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Quantitative characterization of benthos from lotic  
bodies of water in Kamachotka

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Kolichestvennaya kharakteristika bentosa tekuchikh vodoemov  
Kamchatki / Quantitative characterization of benthos  
from lotic bodies of water in Kamchatka.

By: I.M. Levanidova and  
L.V. Kokhmenko

Quantitative analysis of benthos is the most labour-  
consuming and technically intricate stage of hydrological  
investigations, particularly when dealing with rocky bottom  
types and swiftly flowing streams. Until recently (Kurenkov,

\* Figures in the right-hand margins indicate the  
corresponding pages in the original. (Translator)

1964) we had very little information on the biomass of benthos in the streams of Kamchatka. Kurenkov's work includes a brief qualitative description of benthos from lotic bodies of water in Kamchatka. The author mentions among other things that "the biomass of benthos in the upper reaches of the rivers amounts on an average to about 50 g/m<sup>2</sup>," and presents results of three quantitative collections from the rivers Kamchatka and Avacha.\*

In this paper we examine the data from quantitative analyses of benthos from various lotic bodies of water in Kamchatka, which were collected after the work mentioned above appeared in print.

Most of the quantitative collections were carried out by V.A. Levanidov, L.V. Kokhmenko and E.T. Nikolaeva. A few collections (in the river Dal'nyaya and in the tributaries of Kuril'skoe<sup>lake</sup>) were gathered by N.A. Simonova and B.B. Vronskii.

The authors continuously consulted A.G. Ostroumov and I.I. Kurenkov in the matters related to toponymy and typology of rivers. V. Gabdraupova, a senior laboratory technician, assisted in the laboratory processing of the material collected.

The authors wish to thank these colleagues for their help and assistance.

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\*These data are presented in Table 1.

The methods used in collecting quantitative samples were as follows. Individual rocks and pebbles, gathered from the bottom, were immediately placed in a washer made of a silk sieve No. 24. Invertebrates were collected, whereupon the projection of each rock at the bottom was plotted on paper by tracing its outlines in pencil. The area of projection was determined according to the gravitational method (Zhadin, 1956: 289). The number of pebbles or rocks varied in different samples and depended on their size and on the population density of the various organisms found on the rocks.

On fine sediments (i.e. on pebbly-sandy, fine-pebbled sediments, on silty sands or mud) samples were collected with the help of a tube resembling a stratimetric tube and measuring 36 mm in diameter, 150 cm in length.

The upper opening of the tube was closed with a stopper and the tube was driven with force into the bottom sediment. Thereupon it was lifted above the soil surface and a washer was placed under its lower end (as a rule, the sediment falls out of the tube only when the stopper is removed). A sample commonly consisted of four such scoops and the area sampled measured  $1/260 \text{ m}^2$ .

p. 89

When invertebrates were collected from sunken stumps or from hard, finely rocky bottom types, substrate trays were used.

Benthos was eluted through the sieve No 24, and was fixed with a 4% formaldehyde solution.

Several qualitative samples were taken alongside the quantitative ones. Furthermore, entomological samples were collected with the view of capturing adult amphibiotic insects.

In order to identify indeterminate larvae to the species, they were placed inside live boxes (retainer cages) and submerged in the stream until they developed into imagos.

The data shown in Table 1 reflect the volume of biomass and the abundance of bottom invertebrates in streams of a wide typological range, from different geographic zones of the peninsula. These data are, however, far from sufficient for a meaningful analysis or reliable evaluation of the food supply available to freshwater fishes in the bodies of water examined. The principal defects of these data are as follows: collections from individual bodies of water fail to reflect the pattern of seasonal variations; collections of benthos from different streams are not synchronized; the investigations carried out do not cover the entire diversity of stations in the streams (especially in profundal zones) and the samples collected at each particular point are too few.

Despite these shortcomings, the data obtained from our investigations can be used to characterize tentatively streams of different categories with regard to the

quantitative development of their benthofauna.

Rivers and brooks are divided into crenon streams, rhithron streams and potamon streams, on the basis of their altitude of their occurrence and <sup>gradient</sup> of the degree of their fall. This <sup>classification system</sup> subdivision can also be applied to different parts of a stream, since few of them can be classified entirely within one single category.

The streams shown in Table 1 are divided into different groups according to this system of classification. However, it must be kept in mind that the <sup>classification</sup> subdivision is rather tentative, since it is impossible to draw a distinct dividing line between different categories (for example, between a brook and a river with a small water discharge). The transition of different parts of a stream from one altitude to another is as gradual as the transition between different categories of streams. This is particularly true of the streams with copious lower reaches.

Many streams are so specific that it is difficult to assign them to any particular category. There appears to be a definite need for a detailed classification of the streams of Kamchatka.

#### Hypocrenon brooks

Tributaries of Azabach'evo lake, i.e. the so-called

Pervyi\* and Vtoroi\*\* fish "springs," belong to this category of streams. The brooks discharge into the southern part of the lake. They measure 3.5-4 km in length, have a swift flow and form waterfalls here and there. In the upper reaches the rocks are overgrown with moss, at the lower course sand accumulates between them. Water temperature in August is 2.9-4.4°. Considerable numbers of sockeye salmon spawn in these brooks.

At the upper course, in the part of the brooks marked by waterfalls and rapids, the biomass of benthos on the rocks amounted to 13.9 g/m<sup>2</sup>. Furthermore, 66% of the biomass was represented by large larvae of stonefly Arcynopteryx altaica, about 16% by larvae of Simuliidae, the rest by mayflies Baetis sp. No 5 and caddis flies Apatania zonella. On the rocks overgrown with moss the biomass of benthos was 37.1 g/m<sup>2</sup>. Between the rocks, in agglomerations of coarse detritus, it was 76.2 g/m<sup>2</sup>. Eighty-eight percent of the biomass was represented by very large larvae of Arctotipula.

