in rivers of the White or Barents Sea basins. *G. salaris* is believed to have been introduced via stocking from the Vyg hatchery. The density of salmon parr in the River Keret was very low in 1992-98 compared to 1990 and 1991.

On the Kola Peninsula there are 37 main salmon rivers draining to the White Sea basin and 28 salmon rivers draining to the Barents Sea basin. The Kola Peninsula rivers have a considerable reproductive potential. The total area of spawning/breeding grounds of all salmon rivers is 3 857 hectares, 1 104 hectares in the Barents Sea rivers and 2 753 hectares in the White Sea rivers. During the period 1986–91, the abundance of spawners running into the Barents Sea rivers fluctuated from 20 000 to 41 000 (32 000 on average) and between 110 000 to 215 000 fish (152 000 on average) were found in the White Sea rivers.

At present, four hatcheries in the Murmansk region produce juvenile salmon for further release into natural water basins. One hatchery releases juveniles into the rivers of the Barents Sea basin, while the three other hatcheries operate on the White Sea basin rivers. Average release from all the hatcheries is about 450 000 juveniles at age 2+.

In 1993–98, several rivers in the Kola Peninsula were sampled by electrofishing and salmon parr were examined for occurrence of *Gyrodactylus*. *G. salaris* was not found.

Landlocked Atlantic salmon occur in several hydrological systems in European freshwater bodies. Nine of the lakes (Ladoga, Onega, Kuito and others) are located in Russia, one in Finland (Saimaa), one in Sweden (Vänern) and one in Norway (Byglandsfjord). Parasite studies of salmon parr from these lakes are scarce. However, the lakes of the Kamennaya river system, which are situated in the upper tributaries of the Kem river, have been studied and no *G. salaris* were found in the landlocked salmon parr. A river population of landlocked salmon lives in the upper parts of the river Namsen in Norway. In 1997 and 1998, a total of 41 specimens from the river Namsen were studied, but no *G. salaris* was found.

In 1993, *G. salaris* was found on rainbow trout in a fish farm in Siskili at Lake Enare in northern Finland. The fish in the fish farm were slaughtered and the farm was disinfected. One monogenean was found on pectoral fin of a rainbow trout less than 1 km downstream from the infected fish farm in 1996. There are some concerns about the parasite spreading downstream in the river Pasvik, but the river was not investigated in 1997 or 1998 due to lack of financial support.

G. salaris is most probably a recent introduction to Norwegian rivers, and its distribution is associated with stocking of fish from infected salmon hatcheries. In Norway, the primary goal is to prevent the further spread of *G. salaris* and to exterminate the parasite in as many infected rivers and hatcheries as possible. In the period 1981–97, 25 Norwegian rivers were treated with rotenone in an attempt to exterminate the parasite, and so far 13 rivers have been stated healthy after the treatment. The parasite has turned up again in the rivers Skibotnelva, Rauma and Steinkjervassdraget.

In Russia, the *Gyrodactylus*-situation is complex because the parasite occurs naturally where the Baltic salmon occur (Ladoga lake, Onega lake), but not where Atlantic salmon occurr (The White Sea area, and the Kola Peninsula). The development of the *Gyrodactylus* infection in the Atlantic salmon population of the river Keret resembles the development in

Norwegian rivers, with epidemics in the salmon parr population resulting in very low densites of parr and few adult salmon ascending the river. Further spread of the parasite from this river to other rivers in the White Sea area will constitute a great danger to salmon populations in the area. Actions should therefore be taken as soon as possible starting with a barrier in the lower part of the river Keret to prevent salmon from ascending the river. Some years after the building of the barrier the parasite should be exterminated from the river by treating the area downstream of the barrier with rotenone.

Key words: Atlantic salmon, *Gyrodactylus salaris*, Norway-Russia.

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Preface

In a letter dated 25 June 1992, The Norwegian Directorate for Nature Management (DN), referring to the Russian-Norwegian Environmental Commission, invited the Polar Institute of Marine Fisheries and Oceanography (PINRO) to participate in a Russian-Norwegian joint research programme on anadromous fishes. The Norwegian Institute for Nature Research (NINA) was proposed as the Norwegian institution responsible for the scientific work in the joint project. A Protocol of Intents between PINRO and NINA was signed in the same year, and a proposal for a joint research programme was written and sent to DN for funding. The aims of this project have been: 1) to exchange knowledge and technology about surveys in Atlantic salmon rivers, and handling of material, including harmonising of methods and equipment, 2) to survey selected Atlantic salmon populations to collect information about changes in population size and composition, which may indicate changes in the environment and 3) to obtain information about parasites on Atlantic salmon, especially *Gyrodactylus salaris* and salmon lice.

Since 1993 this joint programme has been within the Russian-Norwegian Working Group on the marine environment of the Barents Region, which is one of the working groups which are within the Russian-Norwegian Environmental Commission. The main part of this programme has been a comparative study of life history of Atlantic salmon in four rivers, two Russian and two Norwegian. Included in this study have been growth, density and heavy metal analyses of parr, strategies during smolt migration, and growth and age structure of adult salmon (Jensen et al. 1997, 1998).

In 1994, an agreement of intent for the joint research program about salmon management in Norway and Russia, was made by the Norwegian Directorate for Nature Management (DN) and the Russian Academy of Science, Karelian Research Centre (KRC). The main goal of the research project was studies concerning parasites and diseases among salmon, especially *G. salaris* in the White Sea basin, and NINA was asked to manage the project. In 1995, the *Gyrodactylus* project was included in the program on anadromous fishes.

The results from the *Gyrodactylus* project is presented in this report. The project has been financed by DN, PINRO, KRC and NINA.

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Contents

Abstract ... 3
Preface ... 4

1 Introduction ... 5

2 Material and methods ... 6

3 Results and discussion ... 6
- 3.1 Atlantic salmon rivers in Karelia ... 6
  - 3.1.1 Reproductive potential of the Atlantic salmon in Karelia ... 6
  - 3.1.2 Atlantic salmon catch in Karelia ... 8
  - 3.1.3 Artificial salmon reproduction in Karelia ... 9
  - 3.1.4 Plans for conservation and enhancement of salmon stocks in Karelian rivers ... 10
  - 3.1.5 Investigations of parasites on Atlantic salmon parr in Karelian rivers ... 10
  - 3.1.6 Investigations of salmon parr in the River Keret ... 11
- 3.2 Atlantic salmon rivers in the Murmansk region ... 12
  - 3.2.1 Reproductive potential of the Atlantic salmon in the Murmansk region ... 13
  - 3.2.2 Atlantic salmon catch in the Murmansk region ... 13
  - 3.2.3 Artificial salmon reproduction in the Murmansk region ... 13
  - 3.2.4 Investigations of Atlantic salmon parr in Murmansk rivers ... 13
- 3.3 Landlocked salmon populations ... 14
- 3.4 G. salaris in Lake Enare and in the River Pasvik ... 15
- 3.5 Investigations in Russian hatcheries regarding G. salaris ... 15
- 3.6 G. salaris on Atlantic salmon parr in the River Vefsna, northern Norway ... 16
- 3.7 Parasite fauna of the European grayling in the River Vefsna, northern Norway ... 17

4 Measures against G. salaris ... 18

5 References ... 19

1 Introduction

Biological investigations of rivers in northern Norway in 1975–79 coincidently led to the discovery of the ectoparasite, *Gyrodactylus salaris*, as a serious problem for Atlantic salmon populations in Norwegian rivers (Johnsen 1978, Heggberget & Johnsen 1982). *G. salaris* is most probably a recent introduction to Norwegian rivers, and its distribution is associated with stocking of fish from infected salmon hatcheries (Johnsen & Jensen 1986). Populations of salmon parr and catches of ascending salmon have been severely reduced in infected rivers.

