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HEAVY METAL CONTENT IN PINK SALMON FROM THE EURO-ARCTIC AND SAKHALIN-KURIL REGIONS

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Abstract

Heavy metals Pb, Cd, Ni, Cu, and Zn contained in organs and tissues of the most common species of Pacific salmon, pink salmon, introduced from the Russian Far East to the Euro-Arctic region has been compared to the one that came in the water streams of the Kola Peninsula to spawn - the Umba and Varzuga rivers running into the White Sea, and also caught earlier within their native habitat in two rivers Firsovka and Reydovaya of the Sakhalin-Kuril region. On their way from the latter two rivers into the Pacific Ocean for feeding (fish-growing period) and on their way back to breed, pink salmon crosses the eutrophic but also geochemically impacted natural zone shaped due to the Kuril Chain and the Kuril–Kamchatka Trench, which supplies chemical elements to surface waters through volcanism and upwelling. Concentrations of Pb are the most elevated here. The marine waters of far northwest Russia feel under the anthropogenic environmental impact. It is caused by the Gulf Stream that absorbs domestic and industrial (household) wastewater from the American coast and North European countries and as North Atlantic Current (NAC) flows into the Barents Sea. In addition, over-the-surface flows and aero-industrial shifts from the technically full Kola Peninsula, where various metals are mined, processed, and smelted, primarily Ni and Cu, and Zn and Fe, enrich the marine environment and affect the microelement composition of salmon.

Keywords: Euro-Arctic region, heavy metals, Pacific salmon, pink salmon, Sakhalin-Kuril region

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1. Introduction

The Oncorhynchus genus of pacific salmon is the most important target species of fishery in the Far East.

As these fish species have good nutritional and commercial value, they contribute to the economy of the Far East and throughout Russia, and in some areas, such as Kamchatka, Sakhalin, and the southern Kuril Islands, salmon fishing, artificial reproduction, and processing are the essentials of economics and employment. The most abundant Pacific salmon species in both Asia and North America is the pink salmon (O. gorbuscha). Many studies are devoted to its biology, population dynamics, population structure, and artificial reproduction (breeding). Pink salmon usually has the priority commercial fishery value in the Russian marine waters.

For centuries Atlantic salmon has been the most valuable fish of the sea waters surrounding the Kola Peninsula. However, several decades ago there was a dramatic decrease in the fish (stock) population because of overfishing. For this reason, since the 1930s the Fish Ministry of the USSR had been undertaking measures to control salmon climatically, as the most fast-growing and early ripening salmon, from various regions of the Far East to the White Sea basin. Until the early 1980s, these attempts had failed. Only after having introduced pink salmon roe from brood fishes from the Ola River in Magadan Region in 1985, it was possible to succeed in stable runs of the odd-year line of pink salmon. Over ten years it was distributed in all rivers of the White Sea (Alekseev et al., 2019).

In recent years, the number of odd-year lines of pink salmon in the rivers of the Kola Peninsula has increased significantly. In 2001-2017 the average fish capture was 143.8 t. (45.4-296.5 t.). The rate of dispersal expansion of pink salmon has increased. Much of it is migrating not only to the Russian rivers of the Barents Sea basin but also to the rivers of several northern European countries, where it is supposed to be a threat to Atlantic salmon (Nielsen et al., 2020; Pettit, 2018).

Since 2003, the pink salmon population has been reproducing independently on natural spawning grounds, and the species are sure to be acclimated to the new habitat, at least for the odd year-generation.

Following the publications, acclimatized pink salmon have spread to marine and internal freshwaters in several countries of the North Atlantic Basin by now: in Norway, Iceland, Denmark, Ireland, UK, France, and Germany (Paulsen et al., 2021; Sandlund et al., 2019; Whelan, 2017) (Figure 1).

