IS TRANSPLANTATION OF THE PINK SALMON SUCCESSFUL IN RUSSIA? WHAT FACTORS HAVE AN IMPACT ON ESTABLISHMENT OF SELF-REPRODUCING STOCKS

Transplantation of the Far-East Pink Salmon into the basins of the White and Barents Seas was just one of many projects to introduce hydrobionts by the Soviet Union in the XX century. Until the early 1990's, annually ca. 250 introductions were implemented involving, totally, 35 fish species and 13 invertebrates.

1956 — the start of Pink Salmon transplantation project in the water bodies of North Russia.

The main goal:

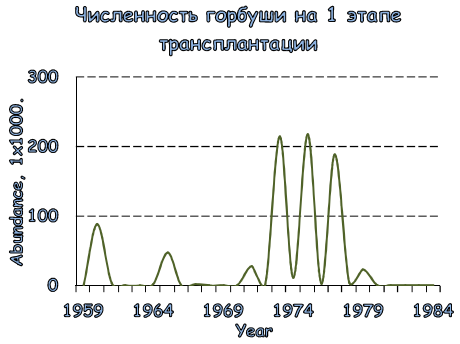
- Establishment of additional source of commercial raw materials on the basis of the food supply of the White and Barents Seas; naturalization of the species in the hew habitat.

2 stages of transplantation:

- 1 (1956-1984) – the active stage with regular delivery of eggs for incubation and follow-up release of larvae. Totally, ca. 248 million eggs were incubated.

- 2 (1985- present days) — the stage of adaptation of the species to new living conditions. Eggs from the Far East (Magadan Region) were delivered four times: in 1985, 1986, 1989 and 1998. Totally, ca. 18.8 million eggs were incubated.

Diagram: numbers of Pink Salmon at Stage 1 of transplantation



- In some years the numbers of Pink Salmon reached 100 thousand individuals and more. However, after 1979, without import of eggs only single individuals of Pink Salmon were observed.

- Reasons: mass mortality of hatching eggs because of early autumn frosts in the introduction area, and death of larvae because of late warming of water in spring.

- As a result, by the end of State 1 none of the main goals of the project was achieved.

Diagram: numbers of Pink Salmon at Stage 2 of transplantation

-The cycle of relatively massive returns of the odd-year line of Pink Salmon started from the generation of 1985 (the numbers reaching 100 thousand individuals and more).

- The even-year line of Pink Salmon at the starting stage ceased to exist without fish farming activities, and only after import of eggs from Magadan Region in 1998, some insignificant returns of the even-year line were observed in 2000 and later years (from several hundreds to 11 thousand).

Different opinions have been expressed about naturalization of Pink Salmon in the new habitat:

- Establishment of a stable self-reproducing population is not realistic and the relatively massive returns in some years only confirm the breeders' feeding abilities.

- The full life cycle is possible, although adverse factors may decrease the efficiency of reproduction.

- Stage-by-stage acclimatization has its advantages and prospects, as well as pasture-type fish farming based on hatchery raring and natural reproduction in successful years.

By the present moment it has been found that the acclimatized Pink Salmon of the odd-year line demonstrates changes in exterior morphology, its fertility is definitely higher, the average weight of males and females is also higher, the life cycle has changed.

According to the data by N. V. Gordeeva (2010, 2017) obtained on the basis of population-genetic monitoring, the introduced species of the odd-year line demonstrate a strong targeted selection which means adaptation to rather unfavorable conditions of reproduction in the new habitat. The even-year line do not demonstrate such processes.

Reproduction efficiency of an introduced species in a new habitat depend on the following:

- **the number of breeders' stocks**
- **the environment conditions;**
- **the amount and quality of sites suitable for spawning and fry feeding;**
- **availability of food supply;**
- **amount of the hatchery fry released;**
- **the harvesting load.**

According to research data, many of these factors have not had a significant impact on the numbers of the breeders and their offspring.

In our opinion, the following factors hamper adaptation and establishment of large commercially valuable stocks of Pink Salmon in the new habitat:

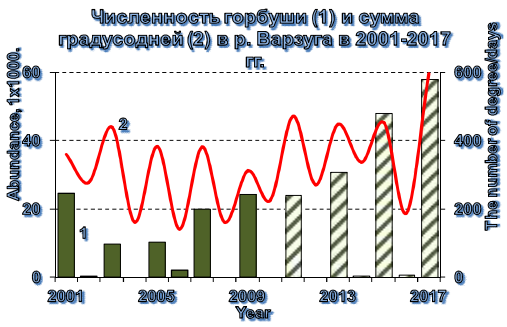
- water temperature in the period of egg development and post-embryo development;

- amount of sites suitable for spawning;

- food supply;

- enemies.

