Pink salmon in the Barents region

With special attention to the status in the transboundary rivers Tana and Neiden, rivers in North West Russia and in East Canada

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Office of the Finnmark County Governor
Department of Environmental Affairs
Report 3 – 2016

The REPORTs from the Office of the Finnmark County Governor, Department of Environmental Affairs presents results from different works relevant for the mentioned department. The main aim is to document and to disseminate information on important environmental issues to a broader audience.

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ISSN 0800-2118

Report no. 3-2016 is mainly published on the internet www.fmfi.no under "miljø og klima" and "Rapportserie". Hard copies are produced after request.

Printing/ layout: Fylkesmannen i Finnmark

For more information concerning this publication contact:

Fylkesmannen i Finnmark
Miljøvernavdelinga
Statens hus
9815 VADSØ

Cover photo: Two pink salmon caught in the river Neiden with käpälä-seine method. The silvery pink has just arrived into the river and the a little brownish pink has been in the river c. 1-2 weeks. Photo Eero Niemelä

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Key words: Pink salmon, *Oncorhynchus gorbuscha (*Walbaum), Pukkellaks/rysselaks, transboundary rivers Tanaelva/Tenojoki and Neidenelva/Näätämöjoki, Kola Peninsula, East Canada, history, distribution, catches and ecology 1972–2015

Writing of the report was supported financially by the Norwegian Ministry of Climate and Environment and the Natural Resources Institute Finland (Luke) and by the working effort of the participating organizations.

Contents

Summary

Pacific pink salmon (*Oncorhynchus gorbusha*, Walbaum) also known as humpback salmon and in Norwegian called *"pukkellaks or rysselaks*". This is a fish species introduced into the rivers which are draining into the Barents Sea and White Sea in Kola Peninsula in northwest Russia. Pink salmon originates from the Pacific Ocean where it occurs in the rivers and at sea on both sides of the Ocean, in Asia and America. Most of it is caught at sea and it is the most important catch in terms of numbers from Pacific salmon species in the Pacific Ocean.

After spawning all adult females and males die. Eggs are hatching the following spring, and smolts are leaving the river during their first summer. Pink salmon matures the following year and migrates back to its home river to spawn, thus life time from spawning to the spawning of the next generation takes only two years. There are stocks which are spawning in odd years and stocks that spawn in even years. The abundance of odd year spawners is usually higher than that of the even year spawners.

Chum salmon introductions in northwest Russia was initiated for the first time in the thirties (1933–1939) but due to the negative results the work was stopped. Later, for the second time the introductions were initiated in the year 1956 and continued to the year 1978, with eggs originated from rivers in the Russian Pacific; Sakhalin and Kamchatka. The eggs were then hatched in Kola Peninsula. A total of over 220 million ova were involved, resulting in the release of 187 million fry and the annual numbers of released smolts exceeded 36 million.

The reason for the introductions was the acclimatization of pink salmon in the Barents and White Sea basins to increase fish production at sea as well as in the rivers. Economic reasons have earlier supported transplanting because the catches of pink salmon grew tremendously being much larger than catches of Atlantic salmon in White Sea area.

Releases of pink salmon fries continued after the year 1978 with variable amounts. The earlier pink salmon stocks conducted in the years 1956-1979 originated mainly from Sakhalin Island and in small amounts from northern rivers in Kamchatka. These introductions failed to make self-reproducing pink salmon stocks because they inherited the trait to spawn too late in the autumn when the approaching winter led to mass mortality of developing embryos in the Kola Peninsula rivers. The selection of a new pink salmon population in the year 1985 from the river Ola (Magadan population) as a donor for introduction of eggs from the odd year stock resulted in the self-reproducing population.

Pink salmon is genetically adapted to migrate and live at sea in the Pacific Ocean. Its migratory behaviour and homing instinct is not as exact in the introduced new areas in the North Atlantic and Barents Sea, as in the original distribution areas. Therefore pink salmon has also migrated to the rivers which are far away from their new home rivers in northwest Russia.

In the latest decades, pink salmon has been occurring in the catches in almost all of the salmon rivers in Finnmark in Norway including also the Finnish areas in the river Neidenelva and Finnish tributaries in the river Tana. Pink salmon not only returned to the rivers in which they had been introduced/ released, but also spread into Norwegian rivers. In the year 1960 there were reports of their presence in more than 40 rivers in Northern Norway. A number of spawning fish were also observed in many rivers in Northern Norway. In some rivers catches have been only sporadic but in some rivers pink salmon is occurring nowadays annually. Pink salmon is also caught in Spitsbergen, Iceland, Scotland and England.

In Russia the numbers of adult pink salmon returning increased each year and some self-reproducing populations developed. In the year 1960 pink salmon ascended into 23 rivers in Kola Peninsula with the numbers of 66 110 fish in the catches. Pink salmon has also established self-reproducing stocks in northwest Russia in many of the rivers draining into the White Sea.

Difference in the spawning time keeps Atlantic salmon and pink salmon separated from each other in the same spawning grounds. Spawning pink salmon in Barents Sea rivers die before Atlantic salmon starts spawning and therefore there is not simultaneous competition on the same spawning sites between these two species.

Sea temperatures in the coastal areas show clear annual fluctuations with periods of warmer and colder years. The survival of pink salmon smolts highly depends on the temperatures in July and August. There is a clear increase in the monthly sea temperatures since the end of 1970s' which is especially observed in the winter temperatures in the Kola section. Warmer sea water in the Varangerfjord might have affected the possible establishment of self-reproducing pink salmon stocks in some of the rivers in Northern Norway.

Pink salmon has been occurring in the entire Tana mainstem up to the confluence of Anárjohka and Kárášjohka. After this point pink salmon can migrate into the large tributary Kárášjohka and its sidestream Iešjohka. In the river Iešjohka pink salmon has been caught below the waterfall Iešjokgårzi. Sporadic catches of pink salmon has been reported from many tributaries in the river Tana system.

During the period of 2004-2015 altogether 330 pink salmon was reported to be caught in the river Tana watershed in Norway. That makes an average of 28 pink salmon annually in the catch. Most (95%) of the fish were caught in the river Tana mainstream, where the highest number of pink salmon was caught within the lowest 40 km (46%) stretch.

In the river Neidenelva pink salmon can ascend the big fall, Skoltefossen, located c. 11 km from the estuary, migrating through the entire Norwegian area and entering up to the uppermost riffles in the headwater close to the Lake Opukasjärvi on the Finnish side. Reported catches in the river Neidenelva in recent years have been quite low.

It is well known and also partly documented that pink salmon has been occurring in the catches in most of the rivers in Finnmark and overall in the coastal and fjord areas in the bagnet and bendnet fishery. Pink salmon has been caught in both small and larger rivers.

High occurrence of pink salmon was latest observed in the years 2007 and 2009 in some of the East Finnmark rivers. Pink salmon occurrence has been documented by diving in the lower stretches of the rivers Karpelva, Neidenelva, Vestre Jakobselva and Komagelva. In these diving surveys there has been found from ten to more than one hundred pink salmon within a limited area of the river. High number of pink salmon in the lower sites of the river Vestre Jakobselv in the year 2007 resulted in the year 2008 to pink smolt migration. This confirmed that pink salmon can spawn successfully and eggs can develop to smolts. In the rivers in Finnmark, however, it is not known the total numbers of pink salmon population because the surveys which have been done tell the population size only within a very limited river stretch. In some rivers in Finnmark like in the rivers Kongsfjordelva, Repparfjordelva and Stabburselva observations do not confirm large numbers of pink salmon populations inhabiting the rivers so far. The data from diving surveys confirms that the occurrence of pink salmon is more frequent than which can be found from official catch statistics.

Pink salmon catches reached the highest values in the rivers in Finnmark in the middle of 1970s'. Reported pink salmon catches might have been highly underestimated over the years in most of the rivers in Finnmark and in the coastal area. Catches occurring in odd and even years indicates that the introductions with both of those stocks have been successful in the rivers in Barents Sea and in White Sea. In the river Tana pink salmon was caught in 1977 all over in the mainstem and in most of the tributaries as far up as in the river Iešjohka, Kárášjohka and Anárjohka which are 250- 300 km from the Tana river mouth. In the year 2007 pink salmon ascended into many rivers in Finnmark.

Migrations into the rivers Tana and Neiden takes place mainly from the middle of June to the end of July having a peak in the weeks 27-29 coinciding with the Atlantic salmon migration. Females are entering a little before than the males in the rivers Tana and Neiden. The proportion of females has been slightly smaller than 50% from the catches in the river Tana. Annual mean sizes clearly differ between the years and these differences can be caused by the changes in the seawater temperatures.

All transplanting of pink salmon in northwest Russia have been ceased since the year 2001 and onwards and therefore the catches after that time in the rivers and at sea in Barents Sea region are originating from self-reproducing stocks in a number of White Sea rivers and in some rivers in Barents Sea.

This report presents the most detailed and comprehensive data from pink salmon collected in Norway and Finland from the rivers Tana and Neidenelva. The report highlights the main results from the newest scientific article written on the acclimatization (Gordeeva *et al.* 2015) and on the ecology and migrations (Zubchenko *et al.* 2004) of pink salmon in White Sea rivers. This report includes also the most comprehensive information on the distribution of pink salmon in the rivers in North West Russia (Veselov, personal information). The report also includes data from the acclimatization of pink salmon in rivers in East Canada.

Photo 1. Mikhail Yakovenko is trapping pink salmon smolts in one of White Sea rivers early 1970s'. Fence is closing the entire river and smolts are collected into the small trap boxes during the entire migration period. There was intensive long-term monitoring on the acclimatization of pink salmon combined to the smolt releases in Kola Peninsula in Russia. Many research reports and scientific articles have been published In Russia over the 55 years. These publications have included wide variety of genetic studies as well as basic ecological and behavioural surveys. Dr. Mikhail Yakovenko was a Head of salmon laboratory at PINRO from the year 1969 to the year 1975. Salmon laboratory was established in the year 1969. Photo; PINRO, photographer is unknown.

Photo 2. Pink salmon trap in June in the year 2003 in the river Indera flowing into White Sea in Russia. Trap is catching descending smolts and ascending adult pink salmon. Photo: I. Bachmet.

1. Introduction

Human activities cause plant and animal species to become introduced to areas they could not have reached by natural dispersal. In some cases it is cultivated or domesticated species that escape after some time and establish viable populations in the wild (Anon. 2000).

Pacific pink salmon (*Oncorhynchus gorbusha,* Walbaum) is a new fish species introduced into the rivers which are draining into the Barents Sea and White Sea in Kola Peninsula in northwest Russia. Pink salmon originates from the Pacific Ocean where it occurs in the rivers on both sides of the Ocean, in Asia and America. It has a simple life history; after spawning all adult fish die, eggs are hatching the following spring; smolts are leaving the river during their first summer; pink salmon is maturing the following year and migrating back to its home river to spawn. Pink salmon is genetically adapted to migrate and live at sea between 35º–60º northern latitudes in the Pacific Ocean. Therefore, its migratory behaviour and homing instinct at sea might not be as exact or the same in the introduced new areas at more than 70º northern latitudes in the North Atlantic and Barents Sea (Berg 1961). Consequently, pink salmon has migrated also to the rivers which are far away from their new home rivers in northwest Russia. Pink salmon has been occurring in the latest decades in the catches in almost all the salmon rivers in Finnmark in Norway including also the Finnish areas in the river Neidenelva and Finnish tributaries in the river Tana. In some rivers catches have been only sporadic but in some rivers pink salmon is occurring nowadays annually. Both Zubchenko *et al.*(2004) and especially Gordeeva *et al.* (2015) are confirming that pink salmon has established self-reproducing stocks in northwest Russia in many rivers draining into White Sea.

The pink salmon introductions that started in the year 1956 with transporting eggs from Russian Pacific rivers to Kola Peninsula. There was, however, some introductions of fall run chum salmon eggs in the years 1933–1939 from Pacific Amur River to White Sea area but it was not successful. The reason for the introductions was according to Dushkina (1994) the acclimatization of pink salmon to the Barents and White Sea basins and thereafter improves the fisheries economy. There are some reports on the success of the acclimatization but Dushkina (1994) made the first main conclusions from the 36 years long investigations. Pink salmon established self-reproducing stocks after many years of effective introduction in many White Sea rivers (Gordeeva *et al.* 2004; Gordeeva *et al.* 2015). Similarly to many other introductions of new plant or animal species to new geographical areas, pink salmon has established self-reproducing stocks especially in the White Sea rivers and maybe also into some rivers in Finnmark county, Northern Norway.

The question arise, are these kinds of transplanting necessary, if there already exist an endemic migratory fish species, in healthy population condition. However, transplanting of pink salmon has been argued that there is still an ecological niche in the rivers for pink salmon because it does not compete with wild Atlantic salmon in juvenile and adult phases. At least this kind of competition has not so far being proved in the Barents Sea area. But, there can be future negative impacts from pink salmon to wild Atlantic salmon i.e. due to parasites, diseases or some unknown reasons which we don't recognize at the moment. Scenarios of pink salmon when occurring in large quantities in some rivers can transmit virus or bacteria which can cause diseases in Atlantic salmon. Pink salmon can be infected by diseases when migrating through coastal areas in Northern Norway and in Northwest coast in Kola Peninsula where intensive cage rearing of Atlantic salmon exists. After ascending rivers pink salmon can carry these unwanted viruses and bacteria and outbreak of disease can take place in wild salmon populations. Usually Atlantic salmon as well as pink salmon are gathering in river pools and other deep areas, and there they are in close contact to each other in July and August. When the global air temperature is increasing then also the water temperature is increasing in northern rivers. This change in the river environment can increase the stress in Atlantic salmon and pink salmon in fresh water followed by outbreak of disease.

The main argument in transplanting has been to increase fish production especially in White Sea fishery. Pink salmon has also been an additional target for the rod fishery in the Kola Peninsula rivers. The tourist fishery in Kola Peninsula initiated with offering pink salmon fishing possibilities in the end of 1980s' for example in the river Kolvitsa, in White Sea basin. Economic reasons have earlier supported these huge transplanting activities because the catches of pink salmon grew tremendously being close to Atlantic salmon catches in some sites in White Sea area. Many recreational fishermen fishing in northern rivers, however, are more interested in to catch wild Atlantic salmon rather than introduced pink salmon. If pink salmon is establishing large, self-reproducing stocks into even more rivers draining into Barents Sea in Northern Kola Peninsula and in the coast of Finnmark this can result to negative impacts in the tourist fishing, which has been developed during the last two-three decades to catch mainly Atlantic salmon. The rod fishery can develop to less attractive if the main catch would be small pink salmon and not pure and large Atlantic salmon. From biological and ethological (=fish behaviour) point of view it is not recognized how Atlantic salmon will behave in the rivers where there is high abundance of pink salmon in July and August in the same stretches of the rivers. Atlantic salmon is moving already in August close to those stretches in rivers where they are going to spawn in the end of September or later in October and in the same sites pink salmon is spawning in the middle of August and dying there rather soon after reproduction.

Earlier Norwegian researchers Berg (1961, 1977) and Bjerknes (1977a) were worried about the possible negative impacts of pink salmon to wild Atlantic salmon. There has, however, not been done any scientific research in Norway from the possible interactions etc. between Atlantic salmon and pink salmon. Some reports have been published in recent years from the numbers of pink salmon in some rivers in Finnmark (Muladal 2009). The catches of pink salmon in Norway are nowadays reported from the river fishery, but data from coastal bagnet and bendnet fishery is not available because the catch of pink salmon has not been asked from the fishermen. Pink salmon catch is most probably included into Atlantic salmon catches at sea and in some of the rivers. All the transplanting of pink salmon in Northwest Russia have been ceased since the year 2001 and onwards, and therefore the catches after this time are originating from self-reproducing stocks in a number of White Sea rivers.

This report presents the most detailed and comprehensive data from pink salmon collected in Norway and Finland from the rivers Tana and Neidenelva. This report also includes some of the main results from the newest scientific articles including acclimatization, migration and ecology of pink salmon in White Sea rivers (Zubchenko *et al.*2004; Gordeeva *et al.* 2015). The collection and analysis of the biological data from the Tana and Neidenelva rivers has been funded by Finnish Game and Fisheries Research Institute (RKTL, since 2015 Luke); The Office of the Finnmark County Governor (FMFI); Laksebrev organization for the River Tana (LBT); Tanavassdragets Fiskeforvaltning (TF) and Neiden Fiskefelleskap. The Norwegian Ministry of Climate and Environment and Natural Resources Institute Finland (Luke) funded the work to compile this report. Cooperation with PINRO Institute (Murmansk, Russia) and with the Institute of Biology, Karelian Research Centre, Russian Academy of Sciences (Petrozavodsk, Russia) made it possible to combine into this research report some of the newest and most interesting results published in Russia on pink salmon in White Sea and Barents Sea. The Office of the Finnmark County Governor provided working facility in Vadsø.

Photo 3. Collection of pink salmon smolts in one White Sea river. Photo: A. Veselov

2. General information on the Pacific salmon genus Oncorhynchus

There are several species of Pacific salmon belonging to the genus *Oncorhynchus* (Figure 1). Originally they have been occurring only in the rivers draining into the Pacific Ocean and Arctic sea. They are anadromous fish: that means they are born in freshwater, spend their adult lives in the sea, and return to the rivers or lakes where they were born when they are ready to spawn. All these migratory (anadromous) Pacific salmon species die after spawning.

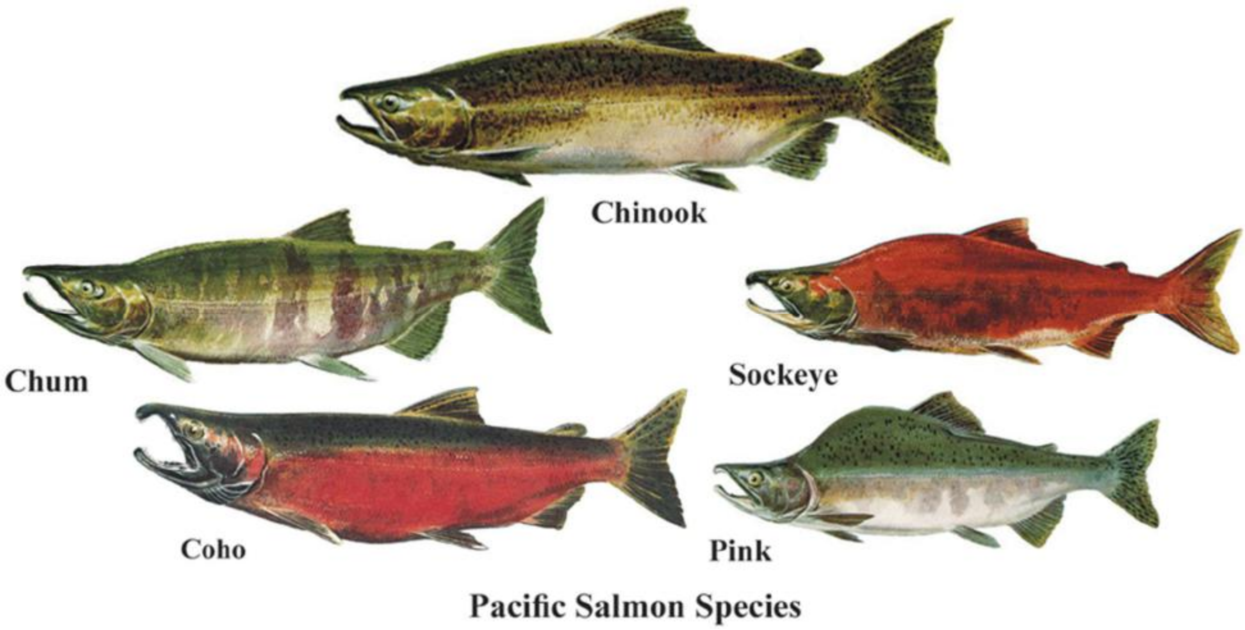


Figure 1. Five most common Pacific salmon species. Pink salmon has been introduced as a new species into Northwest Russia, Kola Peninsula rivers. Source; Internet Plates from U. S. Fish & Wildlife Service

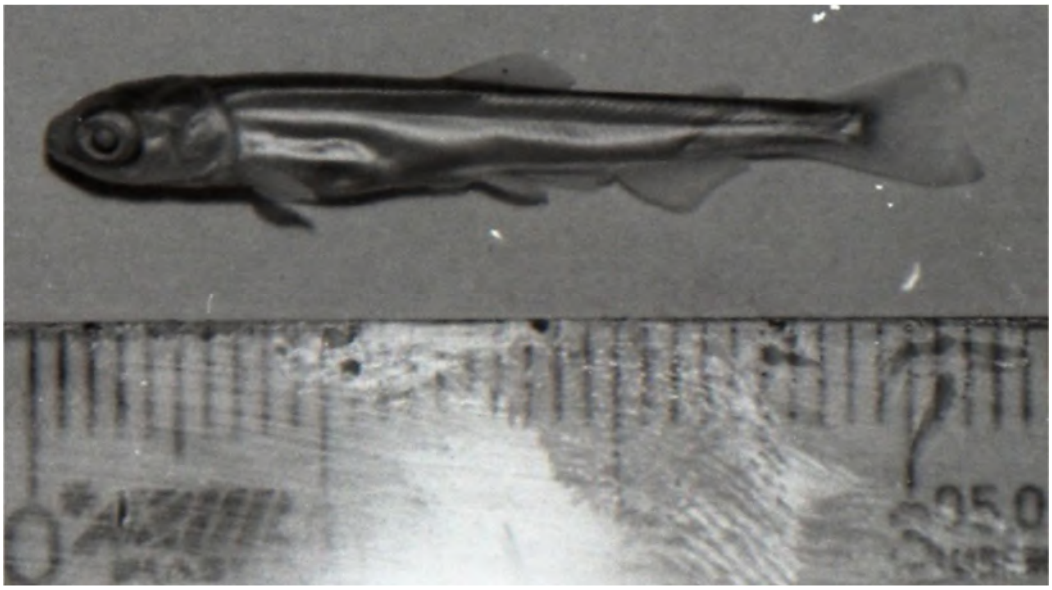


Photo 4. Tiny, silvery pink salmon smolt with the length of 3 cm is leaving the Neidenelva soon after emerging from the spawning nest. After one full year it is migrating back to the river for spawning in the weight of up to 4 kg. Photo Vilhelm Bjerknes

Photo 5a on the left. All pink salmon die during the period between the end of August and middle of September in Barents Sea rivers like this male fish in one of the Tana river tributaries. Photo Truls Halvari.

Photo 5b on the right. Short life history ends to the place of birth for pink and chum salmon. Dead chum salmon are from the Noatak River in Alaska. Photo Narve S. Johansen.

2.1 Pink salmon *Oncorhynchus gorbuscha*

Oncorhynchus gorbuscha (Walbaum), pink salmon (pukkellaks or rysselaks in Norwegian) known as humpback salmon. Also known as humpies, due to the very large hump the males get just behind their heads, during the spawning phase (Figure 2). Pink salmon lives one and half sea summers (first summer when they are migrating to the sea for feeding and the second summer when they are returning to their home river to spawn) and has the simplest and least varied life history. Some but very few pink salmon have two and half sea summer life histories. It has been found also some male pink salmon which have stayed at sea only one summer and then returned into the river to spawn in the sea age of 0+ (Ivankov *et al*. 1975). Pink salmon spawn as two-sea year-olds (age 1+) in both large and small river systems. There are mainly odd year stocks but some even year stocks are also occurring. When the young hatch and emerge from the gravel the following spring, they drift downstream to the sea. The usual length is c. 3-4 cm. In some few rivers pink salmon smolts can reach the length of up to 7 cm during their first river summer. The year and a half of ocean growth is rapid. A typical weight is from 1.3 to 2.3 kg. In the Pacific Ocean the average weight of a mature pink salmon is 2 kg and a few can come up to 4.5 kg. Though they are the smallest of the *Oncorhynchus* species, they are the most abundant in number. They spend the shortest amount of time in freshwater, spawning in two year cycles very close to the mouth of streams with little to no upstream migration. In the ocean they appear to have steel blue to blue green backs, silver sides, and a white belly with large oval spots covering their back, adipose fin and both lobes of the caudal fin. During the spawning phase pink salmon have dark backs with a pinkish wash and green blotches on their sides. It can be distinguished easily from Atlantic salmon by large oval spots on the back and both lobes of the tail fin. It has been occurring in North America from Klamath River to northern Alaska, but scarce below Puget Sound. It is abundant in British Columbia and Alaskan rivers. Found in Mackenzie River emptying into Arctic. In Russia it occurs originally from Bering Strait along the coast of Asia as far south as Korea. It occurs also in the rivers Kolyma, Irdigirka, Lena and Yana.

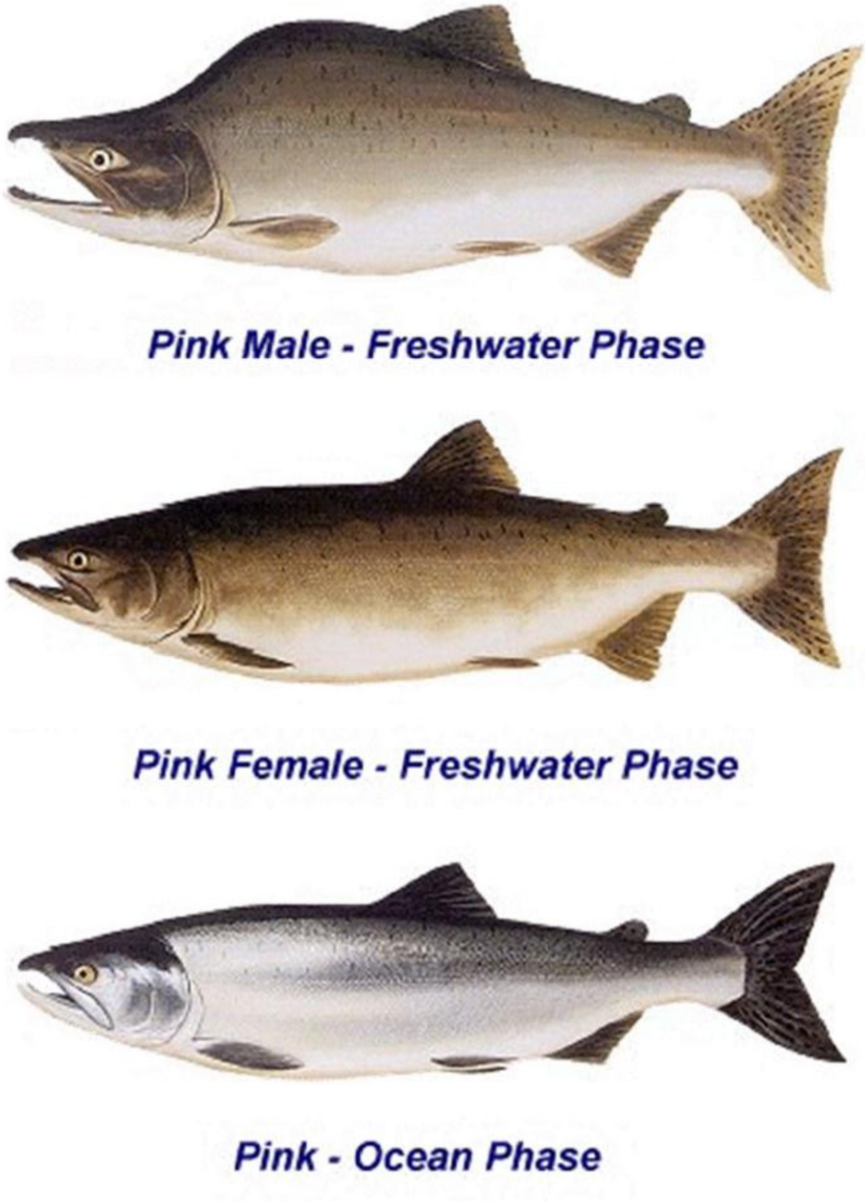


Figure 2. Pacific pink salmon (Oncorhynchus gorbuscha) and its ocean and freshwater phases. Very large spots on the back and large black oval blotches on both tail lobes. Very small scales. Spawning adults take on a dull gray coloration on the back and uppside sides with a creamy white color below. Males develop a pronounced hump.Source; Source; Internet; Plates from U. S. Fish & Wildlife Service

2.2 Keta salmon *Oncorhynchus keta*

Oncorhynchus keta (Walbaum) keta salmon (ketalaks and/ or hundlaks in Norwegian), also known as chum salmon, dog salmon and silverbright or calico salmon (Figure 3). Chum comes from a word meaning variegated coloration in the native language. In the Pacific Ocean chum arrive in coastal streams in late fall, although there are also summer chum that runs to northern British Columbia streams as early as July. Most populations reproduce near the mouth of their stream. Spawning fish of this species do not usually travel far inland to spawn. One exception is the Yukon River chum, which travel some thousand kilometres upstream before stopping to spawn. Like the young of the pink salmon, chum start for the sea almost as soon as they emerge from the gravel as fry. The chum reaches maturity in the third or fourth summer at a size ranging between 3.5 and 4.5 kg. These fishes generally live 3-5 years. Fish is silvery on the sides, shading to metallic dark blue on the back. It has faint purple bars on the sides. When in the ocean they are metallic, greenish-blue along the back with black speckles which closely resemble sockeye and coho. During the spawning phase males get vertical bars in reds, greens, and purples, while females get a black horizontal stripe. The typical weight of the fish is from 3.5 kg to 7 kg. They have the most widely distributed population and the greatest biomass. They are the second largest Pacific salmon (following the Chinook). The species occurs in North America from San Francisco Bay to Bering Strait but not numerous south of the Puget Sound. Most numerous occurrence is on the Arctic coast of Alaska, east of the Mackenzie river. In Russia keta salmon is occurring in the rivers of Siberia in the Arctic Ocean, west to the river Lena, and in the Pacific Ocean especially in the Amur River. The chum occurs also
in Japan and Korea.

Photo 6. Chum salmon (Oncorhynchus keta) caught by Eivind Høstmark Borge in River Noatak, Alaska. Chum salmon was also released in smaller amounts into Barents Sea area in the years 1933–1939 and some were caught in the Tana River in the year 1965. Photo: Narve S. Johansen

Photo 7. Chum salmon are caught by recreational fishermen ”just for fun” in the rivers later in the season. Chum salmon are caught by professional fishermen in the coastal areas in Pacific area. Photo: Narve S. Johansen

Figure 3. Pacific salmon, chum (Oncorhynchus keta) and its ocean and freshwater phases. Dull gray back with yellowish-silver sides. No distinct spots on back or tail. Large eye pupil-covers nearly the entire eye. Spawning adults develop olive green coloration on the back with maroon sides covered with irregular dull red bars. Males exhibit many large canine-like teeth. Source; Internet; Plates from U. S. Fish & Wildlife Service

2.3 Other Pacific salmon species

The other Pacific salmon species are:

Oncorhynchus tshawytscha, chinook salmon also known as king salmon and blackmouth weighing from 4.5 kg to 22.5 kg. It is occurring in Russia, North Asia and in North America.

Oncorhynchus kisutch, coho salmon also known as silver salmon. It is occurring in Russia, especially in Kamchatka, the fish does not enter into the Arctic Ocean. It is occurring in the rivers along the Pacific coast. It occurs in Pacific rivers in USA and Canada.

Oncorhynchus nerka, sockey salmon also known as red salmon and blueback. It is found in coastal rivers as far north as the Anadyr and as for south as southern Kamchatka and northern Kuriles. In Northern America it occurs from Klamath River in California to Alaska. It is rare in the Bering Strait and does not enter into the Arctic Ocean.

Oncorhynchus masou, cherry salmon. It is occurring on the western side of the Pacific Ocean from the mouth of Amur to Pusan River in Korea. It is abundant in Japanese rivers.

Oncorhynchus myciss, rainbow trout, steelhead trout. It occurs in numerous rivers from Alaska to northern California.

Photo 8. Many fishermen cannot recognize this kind of fish to be pink salmon. They think it is sea char or a small one-sea-winter salmon. Photo Eero Niemelä

3. Historical introduction and transfer activities of pink and chum salmon

Mills (1989) with numerous referees is describing the introduction of pink salmon as follows: “In Europe early attempts were made to establish various Pacific salmon species. Introductions of chinook salmon were done to the United Kingdom between 1872 and 1880, to France (1872-1900), Germany (1872-1900), Ireland (1891-1900), the Netherlands (1872-1930) and Finland (1930s). Sockey salmon have been released into lakes in Russia and Sweden. The two most popular species of Pacific salmon for release into European waters have been pink and coho salmon. In addition the chum salmon has been introduced to the rivers in the Murmansk region in Russia”.

Childerhose &Trim (1981) are writing: “In the late 1800s millions of chinook, sockeye, pink, and coho salmon eggs were planted in streams in Europe, Hawaii, Australia, New Zealand, Argentina, Chile, Mexico, and Nicaragua. Even greater transfers were made from western North America to the streams of eastern Canada and the United States. Of all the transplantings of Pacific salmon made in these early years, only the chinook and sockeye taken to New Zealands’s South Island can be said to have been successful, although the seagoing sockeye run changed to the landlocked kokanee. Chinook and sockeye thus became the first Pacific salmon to establish themselves in the southern hemisphere”.

Photo 9. Ivan Grinyuk (on the right) with his research team is collecting and studying the development of pink salmon embryos and alevins in some river in Kola Peninsula.Grinyuk acted as a Head of salmon laboratory at PINRO from the year 1975 to the year 1980 when a active phase of pink salmon introduction occurred.

Between 1956 and 1978 large numbers (up to 36 million a year) of pink salmon ova were transferred late October– early November from the Pacific (from Sakhalin Island in the years 1956-62, 67–72, 74–78, 80–81; from Kuril 1960–1962, 67, 72) to the Kola Peninsula (Table I)(Berg 1961; Berg 1977; Bakshtansky 1980; Dushkina 1994; Zubchenko *et al.* 2004). Numbers of eggs from Sakhalin were 199 milj. A total of over 220 million ova were involved, resulting in the release of 187 million fry. Eggs from some other pink salmon stocks (from Kuril Island 46 milj; Kamchatka 2.1 milj.; Magadan 0.5 milj.) were also introduced to Kola Peninsula (Kuzmin & Zubchenko 1993) (Figure 5). According to Dyagilev and Markevich (1979) there was intensions to make introductions with pink salmon and keta (chum) salmon with the annual releases of 9.5 million and 15.5 million eggs, respectively, into the rivers in Barents Sea and White Sea areas. Eggs were incubated mainly in the hatcheries in Murmansk region (Taibolsky, Uragubsky, Kandalaksha, Knyazhegubskaya, Umbsky). In the years 1956–1958 unfed juveniles of the weights 0.16-0.20 g were released under the river ice in their early fry stage in April–May (Kudersky 2005). This early release most probably caused high mortality. There is, however, some evidence on few recaptures in Norway in the year 1959 (Berg 1977; Kudersky 2005).

Photo 10. Pink salmon smolts left Indera river in White Sea during the last week of May. Smolts have typical silvery migration coloration. Water temperature was c. 5 º C when smolts started downward migration and migrations peaked with the temperature 6.2-8.8 º C (Zubchenko et al. 2004). Photo; Aleksei Veselov (in Zubchenko et al. 2004).

Varying numbers of adults were caught each year after these releases (Table I). In Russia the numbers of adult salmon returning increased each year and some natural spawning populations developed (Grinyuk et al. 1978a, b). These fish not only returned to the rivers in which they had been released, but also spread into Norwegian rivers. In the year 1960 there were reports of their presence in more than 40 rivers in northern Norway. A number of spawning fish were also observed in many rivers in this part of the country (Berg 1961; Bjerknes 1977a).

In the year 1960 pink salmon ascended into 23 rivers in Kola Peninsula with the numbers of 66 110 fish in the catches (Berg 1961). Many authors are describing that there was a massive return and high numbers of pink salmon spawners in the rivers in Kola Peninsula (ref. Zubchenko *et al*. 2004). Pink salmon was caught also in Spitsbergen, Iceland, Scotland and England (Mills 1989 and referees therein). Pink salmon was caught in Russia within a huge distribution area covering Arkhangelsk area, Pechora river, Yamal Peninsula and further to Dixon Island in Kara Sea (Kudersky 2005 and references therein). This wide distribution indicates the behaviour which is common for species introduced to new geographical areas.

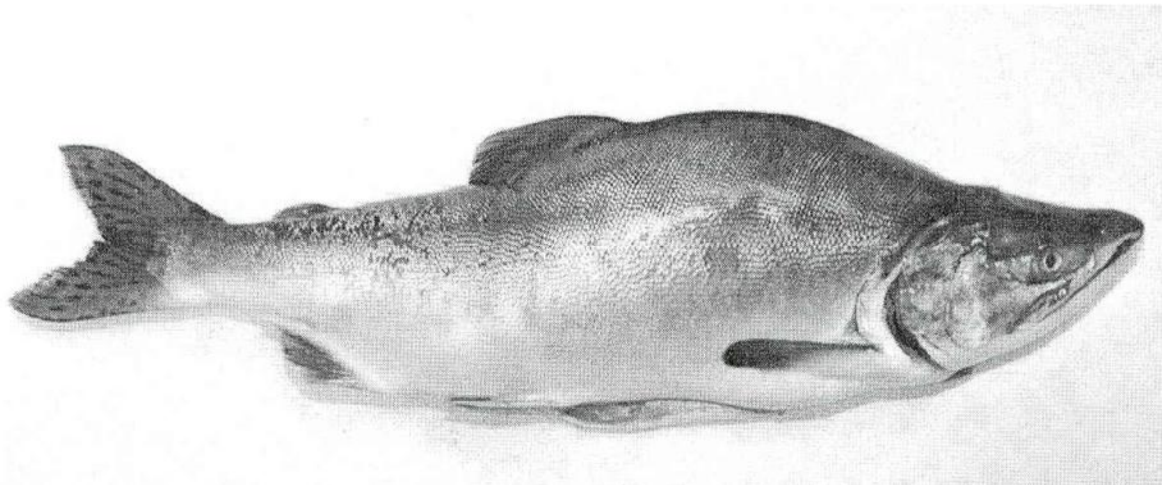


Photo 11. Pink salmon is migrating in North Atlantic and Barents Sea areas without distinct destination unlike Atlantic salmon stocks have genetically oriented migration routes. This fish was caught on 5. August in the year 2000 in Faroe Island waters. Photo; Jan Arge Jacobsen (in Zubchenko et al. 2004).

Table I. Numbers of pink salmon eggs introduced from Pacific Ocean area, number of released fry, numbers of hatched eggs and stocked fry from local production, and numbers of adult pink salmon in the catches. Source; Zubchenko *et al*. 2004.

Year of hatching/ stocking	Number of hatched eggs, import from Far East, million	Number of fry stocked, million	Number of hatched eggs, local prod-uction, million	Number of fry stocked, million	Adult counts, thousands	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	0,1	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				-		1984
1983/1984				-		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	23,2	1999
1998/1999	2,5	1,65	1,2	0,97	8,1	2000
1999/2000			1,14	-	156,0	2001
2000/2001				-	1,1	2002
2001/2002				-	48,3	2003

Dushkina (1994) writes “pink smolt releases took place after three years brake (1966–1967) from 1968-1979 and 1981–1982, and a smaller release from 1985-1987. In 1974 fry released from Murmansk hatchery were from eggs produced in the Barents Sea and they developed into fish. Previously smolts have been released from hatcheries along the shores of the Barents and White Seas. After the cessation of eggs transportation in the 1960s’ (1965–1967) the number of pink salmon gradually decreased. However, there has been an increase since the reinstatement of transportation of eggs from the far east in the 1970s”. From 1964 to 1966 the transportation of eggs from the Far East was abolished to allow for research on the natural spawning of acclimated pink salmon (Dushkina 1994).