In Russia, *Gyrodactylus salaris* occurs naturally in the part of the country where the Baltic salmon occurs (Ladoga lake, Onega lake), and not where Atlantic salmon occurs (The White Sea area, and the Kola Peninsula).

G. salaris was found on salmon parr in the river Keret in 1992 (Bristow et al. 1994, Ieshko et al. 1995). This was the first registration of *G. salaris* in rivers draining to the White Sea.

In 1993, *G. salaris* was detected in a rainbow trout farm in Lake Enare, Finland. The fish farm was disinfected, but there is still some concern about the parasite spreading downstream in the river Pasvik.

The main goals of the *Gyrodactylus* project are:

1. To report on the status of Atlantic salmon populations in rivers draining into the White Sea Basin
2. To map the distribution of *G.salaris* in the drainage area of the White Sea
3. To survey some selected rivers regarding density of salmon parr
4. To investigate hatcheries regarding *G. salaris*
5. To discuss measures against *G. salaris*

2 Material and methods

The parasitological studies of fish in the Russian rivers were made according to Dogiels method (Bykhovskaya-Pavlovskaya 1985) and include studies of all organs. The number of *G. salaris* was counted on each fin and on the body of each fish. The terms prevalence, intensity and mean intensity are used as recommended by Margolis et al. (1982). Density estimates of salmon and trout parr in the rivers were made with electrical fishing equipment according to the removal method (Zippin 1956, Bohlin 1984).

3 Results and discussion

3.1 Atlantic salmon rivers in Karelia

On the Karelian coast, the rivers are of mountainous or semi-mountainous type. They have extreme rapids, usually on the lower sections. One of the main characteristics of the rivers in this region, is the large number of lakes that occurr along their course. The fish community of the Karelian coastal rivers include 15 species, with the most common species being: Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), grayling (*Thymallus thymallus*), whitefish (*Coregonus lavaretus*), pike (*Esox lucius*), perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), burbot (*Lota lota*), minnow (*Phoxinus phoxinus*), bullhead (*Cottus gobio*), stickleback (*Gasterosteus aculeatus*), ten spined stickleback (*Pungitius pungitius*) and flounder (*Platichthys flesus*).

3.1.1 Reproductive potential of the Atlantic salmon in Karelia

According to available data, Atlantic salmon presently spawn in 16 rivers of the Karelian White Sea coast (**Figure 1**). The length of the rivers Keret, Vonga, Kem, Vyg, Suma and Nyukhtcha ranges from 100-200 km. The remaing rivers, Pulonga, Gridina, Kalga, Sig, Kuzema, Pongoma, Letnaya, Shuya, Kuzreka and Kolezhma do not exceed 100 km. The rivers Kem and Vyg are both regulated for hydroelectric purposes, and there are five dams along the river Kem. The data presently avalable on the size of the spawning/breeding grounds (SGA) and spawning beds is displayed in **Table 1**. It should be mentioned that examination of the rivers was conducted in the late 50's. Many rivers were not fully examined at that time and there are discrepancies in the assessment of the SGA sizes. Since that time, the situation in many of them has changed dramatically and for most of the rivers data on the SGA does not exist.

Reliable data on the conditions of the rivers and their spawning statistics is necessary in order to solve the problems of restoration, conservation, abundance and growth of the salmon populations. Therefore the Institute of Biology of the Karelian Research Centre of the Russian Academy of Sciences began a new survey of the salmon rivers in 1990. By 1998, the rivers Pulonga, Keret, Kem, Vyg (lower part) and Kuzreka had been examined fully and the rivers Vonga, Pongoma, Kuzema, Gridina, Kalga, Suma and Shuya had been examined partly.

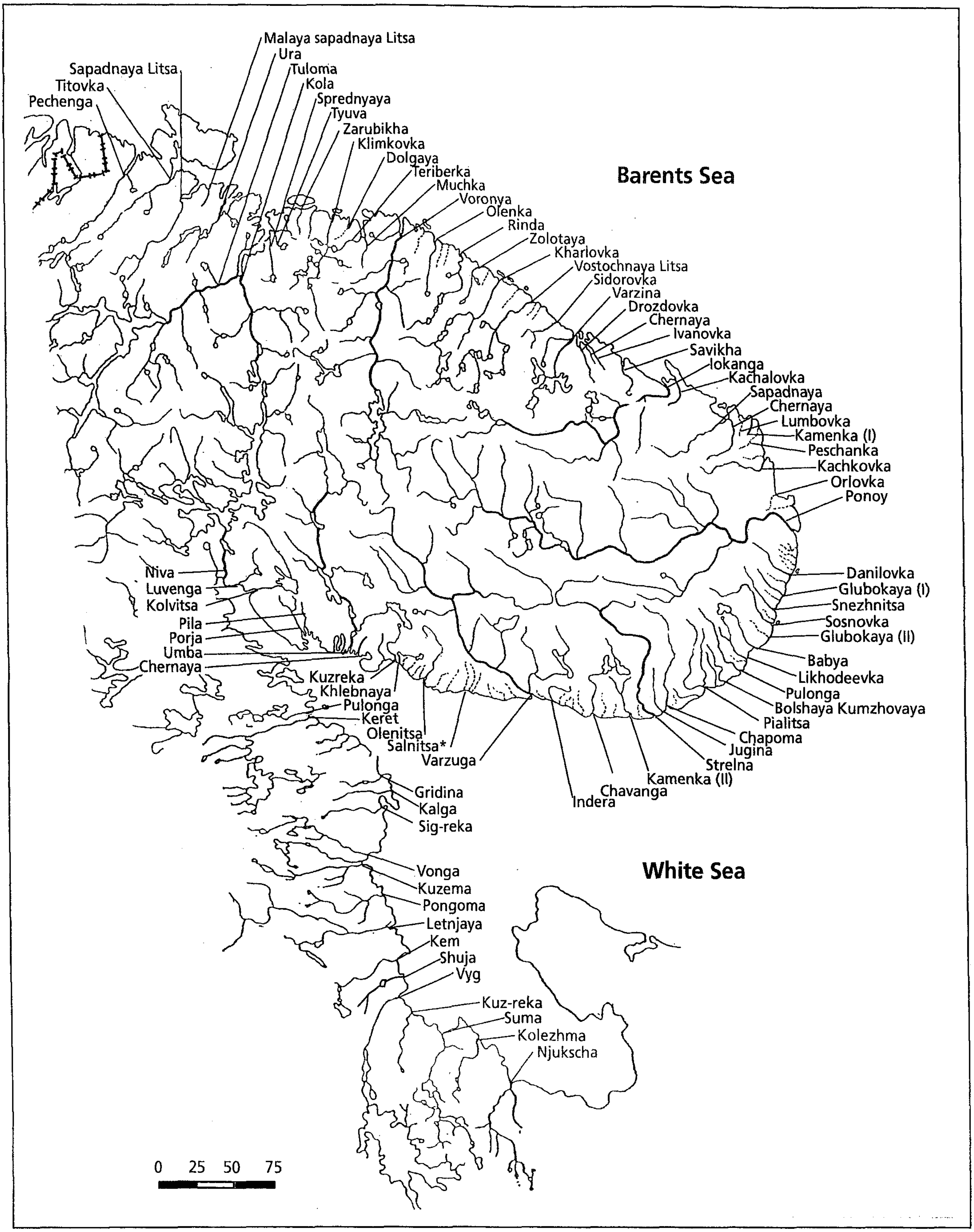


Figure 1. Atlantic salmon rivers in the Murmansk region and in Karelia.*: mainly sea trout.

