A review of benthos investigations on the shelf of the northeastern Sakhalin

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Benthos of the shelf of the northeastern Sakhalin

1. A brief historical review of studies of coastal benthos of the northeastern Sakhalin

The development of the rich natural resources of the coastal areas of the Okhotsk Sea by Kamchadals (Itelmens), Lamuts (Evens), Kuriltses (Ainu), Koryaks and other aboriginal peoples started from time immemorial. The Russians started to develop them in the 17th century. However, first scientific data were obtained only in the first half of the 18th century. At that time, in accordance with Peter the Great's plans, two expeditions to Kamchatka were organized and conducted. As regards to the greatness of these expeditions, there were no similar ones before or even long after them. The Second Kamchatskaya or Great Northern Expedition of 1732-1743 played a very special role in the studies of the biological resources of the Okhotsk and Bering Seas, mainly due to the participation in them of two naturalists – post graduate of Academy of Sciences G.V. Steller and student S. Krasheninnikov. Unfortunately, as a result of Steller's death during the return from the expedition a significant part of his manuscripts and materials was lost. However, some parts of the remaining manuscripts were published in 1751-1774. Some parts of them served as a basis for the scientific works of P.S. Pallas (1787-1811) and V.G. Tilesii (1809-1813). In those works vertebrate animals were mainly described, in particular many fishes and sea cow that is now extinct. However, some attention was paid to marine invertebrates as well. The most significant of them was a fundamental work of P.S. Pallas "Zoogeografiya Rosso-Aziatika (1811)", which is the first inventory of the animal world of the Pacific Ocean. S. Krasheninnikov after he became a professor in 1756 published a two-volume colorful and detailed description of nature and inhabitants of Kamchatka Peninsula and its coastal waters.

In early 19th century one more big sea expedition was conducted. It was the First Russian world expedition under the command of I.F. Kruzenshtern, which

worked in the northern part of the Pacific Ocean, including the Okhotsk Sea, in 1805. Two outstanding naturalists V.G and G.I Langsdorf participated in that expedition. On the expedition vessels “Nadezhda” and “Neva” they visited the Okhotsk Sea, Kamchatka, Sakhalin and the Kuril Islands. They gathered rich collections of fishes, sea invertebrates and plants, made some drawings of living animals from life. In the above-mentioned works Tilesii using Steller’s and own materials gave a description of some animals. In particular, he gave the first description of such commercially important fishes as Pacific cod and Far-eastern navaga (wall-eyed Pollack, Kamchatka steelhead, East Siberian char, capelin, greenling, while some others were almost simultaneously described by Pallas). S. Agard, A. Postels and F. Ruprekht did the treatment of the floristic material.

During the expedition on the vessel “Senyavin” in 1826-1829 under the command of F. Litke along the coast of the Bering and Okhotsk Seas a medical doctor G. Mertens studied the animals of those seas. However, after his sudden death in 1830 the majority of his notes, drawings and collected material were lost. Additional material was collected in 1839-1849 by a laboratory assistant of Zoological Museum of the Academy of Sciences I.G. Voznesenskii, mainly in the Russian-American Territory and in Kamchatka. He visited Iturup Island of the Kuril Islands as well.

The expedition of academician A.F. Middendorf to the northeastern Siberia in 1842-1845 was of major importance for the study of life of the Okhotsk Sea, especially invertebrates and algae. The third stage of that expedition of the outstanding explorer, which started in early April in Yakutsk, was named Okhotsko-Priamurskii. As a result, not only the Shantar Islands were studied, but also a vast western part of the Okhotsk Sea up to the mouth of the Tugur River. Middendorf managed to gather huge collections including, among other material, animals and plants of the coastal waters of the western part of the Okhotsk Sea. As a good contrast to many collections of the previous researchers, the collections of Middendorf were more fortunate. They were delivered to Saint Petersburg safely,

analysed by Middendorf and other prominent naturalists of that time. The results were published in a fundamental work by Middendorf "Puteshestviye na sever i vostok Sibiri" ("Travel to north and east of Siberia") (Middendorff, 1851).

Unfortunately, none of those and all the following expeditions of the 19th century did not study the coastal waters of the northeastern Sakhalin. That area stayed the least studied of all the Okhotsk Sea. The situation changed only by the beginning of the 20th century, when the studies entered a significantly different stage. Data obtained by manufacturers and naturalists were not enough for organizing a most efficient development of fish, sea animals and other natural resources of the far-eastern seas of Russia. For that reason, Priamurskii Office of the Department of Agriculture and State Property was established in Khabarovsk in 1898. Young naturalists V.K. Brazhnikov and N.Ya. Domashnev were appointed the fisheries managers in that Office. They had a sail motor schooner "Storozh" at their disposal. On that schooner V.K. Brazhnikov did a lot of research of fisheries and fisheries objects off Sakhalin and in Amurskii Liman in 1899-1902. In that expedition benthos stations were done for the first time at the northeastern coast of Sakhalin (Fig. 1.1). V.K. Brazhnikov (1907) published the results of the analysis of the faunistic material of the expedition, mainly on decapods.

Some time later Hydrographical Expedition of the Eastern Ocean worked in the Okhotsk Sea under the command of M.Ye. Zhdanko and later B.Davydov on the vessel "Okhotsk". The collection of biological samples was not required in the hydrographical expedition, which purpose was cartographical works, description of coasts and, partially, hydrological studies. However, a good tradition that is now forgotten still existed at that time, when the medical doctors of the expeditions voluntarily acted as naturalists and collected zoological and botanical samples. In 1908 – 1918, thanks to the enthusiasm of the medical doctors of the expedition F.A. Debek, N.G. Shiryaev and G.R. Meder, samples were collected by use of trawls, dredges and planktonic nets in many areas of the Okhotsk Sea, including

those previously not visited by biologists, mainly in its northern part. In 1910 and 1918 several benthos stations were done off the northeastern Sakhalin (Fig.1.2).

Summing up the general results in the area of biological research of the Okhotsk Sea, which were achieved before Russian Revolution, it can be assumed that it was the period when the foundation (even though incomplete) of our knowledge of the nature of that unique reservoir was laid up. It especially concerned its coastal waters, their animals and vegetation and their fisheries resources. However, the northeastern coast of Sakhalin remained one of the least studied areas of the Okhotsk Sea.

The incomplete knowledge of the fauna of the Okhotsk Sea resulted in a mistaken assumption that the fauna of our far-eastern seas, especially the Okhotsk Sea, had an Arctic nature. Both a prominent Swedish marine zoogeographer S. **Экман** and a Russian expert on the fauna of the far-eastern seas P.Yu. Shmidt shared that mistake. The assumption stayed till mid-1930-ies.

A completely new stage in the study of the far-eastern seas started immediately after the establishment of the Soviet government in the Far East. A most outstanding, although short, period of studies of the far-eastern seas, and the Okhotsk Sea in particular, before the Great Patriotic War with Germany was closely connected with the name of an outstanding Russian hydrobiologist, a professor of Leningrad University K.M. Deryugin. All the studies by Deryugin were characterized by a broad complexity, which raised them to a qualitatively higher level. The animal and plant world of the far-eastern seas was studied only in a close connection with complex investigations of the environment. Even plants and animals were studied in a close relationship with each other as components of solid communities or biocenoses. Such ecological approach became the dominant one in the studies of the far-eastern seas, including the Sea of Okhotsk.

The years 1932-1933 were a culmination period in the history of studies of the shelf the far-eastern seas and especially the Okhotsk Sea before the war. At that time in connection with the Second International Meteorological Polar Year

Pacific Research Institute of Fisheries and Oceanography (PRIFO), **State Geological Institute** and Pacific Committee of AS U.S.S.R organized many expeditions simultaneously under the same program in all the far-eastern seas under the general direction of K.M. Derygin. In 1932 only in the Okhotsk Sea three trawlers worked at the same time under command of P.V.Ushakov, P.Yu.Shmidt and I.A. Polutov. During that year as a result of well-planned complex works vast data were obtained, which allowed getting quite a full knowledge of the nature of our far-eastern seas up to the maximal depth. The shelf of the northeastern Sakhalin (Fig. 1.3 and 1.4) was also studied in detail for the first time.

First of all, it became very clear that the faunas of the Sea of Japan and the Okhotsk and Bering Seas should be referred mainly to the boreal type, which refuted the previous assumptions, especially those expressed in P.Yu. Shmidt's works on the Arctic nature of the Okhotsk and Bering Seas.

Unfortunately, all the pre-war works on the Okhotsk Sea, as well as the summarizing report by P.V. Ushakov (1953), presented data on fauna and some information on its distribution under the influence of environmental factors, but they did not give a description of any bottom communities, with an exception of some works by K.M. Deryugin on Peter the Great Bay, I.G.Zaks on the Shantar Archipelago and some others. The bottom communities of the northeastern Sakhalin also remained non-described.

After the war the hydrobiological works in the far-eastern seas started on a larger scale. In addition to traditional far-eastern researchers – scientists from PRIFO and its branches, Zoological Institute of AS U.S.S.R. in Leningrad and Leningrad University, the specialists from Moscow Institute of Oceanology, AS U.S.S.R., VNIRO and Moscow State University (MSU) were actively involved in the study of biology of the far-eastern seas. However, a large complex expedition of ZIN and PRIFO in 1947-1949 collected vast material only at the southern Sakhalin and the southern Kuril Island, without any research of the more northern areas.

Starting with 1949, an immense complex research began in the Pacific Ocean and its seas, mainly of the deep part. The shelf of the northeastern Sakhalin was investigated by use of a few stations during the second (1949), seventh (1951) and twelfth (1952) voyages of R/V "Vityaz".

In 1955 during the Far-eastern Coastal Expedition of the Institute of Oceanology of AS U.S.S.R. a hydrobiological research of the shelf of the eastern Sakhalin was carried out. Data obtained as a result of that expedition as well as those of "Vityaz" (Fig. 1.5) were used for a summarized description of benthos of the Okhotsk Sea (Savilov, 1961; Kuznetsov, 1980). The maps of the distribution of main ecological (or rather, trophic) groups of benthos were made, which reflected zonality connected with depth, bottom sediments and currents.

Starting with 1973, the studies of the PRIFO researchers on stocks, distribution and some aspects of ecology of the commercial mollusks of the family Buccinidae, including the coastal waters of the northeastern Sakhalin (Piskunov, 1979; Shuntov, 1985) were actively conducted.

However, the quantitative characteristic of benthos of the coastal waters of the northeastern Sakhalin remained insufficient. For that reason, in 1974-1977 PRIFO carried out several quantitative surveys of benthos with a purpose to determine the modern state of benthos as the feeding basis for fish and invertebrates (Koblikov, 1979; 1982; 1985; 1988; Koblikov et al., 1990). Although later PRIFO continued the research in the Okhotsk Sea, those surveys played the main role in characterizing the benthos of the shelf of the northeastern Sakhalin (Fig. 1.6) and were used to calculate the productivity and to determine the composition, distribution and trophic structure in that region (Koblikov et al., 1990; Dulepova, Borets 1990).

Laboratory of ecosystems dynamics of the Institute of Marine Biology FEB RAS under the headship of A.I. Kafanov investigated a number of lagoons of the northeastern coast of Sakhalin (Kafanov, 1986).

A new era in the hydrobiological studies of the far-eastern seas was started in 1962-1975 by the coastal expeditions of ZIN AS U.S.S.R. under the leadership of A.N. Golikov. It was connected with the detailed investigations of the upper parts of the shelf by a wide and continuous use of SCUBA-diving equipment. These investigations included the northeastern Sakhalin only in a complex expedition of ZIN and PRIFO in 1978 on R/V "Poseidon" under the leadership of V.G. Averintsev and B.I. Sirenko. The studies at a depth to 40 m were conducted by use of a SCUBA-diving technique of A.N. Golikov, at greater depth they were done by traditional methods.

