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Re-establishment of the Pacific salmon spawning grounds in formerly floatable rivers of Sakhalin.

By A.N. Kanid'ev

Original title: O vosstanovienii nerestilishch tikhookeanskikh lososei na byvshikh splavnykh rekakh Sakhalina.

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SUGGESTED CHANGES by P. F. Elson

Re: FRB translation #1444

Page 1 - title "formerly floatable etc."  
Change title to "in rivers of Sakhalin formerly used for log-driving." (It is important to make this change or the title may be misinterpreted as meaning "formerly navigable" and prospective readers may not, from the title, realize the paper's importance. In the text "floating" could be changed to "log-driving" to advantage, especially on p. 15.

Page 2, line 2 - "in obstructive" = "behind obstructing"  
(a boom in a chain of logs, not the mass of logs contained by a boom).

Page 14, line 2 - "soil" perhaps "substrate" should be substituted because I think cobble stones etc., are meant rather than dirt.

para. 2, line 6 - What does "closely indicated" mean? - smaller? similar? Clarify.

line 10 - ". . . we see that on the average (?) every square" etc.

line 13 - "spawning river" = "spawning run" (of fish)?

Page 15 - For "floating" I would substitute "log driving" or "timber driving" on this page, including "log driving dams," para. 2, line 5.

Page 16 - Change "floating"; etc.

Page 18, line 3 - For "soil" use "substrate."

line 14 - I suspect "mud" = "muddy."

Page 19, line 5 - Influence.

line 18 - "have been" = "were."

line 21 - For "soil" use "substrate" (soil in English implies mud which is not compatible with salmon spawning).

Page 20, line 5 - For "modulus" use "regimen."

line 15 - For "unfloated and submerged logs" use "waterlogged timbers."

line 16 - "disengaged" = "where driving has been discontinued."

Page 22, line 5 - "before" = "behind."

2nd line from bottom - "restoratory" = "restoration."

Page 25, line 1 - "studying."

Page 28, 3rd line from bottom - "soil" = "substrate."

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The re-establishment of the Pacific salmon spawning grounds

in formerly floatable rivers of Sakhalin

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A.N. Kanid'ev

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Izvestia Tikhookeanskogo Nauchno-Issledovatel'skogo Instituta  
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The humpback salmon, the Siberian salmon and the masou salmon enter the nearly two hundred and fifty rivers of the Sakhalin region for spawning. The number of offsprings of these fishes is determined by the size of the spawning schools, embryo-larval development, and the life of the young. In addition, the conditions indispensable to the fresh-water phase of life often appear to be disturbed, undoubtedly influencing the survival of the salmon in its early ontogenetic stage and, in the end, the effectiveness of the natural reproduction (Semko, 1954; Krogius and Krokhin, 1956). Timber felling and floating, carried out in the past, on the rivers of Sakhalin, emerges as one of the main causes giving rise to the worsening of conditions for natural reproduction.

The direct effect of timber floating amounts to the following. Accumulated in obstructive booms of the lower reaches of the rivers or large tributaries, the timber often fills the entire river-bed from top to bottom. Under such conditions the passage by the fish to the spawning grounds is often impaired if not made impossible. Separate, significant timber accumulations were often observed even along the river stretches. During the timber-floating periods, dams spanning the entire rivers were used to raise the water level. In the floatable rivers of Sakhalin such dams cut off parts of the spawning areas. During the fall timber floating, the logs ploughed over the river grounds destroying the spawning mounds of the salmon. In every floatable river, some 25 to 40% of the unfloated timber is left in the river over the winter. In the spring when the ice breaks and the water level rises the timber continues to move. In this manner, regardless of the established schedules for timber-floating works, floating in actual fact continued from spring to fall. During the winter months, in preparation for floating, the timber was amassed at short distances from the felling sites. Transporting the timber in the mountainous regions is often only possible along the tributaries. In such cases the ice and the spawning mounds are destroyed by the caterpillar tractors. It appears that the ground vibrations due to the

tractors in operation adversely affect the embryonic development of the roe even when located out of the way of the work routes.

