International Council for
the Exploration of the Sea

CM 1998/N:13
Theme Session (N) on Ecology of
Diadromous Fishes during the Early
Marine Phase

SALMON RIVERS ON THE KOLA PENINSULA. SOME RESULTS OF ACCLIMATION OF PINK SALMON (*ONCORYNCHUS GORBUSHA* (WALBAUM))

by

A.V.Zubchenko
Polar Research Institute of Marine Fisheries
and Oceanography (PINRO), 6 Knipovich St.,
Murmansk, Russia

N.G.Popov
Murmansk Regional Directorate for Fish
Conservation and Enhancement, 2 Komsomolskaya St.,
Murmansk, Russia

M.A.Svenning
Norwegian Institute for Nature Research (NINA-NIKU),
25 Storgata, Tromsø, Norway

INTRODUCTION

Showing no particular diversity of ichthyofauna reservoirs over the Kola peninsula have always been renowned for valuable species of fish of which Atlantic salmon has occupied and still does a special place. However, compared to other species its abundance has never been high. For example, yearly catch of Atlantic salmon in this region in the period from 1950 to 1997 was only slightly above 600 t even in the best years (625 t in 1965), i.e. hundreds of times less than the catch of the Far East salmon.

Unlike Atlantic salmon pink salmon is one of the most spread species of the Far East salmons, which develops highly abundant populations. In addition it has fast growth rate and matures early. According to literature data (Davidson, Hutchinson, 1938 (quote as in: Kozhin, 1940); Huntsman, Dymond, 1940; Bigelov, Schroeder, 1953; Vedensky, 1954; Scott, Crossman, 1973; Lear, 1975; etc.) first attempts to introduce the Far East salmon into the Atlantic Ocean basin date from 1872. However, they were unsuccessful. In 1901-1932 pink salmon were stocked into rivers draining into the Gulf of Maine (USA), and in various regions in Canada during 1950's and 1960's. However, the species did not develop self-sustaining populations in new areas. The abundance was less than required for commercial harvesting, while adult returns gradually faded. Attempts were also made to introduce pink salmon into basins of the Baltic, Caspian and Black Seas (Shaverdov et al., 1962;

Magomedov, 1970; Radzium, Stankowska-Radzium, 1976). However, these experiments were of no success either.

First attempts to introduce the Far East salmon (chum) into reservoirs over the Kola peninsula were made in the 1930's (1933-1939). However, since the level of breeding technology was low the results were negative and experiments were suspended. They were resumed in 1956. Pink salmon was selected as target species. This species of the Far East salmons turned out to be best suitable for the purpose of introduction, because its juveniles did not stay in rivers for long, fed little during seaward migration and returned to rivers as adult fish in 13-15 months. Rivers on the Kola peninsula have many pebble stretches washed by alluvial waters and are suitable for spawning of pink salmon (Smirnov, 1994). It was also assumed that pink salmon could use surplus food available in the White Sea and would not perform extensive migrations. An ultimate goal of these experiments was a naturalization of the species.

Eggs of pink salmon were hatched mainly at hatcheries located in the Murmansk region (Taibola, Ura Guba, Kandalaksha, Knyazhaya Guba and Umba hatcheries). In some years the Onega hatchery in the Archangel Region was used for these purposes. Most of the eggs was brought from the Sakhalin and Kurils and in smaller quantities from Kamchatka and Magadan region. During first years unfed larvae were stocked, the result of this exercise was that no adults were found to return to rivers (Azbelev, Jakovenko, 1963; Bakshtansky et al., 1963). In 1959 rivers were stocked with fed larvae and already in 1960 adult pink salmon were observed to return abundantly and spawn in rivers of the Kola peninsula. Pink salmon were also found in rivers of Scotland, northern Norway, Iceland and some Siberian rivers (Azbelev, 1960; Berg, 1961; Pyefinch, 1962, Williamson, 1974; Krupitsky, Ustyugov, 1977; Bjerknes, Vaag, 1980). The outcome predestined further active development of pink salmon introduction programmes in the European North of Russia. Over the entire period that followed the success of this work was changeable. In some years the catch was as large as several hundreds tons. However, there are no data available to date which could confirm naturalization of pink salmon. The expediency of introduction of pink salmon into rivers of the Kola peninsula is still debated much. In particular, in connection with uncertainties about interactions between pink salmon and Atlantic salmon. Therefore, there are reasons to examine the issue of introduction of pink salmon to rivers on the Kola peninsula in more detail exactly from this stand.

