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River hydrography of the west coastland of the White Sea

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River hydrography of the west coastland

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Information seulement

The participation of the Karelian Branch of Hydrology and Water /10\* Management in acclimatizing Pacific salmon to northern seas made it possible to obtain new, and systematize existing, data on the hydrology and hydrography of the White Sea rivers. The study utilized the long-term data of the Petrozavodsk Hydrometeorological Observatory on the regimes of these rivers.

The task entailed the collection and analysis of hydrographic data from 27 rivers, a study of the regime of 12 rivers and fieldwork pertaining to 9 typical rivers.

The west coastland of the White Sea contains all types of rivers characteristic of the Karelian region. The length of these rivers ranges from 20 to 400 km, and their drainage areas from 100 to 28,000 km<sup>2</sup>. The project involved a study of medium and small rivers; the field work on the Keret', Gridina, Kalga and Pon'goma rivers was

\*Figures in the right-hand margin indicate page numbers in the original (Tr.).

carried out in 1962, and on the Shuya, Myagreka, Suma, Kolezhma and Nyukhcha rivers in 1964.

The river discharge is a complex process in which the climate plays the determining role.

Such physical and geographic factors as relief, lakes, marshes, the geological structure of the drainage basin and afforestation are of lesser significance, but their effect can be substantial as the size of the drainage basin decreases (Davydov, 1953). Knowledge of the hydrography of this area and identification of the main geographic factors will help in understanding the formation of the surface run-off.

The term surface run-off includes fluid, thermal, ionic and discharge of organic substances. The role freshwater run-off plays in the regime of the White Sea is well known. Hence, not knowing the regime of the entire complex of surface run-off makes it difficult to understand the biological processes which develop in the coastal zone--an area which may contain the key to an understanding of the formation of the fauna and flora patterns of the White Sea.

The characteristics of the hydrographic development, which were determined by the geologic history of the region, predetermined, on the whole, the formation of small rivers which form a system of lakes and short rivers, with little resemblance to the rivers of the plains.

The large rivers of the area in question are the Kem', Vyg and Kovda. They are fairly evenly distributed and their drainage areas are almost of the same size, being 27,000, 28,000 and 22,000 km<sup>2</sup> respectively.

We investigated the medium and small rivers not only in connection with our stated goal but also because their drainage areas contain the clearest outlines of all the geographic features of the area under study.

The west coastland is subdivided into two geographic areas: the Karelian coastland--from the Kovda to the Kem' river(inclusive), and the Pomorsk coastal area--from the Kem' to the Onega river. An analysis of the geographic characteristics indicated that this division has a basis in fact, namely, the rivers of these coastlands are not of the same type. The rivers of the first subarea most clearly reveal the typical features of Karelian rivers: a longitudinal fault-like profile, a high intermediate and linear lake factor and a riverbed with numerous rapids. The rivers of the Pomorsk coastal area have characteristics that are intermediate between Karelian-type rivers and plains rivers of the south and east coastland of the White Sea.

A comparison of the morphological indicators (length of river, size of drainage area, width and length of basin) indicated that all of these values are greater for the Pomorsk area rivers, which suggests that the formation of the river network in this area occurs at a faster pace than in the northern area.

An especially large difference is noticeable in the structure of the lake-river systems and in the structure of the river beds. The sharp outlines of the longitudinal and transverse profiles, the prevalence of rapids in the mouth area (30% in the Keret' river, 50% in the Gridina river), an absence of flood plains and a weak development of riverbed processes--all these attributes characterize the rivers of the Karelian shore.

The Pomorsk area rivers make a different impression. The riverbeds have relatively soft outlines, rocky shores are rare. In the majority of cases the riverbanks consist of sand and clay deposits. The prevalence of rapids in the mouth of the rivers is quite low (3--10%), the Suma river being an exception. Some rivers, such as the Myagreka and the Kolezhma,

have no rapids, only karezhki\* which resemble shallows in the plains rivers. The presence in the riverbed of shoals, capes and islands composed of sands and loam mixed with pebbles convincingly points to the intense processes taking place in the riverbeds in this area. The appropriate conditions for such processes are the porous sediments that make up the catchment basins of the Pomorsk rivers, their gently sloping longitudinal profile and, finally, the fact that these rivers contain few lakes that function as sedimentation basins.