The subsequent, or residual effect of the timber-floating operations consists mainly of (1) impairment of passage by the fish to their spawning grounds, (2) contamination of the spawning grounds by the decaying timber residues and an increased level of silting, and possibly (3) a partial change of the chemical composition of the water. The rivers used for timber-floating, gradually lose their significance in reproduction of salmon; this in turn may appear to be the reason for the reduced catch in the regions of Sakhalin, coinciding with intensified cutting and floating of timber. It should be noted that, in the last decade there has been a decrease in the off-shore salmon catch in all regions of the Far East. The decrease is explained by other reasons, however. Off the western shore of Kamchatka, for example, the catch has dropped by 10 to 20 fold, even though timber-floating in those regions was not extensive. However, in all floatable, spawning rivers the salmon population has dropped several-fold in comparison with the nonfloatable spawning rivers.

In accordance with the resolution, by the Soviet Ministry RSFSR, on the regulation of timber cutting and logging in the Sakhalin region, a gradual exclusion of the spawning rivers from the logging operations began in the year 1960. By the year 1965, timber floating ceased in nearly all rivers. Leaving temporarily the question of hydrological changes due to the reduction of forest area in the river basins, it was necessary to establish the residual effects of timber floating, and to cultivate land-reclamation measures which would lead to the re-establishment of the original quality of the formerly floatable spawning rivers. With this aim, in August of 1963, we carried out research work in the upper reaches of the river Lyutoga ( Aniv Bay ), where, in the course of many years, timber floating was carried out. The various tributaries of the river were used, to varying degrees, for timber floating and through their example it was possible to trace all changes due to short-term and long-term timber floating. In 1961, at the river-head of Lyutoga the final logging operations were carried out, and a year before that, an expedition by the Glavsakhalinrybvod, having explored the Lyutoga, noted a very low quality of the spawning grounds in the majority of the tributaries. In addition to the main river-bed of the Lyutoga, twenty-two tributaries harbouring the spawning grounds of the humpbacked and masou

salmon, were investigated from their sources down to the settlement of Chaplanovo. The qualitative characteristics of the tributaries and the spawning grounds, preferred by the fish, were studied during the spawning period of the species. To this end, the following were determined: the overall number of spawning fish in each tributary, the density with which the spawning grounds were filled, the quality of the soil, the speed of the current, the depth of the river, the temperature of the water and the amount of dissolved oxygen in the water. In order to study the residual effects of logging operations, comparisons of the one-time-floatable and non-floatable tributaries were made with regard to the quality of their spawning grounds and the salmon population of the grounds. The hydrochemical characteristics were determined using the generally accepted methods of Alekin, 1948, and Polyakov, 1950, and the fractional distribution of the soil, according to the method of S.G. Sarkisyan and A.G. Klimovoi, 1955. The area of the spawning grounds was determined on the basis of consideration of the surface area of the river, quality of the soil and the speed of the current. The quantity of spawning fish and spawning mounds and the population density of the grounds were established during a walking tour of all tributaries.

The distribution of salmon among the spawning areas is connected with the general physical and hydrological nature of the spawning river. To this point of the investigation we attached a great deal of significance, nevertheless, in the present work, we are able to present only briefly the characteristics of the main river-bed and its two largest tributaries: Tiobut and Chipian'. So far as the smaller tributaries are concerned, including the tributaries of second, third and higher orders, floatable and non-floatable, we consider it sufficient to examine them by comparing the qualities of their spawning grounds and their hydrological conditions.

The Lyutoga River from its sources to the Chaplanovo settlement

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Originating as narrow mountain streams, the Lyutoga river gradually widens; its depth increases and its flow becomes calm. In different sections of the river pebbles and cobble-stone prevail; in places there is extensive silt deposits. A significant area consists of exposed rock types. In the regions between the sources of the Lyutoga and the mouth of the tributary Lipovka only the masou salmon spawns. Below this tributary, the

humpbacked salmon is also found and is dominant in the spawning grounds of the region near the Splavnyi settlement. Below that the masou salmon does not spawn.

The spawning area is not evenly distributed: from the sources to the mouth of the Lipovka River the spawning grounds amount to no more than 5% of the river area, to the confluence of the tributary Vetvistyi, 40%, to the Splavnyi settlement, and to the Chaplanovo settlement, not more than 25%, the total spawning area is 189,000 square metres.

In 1963 the masou salmon ended its spawning season at the end of August while the humpbacked salmon continued to spawn throughout the entire river. Between the sources of the Lyutoga and the settlement of Pyatirech'e we observed 6180 spawning masou salmon and 89570 humpbacked salmon. Since the time of our inspection, in addition to the spawning fish, we observed spawning mounds; we associated each of the mounds with a pair of fish. The spawning grounds were unevenly populated. The average population density was approximately equal to 0.5 fish per square metre, however, in different parts of the river, population densities of 0.1 to 3 fish per square metre of spawning area were found.