MATERIAL AND METHODS

This paper uses data on the biology of pink salmon (dynamics of spawning run, size and weight composition) gathered on rivers of the Kola Peninsula in 1987-1997 as well as retrospective data for the whole period of pink salmon introductions (number of hatched eggs and juveniles stocked, adult counts, catch statistics, timing of spawning run and juvenile migration etc.) available in archives of PINRO and Murmansk Regional Directorate for Fish Conservation and Enhancement (Murmanrybvod). Ichthyological data were gathered and processed following established methodology (Pravdin, 1966).

RESULTS AND DISCUSSION

From 1987 to 1997 runs of pink salmon into rivers on the Kola peninsula were observed in odd years only. They began in the third decade of June - beginning of July and finished in the third

decade of August - beginning of September. The earliest run to the Barents Sea rivers in this period was observed to begin on 24 June 1989 (Ura river) and to the White Sea rivers on 25 June 1995

(Varzuga river). The latest arrival of pink salmon to the Barents Sea rivers was recorded on 2 September 1991 (Kola river) and to the White Sea rivers on 8 September 1995 (Varzuga river). Mean weight of pink salmon in the Barents Sea rivers varied from 960 to 2000 g, and mean length from 43.2 to 52.6 cm, average absolute fecundity was 1932 eggs, the proportion of females varied from 53.1% to 58.2%. In the White Sea rivers mean weight and length of pink salmon varied from 1500 to 2070 g and from 47.7 to 51.1 cm, respectively, average absolute fecundity from 1782 to 2111 eggs. The proportion of females differed much between years (48.1% - 60%). Fig.1 shows dynamics of pink salmon run into the Barents and White Seas rivers during 1989-1997. In the Barents Sea rivers the run usually reached its peak in the third decade of July, in the White Sea rivers in the second-third decade of July. Table 1 presents data showing the number of hatched eggs, stocked larvae and adult counts from 1956 to 1997. As shown, maximum number of juveniles were stocked in 1962-1964 (23.7-35.4 mill.). However, most abundant runs of pink salmon were observed in 1971-1979 (maximum returns counted were in 1973 - 143.6 thou.adults), when from 1 to 7.3 mill.fry were annually stocked into rivers. In 1960-1997 the harvest in basins of the Barents and White Seas varied from several (1968, 1969, 1984, 1985) to 131.5 thou.pink salmon (1973) (Fig.2). For comparison, in the same period maximum harvest of Atlantic salmon on the Kola peninsula was recorded in 1960 and comprised 215,8 thou.fish .

As shown by Table 1 relatively abundant runs of pink salmon in the last 10 years were triggered off by the 1985 yearclass (in 1986 about 1 mill.fry were stocked). In 1989 an abundant run of pink salmon from natural spawning was observed in rivers of the Kola peninsula. In the same year eggs were brought for incubation from the Far East for the last time (fry stocked in 1990). In 1990 and subsequent years, except 1992, fry derived from pink salmon which returned to rivers of the Kola peninsula were also stocked and in odd years over the whole period abundant runs of pink salmon to coasts of the Kola peninsula were observed. Simultaneously, even-year line vanished completely in absence of stocking in even years. Similar situation was observed during 1967-1979 in the period of active introductions. Weak stock of the 1967 yearclass in conjunction with stocking triggered off most abundant runs of pink salmon in odd years over the whole period of introductions. The last relatively abundant run of pink salmon within the period of active introductions was observed in 1979. In subsequent 7 years there were no regular imports of eggs both in even and odd years, and only single individuals were recorded. All this speaks in favour of hypothesis that pink salmon did not naturalize in reservoirs of the Kola peninsula.

It was already noted before (Grinyuk, Kanep, 1977; Markevich et al., 1978; Dyagilev, Markevich, 1979; Kanep, 1981; Kamyshnaya, Smirnov, 1981) that except in 1960 when 76.3 thou.pink salmon were counted in rivers and coastal waters of the Kola peninsula relatively abundant yearclasses were recorded in odd years and weak in even years. The last even year when single individuals were observed in rivers of the Kola peninsula was 1984 (Table 1).

The same authors (Grinyuk, Kanep, 1977; Markevich et al.,; Dyagilev, Markevich, 1979; Kanep, 1981; Kamyshnaya, Smirnov, 1981) noted that in the 1960's and 1970's pink salmon in even (weak) years entered rivers on the Kola peninsula at later time than in odd (abundant) years. In even years pink salmon began its run in the third decade of June in 1960 only (Kamyshnaya, Smirnov, 1981). In years after (1964, 1974, 1976 - Umba river; 1974, 1976, 1978 - Ponoi river; 1976 - Kola river, 1978 - Teriberka river) spawning runs began in 1-3 decades of July (Kanep, 1981; Kamyshnaya, Smirnov, 1981; Neklyudov, Endaltsev, 1981). For example, in 1976 first spawning runners arrived

in the Kola river (Barents Sea) in the first decade of July while in the Ponoi and Umba rivers in the third decade of July. In 1987-1997 normal timing of pink salmon run in odd years did not change, it took place in the end of June- beginning of July. However, in 1997 in some rivers, for example, Ura, Zap.Litsa first spawning runners appeared only in the second decade of July. Delayed run in odd years was also recorded before. For example, in 1977 and 1979 the run of pink salmon into the Porja river began on 18 July and 27 July, respectively, and as late as 7 August in 1975 (Grinjuk et al., 1981).