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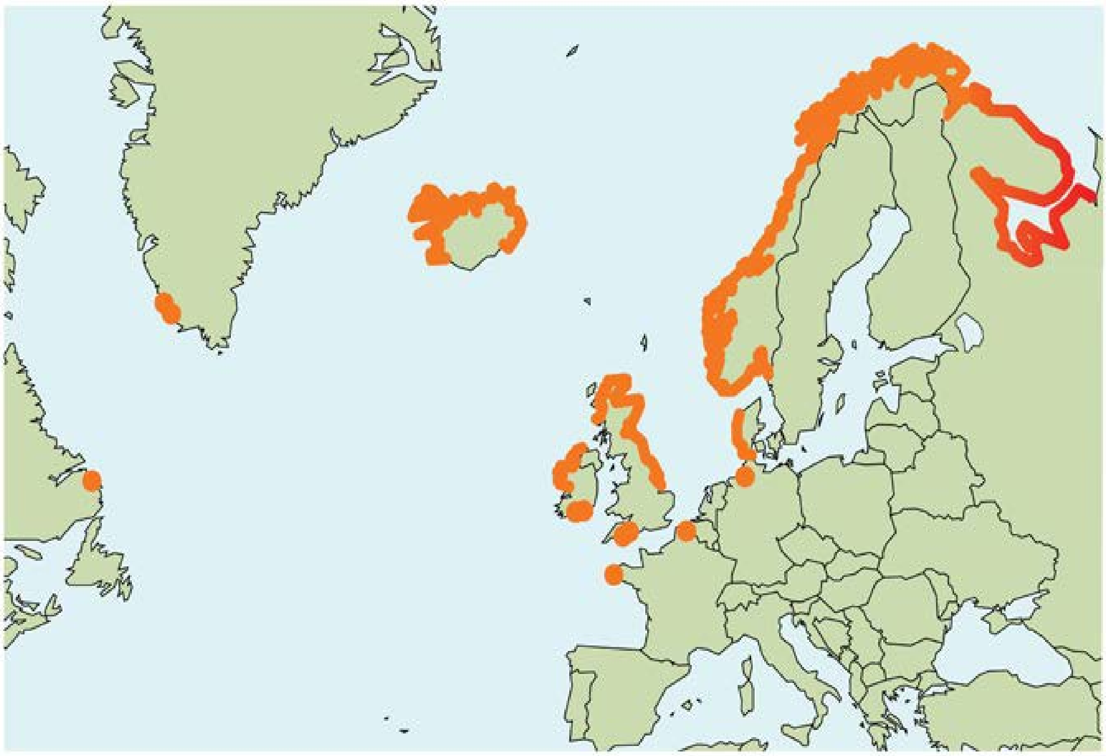

Figure 1. Pink salmon catches in the Atlantic and the Barents Sea basins in 2017. The red-marked areas indicate the main introduction zones in Northwest Russia (Assessment of the risk …, 2020)

Pink salmon are distributed in the same water area as the Atlantic salmon (Salmo salar). Since the first pink salmon fingerling stocking, roe received and brought to the Kola Peninsula, returning spawning rogue fish can be found in the rivers of many countries at once (Alekseev et al., 2019), but the irruption has taken place recently (Sandlund et al., 2019). According to a rather small number of captures (dozens, or hundreds of specimens), it is believed that only a small number of immigrants enter the rivers of the listed states for spawning. The bulk of pink salmon migrates to the rivers of the Kola Peninsula for spawning, where their numbers in odd years are estimated to be the hundreds of thousands (Prusov et al., 2021).

However, the feeding grounds and migration routes of pink salmon introduced into the rivers of the Kola Peninsula have been very poorly studied so far. The feeding grounds and migration routes of Atlantic salmon brood fish and post-smolt (just as pink salmon is thought to be), are mainly from rivers on the Kola Peninsula in the Norwegian Sea. The feeding area is the warm Norway Coastal Current, which is the northern branch of the Gulf Stream.

Within its natural habitat, tiny pink salmon stocking in open waters from different areas in different directions. In September-October young pink salmon of the Sea of Okhotsk move off the coast and begin migrating into the ocean in the Sub-Arctic, or Polar Front, between 40°and 45°N, which is highly productive and a winter pasturable area for Pacific salmon.

In spring, pink salmon move to the feeding area - to the near- Kuril shore Pacific waters - and then, after feeding much, they head for their home waters to spawn. As fattening, wintering, and migrating to spawn, fish may appear repeatedly in the eutrophic Kuril-Kamchatka region. This area has an impact geochemical environment created by underwater and surface volcanism and upwelling, carrying biogenic

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and other elements from the depths of the Kuril-Kamchatka Trench that shape a biogeochemical province in the ocean (Khristoforova et al., 2019a).