***Table 1**. Length of river access for salmon, size of spawning area and size of spawning/breeding grounds (SGA) for salmon rivers in the Karelian region of the White Sea basin. The "Length" data originate from the examination of the rivers in the late 50's, while the "Corrected length" data give the length of the river access for salmon today.*

Main river	Tributary	Length (km)	Corrected length (km)	Size of spawning area (m²)	Size of SGA, (m²)
Pulonga	-	52	52	5 460	15 350
Keret	-	110	106	135 800	675 500
	Chernaya	38	38*	no data	no data
	Elet	48	48*	0	0
	Louksa	13	9*	2 100	41 000
Total for Keret watershed				137 900	716 500
Gridina	-	72	8*	20 000*	100 000*
Kalga	-	59	49*	no data	70 980
Sig	-	59	no data	no data	no data
Vonga	-	106	106*	no data	210 000
Kuzema	-	62.5	no data	no data	40 000*
Pongoma	-	86	86*	no data	458 000 (1956) 284 000 (1959) 650 000 (1981)
Letnaya	-	77	no data	no data	no data
Kem	-	194	4	mosaic	626 000
Shuya	-	85	26*	2 700*	262 800*
Vyg (Low Vyg)	-	188		mosaic	21 000
Kuzreka	-	46	7	0	30 000
Suma	-	164	no data	no data	387 500*
Kolezhma	-	87	no data	no data	60 000*
Nyukhtcha	-	106	no data	no data	513 750*
Total for Karelian rivers				166 060	3 703 880

Note: * preliminary data

3.1.2 Atlantic salmon catch in Karelia

Salmon fisheries on the White Sea developed a long time ago. Catch data are available from the second half of the 19th century. Salmon was then caught in many rivers and along the White Sea coast as well. The fishery was especially intensive in the lower reaches of the rivers Kem, Vyg and Keret. Various fishing modes existed then: the garva, the peremet and the poesd (Russian names for different fishing tools). The most commonly used methods were by zabor and zakol (fences or racks with traps). In 1860, the lower reaches of the Kem contained 158 zabor and zakols (Korablev 1974). In 1880, 265 zabor and zakols were observed along the Karelian coastal area, including 169 on the river Kem.

In the early 1880's, the number of zabors started decreasing because of the rapid growth in wood rafting on the rivers of the Karelian coast, and by 1897 there were only 136 left. In the period from 1875 to 1889, the mean annual salmon catches were 28.8-30.4 tons. In 1890–95, the annual catch increased to 35.2 tons and in 1895-99 it increased further to more than 48.0 tons (Korablev 1974). However, since 1900 a gradual decrease in catch has occurred.

Possible reasons for the reduction in catch are an excessive catch rate the previous decade and the effect of massive wood rafting. Unfortunately, no complete statistical data base exists that would allow for a review of a continous series of observations. However, what is available definitely indicates a constant decrease in fish catch on the Karelian coast of the White Sea (**Table 2**).

The value of fishing in specific areas has varied from place to place and also with time. Early in the 20th century the main salmon fishing areas were concentrated close to the river Keret, although large

Table 2. Average yearly catch (tons) of Atlantic salmon in Karelian rivers (White Sea basin)

River	1890-99	1951-60	1961-70	1971-80	1981-90
Keret	8.1	1.5	0.4	2.5	3.39
Pongoma	6.5	1.99	0.7	0.23	0.32
Vyg	no data	closed			
Kem	no data	5.1	2.2	closed	
All rivers	29.6	19.4	6.6	4.1	7.1

amounts of salmon were also caught near the rivers Gridina, Pongoma and Vyg. In the 1920's the river Kem became the most important river, and in the period 1920-33 nearly half of all the salmon catch for the western coast of the White Sea was obtained here. Presently only one river - the river Keret retains its significance for the fishery. A decline in the catch of adult salmon has been observed in later years in the river Keret (**Table 3**).

Table 3. Number of salmon estimated in the trap (1 day closed, 1–2 days open) in the river Keret during the period 1985–98.

Year	Number of salmon
1985	3 940
1986	3 230
1987	2 427
1988	3 294
1989	3 531
1990	2 520
1991	690
1992	536
1993	687
1994	753
1995	1 066
1996	391
1997	180
1998	607

3.1.3 Artificial salmon reproduction in Karelia

Today, two hatcheries in Karelia are engaged in salmon breeding. A third, the Petrozavodsk hatchery, which began operating in 1977, was closed in 1990 for a number of reasons, principally an excessively low egg and fry survival rate.

The Vyg hatchery was built in 1956 on the river Vyg, 23 years after the construction of the Belomorsko-Baltiiskiy channel and 3 years after the Matkonezhskaya hydropower station was put into operation. By that time, the salmon in the river Vyg were on the edge of total extinction. The Kem hatchery was built on the river Kem in 1971, 5 years after Putkinskaya hydropower station, when the salmon were almost exterminated.

The hatcheries decided to work with eggs from other sources, because the native stocks were very low in both rivers. Eggs for the Vyg hatchery were collected from Kem salmon until 1965. Fry incubation and rearing was conducted in Vyg water, and the young fish (parr) were released into several rivers including the Vyg, Pongoma, Kuzema and Kalga. During 1965-68 eggs from Kola river salmon (Kola Peninsula) were delivered to the Vyg hatchery, with the fry being released into the rivers Vyg, Kem and Pongoma. Later (in 1970) the Vyg hatchery started to collect eggs from Keret river salmon and release the fry into the same river. Only in particular cases were small batches of fry released into the rivers Vyg, Kem and Pongoma. Kem hatchery obtained eggs from Kola river salmon, and released the fry into the rivers Kem, Pongoma and Shuya. Hatchery-reared parr were released at 2 years of age. The total number of parr released did not exceed 200 000–250 000 individuals. The return from these releases made up less than 1 % of the adult population.

3.1.4 Plans for conservation and enhancement of salmon stocks in Karelian rivers

Atlantic salmon production (both natural and artificial) in the Karelian area of the White Sea basin must be considered as extremely unsatisfactory. The reasons for such a situation have been discussed many times in several publications. The salmon stock development strategy in Karelia involves: 1) the possible full use of natural spawning stock coupled with the artificial reproduction and restocking of depleted stocks; 2) regulating industrial activity in the basins of the spawning rivers; and 3) the conservation and protection of spawning beds. Well-founded recommendations on solving these problems can only be given on the basis of a modern detailed inventory of existing spawning stocks to evaluate the present situation. For most of the rivers such data are not yet available. The following tasks are of primary importance:

- Certification of the salmon rivers
- Evaluation of the size and condition of the spawning stocks.
- Organization of regular surveys of salmon parr densities in the rivers and number of spawning redds. This will allow for the forecasting and for the modification of salmon escapements.

In addition the organization of complex investigations on the Keret river requires full accounting of downstream-migrant salmon. Results of current investigations on the Keret (1990-98) indicate an alarming situation. A steep decline in abundance of adult salmon has been observed. During the same period the density of young salmon decreased dramatically. The presence of the monogenean parasite *G. salaris* is the most probable cause of this threat to the Keret river salmon stocks. The parasite is believed to have been introduced via stocking from the Vyg hatchery.