Photo 12. Pink salmon fries with yolk sak taken from the nest on 27. January. Photo; Aleksei Veselov (in Zubchenko et al. 2004).

Dushkina (1994) is referring to Karpevish *et al*. (1991) who confirmed that there is strong relation between the number of acclimatized salmon and the water temperature during spawning and growth has shown that periods with warmer temperatures increase the effectiveness of natural breeding. Some Russian researchers have believed that despite the occurrence of natural spawning of pink salmon in its new location, the creation of a stable self-reproducing population is impossible (Dushkina 1966 ref. Dushkina 1994; Bakshtansky 1980). Dushkina (1994) explains that the process would be hindered by the complex temperature and hydro-geographic conditions involved in spawning in the new location, as well as by the absence of population diversity and the shortness of the life cycle. Dushkina (1994) continues that the majority of researches, however, consider the creation of a stable population in northwest Europe to be possible, although difficult.

Berg (1977) considered that the reason why pink salmon ascended so many different rivers in Barents Sea and White Sea may be that their homing instinct does not function as effectively in the new surrounding as in their natural habitat in the Pacific Ocean. Although very little is known about all the mechanisms of homing on the open ocean by Pacific salmon it is recognized, however, that there are many factors i.e. navigation, orientation and piloting governing the searching of the home river (Griffin 1952). Most probably pink salmon and Atlantic salmon are sensitive to the magnetic field of the earth and the detection of that system could aid in salmon navigation. The differences in the earths-strength fields between the ordinary migration areas in Pacific Ocean and the new migration area in Barents Sea might be so big that pink salmons' homing instinct doesn't work properly and therefore it is distributing within a large geographical area in the North Atlantic. Pacific salmon species in the Pacific Ocean generally return to spawn in their natal streams (Beacham & Murray 1993), and this behaviour has led to the development of discrete populations that display differences in morphology (Taylor & McPhail 1985), timing of spawning (Sheridan 1962; Karpevish *et al.* (1991), development (Beacham & Murray 1987), and other characters that can be interpreted as resulting from selection for specific environments. Fleming & Gross (1990) highlighted that patterns in salmon fecundity are a consequence of negative relationship between latitude and egg size. These adaptations mentioned above into the new environment in the Barents Sea have been important to take into account when selecting pink salmon for stockings.

The latest scientific articles highlight the reasons why, however, there are now self-reproducing pink salmon stocks in White Sea rivers and most probably also in other rivers emptying into the Barents Sea.

Gordeeva *et al.* (2005) explains that odd-year bloodline of pink salmon was successfully introduced into the White Sea basin in 1985, and then even-year pink salmon was carried in 1998. They studied the process of acclimatization of both broodlines of pink salmon, analyzed the variation of several genetic markers (allozyme and microsatellite nuclear loci, and mtDNA), morphological and some biological features in two consecutive generations of odd and even pink in new area and parental population from Magadan oblast (Sea of Okhotsk). In acclimatized odd-year line after eight-nine generations in new area considerable shifts in population genetic structure, external morphology, reproductive features and life cycle were found. Genetic differences between pink salmon in several rivers of the White and Barents Sea and similarity of two generations in Umba River showed first evidence of geographic differentiation and homing ability of successful reproduction of odd-year pink, which indicates adaptation to new environment. However, Gordeeva (2005) did not find any changes in genetic in even-year line, moreover decrease in number testifies to the lack of adaptation. Dorofeeva *et al.* (2005) presented that the data obtained testify that the Magadan population of pink salmon as a donor population appeared to be more successful than the Sakhalin one. It was noted that the odd-year line of the White Sea pink salmon forms early spawning populations and the change of morphological and genetic characters suggest adaptation processes. They also concluded that acclimatization of pink salmon of even-year line has failed.

Gordeeva *et al.* (2015) informs that the earlier pink salmon stocks conducted in the years 1956-1979 originated mainly from the rivers in southern part of Sakhalin Island. During some years pink salmon eggs have been transported also from many northern rivers in Kamchatka. Karpevich *et al*. (1991) explains that the earlier introductions failed due to the fact that transplanted fish (that inherited dates of migration and spawning from donor populations) spawned too late, and the coming of autumn cold weather led to mass mortality of developing embryos in the Kola Peninsula rivers. It has been explained that earlier transplantings were unsuccessful due to the sensitivity to the conditions of freshwater stage of life cycle and complexity of "adjustment" of migration dates (Gordeeva *et al*. 2005; Gordeeva *et al.* 2015 and references therein). Gjedrem & Gunnes (1978) studied the time and water temperature required for embryonic development from egg to hatching in pink salmon and Atlantic salmon. According to their results pink salmon needs 610 day-degrees and Atlantic salmon 510 day-degrees, respectively, in the incubating water temperature of 7-8ºC. This confirms the fact that pink salmon in northern weather conditions like in Kola Peninsula and in Finnmark needs to spawn early in autumn to produce living progeny the following summer.

According to Gordeeva *et al*. (2015) the choice of the river Ola population (Magadan population) as a donor for introduction confirmed the idea on hereditarily fixed adaptations of northern and southern pink salmon populations to hydrothermal regime in spawning rivers. The introduction of eggs from the odd year stock from the river Ola in the year 1985 resulted in the self-reproducing population. Eggs from even year stock in the years 1984, 1986, 1996 and 1998 from the river Ola were released to Kola Peninsula rivers with low subsequent catches. However, these smolt releases from even year stocks and odd year stocks have resulted in the annual catches of pink salmon not only in the rivers Tana and Neidenelva but also in many other rivers and coastal fisheries in Finnmark.

There are many earlier and also new results from the importance of the river ascending time for the salmon survival which have been referred in Laughlin *et al*. (2016). In Laughlin *et al*. (2016) article it has been referred for example to Fleming (1998) who suggests that spawning at specific time periods may be how salmon ensure that larval emergence is adjusted to ensure that local environmental conditions such as temperature are appropriate for survival. Several other studies have shown that there is a strong heritable component to spawning date for Atlantic salmon and for other salmonids such as steelhead trout (*Oncorhynchus mykiss*), pink (*Oncorhynchus gorbuscha*), coho (*Oncorhynchus kisutch*) and chinook (*Oncorhynchus tshawytscha*) salmon (Quinn *et al*. 2002; Dickerson *et al*. 2005; Gibbons *et al*. 2008; Abadia-Cardoso *et al*. 2013). Stream entry timing and spawn timing are strongly related to fitness due to the impact of timing on spawning opportunity and spawning success (Smoker *et al*. 1998; Dickerson *et al*. 2005) and are also important for the survival and rearing of offspring (Morbey & Hendry 2008).

In the period 1991-2000 (except 1996 and 1998) juvenile pink salmon releases originated only from odd - year stocks in White Sea area rivers. From the year 2001 onwards there hasn't been juveniles released in the Kola Peninsula and Archangelsk area in the White Sea with odd-year stocks but in the even-year stocks from the years 2000 and 2002 and some fries were released in the years 2001 and 2003 (Zubchenko *et al*. 2004).

After the intensive transplanting which were ceased in early 2000 self-reproducing pink salmon stocks have been established at least in the White Sea rivers, yielding some hundreds of thousand kilos in annual catches. It is interesting to note that also even year stock has been occurring until recent years in the rivers Tana and Neidenelva and in many other rivers in Finnmark. The wide annual occurrence of pink salmon in the entire Barents Sea area, including Iceland and Spitsbergen and the ascent of mature fish into the rivers for spawning, indicates that their homing migration is not accurate in the new ocean environment although the ability to return to home rivers is genetically governed. This homing instinct and orientation during the sea migration phase has developed for the Pacific Ocean environment, between 35 º - 60º northern latitudes in Asia, and it doesn't function properly in the latitudes of 70º (coast of Finnmark) up to 80º (middle of Spitsbergen), but looks to function quite good in White Sea latitudes with 65º.

The latest information confirms that pink salmon has occurred quite frequent in the coastal areas as well as in some cold rivers in Spitsbergen (Eigil Tofte Bjørvik and Martin A. Svenning; personal information). Eigil Bjørvik tells: "I saw pink salmon in August in the year 2007 close to the lake Dieset in the west coast of Spitsbergen. The river was dry, but there was still one big pool in the river between the lake Dieset and the sea. There were 50-100 humpies in that pool, and we caught a few and one male pink salmon weighed 2.4 kg. I have an impression that there are catches of some humpies at Spitsbergen each year. All the rivers dry out or freeze solid during the winter. I guess there are no potential to establish self- reproducing pink salmon stock in Spitsbergen."

Approximately 9 million chum salmon eggs were transferred during the period 1933-39 from Far East to the rivers in the Murmansk region without any practical success. The experiment was resumed in 1956, and between 1956 and 1959 13 million chum salmon eggs from Sakhalin Island were released to the rivers in Kola Peninsula. Only a few adults were recaptured (Grinyuk *et al.* 1978b). Some chum salmon were caught in the year 1965 in the lower part of the river Tana (Magnus Berg personal information, in Mills 1989).

Photo 13a. Male (above) and female (below) pink salmon caught in August in a river in Spitsbergen in the year 2007. Photo Eigil Bjørvik

Photo 13b. Indigenous Sami salmon gillnet fisherman, Jouni Antti Lukkari, caught this female pink salmon in August in the River Tana, Ailestrykene. Photo Eero Niemelä

Figure 5. Pacific salmon, pink and chum, eggs has been transported from the Pacific Ocean rivers (red circles) in Asia to Kola Peninsula in northwest Russia. Fries from hatched eggs have been transplanted mainly into numerous rivers which are running into the White Sea but also into some rivers draining into the Barents Sea (blue circle).Source: CAFF

Photo 14. The size of migrating pink salmon smolts in may month. Photo: A. Veselov

Photo 15. Female pink salmon is in spawning condition already in the middle of August in Tana and Neidenelva. Pink salmon eggs are larger than the eggs of 1SW Atlantic salmon. Photo Eero Niemelä

Photo 16. Pink salmon alevin with yolk sak, alive eggs and dead eggs (white ones) taken 27. January from nest. Photo; Aleksei Veselov (in Zubchenko et al. 2004).

4. River temperatures in self-producing and non-self-reproducing rivers in Barents Sea and White Sea

River temperature is important for the early life of pink salmon as well as for Atlantic salmon. Pink salmon is spawning in the White Sea and Barents Sea rivers within the period between the second half of August and first half of September and sometimes also earlier in August. Temperatures especially in August and September and during the winter are affecting the speed of the embryo development in pink salmon eggs.

Juveniles released into the White Sea area in the beginning of the acclimatisation originated from stocks, which tended to spawn late in the autumn. Releases from these stocks did not result in self-reproducing pink salmon stocks. In the rivers Tana and Neidenelva Atlantic salmon is spawning between the second half of September and second half of October. In some warmer rivers on the southern side of the White Sea salmon is spawning even later in October or in early November. Difference in the spawning time keeps Atlantic salmon and pink salmon separated from each other on the same spawning grounds. Spawned pink salmon in the Barents Sea rivers die before the Atlantic salmon starts spawning and therefore there is not simultaneous competition on the same spawning sites between these two species. However, there isn't exact documentation if Atlantic salmon avoids the sites in the riffles where pink salmon already has made spawning nests and laid eggs.

The earlier spawning of pink salmon in autumn compared to the later spawning period of Atlantic salmon results to the faster and earlier development of pink salmon embryos in the spawning redds. It's known that the development of pink salmon and Atlantic salmon fertilized eggs to hatched alevins (=hatched eggs) depends on the temperature degree days. Pink salmon eggs are hatched earlier in the following spring than eggs of Atlantic salmon because pink salmon embryos start the development under warm water conditions in August. Due to the faster development, pink salmon alevins are emerging earlier from the spawning gravel than Atlantic salmon alevins. Muladal (2009) describes that in the middle of May in the river Vestre Jakobselva, in Varangerfjord, 70% of pink salmon juveniles still had the yolk sac, but then again the rest of the juveniles had consumed it already. In the river Tana, which is close to the river Vestre Jakobselva, Atlantic salmon fry are emerging from the spawning redds usually in the beginning or in the middle of July and some of them still have residuals of yolk sacs.

Any increase especially in the late autumn water temperatures in August and September, caused by global warming, can affect to the faster development of pink salmon embryos rather than to the embryos of Atlantic salmon. Atlantic salmon is spawning mainly early in October close to the period when rivers will have ice cover and water temperature is at that time between zero and five degrees. Therefore the increase of water temperature in August and September doesn't make the embryonic development faster in autumn for Atlantic salmon eggs. Figure 6 indicates that water temperatures have been in August clearly higher in Tana river since 1990s' than before it. This temperature increase if that is continuing in future in August and September may help pink salmon to establish self-reproducing stocks in the rivers in Finnmark. Some air temperature increase in August in recent years in Northern Finland close to Tana river confirms the warming development

(Figure 7). These air temperature and water temperature changes in northern areas have close relations to the sea temperature changes in Barents Sea and thereafter to the ecology, distribution and catches of migratory pink salmon and Atlantic salmon.

Temperatures in the rivers in White Sea and in Barents Sea area stay close to zero from late October-early November to late March -early April (in White Sea rivers) or to late April-early May in the rivers in Northern Kola Peninsula and in Finnmark (Figure 8).

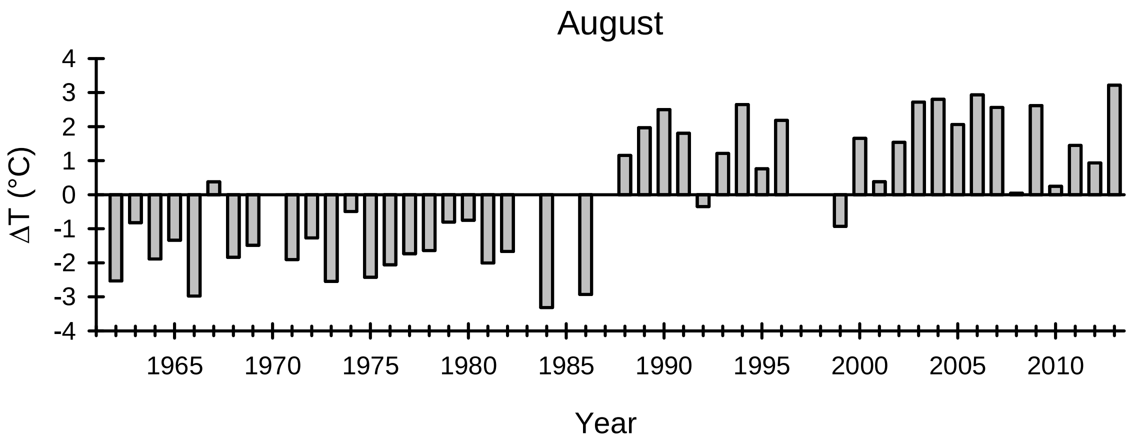


Figure 6. Annual temperature deviations from the long-term mean water temperatures in August in Tana river. Source; SYKE, Luke, NVE.

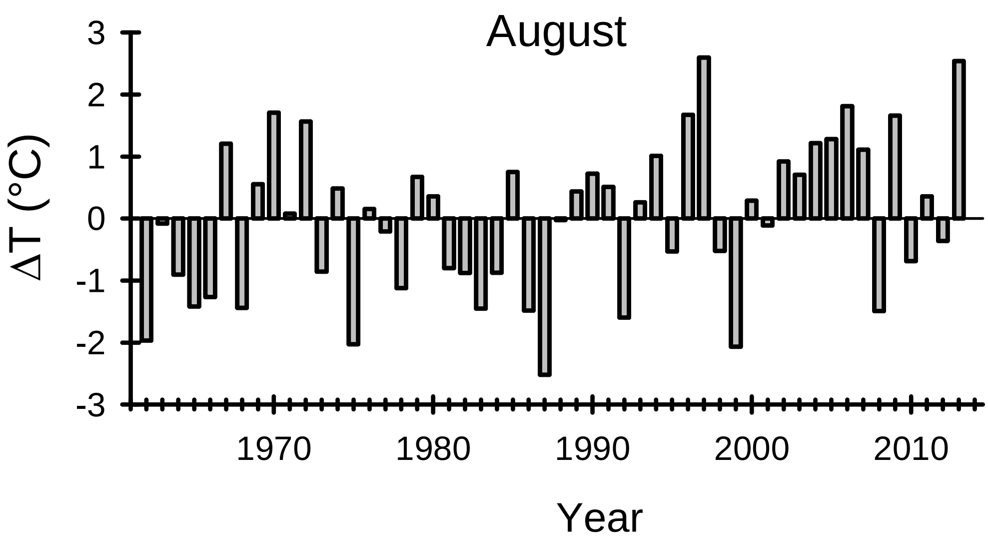


Figure 7. Annual temperature deviations from the long-term mean air temperatures in August at Kevo in Utsjoki in Northern Finland. Source; Finnish Meteorological Institute

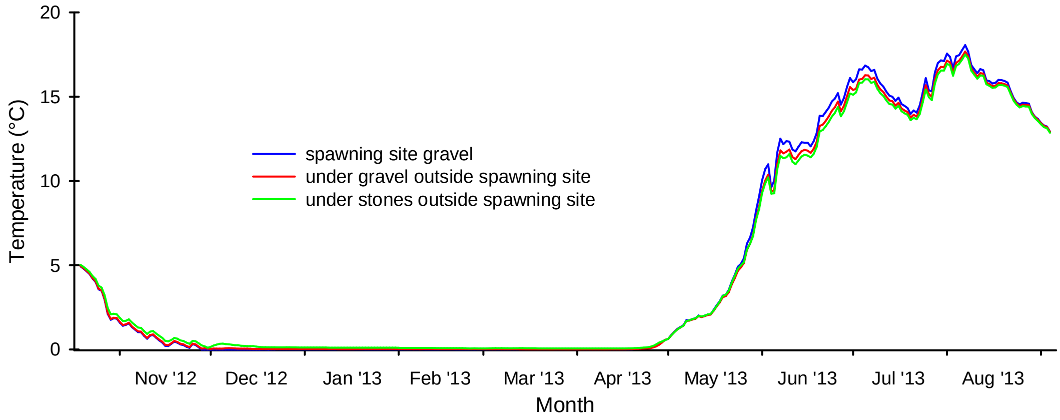


Figure 8. Water temperatures in the lower areas of the river Utsjoki, a Finnish tributary to the river Tana. Water temperatures were measured inside and outside the spawning redds of Atlantic salmon from October 2012 to early September 2013. Big and deep Lake Mantojärvi keeps the water temperature warmer in the end of October and in the beginning of November in the lower part s of Utsjoki than for example in the river Tana and its other tributaries. Source; Luke

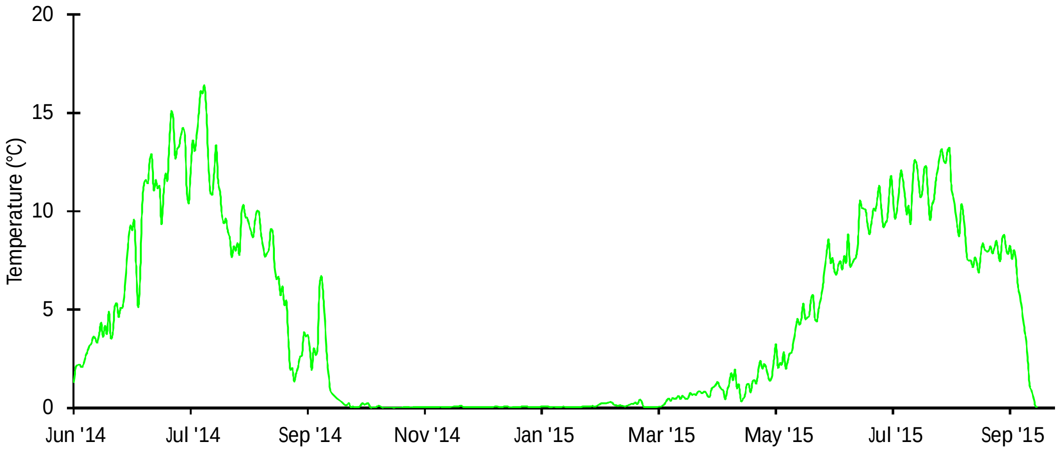


Figure 9. Water temperatures in the river Leavvajohka (a Norwegian tributary of the river Tana). Water temperatures were measured from the beginning of June 2014 to the middle of September 2015. Source; Luke

Water temperatures in the river Leavvajohka (tributary to the river Tana) are demonstrating the coldest environment for salmon in the river Tana watershed (Figure 9). Temperature is close to 0° five to six months yearly like in all other tributaries in the river Tana watershed. This kind of long lasting low temperature might affect negatively to the development of pink salmon alevins and fries especially late in the spring when pink salmon juveniles are consuming the rest of the contents in the yolk sac.

Pink salmon has established self-producing stocks in many White Sea rivers. This can be observed from the pink salmon catches in many rivers in Finnmark until the year 2015 even though all the fry releases were ceased since the year 2001 onwards (Table I). Water temperature regimes in White Sea rivers, for example in the rivers Varzuga and Umba, are favouring the better development of fertilized pink salmon eggs from natural spawning (Figure 10). Water temperatures after egg deposition in August are clearly higher in these White Sea rivers during the second half of August and first half of September compared to the daily water temperatures in Finnmark rivers and in the rivers in Northern Kola Peninsula. This temperature regime is an advantage for the successfully established pink salmon stocks in White Sea rivers. Temperatures in White Sea rivers are clearly higher than in Barents Sea rivers also very early in the summer. These high temperatures, reaching the levels between 15-20 ºC very early in June for example in the river Varzuga, are benefitting pink salmon fries and smolts to have a higher survival in their early life phases in fresh water compared to the survival early in June in the colder rivers in northern Kola Peninsula and in Finnmark. In the year 2013 rivers in Finnmark show a clear warming not until the end of June two -three weeks later than rivers in the White Sea area (Figure 10).

It is clear that pink salmon fry and smolt benefit from the warm water conditions in the rivers early in the summer. Smolts are descending from the rivers in big shoals, meeting the brackish water environment in the river mouths, staying there a variable period of time and then migrating to oceanic feeding areas. McCabe *et al.* (1983) concluded that those Pacific salmon species (steelhead trout, sockey salmon, coho salmon, chinook salmon) which are larger at seaward entry owing to longer freshwater residence periods seem to migrate more rapidly through estuaries and occupy pelagic rather than littoral habitats. Pink and chum salmon smolts owing the length of only 3-4 cm are due to their short body length staying longer periods in estuaries than the above mentioned Pacific salmon species (Healey 1982).

Pink salmon smolts are feeding close to the river estuaries almost one month during which time they are also physiologically adapting to the saline marine environment. In the estuary the young fish, only 4-6 cm long, swim back and forth for quite some time, getting gradually accustomed to more saline waters. After foraging in the river estuaries some weeks pink and chum salmon smolts move relatively rapidly through coastal waters (Groot *et al*. 1989) whereas coho and chinook salmon have a greater tendency to remain in coastal waters (Pearcy & Fisher 1988). Pink salmon starts oceanic life as zooplankton feeders, following the dense masses of small animals drifting with the currents.

White Sea area, where pink salmon has succeeded in establishing self-producing populations in numerous rivers, differs in many ways from that environment which pink salmon smolts meet when descending from Finnmark and Northern Kola Peninsula rivers. If and when temperature conditions are getting more favourable in Finnmark rivers and in the Barents Sea rivers of the Kola Peninsula, especially in the coastal areas early in the summer, pink salmon can establish stable self-producing stocks in many rivers like it has done in the White Sea and in eastern Canada.

White Sea rivers are transporting warmer water early in the summer to the estuaries and coastal areas coinciding with the pink smolt migration. River estuaries in the White Sea area are usually shallow with large sandy bottom areas allowing pink salmon smolts to adapt to the life at sea. These physical circumstances of the river mouths among other environmental factors have made it possible to establish strong self-producing pink salmon stocks in White Sea rivers.

Photo 17. Indera river is flowing into White Sea from north. Shorelines are shallow at sea close to the river allowing pink salmon smolts to adapt to the salt water and new environment. Photo; Alexander Potutkin.

In Finnmark especially in the outermost coastal areas, many rivers are draining usually straight into the deep coastal waters where the brackish water zone is narrow or it doesn't occur at all. Conditions in the estuaries and river mouths in Finnmark are more severe than in the White Sea area and this among other things has delayed pink salmon to establish strong self-producing stocks. To achieve successful reproduction, it looks to be important for pink salmon that there should be shallow estuaries with brackish water where the tiny 3-4 cm long smolts can slowly adapt to the saline seawater. Those rivers in Finnmark where pink salmon self-producing is supposed to happen have large sandy estuarine areas where pink smolts can adapt to the sea life. Such kinds of rivers are f. ex. Grense Jakobselva, Neidenelva, Munkelva, Vesterelva, Bergebyelva, Vestre Jakobselva, Skallelva, Tanaelva, Børselva, Lakselva and Altaelva.

Water temperatures in the rivers are varying between years. Examples from the large annual variations can be seen in the figures 11-17 in the rivers which are draining into the White Sea and into the Barents Sea from Northern Kola Peninsula and from Finnmark. Figures are illustrating the large annual variation in the temperatures in May, June and July. Temperatures late in the spring and early in the summer are affecting the growth of pink salmon and temperatures are governing also the timing of smolt migrations.

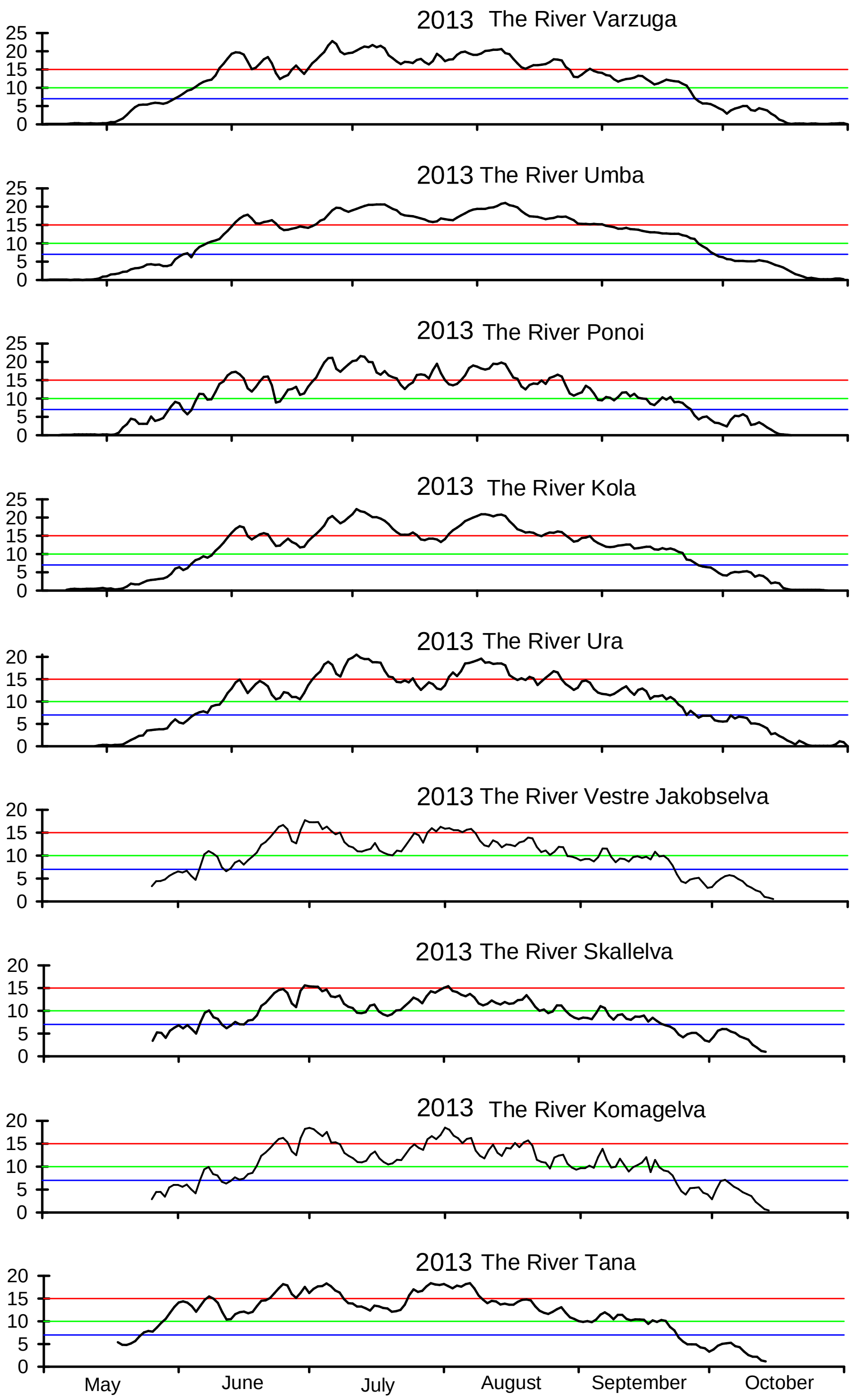


Figure 11. Mean daily water temperatures in some rivers in the White Sea in Russia and in Barents Sea in Russia and in Norway. Red line is 15 degrees line, green line is 10 degrees line and blue line is 7 degrees line. Source; Russian rivers PINRO, Norwegian rivers Luke

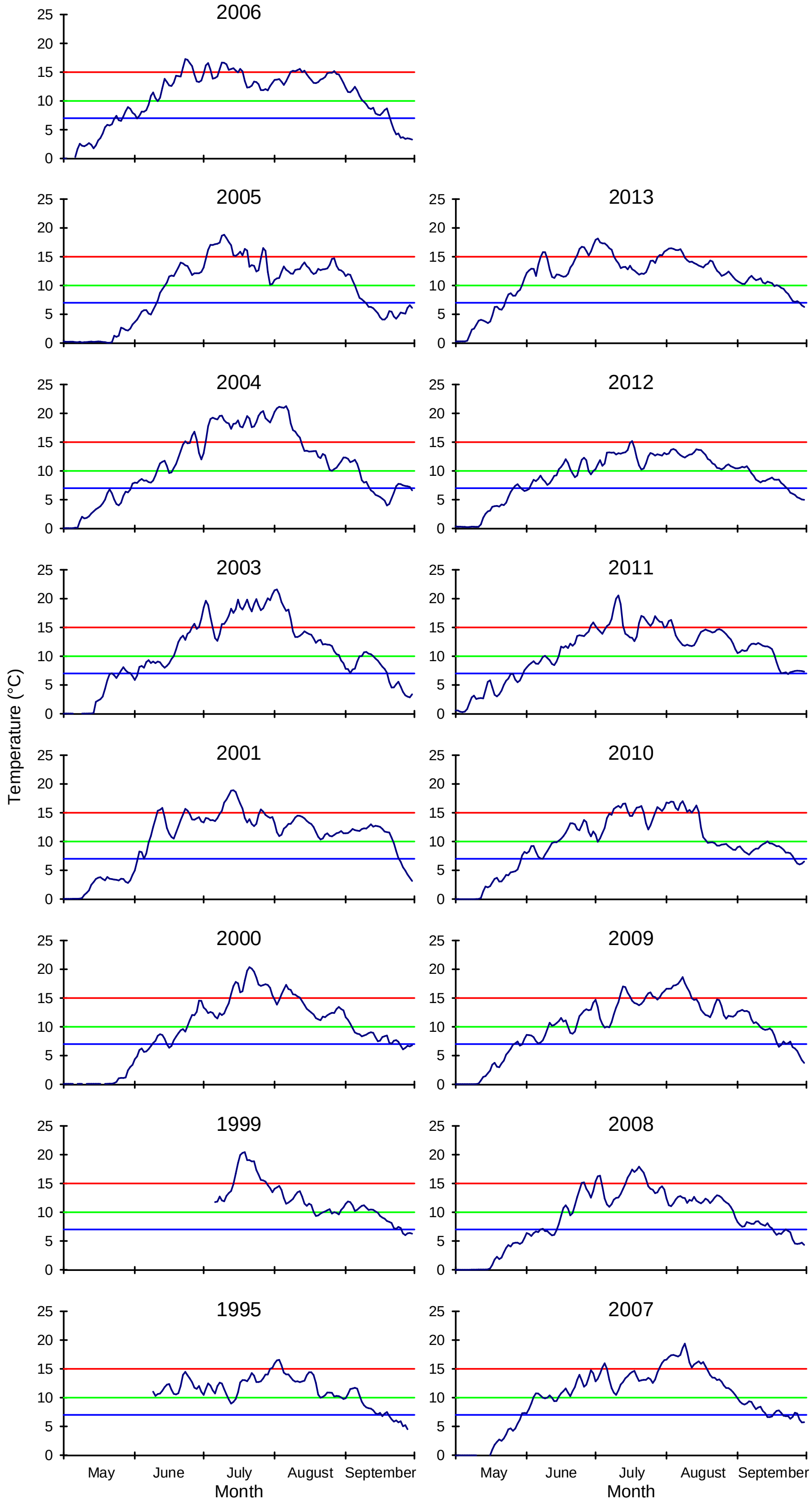
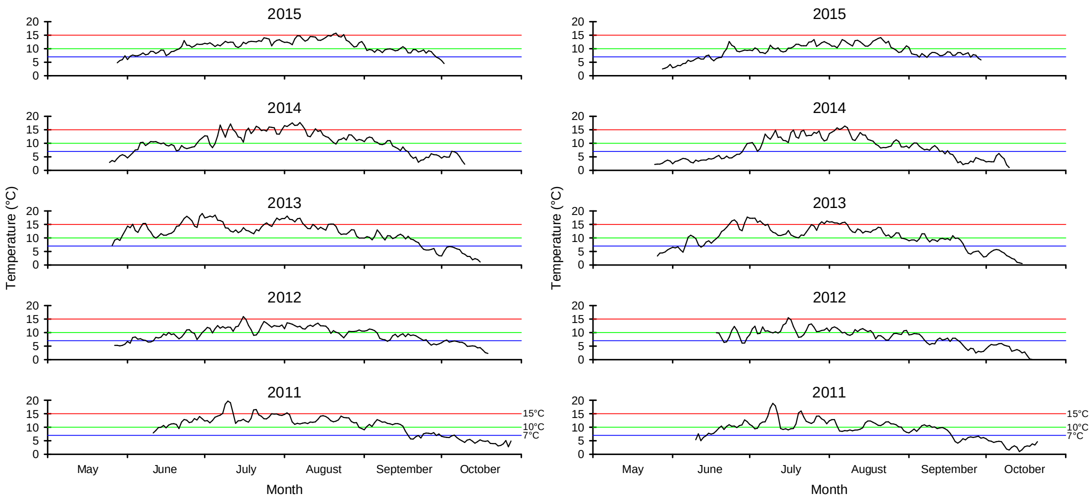
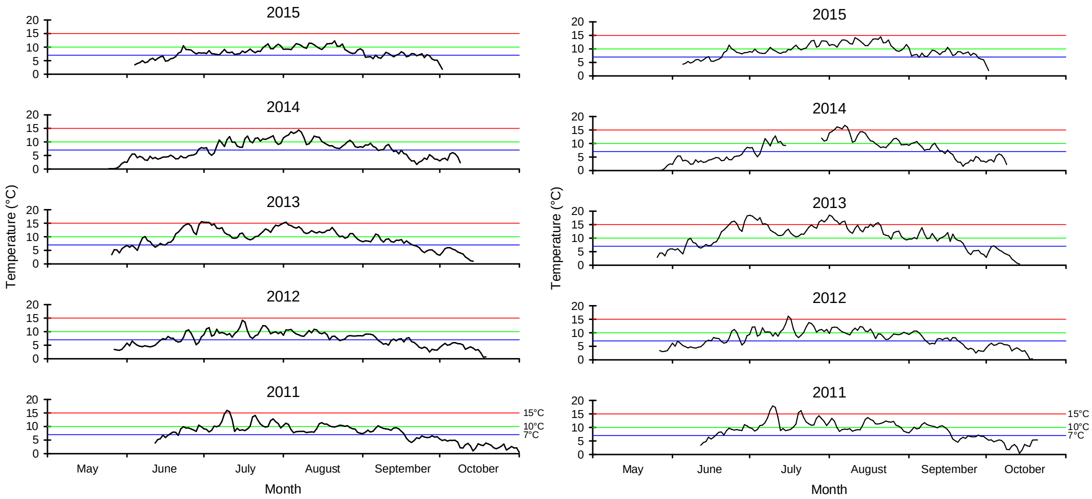


Figure 12. Mean daily water temperatures in the River Neidenelva in Varangerfjorden, Norway. Source; NVE



Vesterelva *Vestre Jakobselva*

Figure 13. Mean daily water temperatures in the River Vesterelva (on the left) and in the River Vestre Jakobselva (on the right) in Varangerfjorden, Norway. Source; Luke



Skallelva *Komagelva*

Figure 14. Mean daily water temperatures in the River Skallelva (on the left) and in the River Komagelva (on the right) in Varangerfjorden, Norway. Source; Luke

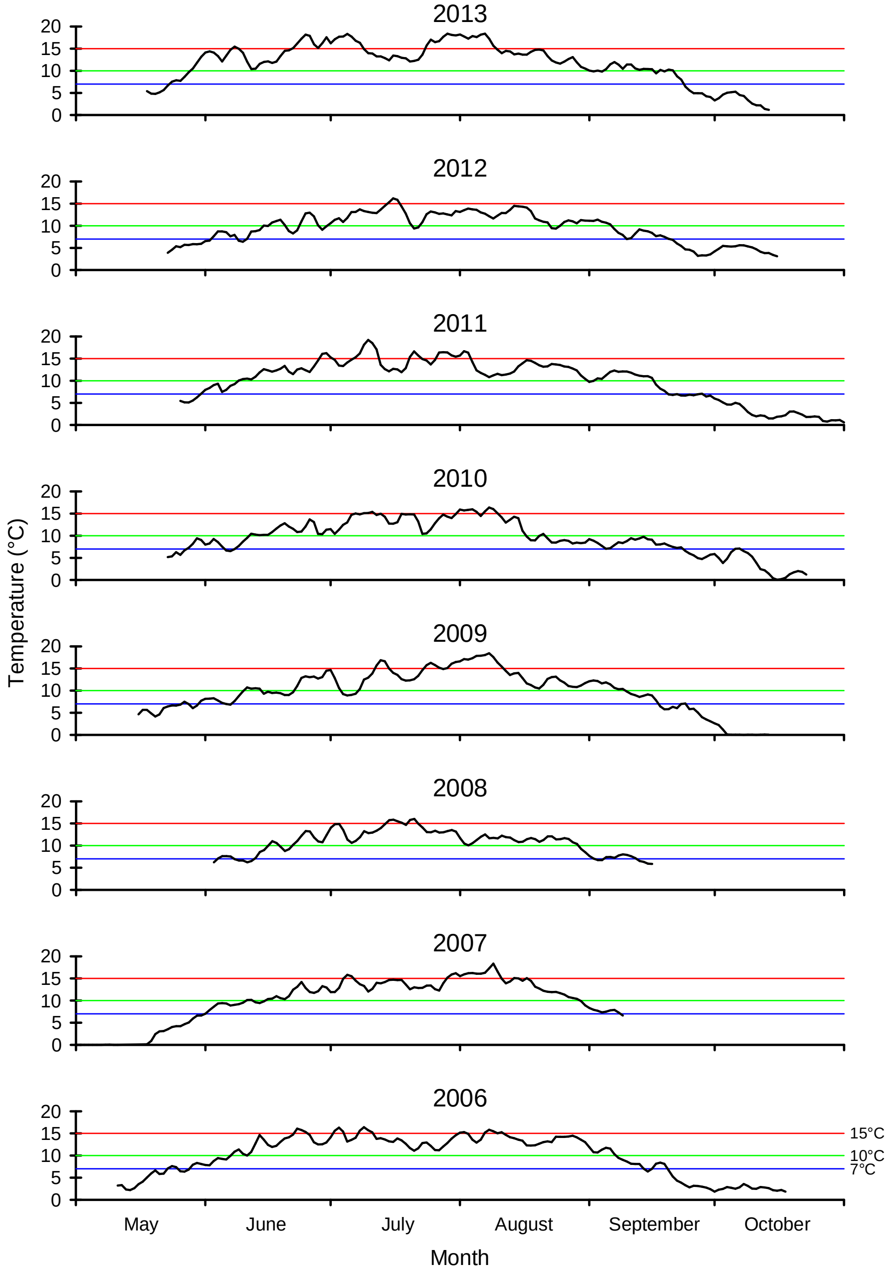
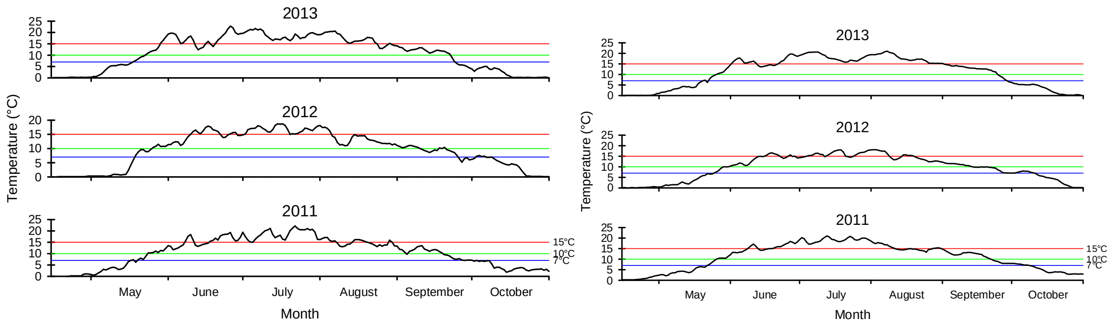


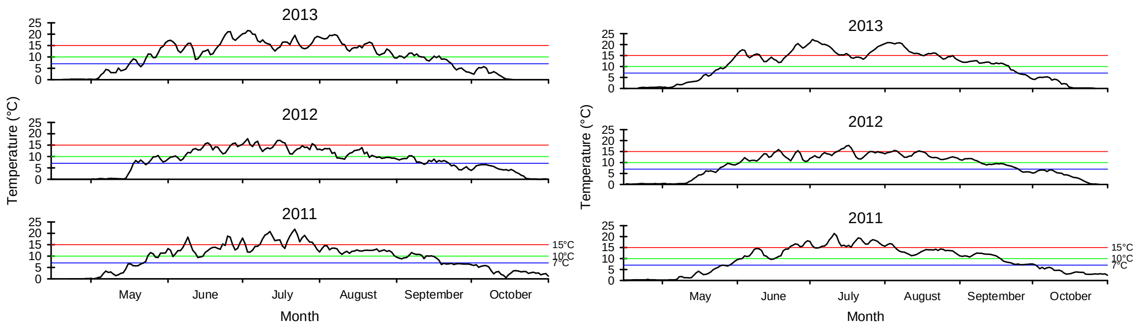
Figure 15. Mean daily water temperatures in the River Tana, Norway/Finland. Source; Luke

Photo 18. Salmon fisherman caught this female pink salmon with gillnet in the River Tana, Ailestrykene. Fish was ready to spawn in the middle of August. Photo Eero Niemelä



Varzuga *Umba*

Figure 16. Mean daily water temperatures in the years 2011-2013 in the River Varzuga (on the left) and in the River Umba (on the right), White Sea, Russia. Source; PINRO



Ponoi *Kola*

Figure 17. Mean daily water temperatures in the years 2011-2013 in the River Ponoi (on the left) in the White Sea and in the River Kola (on the right) in the Barents Sea, Russia. Source; PINRO

Temperatures in rivers, where pink salmon has been successfully introduced in White Sea area and temperatures in the original distribution area in Far East, are very close to each other during the entire summer (Figure 18) (Zubchenko *et al*. 2004). River temperatures are not clear limiting factor for the wider distribution of pink salmon in Barents Sea area. Also the river temperatures in East Finnmark (Figure 11, 12) are similar to the temperatures found in Far East pink salmon rivers (Magadan, Sakhalin, Kamchatka). In pink salmon rivers in Southern Sakhalin water temperatures are 2–4 ºC higher throughout June to early September compared to Kamchatka. In early and middle May and in the end of October water temperatures are about the same in the rivers in East-Finnmark, Northern Kola Peninsula, in rivers flowing to White Sea from north and in Far East pink salmon rivers in Magadan and Sakhalin. It is possible that in the original distribution area in Far East each pink salmon stock is genetically adapted to the temperature regimes in its home rivers.