Being aware of the migration routes and feeding grounds of pink salmon may one can discover the areas of potential inputs of heavy metals (HM). Hydrologic systems are known to be collectors of all types of pollution, including those caused by man-made activities, both regionally and globally.

Feed ingestion of HM is mainly possible during the marine feeding period, which lasts for about one year. The source of contamination should be sought within marine areas where introduced pink salmon have been recorded for a fact- the Barents, the Norwegian, and the North Seas (Novikov & Draganov, 2018).

Monitoring of the content of toxic elements and compounds in the main commercial aquatic biological resources – Atlantic cod, haddock, flatfish, wolffish, invertebrates, conducted by Polar Branch of the Federal State Budget Scientific Institution "Russian Federal Research Institute of Fisheries and oceanography" (VNIRO), indicates that the amount of hepatic and muscle toxic trace elements of fish is within the acceptable concentration (Gigiyenicheskiye trebovaniya..., 2002), except for total arsenic (Zhilin et al., 2018).

A review of the data shows that zinc and other HM concentrations in flipper-footed' hepar are the highest in the waters near southern Norway, the UK, and the Baltic. The main ways of contamination in the Arctic and subarctic marine ecosystem, however, are atmospheric transfer, ocean currents, and rivers (Savinova et al., 1995).

Change of HM and trace elements content in various marine fish tissues due to anthropogenic impact come against the background of their natural content. HM and trace elements in samples of fish fauna and invertebrates of the Barents Sea are represented by copper, zinc, nickel, chromium, manganese, cobalt, iron, lead, cadmium, arsenic, and mercury (Lapteva & Plotitsyna, 2019). Among the trace elements, iron, zinc, arsenic, and copper dominate in the muscles and hepar of the studied fish. The content of cobalt, cadmium, and mercury was minimal (Zhilin et al., 2018).

The elevated concentration of some HMs (Pb, Cd, As, Zn, Ni, Cr, Cu) is a natural phenomenon, as a consequence of the ore deposits containing these elements on the Kola and Scandinavian Peninsulas. An additional source of input is the emission of HM into the atmosphere by metallurgical enterprises, which makes a much greater difference in shaping the environmental composition of Russia's northern seas than off-flow from inflowing rivers (Vinogradova & Kotova, 2019).

The Sakhalin-Kuril region of the Far East is an optimum zone within the natural habitat of pink salmon regarding total environmental conditions. The lack of sources of industrial pollution and the active dynamics of the northern Pacific provides the high quality of fish products from these waters.

The Pacific Ring of Fire, beginning with volcanoes in Kamchatka and continuing with volcanoes in the Kuril and Japanese islands, as well as the more southern island arcs of the western Pacific, including underwater and surface volcanoes, are powerful sources of geochemical impact on the marine environment. Suppliers of chemical elements to the environment are underwater and surface volcanism (Markhinin, 1985) and the Kuril-Kamchatka Trench, which brings biogenic and other elements to the surface by upwelling, forming impact geochemical zones in the Northwest Pacific.

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2. Problem Statement

We have specified the geochemical conditions of the Sakhalin-Kuril region, which are shaped by volcanism and upwelling and can speak of the reasons influencing the accumulation of trace elements in pink salmon. The first data on the trace element composition of introduced pink salmon in the northwest region of Russia will make it possible to conclude about the places of their basic residence.

3. Research Questions

The main subject of the article is introduced (Euro-Arctic region) and wild (Sakhalin-Kuril region) pink salmon and the reasons determining the trace element composition in their organs and tissues.

4. Purpose of the Study

The purpose of the research is to examine the content of heavy metals in introduced pink salmon to the Euro-Arctic region and compare it with the trace element composition of fish from the Sakhalin-Kuril region.