For example, the Kolezhma river has 6 islands over a distance of 6 km; the Nyukhcha river has 15. The islands in the Nyukhcha, Myagreka, Kolezhma and Shuya are quite long--from 400 to 800 m, as a result of which branches begin to form in the lower reaches of the river. It should be emphasized that the smaller the number of lakes in the catchment basin, the more intensive are the riverbed processes.

The most striking evidence of erosional and accumulative processes is revealed by the Myagreka river, which has no lakes. It is well known that the Karelian rivers are not very winding, with a winding factor rarely exceeding 1.1--1.2; their beds, because of slow bank erosion, are very resistant to deformation. The midstream portion of the Myagreka river contains prominent meanders, and here the winding factor can be as high as 1.8.

In the area of the meanders the river has sandy banks, its water is very turbid with a large amount of suspended matter. Sediments are transported by the current to the lower reaches of the river, where they are deposited. These sediments cause marked changes in the outlines of the riverbed. In areas where the erosional products accumulate, capes and shoals are formed, the river narrows to 1--3 m, with stretches of an average

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\*Revisor's note: No standard English equivalent is available for this term, which is at any rate adequately explained in the remainder of the sentence.

width of 35-40 m.

It is not improbable that the old riverbed (in the lower reaches) will divide into a number of small basins in proportion to the accumulation of sedimentation--basins which at present constitute the open sections --and the Myagreka river will lay a new bed for itself. 12

This process of the changing structure of the Myagreka riverbed, resulting from the accumulation of erosional products, suggests a basis for assuming that a number of small lamba\* lakes in Karelia were formed in the same way.

It should be remembered that the accumulation of sediments in the beds of the Pomorsk coastal rivers is also furthered by the ongoing tectonic process of raising the land in the area of Onega Bay of the White Sea--a process that has continued for the past 300 years. It is well known that about 250 years ago large transport vessels which belonged to Peter the Great's fleet entered the Nyukhcha and Suma rivers. At present it is difficult to paddle even small boats in the lower reaches of these rivers.

All this points not only to the different types of rivers of the west coastland but also underlines the ongoing changes in the regime of these rivers, which undoubtedly affects the ecology of the coastal zone of the White Sea.

An examination of the hydrography of the area should pay special attention to the prevalence of lakes and bogs in the river drainage basins. These two geographic factors are interrelated and determine a number of characteristics, such as the degree of the development of the river network, the run-off regime and water humification. The prevalence of lakes and bogs varies widely--of lakes, from 0 to 20%, of bogs, from 10 to 90%.

\*Revisor's note. No suitable English equivalent is available for this term, which is felt to be a local modifier applied to Karelian lakes.

Editors note: These are lakes with no surface inflow or outflow.

An average lake factor is one of the common characteristics of the catchment basins and, judging by a series of existing relationships, it reflects sufficiently accurately the specificity of a number of characteristics of lake rivers. For example, there is an inverse link between the prevalence of lakes and the density of the network of rivers, which confirms the conclusions reached by B.P. Panov (1954). An inverse relationship exists between an average lake and bog factor in the catchment basins, which was established earlier for the Suna and Shuya rivers (Gritsevskaya, 1964). The very boggy rivers are those that have links with few lakes, whose lake factor ( $K_{oz}$ ) amounts to less than 5%. Such rivers are the Letnyaya, Myagreka, Kuzreka and Khlebnaya, whose catchment basins are over 50% boggy. Hence the conclusion that the most humified water is found in rivers that are only slightly regulated.

The river water regime, and especially the fluctuation of the water level, is very important for diadromous and semidiadromous fish.

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An analysis of the data indicated that the character of the water level fluctuation is closely related to the quantity of the average lake factor.

Figures 1 and 2 contain graphs of water level fluctuations of two rivers during typical years: the Suma river, with numerous lakes, and the Myagreka with no lakes. These figures clearly reveal the contrast in the water regime of these rivers.

Equally interesting is the correlation of the maximal rise in the water levels at high water for rivers with a varying lake factor. Table 1 contains data for years with varying water content. These data indicate the prominent inverse relationship between the maximal rise in the water level and the degree to which the river is regulated. The run-off fluctuations of the White Sea rivers are characterized by the same patterns.