In the middle part of the brooks, on the rocks measuring 9-11 cm in diameter, the biomass of benthos was 19.3 g/m<sup>3</sup>, 80% of which consisted of Orthoclaadiinae larvae

p. 90

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\*The First. (Translator)

\*\*The Second. (Translator)

and other Chironomidae, while larvae of the mayfly Baetis sp. No 5 amounted to about 20%. The rocks overgrown with moss (and measuring 10-15 cm in diameter) were populated much more abundantly with regard to both the species composition and the number of organisms: the biomass of benthos on one such rock was 210 g/m<sup>2</sup>. In the Vtoroi fish "spring," benthos from the rocks covered with moss consisted 83% (by weight) of Chironomidae larvae and pupae; Planaria amounted here to 7%; stoneflies to 4%. Oligochaetes, Acarina, Cumacea, larvae of caddis flies Apatania zonella and of mayflies Baetis sp. No 5, Cinygmula cavum, larvae of dipterous insects were also found here. In the lower reaches (60 km from the mouth), on the rocky-pebbly bottom, the biomass of benthos varied between 5.5 and 16.4 g/m<sup>2</sup> (amounting on an average to 9.9 g/m<sup>2</sup>) and Chironomidae constituted 63% of this biomass. The species structure of the remaining population was the same as in the sections farther upstream.

In a small depression in the bed (a "bowl" 7cm in depth) with a fine pebbly bottom and a sluggish, scarcely perceptible flow, the biomass of benthos was greater (19.4 g/m<sup>2</sup>), but consisted exclusively of Chironomidae (70.5%) and Oligochaetae.

#### Small eucrenon rivers

The river Lotnaya, a southeastern tributary of Azabach'e lake, is a typical eucrenon stream nearly

throughout its course. <sup>high</sup> The ~~large~~ elevation, ~~from which~~ <sup>from</sup> ~~this~~ river flows, approaches <sup>near</sup> ~~closely~~ the lake, as a result of which the Lotnaya river traverses a level ground only in the last few hundred meters. Its flow is very swift, in the area of rapids the flow is torrential. The bottom is predominantly rocky; pebbly sections are relatively small; sandy bottom occurs rarely; drift-wood is carried away by the current. Water temperature on August 5, 1965, was 9.8°.

Fairly large schools of sockeye salmon migrate into the Lotnaya river for spawning.

Fauna from the bottom type prevalent at the upper course (large rocks 19-21 cm in diameter) was examined 4 km above the mouth. The mean biomass of benthos on the rocks was 23.0 g/m<sup>2</sup>. The composition of the benthos collected from the rocks, is shown in Fig. 1a.

In the zone of rapids 70% of the rocks was inhabited by large colonies of Simuliidae, the biomass of which was 26 g/m<sup>2</sup>, i.e. 70% of the total volume of benthos. Chironomidae amounted to over 5 g/m<sup>2</sup> (Orthocladiinae predominated); larvae of mayflies (Cinygmula malaisei and Baetis sp. No 5) ranged third with regard to their biomass and population density. The overall population density of invertebrates was 16 thousand specimens per square meter. Blepharoceridae, typical rheobionts, may be regarded as index forms of this biotope.

In the same section of the river, though outside the

rapids, the biomass of benthos on the rocks overgrown with green algae amounted to  $8.6 \text{ g/m}^2$ , of which 92% was represented by larvae of Chironomidae (essentially Orthoclaadiinae) and about 2% by Hydracarina.

Malaya Nikolka (a secondary tributary of the river Kamchatka at its middle course) is another small eucrenon river. It originates in a spring and has a less torrential flow than the river Lotnaya, as a result of which sand accumulates in this river between and under the rocks. The biomass of benthos on one of the rocks of the bar was  $91.8 \text{ g/m}^2$ ; half of this biomass was represented by larvae of Simuliidae, about 40%--by mayflies Cinygmula malaisei. On the finely textured silty bottom near the spring opening the biomass of benthos was  $21.2 \text{ g/m}^2$  (Fig. 1b).

p. 91

In the lower reaches of the eucrenon rivers, which traverse a plain prior <sup>i)</sup> to <sup>into the sea?</sup> discharging, the biomass of benthos is fairly small. For example, in the mouth of the river Khakytsin (a tributary of Kuril'skoe lake), in April, small Chironomidae predominated numerically among the invertebrates (which inhabit the pebbles lying on the sand and on the fine sediment at the bottom), while mayfly, stonefly and caddis fly larvae predominated by weight. The total biomass of benthos amounted here to  $9 \text{ g/m}^2$  (Fig. 1c), its population density was  $20 \text{ specimens/m}^2$ .

Биомасса и плотность донных беспозвоночных

Показатели	р. Хайрюзская (притоки 2-го порядка)	р. Авача (нижнее течение)			р. Плотникова	р. Сокоч (приток р. Плотниковой)		р. Жупанка (приток верхнего течения р. Камчатки)	р. Озерная (Курильская), верховье	р. Унковская (верховье)	р. Дальняя (исток)
1	2	3	4	5	6	7	8	9	10	11	
Дата	июль, август <sup>1</sup>	начало сентября <sup>1</sup>			конец апреля— начало мая <sup>2</sup>	конец апреля— первая половина мая		конец апреля— начало мая <sup>2</sup>	14 апреля	21—22 августа	9 января
43	24	25	26	27	28	29	30	31	32	32	
Грунт	заилеп. мелкая галька, песок	иллистый песок у берега	песок на середине русла	заилепший песок	крупная галька	галька с песком	крупная галька	крупная галька	камни и галька	галька	галька с водорослями обростаниями
44	44	45	46	47	48	49	50	51	52	53	54
Количество проб	9	1	1	4	7	3	4	4	1	3	2
67											
Биомасса, г/м <sup>2</sup>	2.8	21.4	0.13	57.6	81.4	38.0	15.2	56.5	42.1	31.1	28.5
68											
Численность, экз/м <sup>2</sup>	—	2300	20	34320	13500	7627	8512	3350	78330	34950	1150
69											

<sup>1</sup> Данные И. И. Куренкова (1964). \* I. I. Kurenkov's data (1964).  
<sup>2</sup> Данные Е. Т. Николаевой (1968). \*\* E. T. Nikolaeva's data (1968).