Bottom biocenoses and regularities of their distribution on the shelf were studied. A close connection between the distribution of water masses, the degree of macrobenthos development and trophic structure of the community was shown (Averintsev et al., 1982). The composition and structure of the bottom population of Nabil and Piltun lagoons off the coast of the northeastern Sakhalin were studied (Tabunkov et al., 1988).

In 1992-1993 the researchers of IMB under the leadership of V.I.Fadeyev made hydrobiological and trawling collections in the upper part of the shelf of the northeastern Sakhalin in the areas adjacent to Piltun lagoon. Unfortunately, the results have not been published yet. Only minor data obtained in 1995 in the same place by the participants of the expedition of IMB under the leadership of Ye.I. Sobolevskii were published (Sobolevskii et al., 2000).

From 1990 to 1998 the benthos investigations on the shelf of the northeastern Sakhalin were conducted by the expeditions of SakhRIFO and Far Eastern Research Institute of Hydrometeorological Studies (FERIHS), mainly in the Piltun-Astokhskii area.

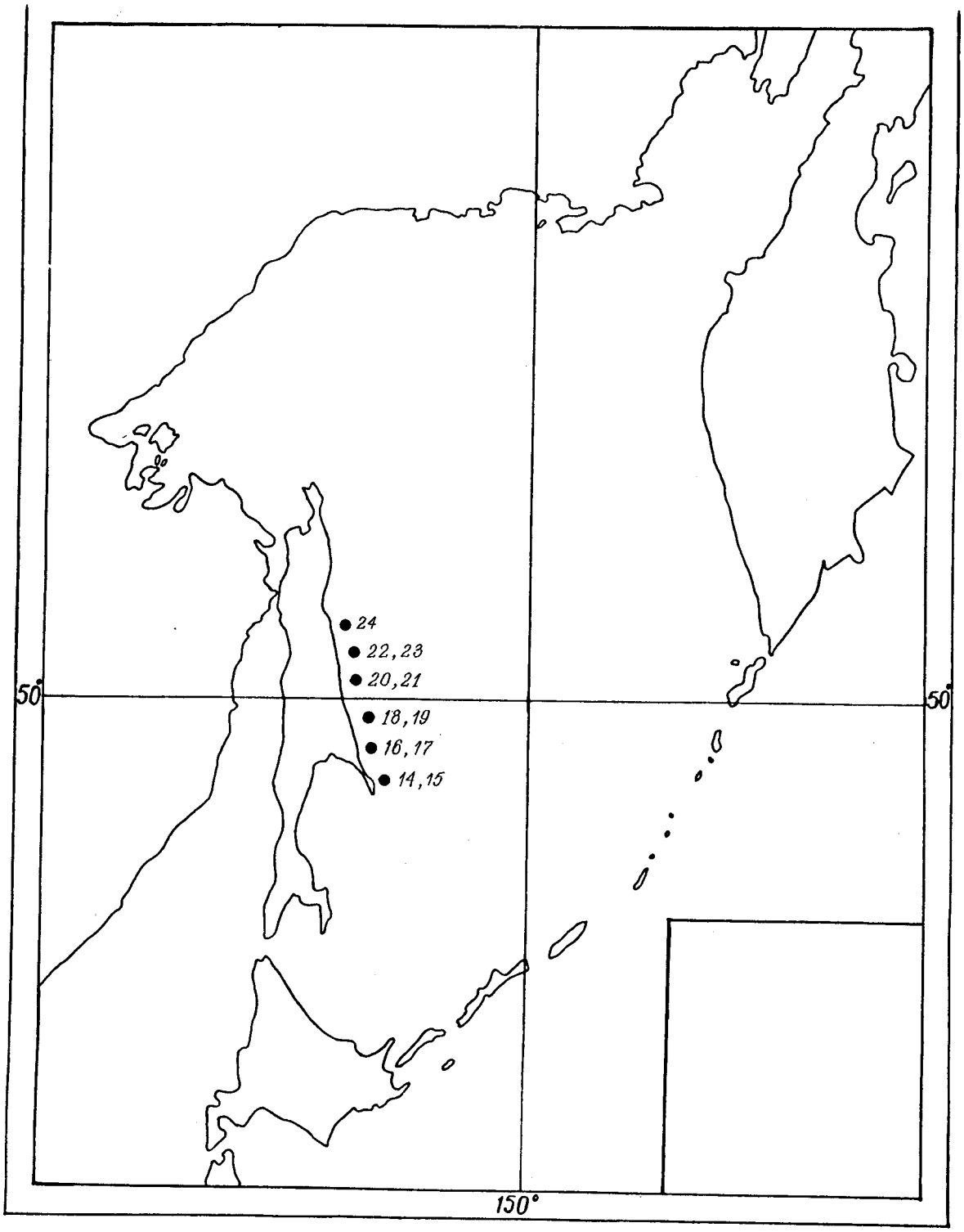

Fig.1.1.Benthic stations of the schooner "Storozh" in 1899-1902. off the northeastern Sakhalin (From: Ushakov, 1953)

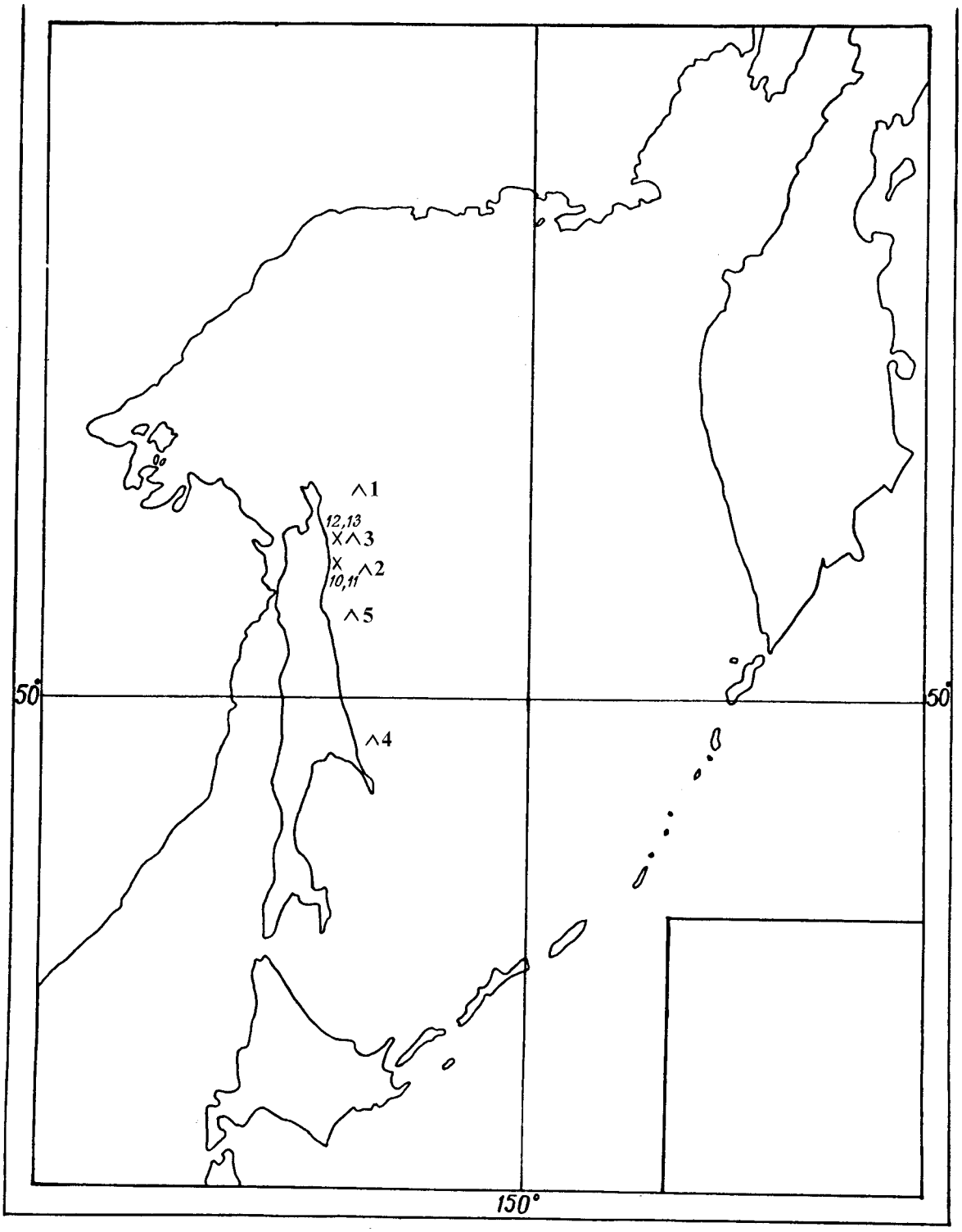

Fig.1.2. Benthic stations off the northeastern Sakhalin
Of the Hydrographic expedition of the Easter Ocean in 1910 (crosses) and in 1918. (ticks) (From: Ushakov, 1953)

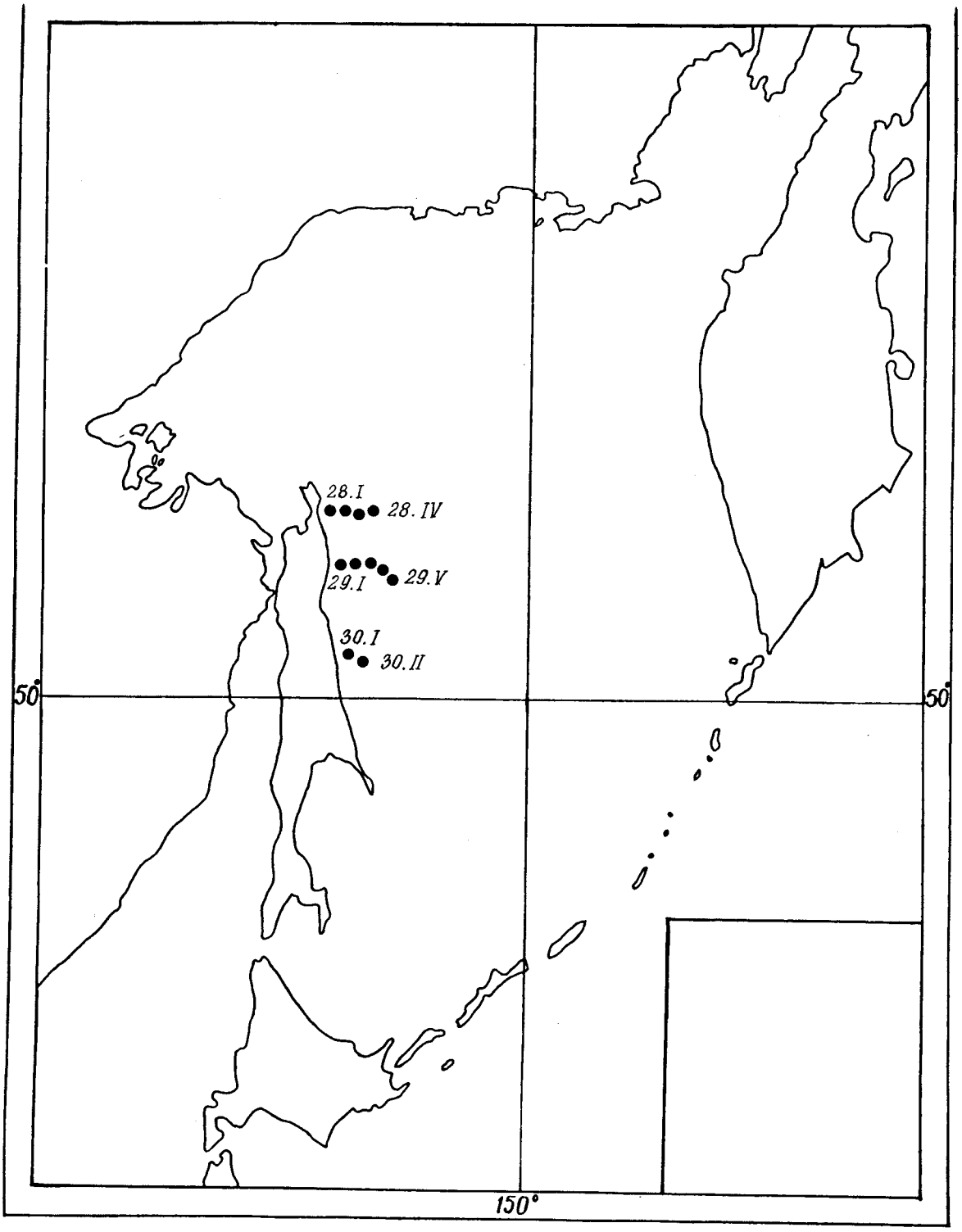

Fig.1.3. Benthic stations off the northeastern Sakhalin on **р/т** «Ara» in 1932. (From: Ushakov: Ушаков, 1953)