The information obtained in these investigations will form the basis for identifying the potential productivity of salmon rivers and for the elaboration of measures to optimize the Atlantic salmon catch. In addition, data on the status of natural reproduction is necessary for optimizing enhancement.

It would be advisable to include the following measures in the plan for the development of salmon enhancement in Karelia:

1) Kem hatchery should work only with Kem river salmon.
2) To construct a hatchery on the River Keret, which should utilize only Keret river salmon. The primary research goal should be to determine the optimum capacity and location of the hatchery on Keret and to work out the most efficient scenario for the operation of the Vyg hatchery based on the use of Vyg river salmon (brood stock capture and holding and locations and form of parr release into the river).
3) To study the possibility of building hatcheries on the rivers Gridina, Pongoma, Kuzema and Shuya, which are the most promising for salmon enhancement. To achieve this task the investigations asessing the salmon population, and size and condition of these rivers SGA's need to be continued.
4) Taking into consideration that the aforementioned suggestions will require financial investment and time, as well as solving other problems (e.g. lack of high-quality, locally produced food for salmon production), special attention should be given to increase the efficiency of the existing hatcheries.

3.1.5 Investigations of parasites on Atlantic salmon parr in Karelian rivers

The first notes on parasites of salmon parr in the White Sea basin came from Dogiel & Petrushevsky (1935) who reported 12 freshwater species. These data were supplemented by Malakhova (1972) who studied salmon parasites in the river Keret. The parasite fauna of salmon parr consisted of five freshwater species which have complicated life cycles. Mitenev & Shulman (1985) reported 27 parasite species on young salmon parr from the rivers of the Barents and White Sea basins. Their analyses showed significant quantitative and qualitative differences in fauna from various areas of the regions. They also noted that the fauna is very impoverished in the southern part of the region (Karelia, Arkhangelsk region), primarily due to the disappearence of species.

The parasites of salmon parr in eight rivers flowing into the White Sea basin were studied in July-August 1992-97 (**Table 4**).

Fish were collected from spawning/breeding areas by electrofishing. The sampling localities were in the lower rapids of the rivers near the river mouths. However, in the river Keret 3 localities in the Varatsky, Sukhoi rapids, and upper reaches were also sampled.

In 1995, the rivers Gridina and Kalga were investigated. The average salmon parr abundance in the rivers Vonga, Pongoma, Gridina and Kalga in 1993-95 was about 0.4-1.5 parr/m².

Table 4. Number of salmon parr collected for parasite examinations in rivers flowing into the White Sea in the Karelian region (in 1994 and 1996 only G. salaris infection was studied).

River	1992	1993	1994	1995	1996	1997	1998
Keret	30	30	30	15	60	-	55
Pulonga	15	-					16
Vonga	15						
Pongoma	15						
Gridina				25			
Kolezhma					0		
Kuzema	0						
Kuzreka						0	
Shuya						-	
Kalga				15			
Kem				5			
Vyg					1		
Suma					15	-	

3.1.6 Investigations of salmon parr in the River Keret

The river Keret is situated in the taiga zone of northern Karelia. The river Keret begins at Lake Petri and flows through four lakes. Total length of the river is 110 km, and the length of the lake section is 34 km. The total drop in river elevation is 90.6 m and mean flow rate is 23.3 m³/s. There are 18 rapids in the river Keret. Normal smolt age in the river Keret is three years.

In the river Keret, investigations of young salmon density began in 1990, while parasitological investigations have continued every year since 1992. The figures in **Table 5** are based on samples of 15 salmon parr from each site.

In 1992, *G. salaris* was found infecting fins, skin and gills of all salmon parr in Varatsky. In the lower part of the river no parasites were found. The parasite had not been previously recorded on salmon parr in rivers of the White or Barents Sea basins (Ieshko et al. 1995). In 1993, only the Varatsky region was investigated. Fifty-seven percent of the salmon parr were infected and the mean intensity was lower than in 1992. In 1994, almost all salmon parr in the Varatsky and Sukhoi regions were infected, but the mean intensity was quite low in the Sukhoi region. In 1995, the prevalence and mean intensity in the Varatsky region were the same as the year before, while *G. salaris* was not found in the upper parts of the river. As the data of 1996 shows, all locations sampled in the river Keret had *G. salaris* (**Table 5**). In 1997, only two

Table 5. Occurrence of G. salaris on salmon parr (prevalence (P) and mean intensity (I)) from different years and locations in the river Keret. "Lower part" is the section between the outlet of the river and the salmon trap. Varatsky is situated 20 km from the sea, while Sukhoi and the "Upper part" are situated 80 km and 105 km from the sea, respectively.

	1992		1993		1994		1995		1996	
Locations	P	I	P	I	P	I	P	I	P	I
Lower part	0	0	-	-	-	-	-	-	100	75
Varatsky rapid	100	226	57	13	100	399	100	313	100	314
Sukhoi rapid	-	-	-	-	93	6	-	-	100	66
Upper part	-	-	-	-	-	-	0	0	80	7

salmon parr were found, and both were infected. Investigations carried out in 1998 showed that the intensity of the infection of the parr was much higher in September than in July (**Table 6**). It can thus be assumed that heavily infected parr die when the river becomes covered with ice. Moreover, infestation was highest in the river stretches inhabited by both second and first year fish (**Table 6**).

G. salaris is believed to have been introduced via stocking from the Vyg hatchery. In the period 1986–89, landlocked young salmon were transported from the Petrozavodsk hatchery to the river Shuja (Onega basin) by helicopter. During one of those years, this helicopter also transported young salmon from the Vyg hatchery to the river Keret the same day. The young salmon from the Vyg hatchery were transported in the same tank as the landlocked salmon. *G. salaris* had probably survived in the tank after the transport of the landlocked salmon and was introduced via salmon from the Vyg hatchery to the river Keret.

The density of salmon parr in the river Keret in the Sukhoi and Varatsky rapids was very low in 1992-98 compared to 1990 and 1991 (**Table 7**).

3.2 Atlantic salmon rivers in the Murmansk region

In the Kola Peninsula there are 37 main rivers inhabited by Atlantic salmon that drain to the White Sea basin (Zubschenko et al. 1991). The passable river stretch for Atlantic salmon in most of these rivers is rather short. In many of the rivers the salmon migrate up 20-30 km, and in some rivers only 5-10 km from the mouth because of impassable waterfalls. Favourable hydrological conditions and large areas suitable for spawning and breeding, however, compensate for the short lengths. It should be noted that the Varzuga river, one of the richest salmon rivers on Earth, flows here. The total spawning area for Atlantic salmon in this river is more than 1.500 ha (Kazakov et al. 1992), and estimated parr densities in 1994 and 1995 averaged 28.8 ± 12.0 and 19.3 ± 5.9 individuals per 100 m², respectively (Jensen et al. 1997).

There are 28 salmon rivers on the Kola Peninsula draining into the Barents Sea. In two rivers (Tuloma and Iokanga) can Atlantic salmon migrate more than 200 km, while in six other rivers (Pechenga, Bolschaya Zapadnaya Litsa, Teriberka, Voronja, Harlovka, Vostochnaya Litsa) they can migrate more than 100 km. All the other rivers are much smaller, but still rather productive.

