Achievements in the Life Sciences 8 (2014) 55–60

FEFU FAR EASTERN FEDERAL UNIVERSITY

Contents lists available at ScienceDirect

Achievements in the Life Sciences

journal homepage: www.elsevier.com/locate/als

The Role of the Biogeochemical Conditions of the Marine Environment on the Trace Element Content in Pacific Salmon

Nadezhda K. Khristoforova [a,b], Vasiliy Yu. Tsygankov [a,*], Margarita D. Boyarova [a], Olga N. Lukyanova [a,c]

[a] *Far Eastern Federal University, 8 Sukhanova Street, Vladivostok 690990, Russian Federation*
[b] *Pacific Geographical Institute FEB RAS, 7 Radio Street, Vladivostok 690041, Russian Federation*
[c] *Pacific Research Fisheries Centre (TINRO-Centre), 4 Shevchenko Lane, Vladivostok 690950, Russian Federation*

ARTICLE INFO

Available online 7 August 2014

Keywords:
Mercury
Arsenic
Lead
Cadmium
Zinc
Copper
Pink salmon
Chum salmon
Kuril waters

ABSTRACT

The levels of six chemical elements (mercury, arsenic, lead, cadmium, zinc and copper) were examined in two species of Pacific salmon, genus *Oncorhynchus*, pink salmon (*O. gorbuscha*), and chum salmon (*O. keta*) that were caught in the Kuril waters in July 2013. Concentrations of toxic elements (Hg, As, Pb, Cd) in both species were shown to be below the maximum concentration limits of these trace elements for seafood. The concentrations of these elements were compared between wild salmon and hatchery salmon of the Pacific and Atlantic oceans.

Introduction

Despite the apparent uniformity and homogeneity of the water masses in the sea, there are areas similar to terrestrial biogeochemical provinces. Abnormalities or deviations from the background in the environment and biota stipulated by the geochemical features of these zones are not as pronounced as in the sea. They appear not only in the existence of endemic diseases caused by changes in the mineral metabolism of terrestrial organisms but also in distinctive biocenoses and mineral compositions of organisms. In the sea, the difference between the concentrations of elements in a biogeochemical province and beyond it may not be as sharp as on land because of the nature of the environment.

The impact zones of anthropogenic origin, established in coastal areas, are well known. They are caused by technogenic pollution, which creates an abnormal concentration of a number of elements and compounds.

The impact zones of natural-anthropogenic origin are estuarine river zones, which reflect the nature of the drained soils and the character of polluted wastewater in the solid and liquid effluent to the sea.

* Corresponding author.
E-mail address: tsig_90@mail.ru (V. Yu Tsygankov).
Peer review under responsibility of Far Eastern Federal University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.als.2014.06.009

Natural impact zones of the seas, which have peculiar biogeochemical provinces stipulated by the seepage of highly mineralized undersea brines and are influenced by deep and shallow streams of volcanic products, are understudied. Only upwellings, as highly productive areas of the ocean, have long attracted scientific study. The remaining zones with peculiar biocenoses have been studied for three or four decades. However, although the study and selection of biogeochemical provinces on land has a longer history, it began relatively recently, in the 1930s, by V.I. Vernadsky and A.P. Vinogradov.

The waters of the Kuril Islands and the Kamchatka coastal waters are areas where the effect of upwelling and volcanism is clearly manifested. However, although the high productivity of the Sea of Okhotsk and the Kuril–Kamchatka region and its causes are the subject of the detailed scrutiny of hydrobiologists, hydrochemists, and fishery science, the chemical composition of organisms and the factors that determine the content of micro-elements in organisms are much less studied. During the 1980–1990s, inhabitants of the intertidal and subtidal zones of Kamchatka and Kuril Islands, primarily indicator organisms, such as clams and brown mytilids fucus algae, interestingly showed enrichment by heavy metals — cadmium, zinc, nickel and other elements. Though these benthic organisms characterized the chemical and environmental conditions of their habitat, they did not give an idea of the more open waters of the region inhabited by nekton organisms. The most representative organisms are pelagic fish, and among them, the most important species from an economic point of view are the salmons.