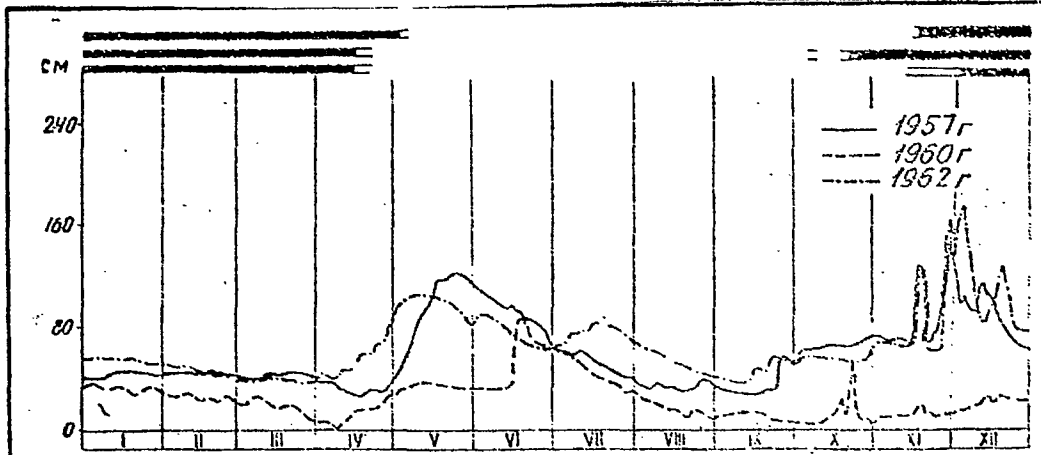
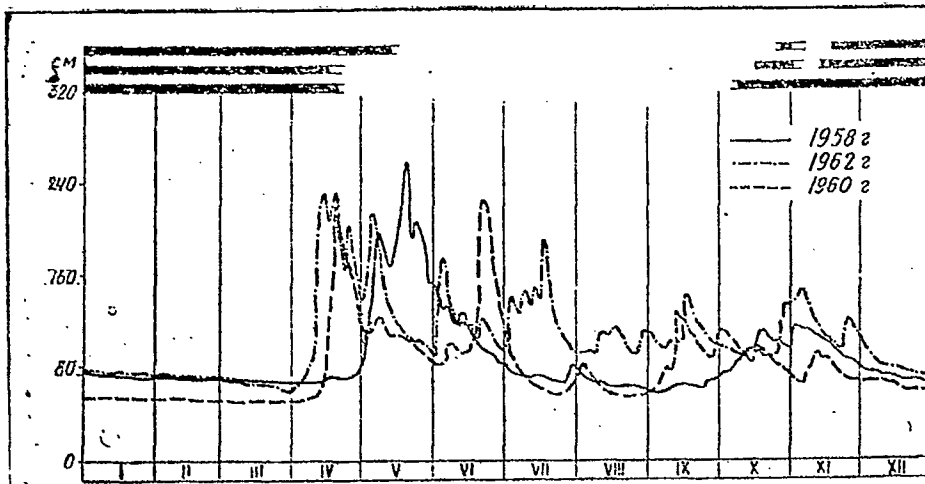


Рис. 1. График колебаний уровней воды в р. Суме. ( $K_{Oz}=13\%$ ) у с. Сумпосад, за годы различной водности  
**Fig.1. Graph showing fluctuations in the water level of the Suma river ( $K_{Oz} 13\%$ ) at the village of Sumposad, during years with varying water content.**



**Fig.2.** Graph showing fluctuations in the water level of the Myagreka river ( $K_{Oz} 0$ ), during years with varying water content.

Рис. 2. График колебания уровней воды в р. Мягреке ( $K_{Oz}=0$ ) за годы различной водности

Река <b>river</b>		К <sub>03</sub> %	1960 г.	1961 г.	1962 г.
<b>Karelian coast</b> Карельский берег					
Кереть <b>Keret'</b> . . . . .	17,5	47	154	98	
Гридина <b>Gridina</b> . . . . .	14,2	29	106	80	
Кузема <b>Kuzema</b> . . . . .	9,7	73	143	104	
Летняя <b>Letnyaya</b> . . . . .	1,6	125	177	161	
<b>Pomorsk coast</b> Поморский берег					
Сума <b>Suma</b> (Сумпосад) <b>(Sumposad)</b> . . . . .	13,0	34	98	69	
Шуя <b>Shuya</b> (Беломорск) <b>(Belomorsk)</b> . . . . .	7,0	90	134	113	
Нюхча <b>Nyukhcha</b> . . . . .	2,5	103	194	137	
Мягрека <b>Myagreka</b> . . . . .	0	164	235	167	