Table 6*. Seasonal dynamics of salmon parr infestation by G. salaris in the river Keret in 1998.*

Locality	Age group	JULY Number of fish	JULY Prevalence %	JULY Intensity (mean)	SEPTEMBER Number of fish	SEPTEMBER Prevalence %	SEPTEMBER Intensity (mean)
Morskoi	0+	5	100	1-139 (33)	9	100	15-2 531 (801)
Morskoi	1+	2	100	144-340 (242)	3	100	3 037-5 895 (4 710)
Sukhoi	0+	15	20	1- 13 (5)	15	46.6	1- 144 (35)

Table 7. Density of salmon parr (n/100 m²) in different locations and years in the river Keret.

Location	1990	1991	1992	1993	1995	1996	1998
Lower part	-	-	25.0	-	-	4.5	-
Varatsky rapid	62.0	42.0	6.0	0.4	0.8	0.2	2.0
Sukhoi rapid	72.0	-	-	1.8	6.0	0.9	7.5
Upper part					25.0	0.8	-

3.2.1 Reproductive potential of the Atlantic salmon in the Murmansk region

The Kola Peninsula rivers have a considerable reproductive potential. The total area of spawning/breeding grounds for all salmon rivers combined is 3 857 hectares, with 1104 hectares in the Barents Sea rivers and 2 753 hectares in the White Sea rivers. During 1986–91, the abundance of spawners running into the Barents Sea rivers fluctuated from 20 000 to 41 000 (average 32 000), and that the White Sea rivers fluctuated from 110 000 to 215 000 fish (average 152 000) (Zubschenko & Kuzmin 1991).

3.2.2 Atlantic salmon catch in the Murmansk region

Since 1922, nearly complete records of salmon catches in rivers of the Kola Peninsula and its coastal areas exist. In the period 1922–90, the catch varied between 130 tons (1932) and approximately 750 tons (1937, 1938). Berg (1935, 1948) considered that the abundance of salmon is subject to natural fluctuations with a 9-11 years periodicity. In fact, the lowest catches were registered in 1921, 1932, 1942, 1951, 1963, 1972 and 1982. Azbelev (1960) remarks that as a rule the minimum catches are registered in the first decades, and long-term depressions in salmon abundance always begin in the middle or the end of a decade and continue until the middle of the following one. Such depressions were registered on the Kola Peninsula in 1921-32 and in 1963-72 (Zubscenko & Kuzmin 1991).

3.2.3 Artificial salmon reproduction in the Murmansk region

The Murmanrybvod has been artificially breeding Atlantic salmon in the Murmansk region since the middle of 1930's. The main purpose of which was to increase salmon stocks and to compensate for the damage to salmon production caused by the building of hydropower stations. At present four hatcheries, which produce juvenile salmon for further release into natural water basins, are operating in the Murmansk region:

- Taibola (Barents Sea basin)
- Kandalaksha (White Sea basin)
- Umba (White Sea basin)
- Knyazhaya Guba (White Sea basin)

One hatchery releases juveniles into rivers of the Barents Sea basin, while the other hatcheries release fish into the White Sea basin rivers. The average release from all the hatcheries combined is about 450 000 juveniles at age 2+.

Eggs for the hatcheries were collected from wild Atlantic salmon. Egg incubation and breeding of juveniles took place under natural water temperatures. Rearing technology of juvenile salmon is designed to mimic natural conditions as closely as possible. During two years of rearing, their weight reaches 10-12 g, on average. They are stocked in rivers at an age of 2 years. At that time the bulk of juveniles were parr, and 10-15 % of them were close to smolting.

The hatcheries release their juveniles in spring after the spring freshet at river temperatures of 3-5 °C. The majority of juveniles live in the river for one year before running to the sea. After one year in a river reared juveniles do not differ in their physiological and biological characteristics from the wild ones. The return as spawning migrants averages about 1 % (Kuzmin & Zubschenko 1991).

3.2.4 Investigations of Atlantic salmon parr in Murmansk rivers

There is a danger of the further spread of *G. salaris* from the river Keret to other White Sea rivers. Specialists from PINRO therefore, monitor the most important salmon rivers within the Murmansk region.

Annual parasitological investigations are carried out on the following White Sea rivers: Kovda, Virma, Kanda, Lubche-Savino and Niva, as well as the Umba, Kandalaksha and Knyazhegubsky hatcheries. *G. salaris* has not been found.

In 1993–98, several rivers were sampled by electrofishing, and salmon parr were examined for invasion with *Gyrodactylus* (**Table 8**). Gills, skin and fins of live fish were examined. *G. salaris* was not found. Full parasitological dissections of caught fish were conducted, and material on parasite fauna was collected.

In 1997, monitoring continued in the basin of the Tuloma river. Wild young salmon were sampled in the inflows of the Tuloma. No evidence of gyrodactylids was found. In 1997, parasitological investigations were carried out in the Baltic sea rivers originating in the Murmansk region: Sallajoki, Kuolajoki and Tennijoki. *G. salaris* was not found. The dominant fish species in these rivers were brown trout and grayling. Young Atlantic salmon were absent. In 1998, the monitoring continued in the index rivers of the White Sea basin (Kovda, Virma, Kanda and Niva).

***Table 8**. List of rivers where samples were taken by electrofishing and salmon parr were examined for occurrence of* Gyrodactylus *in 1993–98 (Murmansk region).*

Year	River	Number of salmon parr examined	Age composition of sample
The White Sea basin			
1996	Kovda	5	(0+):5, (1+):20
	Kanda	21	(1+):1, (2+):7, (3+):14
	Virina	10	
	Lubche-Savino	no salmon parr in samples	
	Valas	"	"
	Niva	"	"
	Bezimeni	"	"
1997	Kovda	25	
	Virma	10	
	Kanda	11	
	Niva	20	
1998	Kovda	20	
	Virma	7	
	Kanda	15	
	Niva	20	
The Barents Sea basin			
1993	Kola	19	(1+):7, (2+):6, (3+):5, (4+):1
1994	Kola	23	(0+):1, (1+):8, (2+):13, (3+):1
The Tuloma River inflows			
1993	Pecha	21	(1+):8, (2+):11, (3+):2
1994	Pecha	16	(0+):4, (1+):1, (2+):5, (3+):6
1996	Pecha	13	(1+):3, (2+):9, (3+):1
	Shovna	10	(0+):1, (1+):4, (2+):3, (3+):2
	Pak	11	(0+):6, (2+):5
	Kertcha	18	(1+):11, (2+):4, (3+):1
The Baltic Sea basin			
1997	Sallajoki	no salmon parr in samples	
	Kuolajoki	"	"
	Tennijoki	"	"

3.3 Landlocked salmon populations

Kazakov (1992) summarized the current status of Atlantic salmon in European freshwater bodies which complete their whole life-cycle in fresh water. He mentions nine lakes in Russia (Ladoga, Onega, Kuito and others), one in Finland (Saimaa) and one in Sweden (Vänern) with populations of landlocked salmon. In addition, one exists in Norway (Lake Byglandsfjord). This population was saved from extinction in the 1970's. "Småblank" is a river-dwelling landlocked salmon living in the upper regions of the River Namsen in Norway. Most of the lakes and rivers drain into the Baltic, White or Norwegian Seas (Kazakov 1992).