On the basis of many years' research Markevich et al., (1978) have concluded that in odd years pink salmon mature earlier than in even years. In odd years the spawning takes place in the end of August - first days of September, while in even years 2.5 - 3 weeks later. In these circumstances early stages of embryogenesis of two adjacent lines develop under different temperature conditions. In odd years at optimal temperatures, in even years at temperatures below 4.5°C which according to these authors causes mortality of almost all fertilized eggs, whereas survived post-embryos are deformed and die soon. According to Dyagilev and Markevich (1979) significant difference in the time of spawning of pink salmon in even and odd years suggests that thermal conditions in rivers of the Kola peninsula during spawning are such that make it practically impossible the development of deposited eggs in even years and allow it to a limited extent in odd years. In this connection it should be mentioned that this factor is probably responsible in general for low abundance of pink salmon in the Barents Sea rivers (Fig.2) where temperatures during spawning season, early embryogenesis and post-embryo development are much lower than in the White Sea rivers.

In connection with the same issue Agapov (1986) pointed out that there was a persistent and significant difference in the dynamics of spawning run of pink salmon in even and odd years. It was evident in earlier (2 weeks) and prolonged (approximately 20 days) run of pink salmon from odd-year line and caused by relationship between water temperature, timing of spawning, survival of eggs and embryos. His opinion is that a combination of these factors impacts on both adult returns and dynamics of their run. This relationship was established through analysis of sea catch. However, as said before the timing of pink salmon migration into rivers and its duration in odd years also vary much. This is also relevant for Atlantic salmon migration into rivers and research data confirm clear relationship between timing and dynamics of migration and hydrometeorological conditions (wind, currents, water temperature and level). Besides, in discussion of this issue we should not forget that the abundance of pink salmon in even years has always been low. In those years it occurred as by-catch in Atlantic salmon and White Sea herring fisheries, and statistical data concerning frequency of its occurrence are rather contradictory.

Therefore, it follows from the above said that even though eggs from adults which spawn fairly early develop under favourable conditions, larvae experience unfavourable conditions in spring and most of them die (Agapov, 1986). Practically all eggs from spawning which takes place at later times die (Markevich et al., 1978). In addition, in rivers of the Kola peninsula eggs are, as a rule, laid by pink salmon close to the coastal line because spawning takes place during autumn flood. In the Far East this leads to freezing of eggs and their subsequent mortality during the period of lowest water level in winter season (Nikolsky, 1952). High water level causes movements of soil which in turn could be the cause of egg mortality, vulnerable to mechanical disturbance (Smirnov, 1975). All this combined with unsuccessful attempts to introduce pink salmon in even years once again confirms the hypothesis suggested before that pink salmon have not naturalized in basins of the Barents and White Seas and this will not happen, at least, in the nearest future. In this light a

question arises whether one should at all aim at naturalizing pink salmon especially in view of the fact that there is much uncertainty at least in many respects about its relations with Atlantic salmon.

When the abundance of pink salmon is high it enters all rivers on the Kola peninsula where Atlantic salmon is a predominant species. In certain periods of freshwater life they undoubtedly compete with each other and even develop antagonistic relations. However, there is only scarce and often contradictory evidence available to confirm this. As an example of antagonistic relations an observation by Bakshtansky (1964) can be referred to, who found 20 pink salmon fry in stomachs of 9 Atlantic salmon smolts. Competitive relations can show first of all in feeding. For example, the degree of diet similarity in Atlantic and pink salmon fry is 52.9% and it is 22.9% for Atlantic salmon smolts and pink salmon older fry (Grinyuk et al., 1981). However, Grinyuk and Shustov (1977) noted good food supply available for fry which they believed could be associated with a rather low contemporary abundance of Atlantic salmon and relatively short residence of juvenile pink salmon in rivers. Therefore, even when the abundance of juvenile pink salmon was high which was observed in rivers of the Kola peninsula when temperature conditions were favourable, they did not compete with juvenile Atlantic salmon for food, since their residence in rivers in those years was very short. In years with unfavourable hydrological conditions the migration of pink salmon fry is prolonged. For example, in 1978 the migration of fry in the Varzina river lasted from the beginning of July to mid-August. However, the abundance of juveniles in those years was rather low. Nevertheless, competitive relations in feeding are typical of salmon in the Far East rivers (Kokhmenko, 1965). Therefore, such situation could hypothetically develop in rivers of the Kola peninsula as well provided the abundance of juvenile pink salmon be very high. However, there are no realistic prerequisites for this for the present. Even considerable efforts to introduce pink salmon have not yielded appreciable results. Guess-estimation suggests that its abundance even in the best years did not exceed 200-3000 thou.individuals, whereas it can potentially reach 2 mill. individuals in rivers of the Kola peninsula (Agapov, 1986).