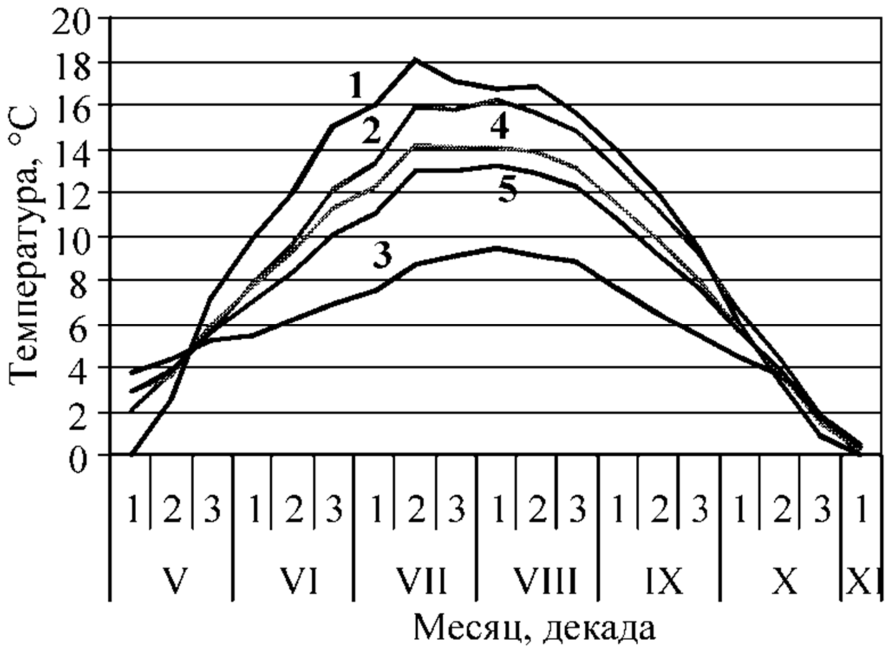


Figure 18. Monthly river temperatures from May to December. Lines 1-3 indicates pink salmon rivers in Far East and line 4 indicates rivers in White Sea and 5 rivers in Barents Sea. Source; Zubchenko et al. 2004.

Another environmental factor possibly regulating distribution and abundance of pink salmon in the rivers in Barents Sea area is the harsh winter conditions like ice coverage and the length of open water period. Like from the figures 6, 7 and 9 can be observed water temperature is c. 0 ºC in the Rivers in Barents Sea area and in rivers in northern White Sea from the end of October to late April or Early May. In the pink salmon rivers in Far East the length of winter period is about the same. Ice covers the rivers normally from November to early or middle May taking c. six months in Barenst Sea and White Sea rivers. In Far East the length of the ice cover period in pink salmon rivers is variable depending on the geographical situation of the river.

Distribution of pink salmon to new rivers in Barents Sea area depends strongly on the geomorphological quality of the rivers. Pink salmon needs especially good spawning grounds where it can dig spawning pits. The most important requirement for successful spawning area is that the river bottom material consists of small stones and pebbles and in riffles there is appropriate water velocity. It is important that small stones and pebbles are easy to move when female pink salmon is digging nest. All in all, in the rivers in Barents Sea area water temperature conditions in autumn and in the winter are favouring the further distribution of pink salmon and geomorphology in most of the rivers offers potential spawning sites. What can limit the distribution of pink salmon to new rivers are unexpected and sudden high mortalities of pink salmon smolts. These mortalities are mainly natural caused by predation in early life stage and also in some cases environmental factors like too warm water in August can prevent spawning.

As an example from the late smolt migration in the year 1979 in the middle of July pink salmon smolt of the length 3.5 cm was caught c. 130 km upstream from the Tana estuary (Eero Niemelä personal information). It can be possible that smolts after descending so late in the summer to Tana estuary meet there high mortality caused by seatrout. Maybe this possible high mortality in Tana river mouth and Tanafjord has kept the pink salmon population quite low in the River Tana system, if there has been annual smolt production.

The life of young pink salmon is quite safe in rivers. First it stays many months from the middle of August to the next spring hidden below small stones and pebbles in the river bottom. Then it starts the journey to sea in large shoals. The life in the river is short and it does not compete with other salmonids from the feeding territory, because it has migrated already in late May or early June seawards before juvenile Atlantic salmon and trout start their feeding in fixed sites in their river habitats.

Photo 19. One of the largest pink salmon caught in the River Tana weighing 3.4 kg. Photo Eero Niemelä

5. Sea temperatures in the Barents Sea close to the transplanted rivers

It's known that sea temperatures in the estuaries, fjords and finally at sea are affecting the survival and growth of Atlantic salmon (Friedland 1998; Friedland *et al.* 2003) as well as pink salmon smolts (Rogers & Ruggerone 1993). For example, sea temperatures in the Tanafjord (Figure 19) show annual fluctuations, though the fluctuations are rather small from year to year, this in contrast to the wide temperature fluctuations observed in the River Tana (Figure 11) or for that matter other rivers draining to the Barents Sea and White Sea (Figures 9-12, 14-15). Therefore, temperatures in rivers can affect the period when pink salmon smolts are migrating to the estuarine areas. If temperatures in the rivers are high early in summer pink salmon smolts are migrating earlier to sea and they meet salty ocean water, when sea temperature still might be too cold for them, resulting in high natural mortality. These temperature relationships between the rivers and the sea can partly result in the high annual fluctuations in pink salmon stocks.

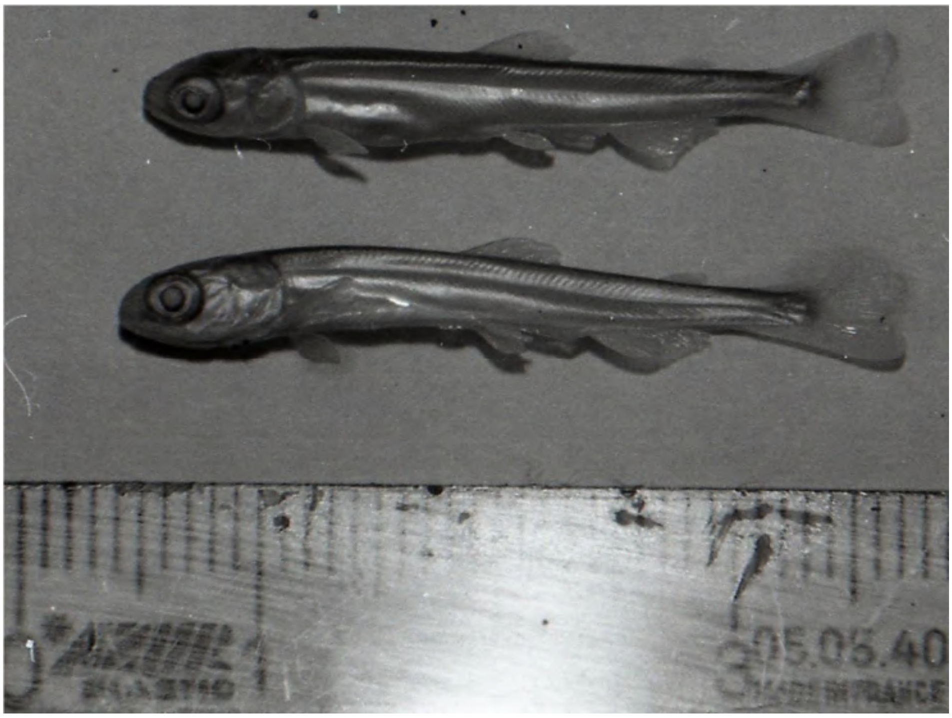


Photo 20. Juvenile pink salmon smolts caught in the River Neidenelva late in June in 1976. Smolts left the river in the mean length of c. 3.3 cm. These tiny smolts had silvery color on the skin like in Atlantic salmon smolts in the length of c. 16 cm. Photo Vilhelm Bjerknes

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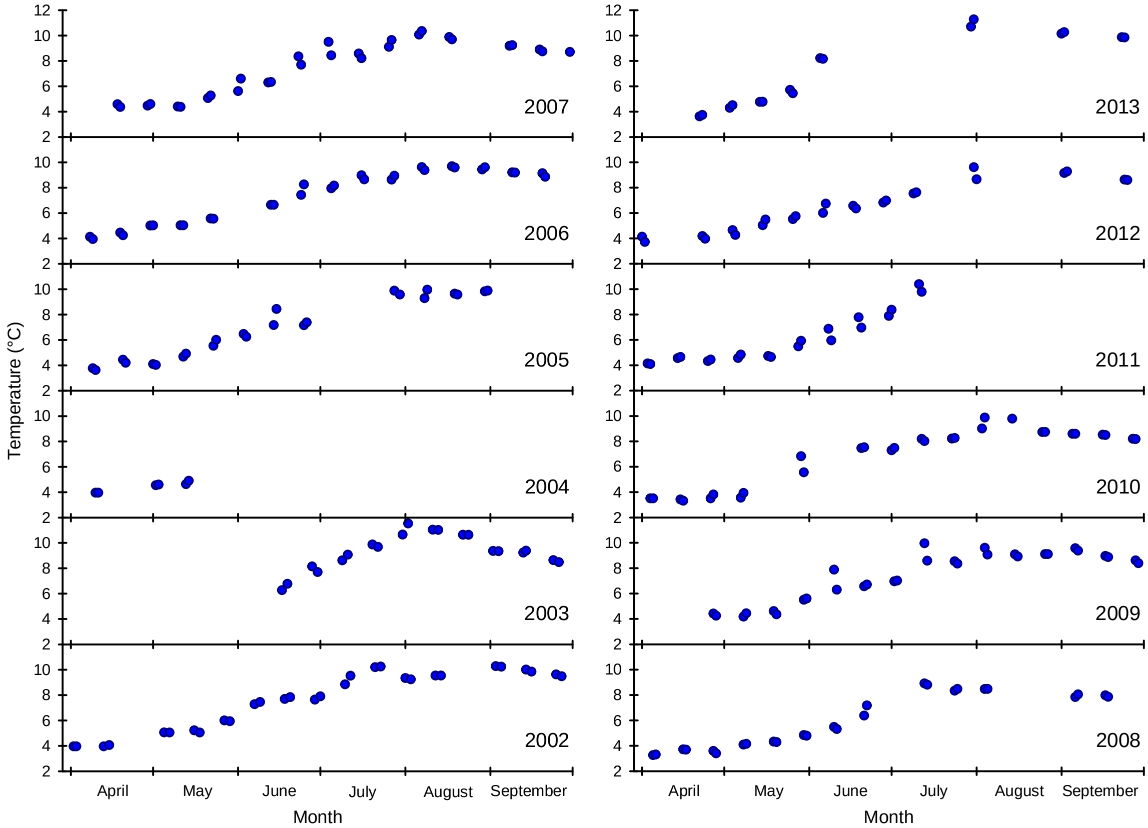


Figure 19. Sea surface temperatures in Tanafjord during summer months. In July, when pink salmon smolts are ascending into the sea, sea surface temperatures are varying from year to year being between 8º and 10º C. Source; IMR Norway.

Sea temperatures in the coastal areas like in Varangerfjorden and in the Kola section show clear annual fluctuations with periods of warmer and cooler years. Long-term temperature fluctuations are clear each month. Most important for the survival of pink salmon smolts are the temperatures in July and August (Figure 20) when the size of these descending fishes is still small and they are feeding in the estuaries and /or in the coastal areas. Also monthly mean temperatures in the winter have clear annual variations (Figure 21). Monthly sea temperatures show a clear increase since the end of 1970s'. This can be observed especially in the winter temperatures in the Kola section, but also in Varangerfjorden. Also in summer months temperatures in the Kola section have increased from the late 1970s'.

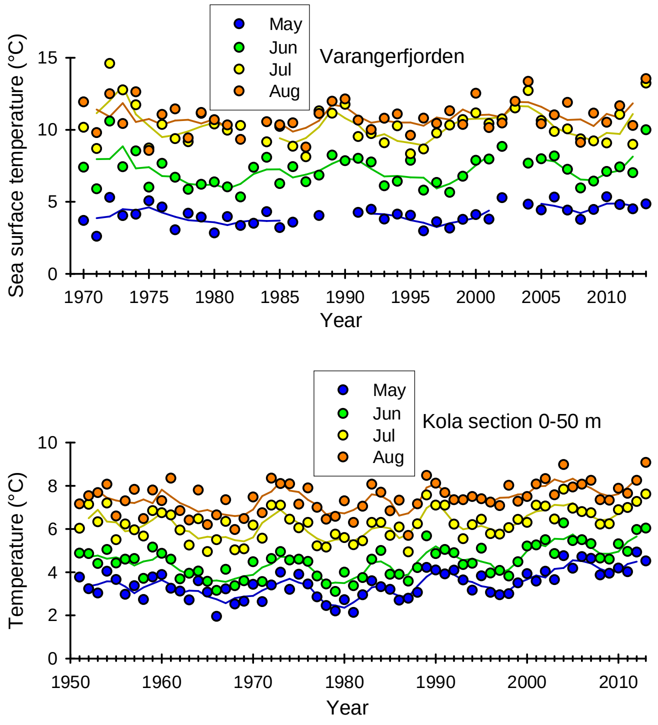


Figure 20. Sea surface temperatures in summer months in the Kola section (0-50m) in Russia and in Varangerfjorden in Norway. Temperatures are mean monthly values. Source Kola section, PINRO Russia; Varangerfjorden IMR Norway.

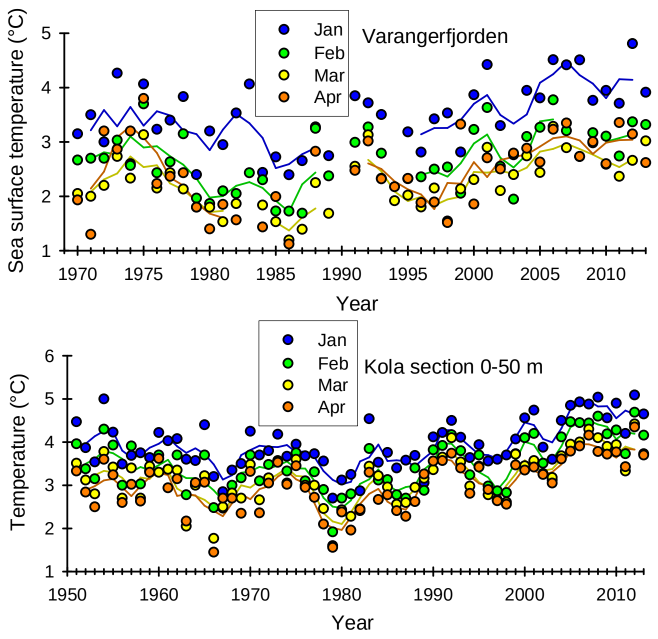


Figure 21. Sea surface temperatures in winter and early spring months in the Kola section (0-50m) in Russia and in Varangerfjorden in Norway. Temperatures are mean monthly values. Source Kola section, PINRO Russia; Varangerfjorden IMR Norway.

Sea surface temperatures are clearly higher in Varangerfjorden than at sea in the Kola section (Figure 22). Therefore, pink salmon smolts which are leaving rivers in Varangerfjorden might have better survival than smolts leaving rivers from northern Kola Peninsula rivers. Warmer sea water in Varangerfjorden might have affected to the possible establishment of self-producing pink salmon stocks in some rivers.

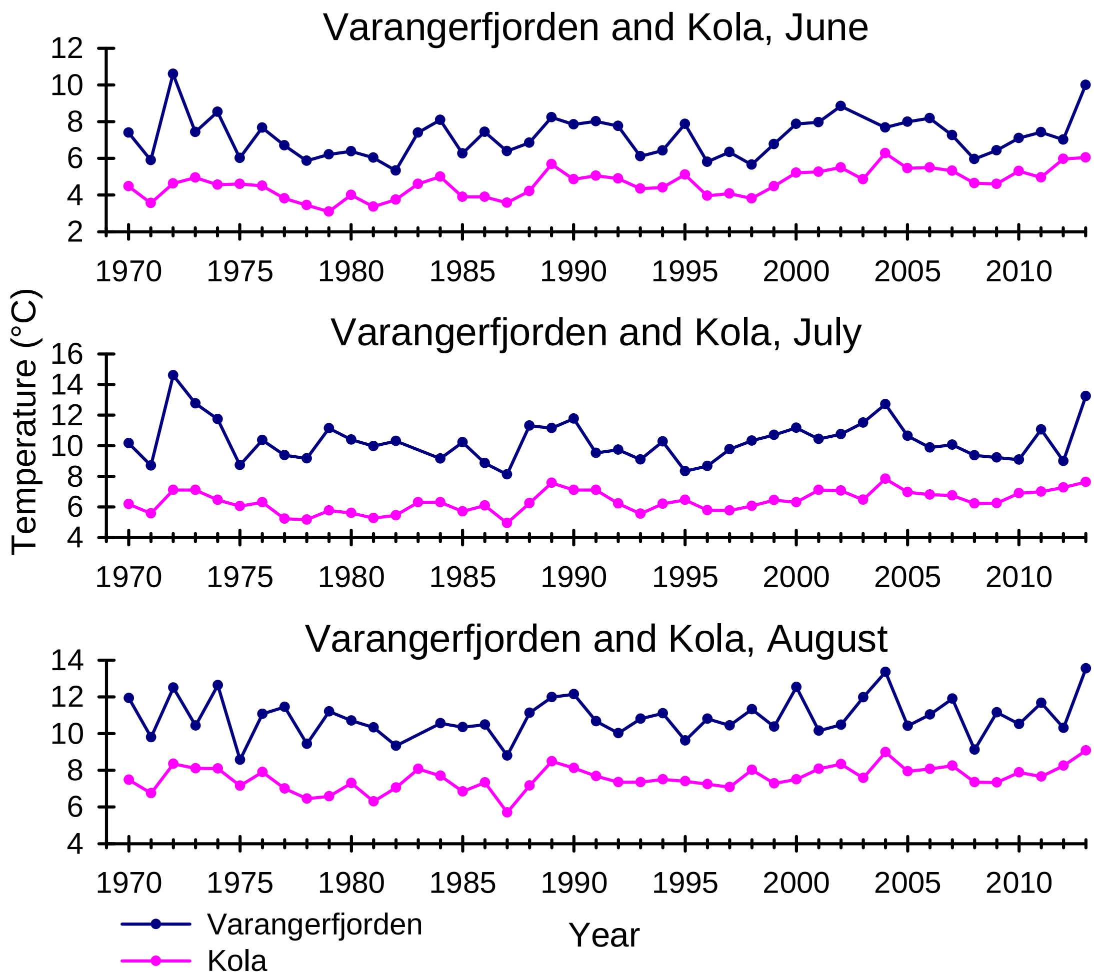


Figure 22. Mean sea surface temperatures during summer months in Varangerfjorden in Norway and in Kola in Russia section. Source Kola section, PINRO Russia; Varangerfjorden IMR Norway.

Sea surface temperatures show long time fluctuations. There have been periods where the sea water temperature has been below the long-term annual mean values. These cold water periods have lasted for a couple of years followed by warmer water periods. It is interesting to note that since the year 1999 there has been a continuous warm water period lasting now for more than ten years (Figure 23). This kind of warming can change the environment not only in the coastal areas but also in the entire Barents Sea area. The increase in the primary algae production at sea is followed by the increase in zooplankton and finally the fish production is increasing. Also the size of pink salmon stocks in the Barents Sea can benefit from an increased primary production.

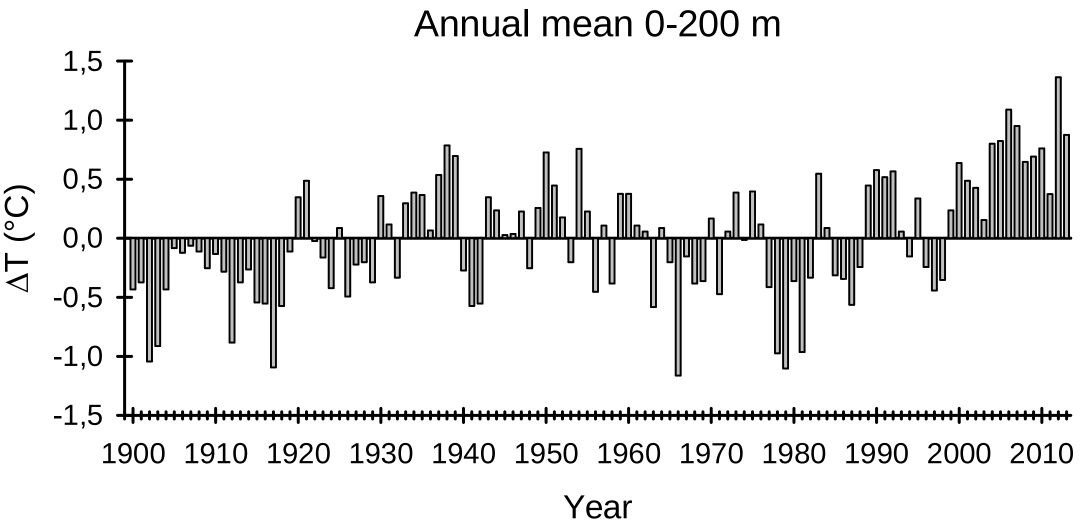


Figure 23. Deviations from the long-term mean annual sea surface temperatures in Kola section in Russia. Source Kola section, PINRO Russia.

As for the Atlantic salmon in the River Tana there can be the same clear relationship between the sea surface temperature and the number of pink salmon in the catches in some rivers in Barents Sea and White Sea. Figure 24 indicates the very clear relations between numbers of small and median size Atlantic salmon caught in the River Tana and the sea temperature in July when those fish left the home river as smolts. However, these kinds of relationships are not foregone conclusions for pink salmon which originally are from the rivers in the Pacific Ocean. It is true that pink salmon is genetically adapted to a different environment and to different oceanic conditions in its original distribution areas between 35 ° - 60° northern latitudes in Asia, compared to the latitude 70° in Kola Peninsula in Russia and in Finnmark in Northern Norway.

The marine distribution of pink salmon in the Pacific Ocean is apparently influenced by a combination of temperature and food availability. There may also be genetically determined, population-specific migration patterns for pink salmon (Pascual & Quinn 1994) and that this is working more precisely only in the Pacific area. The environmental factors are not only proximate stimuli that may affect migration but they are also part of the selection regime that gave rise to the genetic tendencies to migrate to certain locations (Hansen & Quinn 1998).

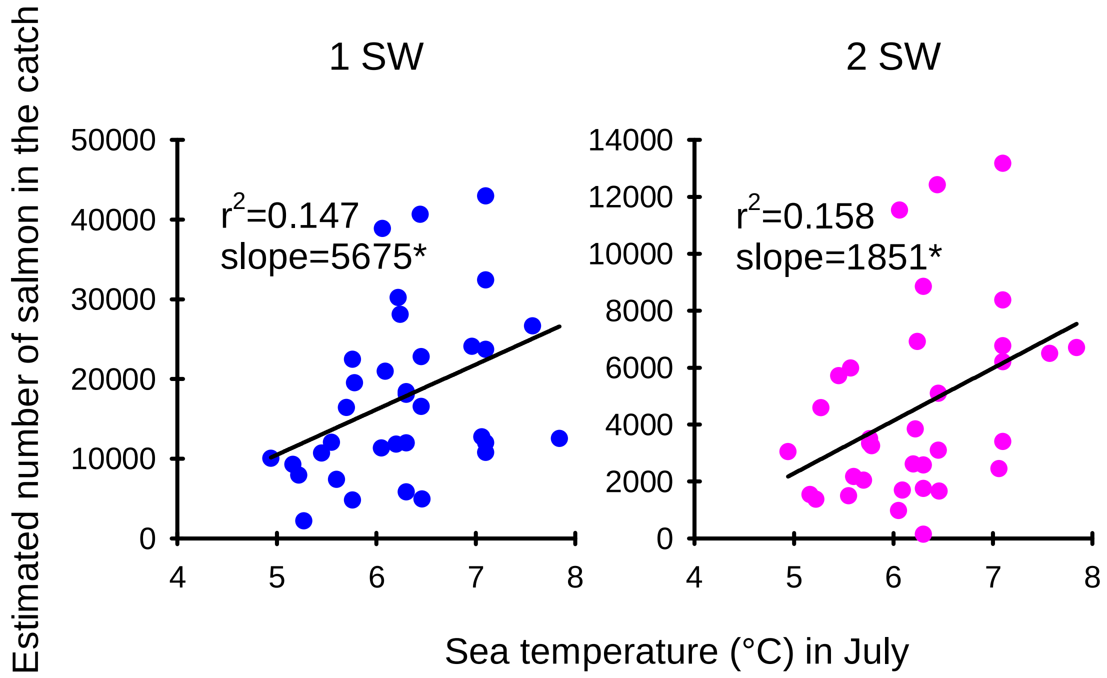


Figure 24. Figure illustrates the clear relationship between the Barents Sea temperatures and number of one-sea-winter (1SW) and to-sea-winter (2SW) salmon in the catches in the River Tana system. Temperatures are those values when smolts from the River Tana descended into the Barents Sea and measures are from Kola section. Source; PINRO (temperatures); Luke (numbers of salmon).

Annual mean temperatures in the Barents Sea are also governing the growth of one-sea-winter (1SW) Atlantic salmon from the River Tana (Figure 25). Comparable to the figures 18, 19 and 21 there can be observed clear annual fluctuations in the sea surface temperatures. There are simultaneous fluctuations in the lengths of 1SW salmon in the River Tana. It can be possible that sea surface temperatures could govern also the growth of pink salmon and therefore the warming of Barents Sea could lead to better survival and growth of pink salmon.

Sea surface temperatures play an important role in the abundance and in the growth of Atlantic salmon in the River Tana (Niemelä *et al*. 2004). Figure 26 indicates clearly that the improved growth results to the higher abundance of salmon. It can be possible that this kind of relationship can be established also for pink salmon.

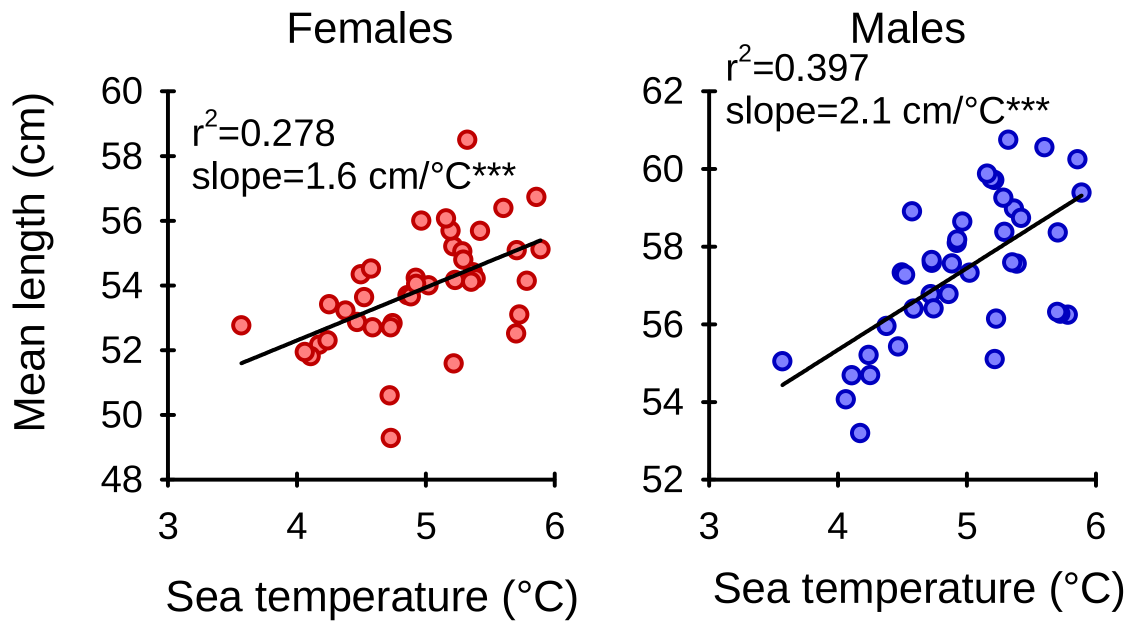


Figure 25. Figure illustrates the clear relationship between the annual mean temperatures in the Barents Sea (Kola section) and the mean lengths of 1SW salmon in the River Tana system. Source; PINRO (temperatures); Luke (lengths of salmon).

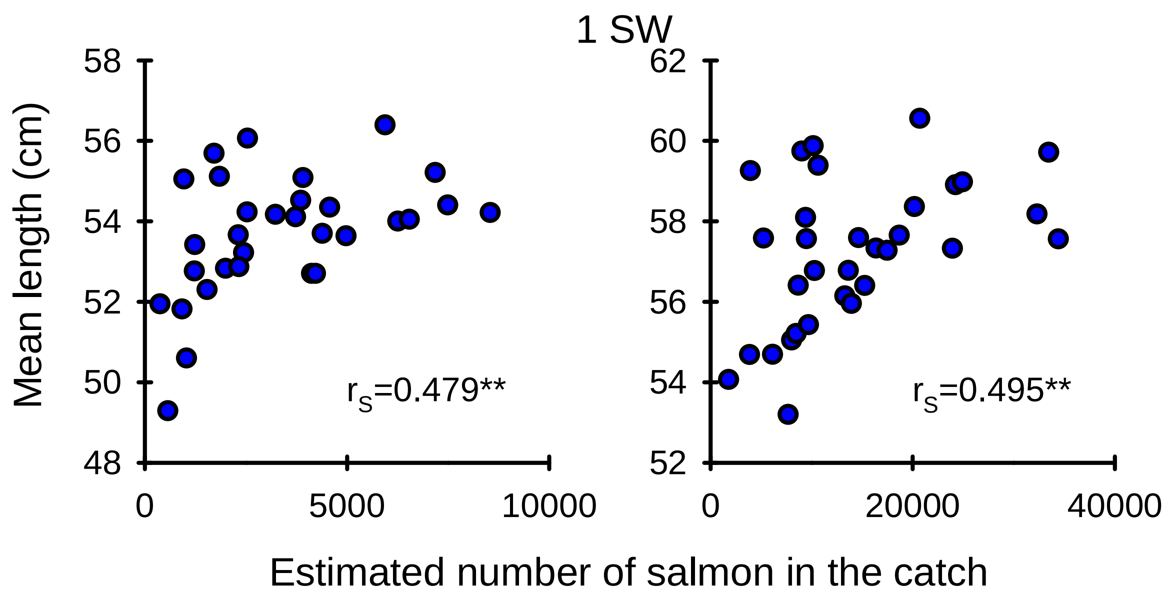


Figure 26. Relationship between the estimated numbers and mean lengths of 1SW female (figure on the left) and 1SW male (figure on the right) Atlantic salmon in the catches in the River Tana watershed. Figure illustrates clearly the effect of ocean temperature in July (during the smolt migration from the river to the Barents Sea) to the survival and growth of Atlantic salmon. Source; Luke

6. Distribution in the rivers Tana and Neiden

Pacific salmon, pink salmon, has been recorded in the official catch statistics since the middle of the 1970s’ in the rivers Tana and Neidenelva. The collection of annual catch records from Atlantic salmon and other fish species in these rivers, before the 1970s has not been systematic and the data is therefore poor and unreliable. There is, however, some anecdotic information from early 1960s’ on fish that might have been pink salmon. Local fishermen in the rivers Tana and Neidenelva were not informed about the possibility to catch this new fish species and therefore possible pink salmon catches has been recorded as Atlantic salmon. As late as 2000s it is likely that not all of the pink salmon are recognized by the anglers. There are some similarities between the silvery Atlantic salmon and a silvery pink salmon, which have just ascended into the rivers. But after some weeks staying in the river it is easier to distinguish at least the male pink salmon from Atlantic salmon. In the year 2015 there were analysed 11 pink salmon in the scale collection project in the River Tana Norway but from those 11 fish four were first identified by local fisherman to be Atlantic salmon or seatrout. Therefore the informed pink salmon catches are far below the real catches of this new species in the fisheries in all the rivers and at sea.

Pink salmon has been occurring in the entire Tana mainstem up to the confluence of Anárjohka and Kárášjohka and after that point pink salmon can migrate into the large tributary Kárášjohka and its tributary Iešjohka. In the Tana River there are two large riffles, Storfossen and Ailestrykene, but they are not restricting the distribution of pink salmon. In the River Iešjohka pink salmon has been caught below the waterfall Iešjokgårzi. There are some smaller tributaries in the River Iešjohka and it is possible for pink salmon to pass also there.

Between the years 2004-2015 the catch data collection for the River Tana has been improved compared to earlier years in Norway and altogether 336 pink salmon was informed to be caught. This makes an average of 28 pink salmon annually in the catch. Most (94%) of pink salmon in the River Tana watershed in Norway were caught in the River Tana mainstem (Table II). The rest were caught in the uppermost areas of the system, like from the lower Kárášjohka (1%), upper Kárášjohka (1%), Iešjohka (<0, 1%), Anárjohka (2%) and Maskejohka (<0.1%). Catch distribution within the River Tana mainstem in Norway indicated that the highest number of pink salmon was caught within the lowest 40 km (46%) where the fishery with weirs and gillnets is effective. Then within the next 25 km above the lowermost area there was caught 34%, and 19% was caught between the area from the Norwegian -Finnish border up to the River Leavvajohka and the rest 1% was caught within the area between Leavvajohka and Kárášjohka river mouth.

Combining all the catch data and scale information data together from Norway and Finland collected in the years 2004-2015 from the entire Tana watershed it is possible to see that most (40%) pink salmon have been caught between the area from the border of Norway and Finland up to the Leavvajohka area (Figure 27). This area is located c. 60 - 140 kilometres above the Tana river mouth. The second largest amount and proportion

(30%) of pink salmon is caught within the lowest 40 kilometres above the estuary just after pink salmon have ascended the river.