The part of the Lyutoga River studied by us, has a number of tributaries which are of extreme significance to spawning. More than 31,000 humpbacked salmon and 18,300 masou salmon were noted in these tributaries.

The tributary Tiobut

The tributary originates from two sources which come into confluence after a distance of 3 miles. The river-bed in the upper reaches is narrow, full of rapids, and has a steep gradient. Tiobut is a very deep tributary. The average current speed is between 70 and 80 centimetres per second. The river ground is basically made up of large pebbles, cobble-stone and broken rocks. In many parts, boulders prevail. Over a large stretch of the river, the floor of the river is covered with exposed rock types. Between the river sources and the point of confluence with the Vishneva River, the exposed rock represents 10% of the river floor, below the mouth of the Vishneva River, up to 40% and near the settlement of Chistovođnyi, up to 70%. In the part of the Tiobut River between the Chistovođnyi and Chaplanovo settlements, the exposed rock types make up about one half of the river-bed area.

The amount of spawning area varies along the

river: between the sources and the tributary Pravyl, the spawning area covers 10% of the river-bed area, farther towards the Komsomol'skogo settlement, it covers 30% of the river-bed area. Farther down along the river stream the spawning areas decrease: between the mouths of the Vishneva and Ozhedaevka Rivers it is 20% of the river-bed area; between the Chistovodnogo and Chaplanovo settlements, 15%. The total spawning area of the Tiobut River, excluding the tributaries, is 100,000 sq. metres.

In the Tiobut River, spawning is done mainly by the masou salmon and to a lesser extent by the humpbacked salmon. In the spawning grounds of the main river-bed of the Tiobut we noted 35,100 masou salmon and 13,500 humpbacked salmon. The spawning grounds of the two species were noticeably separated along the parts of the river. Between the river sources and a point just above the confluence point of the Vishneva River, the spawning grounds were those of the masou salmon; below that, both the masou and the humpbacked salmon spawning grounds were observed, although, the masou outnumbered the humpbacked salmon by nearly four-to-one. Above the Chistovodnogo settlement spawning by the masou salmon is rare, and in the section of the river, between the Ozhedaevka River

and the Chaplanovo settlement, only the humpbacked salmon spawns. In those parts of the river in which the spawning grounds of both the masou and the humpbacked salmon were present at the same time, the grounds of each species were clearly separated, and distinguished by the nature of the soil, the depth of the river and the speed of the current.

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The Tiobut River has many tributaries of various sizes. Some of these tributaries, in turn, have tributaries of their own. Spawning of the salmon was observed in all these areas. The spawning area of the Tiobut tributaries was equal to 74,000 square metres. During the salmon spawning period we observed 41,700 spawning masou and 7,800 humpbacks.

Thus, together with its tributaries the Tiobut River contains 174,000 square metres of spawning grounds in which, in 1963, 76800 masou salmon and 21,300 humpbacked salmon took part in spawning.

#### The tributary Chipian'

The tributary originates from three source streams, each about 1 metre wide. The depth of the river along the entire length varies greatly. Its flow is more calm than

that of the tribut or that of the upper reaches of the Lyutoya. In the different parts of the river the average range of current speed variation is 30 to 50 centimetres per second. The river ground consists primarily of large and small pebbles; in some areas cobble-stone predominates. Rock types that cover the river bottom, are only found in isolated areas.

In the Chipian', spawning is done primarily by the humpbacked salmon. Spawning grounds are numerous and of good quality, but unevenly distributed through the river: from the sources to the tributary Vyrukka the spawning grounds cover 30% of the river-bed; down to the tributary Dal'nyaya they cover 20% of the river-bed, and farther below, a large part of the river-bed serves as spawning grounds for the humpbacked salmon and broken only by pits and shallow waters. The total spawning area is 75,000 square metres.

The Chipian' was appreciably better filled with fish than the other tributaries. During the spawning period of the humpbacks there were 2 to 15 fish per square metre of spawning area. In the upper reaches of the river the population was less dense in comparison with the

population densities of the middle and lower parts of the river. The main river-bed of the Chipian', excluding the tributaries, was visited by 144,000 humpbacks and 770 masou for spawning purposes. A small number of humpbacks and nearly all of the masou salmon spawned in the tributaries of the Chipian'.