ских рек **Maximal rise of water level  
at high water (cm).**

Максимальная величина подъема уровня в половодье, см

Таблица 1  
Table 1

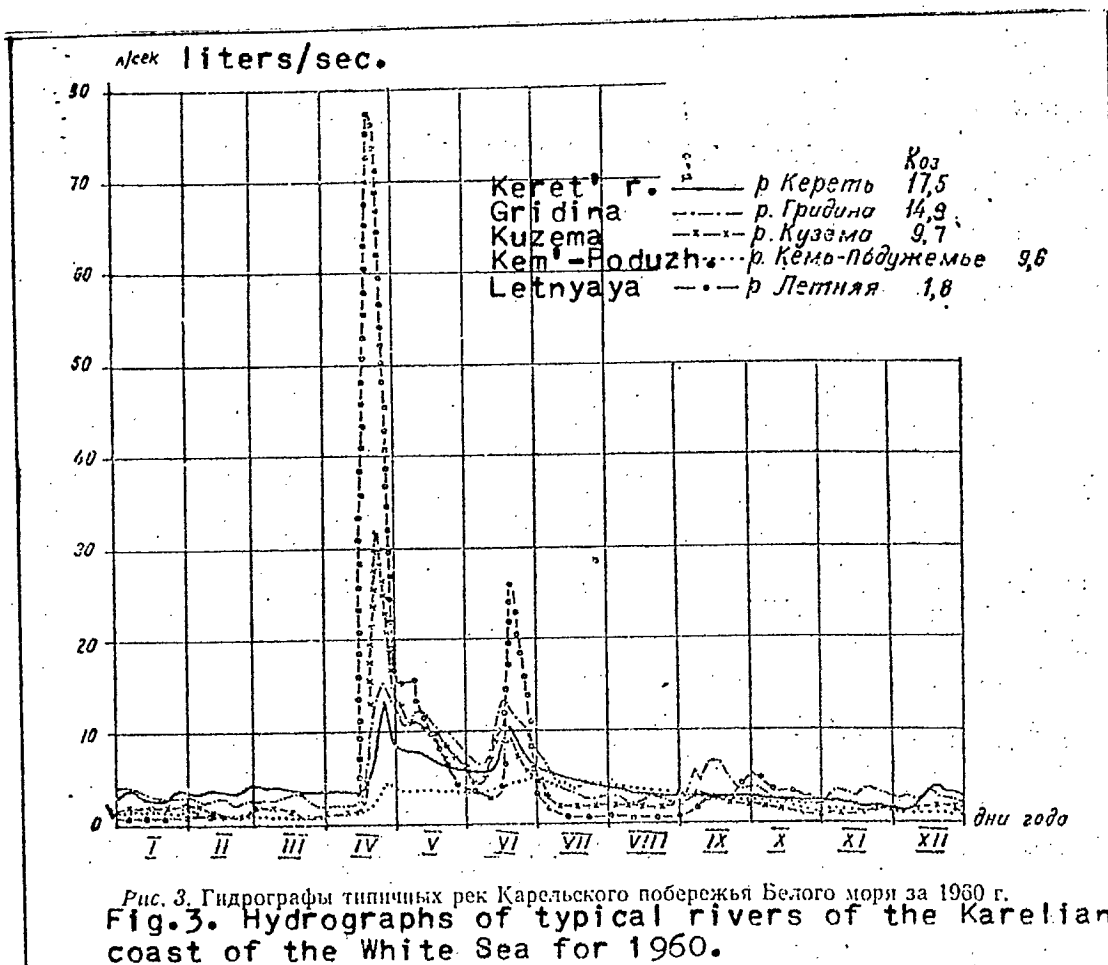
Figures 3 and 4 show run-off hydrographs for rivers of the Karelian and Pomorsk coastal areas for 1960, when the water content was low. Table 2 shows correlations of amounts of run-off for two months: during the winter low-water period and high water of 1958, when the water content was high, and of 1959, when the water content was low. The effect of the average lake factor on the run-off is most prominent in the year with the high water content.