в реках Камчатки (среднее из проб)

ТАБЛИЦА 1  
Таблица 1

Притоки оз. Курильско-10 го и р. Озерной		11 Притоки оз. Азабачьего							12	13	
кнжучевый "ключ" (рсокреп)	р. Хакыцин (устье)	р. Пономарская	р. Сиоидовка	р. Ламутка	р. Лотная (верхнее течение)	Первый рыводный "ключ"	Второй рыводный "ключ"	р. Малая Николка, приток 2-го порядка р. Камчатки (среднее течение)	нижнее течение	верхнее течение	
14	15	16	17	18	19	20	21		22	23	
11 апреля	18 апреля	начало августа	8 августа		5 августа	10 августа	11 августа		15 июля	6 мая	конец апреля—май
33	34	35	36		37	38	39	40	41	42	
галька с песком	галька с мелкой пемзой	галька, песок, детрит, коряги	камни с водорослями обрастаниями, галька, песок, детрит	крупные камни	крупные камни	камни и галька	камни, обросшие мхом	галька и граний в низовье	камни, галька	илстый песок у берега	галька
55	56	57	58	59	60	61	62	63	64	65	66
1	1	9	4	2	2	6	2	1	1	1	9
12,0	9,0	46,9	15,2	7,9	23,0	23,6	210,0	19,6	91,6	7,7	14,6
3010	2130	12990	13180	9160	10920	14790	59100	7540	12380	6080	15810

11

Table 1

Biomass and population density of benthic invertebrates in the streams of Kamchatka (mean data from the samples)

1--Indices; 2--Khairyuzovaya river (secondary tributaries); 3--Avacha river (lower reaches); 4--Plotnikova river; 5--Sokoch river (a tributary of the river Plotnikova); 6--Zhupanka river (a tributary at the upper course of the river Kamchatka); 7--Ozernaya river (Kuril'skaya), upper reaches; 8--Ushkovskaya river (upper reaches); 9--Dal'nyaya river (source); 10--Tributaries of Kuril'skoe lake and of the river Ozernaya; 11--Tributaries of Azabach'e lake; 12--Malaya Nikolka river, a secondary tributary of the river Kamchatka (middle course); 13--Kamchatka river; 14--Cohoe "spring" (rheokrene); 15--Khakytsin river (mouth); 16--Ponomarskaya river; 17--Snovidovka river; 18--Lamutka river; 19--Lotnaya river (upper reaches); 20--Pervyi fish "spring"; 21--Vtoroi fish "spring"; 22--Lower reaches; 23--Upper reaches; 24--Date; 25--July, August\*; 26--Early September\*; 27--End of April-early May\*\*; 28--End of April-first half of May; 29--End of April-early May\*\*; 30--April 14; 31--August 21-22; 32--January 9; 33--April 14; 34--April 18; 35--Early August; 36--August 8; 37--August 5; 38--August 10; 39--August 11; 40--July 15; 41--May 6\*; 42--End of April-May; 43--Bottom type; 44--Silted up, fine pebble, sand; 45--Muddy sand near the banks; 46--Sand in the middle of the river-bed; 47--Silted up sand; 48--Cobble; 49--Pebble and sand; 50--Cobble;

51--Cobble; 52--Rocks and pebble; 53--Pebble;  
 54--Pebble overgrown with algae; 55--Pebble and  
 sand; 56--Pebble with fine pumice; 57--Pebble,  
 sand, detritus, stumps with roots; 58--Rocks  
 overgrown with algae; pebbles, sand and detritus; 59-- Large rocks;  
 60--Large rocks; 61-- Rocks and pebble; 62-- Rocks overgrown  
 with moss; 63--Pebble and gravel in the lower  
 reaches; 64--Rocks, pebble; 65--Muddy sand near  
 the banks; 66--Pebble; 67--Number of samples;  
 68--Biomass, g/m<sup>2</sup>; 69--Abundance, number of  
 specimens/m<sup>2</sup>.

#### Rhithron brooks

The river Snovidovka (a northwestern tributary of Azabach'e lake) may serve as an example of such a brook. With regard to the degree of erosion of its bed, this stream can be classified as a river, but with respect to its yield in August it is rather a brook. Its relatively small degree of fall, moderate volume of flow and small water discharge determine the type of its bottom and the composition of its benthofauna. Rocky bottom types prevail in the upper and middle reaches, and pebbly bottoms with occasional sandy areas and remains of wood prevail in its lower reaches. On August 8, 1965, water temperature was 10-10.6°. Quantitative collections of benthos were gathered at the middle course of the brook.

The biomass of benthos varied in different stations of the brook between 7.8 and 31.7 g/m<sup>2</sup>: it amounted on an

average to 10.7 g/m<sup>2</sup> on rocky and pebbly bottom types, to 19.6 g/m<sup>2</sup> on finely textured sediments (Fig. 1e).

A characteristic feature of benthos in the brooks of this type is that it contains a considerable percentage of Chironomidae (on an average about 50%, on the rocks overgrown with moss about 65%). Therefore, benthos is here an excellent food base for the salmon spawning in this stream. Benthos collected from rocks and pebbles in the areas marked by a sluggish flow, abounds in larvae of various insects: Capnia, Nemoura arctica, Suwallia teleckojensis, Arctotipula; Ephemerella triacantha, Chitonophora aurivilii, Cinygmula cavum, Baetis tenax predominate in the benthos from the areas marked by a moderate flow, while larvae of Baetis sp. No 5 are the dominant organisms in the benthos from swiftly flowing parts of the stream.