In the Chipian' tributaries, 27,400 square metres of spawning grounds were noted. On these grounds spawning was carried out by 23,500 humpbacks and more than 23,200 masou salmon. Consequently, the spawning area of the Chipian' and its tributaries totalled 102,400 square metres. 107,500 humpbacks and about 24,000 masou salmon carried out spawning there.

A more detailed study of the spawning grounds was carried out in the upper reaches of the Lyutoga River and its tributaries Tiobut and Chipian' (see table 1). This study permitted us to observe certain regularities. The spawning mounds of the humpbacked and masou salmon, in the main river-bed of the Lyutoga, were predominantly pebble. The speed of the current during the construction of the mounds varied between 38 and 68 centimetres per second; the depth varied between 9 and 30 centimetres. A relatively low water temperature and the high current speeds

made possible a high content of dissolved oxygen in the water: 10.3 to 11.0 milligrams per litre.

As in the main river-bed of the Lyutoga, the make-up of the spawning mounds in the Tibout was predominantly pebbles of different sizes. The current speed in the spawning grounds varied between 36.7 and 79.8 centimetres per second. The depth over the mounds varied between 8 and 24 centimetres. The water temperature on the grounds ranged from 9.0 to 13.0 degrees C and the dissolved oxygen content, 9.3 to 11.4 milligrams per litre.

The spawning grounds of the humpbacked salmon in the Chipian' River, in comparison to those described above, are characterized by a lower speed of the current, lower content of dissolved oxygen and a higher water temperature at the time of spawning (see table 1).

Having completed the study of the fractional composition of the soil making up the spawning mounds, and the conditions prevailing over the spawning grounds, we could characterize the spawning grounds of the two species more exactly. The spawning grounds of both the masou and the humpbacked salmon are characterized by the determining conditions, specific to each species. The masou spawning mounds, located in the upper reaches of the river

and tributaries, include nearly twice as much of the coarse fractions of the soil, and one third less gravel and sand. The higher oxygen content in the waters of the masou spawning grounds is explained by the higher current speeds and the lower water temperatures than those found in the spawning grounds of the humpbacked salmon. The depth above the spawning mounds of the masou salmon is also, on the average, one third less than that over the nesting mounds of the humpbacks (Table 1).

As a result of the work, it is established that in the upper reaches of the Lyutoga, between the sources and the Chaplanovo settlement, including the tributaries Tiout and Chipian', there are 465,400 square metres of spawning grounds. Several small tributaries were not investigated but their spawning area will be a little more closely indicated. In the investigated parts 438,000 salmon in all were noted. Of these nearly 123,400 were masou salmon and 314,600, humpbacked salmon. Comparing the spawning area and the number of salmon that spawned, we see that every square metre of spawning grounds was visited by just under one fish, that is, the grounds were incompletely filled, regardless of the fact that in 1963 the spawning river was more abundant than in the previous years. The spawning grounds of the Chipian' River were filled better than those in the

main river-bed of the Lyutoga or the tributary Tiobut.

The Effects of Floating

After studying the spawning grounds, and determining the degree to which the grounds were filled with salmon, we could turn to a comparative analysis of the one-time-floatable and the non-floatable tributaries. Likewise, we could study the effects of the wood remains and the floating dams on the salmon. During the study of the tributaries used by the salmon, some partly demolished dams used in floating work were discovered. Some of them, under low-water conditions, could hinder the passage of the salmon to the upper parts of the spawning grounds. Upstream from these dams, the spawning grounds of the masou salmon were frequently found. During the period of our observation, the spawning process of the masou salmon went on above many such dams. The masou salmon proceeding upstream to the upper reaches of the rivers is more successful than the other salmon; it is more capable of overcoming obstructions along the way. In the off-shore regions of the sea, according to P.A. Doinina (1952), the masou salmon is the first to appear. Its spawning run in the rivers, during the periods of high water levels, is also early in comparison to that of the humpbacked salmon. For example, the masou salmon

enters the Lyutoga River at the beginning of May. These factors enable the masou to pass the dams. As for the passage of the humpbacked salmon, the undemolished dams can present a hindrance. Besides the remaining dams in the formerly floatable tributaries, there were logs, half buried in sand and pebbles, scattered in the various parts of the river. The last timber-floating work in the upper reaches of the Lyutoga was done in 1961; many tributaries, however, were excluded from such work even earlier. During the investigation of the rivers in 1963, the spawning grounds of the masou and the humpbacked salmon were observed in both the formerly floatable and non-floatable tributaries. Below, we present a comparison between several non-floatable and formerly floatable tributaries:

1. Azytka (non-floatable). The speed of the current over the spawning grounds was 05.2 cm/sec; silting up was negligible; the water was clear; the spawning grounds made up 40% of the river area; on the average, 2.2 fish per square metre participated in spawning; spawning took place for a distance of two kilometres from the river mouth; the oxygen content in the water, on the 24th of August, was 10.1 milligrams per litre.