The characterization of the rivers would be incomplete without some data on the chemical hydrology. This information was compiled on the basis of data of the Petrozavodsk Hydrometeorological Observatory from 1955-1964 for the Kem', Keret', Gridina, Segezha, Pon'goma, Suma, Nyukhcha and Chirka-Kem' rivers. The total watershed area of these rivers amounts to 80% of the overall area of the west coastland of the White Sea.

The mineralization of the river waters is low, varying slightly in the coastal area from 11 to 25 mg/liter at high water and from 15 to 50 mg/liter at low water. The content of organic matter fluctuates the most, which is due to the large variations in the boggy conditions of the river watersheds. Thus permanganate oxidizability in the White Sea rivers varies on the average from 10 to 30 mgO/liter, and the color of the water varies from 30 to 130<sup>o</sup> on the pt-Co scale.

A fairly clear correlation can be noted between the content of organic matter and the value of the lake and bog factors.

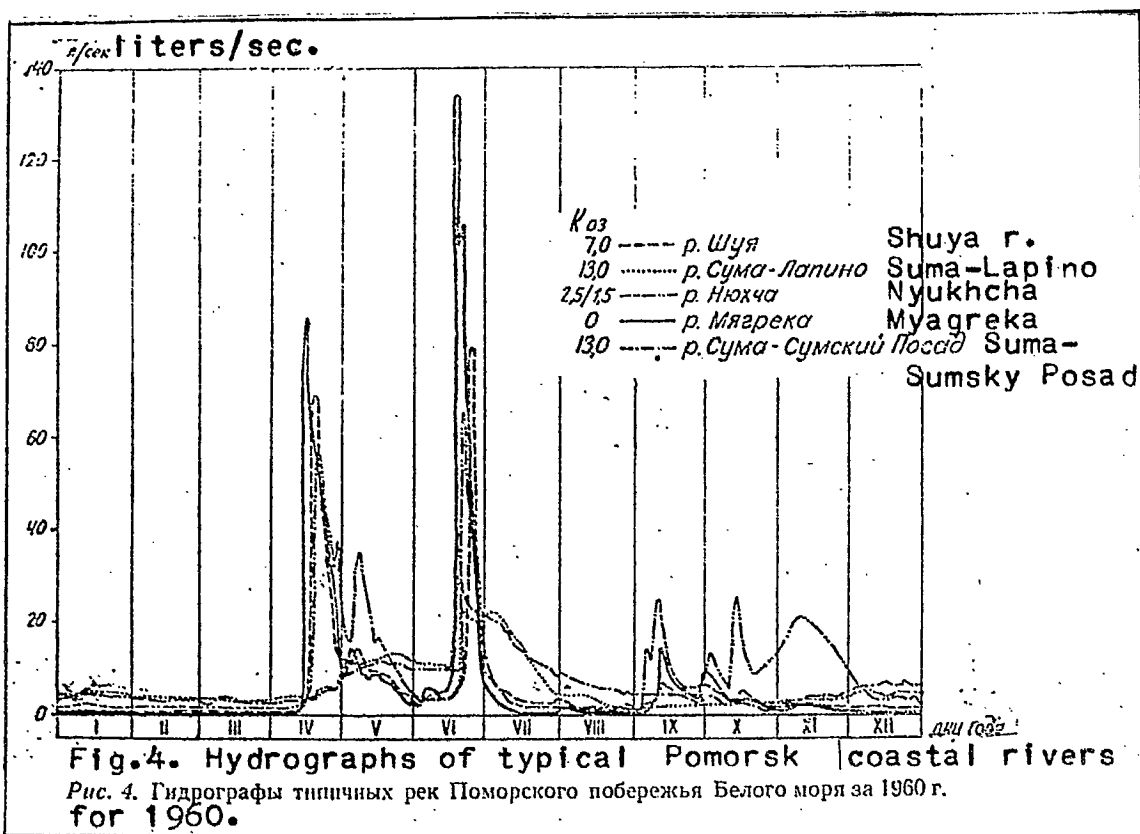
M.P. Maksimova, who studied the White Sea rivers in 1961-62, obtained very interesting data on chemical hydrology. They are valuable primarily in that they disclose something of the chemical hydrology of small hitherto uninvestigated rivers. However, a number of comments are in order regarding Maksimova's method of investigation and the conclusions she draws.