#### Small rhithron rivers

Most rivers of Kamchatka flow in part through foothills and traverse stretches of piedmont varying in length. Some of the rivers are, however, of the rhithron type along their entire watercourse. Such rivers are usually found in narrow valleys.

The Ponomarskaya river (a tributary of Azabach'e lake) is a characteristic representative of this category. It arises from the confluence of two mountain brooks and has

a moderate flow, a small (less than 1 m) depth and a rocky-pebbly bottom throughout its length, except for a small area near the mouth. In the middle and lower reaches of the river there are, however, numerous "traps" (deep spots with a very sluggish current). Sand, mud and tree leaves accumulate at the bottom of such "traps." Fairly large bands of silty sand and pebble also extend along the banks. A multitude of stumps and accumulations of vegetable remains are found in the places marked by a sluggish flow. Water temperature in August is 7.2-8°.

The samples of benthos collected in the lower reaches of the river in August show that the benthos varies with regard to both the volume and the species structure, a circumstance due to the diversity of stations in different parts of the watercourse. The density of its invertebrate population varied between 400 and 44,000 specimens/m<sup>2</sup>; their biomass fluctuated between 0.1 and 202 g/m<sup>2</sup>.

The benthic fauna collected in the river Ponomarskaya from fine bottom sediments was richer than that found on rocky-pebbly grounds on account of large larvae of Tipuliidae (Fig. 1f). However, these larvae amounted to nearly 50% of the biomass even in the benthos gathered from pebbles (Fig. 1g).

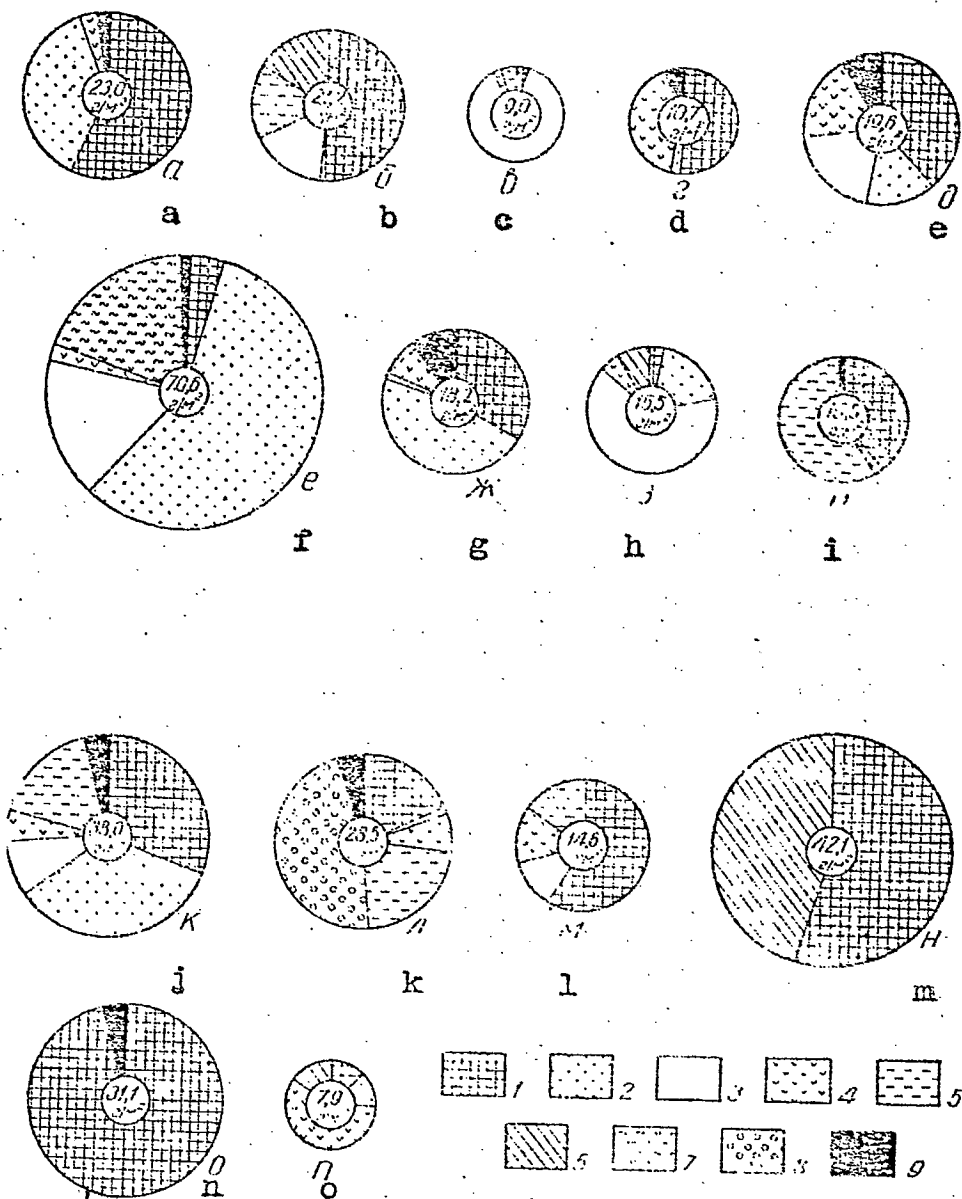


Fig. 1

Biomass and composition of benthos from the rivers of Kamchatka

LEGEND: 1--Chironomidae; 2--Diptera;