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Kama (formerly floatable). The speed of the current over the spawning grounds was 52.3 cm/sec; silting up of the spawning grounds was negligible; the water was clear; the spawning grounds made up 60% of the river area; on the average, 1.7 fish per square metre took part in spawning.

2. Vetvistaya (non-floatable). The speed of the current over the spawning grounds was 55.5 cm/sec.; the soil slightly silted up; clear water; the spawning grounds made up 80% of the river area; on the average 1.2 fish per square

metre took part in spawning.

Lipovka (formerly floatable). The speed of the current over the spawning grounds was 57.1 cm/sec.; soil slightly silted up; the water was clear; the spawning area made up 30% of the river area; on the average 0.6 fish per square metre took part in spawning. The masou salmon spawned up to 7 km from the mouth of the river. Above that the spawning grounds were cut off by the dams that were used in timber-floating work. On the 22nd of August, the water on the spawning grounds contained 11.0 milligrams of oxygen per litre.

3. Glukhaya (non-floatable). The speed of the current over the spawning grounds was 49 cm/sec.; negligible silting up of the grounds; clear water; the spawning grounds made up 50% of the river-bed area; on the average 0.1 fish per square metre took part in spawning.

Perevalochnaya (formerly floatable). The current speed over the spawning grounds was 43.3 cm/sec.; the soil not silted up; clear water; the spawning grounds made up 85% of the river area; on the average 3.0 fish per square metre took part in spawning.

4. Gorelaya (non-floatable). The speed of the current over the spawning grounds was 28.2 cm/sec.; the soil heavily silted up; the water was light brown coloured; the spawning grounds made up no more than 5% of the river area. In the entire tributary, 250 fish took part in spawning.

Svetlaya (formerly floatable). The speed of the current over the spawning grounds was 60.6 cm/sec.; silting up of the grounds was negligible; clear water; the spawning grounds made up 65% of the river area; on the average 0.8 fish per square metre took part in spawning; there were two partly demolished dams which did not hinder passage of salmon.

The parallel comparison of the non-floatable and formerly floatable tributaries does not show any differences so far as the more characteristic signs, present in the spawning rivers, are concerned. The mean current speed in the formerly floatable tributaries varied between 43.3 and 60.6

centimetres per second. That is, the latter included all the current speeds found in the spawning grounds of the formerly floatable rivers. The soil composition and the quality of the spawning grounds in the formerly floatable tributaries did not differ from those of the non-floatable rivers. Silting up of the spawning grounds was negligible in all tributaries with the exception of the Gorelaya river in which timber-floating works were never carried on. The soil of the Gorelaya was heavily silted up, the current speed was relatively low and the colour of the water was a shade between light-brown and brown. Such colour of water is not found in spawning rivers (Kuznetov, 1928). The tributary, in effect, was not visited by the salmon. This is explained by the fact that the river, fed from a mud source, has a gas composition, an active reaction medium, oxidizing agents, and other hydrochemical indices falling beyond the limits of adaptation of the salmon. The total spawning area, in both the floatable and the non-floatable tributaries, varied between large limits and thus likewise did not confirm the presence of the expected changes arising from timber-floating works. The spawning area of a river is determined by the nature of the soil, inclination of the river-bed, and the availability of forest in the river basin; that is, the spawning area is determined

by those indices which essentially do not change as a result of timber floating works. The size of the spawning area in a river, certainly does not present itself as a statistical quantity and often changes very significantly under the influence of the hydrological conditions. The latter conditions are determined by the climatic factors which depend on the extent of the forest cover over the area of the river system.

The quality of a spawning area is evaluated on the basis of fish population density. For every square metre of spawning area located in the non-floatable tributaries we observed, on the average, 0.1 to 2.2 fish. In the formerly p.141 floatable tributaries we observed 0.1 to 3 fish per square metre. Therefore, the extent to which the spawning grounds in the formerly floatable rivers are filled by the fish also does not provide a basis for assuming unfavourable changes. A qualitative comparison of the spawning rivers presently being used for floating operations and of the spawning rivers and tributaries that have been excluded from the floating operations several years ago, showed significant differences between the two cases, in particular, with regard to the soil composition. So far as the soil composition is concerned, there was no difference found between the formerly floatable and the non-floatable rivers.