5. Research Methods

The objects of the study are mature pink salmon adults (O. gorbuscha Walbaum, 1792) that entered the keepnets (stocking ponds) of the Umba Fish Hatchery (Farm) (the Umba River, the Kola Peninsula), 5 km from the mouth and in the Varzuga River (Kolonikha fish inventory fence) (Figure 2), about 10 km from the mouth during anadromous migration in July 2019 (Figure 2).

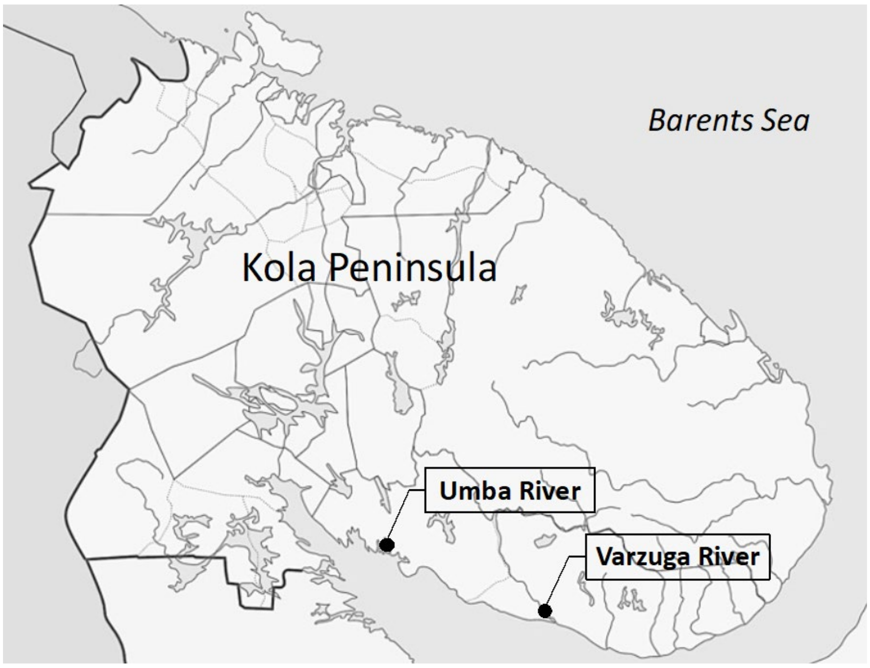

Figure 2. Pink salmon sampling locations in the rivers of the Kola Peninsula

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Ten specimens (five females and five males) were collected from each study area for research. Fish were dissected for organs and tissues in Murmansk. The samples were frozen and transported to Vladivostok for chemical analysis. All elements were determined from acidic minerals according to the Russian National Standard (GOST 26929-94) by an atomic absorption spectrophotometer Shimadzu AA 6800. The accuracy of determination of elements, as well as possible contamination of samples during the analysis, was controlled by comparing with calibrators, including a blank (zero) solution. The accuracy and precision of the method used were confirmed by regular analysis of standard sample SRM-1566a (oyster tissue, National Bureau of Standards, USA). The work was carried out at the "Center for Landscape Diagnostics and GIS Technologies" core facility at the Pacific Geographical Institute FEB RAS.

The results of micronutrient concentrations in organs and tissues of pink salmon are presented in µg/g of wet weight and shown in Table 2. For comparison, these are the data on the content of elements in pink salmon caught in the waters of the Sea of Okhotsk (the Reydovaya River, Iturup Island) in October 2016 and (the Firsovka River, southeast coast of Sakhalin Island) in September 2018 (Khristoforova et al., 2019b) (Fig. 3). The average, standard error, and validity of compared values (using Mann-Whitney U-test) were calculated in SPSS Statistics 21 for Mac OS X. Assessed elements included Zn, Cu, Ni, Cd, and Pb.

Figure 3. Pink salmon sampling locations in the Sakhalin-Kuril region

AC-AD lengths and average body weights of pink salmon from the Euro-Arctic and Far East rivers are shown in Table 1.