3--Stonefly; 4--Mayfly; 5--Caddis fly;  
 6--Planaria; 7--Oligochaetes; 8--Molluscs;  
 9--Others. a--Upper course of the river Lotnaya,  
 large rocks; b--Malaya Nikolka river, fine silty  
 bottom sediment near the spring opening; c--Mouth  
 of the river Khakytsin, pebbly bottom; d--Snovi-  
 dovka river, rocky-pebbly bottom; e--Snovidovka  
 river, fine silty bottom sediment; f--Ponomarskaya River, fine silty  
 bottom; g--Ponomarskaya river, pebble; h--Ponomarskaya river,  
 stumps on a pebbly bottom; i--Sokoch river, rocky-  
 pebbly bottom; j--Sokoch river, fine pebbly-sandy  
 sediment between the rocks; k--Upper reaches of  
 the river Dal'nyaya, pebbly bottom; l--Upper  
 course of the river Kamchatka, silted up pebbly  
 bottom; m--Upper course of the river Ozernaya  
 (Kuril'skaya), silted up pebbly bottom; n--Upper  
 reaches of the river Ushkovskaya, pebbly bottom;  
 o--Middle course of the river Lamutka, rocky  
 bottom (littoral zone).

p. 93

The poorest benthic fauna was collected from bare  
 pebbles of the medial (limnetic) zone (0.1 g/m<sup>2</sup>). It con-  
 sisted of Chironomidae larvae, Acarina, Planaria. Larvae of  
 mayflies (Cinygmula cayum, Ephemerella triacantha, Ameletus  
Camtschaticus) were found occasionally on the reverse sur-  
 face of pebbles.

The paucity of the pebbly bottom in the limnetic  
 zone is probably due to the fact that the <sup>stream</sup> bottom horizons  
 freeze up in the winter, as well as to the displacement of  
 pebbles during the flood.

Pebbly bottom types are less mobile in the rivers

of the Amur basin. This is attributed to the activities of larvae of the many species of caddis flies belonging to the families Psychomyidae, Hydropsychidae, Arctopsychidae and, particularly, Stenopsychidae, which build their trap-nets and pupal cases between the pebbles. Silt and sand accumulate between such firmly immobilized pebbles, vegetable growths develop on them and serve, in their turn, as a refuge for minute invertebrates. Such Trichoptera are represented in Kamchatka rivers by two species only: Hydropsyche nevae and Arctopsyche ladogensis. The latter species inhabits relatively large rhithron streams, while Hydropsyche nevae is also found in small, moderately swift rivers. No larvae of either of these species have been found in the river Ponomarskaya.

On larger rocks of a small rapid the biomass of benthos exceeded that recorded in the medial ( $22.8 \text{ g/m}^2$ ) and was represented essentially by Simuliidae larvae (81% of the total biomass).

In a quiet stretch at the middle course of the river, where the bottom is sandy, benthos was poor. It amounted to  $2.6 \text{ g/m}^2$  ( $10,100 \text{ specimens/m}^2$ ) and consisted of Chironomidae larvae, other Diptera and Oligochaetes.

Benthos is markedly more abundant on the sandy bottom of the littoral zone, where there is a considerable number of pebbles. The biomass of benthos in this biotope is  $99.7 \text{ g/m}^2$ . The presence of large larvae of dipterous

insects (Arctotipula, Dicranota and others) amounting to 75% of the total biomass, is a feature characteristic of this biocoenosis. The population density of such larvae is 1300 specimens/m<sup>2</sup>. The biomass of benthos (not including Arctotipula larvae which cannot be used for food by salmon fry because of their size) amounted to 24.7 g/m<sup>2</sup> and consisted essentially of Oligochaetae, larvae of mayflies and stoneflies. Furthermore, young larvae of Capnia and Nemoura arctica, as well as adult larvae of Suwallia teleckojensis were found in large numbers near the banks.

The species structure of the fauna found on the pebbly-sandy bottom was approximately the same, but its biomass was considerably smaller (31.6 g/m<sup>2</sup>).

The biomass of invertebrates on a stump lying on the pebbly bottom, was 15.5 g/m<sup>2</sup>. Larvae of stoneflies Suwallia teleckojensis predominated in it both numerically and by weight (Fig. 1h).

The biomass of benthos on the somewhat silted up sand and fine pebble in the shallow <sup>backwaters?</sup> offshoots of the river was 22.8 g/m<sup>2</sup>; in concentrations of vegetable remains it was 25.5 g/m<sup>2</sup>. The composition of benthos was the same in the two biotopes: it consisted of Chironomidae larvae, large dipterous insects (Arctotipula, Dicranota) and larvae of stoneflies (Capnia, S. teleckojensis).

In a miniature "trap" enclosing an agglomeration of coarse vegetable detritus, large larvae of caddis flies

Onocosmoecus flavus, Hydracarina and larvae of stoneflies Nemoura arctica live on the sandy-pebbly bottom alongside the forms listed above. The biomass of benthos is here up to 202 g/m<sup>2</sup>.

A multitude of young larvae of stoneflies Rhabdiopteryx quadrata and mayflies Chitonophora aurivillii appear here in October.

Rhithron rivers are very common in Kamchatka. In contrast to the river Ponomarskaya, these rivers leave foothills in the middle of their course and traverse vast stretches of wide, alluvial valleys. In this part of their

p. 94

watercourse the rivers meander a great deal, but have nevertheless a swift flow, low water temperatures in the summer, and are characterized for the most part by pebbly bottom types. Fine fractions accumulate only in the lowermost reaches of these rivers, where they slow down and change to potamon streams.

The river Sokoch belongs to this category. Another characteristic feature of this river is that it originates in a lake, as a result of which its <sup>flow is stabilized?</sup> source is in regiment and it does not flow through the mountains at any point. The river has a length of 25 km, a water discharge (at the time of low water) of about 5 m<sup>3</sup>/sec.; summer temperatures of the water do not exceed 12°. In the lower reaches, where the samples were taken (near the place where this stream

discharges into the river Plotnikova), pebbly-sandy bottom types predominate; pebbly-rocky stretches of the bottom are found occasionally. The river Sokoch is a typical salmon spawning ground.