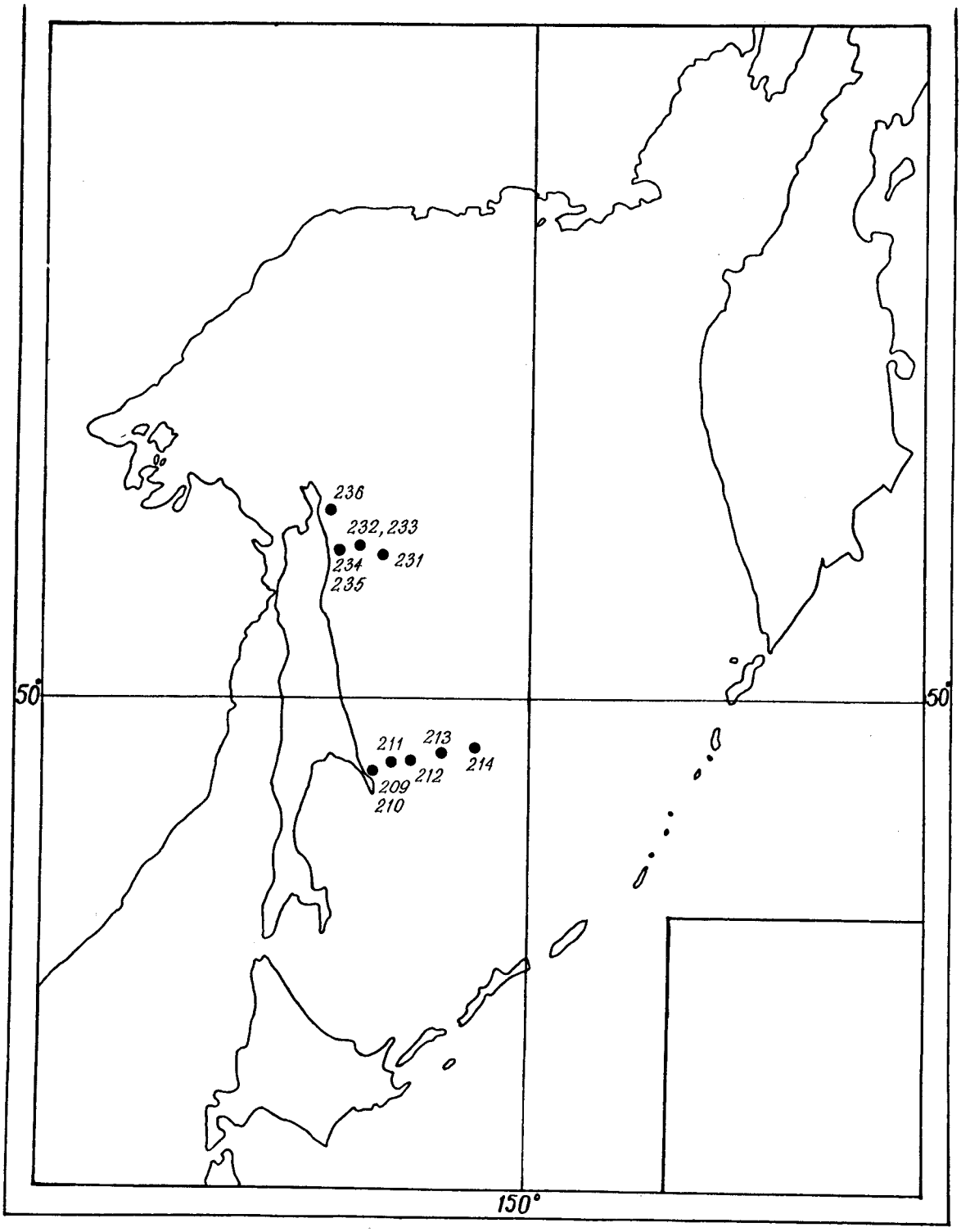

Fig.1.4. Benthic stations on **р/т** “Gagara” off the northeastern Sakhalin in 1932

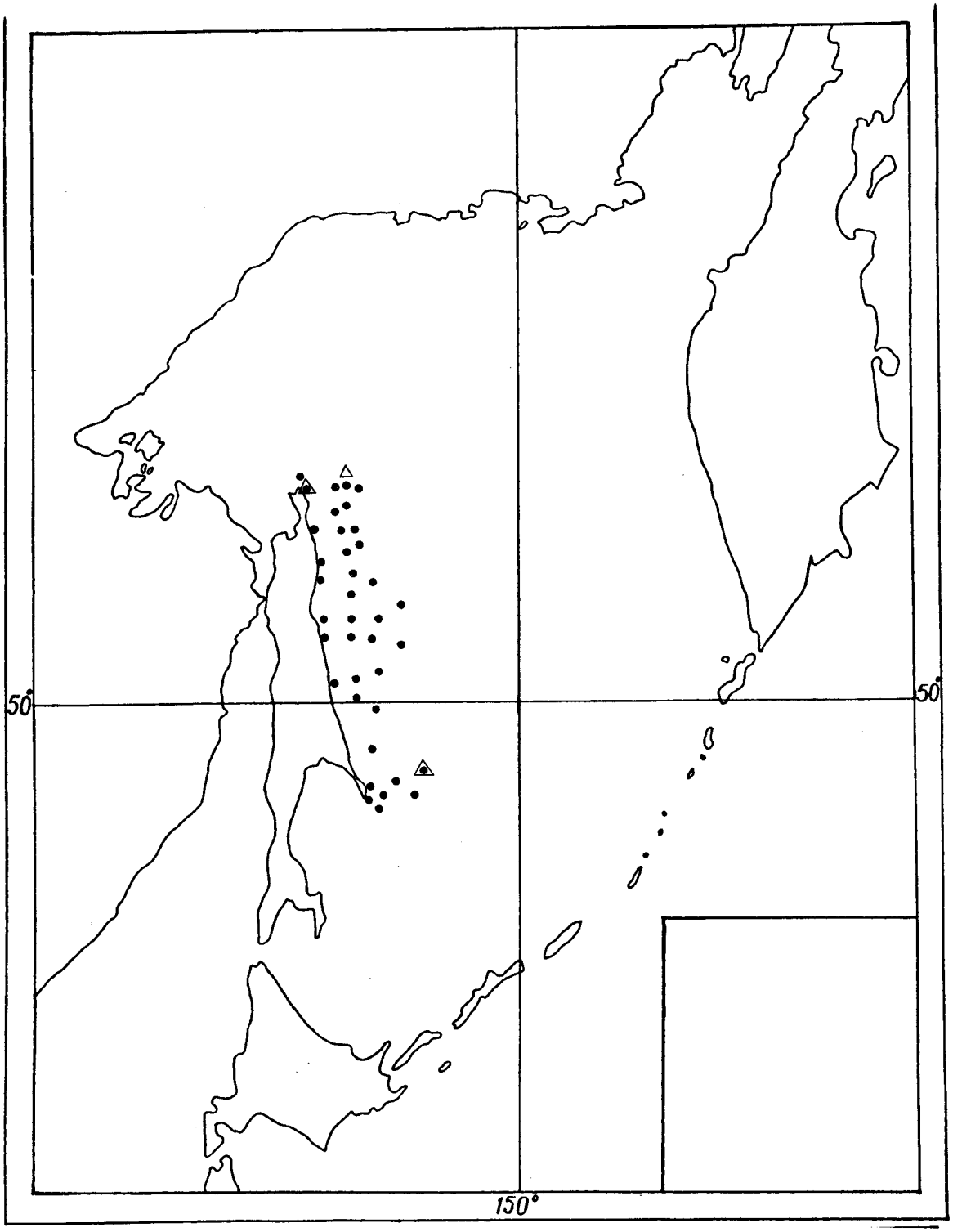

Fig.1.5. Map of benthic stations off the northeastern Sakhalin on E/V "Vityaz" in 1949-1954. Black circles – quantitative dredging stations; light triangles – trawling stations (From: Savilov, 1961)