The situation is even more unclear with respect to relations between adult Atlantic and pink salmon. Kamyshnaya and Smirnov believe (1981) that pink salmon can not displace Atlantic salmon in its ecological niche, since they have different preferences with respect to spawning habitat, pink salmon spawns earlier than Atlantic salmon and can not destroy its spawning redds. Evidence provided by investigations carried out on the Sidorovka river in 1978 was somewhat different and suggested certain competition between Atlantic salmon and pink salmon (O.G.Kuzmin, personal communication). Pink salmon which entered the river earlier than Atlantic salmon occupied holes available in the river and kept off Atlantic salmon from them. During surveys in the catchment of the Ponoi river in 1961-1965 redds were laid by Atlantic salmon and pink salmon on the same spawning grounds at a distance from 1 to 3 m between them. Some spawning redds were found to contain both Atlantic salmon and pink salmon eggs. In 1973 on the Porja river all spawning habitat normally used by Atlantic salmon was occupied by pink salmon. Its abundance (about 1500 individuals) was approximately 20 times more than the abundance of Atlantic salmon and several times exceeded the capacity of spawning grounds. The spawning season dragged out from the end of August to early September. As a consequence one and the same spot was used by several spawners to build redds, which led to deterioration of quality of the latter and lessened spawning success. Some pink salmon spawned in the estuary. Therefore, when the space is limited (small river length and width) and when the number of pink salmon in a spawning run exceeds the number of Atlantic salmon a territorial competition develops between them for best passages in rivers, rest holes, spawning grounds. However, pink salmon spawns earlier than Atlantic salmon, therefore, pre-spawning competition should not impact much on production of the latter. A collation of long-

term abundance data for Atlantic and pink salmon has not suggested any definite answer to this question either (Fig.3). The figure shows conformity of fluctuations of Atlantic and pink salmon abundance. These fluctuations correlate with temperatures during both freshwater and sea stages of life of these species. It can be assumed that in years when the abundance is high of both Atlantic salmon and pink salmon competitive relations aggravate and affect their abundance, and that of pink salmon to a greater extent because it declines almost to nil. However, this is only an assumption.

As was said before, until recently some competitive relations were tracked only in small rivers of the region. Pink salmon migrated into larger rivers of the Kola peninsula such as Ponoi, Varzuga, Jokanga, Tuloma in small numbers only. In 1997 for the first time in the history of introductions of Pacific salmon to rivers on the Kola peninsula more than 18 000 pink salmon entered the Varzuga river which was already comparable with the abundance of Atlantic salmon stock in this river. Nevertheless, abundant run of pink salmon into this river apparently did not affect the timing and dynamics of summer run of Atlantic salmon (Fig.4). Whether it has affected the production ability of Atlantic salmon remains to be seen in a few years' time.

So, to sum up the above said it can be unambiguously stated that pink salmon did not naturalize in reservoirs on the Kola peninsula. A positive result could probably be achieved through selection in northern parts of the native pink salmon distribution area of early spawners for introduction programmes. However, even then the abundance of pink salmon would be subject to powerful fluctuations. There is no evidence available to date confirming adverse impact of pink salmon on Atlantic salmon, although there is certain competition for spawning habitat. In this connection absolutely unacceptable is a view expressed by Berg (1977) that pink salmon might displace Atlantic salmon whose stocks are becoming extinct under the pressure of unfavourable anthropogenic effects. In our opinion, in this situation ranching of pink salmon could be most optimal alternative since we can then have stable production by regulating the process of egg hatching and stocking of fry.

REFERENCES

AGAPOV V.S., 1986. Life cycle of pink salmon *Oncorhynchus gorbuscha* (Walbaum) acclimated in the European North of the USSR. J.: Voprosy ichthyologii, v.26, vyp.5, pp.779-794 (in Russian).

AZBELEV V.V., 1960. On scientific research to enhance the efficacy of acclimation of the Far East salmons in basins of the White and Barents Seas. PINRO Scientific and Technical Bull., No.1(15), pp.15-19 (in Russian).

AZBELEV V.V., JAKOVENKO M.JA., 1963. Materials on acclimation of pink salmon in basins of White and Barents Seas. Trudy PINRO, vyp. 15, pp.7-26 (in Russian).