The reasons for this will become clear if we consider the hydrological conditions present in the rivers of Sakhalin. The width, depth, the speed of the current and the water drainage, vary greatly over the period of one year. The drainage modulus for the Lyutoga River, as given by the Sakhalin hydrometric service, for example, changes over the seasons by a factor of six. The water level changes due to the melting of the snow in the spring, and in the fall, due to extensive sedimentation. During the high water level periods of the spring and fall, the speed of the current sharply increases. The current then carries silt, sand, leaves and in some places even pebble and cobble-stone. In the formerly floatable rivers, the current in addition carries bark that settled to the river bottom, unfloated and submerged logs. In this manner, a river, disengaged from floating operations, with the aid of a few regulations, over a time period of two to three years, rids itself of the residual timber and becomes equal in quality to the rivers that were never used for floating. A good example of this is the tributary Chipian' of the Lyutoga River. In 1963, timber-floating works were discontinued in the Chipian'. In 1961, an expedition inspected the Lyutoga and its tributary Chipian' and

reported unsatisfactory condition of the spawning grounds.<sup>1</sup> The total spawning area, as determined by the expedition, was 60,000 square metres. Neither spawning fish nor spawning mounds were found, even though the salmon run up the river was comparatively good that year. In our investigation of the tributary Chipian' in 1963, we found the spawning grounds to be of very high quality and totaling 102,400 square metres in area. The extent of silting of the grounds was low, while the bark and the wetted logs, present during the floating periods, were not found. During the spawning period we observed 167,500 humpbacks and 24,000 masou salmon in spawning. The average population density in the spawning grounds was approximately 1.8 fish per square metre, which is a good index for a spawning river. Similar examples are available in other tributaries. It must be noted that the spawning run of the salmon in 1963 was more abundant than in the previous years, and therefore, a higher population density in the spawning grounds was to be expected. However, the quality indices, not dependent on this fact, were incomparably higher for this river than in 1961.

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<sup>1</sup> Otchet po obsledovaniyu nerestovykh rek Anivskogo raiona v 1961 godu ( An account of the 1961 inspection of the spawning rivers of the Anivsk region). Manuscript, archives of the Sakhalinrybvoð.

Our observations allow us to conclude that the spawning rivers are most adversely affected by the floating process itself, rather than by the after effects of the process. During the floating period, booms and timber congestions forming before the booms interfere with the passage of the salmon to their spawning grounds; the moving timber frightens the fish and ploughs over their spawning nests; the sunken bark and silt cut down the water circulation over the spawning mounds.

The booms and the dams remain to contribute to the after effects of the floating industry. The booms, located in the lower reaches of the river, normally do not contribute to the impairment of passage to the spawning grounds by the salmon. The dams, however, can survive for several decades after the floating operations are discontinued. For example, in the upper reaches of the Yasnomorka River (western shore of the southern Sakhalin) there were two dams; one, permitted the masou salmon to pass freely, the other, before its demolition, impaired the passage of the salmon. Thus, the analysis of the material yields a basis to suppose that the restoratory work, on the rivers excluded from floating timber, needs

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only to consist of the demolition of booms and dams. Following such action, a formerly floatable river becomes equal in quality to a non-floatable river after a period of two to three years. It must be pointed out at this time that a lowering in the forest reserve, due to the felling operations in the river basins, brings about a change in the hydrological conditions quite independently of the floating works. Floating operations on the Lyutoga River have been carried on for several decades. The records of the Sakhalin forest research station show that at present only 33 to 40% of the Lyutoga River system is covered with forest. Of course, the forest is best preserved in the upper reaches of the river and its tributaries; as a result their optimum hydrological conditions and significance to spawning are little changed. This is supported by our measurements of the current speed, water temperature and oxygen content, all of which are within the limits of the optimum values. The better preservation of forest in the upper reaches of the Lyutoga was responsible for the preservation of the spawning area (Semko, 1954 b). Of the 873,100 square metres of the spawning grounds, observed in the Lyutoga river <sup>1</sup>

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<sup>1</sup>The report on the work done by the Aniv KNS, in 1963. Manuscript, archives of the Sakhalinrybvod.