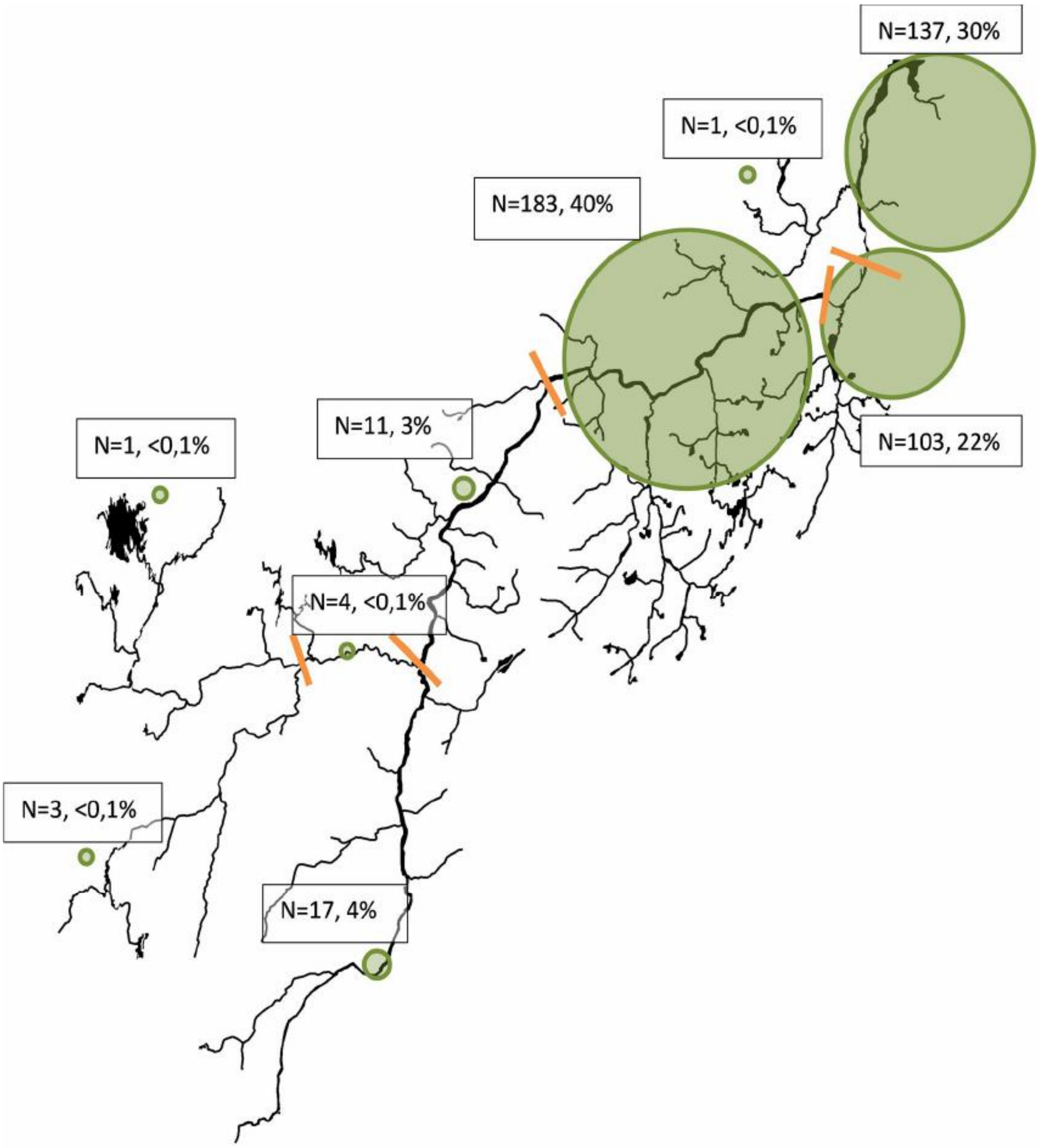


Figure 27. Numbers and proportions of pink salmon caught in the River Tana watershed within separate geographical areas (orange lines) in the years 2004–2015. Material from Norway is based on the official catch reports and from Finland on scale information. Source; TF and Luke

In the years 2012–2015 pink salmon catches were caught in two quite concentrate areas; close to the rivermouth, between the areas Rustefielbma and Bonakas, and in the area c. 40–50 km upstream from the rivermouth, between Tana bru and Holmesund (Figure 28, Table II). The third area was close to the river Buolbmatjohka. These three areas are also indicating the most important sites for Atlantic salmon fishing in Norway.

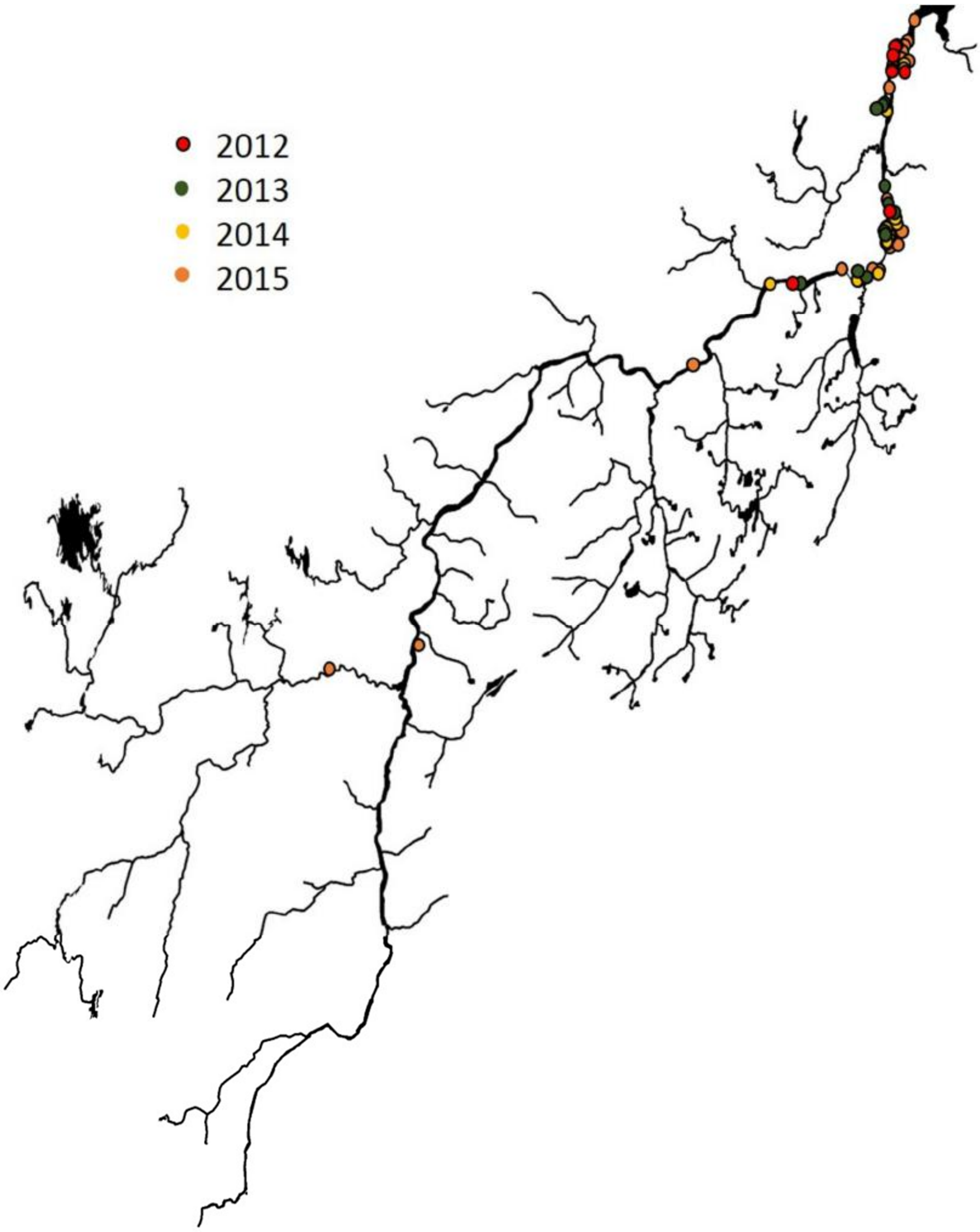


Figure 28. Sites in the river Tana watershed where pink salmon catches were caught by local fishermen in Norway in the years 2012–2015. Source: TF

Table II. Numbers of pink salmon caught in the years 2004–2015 in Norway in the river Tana watershed. Source: TF

Year	Tana river -mouth to Tana bru	Tana bru to Finnish-Norwegian border	Tana river from border to Levajok	Tana river from Levajok to Karasjohka	Maske johka	Anar johka	Karasjohka below Skaidigeacci	Karasjohka above Skaidigeacci	Iesjohka	Total
2004	10		4							**14**
2005	47		40	1				1		**89**
2006	3					2		1	1	**7**
2007	46	65	8	1		2	3	1		**126**
2008	1	3								**4**
2009	1	5	8	1	1					**16**
2010						1				**1**
2011	2	4								**6**
2012	5		1					1		**7**
2013	9	2								**11**
2014	7	15	2				1			**25**
2015	13	12	3	1			1			**30**
	144	**106**	**66**	**4**	**1**	**5**	**5**	**4**	**1**	**336**

Catch data has been collected annually from all fish species in Tana watershed in Finland since the year 1973 onwards. Local fishermen have been using gillnets, weirs, driftnets and rod for salmon, seatrout and pink salmon fishing. Salmon is the main target in all these fisheries and seatrout and pink salmon are bycatches. Figure 29 indicates the numbers of fishermen for each year who have had pink salmon catches. In all four areas during early 1970s' it was quite high numbers of fishermen with pink salmon catches and then around 1980s' pink salmon was not common catch. Table I also indicates low abundance of pink salmon in White Sea area. It is also interesting to note that in 1970s' and since the end of 1990s' pink salmon was caught every year originating from odd year and even year stocks. High numbers of fishermen caught pink salmon in the year 2007. The reason for that was successful spawning in the year 2005 and low natural mortality for pink salmon smolts in the year 2006 and favorable ocean conditions for the maturing pink salmon in the years 2006 and 2007. These factors resulted into higher abundance of pink salmon as well as for Atlantic salmon also in Tana river and as a final result many local fishermen caught pink salmon.

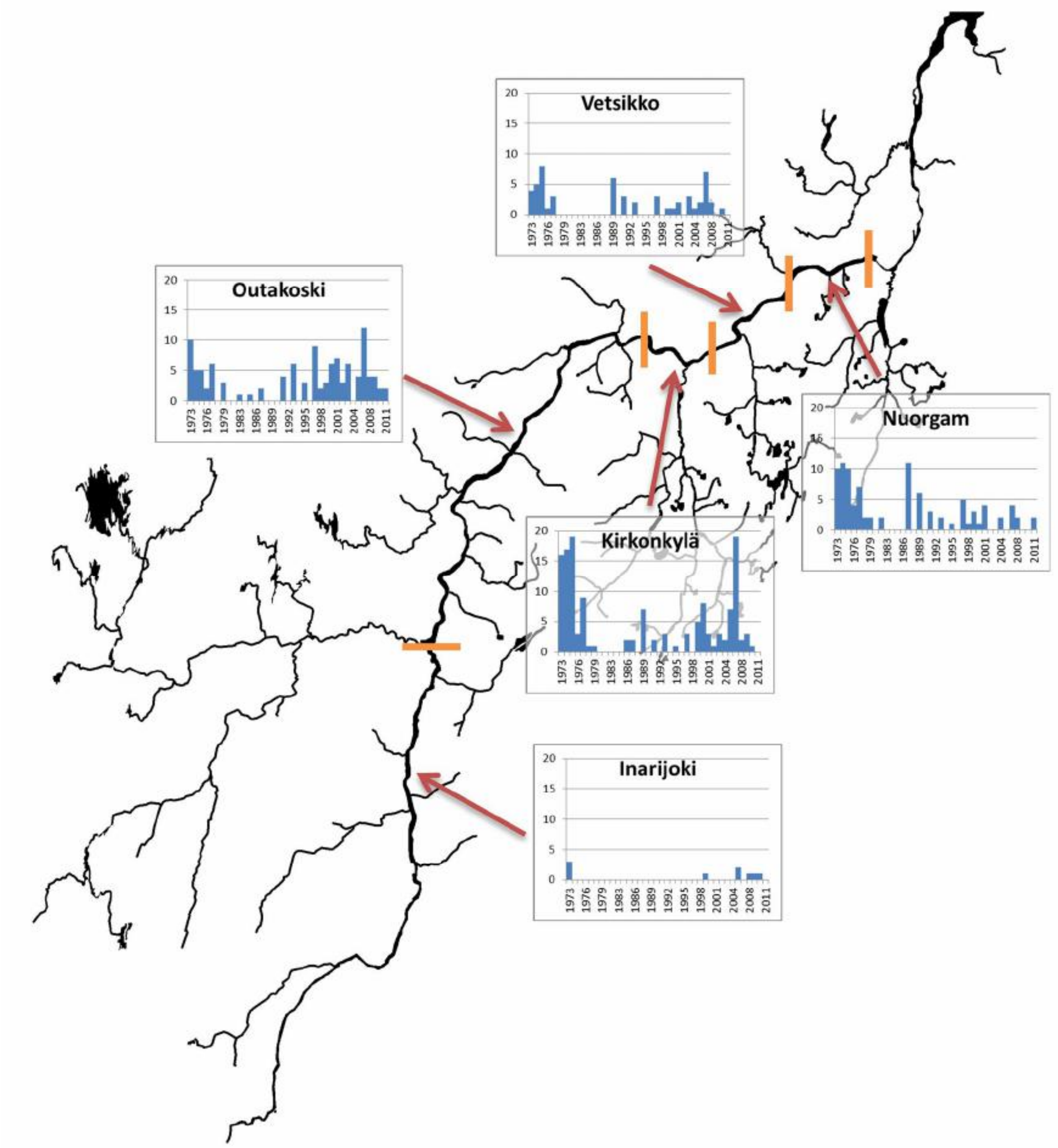


Figure 29. Numbers of fishermen who have informed to catch pink salmon on the Finnish side in the Tana River in the years 1973–2008.Source; Luke

In the border river Anárjohka, pink salmon can migrate without any real obstacles to the uppermost areas of the river and also into the tributaries of the River Anárjohka. Pink salmon has been caught at least in the Angeli area in 2014 (Raimo Torikka, personal information). Pink salmon has been caught in Finland, in almost all of the tributaries of the River Tana and especially in the middle of 1970s' its distribution area was the widest.

Several monitoring surveys have been carried out in the River Tana watershed during the last years (Figure 30). These monitoring activities have given basic information on the possible abundance, spatial and temporal occurrence of Atlantic salmon and seatrout, but also information on the presence of pink salmon.

Underwater camera counting’s in the River Utsjoki, a Finnish tributary, confirm ascend of 1-3 pink salmon annually during the last ten years. There has been video monitoring also in the Norwegian tributary River Lákšjohka since 2009, and 1-2 pink salmon have ascended almost annually (Panu Orell, personal information). In the year 2010 some pink salmon has been caught in the River Lákšjohka (Steinar Pedersen, personal information). No pink salmon were observed in the video monitoring in River Váljohka (2015) (Panu Orell, personal information).

Two smaller Finnish tributaries (Akujoki and Ylä-Pulmankijoki) have been monitored by drift counting annually since 2003, and two tributaries (Kalddasjoki and Niljoki) have been monitored several years in the same period. So far, no pink salmon has been observed (Panu Orell, personal information). On the Norwegian side the local salmon management body (River Tana Fish management - TF) has carried out drift counting surveys in several tributaries in the period 2012-2015. The counting has covered sections of 4-10 km of the tributaries. So far, no pink salmon has been observed (Narve S. Johansen, personal information).

These above mentioned monitoring surveys in Tana river system and the annual catch information data combined with the fish scale collection are one of the best long-term research carried out in northern rivers and covering the abundance and the ecology of all migratory fish species.

Photo 21. Pink salmon fries on the 2nd April in White Sea river. Yolk sac is already absorbed and fry have started to use external food. Fries have to feed still from one and a half to two months in the river before they will be smolts. Photo; Aleksei Veselov. (in Zubchenko et al. 2004).

Figure 30. Tributaries of the Tana river that have been monitored by video counting or by drift counting the last years. Tributaries that have been monitored by video counting are Utsjoki (2002-15), Lákšjohka (2009-15) and Váljohka (2015). Tributaries marked with blue circles are Finnish tributaries that have been surveyed by drift counting, including Akujohka and Upper Buolmátjohka (2003-15), and Nilijohka and Kaldasjohka which have been monitored several years in the same period. Tributaries marked with red circle are Norwegian tributaries that have been monitored by drift counting one or more years in the period 2012-15, including Sommerelva (2013-15), Geaimmejohka (2013-14), Váljohka and Baisjohka (2014-15). The drift counting in the Norwegian tributaries have not covered the total salmon bearing stretch, but typically sections of 4-10 km. Source: TF and Luke. Illustration map: Bente Strømodden

Photo 22. Drift counting of anadromous fish in the river Levajok/Leavvajohka (photo: Tonje Halvari).

Photo 23. Juvenile pink salmon smolt (below) and 1+ year old Atlantic salmon parr (above) caught in the River Neidenelva late in June in 1976. Pink salmon smolt age is 0+ Atlantic salmon parr is one year older (1+). Photo Vilhelm Bjerknes.

Photo 24. Pink salmon caught from the River Anarjohka, at village of Angeli, in the end of August. Distance to the Tana river mouth is c. 280 km. This male pink has some marks from the teeth of a seal. Photo Raimo Torikka

In the River Neidenelva pink salmon can pass the big waterfall, Skoltefossen, located c. 11 km from the estuary, migrating the entire Norwegian area and entering up to the uppermost riffles in the headwater close to the lake Opukasjärvi on the Finnish side.

7. Distribution in the rivers in Finnmark County

After the first unsuccessful transplanting's of chum salmon in the years 1933-1939 the attempts were resumed in the year 1956 with both pink and chum salmon (Berg 1961). Some of these transplanting's succeeded because a few pink salmon might have been caught in Norwegian waters in the year 1958 (Abrahamsen, personal information in Berg 1977). Berg (1977) describes that "the fishermen did not then know the fish and did not send them in for examination, so the information cannot be confirmed".

Every year since 1960 when a high number of pink salmon has been caught in Norwegian coastal waters, spawning pink salmon have been observed in many Norwegian rivers (Berg 1977). Already in the year 1960 pink salmon has observed to be spawning in the River Bergebyelva in East Finnmark and in early June of 1961 pink salmon smolts were observed to migrate to the sea (Berg 1977). This is the first observation from a successful development of eggs to migrating pink salmon smolts which were on their way to the sea. Berg (1977) had a hypothesis that pink salmon propagate in many Northern Norwegian rivers, and parts of the sea stock may belong to certain rivers. He proposed that such rivers are Neidenelva and Tanaelva. He also thought that the reason why the pink salmon ascend into many different rivers, may be due to the fact that the homing instinct may not work as well in the new surroundings in the Atlantic as in the natal habitat in the Pacific. Therefore from an ecological point of view there might be problems in the long-term run. For example juvenile pink salmon migrate as tiny smolts to the river mouths where they reach the estuary, spend there some time getting acclimatized to saline water and then they follow paths taken by their ancestors for countless generations. This seaward orientation mechanism, however, has been developed for the successful migrations in the Pacific Ocean areas over millions of years ago and it can be seen to be genetically determined and it does not function properly in the new sea environment in the North Atlantic. Therefore there have been wide distributions of pink salmon stayers in the areas of the North Atlantic from southern Norway, Scotland, Iceland and up to Svalbard in coastal areas, fjords and in rivers.

In the year 1976 Bjerknes (1977b, c) documented also pink salmon smolt migration following a high occurrence of pink salmon spawners in the year 1975 in the River Neidenelva.

Berg (1977) highlighted that pink salmon is well established in northern Norway, especially in Finnmark. He also thought that pink salmon in the rivers in eastern Finnmark may be self-reproducing. And in some rivers, i.e. Grense Jakobselva, Neidenelva, Komagelva, Tana spawning has been observed every year and the stocks are fairly dense. Berg (1977) made the conclusion that even if pink salmon is well established; the stock may yet again disappear.

It is well known and also partly documented that pink salmon has been occurring in the catches in most of the rivers in Finnmark and overall in the coastal and fjord areas in the bagnet and bendnet fishery. Pink salmon has been caught in small and also in large rivers like in the Alta river (Aandahl 1974).

High occurrence of pink salmon has been observed in the years 2007 and 2009 in some rivers in eastern Finnmark (Muladal 2009). For example in the lower stretches of the rivers Karpelva, Neidenelva, Vestre Jakobselva and Komagelva he found under diving surveys from ten to more than one hundred fish within a limited area of the river. High number of pink salmon in the lower sites in the River Vestre Jakobselva in the year 2007 resulted in the year 2008 to pink salmon smolt migration. This confirmed once again that pink salmon can spawn successfully and eggs can develop to smolts. However, the total numbers of pink salmon population in the rivers in Finnmark, it is not known, because the surveys which have been done tell the population size only within a very limited river stretch. In some rivers in Finnmark, like in the rivers Kongsfjordelva, Repparfjordelva and Stabburselva there have been underwater cameras to count numbers of ascending fish. These camera observations do not confirm large numbers of pink salmon populations inhabiting the rivers so far. Muladal (2009, 2010, 2013 and 2015) and Muladal & Kanck (2009) have, however, made annual conclusions during the last years from the abundance of pink salmon from diving surveys in numerous rivers in Finnmark. The data from these diving surveys confirms that the occurrence of pink salmon is more frequent than which can be found from official catch statistics.

Håvard Vistnes's (personal information) data from underwater camera survey and drift counting in the River Kongsfjordelva, in East-Finnmark, indicates that there is annually very few pink salmon ascending. Since the year 2007 there have been observations of 2-10 pink salmon each season based upon video and drift counts. There has been video counting in the River Kongsfjordelva from the year 2010 and onwards. Video camera is located close to the river mouth and therefore all pink salmon which have ascended into the river have been recorded. Maximum number of pink salmon has been 13 which were counted in the year 2015. Pink salmon in the catches has varied annually 0-4 fish.

Yngve Nilsen (personal information; Vest-Finnmark Jeger- og Fiskeforening) informs that the camera counting in the River Repparfjordelva, in West-Finnmark, has recorded during last year's only 1 pink salmon and that was in the year 2014. The underwater camera is situated in the upper part of the fishway located c. 30 km from the river mouth. Due to the large distance of the camera from the river mouth it is believed that only very few pink salmon migrate so far in the river system. Like in many other rivers pink salmon prefers to stay closer to the lower areas in the River Repparfjordelva, too. In August 2015 fishermen observed pink salmon in the lower areas of the River Repparfjordelva and they arranged fishery with rather small effort but succeeded to catch c. 20 pink salmon within a few days.

Svein Ingebrigtsen (Stabbursnes Naturhus og Museum) informs that there has been sporadic pink salmon catches during the last 20-30 years. Pink salmon catches are not collected with a specific purpose. They think that the pink salmon populations haven't been increasing.

Tor-Erland Nilsen (ALI) told that in the River Alta there has been annually very few pink salmon observations. In the year 2015 two pink salmon were caught.

Harald Muladal (personal information; Fisheries manager, Dep. of Environment, Office of the Finnmark County Governor) tells that the reports of pink salmon like also escaped salmon catches are not correct because the fisheries organizations don't have good system for reporting these species. And if organizations have this method the quality of statistics might not be satisfied because fishermen don't report systematically. Muladal also tells that the catch reporting from the coastal catches for pink salmon and for escaped salmon is not at all possible within the catch data information system at the moment. County Governor's office has tried with some local fisheries organizations to eradicate pink salmon from some rivers during the last years. These rivers (Karpelva, Neidenelva, Vestre Jakobselva) are situated in eastern Finnmark. In the year 2015 this was also done in the River Russelva in West-Finnmark. From the River Neidenelva the numbers of pink salmon caught with gillnet in the autumn has risen up to some hundred fish. Also from the River Vestre Jakobselva some hundred pink salmon has been caught during the spawning time with gillnets. As a conclusion Harald Muladal says that it has been caught much more pink salmon than it is reported to the fisheries organizations or into the official catch information centre. Muladal says that there is annual reproduction of pink salmon in the following rivers: Grense Jakobselva, Karpelva, Munkelva, Neidenelva, Klokkerelva, Nyelva, Vesterelva, Bergebyelva, Vestre Jakobselva, Storelva (Vadsø), Skallelva and Komagelva. There might be reproduction also in the rivers Syltefjordelva, Kongsfjordelva, Risfjordelva and Sandfjordelva (Gamvik).

In the table III Berg (1977) collected information from the annual occurrence of pink salmon in Northern Norway between the years 1960 and 1976. Wide distribution of pink salmon catches in many rivers in Northern Norway gives a signal of natural spawning. Table II, however, highlights the fact that catch questionaries' do not necessary tell the truth on the pink salmon population in particular rivers. Data presented in the table II is from Scanatura.no Internet pages from other rivers except the River Tana. In the River Vestre Jakobselva there has not been information from pink salmon in official catch reports since 2009 although in the neighbouring rivers Vesterelva and Bergebyelva pink salmon catches were reported. Nevertheless it is interesting to note that there have been odd year and even year stocks in many rivers. The low numbers of pink salmon in some rivers can be explained by the fact that fishermen maybe do not recognize pink salmon in summer or pink salmon might ascend rivers after the fishing season is over.

Photo 25. Pink male salmon in Kongsfjordelva. Photo Håvard Vistnes

Table III. Copy from the table presented in Berg (1977) illustrating the numbers of fry stocked annually in Russia in Barents Sea and White Sea area. The numbers of pink fry stocked in the years 1959-1970 are from Surkov & Surkova (1971) (ref. Berg 1977).

Table 1. *Sovjet stockings of pink salmon and subsequent records in Norway.*

Year	Fry stockings in millions	Year	Norwegian records
1959	15.3	1960	20—25,000 kg. Reports from more than 40 rivers in North Norway and found over the whole country. A number of spawning pink observed in many rivers in North Norway.
1960	14.4	1961	2—3,000 kg. Spawning in many rivers but not in great numbers. Several caught in Svalbard. (GULLESTAD 1970.)
1961	10.4	1962	4 reports only.
1962	34.5	1963	About 30 fish reported.
1963	23.7	1964	About 10 reported.
1964	35.9	1965	At least 20,000 kg. Numerous in almost all rivers in Eastern Finnmark. 2 caught in Svalbard. (GULLESTAD 1970.)
1965	None	1966	Found southwards to Trøndelag. Very few, only 5 reports.
1966	None	1967	Very few, about 30 reports, few from rivers.
1967	None	1968	No reports.
1968	5.0	1969	5 reports from Varanger, Finnmark.
1969	8.0	1970	Few reports.
1970	7.0	1971	20—25,000 kg. About the same as in 1960, but more concentrated in Eastern Finnmark. Hundreds caught in rivers. 1 caught in Svalbard. (GULLESTAD 1973.)
1971	?	1972	Some reports from Varanger, some caught in rivers.
1972	?	1973	Better than in 1960. Spawning in rivers as far southwards as in Trøndelag. Numerous in some rivers in Eastern Finnmark.
1973	None?	1974	Not numerous, spawners observed in several rivers especially in Eastern Finnmark.
1974	None?	1975	The run as in 1960. Spawning observed in many rivers, especially in Finnmark.
1975	None?	1976	A number in Finnmark, and some spawners in the rivers there. Single specimens observed in the sea and rivers as far south as Mandal.

Photo 26. Pink salmon male in the automatic counting chamber in the River Repparfjordelva in West Finnmark. Photo Yngve Nilsen.

Table IV. List of some rivers in Finnmark and numbers of pink salmon caught in recent years. In the rivers Neidenelva and Tana there are three numbers of pink salmon; official catch statistic information (Neidenelva stat.Nor; Tana stat.Nor), scale data information in Norway and in Finland. Source; Scanatura.no; Luke; TF.

River	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Grense Jakobselva						3	8	1	5	4	1	46	1
Karpelva								-	-	-	-	-	-
Munkelva								-	-	-	-	-	-
Neidenelva statistics Nor					61	4	12	1	8	15	6	6	8
Neidenelva scales Nor	4		2		6		2		1		5	2	1
Neidenelva scales Fin	3										1		
Klokkerelva								-	-	-	-	-	-
Vesterelva								-	-	2	1	13	3
Bergebyelva								-	-	1	-	2	5
Vestre Jakobselva							-	-	-	-	-	-	-
Skallelva							1	-	2	-	-	3	6
Ordo									-	-	-	-	-
Kongsfjord-elva													
Tana statis-tics Norway	90	14	89	7	126	4	16	1	6	7	11	25	30
Tana scales Norway	39	7	64	3	102	3	14	2	4	2	16	13	11
Tana scales Finland	26	4	51		54	4	2	3	1	2	4	10	11
Laggo								-	-	-	-	-	-
Risfjordelva								-	-	-	-	-	-
Sandfjordelva Gamvik								-	-	-	-	-	-
Futelva Mehamn								-	-	-	-	-	-
Veidneselva											-	-	-
Børselva							1	-	2	-	1	2	2
Lakselva, Porsanger						-	-	-	-	-	-	-	-
Repparfjord-elva								-	4	-	3	1	8

8. Pink salmon in the River Tana

8.1. Catches

After the first releases of chum (keta) salmon juveniles in the years 1933-1938 into the rivers Kola (draining into the Barents Sea on the Northern side of the Kola Peninsula) and Onega (draining into the White Sea on the southern side of the White Sea basin) there was only few salmon returning to the fishery in 1930s'. No historical information (traditional knowledge) is available from the River Tana or Neiden describing "strange" looking salmon in the catches. Official salmon catch reporting started in Finland in the early 1970s'. There is, however, some information on historical salmon catches dating back to the decades of 1950s' and 1960s'. This information has been collected by personal interviews retrospectively during the years 1970-1973. In Norway the River Tana salmon catches were covering mainly the fishery in the lower areas of the river before 1970s'.

The first information of pink or keta salmon in the catches have been done in the River Tana in the 1960s' but the volume of the catches is not known. A more reliable collection of catch statistics started in Finland and in Norway in the early 1970s' and from the year 1972 onwards there are regular annual questionaries' in which also pink salmon catches can be reported. It is for sure that there have been pink salmon catches also in 1960s' and that this new salmon species has been caught both in the main stem of the River Tana and in the tributaries. It is most probable that fishermen have included pink salmon catch into the catches of Atlantic salmon in 1960s' and also in later decades. Especially for tourist fishermen it might have been difficult to distinguish the salmon species from each other and pink salmon has been included into salmon catches especially in June and early July, when the pink salmon still looks like a silvery salmon.

Reported pink salmon catches might have been highly underestimated in the River Tana watershed. Reported total catches reached the level of 2500 kilos in the year 1977 which might be far below the real catch (Figure 31). In the year 1977 pink salmon was caught all over the Tana river and in most of the tributaries as far up as in the River Iešjohka, Kárášjohka and Anárjohka which are 250- 300 km from the Tana river mouth. It is also interesting that there has been catches in both odd- and even years although the catches in odd years have been clearly higher. Catches occurring in odd and even years indicates that the introductions with both of those stocks have been successful in the rivers in Barents Sea and in White Sea.

Official reported pink salmon catches in the River Tana in Norway have been as follows:

- in 1973 reports of huge numbers of pink salmon in Iešjohka below the Iesjåkgårzi and in 1975 and 1977 reports of pink salmon catches in Iešjohka (Bjerknes 1978)
- in 1973 two persons informed to have caught 75 kg and 240 kg pink salmon in the River Tana between Leavvajohka and Kárášjohka river mouth (Hansen *et al.* 1975)
- in 1975 Tana watershed 4700 kg (Bjerknes & Rikstad 1978) (unclear estimate)

- in 1976 from Tana watershed 521 (kg) / 306 (number) (Anon. 1976)
- in 1977 from Tana watershed 1300 kg (between Tana estuary and Storfossen 1109 kg; River Maskejohka 72 kg; between Storfossen and Karasjohka river mouth 6 kg; Iesjohka-Karasjohka-Anarjohka 86 kg; other tributaries and no information from the site 28 kg). Catch distribution: Driftnet 178 kg, weir 717 kg, gillnet 59 kg, rod 351 kg (Anon. 1977)
- in 1978 from Tana watershed 44 kg/25 number (Anon. 1978)
- in 1979 from Tana watershed 370 kg (Anon. 1979)
- in 1980 from Tana watershed 9 kg/6 number. All were caught with driftnet (Anon. 1980)

Official reported pink salmon catches in the River Tana in Finland have been as follows (Toivonen & Heikinheimo 1978):

- in 1972 from Tana mainstem 1 pink salmon with rod in Ailestrykene
- in 1974 from Tana watershed 238 kg (Tana 228 kg; Anarjohka 2 kg; Utsjohka 5 kg; Vetsikkojohka 1 kg; Polmakjohka 2 kg)
- in 1975 from Tana watershed 177 kg (Tana 168 kg; Anarjohka 6 kg; Utsjohka 2 kg; Vetsikkojohka 1 kg)
- in 1976 from Tana watershed 147 kg
- in 1977 from Tana watershed 720 kg. One fisherman informed that he had got one chum salmon (*O. keta*)

Transplanting's of pink salmon into the White Sea rivers stopped in the year 2001. While there still has being pink salmon catches in Norway and in Finland all over in the River Tana watershed, it is suggested that pink salmon actually has established self-producing stocks somewhere. There might have been annual pink salmon spawning in the River Tana system. Fishermen have annually reported female pink salmon, which have been full of eggs. There is conducted annual electrofishing research to monitor juvenile Atlantic salmon densities and occurrence but only on 20. July in the year 1979 it was found one pink salmon smolt in the River Tana close to Leavvajohka (Eero Niemelä, pers. information). Reason for the absence of pink salmon juveniles in the electro fishing sites might be that pink salmon smolts have already migrated to the Tanafjord in June and early July before the monitoring of juvenile salmon densities starts.

Pink salmon catches in the River Tana, however, most probably are reflecting successful reproduction over the resent years in White Sea rivers. The instinct to migrate precise to the home river in Barents Sea and White Sea area might be weakened for pink salmon because its homing behaviour is adapted to the coastal areas of the Pacific Ocean.

Pink salmon catches show a declining trend since the last high odd year catches in 2007. In a long-term perspective it is very important to intensify the catch data collection from pink salmon by educating and informing fishermen to observe correctly the differences between the two salmon species.

Although the sea temperatures in Kola section have clearly increased since the year 1980 especially in June and July (Figure 19) when pink salmon smolts are descending from rivers to sea and the monthly sea temperatures have also clearly increased in the winter months (Figure 20), the catches of pink salmon have declined in the River Tana watershed. Catch development in the River Tana might be dependent on the pink salmon smolt survival in the White Sea area, homing migration routes for pink salmon as well as the accuracy of catch reporting.

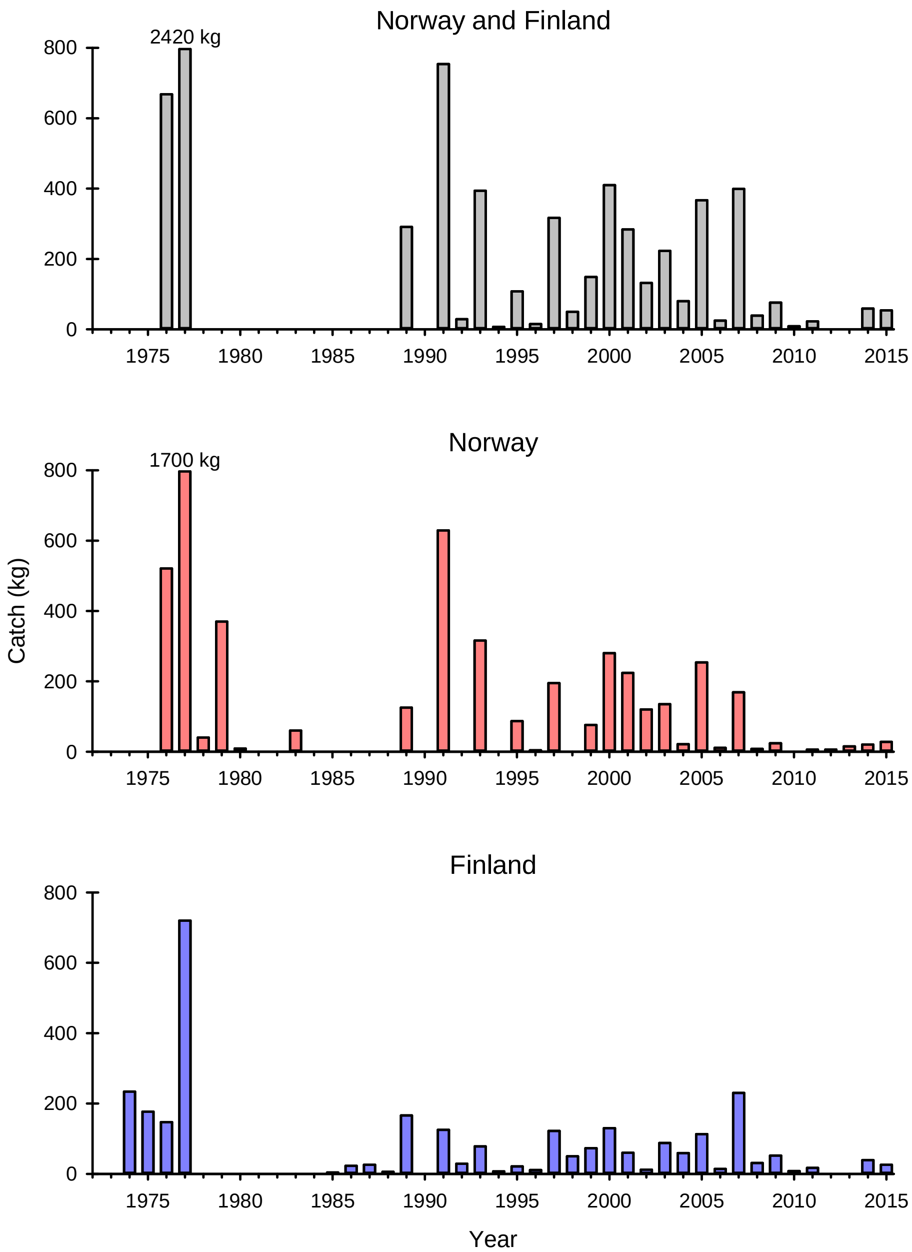


Figure 31. Pink salmon catches in the River Tana watershed. Source: TF, FMFI and Luke.

In the River Tana there are five fishing methods (rod, weir, gillnet, driftnet and seine) exploiting migrating fish like Atlantic salmon, seatrout and pink salmon. Driftnet is operating in the beginning of the fishing season from May 20. to June 15. All other fishing methods are operating throughout the season which closes 31. August.

Rod fishing is exploiting almost equal catch percentages of pink salmon in the River Tana in Norway between three large areas (Figure 32). In the area from Tana estuary to Tanabru the rod catches are taken in the uppermost area close to the village of Tanabru. In Tanabru there is the most famous rod fishing site, Seidastryket, where the catch of pink salmon is taken with the rod fishery using a boat. Weir fishing takes the highest proportions of the catches in all the areas. In the area between Tanabru and Norwegian-Finnish border weirs are the most important fishing gear to catch pink salmon. Within this area the use of gillnets is not so intensive compared to the areas above and below it. Some small percentage of the pink salmon catch is also taken with driftnets in the lowermost area. This indicates the early migratory behaviour of pink salmon before June 15. Weirs and gillnets are passive fishing gears where the minimum mesh sizes from knot to knot is 58 mm and they might be a little selective gears allowing the smallest pink salmon to swim through the meshes. Pink salmon smaller than 1 kg can easily swim through the 58 mm mesh sized weirs and gillnets in June and July before pink salmon males have got the very large spawning hump just behind their heads.