BAKSHTANSKY E.L., 1963. Surveying of migration of pink salmon and chum fry in the European North. Trudy PINRO, vyp.15, pp.35-43 (in Russian).

BAKSHTANSKY E.L., 1964. Impact of predators on pink salmon *Onchorhynchus gorbuscha* (Walb.) and chum Oncorhynchus (Walb.) fry in the White and Barents Seas J.: Voprosy ichthyologii, v.4, vyp.1(30), pp.136-141 (in Russian).

BERG M., 1961. Pink salmon (Oncorhynchus gorbuscha) in Northern Norway in year 1960. Acta Borealia.A.Scientia, v.17, p.1-23.

BERG M., 1977. Pink salmon, *Oncorhynchus gorbuscha* (Walbaum) in Norway. Rept.Inst.Freshw.Res.Drottingholm, v.56, p.12-17.

BIGELOV H.B., SCHROEDER W.C., 1953. Fishes of the Gulf of Maine. Fish Bull.Fish and Wildlife Serv.,v.53,No.74, 577 p.

BJORKNES V., VAAG A.B., 1980. The status of pink salmon in northern Norway. ICES CM. 1980/16, 11 p.

DJAGILEV S.E., MARKEVICH N.B., 1979. Time difference in maturation of pink salmon *Oncorhynchus gorbuscha* (Walb.) from odd and even years as a major factor which determined different results of its acclimation in the north of the European part of the USSR. J.: Voprosy ichthyologii, v.19, vyp.2, pp.230-245 (in Russian).

GRINJUK I.N., SHUSTOV JU.A., 1977. Biology of Atlantic salmon and juveniles of other fishes in the Ponoi river catchment. Trudy PINRO, vyp.32, pp.79-86 (in Russian).

GRINJUK I.N., KANEP S.V., 1977. Thermal conditions during acclimation of the Far East salmons in basins of the White and Barents Seas. Issues of fisheries oceanography of the world ocean. Murmansk, pp.51-53 (in Russian).

GRINJUK I.N., SALMOV V.Z., NEKLJUDOV M.N., 1981. Efficacy of natural production of pink salmon in the Ponoi river. Biological resources of the White Sea and inland waters in the European North, 23-25 January, 1980, Petrozavodsk, pp.125-129 (in Russian).

HUNTSMAN A.G., DYMOND J.R., 1940. Pacific salmon not established in Atlantic waters. Science, v.91. No.2367, pp.447- 449.

KAMYSHNAJA M.S., SMIRNOV A.I., 1981. Production of pink salmon introduced into basins of the Barents and White Seas. Contemporary problems of ichthyology. NAUKA Press, Moscow, pp.196-225 (in Russian).

KANEP S.V., 1981. Dynamics of run, spawning and biological parameters of pink salmon from rivers Umba and Sidorovka. Biological resources of the White Sea and inland waters of the European North, 23-25 January 1980, Petrozavodsk, pp.121-124 (in Russian).

KOZHIN N.I., 1940. Acclimation of the Far East salmonids. J.: Rybnoe khozjaistvo, No.3, 36 p (in Russian).

KRUPITSKY JU.G., USTJUGOV A.F., 1977. The pink salmon, Oncorhynchus gorbuscha, in the rivers of the north of Krasnoyarsk Territory. J.Ichthyol., v.17, pp.320-322

LEAR W.H., 1975. Evaluation of transplant of Pacific pink salmon (Oncorhynchus gorbuscha) from British Columbia to Newfoundland. J.Fish.Res.Board Canada, v.32, No.12, pp.2343-2356

MAGOMEDOV G.M., 1970. Results from study of acclimation of chum and pink salmon in the Caspian Sea. Trudy VNIRO, v.76, pp.153-159 (in Russian).

MARKEVICH N.B., DJAGILEV S.E., AGAPOV V.S., 1978. Development of local populations of pink salmon in the European North of the USSR /southern coast of the Kola peninsula/Biology of salmonids. Thesis of paper at the quadrilateral international conference / USSR, USA, Canada, Japan/, Juzhno-Sakhalinsk, October 1978, Vladivostok, pp-16-18 (in Russian).

NEKLJUDOV M.N., ENDALTSEV N.V., 1981. Dynamics of run and biological structure of pink salmon in the Ponoi river. Biological resources of the White Sea and inland waters of the European North, 23-25 January 1980. Petrozavodsk, pp.118-121 (in Russian).

NIKOLSKY G.V., 1952. On the type of stock dynamics and nature of spawning of pink salmon *Oncorhynchus gorbuscha* (Walb.) and chum *O.keta* (Walb.) in the Amur river. Reports of the USSR Academy of Science, v.86, No.4, pp.873-875 (in Russian).

PRAVDIN I.F., 1966. Guidelines on fish research (mainly freshwater), Moscow, 376 p. (in Russian).