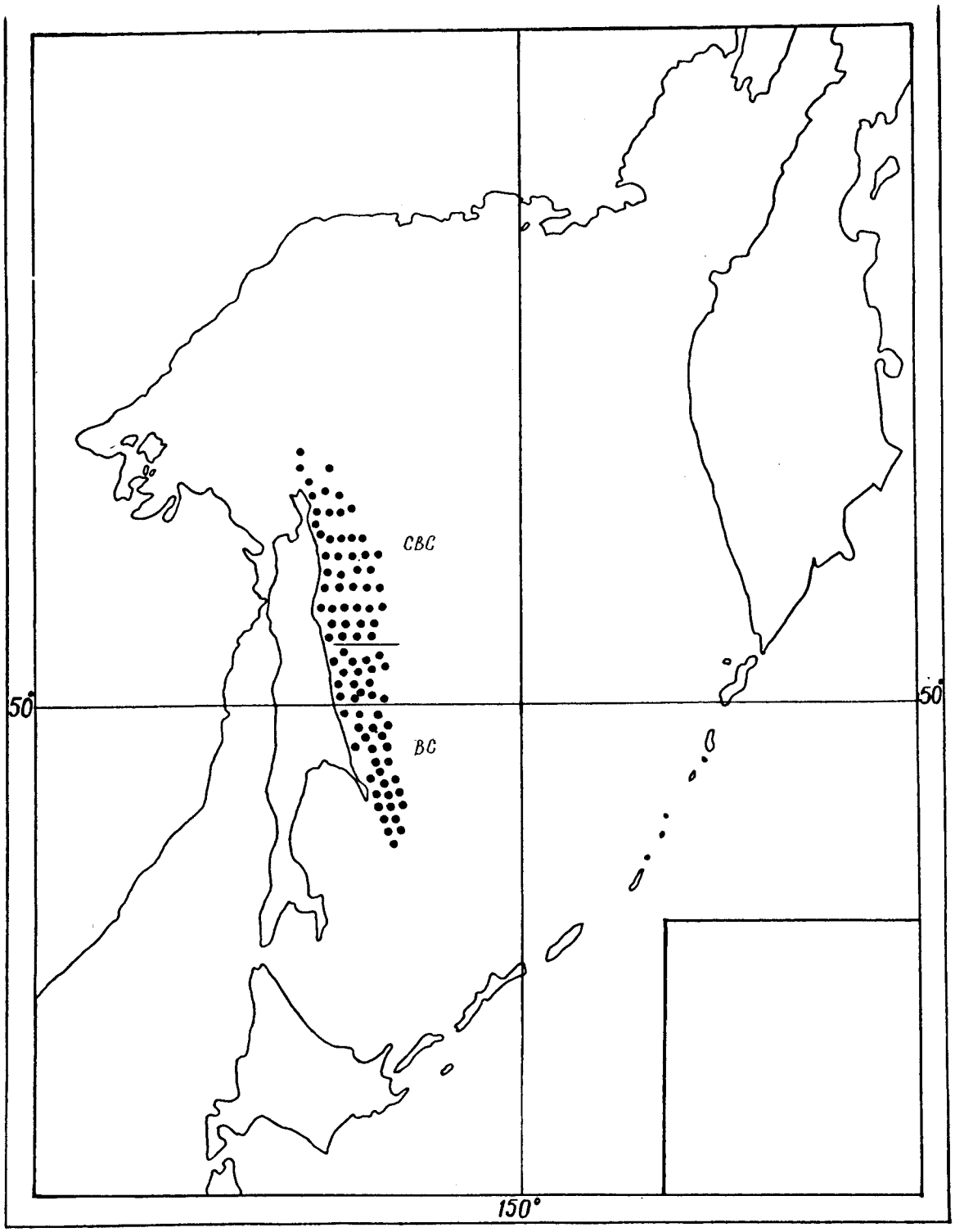

Fig.1.6. Map of benthic stations of PRIFO off the northeastern Sakhalin in 1974-1986. NES – norther part of the eastern Sakhalin; ES –central part of the eastern Sakhalin (From: Koblikov et al., 1990)

2. Trophic zonality of bottom fauna of the shelf and upper horizons of the slope of the northeastern Sakhalin

A comprehensive study of habitat conditions of commercial bottom fishes and invertebrates, in addition to the determination of the state of their feeding base, essentially depends on the investigation of the trophic structure of benthos of this part of the sea as a whole. The trophic factor is one of the main factors influencing bottom animals, by a certain and regular pattern forming the structure of all bottom population. Based on the trophic characteristic of aggregations of benthic forms, it is possible to explain to a certain degree the distribution of biocenoses, the change of one biocenosis by another, to characterize the changes in bioproductivity in different parts of the sea. Moreover, establishing accurately food groups of a certain fauna and the areas of their dominant development can serve as indicators of long-term hydrodynamic, hydrochemical and geological processes on the sea bottom. A scheme of division of sea bottom animals into ecologically isolated groups and adapted types was suggested by Savilov (1957, 1961). That scheme took into account all the previous works of researchers in the area of feeding, distribution, dependence on different environmental factors (bottom, currents, presence of organic matter). He used as a basis for that scheme, first of all, the differences in feeding behavior. Four main feeding groups were distinguished: sestonophages, species that collect detritus from the surface of the bottom; species that fully engulf the ground; predators and necrophages. Besides, A.I. Savilov took into account the ability or disability of hydrobionts for moving and their preference of certain physical characteristics of the ground (both as substratum for attachment of the animals on the bottom and as a carrier of food material for the digging forms). Therefore, the scheme took into consideration motile and non-motile animals attached to hard or loose substrate. Using the scheme of division of bottom fauna into trophic ("ecological" by the terminology of A.I. Savilov) groups suggested by A.I. Savilov and accepted by

Russian hydrobiologists, let us have a look on the composition and distribution of non-motile and motile sestonophages, collecting and non-selective detritophages and carnivorous animals.

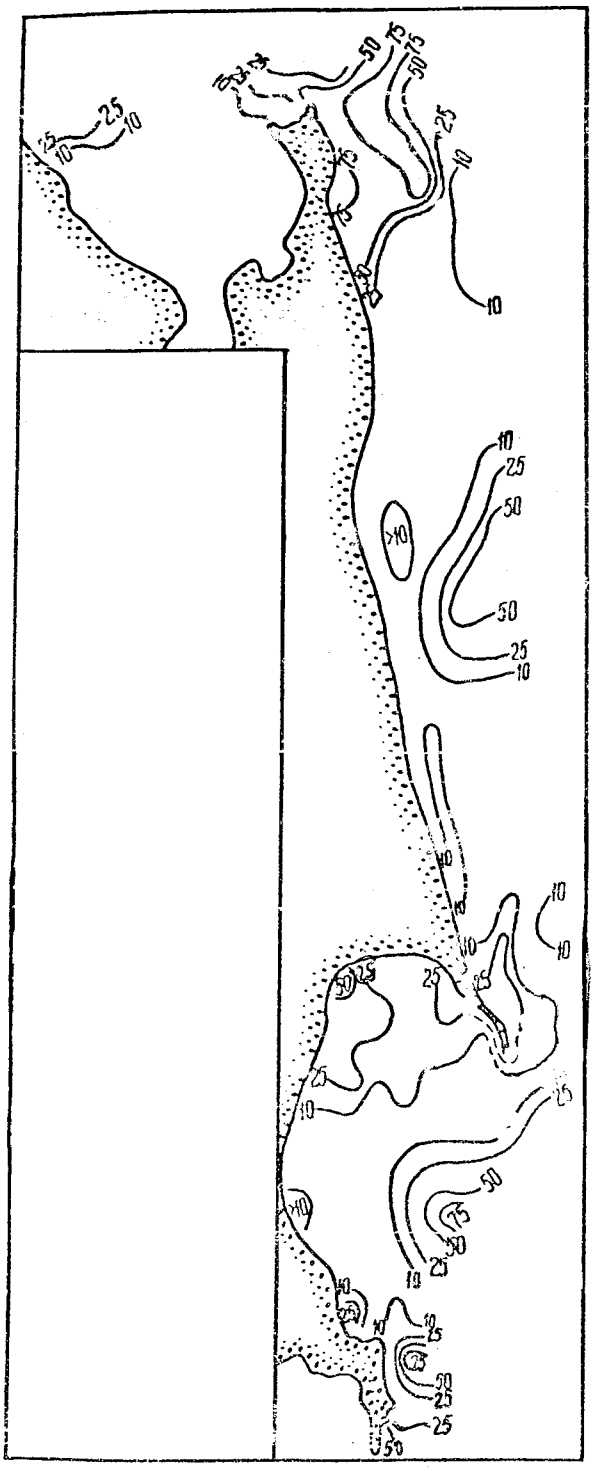

Fig.2.1. Distribution of biomass of non-motile sestonophages (%)

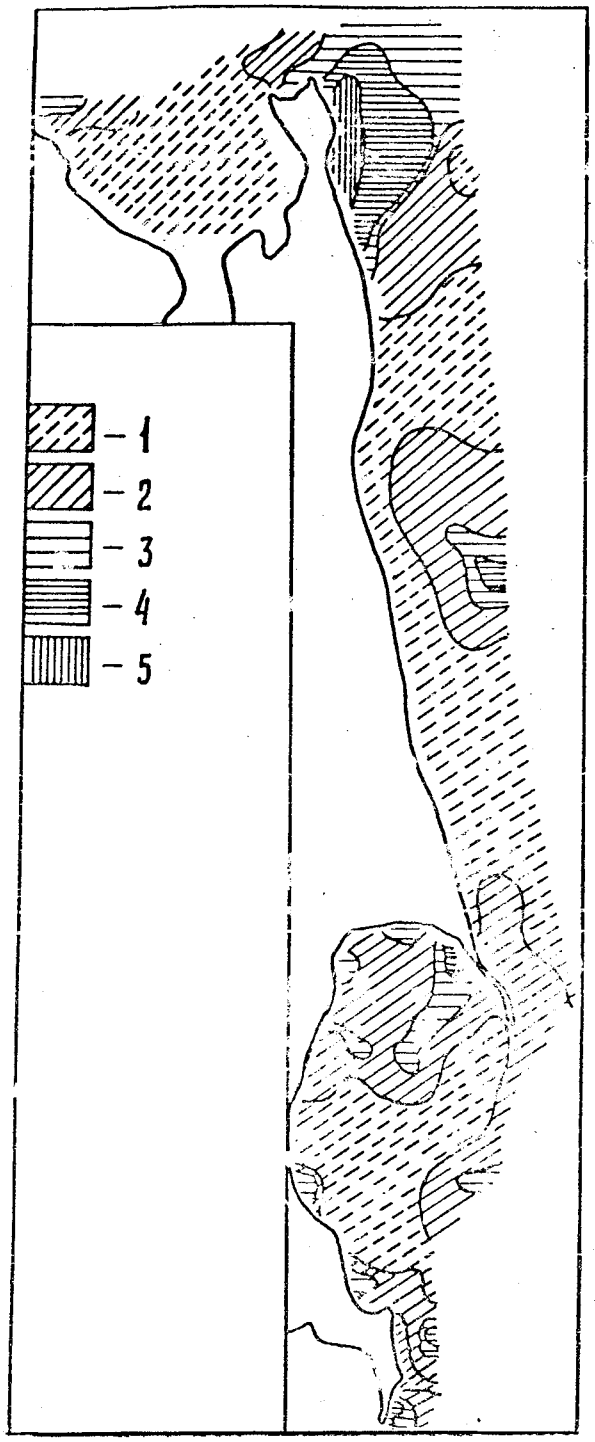

Fig.2.2. Distribution of biomass
of non-motile sestonophages (g/m2):
1 – less10, 2 – from 10 to 100,
3 – from 100 to 200,
4 – from 200 to 500,
5 –over 500