Table 1. Morphometric indices of pink salmon brood fishes from the Firsovka, Reydovaya, Umba, and Varzuga rivers

Date of Sample collected	Collection site, sex	Average fish mass, gram (min-max)	Average length AC, cm (min-max)	Average length AD, cm (min-max)
October 2016	Reydovaya River, ♀	1329 (1278–1380)	47,0 (45–49)	43,0 (41–45)
	Reydovaya River, ♂	1912 (1686–2362)	53,0 (56–52)	50,0 (52–48)
September, 2018	Firsovka River, ♀	871 (602–1208)	43,6 (39–48)	40,6 (36–45)
	Firsovka River, ♂	1376 (1024–1732)	51,6 (47–56)	48,0 (43–52)
July 2019	Umba River, ♀	1059 (881–1326)	45,0 (41–49)	42,7 (39–46)
	Umba River, ♂	916 (671–1424)	41,2 (37–49)	39,0 (35–47)
August 2019	Varzuga River, ♀	1204 (886–1421)	45,3 (43–47)	43,0 (40–45)
	Varzuga River, ♂	1188 (1031–1561)	45,0 (43–49)	43,0 (41–47)

As many authors note, pink salmon is characterized by a rather large size even compared to Sakhalin fish. This feature is caused by its allocation to natural territorial complexes with special properties of spawning watercourses (hydrological regime of rivers, quality of spawning grounds), coastal sea areas (feeds provision, thermal regime), and climatic parameters that influence the reproduction level.

Acclimatized pink salmon collected for the research in the rivers of the Kola Peninsula is referred to as the odd-year generation. It is distinguished by high abundance in the previous two decades. Fish in multiple generations tend to be smaller than those in low abundance generations. In addition, pink salmon reproduction in their natural habitat is turned out to be under more comfortable conditions than in their new habitat. This probably explains it is a bit lower in length and weight parameters compared with pink salmon from the southern Kuril Islands.

6. Findings

Among the trace elements found in organs and tissues of Euro-Arctic pink salmon, cadmium was the most minor, its content was thousands of μg/g (0.007 and 0.006 respectively) in muscles and male germ glands (gonads) from Varzuga, while it was 4-10 times higher in fish from Umba. As follows from Table 2, it increased sharply in the fish liver from both rivers of the Kola Peninsula and was as contrasting as in the liver and other organs and tissues of pink salmon from the Sakhalin River Firsovka. On the opposite, neither Cd, Ni, Cu nor Zn gave such sharp rushes of concentrations and were almost evenly distributed between organs and tissues in fish from the Reydovaya River. The reason for this distribution seems to be the spatial proximity of the spawning river to the feeding ground. Having passed the strait between the islands of Urup and Iturup and turning to the southwest, the fish reach the native river in a very short time, without even having time to digest the food eaten. That is what we and other researchers have repeatedly noted during fish dissections.

Undoubtedly, redistribution of such a toxic element as Cd takes time, and fish reaching the spawning grounds have time to do so for a long time of anadromous migration. The nearly uniform distribution of Cd in the organs and tissues of fish from the Reydovaya River has one important negative effect - the close or almost equal to threshold limit value amount of this metal in the milts and caviar of

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fish eaten by humans. The example of Cd and its running into the detoxification organ suggests that 'hurricane' (heavy) concentrations of Zn and especially Cu in the liver of Kola Peninsula fish are caused not only by high rates of these metals in the environment and feed in the feeding areas (as measured in their muscles and gonads) but also by long-distance travel to the spawning areas.

Table 2. Comparison of trace element content in organs and tissues of pink salmon from the Sakhalin-Kuril and Euro-Arctic regions, µg/g wet weight