PYEFINCH K.A., 1962. Capture of pink salmon on the Scottish coast. Ann.Biol., v.17 (1960), p.238.

RADZIUN K., STANKOWSKA-RADZIUN M., 1976. Jorbuszagosc z Dalekiego Wschodu w Balbyku Iospod rybna. v. 28, No.7, pp.18-19.

SCOTT W.B., CROSSMAN E.Y., 1973. Freshwater fishes of Canada. Bull.Fish.Res.Board Canada, No.184, pp.1-966.

SHAVERDOV R.S., BERIDZE I.O., DOLIDZE E.P., NINUA N.SH., URUSHADZE A.G., 1962. On acclimation of pink salmon in the basin of the Black Sea. Papers of research station of Georgia, v.7, pp.61-67 (in Russian).

SMIRNOV A.I., 1975. Biology, reproduction and development of the Far East salmons. Moscow, MGU Press, 336 p. (in Russian).

SMIRNOV A.I., 1994. Ecological approach to experiments with pink salmon and chum in basins of the Barents and White Seas. Sytematics, biology and biotechnology of breeding of salmonids. Materials of the Vth Russian conference, St.Petersburg, pp.181-183 (in Russian).

VEDENSKY A.P., 1954. Pink salmon age and regularities of variation of its abundance. TINRO News, v.41, pp.111-195 (in Russian).

WILLIAMSON R.B., 1974. Further captures of pink salmon in Scottish waters. Scott.Fish.Bull., v.41, pp.28-30.

Table 1. Results of acclimation of pink salmon on the Kola Peninsula in the period 1956 to 1997

Year of hatching/ stocking	Number of hatched eggs, import from Far East, mill.	Number of fry stocked, mill.	Number of hatched eggs local production, mill.	Number of fry stocked, mill.	Adult count, thou.	Year of return
1956/1957	9,8	3,5	-	-	-	1958
1957/1958	6,4	6,2	-	-	-	1959
1958/1959	17,2	15,4	-	-	76,3	1960
1959/1960	15,4	14,4	-	-	2,8	1961
1960/1961	12,1	10,4	2,34	0,01	0,1	1962
1961/1962	38,5	34,3	0,24	0,21	0	1963
1962/1963	24,7	23,7	0,05	0	1,9	1964
1963/1964	44,0	35,9	-	-	47,8	1965
1964/1965	-	-	0,08	0,04	0	1966
1965/1966	-	-	0,09	0,03	2,4	1967
1966/1967	-	-	-	-	0	1968
1967/1968	6,3	5,0	-	-	0,1	1969
1968/1969	10,0	6,0	-	-	0,4	1970
1969/1970	10,6	7,3	-	-	27,8	1971
1970/1971	5,3	4,0	0,06	0	1,7	1972
1971/1972	8,0	4,2	0,17	0	143,6	1973
1972/1973	4,9	3,5	0,10	0	9,9	1974
1973/1974	-	-	2,28	0,94	103,9	1975
1974/1975	5,5	3,4	0,13	0	2,6	1976
1975/1976	5,0	5,0	1,13	0,15	107,7	1977
1976/1977	5,0	4,7	0,32	0	3,5	1978
1977/1978	5,0	4,9	1,44	0,68	22,6	1979
1978/1979	5,0	4,4	-	-	0,04	1980
1979/1980	-	-	0,2	0,07	0,13	1981
1980/1981	3,3	3,1	-	-	0,03	1982
1981/1982	3,1	0,24	-	-	0,04	1983
1982/1983	-	-	-	-	single	1984
1983/1984	-	-	-	-	single	1985
1984/1985	0,7	0,4	-	-	0	1986
1985/1986	2,3	1,0	-	-	2,54	1987
1986/1987	10,0	0,1	-	-	0	1988
1987/1988	-	-	-	-	33,5	1989
1988/1989	-	-	-	-	0	1990
1989/1990	4,0	?	0,1	0,07	66,1	1991
1990/1991	-	-	-	-	0	1992
1991/1992	-	-	-	-	31,6	1993
1992/1993	-	-	-	-	0	1994
1993/1994	-	-	0,57	0,32	29,6	1995
1994/1995	-	-	-	-	0	1996
1995/1996	-	-	0,99	0,55	98,3	1997
1996/1997	-	-	-	-	0	1998
1997/1998	-	-	0,93	0,5		1999