2.1. **Non-motile sestonophages**

This trophic group includes bottom animals that get food from the off-bottom water layers by filtration or passive expectation. In the area studied, this group is characterized by a significant species diversity and is represented by many species of hydroids, hydrocorals, bryozoans, sea squirts, brachiopods, sponges, barnacles, some bivalve mollusks, some polychaetes (Family Sabellaniidae, Sabellidae, Serpulidae), sea lilies, some species of holothurians. This group is most demanding to certain conditions including relief, ground, aeration of the off-bottom water layers and transfer of food particles suspended in water. Along the northern end of the eastern Sakhalin the biomass of this group is very high and in the places closest to the coast at 54º north reaches 954 g/m^2. Such significant development of non-motile sestonophages in that area of the shelf of the northern Sakhalin (sometimes to 80-96% of total biomass) is due to the presence of coarse-grained grounds (Bezrukov, 1960; Koblikov, 1985) and the high activity of the East Sakhalinian Current (Moroshkin, 1966). Many species of bryozoans and hydroids, mass aggregations of Balanus balanoides, Balanus sp. are found on stony ground; filter-feeding bivalve mollusks are represented by Hiatella arctica, Musculus niger; polychaetes Idanthirsus armatus are found almost everywhere. The sestonophagous polychaetes- Chone teres, Sabella maculata, Potamilla neglecta, P. reniformis oligophthalmos are dominant on mixed gravel-sand silty sediments. The sponges Phakellia cribrosa, Halichondria sitiens, Esperiopsis digitata, Hymeniacidon assimilis, Axinella blanca were observed in mass (to 70% catch) in both dredging and trawling samples. In the northeastern part of the shelf the number of non-motile sestonophages decreased in a regular manner further from the coast and the change of ground **(**a gradual decrease of the particles diameter). The entire coast to 20 m isobath, as a rule, was inhabited by barnacles, attached bivalves (Mytilidae), hydroids, bryozoans, polychaetes from the family Sabellariidae, colonies of sinascidia. As the depth increased, sponges and polychaetes Sabellidae became dominant. Beyond 100-m isobath**,** in addition to the

above-mentioned animals foraminiferans of the family Hyperamminidae were found abundantly. On coarse aleurites beyond 200-m isobath, that group was represented by the sea lilies Heliometra glacialis maxima, and sestonophagous polychaetes. Further to the south coarse-grained sediments gave place to fine sand, where the fauna of non-motile sestonophages, in spite of the activity of the Eastern Sakhalinian current, was represented very poorly, - from 0.01 to 1-3% total biomass (up to 9 g/m^2). On gravel and stones in that area hydroids and bryozoans occured in a very small number, sabellid polychaetes were found rarely. An increase (to 200 g/m^2) in the biomass of the group on fine sand and coarse aleurite grounds with a mixture of gravel and pebbles beyond 100-m isobath at 52-51º north attracts attention**.** The coarse-grained inclusions were inhabited by Chelyosoma orientales, Eunephtya sp., Balanus sp., and hydroids. The sponges Phakellia cribrosa, Myxilla inerustans, Halyclona aquendrictus, Halichondria panicea were widely represented. On homogeneous grounds, Heliometra glacialis maxima, Pavonaria finmarchica and polychaetes Sabellidae were found. Further south than 51º north to the base of Terpeniya Peninsula non-motile sestonophages were developed very poorly, their biomass, as a rule, did not exceed 2-5 g/m^2. The presence of aleurite grounds in that area, probably, made it impossible for many species of that feeding group to live there (according to Savilov, 1957 - "non-motile" sestonophages of hard substrate**).**

Considering the distribution of non-motile sestonophages as a whole throughout the area studied, it can be noted that these animals are connected with the zones of active hydrodynamics close to the ends of the island and on the border of the island sandbar, with their typical coarse-grained sediments**.**

In addition**,** non-motile sestonophages can inhabit (and they do it) soft bottom**,** where the processes of deposition of sediments are dominant over the processes of spreading of sediments**.** As regards the number, this group inhabits coarse-grained sediments significantly more richly **(**Fig. 2.1 and 2.2).

2.2. **Motile sestonophages**

The characteristics of this food group are: 1) active filtration of the water layers that are closest to the bottom; 2) to a different degree motile life style; 3) attachment mainly to sandy sediments; 4) a requirement of a relatively active motion of the off-bottom waters**.** This group includes many species of bivalve mollusks, the sand dollar Echinarachnius parma, some species of amphipods Fam. Ampeliscidae), cumaceans, some echiurids (Echiurus), polychaetes Chaetopterus variopedatus.

In the area studied, motile sestonophages were attached**,** mainly, to the zones with active hydrodynamics and good aeration of off-bottom water layers, which was observed in the northern part of that area. That group, as regards its number, reached its maximal development there (Fig. 2.3). The motile sestonophages reached the highest absolute and relative biomass values on fine sands in Sakhalinskii Bay and at the northeastern coast of Sakhalin. The biomass of the group was formed mainly at the expense of common bivalve mollusks Serripes groenlandicus, Liocyma fluctuosa, Mya truncata, Astarte alascensis alascensis. Further along the northeastern coast of the island, the motile sestonophages were again represented by sand dollars that formed aggregations with a biomass over 2000 g/m^2. In that region (52º30' north**)** at a depth of 20-50 m, dense fine sands were dominant and the activity of the Eastern Sakhalinian current was rather high. As the current rate decreased and coarse-aleurite silty grounds appeared, sand dollars gradually gave place

to filter-feeding bivalve mollusks –Ciliatocardium aliatum, Serripes groenlandicus, Astarte alaskensis, Tridonta borealis borealis, T. montagui orientalis, Astarte sp., Liocyma fluctuosa, Axiopsida orbiculata orbiculata, Serripes groenlandicus and holothurian Cucumaria japonica. A relative abundance of that group comprisedthere 10-27%.

As a whole, motile sestonophages often formed largest aggregations on the shelf of the northeastern coast of Sakhalin and in their distribution they wereattached to sandy grounds of the lower horizon of sublittoral (Fig. 2.3 and 2.4).

2.3. Collecting detritophages of loose substrates

In contrast to the above mentioned trophic groups, the representatives of collecting detritophages were attached in their development to the sea zones, where the off-bottom motion of water was slow, and the process of sedimentation of suspended organic particles was dominant over the process of their transfer (Kuznetsov, 1980). The animals of that ecological group adjusted to such conditions received food material from detritus, by collecting its particles from the surface of the bottom. That trophic group included numerous species of bivalve mollusks, brittle stars, polychaetes, echiurids and some holothurians that in the process of evolution developed ability to collecting detritus from the surface layer of the ground (Savilov, 1961).

Further to the south from Sakhalinskii Bay along the northern end of the eastern Sakhalin, the biomass and relative number of collecting detritophages decreased significantly (to fractions of a gram and per cent). Only beyond the border of 200-m isobath on coarse aleurites and fine aleurite silts, the total number of the representatives of that group increased (Fig. 2.5 and 2.6). In general terms, all the shelf of the

northeastern Sakhalin to 49º45' north was inhabited by collecting detritophages rather poorly.

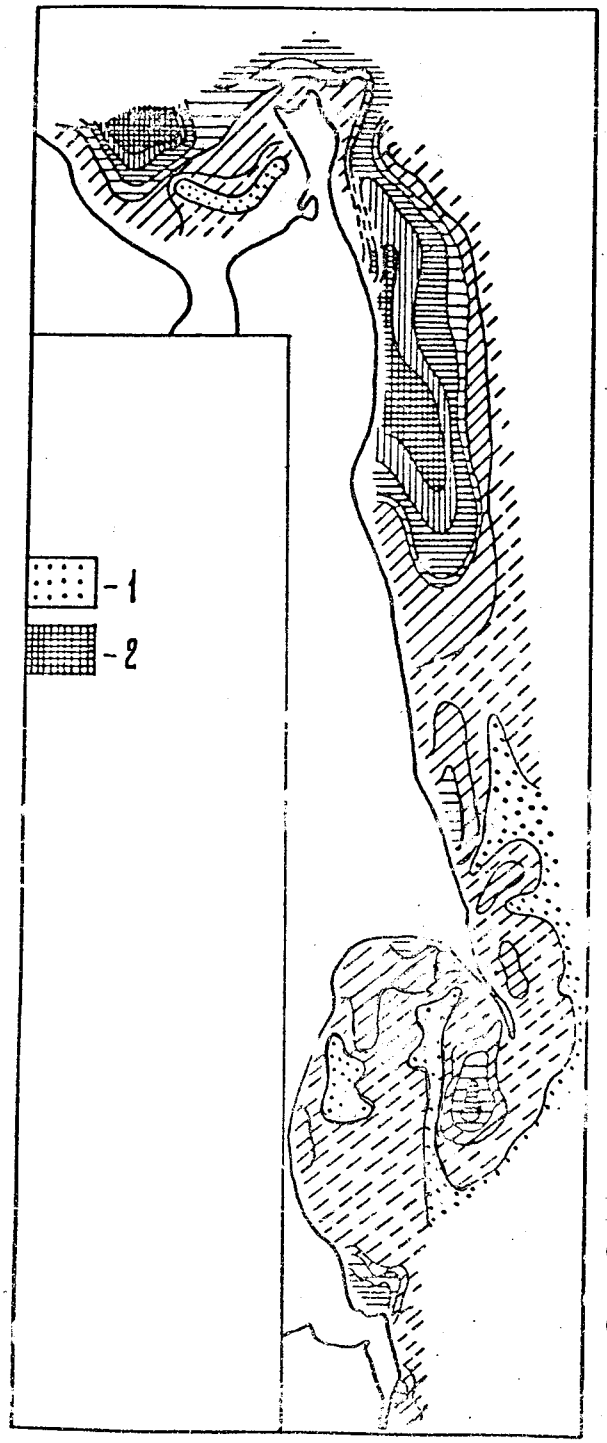

Fig.2.3. Distribution of biomass of non-motile sestonophages (g/m2): 1 – less 0.1; 2 – over 1000. Other conventional signs as in Fig.2.2.

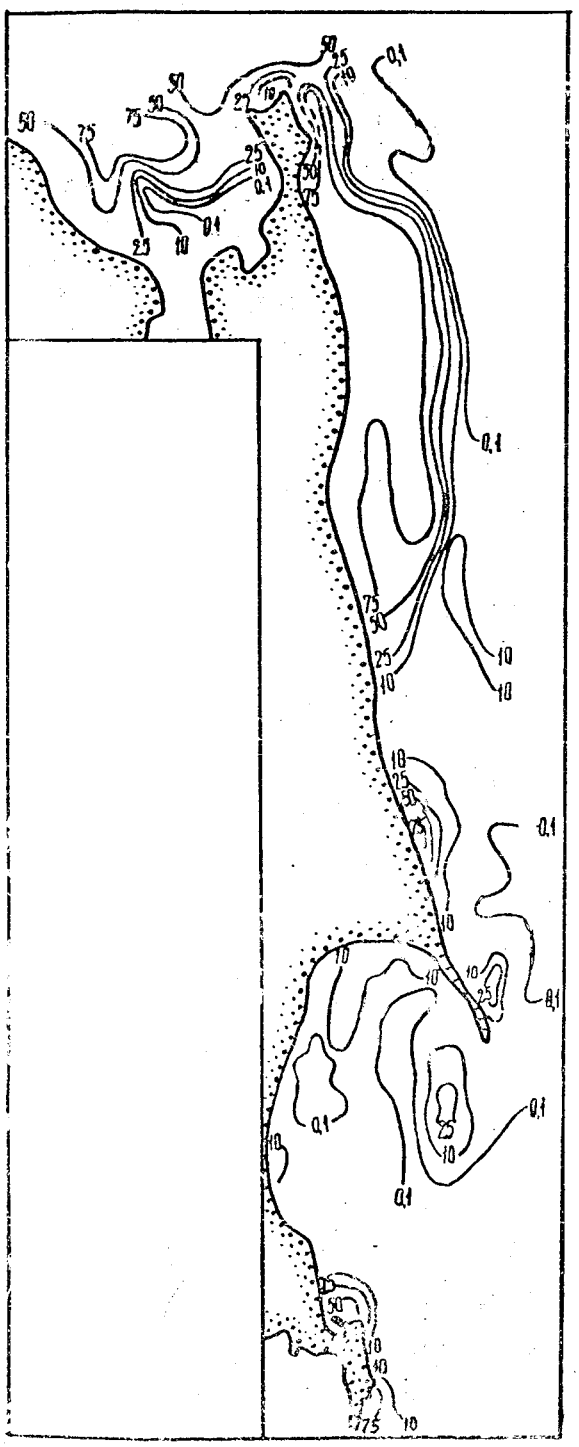

Fig.2.4. Distribution of biomass of motile sestonophages (%)