At the end of April and in early May the biomass of benthos on the finely textured sediment between the rocks was twice that found on the rocks or on the pebbles. Furthermore, larvae of large dipterous insects predominated here, as they did in the river Ponomarskaya (Fig. 1i,j). Chironomidae larvae (Syndiamesa orientalis) and other Orthocladinae were abundantly represented in both stations.

Larvae of stoneflies and mayflies were found in all the samples collected at that time of the year, but were at early stages of development (Cinygmula cavum, Baetis tenax, Ephemerella triacantha, Suwallia teleckojensis) and measured mere 1-4 mm in length. Larvae of Diura nanseni, Oligoplectrodes potanini, Chitonophora aurivillii were represented by the middle growth stages. The biomass of benthos should therefore increase by the end of May and in early June, with the growth and development of the larvae.

The Dal'nyaya river flowing from Dal'nee lake into the river Bystraya (a tributary of the river Paratunka), is another rhithron river in regiment. It differs, however, from the river Sokoch because of its smaller size, in depth, water discharge and speed of its flow. Coarse gravel is the predominant type of bottom in this river. It is silted up

near the banks, is overgrown with algae in the <sup>middle</sup> ~~medial~~.  
 Prevalent depth: about 0.5 m. Sockeye salmon migrate down <sup>? up</sup>  
 the river Dal'nyaya to their spawning grounds in the lakes.  
 Sockeye and coho salmon spawn in the river itself.

The biomass of benthos (Fig. 1k) estimated at the upper course of the river in January, may be regarded as fairly great (28.5 g/m<sup>2</sup>). It consists essentially of larvae of amphibiotic insects represented by early and middle stages of development. The biomass of benthos should increase considerably towards spring with the growth of larvae.

Benthos from the headwaters of the river Dal'nyaya is mixed from the ecological viewpoint and consists of representatives of a variety of assemblages. The species adapted to swiftly flowing waters, are here lacking. For example, larvae of Baetis sp. No 5 were found only in the river Bystraya having a greater degree of fall. A multitude of molluscs (Limnaea auricularia lanuginosa, Pisidium, Planorbis), bryozoans, hydras, large Planaria, leeches of the genus Glossiphonia, Ostracoda, larvae of caddis flies Hydatophylax variabilis, H. nigrovittatus, chironomids Syndiamesa orientalis, Brillia modesta and others, larvae of stoneflies Suwallia teleckojensis and Capnia sp. sp., amphipods Gammarus lacustris inhabit silted up littoral areas, thickets of algae and stumps. Larvae of insects of the tachypotamophilic assemblage (Arcynopteryx sp., Diura nanseni, Chitonophora aurivillii, Mystrophora intermedia, Apatania crymophila,

Hydropsyche nevae), as well as crenobionts (Arcynopteryx altaica and Apatania zonella) predominate on slightly silted up pebbly types of bottom.

The river Zhupanka, a tributary of the river Kamchatka at its upper course, has the character of a rhithron river only in its lower reaches, where it flows through a wide alluvial valley. In the upper reaches and, partly, at the middle course this is a typical crenon stream

p. 95

characterized by a swift flow, a pebbly bottom and clear, cold waters even after it descends into the valley and nearly as far as the mouth. The great biomass of benthos (56.5 g/m<sup>2</sup>) collected from the pebble of the bar in the lower reaches of the river, consisted of two species of caddis flies: Mystrophora intermedia and Apatania crymophila. At the time, when the river was investigated (end of April-early May), both species were represented by adult larvae and by young pupae varying in abundance between 720 and 7400 specimens/m<sup>2</sup>.

#### Large rhithron rivers

This category includes the rivers and parts of rivers that are located in foothills, but are larger and have a greater volume of flow than the streams described in the preceding chapter. The valleys of such rivers are composed of alluvium and may be either narrow, or wide.

Rivers from the western shore of Kamchatka are also assigned to this type, even though they traverse a plain over a distance of several dozen kilometers (in the region of the Western Kamchatka depression). These rivers were assigned to this category on the basis of their hydrology, ichthyofauna and composition of benthic biocoenoses.

The river Plotnikova (basin of the river Bol'shaya on the western coast of Kamchatka) originates in Pachinskoe lake, but, due to its large degree of fall in the upper reaches, it is a torrential crenon stream with a rubbly bottom. The river acquires a premontane character only at its middle course, near the village Pachinki, where the sampling was done. At this point the water discharge is 5 to 30 m<sup>3</sup>/sec in the spring and in the autumn, up to 190 m<sup>3</sup>/sec during the summer flood. The depth of the river at the time of low water is 0.5-1 m; summer temperatures of the water do not exceed 11°; the mean water temperature in August is 8.2°.

The collections gathered from the transverse section of the river in the zone of the bar at the end of April and in early May show that the biomass of benthos was great both on the cobble (81.4 g/m<sup>2</sup>) and on the fine sediment between the cobbles (57.6 g/m<sup>2</sup>), but that the percentage of different groups varied in these stations: Chironomidae amount to 41% (by weight) on the sandy-pebbly bottom, to a mere 7% on the rocky bottom. The population density of caddis flies

(Mystrophora intermedia, Arctopsyche ladogensis, Oligoplectrodes potanini, Apatania stigmatella, A. crymophila and Hydatophylax nigrovittatus) was up to 7600 specimens/m<sup>2</sup> on the cobble. These species were represented by pupae and larvae (adult and middle developmental stages), as a result of which the biomass of caddis flies was equal on an average to about 72 g/m<sup>2</sup> and amounted to 89% of the total biomass of benthos. The same species were collected on the finely textured sediments, but they amounted in this instance to a mere 42% of the biomass. Mayflies were represented at this time of the year by early growth stages of larvae and were collected largely from fine sediments. They amounted to about 16% of the total biomass (Chitonophora aurivillii, Baetis tenax, Cinygmula cavum).