by the observation and control station of Aniv in 1963, 465,400 square metres, or more than one half of the total, are located in the upper reaches of the river, and the upper tributaries above the Chaplanovo settlement. Under optimum spawning conditions, the spawning grounds of the upper Lyutoga alone could accommodate close to a million fish (Kuznetsov, 1928, Kaganovskii, 1949, Gemko, 1961). Ordinarily, however, this does not take place. The undesirable effects due to insufficient regulation of the salt-water salmon industry and the low population of the spawning grounds in the rivers of the south-western Sakhalin can be explained simultaneously as follows. All hydrological changes, following the cutting down of forest, show up most clearly in the lower reaches of the rivers. For example, the water temperature in the lower Lyutoga, during the spawning run of the salmon, reaches 24 to 26 degrees C; such temperatures are in excess of the optimum value (Levaničov, 1954). Small vessels enter the lower Lyutoga River generating noise and to some degree polluting the water with oil. It is known that the Pacific salmon are very sensitive even to a low level of water pollution by foreign chemical matter. Consequently, the seemingly insignificant pollution of the lower Lyutoga hinders the entrance of the salmon into the river.

In studying the necessary trend of work, leading to the re-establishment of the previously floatable rivers, it is proper to touch upon the subject of restoration of all rivers in general. Each year, more resources are being spent by the Sakhalinrybvod on restoration of the spawning rivers. In 1960, for example, 2,471,000 rubles were spent for this purpose. Restoration work mainly consists of clearing the river-beds of obstructions and fallen trees. Such works are labour-consuming. A lack of near-by roads makes it difficult and often impossible to apply technology. Furthermore, the importance of such activity to the improvement of the quality of the spawning rivers appears to be questionable. Observations have shown that natural obstructions impassable to salmon do not exist and therefore there is no requirement to clear them. The fallen trees and bending of the river-bed even have favourable significance to the preservation of the spawning river quality. For example, during the spawning run, the salmon make a stand over shadowed by snags and fallen trees. During the high water level seasons, obstructions, fallen trees, river bends and uneven river bottoms smooth out the action of the flood, reducing the speed of the current.

as a result, the fine components of the soil, which sometimes fill up the spawning grounds, are, to a significant degree, prevented from drifting. In the relatively low water periods of the winter, such obstructions serve as natural dams in the various parts of the river, raising the water level in the spawning grounds and improving the circulation of water over the spawning mounds. The restoration works must be aimed, first of all, at the removal of those obstructions which cannot be overcome by the salmon on the way to the spawning grounds. For example, river mouths, or some spawning rivers, are often filled up by sand and pebbles; even though the water seeps through, penetration by the fish is not possible. Many spawning rivers contain waterfalls impassible by the fish. We know of eleven such waterfalls in the rivers of Sakhalin. It was estimated that the waterfalls cut off 500,000 square metres of spawning area. Any possibility of some sort of improvement of the quality of the spawning grounds at this time seems unlikely. Only the necessity to implement the measures, proposed by certain observers (Nikol'skii, 1954, Krogius and Krokhin, 1954, Vasil'ev, 1959), to prevent the drying up and freezing up of the spawning mounds, has no opposition. Excluding the technical difficulties, all

of which are surmountable, there remains the unresolved question of the aim that the works for improvement of the spawning grounds should take. For example, spawning grounds, which by the criteria known to us, are equal in quality are not equally visited by the fish. The same types of salmon, rising upstream during a spawning run, often prefer different parts of a river even when the parts are of different hydrological make-up. I.I. Kuznetsov, 1928, A.S. Semko, 1939, A.G. Kaganovskii and other researchers indicate that the distribution of salmon among the spawning grounds depends also on the quantity of the fish coming in for spawning. The choice of the spawning ground, as we have repeatedly pointed out, is determined, for the most part, by the time of entrance into the river, by the maturity of the reproductive products and by the general physiological condition of the fish. Therefore, before carrying out any kind of work directly on the spawning grounds, it is necessary to study more deeply the principles conforming with the natural reproduction of salmon.

The work carried out on the Lyutoga River allows us to state the following basic conclusions.

1. In using a river for floating of timber, the greatest harm to the reproduction of salmon is done by the floating process itself. The subsequent effects of floating are not of permanent nature. In two to three years after discontinuing the timber-floating works in a river, the spawning rivers clear themselves of remnants of timber, bark and silt. Following this period, the formerly floatable rivers become equivalent to the non-floatable rivers with respect to the quality of the soil, the area condition of the spawning grounds and the distribution and concentration of the salmon in the various parts of the spawning grounds.