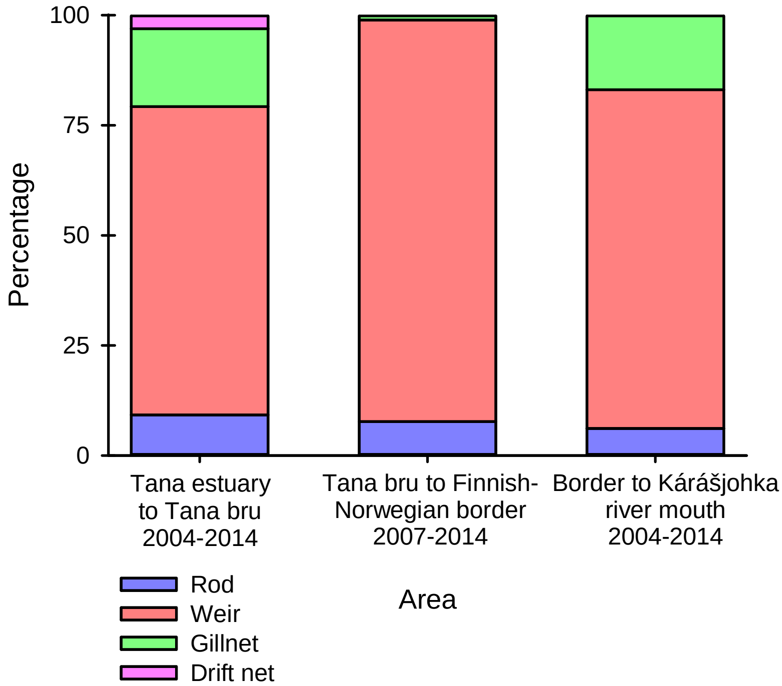


Figure 32. Pink salmon catches in terms of numbers for four fishing methods in three areas in the River Tana mainstem in Norway. Source; TF and FMFI catch statistics in the years 2004–2014.

There looks not to be selectivity in the catches between sexes caught with rods, weirs and gillnets, nor on the Norwegian side (Figure 33) and on the Finnish side (Figure 34) of the River Tana. The rod fishery, however, is more popular on the Finnish side than on the Norwegian side and therefore almost 25% of pink salmon catches in both females and males has been caught with rods in Finland, compared to the very low percentages caught with rod in Norway. The main explanation to the differences in the catch distributions between fishing methods in Norway and Finland is the difference between the fishing cultures in the respective countries. Another reason for the seen differences is that here is mainly fishing with weirs in the lowermost area in Norway. Pink salmon which have just entered into the River Tana from Tanafjord can be also less active to seek lures and wobblers. Their activity to seek lures can increase with time in July and August and therefore they are occurring in higher proportions in the Finnish rod catches. It is interesting that males do not occur in higher proportions in the rod catches because it could be assumed that they are getting more aggressive towards the spawning season and therefore males could be caught easier than females with rods.

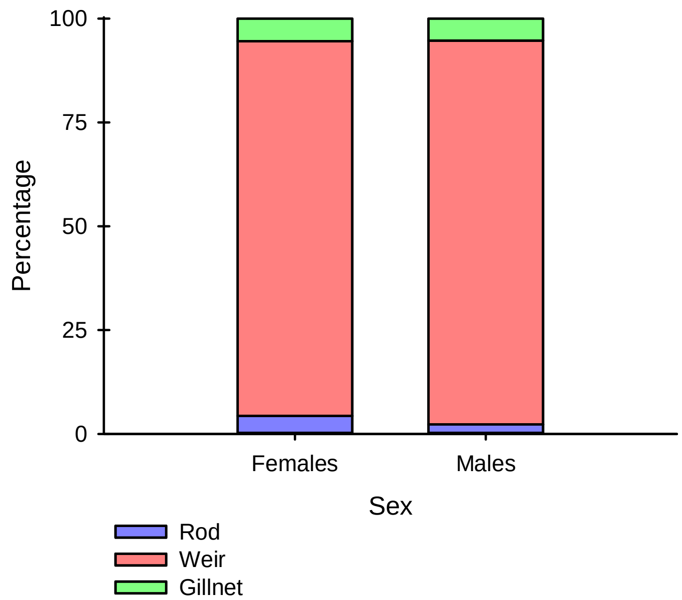


Figure 33. Female and male pink salmon catches in terms of numbers for the three fishing methods in the River Tana in Norway. Source; TF and FMFI scale data in the years 1986–2015.

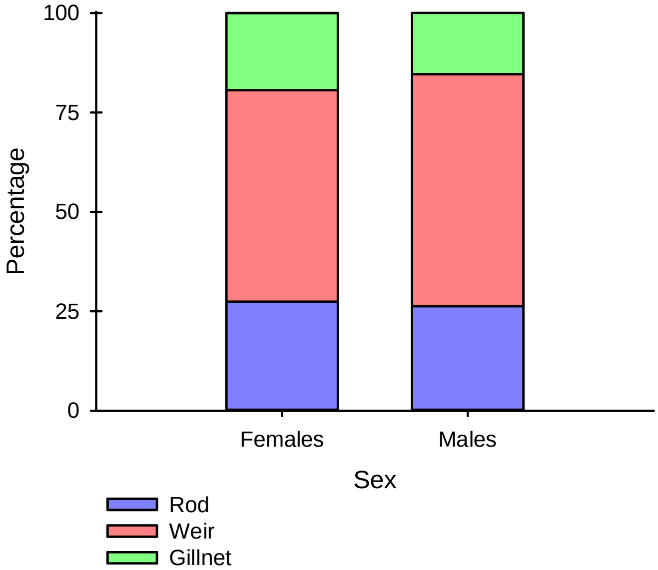


Figure 34. Female and male pink salmon catches in terms of numbers for the three fishing methods in the River Tana in Finland. Source; Luke scale data in the years 1974–2015.

Photo 27. Pink salmon (on the left) and Atlantic salmon (on the right) caught c. 25 km above the Tana estuary. Both fish had been foraging at sea for one full year but the pink salmon left some northern river one year ago in the length of c. 3.3 cm in the smolt age of 0+ and the Atlantic salmon left the River Tana in the length of c. 16 cm and in the smolt age of 5+ years. Photo Eero Niemelä.

Table V indicates that pink salmon is caught almost every year with all the possible fishing methods which are used from the middle of June to the end of August. The numbers of pink salmon caught are based on the catch reporting combined with the scale data information. It has been found that professional salmon fishermen can’t recognize all the pink salmon and those fish are informed to be Atlantic salmon. This error in recognising the right species happens early in the summer when these two salmon species are looking very similar. In the years 2004-2015 fishermen caught altogether 560 kg pink salmon. Mean annual catches were 46 kg and 28 fish.

Table V. Annual pink salmon catches in numbers and weights between fishing gears in the River Tana watershed in Norway in the years 2004-2015. Source; TF and FMFI catch statistics.

Year	Driftnet	Rod	Weir	Gillnet	Total
2004		1	12	1	**14**
2005	4	4	69	12	**89**
2006		5		2	**7**
2007		11	100	15	**126**
2008		3	1		**4**
2009		3	12	1	**16**
2010		1			**1**
2011		1	4	1	**6**
2012		3	2	2	**7**
2013		1	7	3	**11**
2014			22	3	**25**
2015		9	18	3	**30**
Total in numbers	**4**	**42**	**247**	**43**	**336**

Year	Driftnet	Rod	Weir	Gillnet	Total
2004		1,5	18,7	1	**21,2**
2005	8	7,4	138,2	39,1	**192,7**
2006		8,7		2,7	**11,4**
2007		17,8	128,9	22,5	**169,2**
2008		7	1		**8**
2009		4,2	19,51	5,1	**28,81**
2010		1			**1**
2011		1,5	7,1	2	**10,6**
2012		5,3	4,3	4,2	**13,8**
2013		1,2	10,9	5,2	**17,3**
2014			32,73	3,5	**40**
2015		14,53	28,46	5,5	**48,49**
Total in weight	**8**	**70,13**	**389,8**	**90,8**	**562,73**

8.2. Timing of the catches

It's known from the coastal areas in the Pacific Ocean and from the rivers therein like also from the coastal areas as well as from the rivers in the White Sea that pink salmon is ascending the estuaries in summer, staying there for a while and then migrating upstream and navigating to the areas, where it was born (hatched) a year ago. This same migration timing takes place in the River Tana although we suppose that these pink salmon are not coming back to the river where they were born. Some of these pink salmon spawners, however, might have been born somewhere in Tana watershed. It is most obvious that there are a lot of stayers from the stocks transplanted into the White Sea rivers where they have now established self-reproducing stocks. Because pink salmon stocks have inherited the instinct to make feeding and spawning migrations within the Pacific Ocean area, there must be quite high proportion of fish which are orienting to "wrong" rivers. It is also true that the transplanted fish are originating from many rivers in the Pacific Ocean which might weaken their homing migration in Atlantic area. It might also be some kind of social behaviour within pink salmon when they are following large grilse (1SW salmon) shoals from the feeding areas to the spawning rivers. Some limited data exist, that pink salmon is occurring within a large area in the North Atlantic and Barents Sea. Pink salmon can then follow matured wild salmon stocks towards the North Norwegian coastal areas, fjords therein, and finally migrate with larger or smaller wild salmon shoals into the rivers.

Pink salmon are anyway migrating in smaller or larger shoals in the coastal areas because salmon fishermen have been catching many of those fish at the same time in their fishing gears. Bend nets which are at the moment the most common used fishing method in Finnmark. Bend nets are selective fishing gears with the mesh sizes larger than 64 mm from knot to knot. These nets are catching the largest pink salmon, usually larger than 1.5 kg. In the coastal salmon fishery pink salmon is occurring usually at the same time as salmon belonging to the smallest size group (<3kg). This confirms that pink salmon and 1SW salmon are migrating in loose shoals clearly later than the median size (3-6 kg or 2SW) salmon or the large size (>6 kg, 3-4 SW or previous spawning) salmon.

In Norway most of the pink salmon catches in the River Tana is taken early in July, in the week 27 (Figure 35). Catches are declining after the peak. Figure 35 indicates that pink salmon is available to be caught during almost the entire fishing season except from very early in the summer, when the large sized salmon is the main target in the Atlantic salmon fishery. Pink salmon in the catches is only bycatch because nobody is fishing it on purpose. When combining all pink salmon scale data from Norway and Finland from the entire Tana mainstem we can clearly see that July is the most important month for the fishery (Figure 36). Catches in August, however, are rather low but pink salmon can still be caught to the end of the month. Fishing effort within the lowest 40 km upstream from the Tana estuary in August is low, which affects to the amount of pink salmon in the catches.

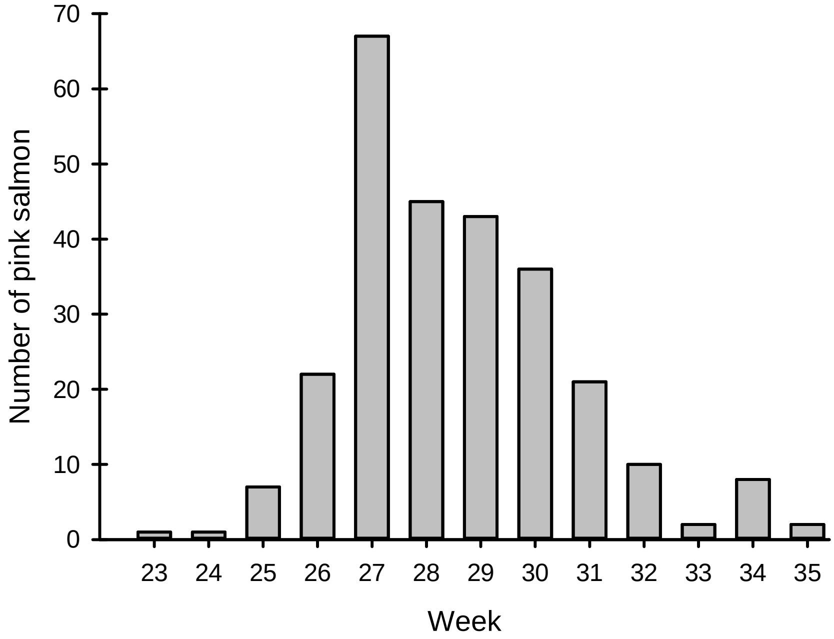


Figure 35. Weekly numbers of pink salmon in the catches in the River Tana in Norway. Source: TF and FMFI. Fish scale data from the years 1974–2015.

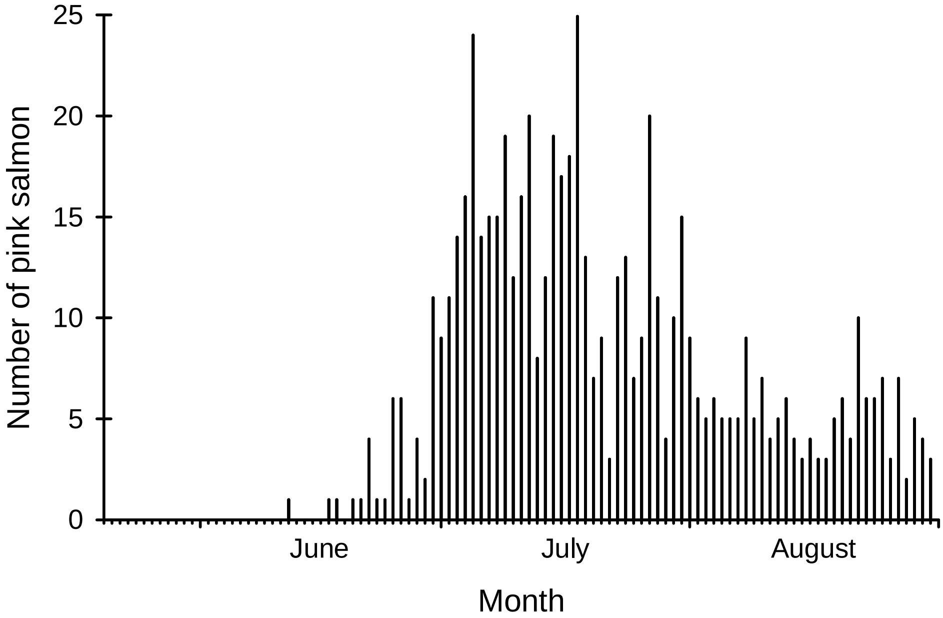


Figure 36. Daily pink salmon catches (numbers) in the River Tana watershed in Norway and Finland. Source: TF, FMFI and Luke. Fish scale data from the years 1974–2015.

Most of the pink salmon catches caught in the River Tana is caught within the area of 60 km above the estuary. This area is Norwegian. Figure 37 and especially figure 38 informs about the differences in the timing of pink salmon in the Norwegian and Finnish catches. In Finland 50% from the catch is taken c. July 15. and in Norway it is taken c. 10. July. Figure 38 informs also that the rest of the catch in Finland accumulates during one and a half month time period.

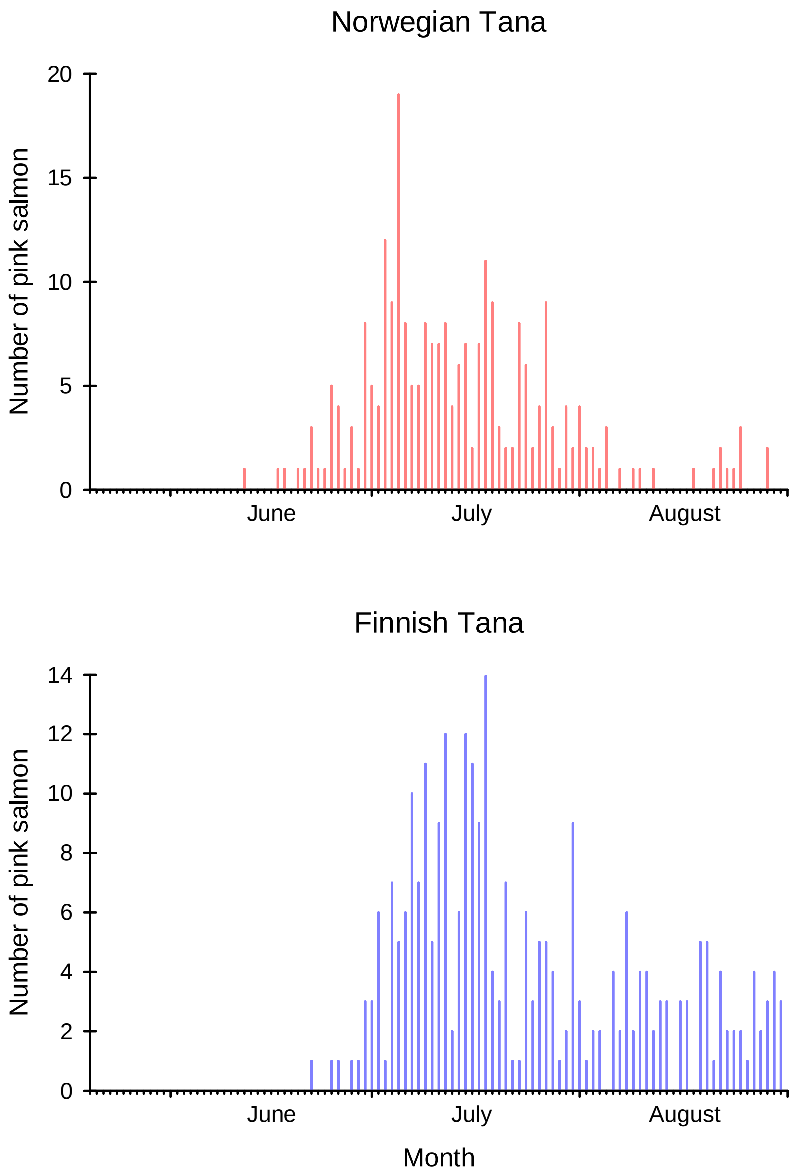


Figure 37. Daily pink salmon catches (in numbers) in the River Tana watershed in Norway and Finland. Source: TF, FMFI and Luke. Fish scale data from the years 1974–2015.

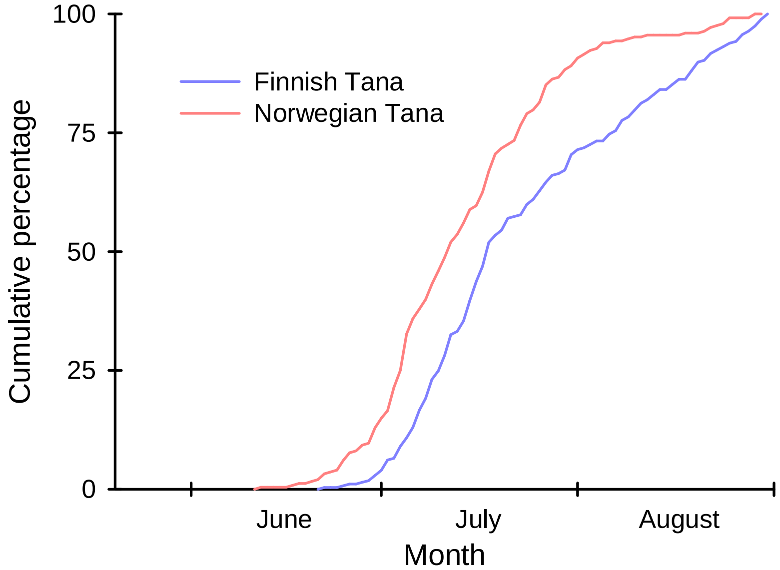


Figure 38. Cumulative percentages of pink salmon catches (in numbers) in the River Tana mainstem in Norway and in Finland. Source: TF, FMFI and Luke. Fish scale data from the years 1974–2015.

Photo 28. Pink salmon, c. 2.5 kg, caught in the River Tana in the early 1980s'. Tom Clayhills is measuring the fish at the Kevo Research Station. Photo Eero Niemelä

The way of collecting catch statistics on the Norwegian side of the River Tana was renewed in the year 2004, which improved the accuracy. Especially, for the catch distribution between the different fishing gears became more reliable. Figure 39 represents the distribution of pink salmon catches between different fishing gears. Already presented in figure 32 the general distribution of pink salmon between different fishing gears, and presented in even more details during the summer in figure 39. Early in the summer before 15. June drift net fishery is targeting to pink salmon. During the period when fishermen are using driftnets, the interest and use of other fishing gear is limited. After the driftnet fishing season all other methods are in use. Throughout the summer catch distributions between the fishing gears don't change significantly although the proportion of pink salmon caught with gillnets is increasing towards the end of August. One reason for this increased catch of pink salmon in gillnets must be the shortening of the daylight in August compared to the long light nights in June and July. In dark nights pink salmon cannot observe gillnets.

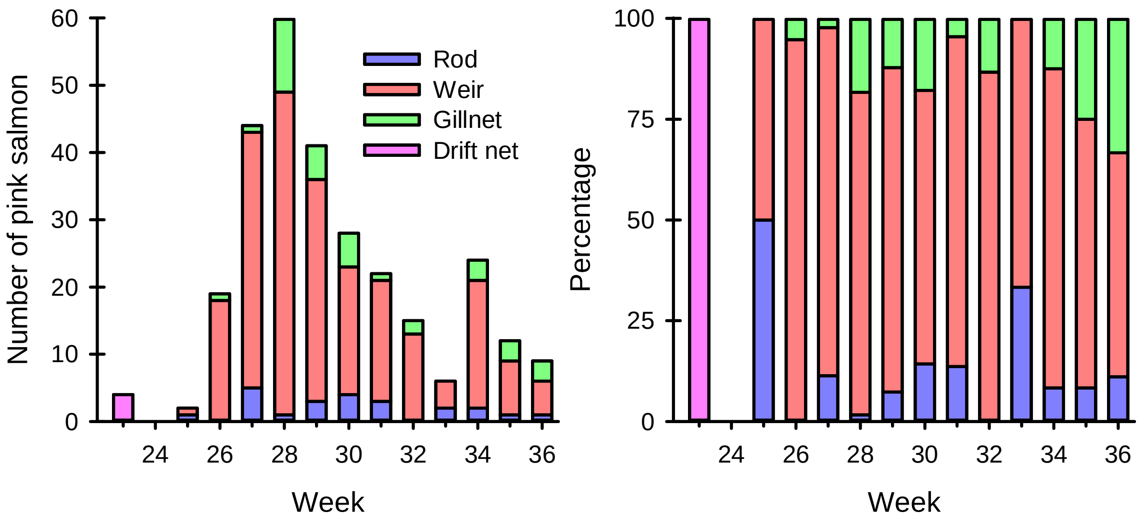


Figure 39. Pink salmon weekly catches (in numbers and percentages) for four fishing methods in the River Tana in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

Photo 29. Female pink salmon (above) in spawning condition and ready to release eggs in the middle of August in the River Tana, Ailestrykene. Pink salmon male caught early August in the River Tana. Photos Eero Niemelä.

Pink salmon is migrating into the River Tana the entire summer from June to the end of August. In the lowermost area of the River Tana from the estuary to Tana bru pink salmon is occurring in the catches every week during the summer (Figures 40 and 41). It is obvious that some pink salmon are migrating into the River Tana also in September after the fishing season ends. The increase of pink salmon in the weekly catches towards the end of August in the upper areas of the River Tana is indicating that fish are migrating to spawning sites maybe into the rivers Karasjohka, Iesjohka and Anarjohka. It might be also possible that pink salmon in the upper areas of the River Tana is more vulnerable to be caught with gillnets and weirs when nights are getting dark in August. In August pink salmon is also searching for spawning sites and therefore it is moving around the riffles where some gillnet fishery still exists in the end of August.

To eradicate occurring pink salmon and to hamper its possibilities to reproduce in the River Tana watershed fishery towards this new species should be increased during three weeks in the middle of July. In practice this is kind of selective fishery is impossible to carry out, a fishery which only targets to pink salmon, because the wild 1SW Atlantic salmon has at the same time its peak in its spawning migration (Figure 42).

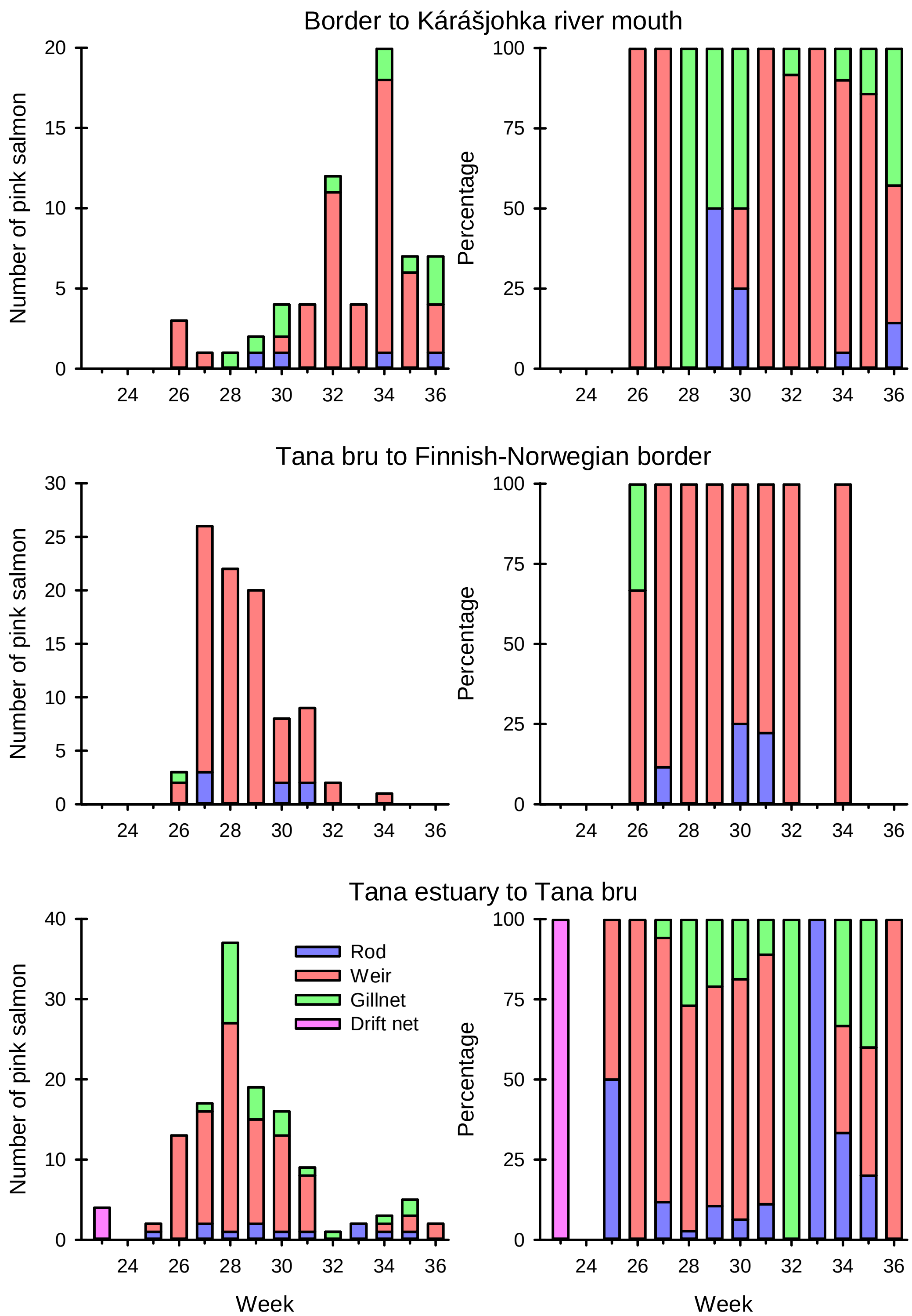


Figure 40. Weekly pink salmon catches (in numbers and percentage) for four fishing methods in three areas in the River Tana mainstem in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

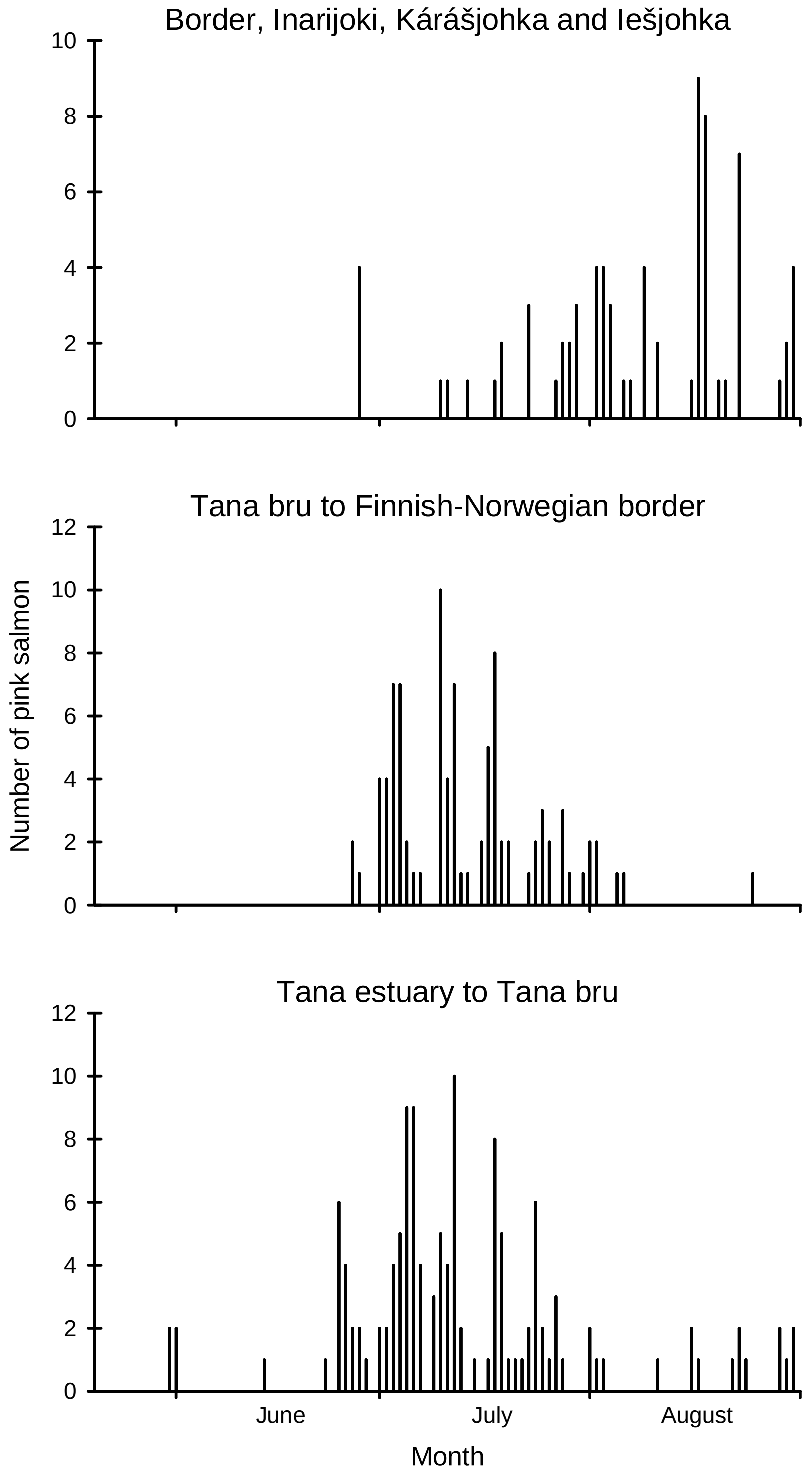


Figure 41. Daily pink salmon catches (in numbers) in three areas in the River Tana watershed in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

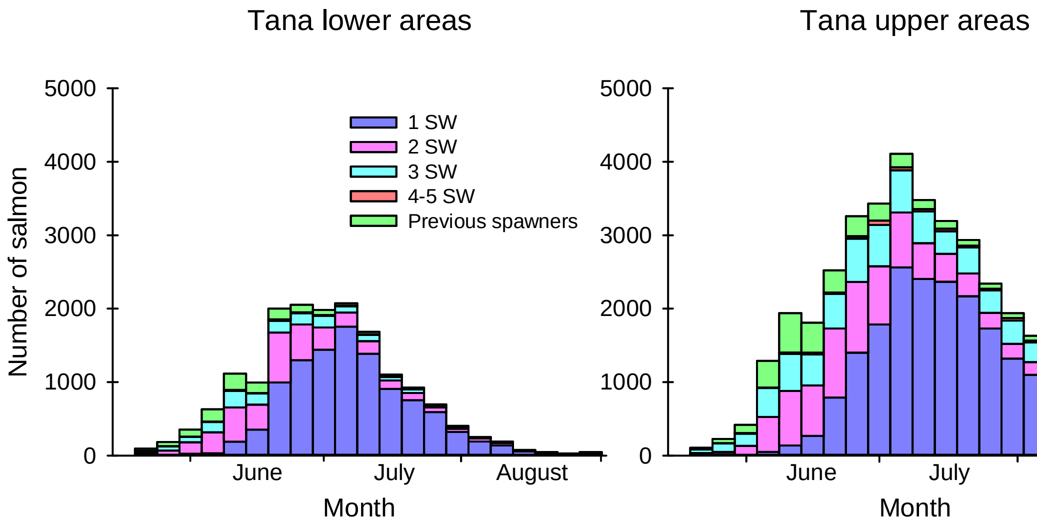


Figure 42. Timing of the wild Atlantic salmon (1-5SW and previous spawners) in five days period in the catches in the lower area (within 60 km from the estuary upstream) and in the upper area (between 60 km and 220 km from the estuary) in the River Tana. Source; TF, FMFI and Luke. Fish scale data from the years 1997–2015.

Photo 30. Pink salmon (below) and wild Atlantic salmon (above). Both these male fish have been growing one year at sea before they were caught in the River Tana early in July with weir. Photo Eero Niemelä

Cumulative catches in the River Tana in Norway indicate clearly that pink salmon is migrating quite fast through the lowermost 60 kilometres up to the Finnish-Norwegian border area (Figure 43). Almost 50% of the catches are caught very early in July within the two lowermost areas but in the uppermost area in the River Tana on the Norwegian side 50% is caught as late as in the middle of August.

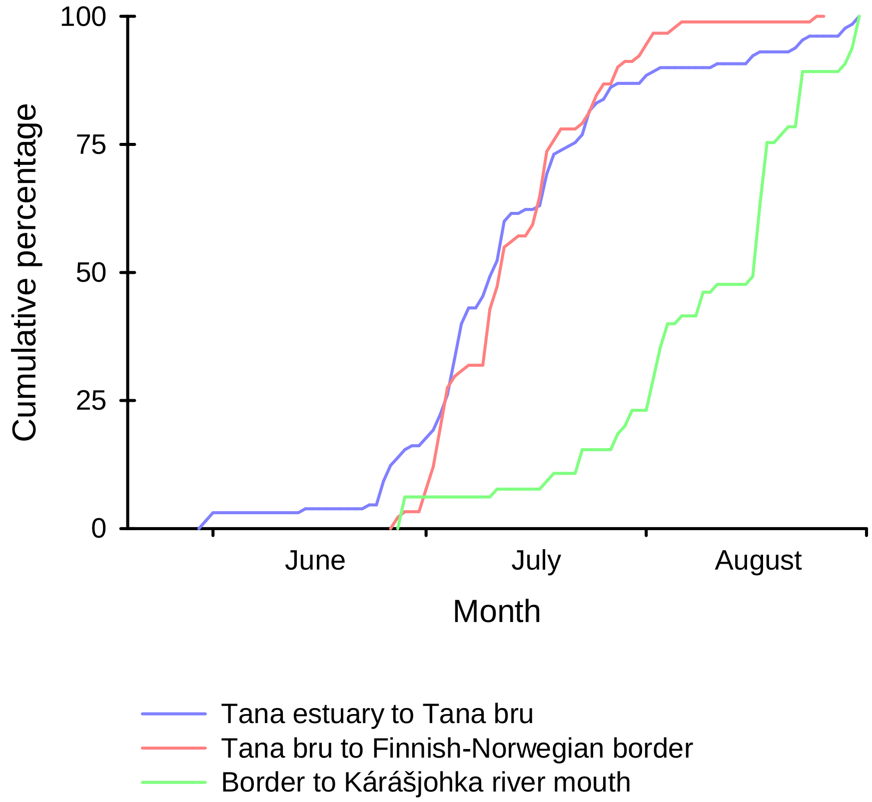


Figure 43. Cumulative percentages of pink salmon catches (in numbers) in three areas in the River Tana mainstem in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

There are both odd year and ever year stocks of pink salmon transplanted into White Sea rivers. In figure 31 it can be observed that odd year stocks are stronger and more numerous in the annual catches over the years. In odd years catches are distributed almost to all of the summer weeks (Figure 44). Pink salmon migration and the weekly timing of the catches take place differently between the years. A lot of environmental parameters at sea are governing the timing of migrations along the coastal areas and also environmental conditions like the water temperature in the river.

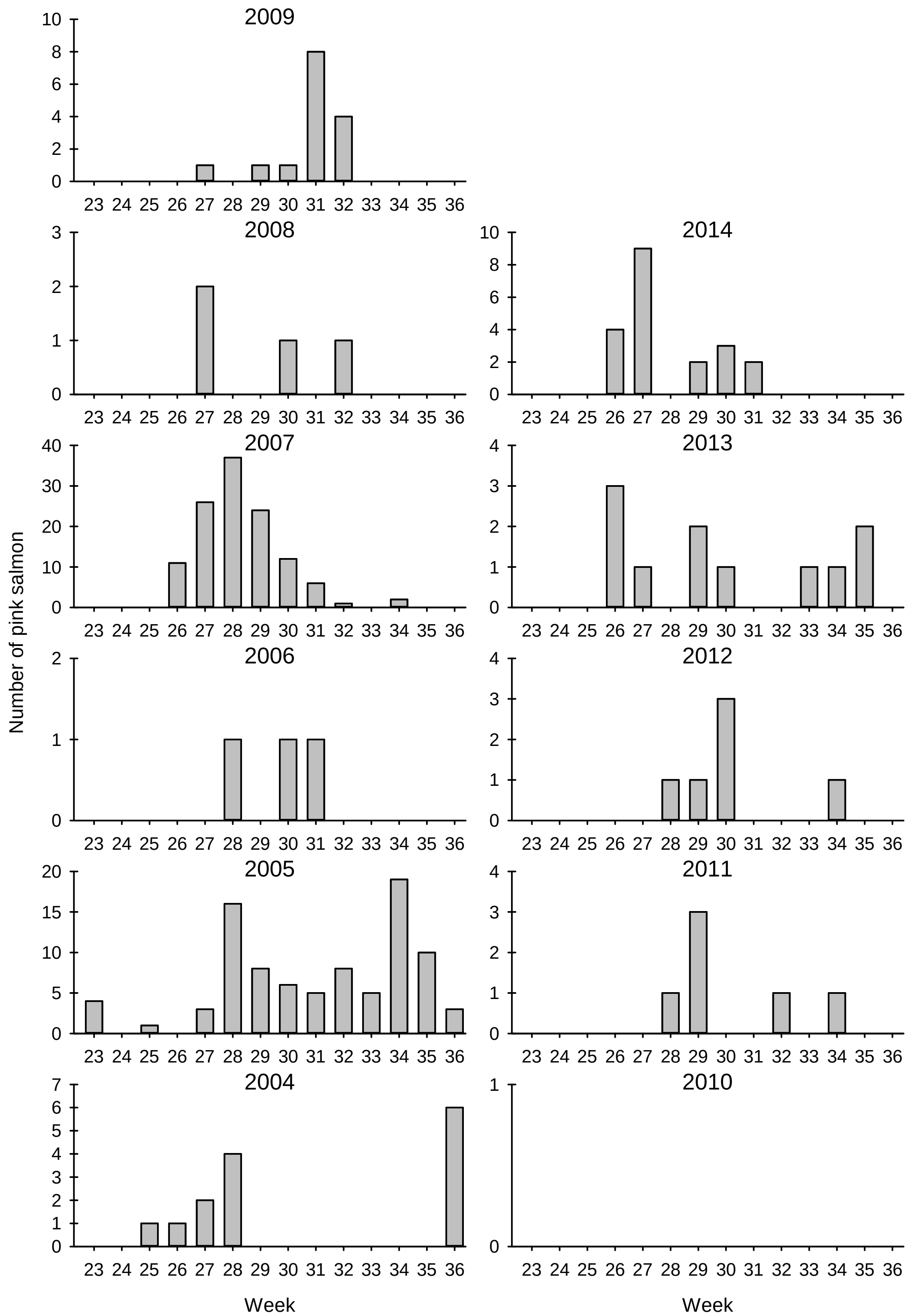


Figure 44. Annual and weekly pink salmon catches (in numbers) in the River Tana watershed in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

8.3. Sex distribution

The proportion of females within the spawning population is highly relevant when estimating the establishment of new fish species like the pink salmon in a new watershed. In the River Tana proportion of females has been little lower than 50%, observed from the biological material collected during the fishing season over many years (Figure 45). Compared to other studies in the Barents Sea area the proportion of males has exceeded females with 70-80% (Muladal 2009). Muladal (2009) made these estimates in the end of August from the rod fishery samples and from the diving surveys in the end of September and beginning of October when pink salmon had already finished spawning. Therefore the proportion of males might be too high compared the percentages in the River Tana. In August in the year 2009 the proportions of females in the rivers Komagelva, Vestre Jakobselva and Neidenelva were 33%, 19% and 26%, respectively (Muladal & Kanck 2009). In the White Sea area in the River Umba the proportion of females in the spawning run was 59-78% (Gordeeva *et al*. 2015) and in the River Ola it was 48-53% (Chereshnev *et al*. 2002; reference in Gordeeva *et al*. 2015) which is about the same as in the River Tana. All pink salmon in the River Tana watershed are maturing and most of fish caught very late in July and all fish caught in August have been in spawning condition.