According to Kazakov (1992), five lakes with populations of landlocked salmon drain to the White Sea basin. The lakes Segozero and Wigozero belong to the watershed of the river Vyg and the lakes Kujto, Kamennoe and Njukozero belong to the watershed of the river Kem (figure 1 in Kazakov 1992). The salmon populations in the Kujto lake have not been investigated for *Gyrodactylus*. The lakes of the Kamennaya river system which are situated in the upper tributaries of the Kem river, were investigaed by Ieshko et al. (1982). In the specimens of landlocked salmon that were studied, no *G. salaris* was found (Ieshko et al. 1982).

A total of 41 specimens of "Småblank" from the upper parts of the river Namsen collected in 1997 (11 specimens) and 1998 (30 specimens) were examined for the occurrence of *G. salaris*, but no *G. salaris* was found. All specimens collected in 1997 and 15 specimens collected in 1998 were studied parasitologically according to Dogiels method. The results are given in **Table 9** and **Table 10**.

The parasite fauna resembles that on landlocked salmon in rivers in the Onega lake system.

Table 9*. Parasite fauna of 11 specimens of land-locked salmon collected in the river Namsen in September 1997.*

Parasites	No. infected	Min-max
Myxidium sp.	1	+
Chloromyxum sp.	4	+
Myxobolus sp.	3	+
Capriniana piscium	4	+
Apiosoma sp.	4	+
Crepidostomum farionis	11	5-26
Diplostomum volvens	8	1-45
Ichthyocotylurus erraticus	3	2-5
Apatemon annuligerum	1	1-1
Contracoecum sp.	2	1-1

Table 10*. Parasite fauna of 15 landlocked salmon from the river Mellingselva, a tributary to the river Namsen, in August 1998.*

Parasites	No. infected	Min-max
Chloromyxum sp.	10	+
Myxobolus sp.	6	+
Capriniana piscium	7	+
Apiosoma sp.	6	+
Diphyllobothrium dendriticum	1	1-1
Crepidostomum farionis	6	1-25
Phyllodistomum conostomum	1	1-1
Diplostomum rutili	3	1-1
Diplostomum sp.	8	1-3
Ichthyocotylurus erraticus	3	1–4
Cystidicoloides tennuissiama	1	1-1
Acarina	1	1-1

3.4 *G. salaris* in Lake Enare and in the River Pasvik

In 1993, *G. salaris* was found on rainbow trout in a fish farm in Siskili at Lake Enare in northern Finland. All fish in the fish farm were slaughtered and the farm was disinfected. Later the fish population in the farm was rebuilt from disinfected eggs. One monogenean was found on a pectoral fin of a rainbow trout less than 1 km downstream from the infected fish farm in 1996 (reported by Dr. P. Koski, National Veterinary and Food Research Institute, Regional Laboratory Oulu, Finland during the third meeting in November 25, 1996 on *G. salaris* in the Barents Region).

Lake Enare drains into the river Pasvik in Norway. Investigations in the River Pasvik below Boris Gleb were conducted in 1993 by the County Governor in Finnmark, Environmental Department. Atlantic salmon fry and parr (1+ and 2+) were found, clearly indicating that spawning had occurred in this area (Memorandum from a meeting of the Norwegian-Finnish Border Commission 20.-22.9.1993). No *Gyrodactylus* was found.

Parasitological investigations were planned, but not carried out in the river Pasvik in 1997 and in 1998, because of lack of financial support.

3.5 Investigations in Russian hatcheries regarding *G. salaris*

Every year salmon parr from hatcheries in the Karelian region are studied. *G. salaris* was found on landlocked salmon parr in the Petrozavodsk hatchery in the middle of the 1980's (E. Rumjantsev, personal communication).

In spring 1995, 25 young salmon from each of the four hatcheries in the Murmansk region were examined by PINRO. *G. salaris* was not found.

In Murmansk region, three small freshwater rainbow trout farms exist. In February–March 1996, PINRO investigated the largest of these fish farms. A total of 67 specimens of rainbow trout yearlings from cages located in the basin of the Tuloma river were examined. Four specimens of *Gyrodactylus* were found on fins of two fish. They were fixed and studied, and all materials including preparations were sent to Dr. G. Malmberg in Stockholm for final identification. As a result, it was stated that the parasites belonged to the species, *Gyrodactylus lavareti*. In addition to *G. lavareti*, 11 other parasite species were identified.

Salmon parr from the Kandalaksha hatchery have been investigated every year since 1995 by PINRO. Hatcheries and fish farms in the Murmansk region have been inspected every three months by the Ichthyopathology Service of the Murmansk Regional Veterinary Laboratory (cfr. Kalinina 1996). *G. salaris* has not been found.

3.6 *G. salaris* on Atlantic salmon parr in the River Vefsna, northern Norway

G. salaris was probably introduced into the river Vefsna by stocking of Atlantic salmon smolts from infected hatcheries in 1975 and 1977. An outbreak of the parasite was registered in 1978, and within two years the parasite had spread throughout the whole watercourse. There was a rapid rise in prevalence rate and degree of infection. The density of salmon parr decreased from a high level before the *Gyrodactylus* outbreak to close to zero after the outbreak (Johnsen & Jensen 1988).

In 1992, the fish ladder in the waterfall Laksforsen was closed in an attempt to prevent the ascension of Atlantic salmon. In spite of this, some specimens ascended in 1992, but from 1993 the ascension was effectively prevented.

In September 1996, 19 salmon fry (0+) with a size varying between 29 and 40 mm, were collected below Laksforsen and the number of *G. salaris* was counted on each fish. The number of parasites varied from 90 to 693 on each fish with a mean intensity of 245 parasites per fish (**Table 11**).

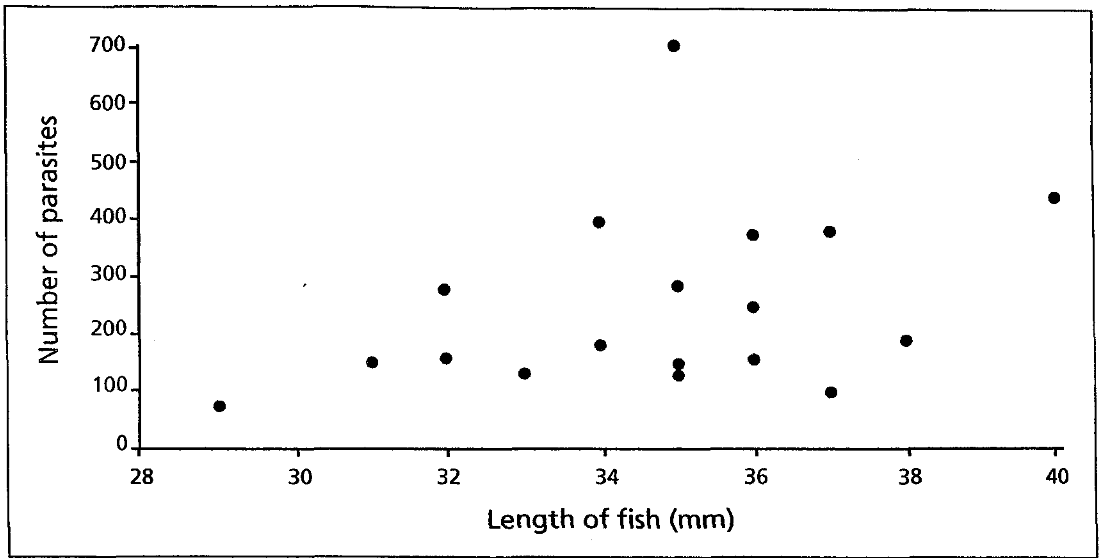
The number of parasites seems to increase with increasing length of the fish (**Figure 2**).