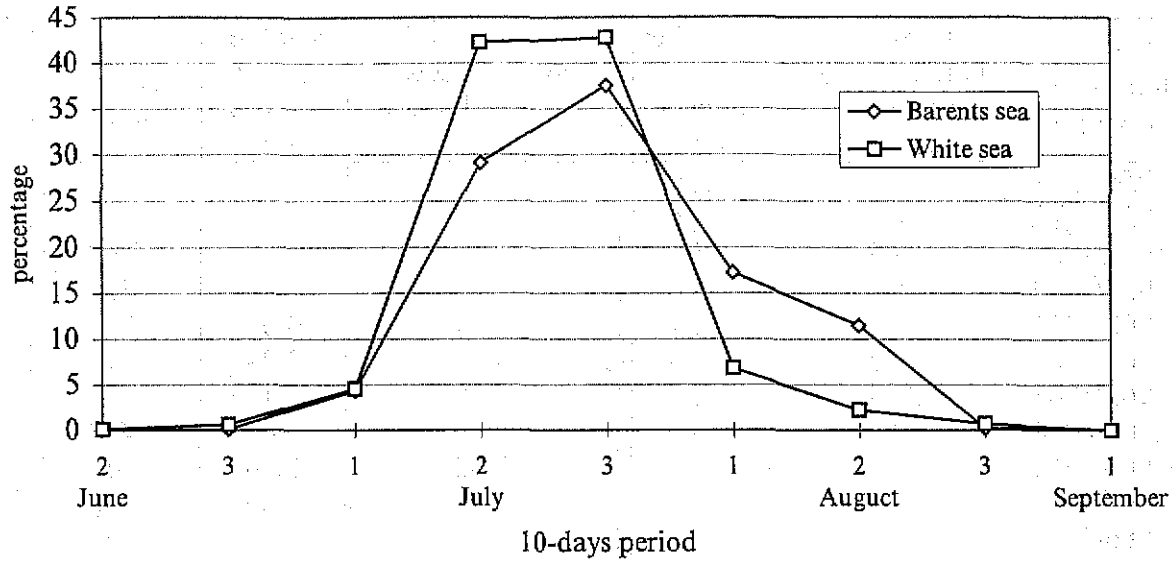

Fig. 1. Dynamics of pink salmon run into rivers
of the Kola Peninsula in 1989-1997

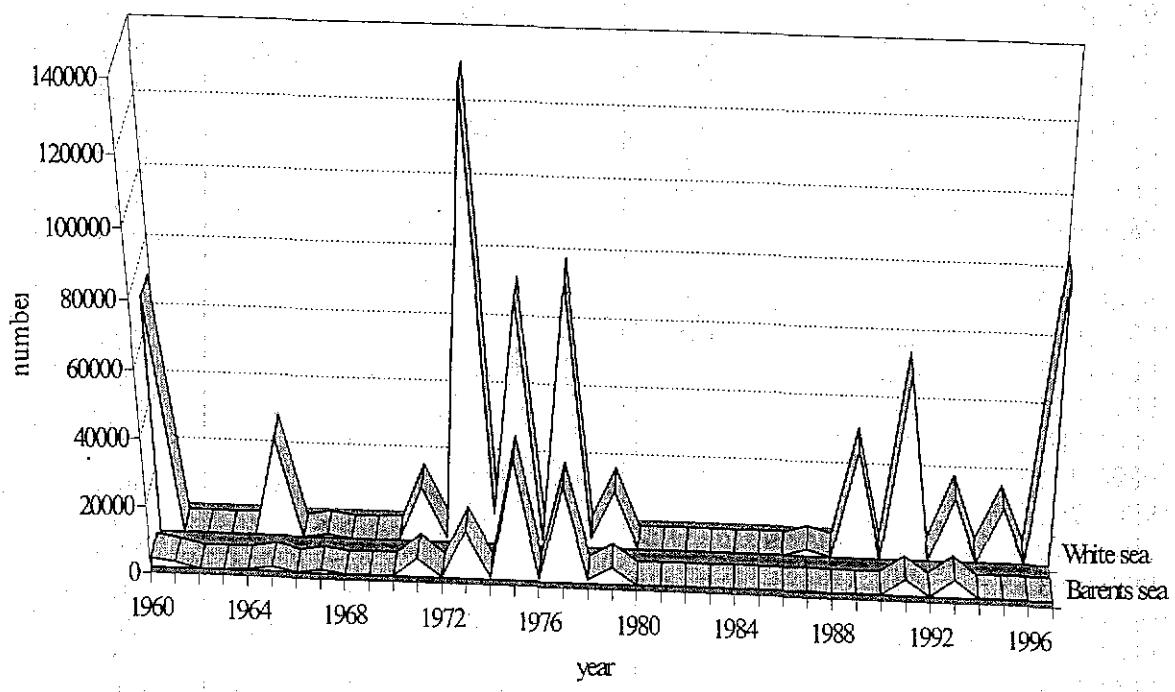

Fig. 2. Catch of pink salmon in rivers and coastal zone
of the Kola Peninsula in 1960-1997