Sex ratios are almost equal throughout June and July in the River Tana. Then in the middle of August the proportion of males increases up to 75% and later coming back to 50% (Figure 46). The rapid increase in the male proportion can be explained by the change in the behaviour of the males, when they are searching for females in the spawning areas. This suddenly increased swimming activity results that they are caught with gillnets and rods.

Early in the season the proportion of females slightly exceed that of the males in the catches and later in the season males clearly exceed the proportions of females. The catch of females is cumulating faster than that of males indicating that females are ascending slightly earlier than males into the River Tana (Figure 47).

Photo 31. Male pink salmon in full spawning condition. The fish was caught with gillnet in the River Tana. Photo Eero Niemelä

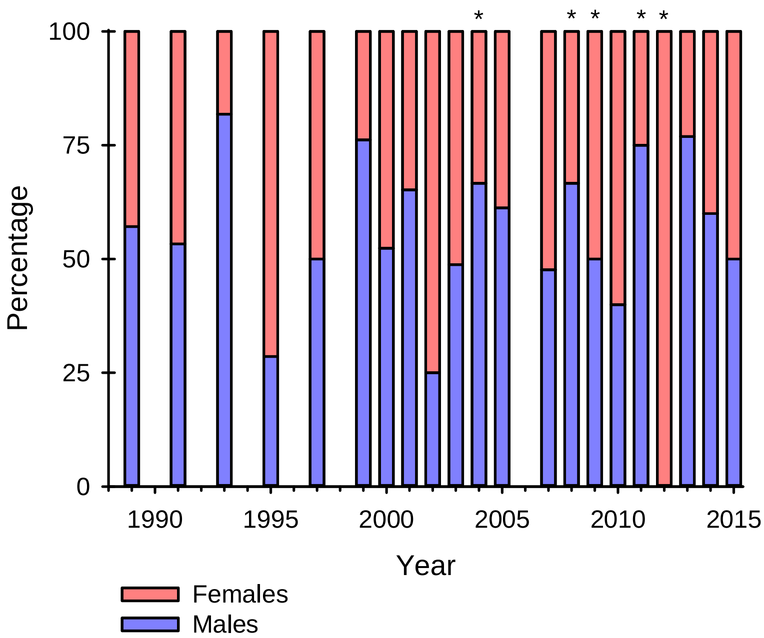


Figure 45. Sex distribution in the River Tana. Stars above the bars indicate that the number of samples was below 5. Source: TF, FMFI and Luke. Fish scale data from the years 1989–2015.

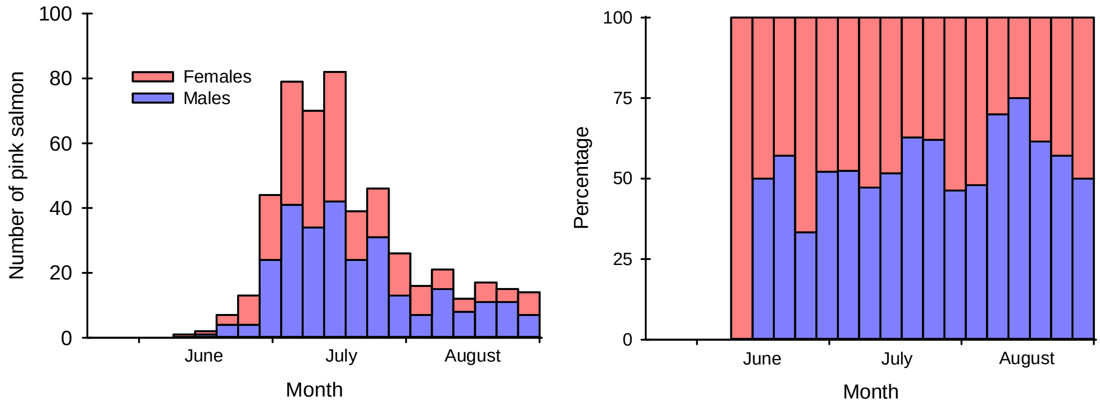


Figure 46. Sex distribution in five day intervals in the River Tana mainstem. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

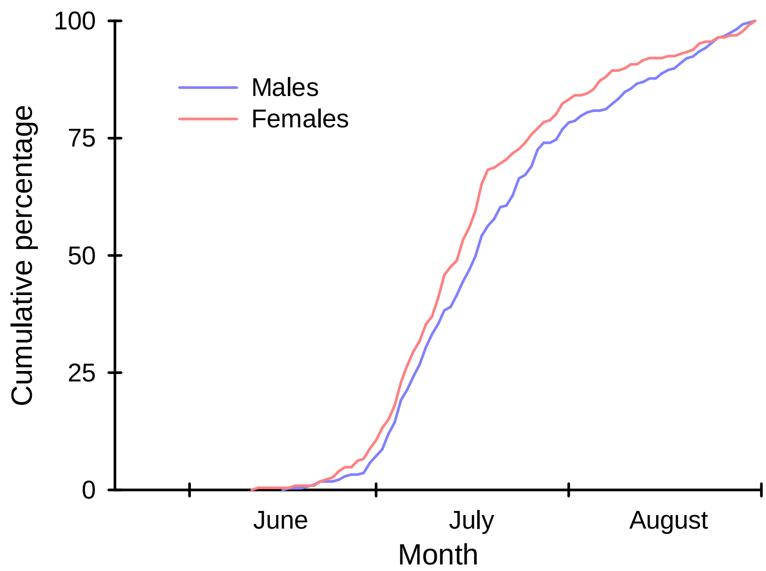


Figure 47. Cumulative percentages of female and male pink salmon catch in the River Tana mainstem. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

In the smallest and in the largest size groups males occurred in majority (48 and 49). In the mean size group the proportion of males and females is almost equal. The largest pink salmon are males which have ascended late in the summer into the river. These large males have been growing almost two months longer at sea than their counterparts who ascended late June and early July.

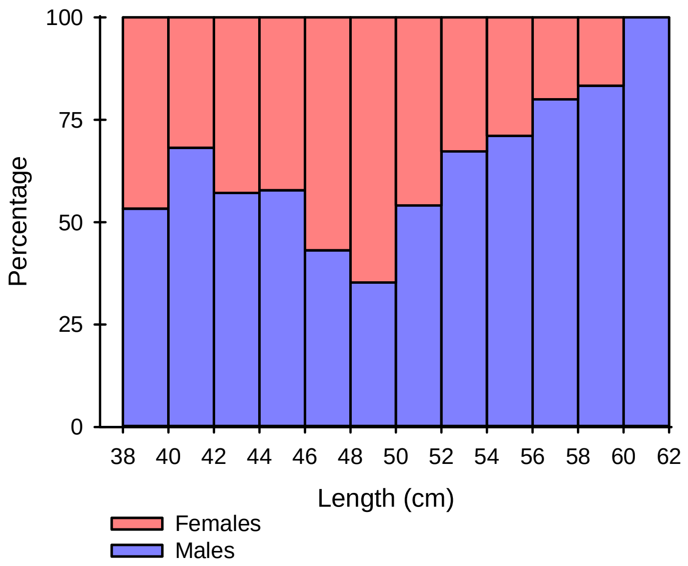


Figure 48. Sex distribution according fish length. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

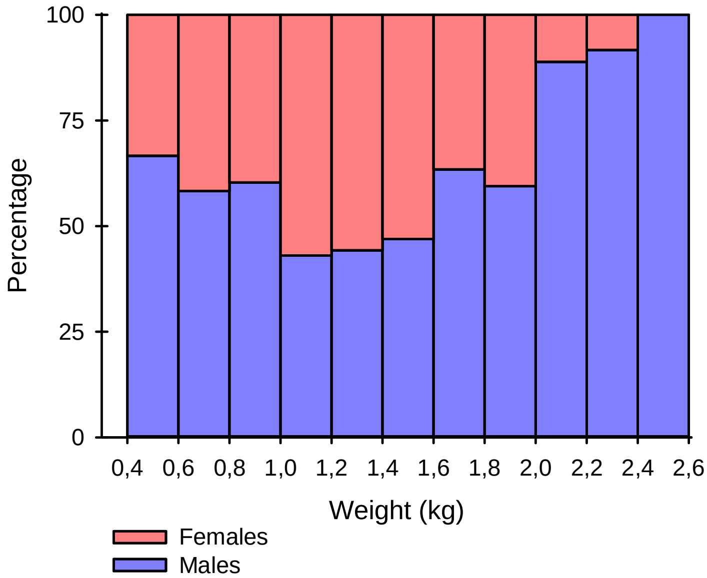


Figure 49. Sex distribution according fish weight. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

8.4. Growth

According to the catch data information the mean size of pink salmon ranges from 1.4 kg to 2 kg (Figure 50) in the years 2004-2014. Weights in the catch information are based in many cases to the estimations done by the fisherman and not to the real measured weights. The same estimated weights for each individual pink salmon are used when the mean weight of fish for various fishing methods is presented here. The mean weights for pink salmon are almost the same for rod, weir and gillnet (Figure 51).

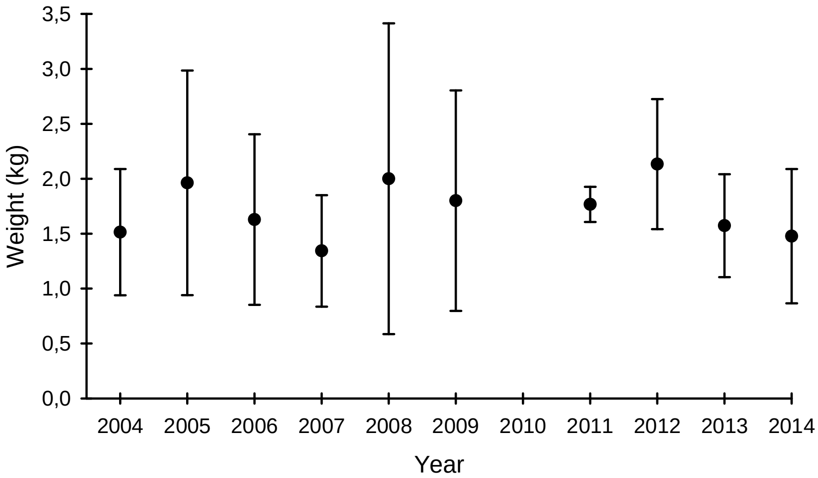


Figure 50. Mean weight of pink salmon in the River Tana in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

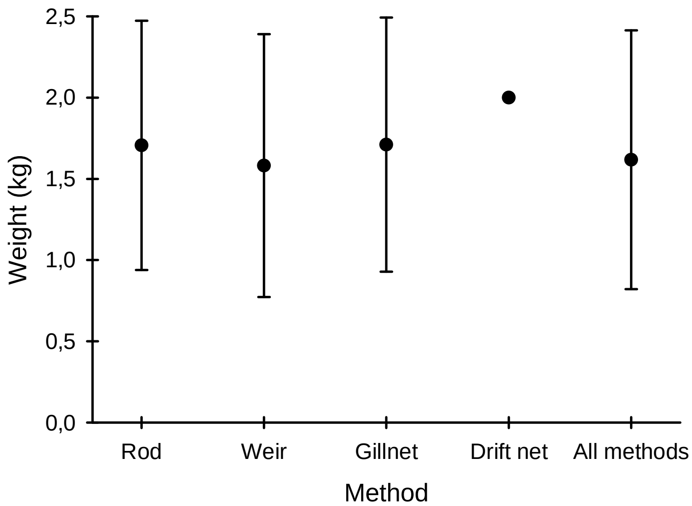


Figure 51. Mean weights of pink salmon for different fishing methods in the River Tana in Norway. Source: Catch data, TF and FMFI for the years 2004–2014.

Photo 32. Female pink salmon in full spawning coloration early in August in the Ponoi River in Kola Peninsula. Photo; Sergey Prusov, PINRO.

Photo 33. Soon after spawning pink salmon are dying. Dead bodies are bringing some nutrients into oligotrophic northern rivers. Male salmon in the photo was still alive and was caught in the River Ponoi in Kola Peninsula. Photo; Sergey Prusov, PINRO

Photo 34a. Soon there is nothing left. Dead pink salmon bodies offer food for some birds and small mammals, Photo; Sergey Prusov, PINRO

Photo 34b. In August-September after rain water level in the rivers is rising and the increased discharge is cleaning shorelines. Next pink salmon generation is already safely hidden in the form of developing embryos in spawning nests under the gravel. Photo; Sergey Prusov, PINRO

Annual mean weights and lengths of female pink salmon are mostly smaller than those of the males in the River Tana watershed (Figure 52). Mean lengths and weights were significantly smaller in the middle of 1970s than since the middle of 1980s and onwards. Annual mean sizes clearly differ from each other and these differences can be caused by the changes in the seawater temperatures in the North Atlantic and in the Barents Sea and also changes in the period, when pink salmon are ascending into the River Tana (see Figure 44). Its well-recognized that sea temperatures are regulating the primary production at sea as well as the abundance of food items consumed by pink salmon.

The annual mean lengths of 1SW Atlantic salmon in the River Tana are positively correlated with the sea temperatures (see Figure 25) and it can be assumed that there is also same kind of relationship between the ocean temperatures and the mean lengths of pink salmon. For the Atlantic salmon there is also positive and significant relationship between the sea temperature and the numbers of 1SW salmon in the catches in the River Tana (Figure 24). For pink salmon, however, as a new transplanted species the relationship between the sea temperature and the numbers of fish in the catches in the River Tana is very unlikely. This is because pink salmon catches in the River Tana still depend most likely on the success in the juvenile production elsewhere. Anyway the mean lengths and the mean weights of pink salmon don't show any increasing or decreasing long-term trends but still some annual variations (Figure 50). Therefore it is not possible to find positive correlation for pink salmon between the mean lengths and numbers of fish in the catches which correlation is obvious for 1SW salmon in the River Tana (See Figure 26).

Photo 35. Dr A Zubchenko(to the left) and Dr A. Veselov (to the right) measuring the lengths of adult pink salmon in Russia. Photo: Unknown

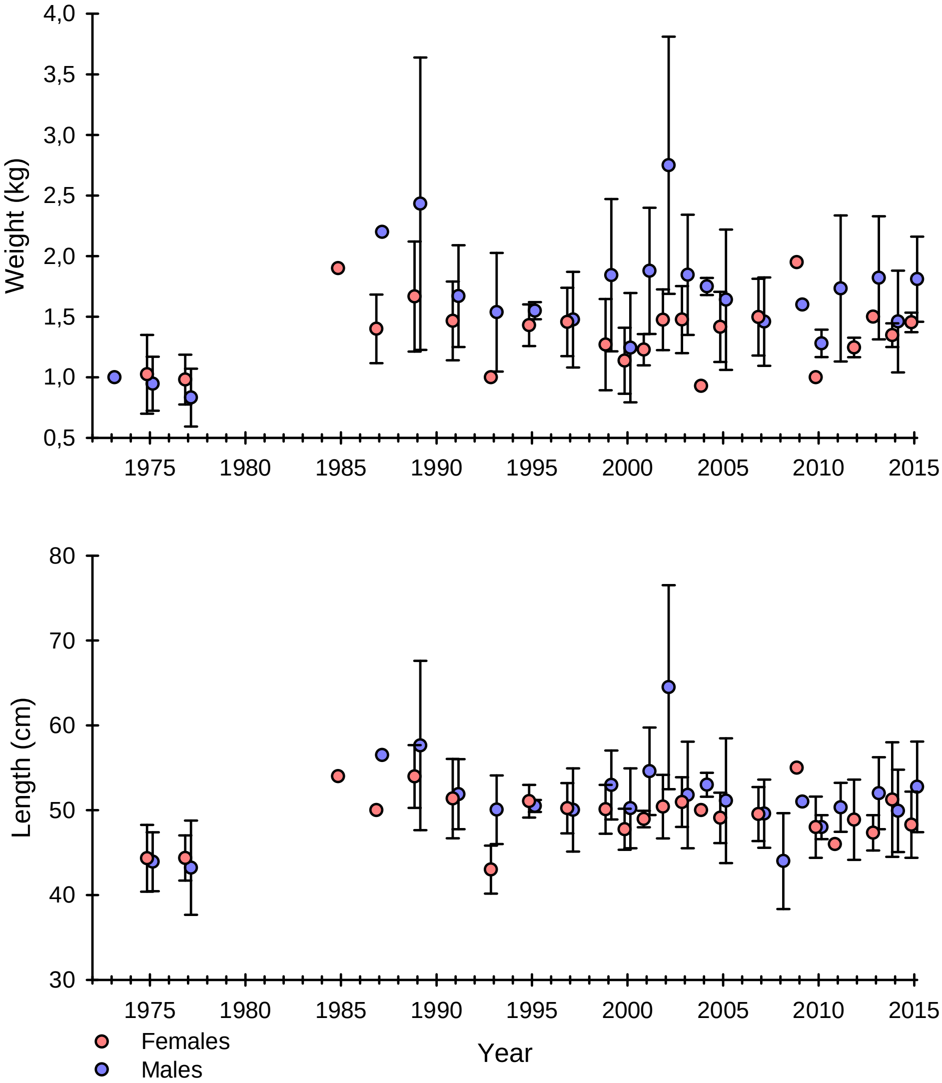


Figure 52. Mean weights (kg, SD) and lengths (cm, SD) of pink salmon in the River Tana. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

Although pink salmon is migrating into the River Tana during numerous weeks in the summer (see Figures 40 and 41) during a so called “river ascending window” their mean lengths stay almost the same (Figure 53). Only the mean lengths of males caught in the end of August are larger than fish caught earlier. This indicates that these late runners have been feeding in the coastal areas and they have been growing at sea in August. Interesting finding is that the mean weights of females clearly declined from c. 1.5 kg early in August to c. 1 kg in the middle of August. That most probably indicates the loss of weight due to the release of eggs to spawning redds in the River Tana.

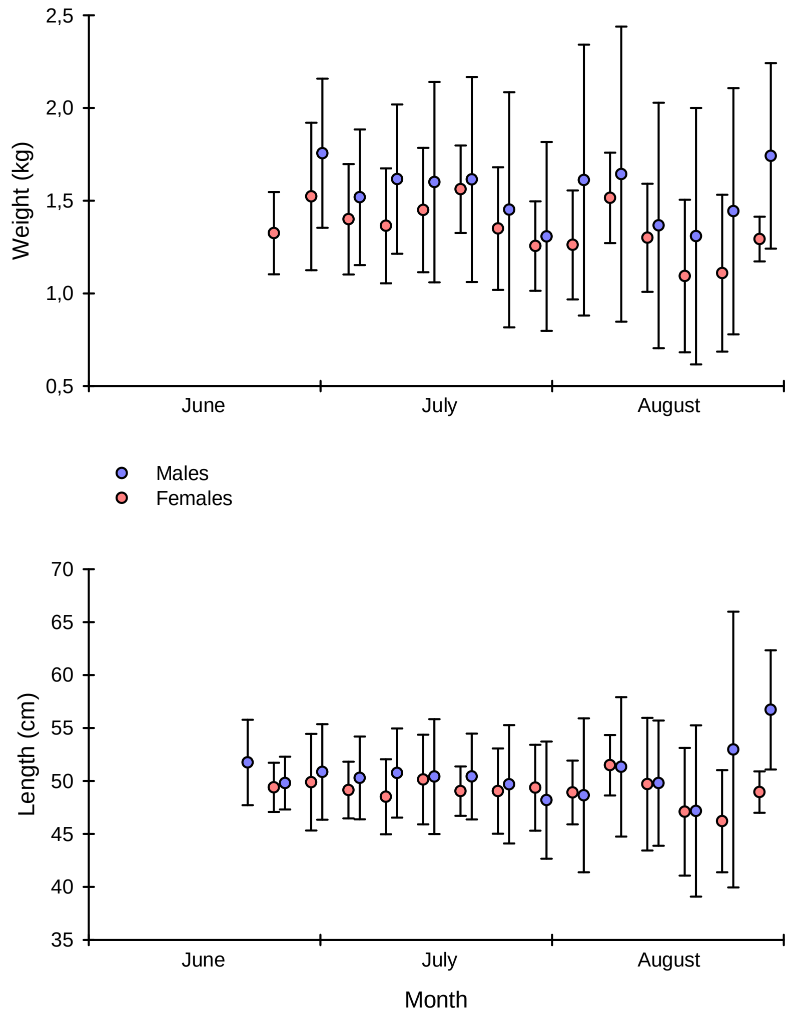


Figure 53. Mean weights (kg, SD) and lengths (cm, SD) of pink salmon in five day intervals in the River Tana. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

All pink salmon caught in the River Tana have the same age. They have migrated as a smolt to river estuaries and from there to the ocean. They have migrated back to coastal areas during the following year and ascended the River Tana. Figures 54 and 55 are presenting the large variation in the sizes of pink salmon. The weights of the smallest mature males have been between 300 and 400 grams and of the smallest females between 500 and 600 grams. Mean weights for females and males have been 1.4 kg and 1.6 kg, respectively (Table VI). The lengths of the smallest mature males and females have been between 33 and 35 cm. Mean lengths for females and males have been 49 cm and 51 cm, respectively (Table VI).

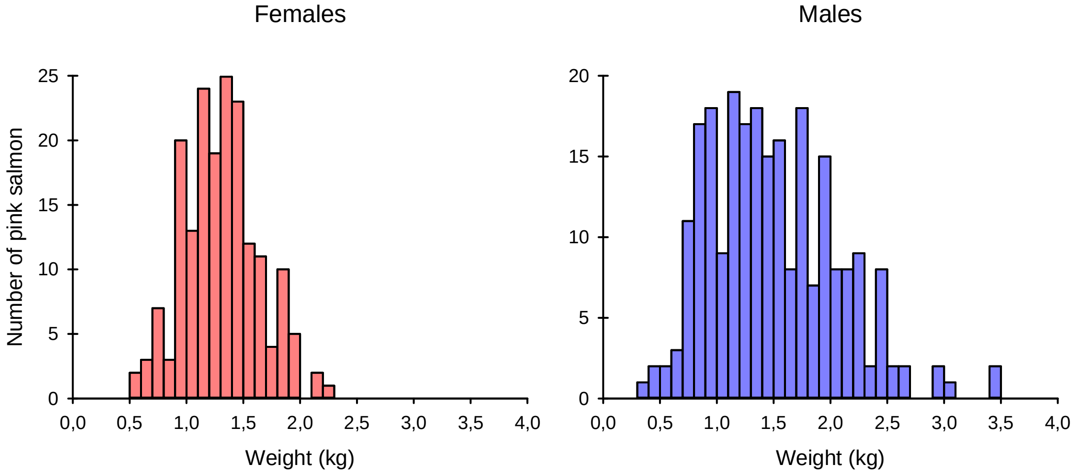


Figure 54. Weight distribution of pink salmon in the River Tana. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

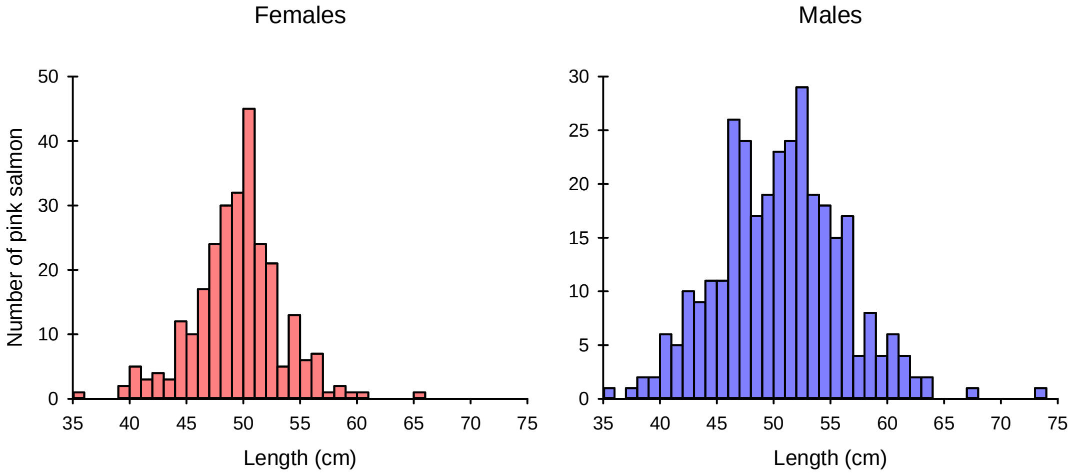


Figure 55. Length distribution of pink salmon in the River Tana. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

Table VI. Mean lengths and weights of pink salmon in the River Tana. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2014.

	Males	Females
Length		
Mean length	51.0	49.6
Min. length	39.0	40.0
Max. length	67.0	60.0
SD	5.7	3.3
N	239	204
Weight		
Mean weight	1.6	1.4
Min. weight	0.4	0.7
Max. weight	3.3	2.3
SD	0.3	0.3
N	169	132

Figure 56. Scales of mature pink salmon that migrated to the sea as a smolt in the year 2013 and were caught as mature fish in the River Tana in the year 2014. Scale on the left: fish was caught in July 2. with the length 51 cm and weight 1.2 kg. Scale in the middle: fish was caught in July 13. with the length 46 cm and weight 1.8 kg. Scale on the right: fish was caught in August 11. with the length 53 cm and weight 1.6 kg. There is no erosion in the edges of the scales indicating that these fish have ascended and been caught in the River Tana within short time period. From the scales it is possible to see the period in which the pink salmon was roaming the estuary of some river. The first winter band is made from strias which are very close to each other. Source; Luke.

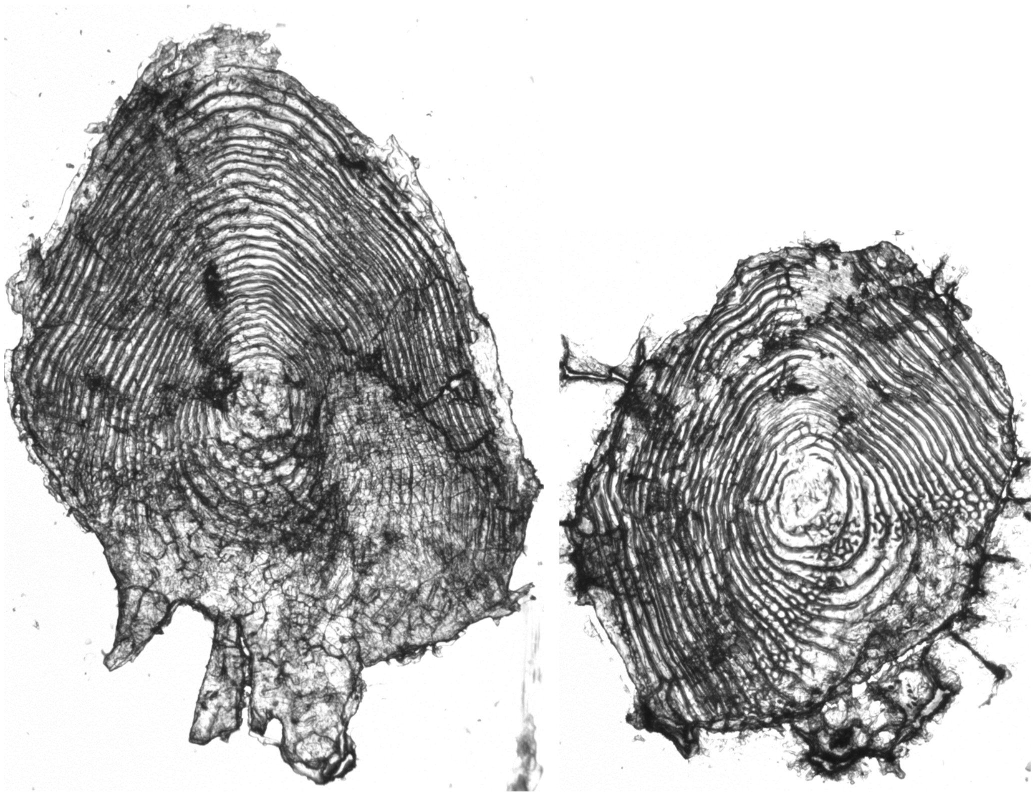


Figure 57. Scales of mature pink salmon that migrated to the sea in the year 2013 and that were caught as mature fish in the River Tana in the year 2014. Scale on the left: fish was caught in July 24. with the length of 52 cm and weight of 1.4 kg. Scale on the right: fish was caught in August 5. with the length of 56 cm and weight of 1.9 kg. There is large erosion in the edges of the scales indicating that these fishes have been in the River Tana already from some weeks to even 1.5 months before they were caught. Source; Luke.

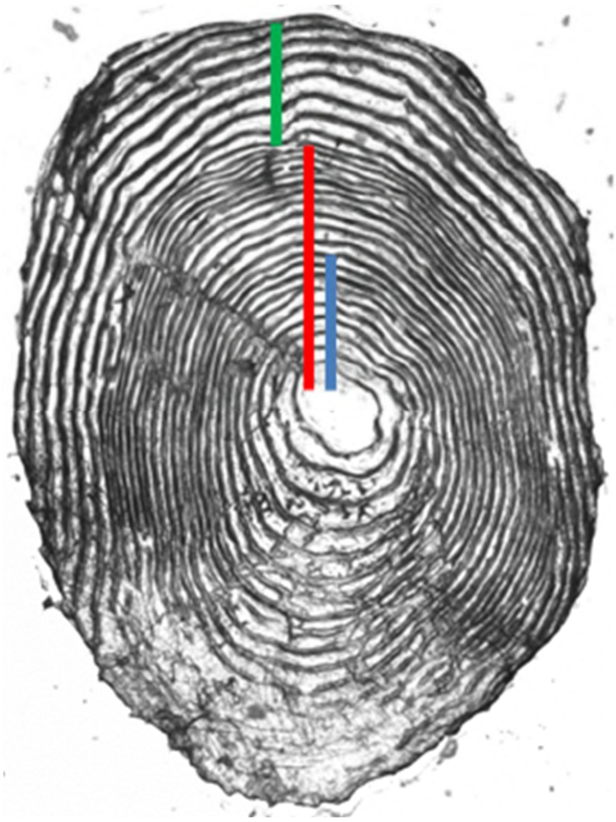


Figure 58. Life history of pink salmon can be interpreted from the scale. Pink salmon is hatching from the egg which is hidden in the spawning redd. The size of fry when hatching is c. 1.4-1.7 cm in length. After hatching juvenile pink salmon is called alevin, which is still carrying yolk sack. The alevin is still staying under the gravel for many weeks. After the yolk sac material is absorbed juvenile fish is called fry in the length c. 2.4 cm. The fry starts to search for food already in the redd. Fry is emerging from the redd to the upper layers of the gravel bottom. Early in the summer, in the rivers Tana and Neiden between the end of June and middle of July fry is having a silvery colour on the scales and it is called smolt. Smolts are migrating in large shoals with the length of 3-4 cm to the river mouths. They stay about a month in the estuaries adapting into the brackish and full saline seawater. In the scale figure 54 the blue line indicates the fry-smolt phase in fresh water period in the river and salt water period in the estuary area, red line indicates the entire growth period during the entire first year ending to the end of the first winter at sea. Green line indicates the growth at sea during the second summer before pink salmon is entering the river. Source; Luke.

Photo 36. Pink salmon smolt in silvery coloration on the way to sea. Photo; Aleksei Veselov (in Zubchenko et al. 2004).

Pink salmon leaves the river in the length of 3-4 cm. Thereafter it is staying about one month in the estuary area where the fast growth starts. Figure 57 shows that between the years there is large variation in the length of fish when it is leaving the estuary. Pink salmon caught from the River Tana have most probably their origin somewhere else and therefore information from the figure 59 explains the growth pattern somewhere else. Back calculated length of pink salmon, when leaving estuary indicates that in the year 1999 the mean length was 25 cm and in the year 2006 it was c. 12 cm. This large variation in the length, when fish is leaving estuaries, must have an effect to the survival. If this length is small it’s probable that those fish have higher mortality at sea than larger fishes.

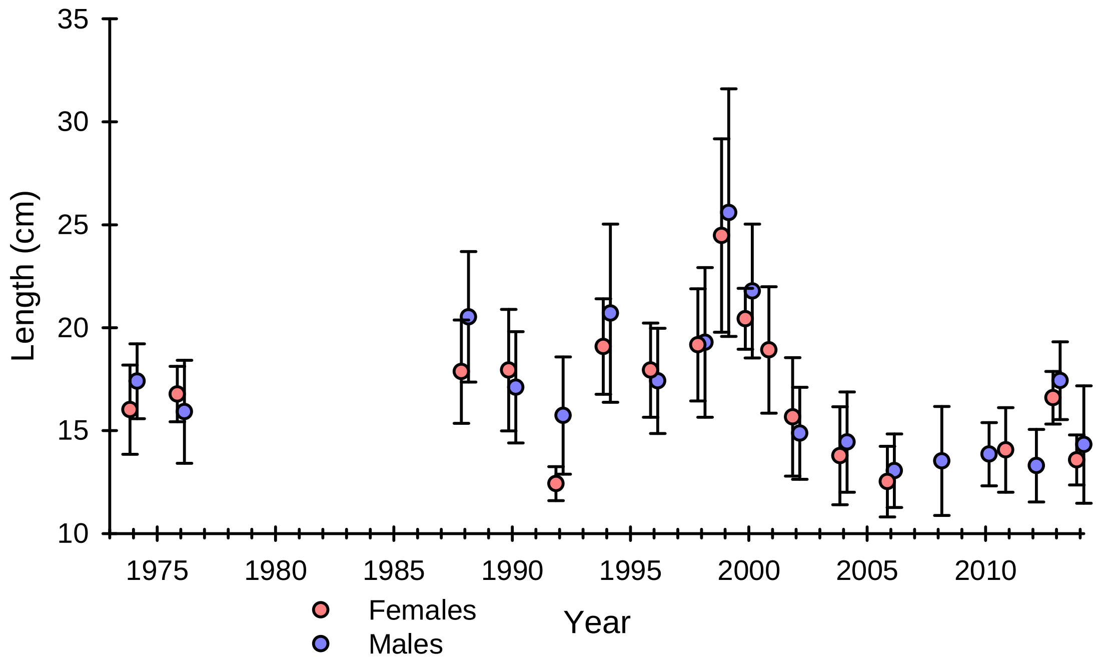


Figure 59. Back calculated length (Fraser-Lee method) of pink salmon at the length when they are leaving the estuary and start their migration to the feeding grounds at sea. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

In the River Kola (in Russia) close to the city of Murmansk pink salmon smolts had the mean length of 5 cm and weight of 1.1 g which indicated that they have been growing in the river before seaward migration. Some of those pink salmon smolts migrated seawards as late as in August with the length of 7.7 cm and weight of 3.9 g (Berg 1961).

It is natural that back calculated length to the end of the first year at sea fluctuates between the years. One reason to the annual different lengths is the variation in the lengths when fish left the estuary. Pink salmon grew fast somewhere in the estuary area in the year 1999 (Figure 59) and the same fast growth continued at sea in the year 2000 (Figure 60). Figure 58 indicates that there hasn't been any notably long-term change in the ocean growth.

Pink salmon has a clear growth model which is almost the same for both males and females (Figure 61). Large males are fatter compared to females of the same size.

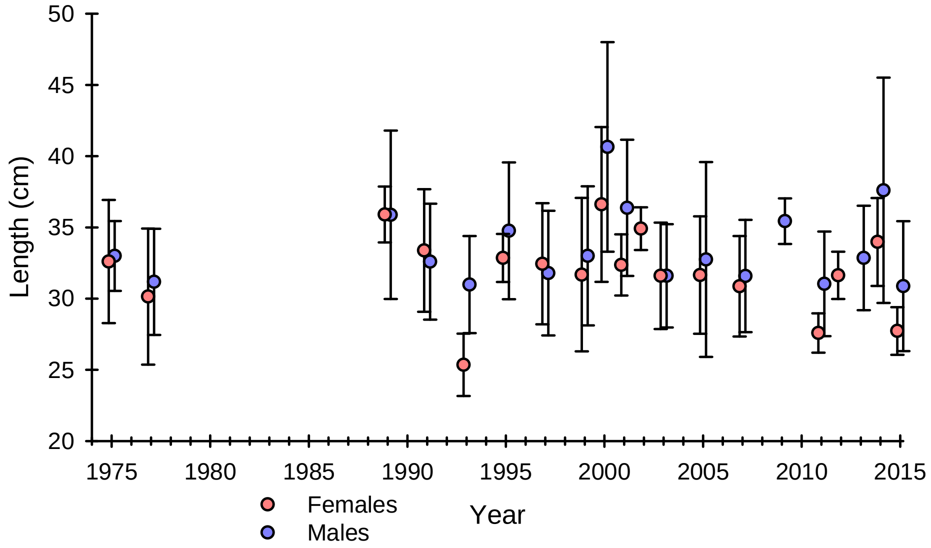


Figure 60. Back calculated length (Fraser- Lee method) of pink salmon to the end of the first year. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

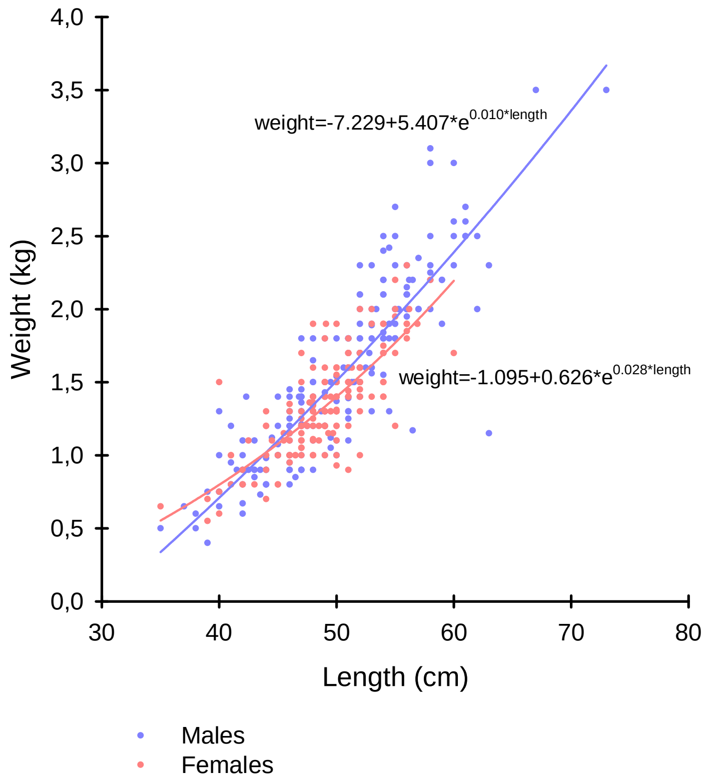


Figure 61. Length-weight relationship for pink salmon caught in the River Tana. Source: TF, FMFI and Luke. Fish scale data from the years 1975–2015.