Stoneflies (Diura nanseni, Rhabdiopteryx quadrata, Suwallia teleckojensis) were also represented by larvae of the early or middle growth stages; in the two stations their biomass did not exceed 2-3% of the total biomass of benthos.

The river Avacha enfluent into the Gulf of Avacha, is a considerably larger rhithron stream. It arises from the confluence of small mountain rivers and crosses considerable stretches of foothills. Having reached the valley, the river Avacha retains its rhithron character virtually down to its lowermost reaches: pebbly bottom types predominate, the water is very transparent (at the time of the low-  
water level it contains 10-15 <sup>10-15 ppm alkalinity</sup> g/m<sup>3</sup> of limestone (literally solid suspension);

ppm = parts per million

84 g/m<sup>3</sup>  
 during the flood (84 g/m<sup>3</sup> or less), the maximum water temperature is 7-8°, the discharge of water is 75 m<sup>3</sup>/sec in the spring and 300-570 m<sup>3</sup>/sec in the summer, predominant depths at the time of low water are 1-1.5 m.

p. 96

The quantitative collections gathered from the silted up littoral sands and from the patch of eluted river sand in the stream-channel (Table 1), fail to reflect typical stations of this river. The great biomass recorded in the littoral zone (21.4 g/m<sup>2</sup>), consists almost entirely of Gammarus (12.1 g) and larvae of Chironomidae (7.5 g).

The qualitative collections of benthos gathered from the rocky bottom and from the sod in April and November, and the entomological collections obtained in the same area in June (region of the settlement Elizovo) reveal the following.

Trichoptera were found in considerable numbers on the littoral rocks at the end of April. These were adult larvae and young pupae of Mystrophora intermedia, young larvae of Onocosmoecus flavus, as well as adult larvae of stoneflies Capnia nigra. A mass flight of stoneflies Arcynopteryx compacta, Arcynopteryx sp., Diura nanseni and Rhabdiopteryx quadrata, the larvae of which live for the most part in the <sup>middle</sup> ~~medial~~, was observed here in June. The caddis fly species, which participated in the flight, were Mystrophora intermedia and Apatania crymophila.

In November, near the shore, where the current is

swift, early larval stages of caddis flies Mystrophora intermedia, stoneflies Rhabdiopteryx quadrata, Capnia nigra, mayflies Chitonophora aurivillii, Ch. mucronata and large larvae of caddis flies Oligoplectrodes potanini were collected on the washed out turf, at the depth of 1 m. The significant numbers of imagos participating in the flight and the fact that adult larvae of these insects are either large or medium-sized may be regarded as evidence that the biomass of benthos on the rocky bottom of the river Avacha is great.

Headstreams of the large rivers from the western coast (Bol'shaya, Kikhchik, Voronskaya, Oblukovina, Icha, Khairyuzova, Tigil'), as well as of other powerful streams running off the Sredinnyi range, are located in the mountains. Having emerged from the foothills into the West-coast lowland, these rivers retain their swift flow over a distance of 30-40 km. As a result of this the bottom of these rivers is predominantly of the pebbly, pebbly-sandy or sandy-pebbly type, except for the lowermost reaches, where it gives way to the sandy-silty sediment characteristic of potamon rivers.

The low temperature of water, its transparency, and relatively small depth, as well as the presence of pebbly bars in these rivers are also features characteristic of rhithron streams. The rivers serve as spawning beds for salmon almost along their entire length.

We have no quantitative collections from these rivers at our disposal, however, the composition of their hydrofauna evidences that the tachypotamophilous assemblage recorded in the rhithron rivers, also predominates here. Apart from the guide forms listed for the preceding category of rivers, we found here species, such as mayflies Rhithrogena sibirica, Heptagenia kibunensis, and H. soldatovi, that were not encountered elsewhere. Caddis flies Brachycentrus subnubilus, a potamobiont, is also found here.

The data discussed above show that the benthos collected in the rhithron rivers from the western coast of Kamchatka consists essentially of such potamobionts and numerous rhithrobionts, and that it is abundant.

The river Kamchatka can also be assigned to this subgroup. Near the source this is a eucronon river. Farther down it flows through foothills and emerges in the middle of its course in the Central Kamchatka Depression. Even while traversing the lowland, the river Kamchatka retains certain characteristics of a rhithron stream as far as the settlement Kozyrevska. Farther on this becomes a typical potamon river with a large water discharge (450-1000 m<sup>3</sup>/sec at the time of low water) and a high index of turbidity (up to 290 g/m<sup>3</sup>).

Quantitative collections of benthos were gathered in the lower part of its upper reaches (i.e. in the region of the settlement Mil'kovo) at the end of April and in early May. The collections were made only from the areas with a

silted up pebbly bottom. The biomass of benthos in this biotope is smaller than in the other rhithron rivers. This

p. 97

may be due to the relatively large amounts of suspension in this river and to a lesser transparency of its water.

Because of the considerable quantities of silt in this station, Chironomidae predominated here in the benthos (60% of the total biomass, Fig. 11). Larvae of other insects belonged for the most part to the tachypotamophilic assemblage, however, we also found here the caddis fly species Brachycentrus subnubilus, a typical potamobiont.

The river Ozernaya, a large rhithron river originating in Kuril'skoe lake, occupies a somewhat special position. The upper reaches of the river Ozernaya are characterized by a sluggish flow and predominantly silted up, pebbly types of bottom. The biomass of benthos calculated on the basis of one single sample, proved to be great ( $42.1 \text{ g/m}^2$ ) and consisted of Chironomidae and Planaria (Fig. 12). Larvae of the other amphibiotic insects, which constituted the major bulk of the biomass in the rivers examined earlier, were lacking. At the distance of six kilometers from the source the character of the river alters: its speed increases and it forms rapids. Chironomidae are few in the qualitative collections from this part of the river, and the biomass of benthos consists for the most part of larvae of large and medium-sized species of stoneflies,

mayflies and caddis flies (Ephemerella aurivillii, Baetis sp. No 5, Suwallia teleckojensis, Isogenus rubecula, Arcynopteryx altaica, Ecclisomyia camtschatica, Apatania stigmatella and others).