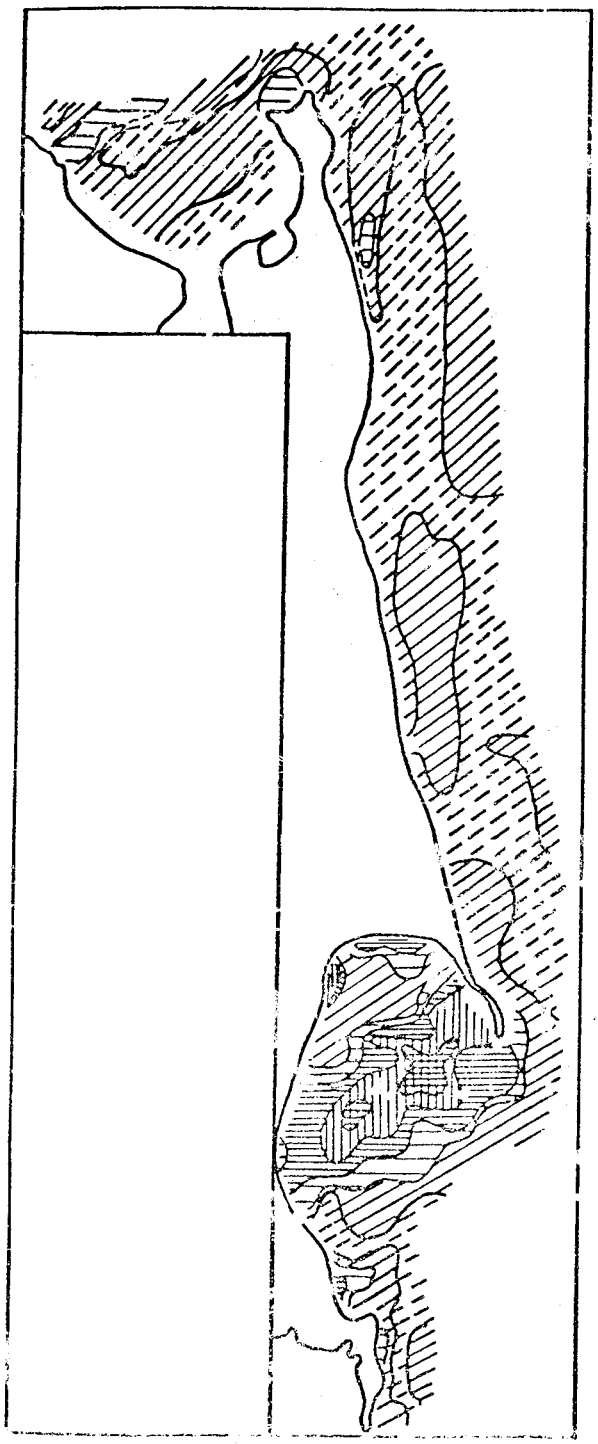

Fig.2.5. Distribution of biomass of collecting detritophages (g/m2). Conventional signs as in Fig.2.2.

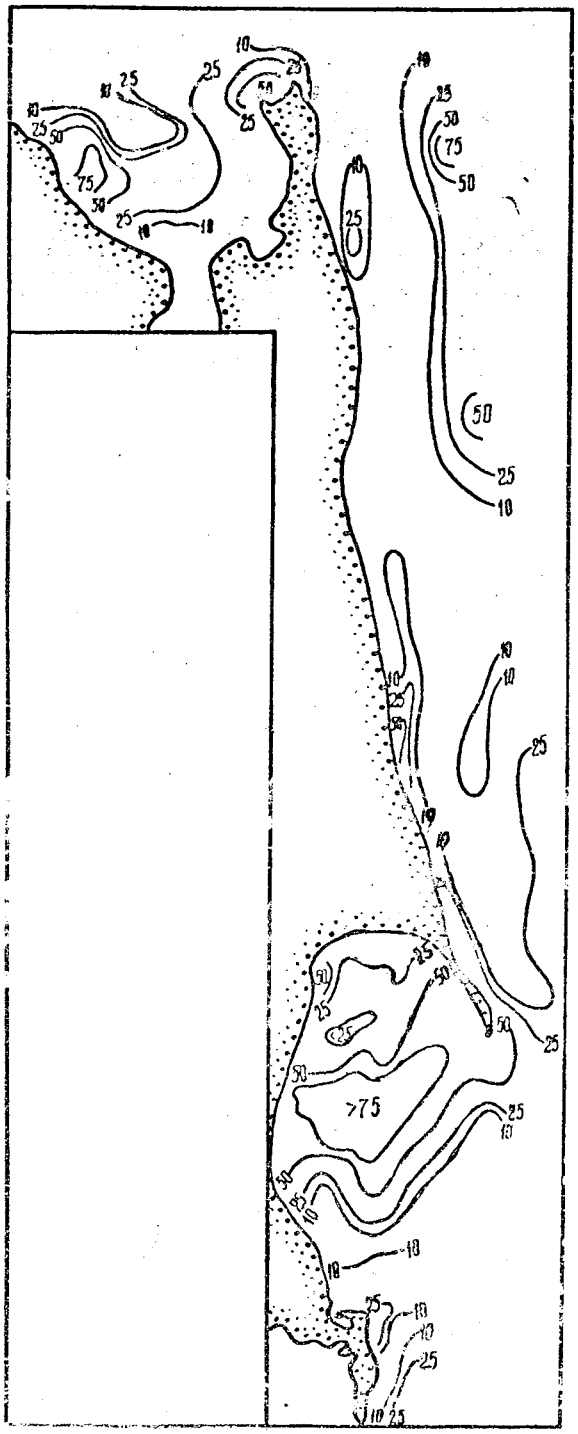

Fig.2.6. Distribution of biomass of collecting detritophages (%). Conventional signs as in Fig.2.2.

An exception were, probably, only the coastal areas off Terpeniya Peninsula (biomass up to 84 g/m^2) and outer border of the shelf (to 18 g/m^2).

2.4. **Non-selective detritophages**

The representatives of that trophic group were characterized by getting food material out of the ground by its non-selective engulfing**.** Non-selective detritophages – non-motile, living in the ground animals**,** were represented in the area studied by polychaetes of the Family Malpadiidae, Capitellidae, Opheliidae, Ariciidae, Artacama proboscidea, the sipunculan Golfingia margaritocea, the starfish Ctenodiscus crispatus, some holothurians of the family Malpadiidae.

In Sakhalinskii Bay and in the northeastern part of the area studied, non-selective detritophages werefound very rarely. The representatives of that group, as a rule, did not form aggregations larger than several grams per m2. Most often their biomass comprised several fractions of a gram (Fig. 2.7). That group in Sakhalinskii Bay only at one station exceeded 10% total biomass of macrobenthos (Fig. 2.8). Silty soft sand there were inhabited by Scoloplos armiger, Praxillella praetermissa, Phadine gracilor. Further to the south from the northern end of the island, a gradual increase in both absolute and relative number of the representatives of that group was observed. Maximal biomass (to 400 g/m^2) was observed beyond 50-m isobath on coarse aleurites, fine aleurite and aleurite-clay silts.

The macrobenthos biomass in the upper sublitoral at 51-49° north wasmainly formed by the sipunculan Golfingia margaritacea and the polychaetes Axiothella catenata, Nicomache lurubricalis, Brada

villosa, Artacama proboscidea, Praxillella praetermissa, as well as holothurians from the family Molpadiidae. To the south from 51°30'

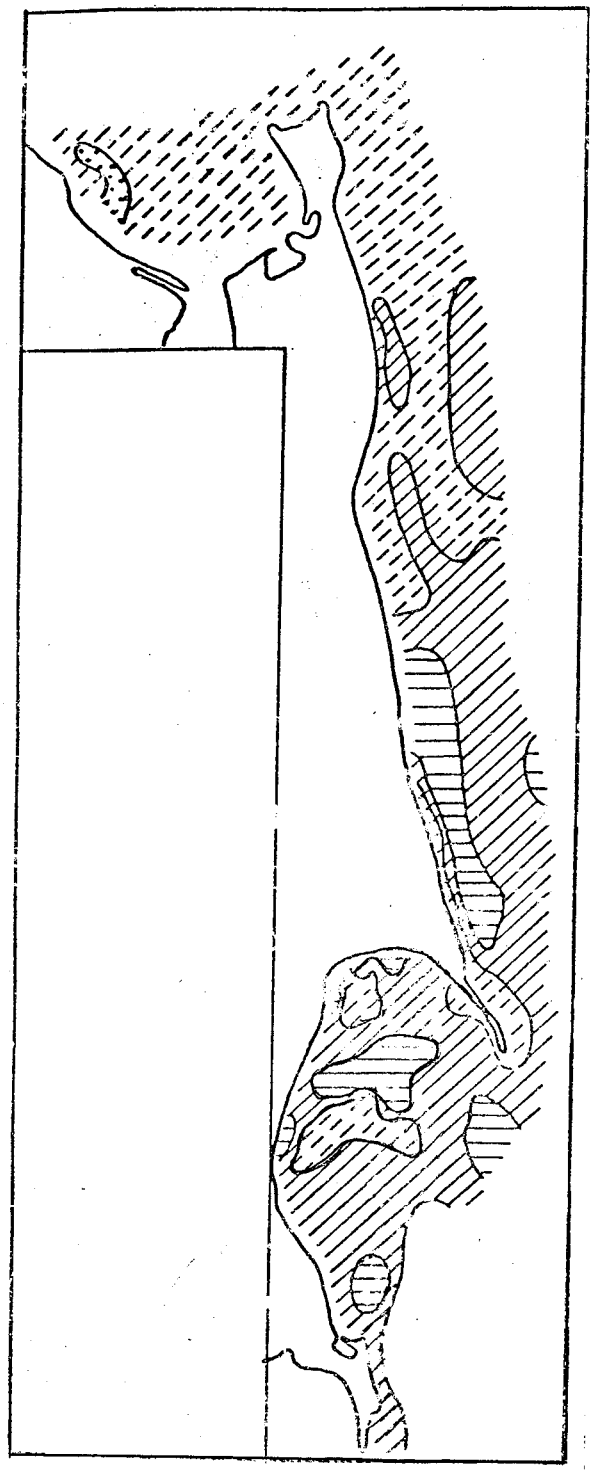

Fig.2.7. Distribution of biomass of non-selective detritophages (g/m2). Conventional signs as in Fig.2.2.