9. Pink salmon in the River Neidenelva

First recorded catch of pink salmon in the River Neidenelva was in the year 1960 (Berg 1961, Bjerknes 1977a). Bjerknes (1977b) describes that pink salmon catches occurred also in the River Neidenelva in 1969, 1971, 1973 and 1975. The accuracy of the catch information for all fish species has been poor in 1970s' and 1980's at least for the rod fishery. It might be that pink salmon catch has been included into the Atlantic salmon catch, at least those pink salmon which have been caught in June and July when they look like Atlantic salmon. From the pink salmon spawning in the autumn 1975 pink salmon smolts were migrating seawards in the year 1976. This was the first time when smolts were observed in Norway although it has been information on spawning in many rivers in Finnmark in 1960s (Berg 1961). Pink salmon smolts were collected between 17.-23. June and their mean length was 32 mm (28-37 mm). During that time the yolk sac was totally absorbed.

Bjerknes (1977c) presents that in the lower areas of the River Neidenelva like in many other rivers in Finnmark the environmental conditions are favouring pink salmon spawning. He thinks that there has been juvenile pink salmon production already over many years in the River Neidenelva. The lowermost 12 km in the River Neidenelva is especial suitable for pink salmon spawning because the bottom structure is consisting of small stones and of gravel.

First documented observations from the pink salmon migration in the River Neidenelva are from the trap in the fish ladder in the year 1975 between 19. June and 22. July (Bjerknes 1977c). During that 26 days trapping period they caught 11 pink salmon, 18 seatrout and 68 salmon. The first pink salmon migrated upstream 14. July and the first salmon 19. June.

Fish ladder in Skoltefossen in the River Neidenelva with counting trap or video counting has been working in the years 1990, 1992, 1993, 1994, 1995, 1996, 2002, 2006, 2009, 2011 and 2012. Only in the year 1993 one pink salmon has been observed to pass the Skoltefoss through the fish way (Niemelä *et al.* 2015). Some pink salmon has been caught in some years in the Käpälä-seine fishery below the large Skoltefossen waterfall. On the Finnish side of the River Neidenelva, however, there has been pink salmon catches since the year 1973 onwards. This indicates that pink salmon maybe prefers to jump over the big fall in Skoltefossen than to search to the fish way on the opposite side of the river. After crossing the Skoltefossen pink salmon can migrate like Atlantic salmon to the uppermost spawning sites which are on the Finnish side.

There has been some gillnet fishery and diving in the end of August and in September to monitor the abundance of pink salmon within the lowermost 12 km of the River Neidenelva (Muladal & Kanck 2009). They have made diving observations in the upper sites of the potential pink salmon spawning grounds within the lowermost 12 km from Skoltefossen to the estuary. Numbers of pink salmon in those limited sites have been more than 100 fish in the year 2007 but none in the year 2008. As a conclusion we can say that there has been almost annual catches of pink salmon in the lower areas of the River Neidenelva at least during the last 20-30 years. Also catch information from the

Finnish side from the uppermost areas in the River Neidenelva strongly support the frequent occurrence of pink salmon in the River Neidenelva. Anyway we are not sure if pink salmon has already established self-reproducing stock in the River Neidenelva. Catch information in Norway has been more precise after the year 2007 than before it and at least catch information indicates that somewhere in the Barents Sea or White Sea pink salmon has established self-reproducing stocks (Gordeeva *et al*. 2015) out of which pink salmon juvenile production is enabling catches also in the River Neidenelva.

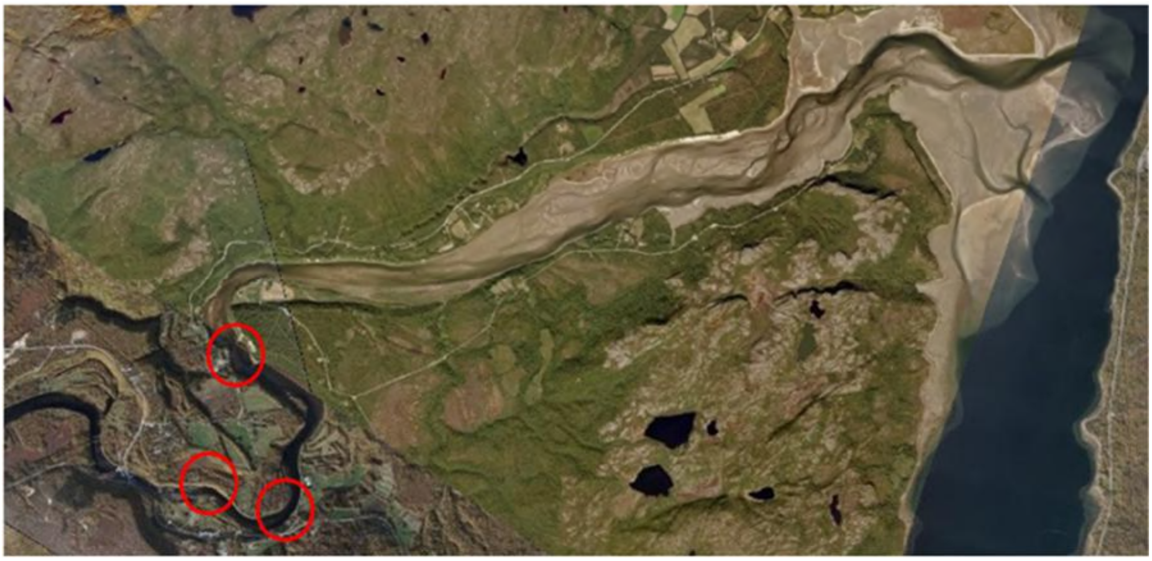


Photo 37. Air photo from the lowermost area of the River Neidenelva where pink salmon has been spawning successfully in some riffles within the area of 10 kilometres above the estuary. Red circles indicate the lowermost spawning area for pink salmon in the River Neidenelva. The lowermost c. 6 km upstream from the estuary is sandy bottom areas where pink salmon cannot spawn. Source; Norge i bilder.

9.1 Catches

Pink salmon catches in the River Neidenelva in Norway was almost 100 kilos in the year 2007. Since that year catches have declined being clearly below 20 kilos annually (Figure 62). It was expected that catches should increase in the year 2009 and then in 2011 but they stayed low. There has been pink salmon catches in odd and even years indicating that the earlier Russian stockings have succeeded to make self-reproducing stocks somewhere in the north although all transplanting was stopped with odd year stock in the year 1998 and with even year stock in the year 2001.

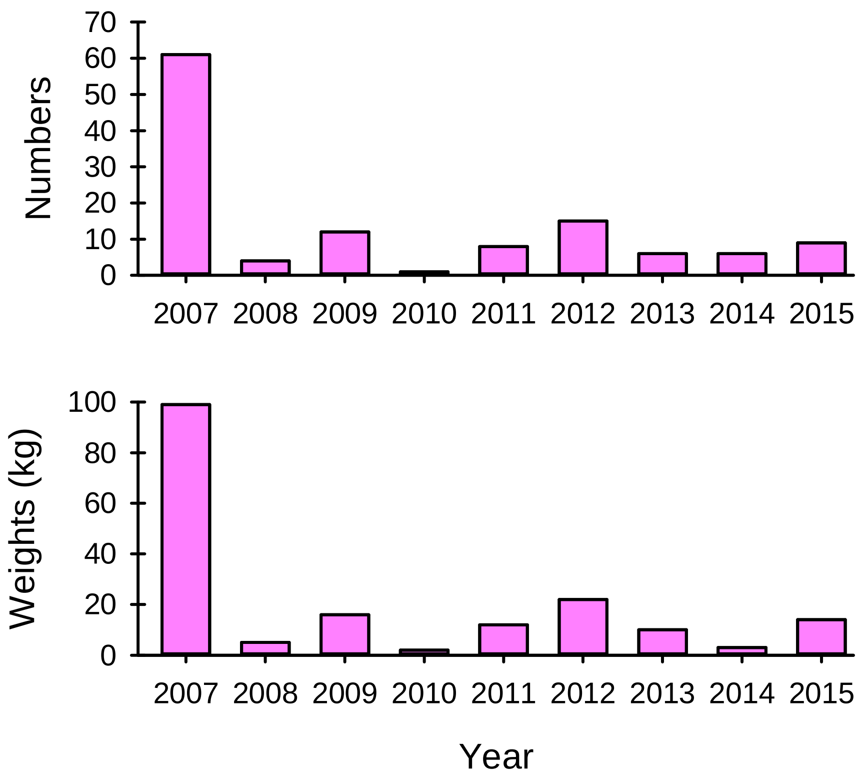


Figure 62. Pink salmon catches in the rod fishery in the River Neidenelva in Norway. Source: Scanatura.no

In the River Neidenelva in Norway Atlantic salmon makes most of the catch with 75% in the period 2997-2015 and seatrout is the second most important species with c. 15% (Figure 63). The proportion of pink salmon in the catches was the highest in the year 2007 with 3% but after that its proportion has been c. 0.5% in all the catches. From the total catch weight pink salmon made c. 2% in the year 2007 and later the proportions have been below 0.5% (Figure 64).

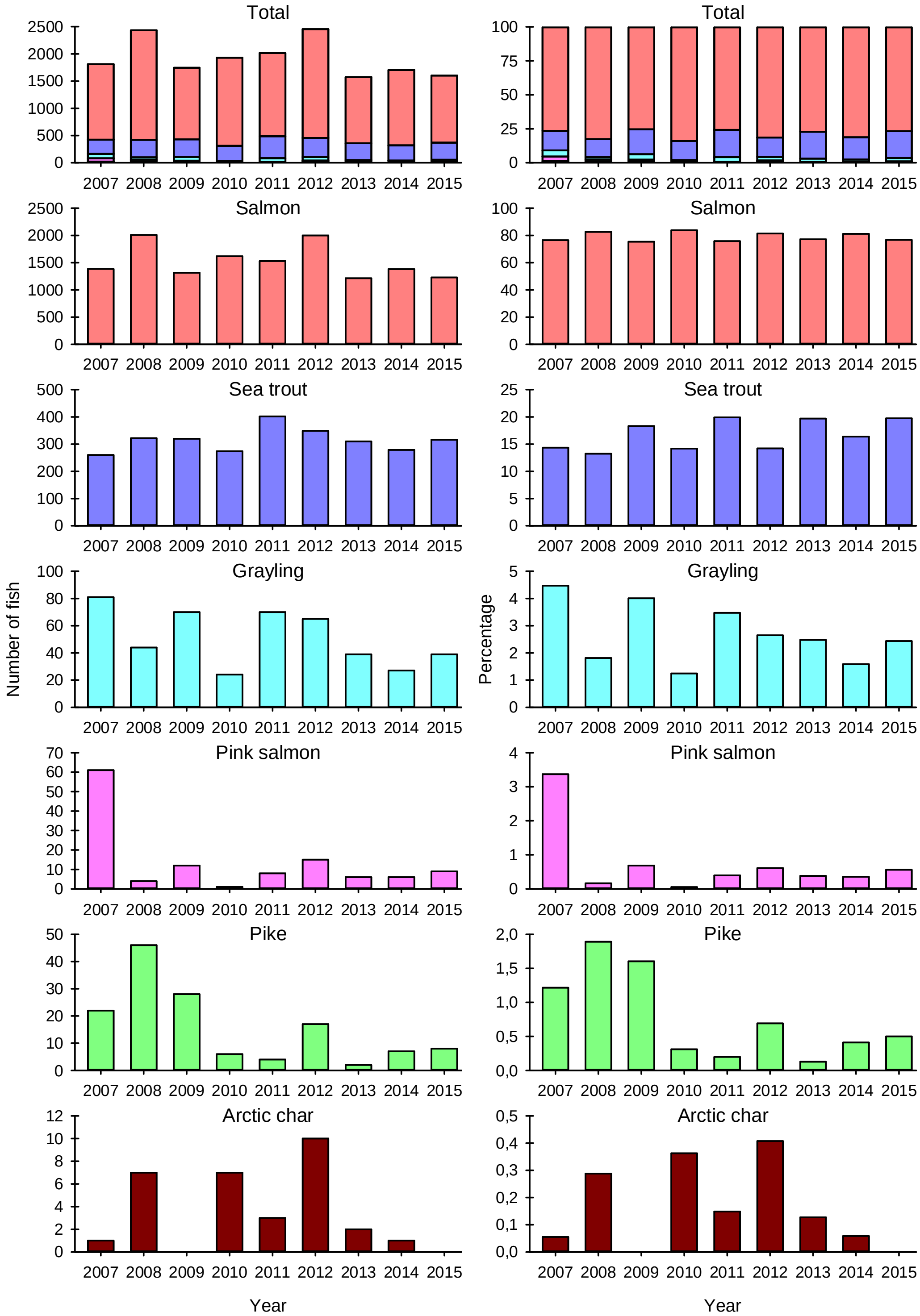


Figure 63. Annual catch (numbers and percentages) of six fish species in the River Neidenelva in Norway. Source; Scanatura.no.

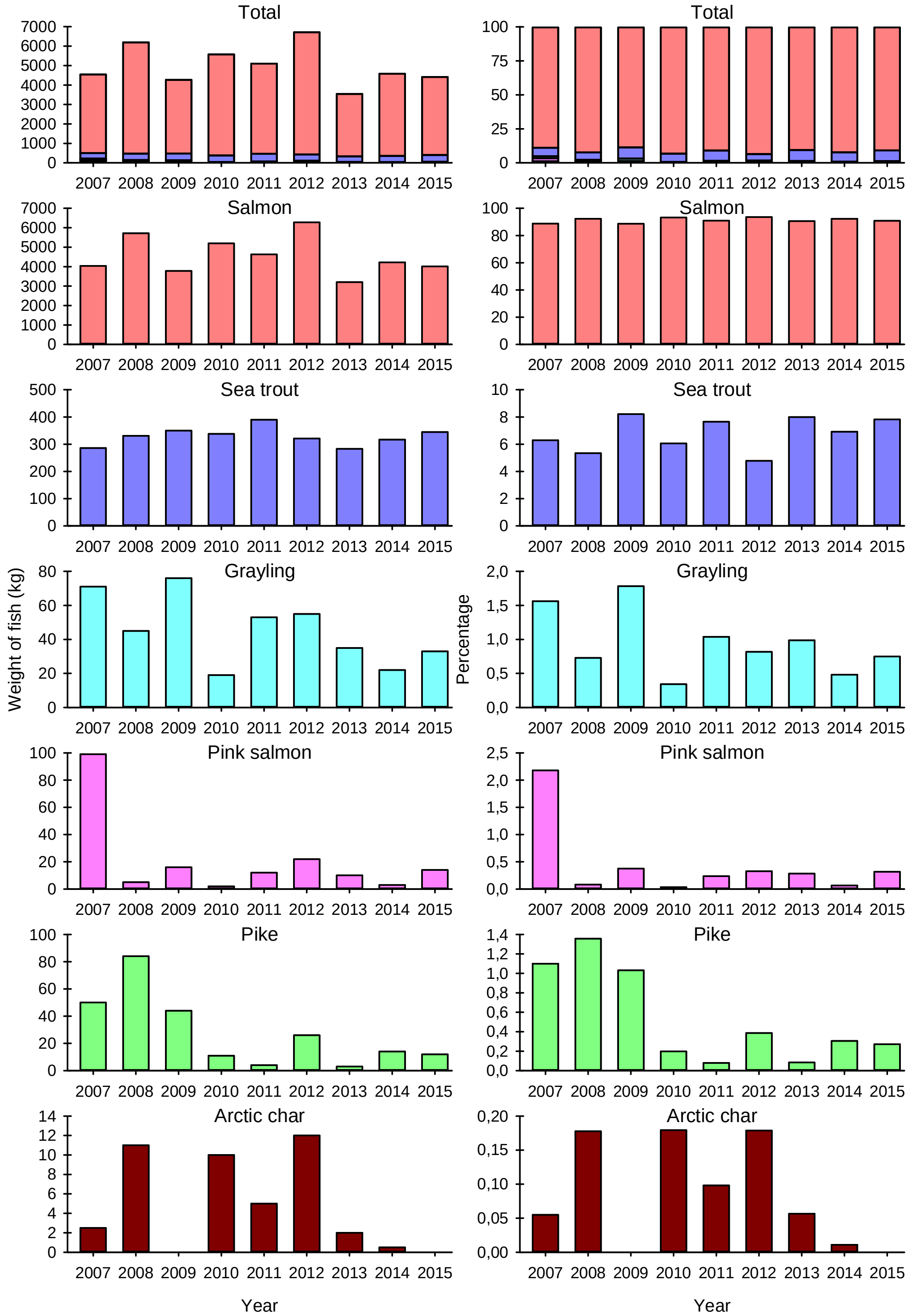


Figure 64. Annual catch (in weight and percentage) of six fish species in the River Neidenelva in Norway. Source; Scanatura.no.

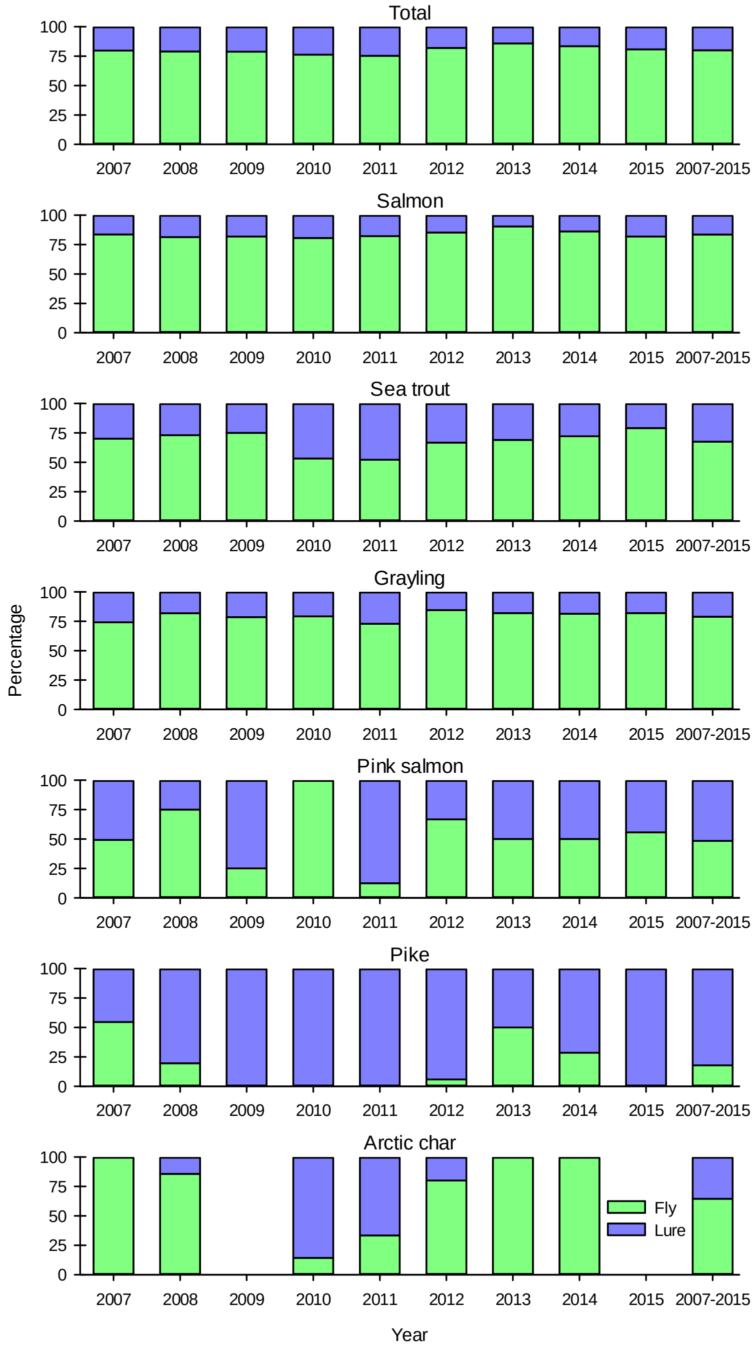


Figure 65. Proportions of fish caught with fly and lure in the River Neidenelva in Norway. Source; Scanatura.no.

There is possibility to catch fish with both fly and lure in the River Neidenelva. Some areas are reserved only for fly fishing and some for lure fishing. It is interesting to note that most of the Atlantic salmon catch has been taken with a fly (c.80%) (Figure 65). The catch of pink salmon, however, is taken almost 50-50% between fly and lure.

Pink salmon catches in the upper areas of the River Neidenelva, on the Finnish side, have been usually low except the catches in the years 1973, 1975 and 1993 (Table VII). Usually pink salmon catches are representing below 0.5% from the total catches. Also some recreational fishermen have caught a few pink salmon. Most of the pink salmon caught on the Finnish side are caught with gillnets. Since the year 2008 catch questionnaire has not included pink salmon catches in Finland in the River Neidenelva and therefore pink salmon catches are lacking.

Table VII. Pink salmon catches (kg) and proportions from the total catch caught by local fishermen with nets on the Finnish side in the River Neidenelva. Source; Luke.

Year	Catch (kg)	Proportion (%)	Year	Catch (kg)	Proportion (%)
1973	305	13.0	1991	7	0.2
1974			1992	8	0.2
1975	50	3.2	1993	34	1.8
1976			1994	4	0.2
1977	5	0.3	1995	2	0.2
1978			1996		
1979			1997	6	0.4
1980			1998	1	0.1
1981			1999	1	0.1
1982	3	0.2	2000		
1983			2001	10	0.3
1984			2002	1	4.3
1985			2003	7	1.0
1986			2004		
1987			2005	4	0.5
1988	7	0.4	2006		
1989	11	0.5	2007	2	0.2
1990	2	0.1			

9.2 Timing

Pink salmon starts its migration up into the River Neidenelva early in the summer from the week 23 onwards (Figures 66 and 67). Slowly the numbers of pink salmon in the catches increase partly due to the increased rod fishery effort in early and middle of July. Peak migration takes place in the weeks 28 and 29 although there is higher numbers of pink salmon caught in the week 34. This high number of pink salmon caught late in the season, in the week 34, might be real new migration into the river or it is caused by the increased aggressive behaviour of fish that have moved closer to spawning sites and therefore fish are more aggressive to bite on the lures. Anyway, pink salmon is spawning already in the end of August and they have gathered into smaller or larger shoals to shallow water areas. Those are the areas which rod fishermen also prefer to fish in, in August.

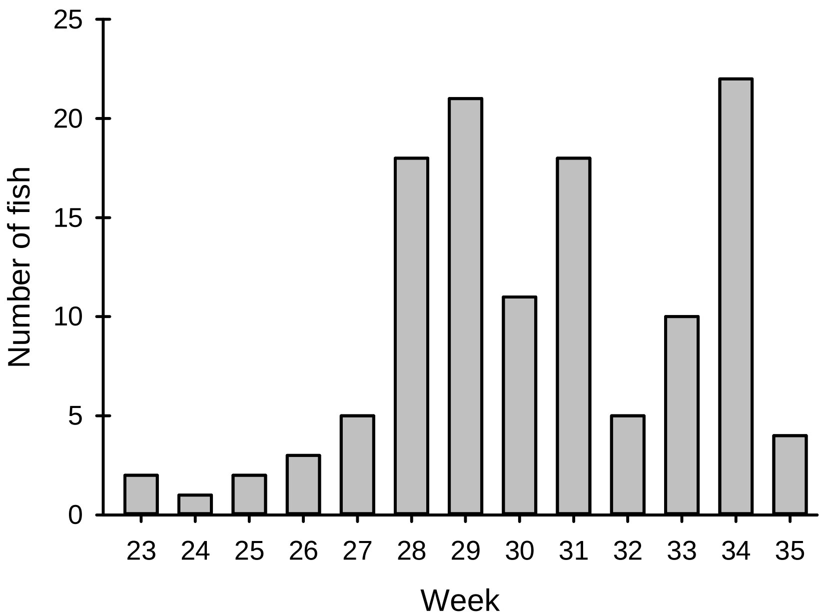


Figure 66. Weekly pink salmon catches in the rod fishery in the River Neidenelva in Norway in 2007–2015. Source: Scanatura.no.

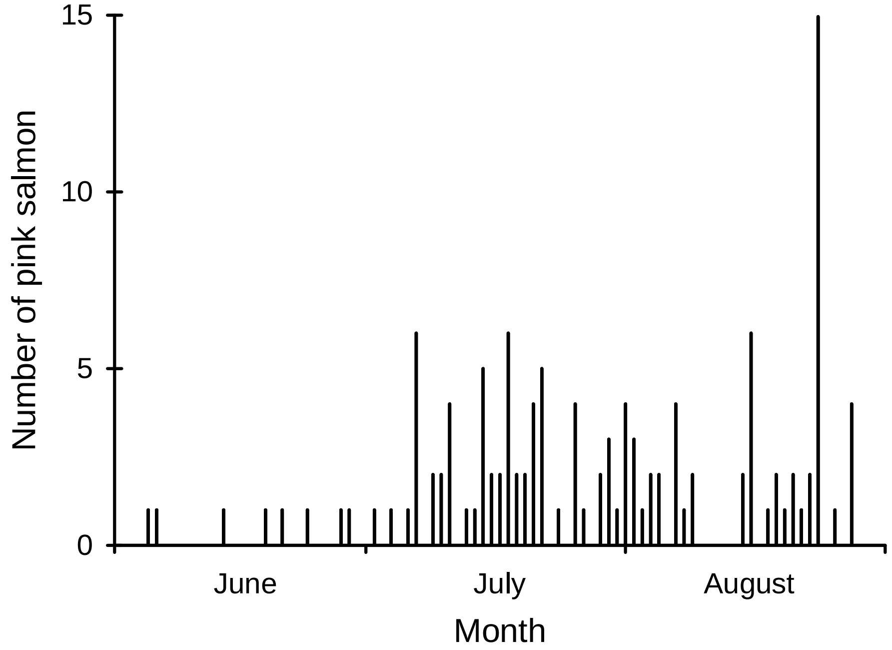


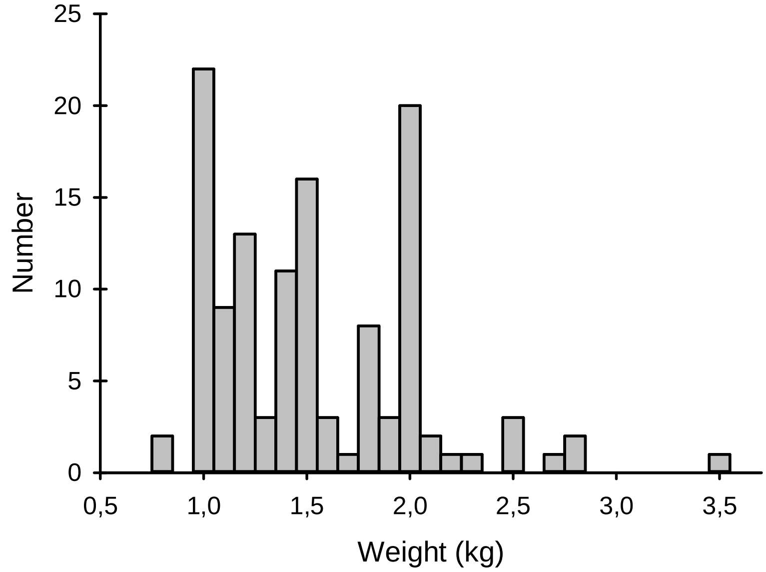
Figure 67. Daily pink salmon catches in the rod fishery in the River Neidenelva in Norway in 2007–2015. Source: Scanatura.no.

Photo 38.Capture of spawners in an eutrophic river in Russia. Pink salmon is ascending into the rivers mainly from the middle of July and onwards. Photo A. Veselov

9.3 Size

Size of the pink salmon caught in the River Neidenelva is from 800 grams to 3.5 kilos (Figure 68). Most of the fish weigh less than 2 kilos. The mean weight is slightly varying from year to year (Figure 69). During the last years mean weight has been quite stable. These mean weight values are from the catch information and not from scale collection program and therefore they do not necessary inform the real annual changes.

Photo 39. Male 1SW Atlantic salmon and male pink salmon (Pacific salmon) caught in the river Tana by Reidar Varsi. Photo Reidar Varsi.



Figute 68. Weight distribution of pink salmon caught with rod in the River Neidenelva in Norway in 2007-2015. Source; Scanatura.no.

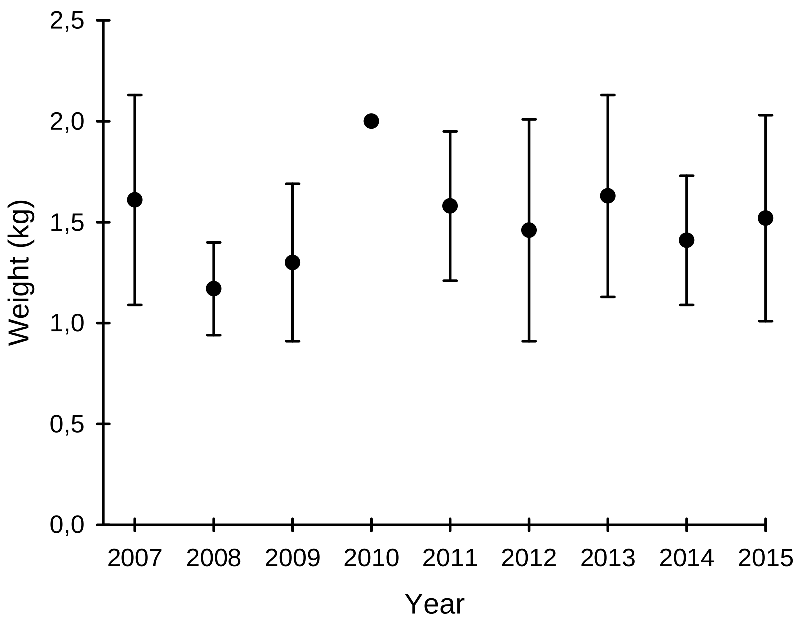


Figure 69. Mean annual weights (kg, SD) of pink salmon caught with rod in the River Neidenelva in Norway. Source; Scanatura.no.

Mean size of pink salmon caught during the summer in the lower areas is staying quite stable (Figure 70). Data is based on the catch data information and not on the scale program.

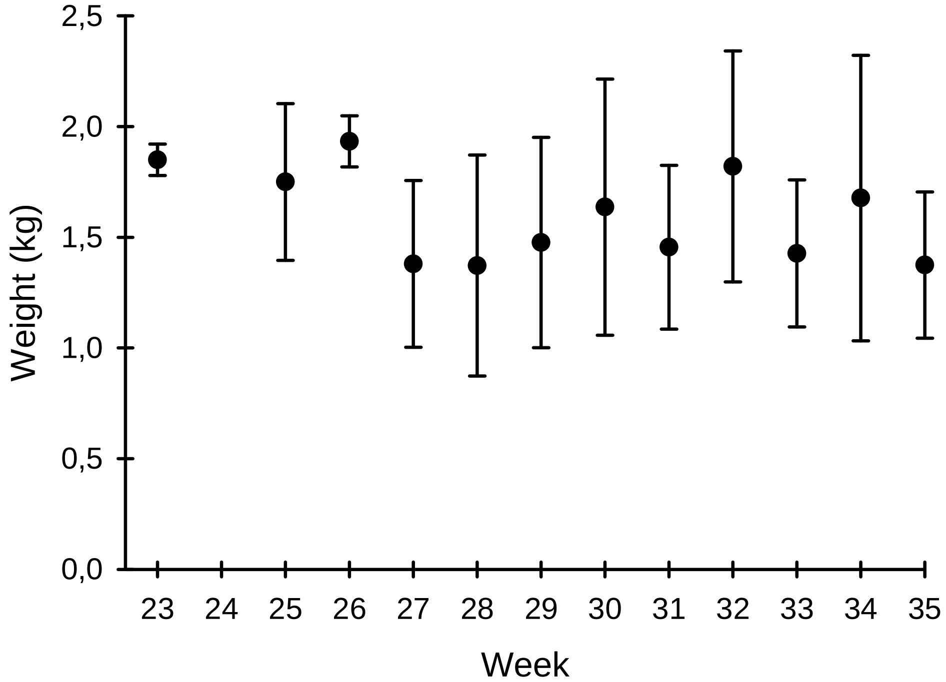


Figure 70. Mean weekly weights of pink salmon caught with rod in the river Neidenelva in Norway in 2007-2015. Source; Scanatura.no.

10. Pink salmon in North West Russia

10.1 Catches and occurrence

Tables below are indicating the occurrence of pink salmon and Atlantic salmon in the rivers of North West Russia. Distribution of pink salmon is covering largely the Barents Sea and White Sea rivers.

Tables VIII-X. Tables are indicating the occurrence of pink salmon and Atlantic salmon in the Rivers in the North West Russia (source personal information A.Veselov).

Table VIII Rivers Kola Peninsula South

Name of the river	Existence of spawning pink salmon	Existence of spawning Salmo salar	Existence of spawning Salmo trutta	Length of river, km	Drainage area, km2	Fall, m
Ponoy	Yes	Yes	Yes	425,7	15467,2	292
Varzuga	Yes	Yes	Yes	254,0	9836,0	180
Umba	Yes	Yes	Yes	124,8	6248,5	149
Strelna	Yes	Yes	Yes	213,2	2774,1	190
Chapoma	Yes	Yes	Yes	115,3	1106,6	202
Pyalitsa	Yes	Yes	Yes	91,6	946,3	230
Kitsa	Yes	Yes	Yes	52,0	1646,0	138
Kachkovka	Yes	Yes	Yes	59,4	842,6	228
Pulonga	Yes	Yes	Yes	77,5	733,5	206
Sosnovka	Yes	Yes	Yes	78,8	582,0	260
Chavanga	Yes	Yes	Yes	51,1	1212,1	169
Olenitsa	Yes	Yes	Yes	62,2	402,8	129
Bab'ya	Yes	Yes	Yes	41,5	348,3	218
Kamenka (2)	Probable	Yes	Yes	53,0	315,4	154
Likhodeevka	Yes	Yes	Yes	37,0	307,8	210
Danilovka	Yes	Yes	Yes	38,8	262,2	214
Snezhnitsa	Yes	Yes	Yes	40,8	235,5	207
Yugina	Probable	Yes	Yes	43,8	206,8	166
Bolchaya Kumzhevaya	Probable	Yes	Yes	42,6	148,7	188
Indera	Yes	Yes	Yes	34,0	284,6	93
Salnitsa	Probable	Yes	Yes	21,7	119,5	114
Chernaya	Probable	Yes	Yes	24,4	102,5	83
Khlebnaya	Probable	Yes	Yes	19,4	261,2	90
Ust'-Pyalka	Yes	Yes	Yes	45,0	290,0	208
Lumbovka	Yes	Yes	Yes	85,3	1038,8	261
Kamenka (1)	No	Yes	Yes	59,1	482,9	281
Pila	Yes	Yes	Yes	47,1	322,9	49
Por'ya	Yes	Yes	Yes	40,1	233,7	273
Peschanka	No	Yes	Yes	31,8	158,2	182
Chernaya (2)	Yes	Yes	Yes	31,6	232,8	233
Orlovka	No	No	No	15,6	256,3	122
Zapadnaya	No	Yes	Yes	36,5	169,2	226
Glubokaya (1)	No	Yes	Yes	26,8	169,3	198
Glubokaya (2)	No	Yes	Yes	28,2	152,4	202
Kuzreka	Yes	Yes	Yes	41,5	254,5	86
Kolvitsa	Yes	Yes	Yes	8,7	1309,7	58
Luvenga	Yes	Yes	Yes	30,2	202,0	178
Ryazanka	No	Yes	Probable	29,0	101,6	79

Table IX. Rivers Kola Peninsula North

Name of the river	Existence of spawning pink salmon	Existence of spawning Salmo salar	Existence of spawning Salmo trutta	Length of river, km	Drainage area, km2	Fall, m
Paz		Yes	Yes	116,6	2532,3	119,6
Pechenga	Yes	Yes	Yes	101,2	1828,9	225
Anikeeva	Yes	Yes	Yes	19,3	59	169,7
Tipanova	Yes	Yes	Yes	16,1	60	225
Moche	Yes	Yes	Yes	12,2	35	196,4
Bolchaya Eina	Yes	Yes	Yes	11,1	40	200,1
Titovka	Yes	Yes	Yes	79,1	1226,3	322
Bolchaya Zapadnaya Litsa	Yes	Yes	Yes	98,9	1687,9	220
Malaya Zapadnaya Litsa	Yes	Yes	Yes	23,1	126,1	140
Urisa	Probable	Yes	Yes	16,7	106,5	99
Ura	Yes	Yes	Yes	73,4	1029,5	222,4
Sajda	Probable	Yes	Yes	14,7	57,9	95,3
Belokamenka	Probable	Yes	Yes	12	44,6	61
Kulonga	Probable	Yes	Yes	19,1	105,7	178
Bolchaya Lavna	Yes	Yes	Yes	23,3	245,7	208
Tuloma	Yes	Yes	Yes	59,8	18231,5	134,4
Kola	Yes	Yes	Yes	75	3845,6	140
Vaenga	No	Yes	Yes	7,3	142,8	151,2
Srednyaya	Yes	Yes	Yes	55,3	567,4	208
Bolchaya Tyuva	Yes	Yes	Yes	37,2	351	148
Malaya Tyuva	Probable	Yes	Yes	17,8	119,9	153
Zarubikcha	Probable	Yes	Yes	28,1	181,3	320
Tipunova	Yes	Yes	Yes	15,7	186,9	310
Klimkovka	Yes	Yes	Yes	34,5	183,8	250
Dolgaya	Probable	Yes	Yes	17,9	92,8	250
Muchka	Yes	Yes	Yes	31,1	192,1	324
Belousikcha	Yes	Yes	Yes	30,3	186,4	320
Zarubikcha (1)	Probable	Yes	Yes	17,7	72,2	200
Olyonka	Yes	Yes	Yes	52,8	490,6	180
Tryashhina	Probable	Yes	Yes	17,7	129,4	209
Ry'nda	Yes	Yes	Yes	97,6	1018,5	285
Zolotaya	Yes	Yes	Yes	36,1	212,8	215
Tchegodaevka	Probable	Yes	Yes	27,5	145	
Kcharlovka	Yes	Yes	Yes	126	2016,4	222,5
Bolchaya Litsa	Yes	Yes	Yes	118	1872,4	241,2
Sidorovka	Yes	Yes	Yes	39	335	301
Varzina	Yes	Yes	Yes	28,3	473	224,1
Drozdovka	Yes	Yes	Yes	53,4	468	258
Chernaya	Probable	Yes	Yes	23,6	103,8	260
Ivanovka	Probable	???	Yes	21,5	135,2	246,5
Savikcha	Yes	Yes	Yes	26,4	207,2	237,1
Yokanga	Yes	Yes	Yes	202,7	5944,2	270

Continue of Table IX. Rivers Kola Peninsula North

Teriberka	Yes	Yes	Yes	128,3	2226,6	260
Voronya	Yes	Yes	Yes	150,1	9944	153,2
Tuloma (Pecha)	???	Yes	Yes	82	1620	518
Pyajva	Yes	Yes	Yes	19	112	129,1
Yarychnaya	Probable	???	Yes	18,7	121	

Table X. Rivers in Karelia

Name of the river	**Existence of spawning of pink salmon**	**Existence of spawning Salmo salar**	**Existence of spawning Salmo trutta**	**Length of river, km**	**Drainage area, km2**	**Fall, m**
Nilma	Probable	Yes	Yes	16,1	164,5	45
Pulonga	Yes	Yes	Yes	52	640,9	60
Keret'	Yes	Yes	Yes	100,1	3393	90,6
Gridina	Yes	Yes	Yes	60	468,2	73
Kalga	Yes	Yes	Yes	58,6	932,9	71,3
Sig-reka	Probable	No	Yes	57,9	402,1	72,4
Von'ga	Yes	Yes	Yes	98,1	1927	71,3
Kuzema	Yes	Yes	Yes	69	940,4	80,2
Pon'goma	Yes	Yes	Yes	103,1	1200	115,4
Letnyaya	Probable	Yes	Yes	77,3	1007	99,3
Kem'	Yes	Yes	Yes	357,6	28223	220
Shuya	Probable	Yes	Yes	79,9	938	102,4
Vyg	No	No	Yes	313,7	27156	168,1
Kuz-reka	No	???	Yes	44,5	367,2	160
Suma	Yes	Yes	Yes	157,5	2041	175
Kolezhma	No	???	Yes	86,8	755,8	113
Nyukchcha	No	Yes	Yes	104,9	1772	186,2

Pink salmon juveniles were released for the first time in the year 1957. Eggs were from the even-year stock. It was expected to have the first catches in the year 1958 but the introduction was failed (see the table I). Releases were continued with 6.4 milj. fries from odd-year stock in the year 1958 and once again they failed. Pink salmon catch raised suddenly in the year 1960 to 76 000 fish after the release of 15.4 milj. fries in the year 1959. In the year 1960 catches of pink salmon distribution covered large areas in Northern Atlantic (Mills 1989; Berg 1961).