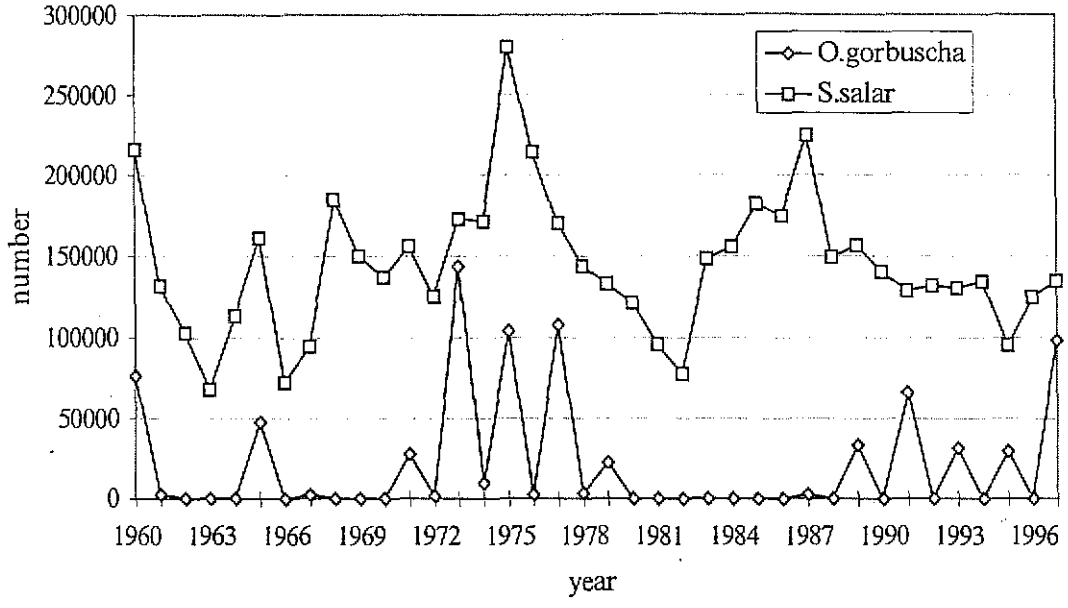

Fig. 3. Dynamics of abundance of Atlantic salmon
in 1960-1997

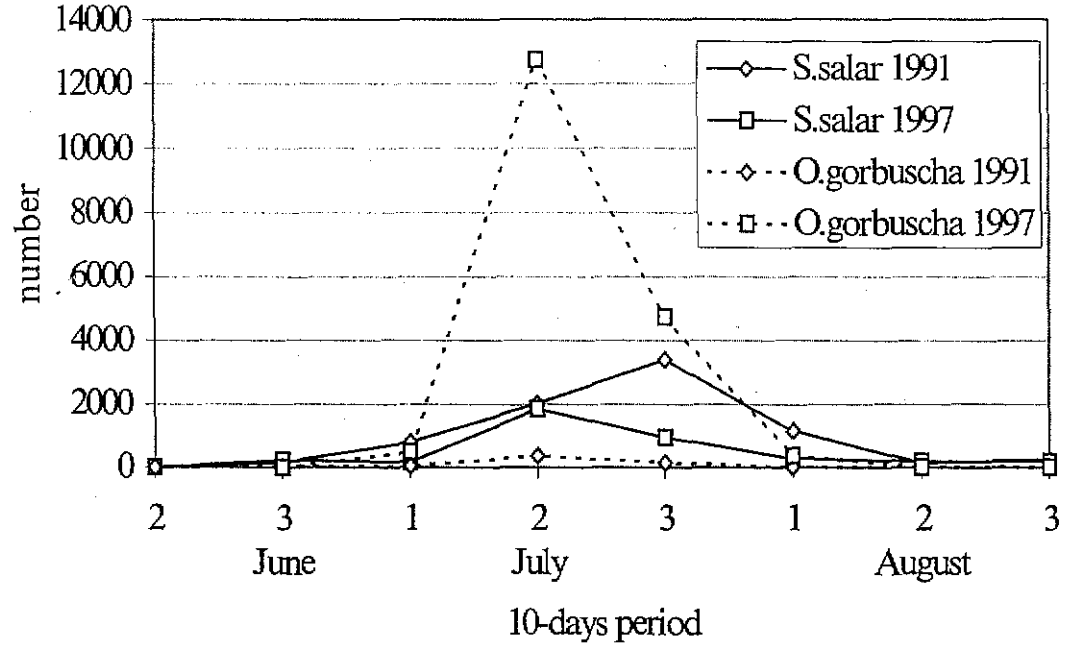

Fig. 4. Dynamics of Atlantic salmon and pink salmon run
into the Varzuga river in 1991 and 1997 rr.