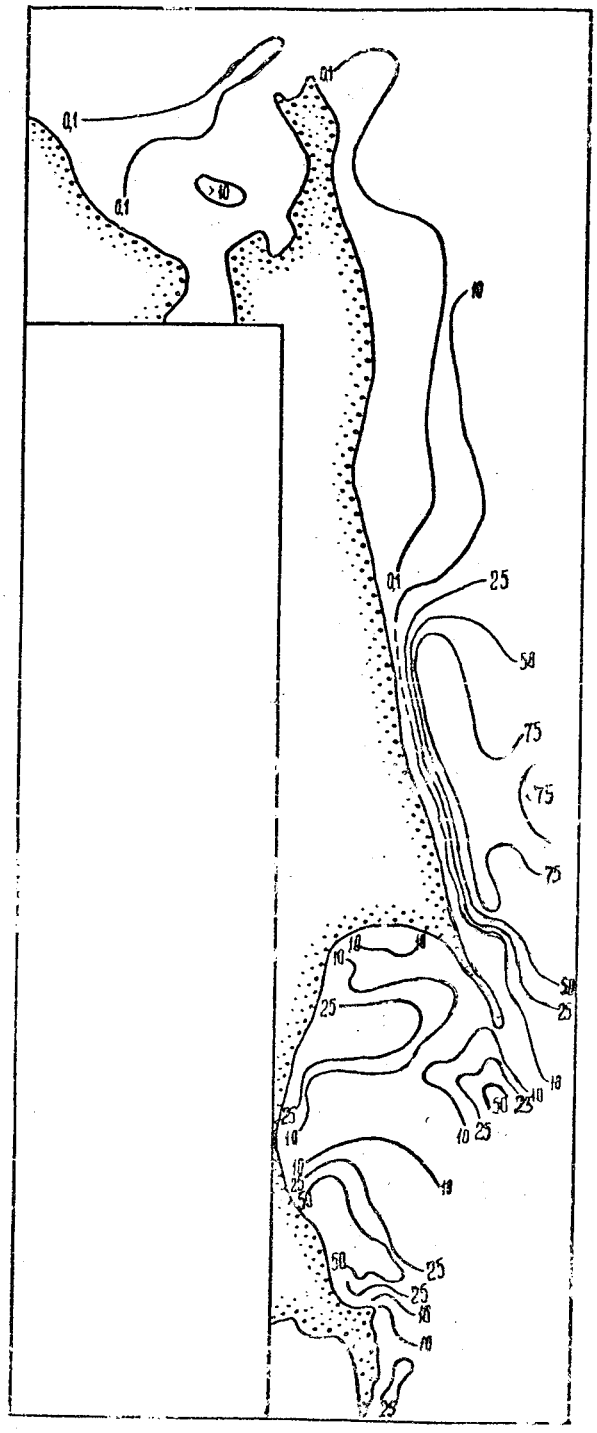

Fig.2.8. Distribution of biomass of non-selective detritophages (%)

north at the depth decline in the upper horizons of bathyal, the biomass over 100 g/m^2 was formed by the starfish Ctenodiscus crispatus and the polychaetes Travisia forbesii, Brada villosa, Axiothella catenata, Capitella capitata. In general terms, the area bordered by 20 and 300 isobath and 51°15' north and 49°30' south, was characterized by a dominant development of faunas of non-selective detritophages as compared with other food groups (to 80-90% total macrobenthos biomass). The areas of such significant dominance were situated at the bottom sites occupied by fine aleurite and aleurite--clay sediments.

If we consider the distribution of non-selective detritophages as related to the depth and type of bottom sediments (Fig. 2.7), it can be assumed that these animals form maximal biomass (over 100 g/m^2) within the depth range of 50-200 m mainly on fine aleurite silts. At the same time, their role in total macrobenthos biomass increases (over 50%) at a depth of 100-200 m and more on fine-aleurite and aleurite-clay ground.

2.5. Carnivorous bottom invertebrates

As a rule, the distribution of bottom predators and necrophages in the studies on the trophic structure of benthos is not specially analyzed. First of all, it is connected with the fact that bottom polyphages in their distribution are closely connected with the distribution of other benthos groups, that serve as their food. An important factor is that a significant number of polyphages are motile components of bottom fauna, which do not form trophic zones (Kuznetsov, 1980). However, the study of space distribution of bottom polyphages is of a significant interest not only because they are an integral part of bottom communities, but also because many of their representatives are an object of fisheries. Among them there are many species of crabs, shrimps, gastropod mollusks, etc.

The food group of carnivorous animals includes bottom invertebrates that feed on living and dead organisms: sea anemones, nemerteans, many species of polychaetes, gastropod mollusks, starfishes, brittle stars, decapods, amphipods and isopods.

On the whole, the distribution of carnivores in the region studied exhibited a spot-like pattern and was connected mainly with the areas with a high macrobenthos biomass. Thus, the greatest number of carnivores (to 113 g/m^2, or 43% total macrobenthos biomass) was observed at a 100-200-m depth range on coarse-grained sediments, i.e. zone of dominance of non-motile sestonophages. At a depth of depth 200 m and more on silty bottom the percentage of carnivores was also high (41%), while their biomass on the average did not exceed 29 g/m^2. In such conditions, non-selective and collecting detritophages were dominant in macrobenthos. Carnivores inhabited fine sands less. On the whole, the relative number of carnivores in the region studied made up 10.7% total average macrobenthos biomass.

Based on the dredging results, it is possible to evaluate the distribution and dependence on various environmental factors large motile representatives of carnivores. For example, the most common predators in the studied region are decapods, and in particular the crabs Chionocetes opilio. In its distribution the following pattern can be distinguished. Large commercial males during our dredging survey in 1977 were registered at 51-52° north beyond the 100-m depth and in their distribution were connected with the zone of dominance of (to 55-60%) non-motile sestonophages (Chelyosoma orientale, sponges, hydroids and bryozoans). Female Ch. opilio in mass were mainly attached to the coastal zone at 49°30’ north at the eastern coast and to the shallow-water areas – at 48-48°45’ north, i.e. the places of dominance of (to 63%) collecting animals, represented by small bivalve mollusks and

polychaetes. Juvenile Ch. opilio were found in large number (over 1000 ind. per dredging) in the same areas as large-sized females.

2.6. Areas of dominance of trophic groups of macrobenthos

When considering the above mentioned main trophic groups from the point of view of their quantitative dominance at different parts of the shelf of the studied region, it is possible to determine the areas of their dominance in bottom fauna for the whole region (Fig. 2.9). Let us focus on the scheme of trophic zonality of the shelf of the eastern coast of Sakhalin. A trophic zone in our understanding is a bottom site occupied by groups of hydrobionts of one trophic type and characterized by similar feeding conditions all the way, i.e. similar abundance, quality and degree of availability of food (Kuznetsov, 1980). In the same way as it was done by A.I. Savilov (1961) in distinguishing ecological zones for the Okhotsk Sea, when distinguishing trophic zones for each station we found the proportion of biomass of animals of different trophic groups. Quantitative dominance of one group or another served as a basis for referring that station to a corresponding zone.

The areas of dominance of trophic groups are presented in Fig. 2.9. The island sandbar of the northern end of Sakhalin is characterized by the presence of a zone of dominance of non-motile sestonophages, which owns its development to the intensive transfer of biogeneous suspended particles by the Eastern Sakhalinian Current. The shelf of the northeastern coast of the island has specific conditions for habitation of bottom hydrobionts, which are determined by coarse-grained sediments beyond 50-m isobath. This factor together with active hydrodynamics determines the development of the fauna of non-motile sestonophages there, which is dominant to 53°30’ north on the average at a depth of 200 m. Motile sestonophages form a dominance zone, which stretches from

the part of Sakhalinian Bay, which is most remote from the coast, firstly eastward, and then along the coastal line as a narrow band (depth range 20-50 m) southward. Further than 53° 15' south the zone significantly widens both as regards its depth (to 200-m isobath), and longitudinally (approximately to 51°15' north). The dominance of sestonophages (mainly sand dollars) at this bottom site of the studied aquatorium is overwhelming (to 99% total macrobenthos biomass). This becomes possible thanks to the presence of fine sands and to the still significant power of the Eastern-Sakhalinian current, enriched with organic matter, which creates optimal conditions for the existence of this species. In the area bordered approximately by 51º15' and 52º15' north and 100 and 200 m isobaths, coarse-grained inclusions (large stones, large gravel, gravel) appear in the bottom sediments, on which the representatives of the fauna of non-motile sestonophages become dominant again. This confirms again a high activity of the enriched current in the area studied. Further to the south from longitude 51º30' the longitude of Terpeniya Cape almost all the shelf of the island is occupied by the dominance area of non-selective detritophages. In accordance with data by K.V. Moroshkin (1966), the intensity of the Eastern Sakhalinian Current gradually weakens at this site of the shelf. P.L. Bezrukov (1960) considered that bottom ground was represented mainly by fine sand. However, our observations allow to assume that the intensity of the off-bottom current significantly gets weaker to such a degree that large aleurites, fine aleurites and aleurite-clay (at 200 m) silts appear even at a relatively small depth (50 m) (successive or in a spot-like manner), which are inhabited by the fauna of detritophages (sipunculans, maldanids). Fine sands stretch as a narrow band only at the coast itself (to 20 m). It is known, detritophages form mass aggregations with dominance over other trophic groups on fine aleurites and mainly on aleurite-clay and clay silts

with an average off-bottom flow rate less than 0.01 m/sec (Kuznetsov, 1976). It is possible that similar conditions are dominant in the eastern Sakhalin (51º15' – 48º40' north). Along periphery the dominance area of detritophages on the shelf a zone of predominance of collecting detritophages stretches as a narrow band that at a depth decline (beyond 200-m isobath) is represented by collecting polychaetes, small bivalve mollusks, brittle stars Ophiura sarsi, O. quadrispina. The western and southwestern peripheries of the zone of development of non-selective detritophages transfer to the dominance area of collecting small clams (Macoma, Yoldia) and polychaetes. In the coastal zone of Terpeniya peninsula on the stony ground, non-motile sestonophages are dominant, which receive food material from the motile costal waters. The extreme north-eastern part (shelf of Shmidt Cape) is characterized by an alternation of the zones of predominance of non-motile, motile and again non-motile sestonophages. The shelf of the northeastern Sakhalin to 51º15' north has well-developed faunas of motile sestonophages. In the upper horizons of bathial non-motile sestonophages and collecting detritophages are represented in mass. Further south from 51º15' north on the shelf an alternation of the dominance areas of all trophic groups is observed (the full set of zones).

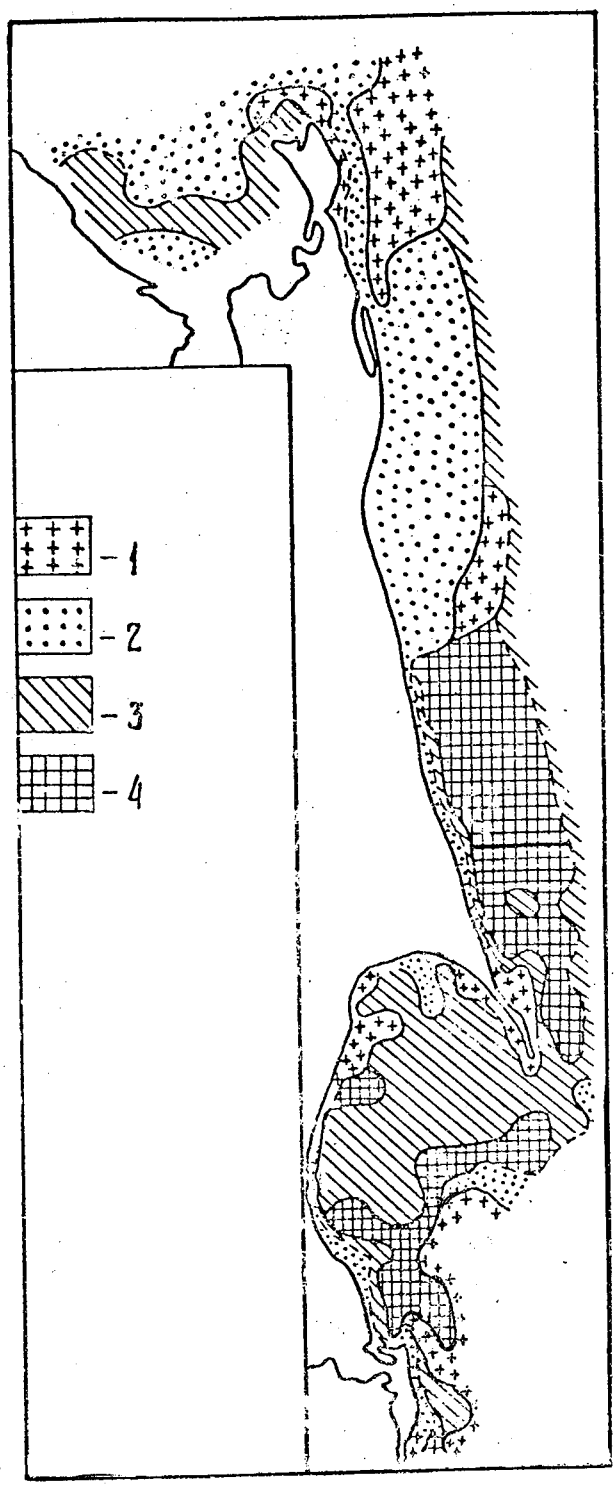

Fig.2.9. Dominance areas of food groups of macrobenthos (trophic zones):
1 – of non-motile sestonophages;
2 –motile sestonophages;
3 – collecting detritophages;
4 non-selective detritophages

3. Quantitative distribution of macrobenthos on the shelf of the northeastern Sakhalin

In this section mainly the results of PRIFO investigations in 1974, 1976 and 1977 are presented, when the total of 299 stations were conducted on the shelf of the Okhotsk Sea, out of which a significant part – along the northeastern coast of the island (Fig. 1.6). To a lesser degree more recent data have been used (Koblikov, 1982, 1985). Less recent and less detailed data of IOAS are presented only on the map of the total biomass of benthos, which was made by A.I. Savilov (Fig. 3.1).