Salmon are large pelagic fish that live primarily in the northern parts of the Pacific and Atlantic oceans, the Arctic Ocean and in the basins of rivers. The two most representative and abundant groups can be distinguished among the fish of the salmon family (*Salmonidae*): Atlantic salmon and Pacific salmon. The most distributed representative of Atlantic salmon is *Salmo salar*. The leading genus of Pacific salmon is *Oncorhynchus*, which includes pink salmon *O. gorbuscha*, chum salmon *O. keta*, sockeye *O. nerka*, coho *O. kisutch*, Chinook salmon *O. tshawytscha* (king salmon), and Sim *O. masou*. There are several species of the genus *Salmo* in the Pacific, but they are fewer in number compared with the Pacific salmon genus *Oncorhynchus*.

Atlantic salmon can be found on both sides of the Atlantic ocean, but its numbers have dropped drastically. By the end of the twentieth and beginning of the twenty-first centuries, wild Atlantic salmon became the object of scientific research and sport fishing. Currently, more than 99% of Atlantic salmon live in fish ponds. Leaders in the production of hatchery salmon are Norway (520–550 thousand tonnes of Atlantic salmon and trout) and Chile (approximately 450 thousand tonnes of Atlantic salmon and trout) (World review…, 2012). At the same time, 50% of Pacific salmon reproduce on natural spawning grounds, while a quarter of the livestock population spawns in Kamchatka. However, even if Pacific salmon are reproduced in fish ponds, after their release, they feed in the open sea and ocean waters — in other words, they lead a pascual lifestyle.

As inhabitants of the epipelagic zone (0–200 m), salmon dwell mainly in the upper layer (0–50 m). The pascual area of Pacific salmon in wintertime is located between 40 and 45° N in the Subarctic or Arctic front, marked by high biological and fishery productivity. With the coming of spring, the warming of the upper layers of water and abundant plankton development the zone of active life shifts towards the North and Northeast. Salmon follow it without leaving the eutrophic area, which is the reason for their rapid growth. Masu salmon is the only type of Pacific salmon found only on the Asian shore, mainly in the Sea of Japan. Chum and pink salmon prevail on both sides of the Pacific — from the Peter the Great Bay and San Francisco to the Bering Strait.

Sockeye and Chinook are quite cold-water species, widely prevailing along the American coast. Chinook is the largest species of Pacific salmon, referred to by Americans as King salmon. All Pacific salmon spawn only once during their lifetime, perishing after spawning. This feature is distinctive from the Atlantic salmon, which spawn up to four times (Rukhlov, 1982; Shuntov and Temnykh, 2005). Different salmon species spawn at different ages: chum enters the river on the third to fifth years of life; pink salmon, growing and developing faster than chum, returns 18 months after migration into the sea; Sockeye salmon spend from 1 to 5 years (average 2–3 years) in the sea; and Chinook salmon live from 1 to 6 years (average 3–4 years).

All Pacific salmon embed their hard roe in the ground (in a dug hole); therefore, they choose gravel and pebble, without a muck-bottom. After the fertilization of hard roe, the female fills in the hollow with pebbles. The roe develops under the hill, while

Table 1
Inshore catching of Pacific salmon in the main fishery areas of the Far East in 2011, th. tonnes (Shuntov and Temnykh, 2011).

Area	All species	Pink salmon	Chum	Sockeye
Anadyr	2.1	0.4	1.4	0.3
Karaginsky	**186.3**	**177.7**	6.4	2.0
Petropavlovsk-Commander	18.1	4.7	2.3	**9.3**
West Kamchatka	44.7	6.0	**14.9**	**21.0**
Magadan region	11.6	9.4	2.1	–
Northern coast of Sea of Okhotsk (Khabarovsky region)	14.5	4.7	9.4	0.1
Amur basin	19.0	4.4	**15.6**	–
Sakhalin Island (Sea of Okhotsk)	**192.3**	**176.7**	**15.5**	–
South Kuril Islands	11.5	6.2	5.3	–
Northern Kuril Islands	3.0	0.3	1.2	0.9
Tatar Strait (Khabarovsky region)	0.2	0.1	0.1	–
Primorye	0.1	0.01	0.1	–
Southwest Sakhalin	1.2	0.05	1.2	–
All 6 species of the Far Eastern basin	**504.6**	**389.7**	**75.6**	**33.6**