Diagram: number of Pink Salmon and total of degree-days in the Varzuga river in 2001-2017

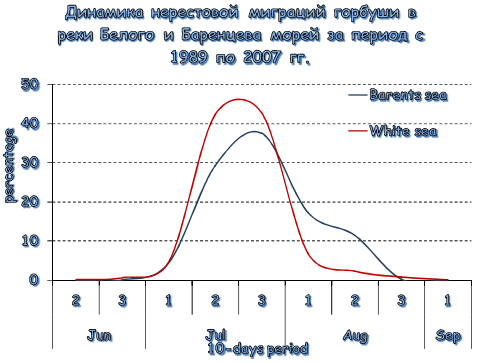


The major limiting factor of Pink Salmon adaptation in the new habitat is the water temperature.

A direct correlation has been identified between the Pink Salmon in odd years and the total water temperature in the rivers in September in the spawning year and in May next year, as well as water temperature at the feeding grounds.

The thermal conditions in the new habitat makes the development of buried eggs practically impossible in even years, and limited in odd years.

Diagram: dynamics of Pink Salmon spawning migration in the rivers of the Barents and White Seas in 1989-2007



In the new habitat, spawning migration of the odd-year and even-year line Pink Salmon starts in the last 10 days of June-early July. It ends in the last 10 days of August – early September. The spawning migration peak takes place in the final 20 days of July.

In odd years Pink Salmon maturates earlier and spawns in late August – first days of September.

In even years it happens 2.5-3 weeks later.

In odd years the early stages of embryogenesis take place at optimal temperatures.

In even years it happens at a temperature lower by 4.5°C which results in death of almost all fertilized eggs.

The low numbers of Pink Salmon in the Barents Sea rivers can, apparently, be related to the temperature factor, as the conditions there are much harsher than those in the White Sea rivers.

- **In the climate conditions of the Russian North, hatching of larvae takes place late in January.**
- **In April, fully-formed larvae with dissolved yolk sacks migrate from the redds towards the soil surface and are ready to feed exogenically when the temperature reaches 2.5-3°C.**
- **Downstream migration of Pink Salmon larvae begins at water temperature 4–5 °C. Usually, such temperatures occur in the second half of May. The average length of downstream migrants is 3-3.5cm, the average weight 0.2-0.3g.**

All the above shows that even when eggs from early spawning breeders develop in favorable conditions, spring-time larvae face harsh conditions and most of them die. Almost all eggs from fish spawning late die. Also, in the rivers of the Kola Peninsula Pink Salmon as a rule leave eggs close to the shoreline because they spawn during the autumn flood. This is the reason why the eggs freeze and die during winter low-water period.

Amount of sites suitable for spawning:

- On the Kola Peninsula 94 water courses longer than 5 km flow into the White Sea.

- Atlantic Salmon is found in 36 rivers and brooks.

- Pink Salmon spawns in areas with small pebbles washed by underflow water.

- Each female occupies a spawning area of 1.2 to 2.5 m^2.

- The identified spawning and feeding grounds in the rivers populated by salmonoids amount to ca. 18.3 million m^2.

- The area suitable for spawning by Pink Salmon amounts to 4% of the total spawning and feeding grounds or, approximately, 0.75 million m^2.

- With the maximum capacity the above spawning area may be used by 0.3 to 0.6 million females, with a female to male ratio as 1:1.5.

Considering the statistical data from catches, these figures deem to be close to the reality.

Competition for food:

- Larvae and downstream migrants feed on zooplankton, nymphs of chironomidae and stone flies, gnats.

- Their competitors are: juveniles of Atlantic Salmon, Brown Trout, other river fishes, and small fishes: minnows, stickleback.

- In the active feeding period Pink Salmon feeds on crustaceans and small fish.

- Pink Salmon's competitors are salmonoids and many sea fishes.

This has an impact on Pink Salmon's survival.

And, filally, **the enimies:**

- During downstream migration by Pink Salmon fry, river and sea predator fishes gather in the estuary sections of the rivers, also seagulls and other fish-eating birds.

- Pink Salmon larvae have been found in Atlantic Salmon smolts' stomachs, and even in White Sea herrings and semi-anadromous whitefish who are not regarded as predators.

Conclusions:

- The fact of adaptation by odd year line Pink Salmon is interesting in terms of science but not commercially.

- The main goal to establish an additional industrial fishing source of raw materials was not achieved.

- The catches of 200-300 tons and in odd years only does not address economy issues concerning employment of the population even in the coastal communities.

- With the considerable financial investments, the registered numbers only several times reached 100 thousand individuals and more, and in even years only once reached 73.3 thousand individuals (in 1960).

- With the above-mentioned limiting factors (water temperature, spawning sites area, food supply, predators) one should not expect a dramatic increase in numbers.

- Why, with Atlantic Salmon stocks in the rivers of the White and Barents Seas, a competitor was introduced, which is in many ways inferior?

- The occurrence of Pink Salmon in other countries' rivers has shown that the use of the White Sea food supply is not the case, because Pink Salmon feeds in the same regions as Atlantic Salmon and has become a competitor for food to Atlantic Salmon and many other valuable commercial fish species.

- Considering today's knowledge, Pink Salmon transplantation into the water bodies of Northern Russia was a mistake.

- Unfortunately, it is not possible to stop the process of adaptation at the current stage. The Pink Salmon behaves rather aggressively in the new habitat, and the only way to confront the expansion of the introduced species is its maximum extraction by all available means.