2. After discontinuing the timber-floating operations in a river, the restorative works should consist of the removal of those mechanical obstructions which lie in the way of the salmon and represent insurmountable barriers to the salmon, namely the dams, booms etc.

3. In the upper reaches of the Lyutoga River and its tributaries there are 465,400 square metres of spawning grounds of the humpbacked and masou salmon. The study of the soil composition and conditions on the spawning grounds gives the necessary material to characterize the spawning places of the masou and humpbacked salmon.

Table 1. The spawning grounds characteristics of the masou and the humpbacked salmon in the Lyutoga River and some of its tributaries.\*

Place of analysis	Date	Fish type	Soil composition, %					O. mg/l	Temp. °C	Current speed cm/sec	Depth over mounds cm
			Sand and gravel	Pebble		Cobble-stone					
				1-5 cm	5-10 cm	10-20 cm	over 20 cm				
A	22. III	humpback	10	55	32	3	--	10.3	13.0	53.7	11
B	23. VIII	»	--	--	--	--	--	10.7	10.9	60.6	21
C	22. VIII	masou	10	30	20	20	20	11.0	12.2	68.5	10
	»	»	5	50	15	30	--	--	--	51.3	--
D	18. VIII	»	10	40	20	25	5	--	9.4	53.1	15
E	»	»	15	35	30	20	--	10.1	9.0	60.0	13
F	19. VIII	»	--	--	--	--	--	10.3	11.5	66.8	17
	»	»	--	--	--	--	--	--	--	79.3	16
G	15. VIII	humpback	20	50	20	10	--	9.3	10.8	65.2	20
H	15. VIII	humpback	15	60	20	5	--	--	13.8	51.3	24
	»	»	10	65	20	5	--	--	--	57.1	--
I	17. VIII	masou	--	--	--	--	--	10.0	10.7	47.3	8
J	17. VIII	»	15	35	25	25	--	--	10.2	51.1	13
	»	»	10	40	20	30	--	--	--	52.3	--
	»	»	10	30	20	40	--	--	--	54.4	10

- A - the Lyutoga, 0.5 km above the mouth of the Lipovka River;  
 B - the Lyutoga, in the region of the Splavno settlement;  
 C - near the mouth of the Lipovka River, a tributary of the Lyutoga;  
 D - the Tiobut, above the tributary Pravyi;  
 E - the Tiobut, above the mouth of the tributary Vishnevaya;  
 F - the Tiobut, 5 km below the Vishnevaya River mouth;  
 G - 0.5 km from the mouth of the Tiobut tributary Ozhidaevka;  
 H - 1.5 km from the mouth of the Ozhidaevka;  
 I - the upper reaches of the Tiobut tributary Vishnevaya;  
 J - the Vishnevaya, 0.5 km above the Poslushnaya River.

Table 1 (continued)

Place of analysis	Date	Fish type	Soil composition, %				O <sub>2</sub> mg/l	Temp. °C	Current speed cm/sec	Depth over mounds cm	
			Sand and gravel	Pebble		Cobble-stone					
				1-5 cm	5-10 cm	10-20 cm					over 20cm
K	»	»	—	—	—	—	7.2	69.7	9		
L	20. VIII	humpback	15	30	25	25	5	10.1	12.5	37.7	15
	»	»	17	33	20	10	15	—	—	41.2	—
M	24. VIII	»	8	32	25	35	—	—	—	51.3	—
	»	»	9	37	27	27	—	9.1	13.9	48.9	16
N	25. VIII	»	25	25	30	39	—	9.5	13.7	37.1	14
	»	»	15	30	33	22	—	—	—	36.3	—
	»	»	20	45	29	6	—	—	—	35.2	—
The average for the humpbacked salmon			15.6	42.2	25.3	15.1	1.8	9.9	12.6	49.1	15
The average for the masou salmon			10.6	37.1	21.5	27.2	3.6	10.3	10.1	59.5	12

- K - the Tiobut tributary Pravaya, near the river mouth;  
L - the Tiobut tributary Staraya Utka;  
M - the Chipian', 4 km from the river mouth;  
N - the Chipian', 2 km below the mouth of the tributary Dal'nyaya.

\* For each place of analysis, the table gives the average figures based on 3 to 5 measurements taken in 1 to 3 spawning areas at each place in 1963.

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<sup>1</sup> Literal translation

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