The Ushkovskii "strait" linking the limnokrene Ushkovskoe lake with the river Kamchatka, is a short, but fairly swift and deep (over 3 m) river. <sup>Flow is stable</sup> ~~It is in regiment~~ only at the time of the low water level: high waters of the river Kamchatka flood both the limnokrene and the "strait." The quantitative collections of benthos described in Table 1, were gathered in the pebbly littoral zone at the river-head. In August the biomass of benthos was great and about 90% of it consisted of Chironomidae larvae (Fig. 1n). Salmon fry from fish-rearing stations feed in both the Ushkovskii "strait" and the lake and find here an adequate food supply.

Water sow-bug (Asellus higendorffii) lives in the Amur basin and in analogous streams effluent from limnokrene, as well as in the limnokrenes proper, in the stations with silted up bottom types. Water sow-bug constitutes a considerable percentage of the biomass of benthos and of the food consumed by young chum. This species does not occur in Kamchatka (it may have become extinct during the Glacial Epoch), even though the environment is here favourable for its existence.

### Small Potamon rivers

The river Lamutka, a southern tributary of Azabach'e lake, is a potamon river meandering over a wide alluvial plain. However, similarly to the large rivers flowing through a plain, this river retains over a considerable distance features that are characteristic of rhithron streams. The river is about 15 km in width and has a moderately swift flow. Rocky-pebbly bottom types predominate in its upper and middle reaches, while the lower reaches have essentially sandy-pebbly and silty-sandy types of bottom. The quantitative collections of benthos carried out in August 7 km from the mouth of the river were gathered from a rocky bottom. These collections show that the biomass of benthos is here smaller than in the rivers examined earlier and amounts to mere 7.9 g/m<sup>2</sup> (Fig. 1b).

Comparison of the biomasses of benthos collected in August from the tributaries of Azabach'e lake shows that the smallest volumes of benthos were found in the river Lamutka. Chironomidae and other Diptera constitute 13% each of the total biomass, Planaria amount to 14%, mayflies to 59%. Ephemeroptera are represented by an impoverished assemblage of rhithrobiontic species and of a tachypotamophilic species, i.e. the eurybiontic Chitonophora aurivillii.

The composition of benthos is even less varied in the small tertiary potamon tributaries of the river

Khairyuzova. These streams do not rise from sources in the mountains, but flow along their entire length through the lowland with patches of swamp here and there.

According to the data of I.I. Kurenkov (1963), in August the biomass of benthos was up to 9-13 g/m<sup>2</sup> only in the still offshoots of the rivers Kekuk and M. Taklyvayam, where larvae of Trichoptera predominated. In the other samples taken from sandy-pebbly bottom types, the biomass of invertebrates amounted to 0.01-1.50 g/m<sup>2</sup> and consisted essentially of oligochaetes and Chironomidae larvae.

#### Potamon parts of rivers

The Kamchatka peninsula is a mountainous country and within its boundaries there is not one single large river flowing entirely through a plain or lowland. The river Kamchatka (from the settlement Kozyrevska on) may be regarded as the most characteristic potamon river. The only information available on this part of the river Kamchatka are I.I. Kurenkov's data (1964) summarized in Table 1. The biomass of benthos was estimated 15 km downstream from the settlement Klyuchi. It amounted to 7.7 g/m<sup>2</sup> in the littoral at the depth of 1 m. Half the biomass consisted of Chironomidae larvae, the remaining half was represented by larvae of other aquatic and amphibiotic insects. It may thus be seen that the biomass of benthos in the lower reaches of the

river Kamchatka was half that recorded at its head.

Evaluation of benthos from the river Kamchatka with regard to its trophic value to salmon fry and to juveniles of other fishes, is not among the objectives of this paper. We merely wish to note that fish intensively feed primarily on larvae and pupae of Chironomidae, on stonefly and mayfly larvae, as well as on representatives of the other groups of fauna found in the river. This may be seen from the following data on feeding habits of young fish: the food spectrum of young sockeye, coho and chinook salmon compiled by I.I. Kurenkov (1964) and listed by large taxonomic units of benthos; the species composition of the food spectrum of young chum determined by E.T. Nikolaeva (1968); the species structure of the food spectrum of young coho salmon determined by Zh.Kh. Zorbidi (in the article appearing in the present symposium).

#### CONCLUSIONS

- (1) Larvae and pupae of Chironomidae, the most valuable items in the food spectrum of young salmon, constitute a considerable percentage in the biomass of benthos from the streams of Kamchatka. Larvae of stoneflies and mayflies are also found here in significant quantities and, because of their size, are readily accessible to the foraging juveniles.
- (2) The smallest biomass of benthos was recorded in the

spring and during the summer near the mouth of the streams, on sandy bottom types in potamon stretches of larger streams and in small potamon rivers (2.8-9.0 g/m<sup>2</sup>). Benthic populations found on the rocks overgrown with plants attain high quantitative indices (up to 210 g/m<sup>2</sup>).

(3) The species of Trichoptera binding (with the help of their trap-nets and pupal cases) mobile pebbles to the river bed in swiftly flowing streams, are poorly represented in the benthos of Kamchatka rivers. This circumstance has an unfavourable effect on the development of benthofauna in such portions of the river bottom.

(4) The absence of the water sow-bug in the benthos of Kamchatka rivers and in their limnokrenes is a shortcoming of this benthos. This crustacean is widely distributed in the waters of Siberia and <sup>the</sup> Far East. Since biotopes favourable for the development of this organism exist in Kamchatka, we suggest that attempts be made to establish this valuable food item of young salmon in the streams of Kamchatka.

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