Organs and tissues	Zn	Cu	Ni	Cd	Pb
Reydovaya River (Iturup Island), fish weight range 1278-2362 g.					
Muscles	1,96±0,08	0,24±0,08	0,12±0,01	0,14±0,012	0,67±0,05
Liver	3,14±0,07	0,32±0,03	0,18±0,01	0,21±0,018	*0,96±0,04*
Male gonads	3,09±0,05	0,33±0,07	0,18±0,01	0,19±0,034	0,89±0,01
Roe	3,01±0,08	0,29±0,04	0,15±0,04	0,18±0,035	0,84±0,05
Firsovka River (Sakhalin Island, Gulf of Patience) (2018), fish weight range 602-1732 g.					
Muscles	1,93±0,28	0,58±0,20	0,37±0,11	0,06±0,014	0,75±0,26
Liver	3,28±0,85	0,59±0,14	0,34±0,09	0,69±0,13	*0,96±0,19*
Male gonads	1,87±0,33	0,40±0,13	0,29±0,15	0,05±0,05	0,64±0,14
Roe	2,13±0,31	0,48±0,18	0,21±0,06	0,04±0,01	0,51±0,13
Umba River (Kola Peninsula), fish weight range 671-1424 g.					
Muscles	5,03±0,71	0,76±0,111	0,96±0,40	0,03±0,04	0,27±0,12
Liver	*33,76±5,03*	*55,57±23,62*	1,01±0,37	0,82±0,53	0,31±0,09
Male gonads	13,51±1,29	0,88±0,18	0,99±0,23	0,06±0,06	0,46±0,13
Roe	23,06±7,14	5,34±1,25	1,14±0,35	0,02±0,03	0,29±0,06
Varzuga River (Kola Peninsula), fish weight range 886-1561 g.					
Muscles	6,38±1,22	0,98±0,43	0,81±0,26	0,007±0,002	0,16±0,05
Liver	*57,18±23,98*	*41,60±18,63*	0,92±0,26	0,23±0,103	0,19±0,04
Male gonads	18,09±6,23	3,84±1,23	0,82±0,23	0,006±0,001	0,15±0,12
Roe	13,29±3,94	0,75±0,30	1,08±0,22	0,03±0,009	0,41±0,12

Note: The Threshold Limit Value of Pb in fish and seafood is 1.0 µg/g wet weight, Cd - 0.2 µg/g wet weight. The highest concentrations of trace elements are shown in bold italics.

The second toxic element that requires obligatory sanitary control is Pb. It can be seen to be much prevalent in pink salmon from the Sakhalin-Kuril region, which is dependent both on the fish entering the ocean for wintering via the Kuril Ridge and the Kuril-Kamchatka Trench, both a natural geochemically impacted and eutrophic area, and on their return to spawn during their anadromous migration (Khristoforova et al., 2019a). Concentrations of Pb in pink salmon from Island Rivers, being high, do not attain the Threshold Limit Value in muscles either, gonads or roe, only the content of this element is very close to the permissible value in fish liver. The concentrations in organs and tissues of pink salmon from the Kola Peninsula are much lower; they are especially low in salmon from the Varzuga River. Its concentration is 4-6 times less than in muscles and gonads of Sakhalin and Iturup fish.

A very indicative element for fish of the Kola Peninsula is Ni. As we noted above, it, as well as Cu, marks the industrial image of the region. However, none of the analyzed samples attracts attention by its strangeness or unexpectedness: distribution is almost even and almost equal for fish from both rivers of Murmansk Region. Nickel distribution in the organs and tissues of the island fish of Sakhalin Oblast is also quite even. However, there is a significant difference between the spawning rivers of the Sakhalin-

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Kuril area: in pink salmon from the Firsovka River the Ni concentration is three times more in muscles; it is two times more in the liver and 1.5 times more in male and female gonads. The Firsovka River is situated in the southeast of Sakhalin and flows into the vast Gulf of Patience. This bay, like the Aniva Bay in the south of the Island, is heavily used by fishing vessels of all ranks and sizes, passenger vessels, oil tankers, liquefied natural gas carriers, coal carriers, and others. It is this traffic that causes nickel pollution. As far as nickel is included in all oil products, its content in the environment will depend on inputs from vessels using marine diesel, as well as on fluid combustion in shore-based thermal power plants and boiler houses. There are many heavy metals in the oil, but elements such as V, Ni, etc., which entered the oil from living organisms in the distant geological past, stand out among them (Bashkin et al., 2013).

The concentrations of copper and zinc in Euro-Arctic pink salmon are the highest, with the highest values of both elements in the liver. However, while zinc is several times higher in the liver than in other organs, copper is tens of times higher, i.e., copper is more contrastingly distributed in fish organisms and especially prevails in the liver. The maximum concentration of copper is 55,57±23,62 μg/g. It was found in the liver of pink salmon from the Umba River. The liver of pink salmon from the Varzuga River is also much enriched with these concentrations. Varzuga River is also highly enriched with this element - 41.60±18.63 μg/g. The distribution of Cu in organs and tissues of pink salmon from the Sakhalin-Kurils region is fairly even, although, as in the case with Ni, its concentrations were 1.5-2 times more in fish from the Firsovka River than in those from the Reydovaya River, which is also obviously influenced by the marine heavy traffic in the Gulf of Patience and its entry into the bay along with bilge water.