Catches have been always higher in White Sea area than in Barents Sea area. In Barents Sea area there has been operating only river fisheries but in White Sea area there operates the coastal fishery as well as river fishery. Figure 71 indicates clearly those years when fry releases have not been operating or there have been used even-year stocks followed by low catches.

Pink salmon catches have been fluctuating largely between the years. Before the year 1985 the numbers of released smolts varied largely affecting the subsequent catches (see the table I). Since the year 2002 all the smolt releases with odd-year stocks have been ceased and all the catches thereafter in odd-years have been dependent only on the natural spawning.

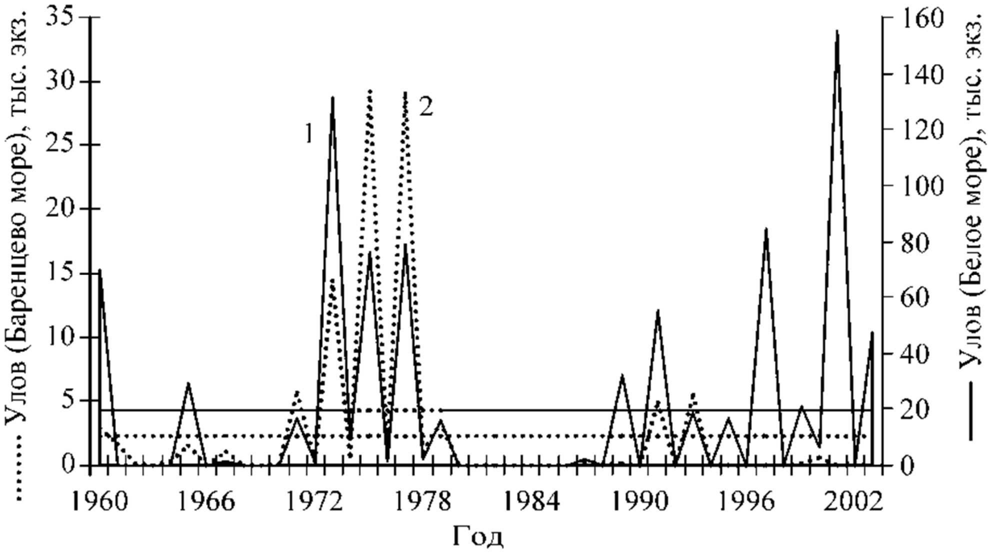


Figure 71. Pink salmon catches in numbers in North West Russia. Number 1 (solid line) in the figure is White Sea catches with numbers on the right axes; number 2 (dotted line) is Barents Sea catches with numbers on the left axes. Source; Zubchenko et al. 2004.

Photo 40. Atlantic salmon and pink salmon fishery takes place in some sites in the White Sea coast. Trap net is in the photo. Photo; Alexander Zubchenko.

Photo 41. Counting fence -RUZ- is operating in Varzuga river catching Atlantic salmon as well as pink salmon. This fence is operating the entire open water period until the river will have ice cover. Photo; Alexander Zubchenko.

Extremely high catches in numbers were recorded in Murmansk Oblast area (includes Barents Sea rivers as well as rivers flowing into the northern White Sea coast) in the year 2009 although there have not been smolt releases since the year 2002 (Figure 72; see table I). Catch in the year 2009 is totally based on the self-reproducing pink salmon stocks mainly in White Sea Rivers. Also the high catch in the year 2007 in Murmansk Oblast area coincides with the increased catches in the rivers Tana and Neiden and with the high abundance of pink salmon observed in some rivers in Finnmark (Muladal 2009). The catch of 156 000 pink salmon recorded in the year 2001 in Murmansk Oblast area is based on the odd-year natural spawning in the year 1999 and partly to the smolt release with 1.14 milj. smolts in the year 2000. Since the middle of 1980s' it was used "new" pink salmon stock originating from Magadan area. This stock has made it possible to establish self-reproducing stocks into many White Sea rivers (Gordeeva *et al*. 2005, Gordeeva *et al*. 2015).

The ocean environmental conditions like the sea temperatures improved the survival of pink salmon smolts and of adult in the summer months in the year 2000 and in the winter months in the year 2001. Sea temperatures increased clearly for the year 2000 in June, July and August in the coastal areas of Kola Peninsula and in the Varangerfjorden compared to the earlier years. The same increase in the sea temperatures was observed in the winter temperatures in January, February and March for the year 2001 (See figures

20 and 21). All in all, the environmental parameters (temperature, high food availability, low predation) at sea were favourable to increase the survival for pink salmon smolts and preadults resulting to high occurrence of pink salmon in northern areas in the year 2001. It is most obvious that the ocean survival of pink smolts is governed at the same manner as the survival for Atlantic salmon in Barents Sea area. Barents Sea temperatures during the Atlantic salmon smolt migration in July are significantly correlating with the abundance of 1SW salmon caught in the Tana and Neiden rivers one year later (Niemelä *et al*. 2004). It has also been observed that the sea temperature is significantly affecting into the growth of 1SW salmon in the Tana River (Figure 25) and therefore it is believed that the same relation works as well for pink salmon in White Sea and Barents Sea rivers.

Exceptional high occurrence of pink salmon was observed in the middle of 1970s' (Figure 72 and Table I) in the years 1973, 1975 and 1977 although at that time the origin of released pink salmon smolts were from Sakhalin and Kamchatka and not from Magadan area which was used successfully for introductions since the year 1985 onwards. The favourable Barents Sea conditions in the middle of 1970s' resulted to high survival of pink salmon smolts and preadults and thereafter to good catches. The same phenomenon was found between the sea temperatures in Barents Sea and the abundance of Atlantic salmon in the Tana and Neiden rivers (Niemelä *et al*. 2004).

Figure 72. Catches in numbers (thousands of fish) for pink salmon in Murmansk Oblast in the years 1960–2009. The year 1985 indicates the year from which period onwards "new" stock from Magadan area in Far East was used in the introductions. Source; Zubchenko et al. 2010.

Within Barents Sea and White Sea areas the most important rivers to produce pink salmon are those which are in the Kola Peninsula, where 2/3 from the catch in tonnes is taken (Figure 73) (Zubchenko *et al.* 2010). The total reported catch was as high as c. 340 tonnes in the year 2001 and most of that was taken within the Murmansk Oblast area in the coastal net fishery and in the commercial trap net fishery in some rivers. Since the year 2003 until the year 2009 reported catches have been around 125–165 tonnes.

Figure 73. Pink salmon catches in tonnes for Murmansk Oblast (1) (Barents Sea rivers and rivers flowing into White Sea from Kola Peninsula), Arkhangelsk Oblast (2) and Karelen (3). Source; Zubchenko et al. 2010.

Photo 42. In the Varzuga river the catch of Atlantic salmon and pink salmon in the counting fence has been controlled over many decades. Obtained data indicates the successful acclimatisation of pink salmon into White Sea rivers. Photo; Alexander Zubchenko

Reported catch of 340 tonnes requires huge production areas in the rivers. Zubchenko *et al*. (2010) have estimated that there is c. 5 220 hectares available in Barents Sea and White Sea areas for pink salmon spawning and juvenile production, which could yield up to 6.5 milj. smolts annually. This amount of smolts could give 330 000 –380 000 pink salmon with the biomass of 1 000 –1 100 tonnes returning to coastal areas.

The importance of pink salmon for the White Sea fishery can be proved from the following calculations (Zubchenko *et al*. 2010):

-based to ICES estimations the numbers of Atlantic salmon in the catches was in White Sea rivers in Kola Peninsula for the years 1999–2008 in average c. 243 000 fish (143 000–345 000) and the biomass 650-680 tonnes.

-the abundance of pink salmon in the catches in the same area was for the years 1999–2008 in average c. 89 000 fish (48 000–156 000) and the biomass 115 tonnes.

-at the same time the estimated numbers of pink salmon was in the spawning stocks within the White Sea rivers in Kola Peninsula 100 000-320 000 fish with the biomass of 140–460 tonnes.

- the total population abundance of pink salmon in White Sea area was estimated to be 480 000–500 000 fish and 700 tonnes

The Kitsa River is flowing into the White Sea from Kola Peninsula. The numbers of pink salmon ascending into the river have fluctuated a lot between the years 1989–2009 (Figure 74). During these yeas only the natural production has made the yield. Zubchenko *et al*. (2010) have estimated the returning coefficient from the estimated numbers of smolts leaving the river and from the estimated numbers of ascending pink salmon one year afterwards. Figure 74 shows the huge annual variations in the returning coefficients. The coefficients don't indicate that from high abundance of pink salmon spawners the result is high numbers of pink salmon in the next generation. Most probably the coefficients are affected strongly by the fluctuating environmental parameters at sea and therefore the mortality of pink salmon smolts can be very heavy in unfavourable feeding and in cold sea temperature conditions. Figure 74 indicates clearly that it might be difficult to make any prognoses for the forthcoming numbers of pink salmon ascending into the rivers based only on the numbers of spawners and their recruits two years afterwards. Sea surface temperatures in Kola section, however, are explaining more precisely the pink salmon return rate (Figure 75) (Zubchenko *et al*. 2004). With the increasing sea temperatures pink salmon return rates are increasing. The increase of the sea temperatures in Barents Sea (Figures 20, 21, 23) in the last 10-15 years can partly explain the increased abundance of pink salmon in some areas. The numbers of pink salmon ascending into the rivers are also depending on the exploitation in the coastal fishery in White Sea area.

Figure 74. Coefficients for pink salmon in the Kitsa River between the numbers of smolts and ascending fish (in thousands) for odd-year salmon stock. Source; Zubchenko et al. 2010.

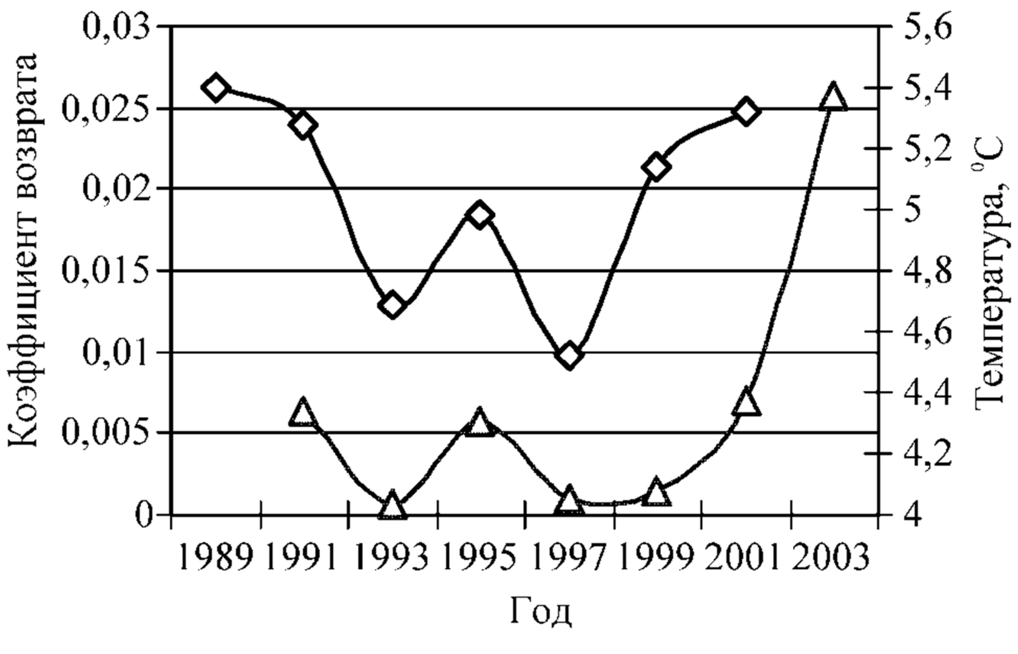


Figure 75. Return rates and sea temperatures in Kola section (0-50 m) in Barents Sea for pink salmon in the Kitsa River (White Sea area). Source; Zubchenko et al. 2004.

10.2 Weight and length

Annual mean weights of pink salmon in White Sea rivers ranged from 1.3 to 1.9 kilos (min. 0.44; max 3.6 kg) and for mean lengths from 47.6 to 50.3 cm (min. 34.3; max. 60.0 cm) (Zubchenko *et al.* 2004). The size of males exceeded that of females in all White Sea rivers in all years throughout the summer (Figures 76 and 77). In rivers where the ascending time takes one month or longer time period it is natural that the late arrivals are larger for both sexes. Late running pink salmon has been growing many weeks longer at sea than the first arrivals.

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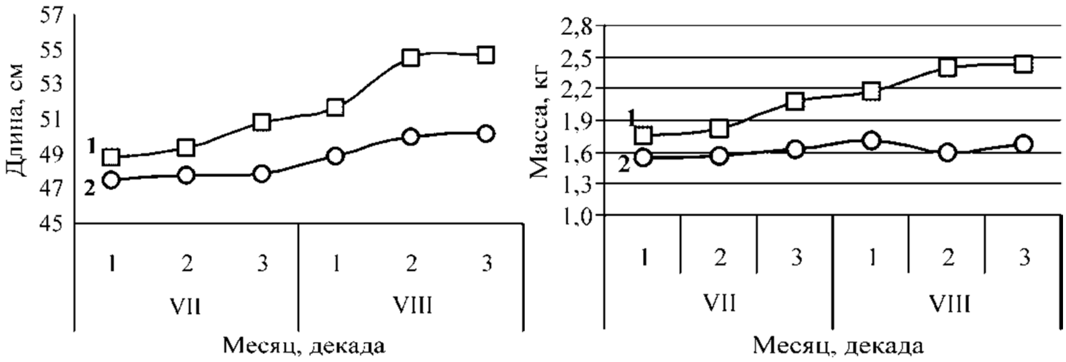

Figure 76. Mean lengths (cm) and weights (kg) for male (1) and female (2) pink salmon during the summer (VII, July; VIII, August) in the year 1993 in Varzuga river in White Sea. Source; Zubchenko et al. 2004.

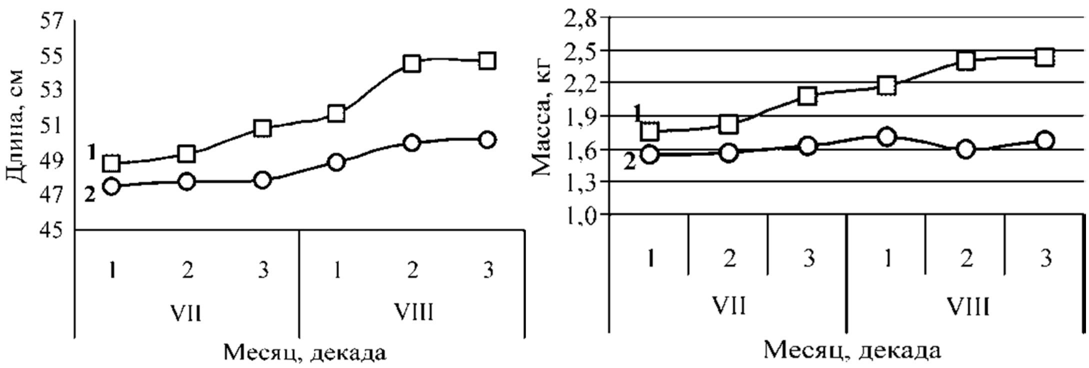

Figure 77. Mean lengths (cm) and weights (kg) for male (1) and female (2) pink salmon during the summer (VII, July; VIII, August) in the year 1993 in Umba river in White Sea. Source; Zubchenko et al. 2004.

10.3 Timing of the catches

Figures 78–81 are clearly indicating the period of the summer, when pink salmon is entering into the rivers in White Sea. Like the timing of the catches in the Tana River the main migration in White Sea rivers takes place around the same time of the summer, in July. In general the highest peak in the migration takes place in July in all the White Sea rivers (Zubchenko *et al.* 2004). There are some but minor differences in the timing between years. Differences between the years most probably are caused by the annual variations in the sea temperatures. River temperatures might have effects into the river ascending time especially in smaller rivers, where the increase in the water temperature late in June or in July can force pink salmon to descend back to the sea. Therefore they avoid to be caught and counted in traps, which normally are situating in the lower stretches of the rivers. Because the ascend time into the rivers Tana, Neiden and White Sea rivers is not clearly differing temporally we can hypothesize that pink salmon does not migrate along the Finnmark and Kola Peninsula coastline from west to east like Atlantic salmon does but it migrates straight from open sea to the Finnmark and Kola Peninsula rivers and therefore the mean ascending time is about the same for all northern rivers.

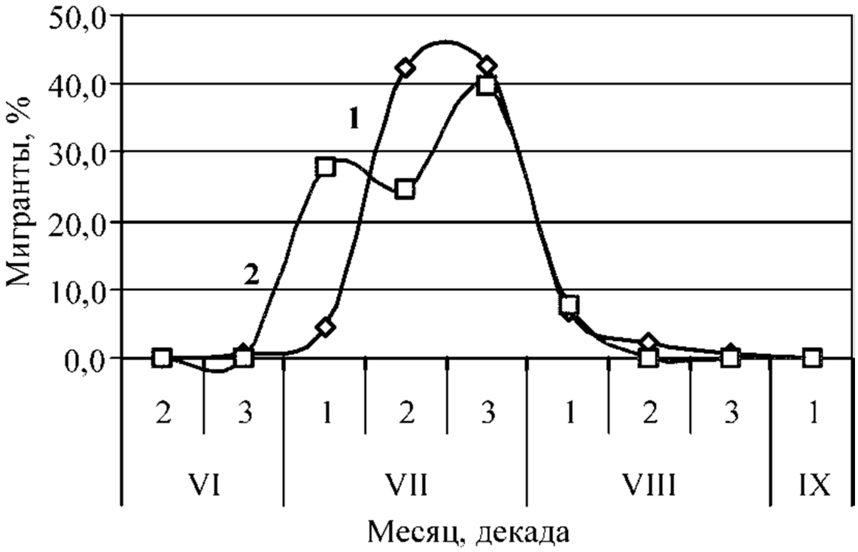

Figure 78. Dynamics of migration of pink salmon (line of odd-years) in the White Sea rivers of the Kola Peninsula in 1989-2001 (1) and in 2003 (2) in June (VI) to September (IX). Zubchenko et al. 2004.

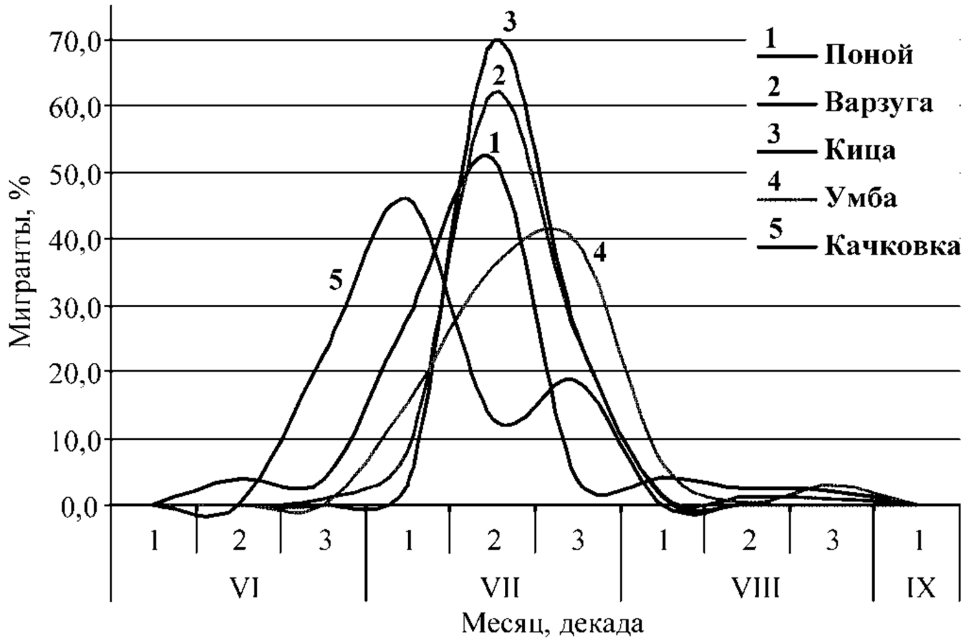

Figure 79. Dynamics of migration of pink salmon in the rivers in the White Sea; Ponoy (1), Varzuga (2), Kitsa (3), Umba (4) and Kharlovka (5) in the year 1991 in June (VI) to September (IX). Zubchenko et al. 2004.

Photo 43. Two pink salmon in Indera river on the way to spawning sites in July in the year 2003. Photo; Aleksei Veselov.

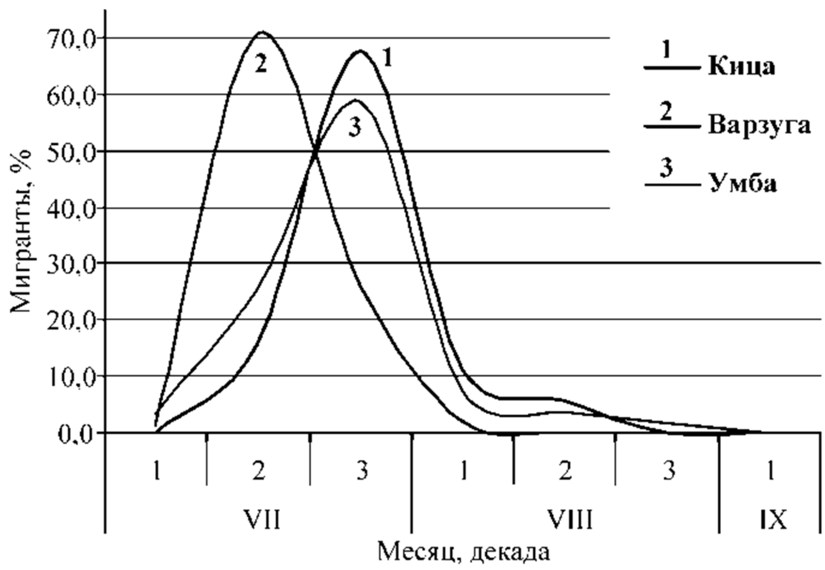

Figure 80. Dynamics of migration of pink salmon in the rivers in the White Sea; Kitsa (1), Varzuga (2) and Umba (3) in the year 1997 in June (VI) to September (IX). Zubchenko et al. 2004.

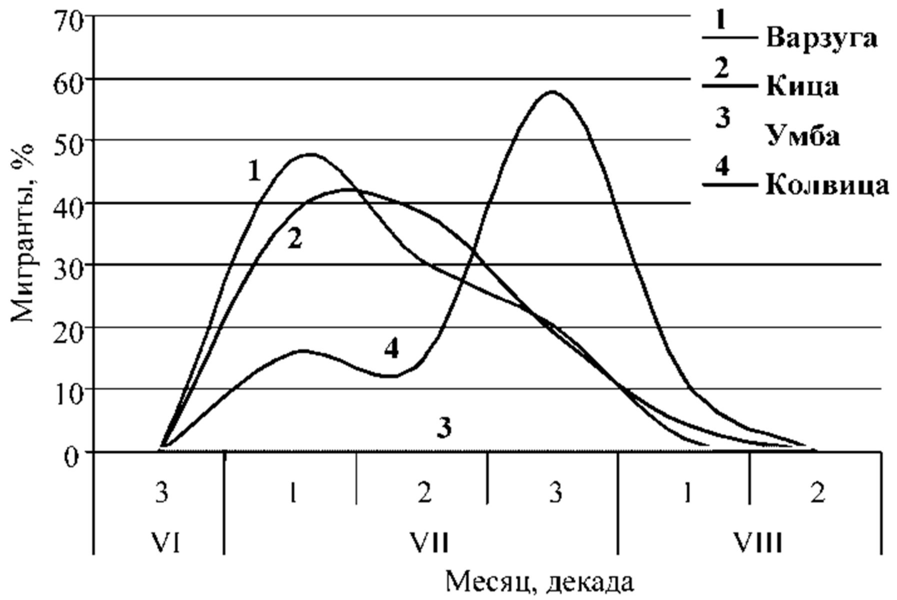

Figure 81. Dynamics of migration of pink salmon in the rivers in the White Sea; Varzuga (1), Kiza (2), Umba (3) and Kolvica (4) in the year 2003 in June (VI) to September (IX). Zubchenko et al. 2004.

10.4 Development of juvenile pink salmon

The average fecundity of pink salmon in the rivers Varzuga, Kitsa and Umba was 1870, 1940 and 2230, respectively (Figure 82) (Zubchenko *et al*. 2004).

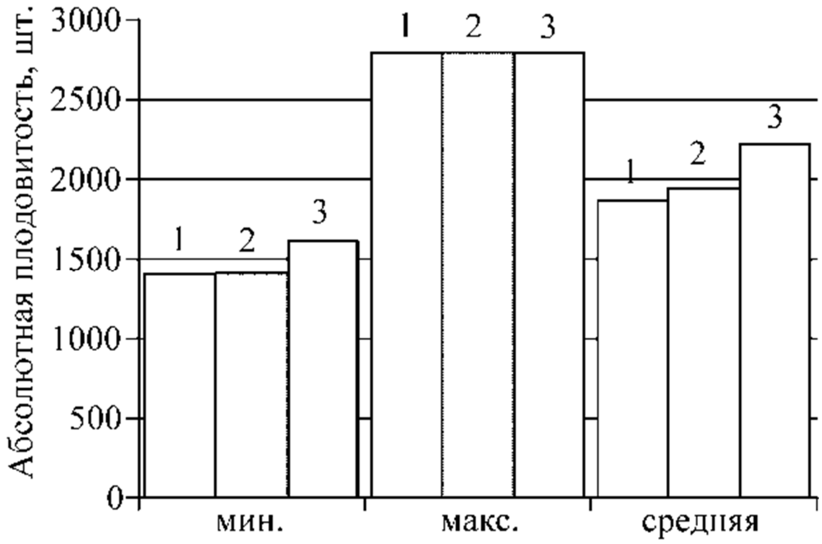

Figure 82. Fecundity (number of eggs) of pink salmon in White Sea area in the rivers Varzuga (1), Kitsa (2) and Umba (3). Bars on the left are minimum values, in the middle are maximum values and on the right are mean values. Zubchenko et al. 2004.

Photo 44. Pink salmon embryos in eyed degree excavated from spawning nest in the end of January in Indera river in White Sea. Photo; Aleksei Veselov.

In the Indera river in White Sea some pink salmon nests were opened January 27 *c*. five months after the spawning. Some but very few eggs had already hatched and alevins had started to use material from yolk sac (Zubchenko *et al.* 2004). Later, in early April, all the eggs were hatched and the lengths of alevins were 30-31 mm and fish had silvery colour. Alevins were still below the small stones and all the yolk sac material was resorbed. The water temperature was -0.1 ºC and the river had ice cover of 0.5 meters.

Photo 45. Winter (January) survey in Indera river in White Sea. Researchers are making opening into the ice to study development of pink salmon embryos in spawning nest. .Photo; Aleksei Veselov.

Photo 46. Spring (April) survey in Indera river in White Sea. Researcher Alexey Veselov is digging pink salmon nest to observe the development stage of alevins and fries. Photo: unknown photographer.

Pink salmon smolts descended the river within short time period, mainly between 23.-30. May. The mean length of smolts was 3.5 cm (3.2-3.8 cm) and mean weight was 0.25 g (0.2-0.3 g). Zubchenko *et al.* 2004 are explaining that the short and quite early downward migration period within *c.* 5 days depended from the fact that all the spawning nests located very close to the river mouth. It is also interesting to note that the water temperature was as low as 5.1 ºC when smolt migrations initiated. Smolt migration was intensive when the daily water temperature was 6.2- 8.8 C. Most (78%) of the pink salmon smolts left the river on daytime between the period from 10 to 18 o’clock and during the night there was only some single smolts migrating downstreams.

10.5 Parasite fauna of pink salmon in the Keret River, White Sea

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First data on parasites of the pink salmon acclimated in the Barents and White Sea drainage basins were gathered by R.P. Malakhova in the 1960s (Malakhova, 1972). The parasite fauna of the fish from the Keret' River comprises 10 species. All the species, with the exception of Unionoidea sp. glochidia and the crustacean *Ergasilus sieboldi*, represented marine fauna. The dominant ones among them were the cestode *Scolex pleuronectis* (prevalence 100/ mean intensity 1980) and trematodes *Brachyphallus crenatus* (100/52), *Lecithaster gibbosus* (100/284). The parasite fauna of pink salmon from the Keret' River surveyed in 1993 and 2003 comprised 17 species: Protozoa – 1, Cestoda – 4, Trematoda – 7, Nematoda – 3, Acanthocephala – 1, Crustacea – 1 (Table VIII.). Marine taxa (13 species) constituted the bulk of the fauna. They were intestinal and lumenal parasites, which infect the fish as they feed on benthos, zooplankton and fish in the sea. The freshwater fauna was represented by broad specialists (infusorians *Capriniana piscium*, parasitic crustaceans *Ergasilus sieboldi* and larvae of trematodes *Diplostomum sp., Ichthyocotylurus erraticus).*

The parasite fauna of pink salmon dispersed across rivers of the White and Barents Sea basins is much poorer compared to waters in the species' natural distribution range. The species composition of its parasites is similar to that in Atlantic salmon, *Salmo salar* L., indicating these fish have similar diets during the marine feeding period (Barskaya et al., 2005). Surveys carried out in 2003 showed that after more than 40 years there happened no noticeable change in the parasite fauna of pink salmon, apart from a decline in the prevalence and intensity of infection with the most common species (Tab). The reason for that possibly is the longer duration of the freshwater period for the pink salmon. Thus, even the fish examined in July 1993 had higher infection rates as compared to the sample examined in September 2003 (Table XI).

Acknowledgements

We thank Drs Bjorn Berland and Glenn Bristow (University of Bergen, Norway) for their work during the parasitological survey of the Keret' River in 1993.

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Table XI. Parasite fauna of pink salmon, *Oncorhynchus gorbuscha*, in the Keret' River (July, 1993; September 2003) (Ieshko, E.P., Shulman, B.S., Barskaya, Yu., Novokhatskaya, O.V.)

Parasite	1993			2003 (Barskaya et al., 2005)		
	Prevalence (%)	Mean abundance (ind./fish)	Intensity of infection (min – max)	Prevalence (%)	Mean abundance (ind./fish)	Intensity of infection (min – max)
1. *Capriniana piscium*	13.3	+	+	-	-	-
2. *Eubothrium crassum*	80.0	8.0	1-51	26	0.7	1-4
3. *Diphyllobotrium sp.*	46.6	1.1	1-5	-	-	-
4. *Scolex pleuronectis*	93.3	79.1	16-326	67	12.7	1 - 104
5. *Cestoda l. gen. sp.*	-	-	-	87	5.7	1 - 92
6. *Hemiurus levenseni*	26.6	0.4	1-3	-	-	-
7. *Brachyphallus crenatus*	86.6	8.1	1-40	46	3.9	1 - 18
8. *Derogenes varicus*	73.3	3.3	1-10	66	7.3	1 - 55
9. *Lecithastergibbosus*	93.3	87.6	1-519	46	3.0	1 - 77
10. *Podocotyle reflexa*	26.6	0.4	1-2	13	0.1	1 - 1
11. *Diplostomum volvens*	-	-	-	33	1	1 - 6
12. *Ichthyocotylurus erraticus*	-	-	-	20	0.3	1 - 2
13. *Anisakis simplex l.*	40.0	1.4	1-12	26	0.8	1 - 6
14. *Pseudoterranova decipiense*	6.6	0.07	1-1	26	0.3	1 - 1
15. *Hysterothylacium aduncum*	86.6	6.4	1-16	40	1.3	1 - 10
16. *Echinorhynchus gadi*	6.6	0.07	1-1	-	-	-
17. *Ergasilus sieboldi*	-	-	-	7	0.1	1 - 1

11. Pacific salmon in Eastern North America

Written by J.B. Dempson

Various species of Pacific salmon (*Oncorhynchus* spp.) were introduced outside their native range into a variety of locations in eastern North America beginning in the late 1800s and early-to-mid 1900s. Many of the introductions were unsuccessful while other attempts succeeded. Introductions of Pacific salmon to the Great Lakes region are well documented with some reports also providing evaluations of stocking success, ecological implications, and harvest information (e.g. Kocik and Jones 1999; Crawford 2001; Crawford and Muir 2008).

Chinook salmon (*Oncorhynchus tshawytscha*) are reported to have been the first of the Pacific salmon species to be introduced to other locations including the Great Lakes, the Saint John River, New Brunswick, Canada, and to various locations in the eastern United States as well as Europe (Davidson and Hutchinson 1938; Scott and Crossman 1973; Emery 1985; Crawford and Muir 2008). The captures of Chinook salmon on the Atlantic coast have been scarce with several documented cases reported for the Saint John River, N.B. (Scott and Crossman 1973), and also from the Annapolis River, Bay of Fundy (Mills 1991). Populations continue to exist in the Great Lakes (Crawford 2001).

Chum salmon (*Oncorhynchus keta*) is the least common of the Pacific salmon species to be used for introductions outside of its natural range (Scott and Crossman 1973). Attempts to establish populations in the Great Lakes (Crawford 2001) and Hudson Bay and James Bay failed (Scott and Crossman 1973). They were also introduced to Europe (Crawford and Muir 2008).

Sockeye salmon (*Oncorhynchus nerka*) or its freshwater form (kokanee) were introduced into Maine, US., and several of the Great Lakes (Davidson and Hutchinson 1938; Scott and Crossman 1973; Crawford 2001). In general, introductions have failed with no evidence of successful spawning in Lake Ontario although several fish were reported in a Lake Huron tributary in 1993 (Kocik and Jones 1999). There have also been several unsuccessful attempts to introduce Sockeye salmon to Europe (Crawford and Muir 2008).

Notwithstanding the somewhat ubiquitous Rainbow trout (*Oncorhynchus mykiss*), Coho salmon (*Oncorhynchus kisutch*) and Pink salmon (*Oncorhynchus gorbuscha*) are the two species of Pacific salmon that have been most successfully introduced outside their native range (Mills 1991). Coho salmon were introduced to the Great Lakes as well as various New England states (Davidson and Hutchinson 1938; Scott and Crossman 1973). In the New England area Mills (1991) reported that the introductions were initially successful but a recent review of exotic salmonids indicated that naturalized populations were never produced (ICES 2013). There were also reports of Coho salmon in various New Brunswick and Nova Scotia streams (Symons and Martin 1978; Martin and Dadswell 1983). Coho salmon were also introduced to Europe (Crawford and Muir 2008).

Pink salmon have been introduced to Maine and other Atlantic coast states (Davidson and Hutchinson 1938; Scott and Crossman 1973) as well as the Great Lakes where they became established in all five lakes (Crawford 2001; Crawford and Muir 2008) and also to Europe (Crawford and Muir 2008). Pink salmon were also introduced to a Newfoundland, Canada, river (North Harbour) in the late 1950s and early 1960s (Scott and Crossman 1964; Scott and Crossman 1973; Lear 1975; Mills 1991). Natural spawning subsequently occurred and stocking ceased. In several years adult Pink salmon returning to North Harbour River totalled 1- to 5000 fish before numbers steadily declined (Lear 1975). No returns were recorded in North Harbour River in 1978 and 1979. From this introduction, Pink salmon were also caught in many areas along the northeast coast of Newfoundland with other incidental reports from Nova Scotia and Quebec. Pink salmon were also caught in Labrador during the 1970s (Lear 1975; Dempson 1980) with another confirmed capture of a pink salmon at Nain, Labrador, in 2014 (I. Bradbury, DFO, pers. comm).

An adult Pink salmon was caught in the Miramich River, New Brunswick, in 1983 (Randall 1984). Dunmall et al. (2013) reported the capture of a pink salmon at East Greenland in 2012 and noted that Pink, as well as Chum salmon, are becoming more common in western Arctic areas in recent years. This contrasts with an earlier review by Stephensen (2006) that concluded that up to the end of 2003 there was no evidence Pacific salmon were any more common now than in the past and in the absence of any confirmed spawning populations documented reports in the Arctic waters likely represent strays.

The origin of the pink salmon caught at Nain, Labrador, in 2014 is unknown, while Dunmall et al. (2013) discussed possible sources for the specimen that was captured at East Greenland in 2012. Pink salmon are reported to have higher straying rates than other species of Pacific salmon (Hendry et al. 2004). They also have the widest distribution of all Pacific salmon species recorded from Arctic areas (Nielsen et al. 2013). Pink and Chum salmon are currently the most common species found in the Arctic and their juveniles are reported to be more tolerant of lower temperatures found in Arctic areas (Nielsen et al. 2013). These attributes coupled with the rather short life cycle for Pink salmon (mostly 2 years; Scott and Crossman 1973) may that Pink salmon could be more likely to stray and successfully colonize new areas in Arctic, or northern areas, more so than other species of Pacific salmon.

Acknowledgements

Authors will thank all the fishermen who have taken samples and measurements from their pink salmon catches in the rivers Tana and Neidenelva. We will thank also Håvard Vistnes, Yngve Nilsen, Svein Ingebrigtsen, Tor-Erland Nilsen and Harald Muladal from their kindly help to inform the occurrence of pink salmon in Finnmark rivers and from their photos from pink salmon.

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