In 1997, no salmon fry or parr were investigated, because of high water flow in the river Vefsna during September. On 21 August 1998 electrofishing was conducted in one location sited approximately 500 m downstream from the waterfall Laksforsen. We found a density of 32.5 0+ salmon/100 m² and 17.5 1+ salmon/100 m². The mean intensity of *G. salaris* on the 0+ and 1+ salmon was 21 and 1325 respectively. The 24 specimens of fry (0+) which were investigated varied in size between 25 and 34 mm. They were all infected and the number of parasites on each fish varied from 1 to 95. The investigation in 1998 took place three weeks earlier than the investigation in 1996. The difference between the intensity of infection among the 0+ salmon in 1996 and 1998 was probably due to the different sizes of the fish in the two years.

Table 11*. Number of G. salaris on fins and body of 19 Atlantic salmon fry (0+) collected below the waterfall Laksforsen in the river Vefsna on 12. September 1996.*

Fish no.	Fish length (mm)	Caudal fin	Anal fin	Ventral fins	Dorsal fins	Pectora lfins	Adipose fin	Body	No. of Parasites
1	38	58	5	5	37	30	2	2	177
2	36	23	13	11	44	16	1	5	149
3	36	73	17	12	42	154	21	12	367
4	37	32	1	3	16	1	0	0	90
5	35	12	6	13	40	24	5	4	139
6	29	14	0	3	7	8	6	0	67
7	36	73	10	16	70	30	5	1	241
8	35	15	4	8	24	19	10	6	121
9	32	50	3	9	15	40	4	0	153
10	34	108	21	33	103	76	7	9	391
11	32	64	12	9	55	40	17	47	276
12	37	63	26	54	73	86	12	18	369
13	35	279	30	43	84	116	12	94	693
14	34	23	8	21	39	39	2	7	173
15	31	45	5	9	29	24	0	2	145
16	32	49	17	7	36	93	7	11	272
17	35	48	36	37	33	70	5	12	276
18	40	86	34	40	38	157	17	14	426
19	33	28	2	5	34	13	8	3	126

Figure 2. *Gyrodactylus salaris* infection on salmon fry of different lengths in the river Vefsna in September 1996.



3.7 Parasite fauna of the European grayling in the River Vefsna, northern Norway

The Directorate for Nature Management plans to treat the river Vefsna with rotenone in an attempt to eradicate *G. salaris* from the watercourse and thus, restore the salmon population. Therefore, the river has been closed since 1992 for ascending salmon at the Laksforsen waterfall. All salmon parr upstream from the Laksforsen waterfall will smoltify and migrate out of the river. The parasite *G. salaris* is very species-specific and will die out when the salmon parr disappear, if it cannot find another host. The grayling is known to be a host for *G. salaris* under experimental conditions, and it is, therefore, important to find out whether the grayling can be a host for *G. salaris* under natural conditions in the river Vefsna. Based on this, we started investigations of the parasite fauna of the grayling in the river Vefsna.

In the period 1995–97, a total of 55 grayling were caught upstream from the waterfall Laksforsen. In 1998, 37 specimens were caught just downstream of the waterfall, where the salmon still have access and spawn each year.

All specimens of grayling were investigated for the occurrence of *Gyrodactylus*, and in addition, parasitological studies according to the method of Dogiel were conducted on 39 specimens of grayling. There were only small differences in the parasite fauna of grayling caught upstream or downstream from the waterfall Laksforsen. The paucity of the parasite fauna is due primarily to the low abundance of grayling in the river, the low number of fish species inhabiting the river, and the paucity of plankton and benthos, as well as presumably the absence of a whole complex of small relict crustaceans.

No *Gyrodactylus* was found parasitizing the grayling from the river upstream of the waterfall Laksforsen. Downstream of the waterfall, one specimen of *Gyrodactylus* was found on 3 grayling. These results indicate that grayling are not an important host for *G. salaris*.

For further details see Ieshko et al. (1999).

4 Measures against *G. salaris*

G. salaris is almost certainly a recent introduction to Norwegian rivers, and its distribution is associated with the stocking of fish from infected salmon hatcheries (Johnsen & Jensen 1986). In 1986, the Norwegian Directorate for Nature Management published a plan for "measures to be taken against the Atlantic salmon parasite, *Gyrodactylus salaris*" (Anon. 1986). The primary goal of this plan is the prevention of further spread of *G. salaris* and its extermination in as many infected rivers and hatcheries as possible. These primary goals were later repeated and underlined in new action plans presented in 1995 (Direktoratet for naturforvaltning 1995) and in 1998 (Anon. 1998).

In the period 1981–97, 25 Norwegian rivers were treated with rotenone in an attempt to exterminate the parasite. The treatment has so far been a success in 13 rivers, which now (per April 1999) have been stated as healthy after the treatment. The parasite has turned up again in the rivers Skibotnelva, Rauma and Steinkjervassdraget.

In Russia, the *Gyrodactylus* situation is complex, because the parasite occurs naturally where the Baltic salmon occur (Ladoga lake, Onega lake), and does not occur where Atlantic salmon occurr (White Sea, and Kola Peninsula). The development of the *Gyrodactylus* infection in the Atlantic salmon population of the river Keret resembles the development in the Norwegian rivers, with epidemics in the salmon parr population resulting in very low densites of parr and few adult salmon ascending the river.

The *Gyrodactylus* situation in the White Sea area was discussed in a meeting of the Russian-Norwegian Working Group on the marine environment of the Barents Region, ("Havmiljøgruppen") in Tromsø 29–31 October 1996. This is a working group within the Russian - Norwegian Environmental Commission. In the protocol from the meeting, the working group states: "The working group points out that a further spread of the parasite *G. salaris* will constitute a great danger. This parasite is registered in a Russian river that drains into the White Sea (the river Keret, Karelia). Taking into consideration the real danger for the further spread of this parasite in the region, the working group recommend that the Russian/Norwegian Environmental Commission straiten out the possibility of treating the river Keret with rotenone and thereby removing the possibility of further spread of *G. salaris* in the White Sea basin".

Based on this a survey of the river Keret was arranged in July 1997. Participants in this survey were representatives from the Karelian Research Centre in Petrozavodsk, the County Governor in Møre og Romsdal, Norway, who has played an important part in the actions taken against *G. salaris* in Norwegian rivers and the Norwegian Instiute for Nature Research in Trondheim. Actual attempts to remove the parasite from the river Keret were discussed after an inspection of the river. The possibilities of removing *G. salaris* from the river Keret are discussed in a report from the County Governor in Møre og Romsdal dated 26 September 1997. It is concluded that actions should be taken as soon as possible beginning with the construction of a barrier in the lower part of the river to prevent salmon from ascending the river. The parasite should be exterminated by treating the river with rotenone downstream from the barrier several years after its erection.

This report was submitted to the Directorate for Nature Management along with a letter from NINA dated 2 October 1997. In the letter it was underlined that the occurrence of *G. salaris* in the river Keret must be considered seriously. There is a possibility for the spread of the parasite to other rivers in the area. In the long run, this will be a disaster for the salmon populations. An extermination of the parasite from the river Keret will put an end to such a development. It was recommended that the Directorate contact the Russian authorities as soon as possible with the intention of building of a barrier in the river Keret.

5 References

Anon. 1986. Handlingsplan for tiltak mot lakse-parasitten *Gyrodactylus salaris* for 10-års perioden 1987—1996. - Direktoratet for naturforvaltning, Trondheim. 1-27 (in Norwegian).