Thus, pink salmon from the Sakhalin-Kuril region spawning in the rivers Firsovka and Reydovaya have increased Pb concentrations, but do not exceed sanitary norms. In contrast, fish from the rivers of the Kola Peninsula - Umba and Varzuga – are affected by geological past and mining present of Murmansk region and are characterized by 2-4 times more nickel content (in all organs and tissues), 2.5-3 times more zinc concentration (in muscles), 2-3 times more copper concentration (in muscles). However, the liver of salmon in the Euro-Arctic region is a real depot of zinc and especially copper, indicating an excessive quantity of these metals in the fish body.

There are two reasons for the heavy metal pollution in the Euro-Arctic region. The first is the Gulf Stream, which crosses the Atlantic Ocean and receives pollutants from the USA and northern European countries, passing into the North Atlantic Current and moving it to the Barents Sea. The main reason for the North Atlantic Current in transporting pollutants from Western Europe to the Barents Sea was confirmed in the scientific publications some decades ago. In addition, there is relatively recent brilliant evidence of this view. In 2010, a group of authors revealed a significant anthropogenic impact on its composition while studying the surficial suspended solid material in the eastern North Atlantic.

The largest concentrations of metals in suspension (Cu, Zn, Cr, Ni, Pb) found between 45o and 60o N proved industrial emissions from aerosol sources in North America and Europe (Buck et al., 2010). Norway with its vast western coastline facing the Norwegian Sea was and is a direct emitter of heavy metal pollution to North Atlantic waters. Today's Norway has significant reserves of iron, titanium, vanadium, zinc, and copper.

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In the first half of the 1970s, it emerged as a major component of important strategic materials: aluminium (thanks to extremely cheap hydroelectric power), ferroalloys (used in electrometallurgy, also thanks to cheap energy), nickel, zinc, and titanium. With the beginning of the North Sea offshore oil production in 1970 and gas in 1971, the Norwegian economy has restructured significantly, but the government has retained the traditional mining industry.

The development of iron ore deposits (in open cast mines) continues. Norway exports half of its iron-ore concentrate that is rich in iron. The country has 10 major copper-zinc ore mines, copper and nickel are smelted, zinc metal and accompanying cadmium are produced, and lead (with silver admixture) ore is mined (Gornaya entsiklopediya, 1987). The information about pollution of the fjord waters and the biota that inhabit them has been known since the 1970s.

For example, Melhuus et al. (1978) reported metal contamination of fucoid algae in Serfjord on the west coast of Norway, where the dominant pollutant was zinc from a smelting plant. High concentrations of heavy metals have also been reported in fucoid algae from Trondheim-fjord near Ilsvik, where the source of copper and zinc pollution was located (Lande, 1977).

Atlantic waters, coming in as a strong stream from the west, have the greatest influence on the hydrodynamic regime of the Barents Sea. It is the resultant shift, permanently directed from the Norwegian Sea that brings in large amounts of Atlantic water. The arrival of warmer, more saline, mineral-enriched Atlantic waters in the southwestern part of the Barents Sea is accompanied by snowballing of plankton.

According to the bulletin of Zenkevich (1963), Biology of the USSR Seas, where observations of hydrobiologists, made in 1930-1950, were reviewed, on abundant Calanus pastures (finmarchicus) in the south-western part of the sea in the upper layers (0-25 m), huge masses of herring, capelin, and other tiny fishes were fattening. Gradually, with the summer coming, from April to August, the wave of red Calanus (due to the colouring of lipid droplets), the most valuable feed, shifts from the west to the east and north of the sea.

Obviously, in the warm Norwegian Sea, copepods, which are one of the pelagic main food links, are even more abundant and have several generations. Just as the amount of heat brought in by the Atlantic waters is decreasing, the number of pollutants brought in is also decreasing. At least, there is a firmly established tendency for their concentrations to decrease from the west to the east, where they generally no more than background levels (Matishov & Golubeva, 1998).