Maksimova selected the water specimens for chemical analysis from the mouth area of the rivers, which could not give her a true picture, especially with regard to the content of organic matter for the river as a whole.

In most rivers, the mouth area is not representative of the content characteristics of this component in other sections of the river.

The specimens taken from the mouth of a river give a true picture of the latter's regime when the entire catchment basin of that river, or three-quarters of it, lies within the White Sea lowland, which is the most boggy part of the west coastland of that sea. This applies to the



Khlebnaya, Unduksa, Leipruch'e, Sig and other rivers.

Our studies of 1962 and 1964 indicated that the content of humic matter of rivers whose main catchment basin lies outside the White Sea lowland varies considerably along the length of the river. The color of the water in such rivers as the Keret', Pon'goma and Kalga, over a distance of only 20--50 km, changed two to three times and invariably increased with proximity to the mouth.

Some investigators, when analyzing materials and compiling data on chemical hydrology, do not take into account the water content for the year during which the materials were collected. Years with extreme water content readings, when the content of various substances in the river water

Таблица 2  
Table 2

Распределение стока в зимнюю межень и половодье  
(в долях от среднегодового)

Река river	Коз Koz	1958 г.		1959 г.	
		IV	V	III	V
Мягрека . Myagreka . . . . .	0	0,07	8,3	0,08	4,9
Летняя . . . . . Letnyaya . . . . .	1,8	0,11	7,0	0,19	7,5
Нюхча . . . . . Nyukhcha . . . . .	2,5	0,20	6,2	0,21	4,5
Шуя . . . . . Shuya . . . . .	7,0	0,23	6,0	0,29	5,0
Кузема . . . . . Kuzema . . . . .	9,7	0,24	3,0	0,67	4,6
Поньгома . . . . . Pon'goma . . . . .	11,1	0,38	2,6	0,82	3,7
Сума (Сумносад) . . . . . Suma . . . . .	13,0	0,56	1,7	0,49	2,4
Кереть . . . . . Keret' . . . . .	17,5	0,47	1,6	0,85	3,0

Distribution of run-off in the winter low water period and during high water.

can be expected to vary significantly from average values, deserve special attention.

In this connection it should be noted that Maksimova's exploratory studies of small rivers were conducted in years with high water levels and an extremely varied run-off distribution during the year and there was no low-water period at all, owing to extensive floods. But the investigator did not take into account the particular features of the hydrological conditions and proceeded to evaluate the chemical hydrology of the White Sea rivers only on the basis of her own data. It is unfortunate that Maksimova did not consult the long-term data on the chemical composition of these waters available at the Chemical Hydrology Laboratory of the Petrozavodsk Hydrometeorological Observatory (PGMO).

All this together culminated in the investigator's inaccurate conclusions regarding her estimate of the content of organic matter. The color of the White Sea rivers was significantly overstated by Maksimova's

data (1963, 1963a). She estimated it to be  $210^{\circ}$  on the pt-Co scale, on average, and the permanganate oxidizability to be 31 mgO/liter. Based on averaged data of the Petrozavodsk Hydrometeorological Observatory, spread over a 10-year period and pertaining to 8 rivers, the color of the river water does not exceed  $60^{\circ}$  at low water and  $70--80^{\circ}$  on the pt-Co Scale at high water; permanganate oxidizability amounts to 10--15 mgO/liter and 15--20 mgO/liter respectively.

Finally, it should be noted that our preliminary conclusion (Gritsevskaya, 1963, 1964, 1964a, 1965) regarding the scant suitability of Karelian coastal rivers as gorbusha (pink salmon) spawning grounds, which was made on the basis of investigations of those rivers, has not changed after our investigation of a group of Pomorsk coastal rivers. Although the Pomorsk coastal rivers Shuya, Kolezhma and Nyukhcha offer more favourable hydraulic conditions (pebble floors, slow currents) for making spawning beds, the possibilities of these rivers are very limited, due to the limited control of run-off in these rivers.

The main reason for the failure in acclimatizing Pacific salmon to northern seas lies in the scientifically-unfounded assertion that the new habitat is suitable for the reproduction of these fish.

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