Anon. 1998. Forslag til handlingsplan for tiltak mot lakseparasitten *Gyrodactylus salaris* – Direktoratet for naturforvaltning og Statens Dyrehelsetilsyn. 1-52 (in Norwegian).

Azbelev, V.V. 1960. Materialy po biologii semgi Kolskogo poluostrova i ee vyzhivaemosti. - Trudy PINRO, vyp.12: 5-70 (in Russian).

Berg, L.S. 1935. Materialy po biologii semgi. - Izvestiya VNIORH, tom 20: 1-113. (in Russian).

Berg, L.S. 1948. Ryby presnykh vod SSSR i sopredelnych stran. - 4 izdanie, M-L, chast 1: 1-466 (in Russian).

Bohlin, T. 1984. Quantitative electrofishing for salmon and trout - views and recommendations. - Information från Sötvattenslaboratoriet No. 4: 1-33 (in Swedish with English summary).

Bristow, G.A., Ieshko, E., Shulman, B. & Berland, B. 1994. Salmon parr parasite from river entering the southern White Sea. - The eighth international congress of parasitology, Izmir, Turkey, October 10.-14., 1994. Abstracts, Volume 1: p. 54.

Bykhovskay-Pavlovskaya, I.E. 1985. Parasites of fish. Manual for study. L. - Nauka: 1-121.

Chubb, J. C. 1970. The parasite fauna of British freshwater fish. - Symp. Brit. Soc. Parasitol., v. 8: 119-144.

Direktoratet for naturforvaltning 1995. Forslag til handlingsplan for tiltak mot lakseparasitten *Gyrodactylus salaris* for perioden 1995–1999. – Utredning for DN nr. 1995–2: 1–96 (in Norwegian).

Dogiel, V.A. & Petrushevsky, G.K. 1935. Opyt ekologiceskogo issledovanija parasitofauny belomorskoi sel'gi. - Voprosyekologii i biocenologiee. L., (in Russian).

Heggberget, T.G. & Johnsen, B.O. 1982. Infestations by *Gyrodactylus* sp. of Atlantic salmon *Salmo salar* L. in Norwegian rivers. – J. Fish Biol. 21: 15–26.

Ieshko E.P., Malakhova R.P. & Golitsyna, N.B. 1982. Ecologicheskie osobennosti formirovaniya fauny parasitov ryb ozer sistemy r. Kamennoy. (Ecological peculiarities of the development of the river Kamennaya system's lakes parasite fauna). - Ecologia parasiticheskih organismov v biogeocenozah Severa. Petrozavodsk: 5-25.

Ieshko, E., Berland, B., Shulman, B., Bristow, G. & Shurov, I. 1995. On some parasites of salmon parr (*Salmo salar L.*, 1758) (Pisces, Salmonidae) from rivers of the Karelian White Sea Basin. - Abstr. Fourth International Symposium of Ichthyoparasitology, Munich, Germany 3-7 October 1995, p. 100.

Ieshko, E.P, Johnsen, B.O., Shulman, B.S., Jensen, A.J. & Schurov, I.L. 1999. The parasite fauna of an isolated population of grayling, *Thymallus thymallus* (L.) in the River Vefsna, northern Norway (in manus).

Jensen, A.J., Zubschenko, A., Hvidsten, N.A., Johnsen, B.O., Kashin, E., Kuzmin, O. & Næsje, T.F. 1997. A comparative study of life histories of Atlantic salmon in two Norwegian and two Russian rivers. – NINA-NIKU Project Report 007: 1-44.

Jensen, A.J., Zubchenko, A., Hvidsten, N.A., Johnsen, B.O., Kashin, E. & Næsje, T.F. 1998. A five year study of Atlantic salmon in two Russian and two Norwegian rivers. – NINA-NIKU Project Report 008: 1-38.

Johnsen, B.O. & Jensen, A.J. 1986. Infestations of Atlantic salmon, *Salmo salar*, by *Gyrodactylus salaris* in Norwegian rivers. – J. Fish Biol. 29: 233-241.

Johnsen, B.O. & Jensen, A.J. 1988. Introduction and establishment of *Gyrodactylus salaris* on Atlantic salmon, *Salmo salar L.*, fry and parr in the River Vefsna, northern Norway. - Journal of Fish Diseases 11: 35-45.

Kalinina, N. 1996. History of development of ichthyopatological service in the Kola Peninsula. – P. 43–47 in Larsen, T., ed. Report from seminar on fish diseases and organisation of the fish health service in the Finnish, Norwegian and Russian parts of the Barents region. Høgskolen i Finnmark 1996-12.

Kazakov, R.V. 1992. Distribution of Atlantic salmon, *Salmo salar* L., in freshwater bodies of Europe. – Aquaculture and Fisheries Management 1992, 23: 461-475.

Kazakov, R.V., Kuzmin, O.G., Schustov, Ju. A. & Shurov, I. 1992. Atlantic salmon of the Varzuga River. - Hydrometpress, Leningrad. 108 pp. (in Russian).

Korablev, N.A. 1974. Iz istorii rybolovstva v Karelskom Pomorie (vtoraya polovina 19 veka). Biologicheskie resursy Belogo moryai vnutrennich vodoemov Evropeiskogo Severa. Petrozavodsk. s. 286-288. (in Russian). (From the history of fishery of Karelian region of
White Sea (the second half of 19 century). - In "Biologycal resources of White Sea and inland waterbodies of European North". Petrozavodsk. p. 286-288 (in Russian).

Kuzmin, O.G. & Zubschenko, A.V. 1991. Artificial reproduction of Atlantic salmon in rivers of the Murmansk region - Materials to the meeting of experts on anadromous fishes, Trondheim 27.10-3.11.1991.

Malakova, R.P. 1972. Parasitofauna semgi *Salmo salar* L., kumzi *Salmo trutta L.* gorbuchy *Onchorchyncus gorbuscha* (Walb.) i siga *Coregonus lavaretus pidchian n. pidchianoides*

Pravdin v bassejne Belogo Morja. Lososevye (*Salmonidae*) Karelii. - Petrozavodsk 1: 21-26 (in Russian).

Margolis, L., Eshc, G.W., Holmes, J.C., Kurtis, A.M. & Schad, G.A. 1982. The use of ecological terms in parasitology (report of an ad hoc committee of the American Society of Parasitologists). - Journal of Parasitology 68: 131-133.

Mitenev, V.R & Shulman, B. 1985. Ekologichskie osobennostiparasitifauny molodi semgi *Salmo salar* L. Evropesjskogo Severa. Eklogisja i vospproizvidstovo proshodnych Isososevych ryb v basssejnach Belogi i Baraeceva morej. - Sb. tr. PINRO. Murmansk. 149-159 (in Russian).

Zippin, C. 1956. An evaluation of the removal method of estimating animal populations. - Biometrics 12: 163-169.

Zubschenko, A.V. & Kuzmin, O.G. 1991. Atlantic salmon stock status in the rivers of the Kola Peninsula. - Materials to the meeting of experts on anadromous fishes, Trondheim 27.10-3.11.1991.

Zubschenko, A.V., Kuzmin, O.G., Novikov, O.N. & Sorokin, A.L. 1991. The salmon recreational catch on the Kola Peninsula. - Polar Institute of Fishery and Oceanography (PINRO). Murmansk. 150 pp. (in Russian).

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