The second reason for heavy metal pollution in the Euro-Arctic region is related to the geology, mineralogy, and mining productions of the Kola Peninsula. The largest apatite-nepheline ore mining and a processing plant Apatit, copper-nickel smelting Severonickel and iron ore production Olkon are located and manufacture products on the Kola Peninsula in Murmansk region.

Pollution from industrial plants processing ore spreads not only by water but also by air (Nickel, Zapolyarny, Pechenganickel are in the extreme north-west of the region in the area bordering Norway). The fourth most populated city in Murmansk Region, Monchegorsk, has a powerful production site of the Kola MMC (Mining and Metallurgical Company), which processes copper-nickel converter matte from Nickel and Zapolyarny, as well as imported converter matte from the Polar Division of MMC Norilsk Nickel.

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On the Kola Peninsula, native zinc is also found, often impregnated with copper (up to 2% by weight) (Obshchaya informatsiya..., 2021). All industrial enterprises discharge effluents into water systems. The watershed, located in the central part of Murmansk Region, divides the flows of pollutants into two parts flowing into the Barents Sea and the White Sea. The Barents Sea receives effluents from the Kola and Tuloma rivers, the Kola Bay and Motovsky Gulf while the White Sea receives effluents from Lake Imandra and the Niva River. In addition, the Kola Bay is home to Murmansk, a major commercial port, and Severomorsk, the main administrative base of the Russian Northern Fleet.

7. Conclusion

The body and environment are interconnected, and the environment on the trace element composition of its inhabitants' organs and tissues is primarily affected through the food. Pink salmon is an active swimmer and a typical anadromous fish capable of traveling great distances in search of food. Researchers of Far Eastern salmon are well aware of how freely the feeding areas of Asian and American pink salmon overlap in the Pacific Ocean. The fish move after plankton and fatten in highly-fed areas. The Kuril waters are classified as food-rich waters. These waters are located in the zone of a specific biogeochemical province. They come second only to the main fishing area of the Far Eastern seas - the Sea of Okhotsk. Their productiveness of them has been kept traditionally high for many years (Shuntov & Temnykh, 2011).

When megaplankton is abundant, the number of small and fine particles capable of sorbing lead rising from the Kuril-Kamchatka Trench will be even more abundant. Therefore, lead adsorbed on biogenic suspension is more easily fixed by organisms of higher trophic level - first by zooplankton and then by its transformer nekton, including schooling fish of upper pelagial level including pink salmon. The specific geochemical conditions during the fish feeding period in the highly-fed Kuril-Kamchatka region, which is rich in biogenic suspended material having high Pbsusp content, influences the mineral composition of salmon.

The main marine feeding area for introduced pink salmon is located southwest of the Barents Sea, in the Norwegian Sea and the North Sea. The increased concentration of HM in the marine environment and organisms of the Euro-Arctic region is probably caused by several reasons: the more polluted waters of the Atlantic, especially the shallow water areas of the North Sea and the Norwegian Sea influenced by the Gulf Stream, compared to the waters of the northwest Pacific; the natural geochemical background formed in the area of the Scandinavian Peninsula and the Kola Peninsula due to natural ore-bearing; technogenic contribution, to a large extent aero-technogenic, from ore mining and processing, through the introduction of pollutants in dissolved and suspended state into the feeding area, and their accumulation in all links of the food chain.

The analysis has shown that pink salmon caught in both the Sakhalin-Kuril and Euro-Arctic waters meet the requirements for the content of the rated toxic elements Cd, Pb for seafood. The content of each of the elements is within the permissible concentrations approved by the Russian standard.

Higher concentrations of Zn, Cu, and Ni in introduced salmon and Pb in pink salmon from the Kuril waters are of the same reason, i.e., geochemical environmental conditions. But the impact situation in the Atlantic coastal waters, fixed by such tracers as zinc, copper, and nickel, is caused by anthropogenic and technogenic activity, while the impact zones in the Western Pacific waters are formed affected by natural factors - modern volcanism and upwelling.

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