Littoral and the adjacent littoral border (infralittoral margin) subjective to the tidal influence at the most part of the coast are represented by gravel and gravel-sandy beaches and are inhabited very poorly. The belts of macrophytes appear only in the south and extreme north of the northeastern coast of Sakhalin. The most common species are Alaria ochotensis and A. marginata and laminarians– Laminaria gurjanavoe, L. cichorioides and other species. Their bushes stretch to a depth of 5-10 m, their biomass in wet weight is about 28 kg/m^2.

The expeditions of IOAS and PRIFO did not study the depth to 16-20 m. At a depth over 20 m at the shelf of the northern Sakhalin in the central part of Sakhalinian Bay and in the northeastern part of Sakhalin southward from Piltun Bay (Fig. 3.2) the spots of the highest benthos biomass– from 1000 to 2167 g/m^2 within the depth range of 20-45 m are observed. Such high biomass is reached, mainly, at the expense of the sand dollar Echinarachnius parma, that contributes from 67 to 98.99% total biomass in that area. As the depth increases to 100-200 m the biomass values stay relatively high (from 200 to 500 g/m^2) at the expense of the coarse-grained aggregations of the bivalve mollusks Ciliatocardium ciliatum tchuktchensis, Liocyma fluctuosa, sand dollar Echinarachnius parma, polychaetes Travisia forbesii, Praxilella praetermissa, species

Spionidae и Cirratullidae. Further south from 51º30' north the total biomass decreases and is 130-150 g/m^2. The minimal biomass 9 g/m^2 is observed at a depth of 20 m. Polychaetes Onuphis cridescens, Scoloplos armiger, Nephthys longisetosa, amphipods Ampeliscidae, and large isopods Saduria entamon represent the bottom fauna in that area.

Further south from51º30' north a gradual increase in macrobenthos biomass to 1092 g/m^2 is observed again. At a depth of 18 m on fine silty sands large aggregations of amphipods are registered, mainly Ampelisca eschrichtii to 7360 ind/m^2 with a biomass of 907.2 g/m^2. On the whole, for this region to a depth of 100 m benthos biomass is 500 g/m^2, mainly, due to the development of the polychaetes Axiothella catanata (to 84 ind/m^2 with biomass 165.2 g/m^2), Praxillella praetermissa (to 72 ind/m^2 with biomass 46.6 g/m^2), ascidia Pelonaia corrugata (to 16 ind/m^2 with biomass 120.4 g/m^2), echiurids Echiurus sp.(to 8 ind/m^2 with biomass 40.0 g/m^2) and brittle stars Amphipholis digitata (to 112 ind/m^2 with biomass 21.6 g/m^2). The aleurite sediments common for that area contribute to the predominance in bottom fauna of collecting and engulfing the ground detritiophages – polychaetes Maldanidae, sipunculans Golfingia margaritacea margaritacea, clams Macoma spp., starfish Ctenodiscus crispatus and some species of brittle stars (Koblikov, 1982).

Resuming data of PRIFO and ZIN RAS on the quantitative account of macrobenthos on the shelf of the northeastern Sakhalin, we give mean values. According to data by V.N. Koblikov (1982), mean macrobenthos biomass in the northern part of this shelf from Shmidt Cape on the north to the cape of Lunskii Bay in the south is 428.6 g/m^2 wet weight, out of which sea urchins comprise 58% biomass, 12.3% - crustaceans, 7.4% - bivalve molluscs and 4.9% - polychaetes. For the southern area from Lunskii Bay to Terpeniya Cape the average biomass is only 211.8 g/m^2.

This decrease of biomass in that region is mainly due to a sharp decrease in the number of sand dollars to 15.2 g/m^2.

According to the more recent and refined data of PRIFO (Dulepova, Borets, 1990) with average macrobenthos biomass for the whole shelf of the Okhotsk Sea within the range of 20-200 m 388 g/m^2 biomass shelf of the whole northeastern Sakhalin southward to Terpeniya Cape is 371 g/m^2.

Table 3.1

Average biomass (1, g/m^2) and proportion of main groups of benthos (2, %) on the shelf of the northeastern Sakhalin (From Koblikov et al., 1990)
A- northern part of the northeastern coast to Lunskii Bay;
B– southern part of the northeastern coast southward from Lunskii Bay toTerpeniya Cape.

Group	A		B	
	1	2	1	2
Rhizopoda	20.4±9.7	4.7	3.4±0.2	1.5
Spongia	7.5±5.0	1.7	+	+
Anthozoa	7.3±2.5	1.7	14.9±5.1	6.6
Hydroidea	4.0±1.2	0.9	1.9±0.7	0.8
Nemertini	+	+	1.5±1.0	0.7
Priapuloidea	+	+	+	+
Polychaeta	22.7±5.4	5.1	42.6±5.6	18.9
Echiuroidea	-	-	15.0±4.4	6.6
Sipunculoidea	2.3±2.0	0.5	61.2±15.8	27.1
Bryozoa	6.1±2.2	1.4	2.9±1.5	1.3
Gastropoda	16.5±3.0	3.7	8.1±3.1	3.6
Bivalvia	22.5±6.3	5.1	11.9±3.4	5.3
Amphipoda	21.4±14.8	4.9	29.0±11.2	12.8
Decapoda	3.1±1.6	0.7	2.9±1.5	1.3
Cirripedia	20.6±2.3	4.7	+	+
Asteroidea	2.2±1.2	0.5	6.5±2.3	2.9
Ophiuroidea	3.5±1.5	0.8	3.2±0.9	1.4
Echinoidea	261.9±71.3	59.9	16.9±16.7	7.5
Holothuroidea	1.3±0.6	0.3	2.8±1.1	1.3
ASdia	9.1±4.8	2.1	+	+
Varia	5.3±2.4	1.2	1.3±0.4	0.4
Average total biomass	437.4±74.4		226.0±27.7	

The northeastern Sakhalin differs from other parts of the Okhotsk Sea by a relatively high abundance of the sand dollars Echinaruchnius parma and amphipods. According to data of these authors, amphipods comprise 7.5% total biomass, while in other parts of the Okhotsk Sea they make from 0.7% on the Pritauyiskii shelf to 2.5% in Terpeniya Bay.

In accordance with PRIFO data (Koblikov et al., 1990), we have close though slightly different values. These authors give for the whole shelf of the Okhotsk Sea a biomass value of 394.4 g/m^2, and for the northeastern Sakhalin 332 g/m^2 with 437.4 g/m^2 for the northern part and 226 g/m^2 for the southern part of the northeastern coast (Table 3.1). Averintsev et al. (1982) using the results of 5 transects by use of dredging, trawling and SCUBA-diving collections gives slightly higher values for the whole shelf of the north-eastern Sakhalin: 470 g/m^2, and for the bays of lagoon type 1670 g/m^2.

Finally, Koblikov et al. (1990) give data on total biomass of main groups of benthos for the northern (A) and southern parts (B) of the shelf of the northeastern Sakhalin (Table 3.2), which are calculated by them.

Starting with 1990 the specialists of FERIHS conducted several expeditions specially in the area of Piltun-Astokhskii platform, situated in the north-eastern shelf of Sakhalin approximately 20 km south-eastwardly from Piltun Bay. The background characteristics of planktonic and benthic communities were studied, but only general data on bottom communities were published (Tkalin, Belan, 1993; Belan et al., 1996). The authors mentioned that in 1990 the state of bottom communities was normal and their productivity was the same as 20 years before. The average biomass of benthos in that region exceeded 500 g/m^2, and in the northern part of the region it was about 1600 g/m^2. The authors give the map of distribution of benthos biomass in August 1990. (Fig. 3.3).

Table 3.2.

Total biomass of main groups of benthos in different parts of the shelf of the northeastern Sakhalin, thous. tons
A - northern area southward to Lunskii Bay;
B - southern area from Lunskii Bay to Terpeniya Cape
(From Koblikov et al., 1990)

Group	A	B
Rhizopoda	645	67
Spongia	237	+
Anthozoa	231	295
Hydroidea	126	37
Nemertini	+	30
Priapuloidea	+	+
Polychaeta	717	844
Echiuroidea	-	297
Sipunculoidea	73	1212
Bryozoa	193	57
Gastropoda	521	160
Bivalvia	711	236
Amphipoda	676	574
Decapoda	98	57
Cirripedia	651	+
Asteroidea	70	129
Ophiuroidea	111	63
Echinoidea	8276	335
Holothuroidea	41	55
ASdia	228	+
Varia	167	26
Total	13772	4474
Area, thous.km^2	31.6	19.8

In 1994 FERIHS conducted benthic survey at 3 testing grounds near the northeastern Sakhalin with 13-20 stations at each of them. All testing grounds were situated in the area of Piltun lagoon or close to it. The first testing ground was situated at 52º55' north, 143º52' east at a depth of 67 m, the second one – at 52º31' north, 144º04' east, depth of 83 m and the third one at 52º26' north, 143º41' east and depth of 32 m. The biomass at the first testing ground ranged from 300 to 8248 g/m^2 (on the average, 1339 g/m^2). Most abundant was the sand dollar Echinarachnius parma, at some stations its biomass exceeded 1000 g/m^2, and at one station it reached 8000 g/m^2, with the population density of 360 ind/m^2. The average biomass at the second testing ground was 1503 g/m^2, and biomass ranged from 298 to 2700 g/m^2. At all stations of the second testing ground E. parma was dominant, its population density reaching 280 ind/m^2 with a biomass of 3000 g/m^2, and the average biomass comprising 80% of total biomass (Table 3.3). At the third testing ground the benthos biomass was twice smaller (to 732 g/m^2), and biomass of sand dollars comprised 75% of it. On the contrary, the role of bivalve mollusks increased (to 13% of total biomass) and higher crustaceans (from 2% at testing grounds 1 and 2 to 5% at testing ground 3) (Belan et al., 1996). Table 3.3 shows the proportion of biomass of the main benthos groups in g/m^2 and in % (in brackets) at the three testing grounds examined in 1994.

The most recent benthos collection by SakhRIFO were conducted in September 1998 at Piltun-Astokhskii testing ground. An analysis of 67 dredging samples in that area showed 127 species of macrobenthos. Amphipods (38 species) and polychaetes (31 species) were dominant in the number of species. Bivalve mollusks (18 species), gastropod mollusks (8 species) and hydroids (5 species) were represented by a significant number of species. Brittle stars and panthopods were represented by three species, sea anemones and ascidia by two species. Cumaceans, sea urchins, isopods, nematodes, priapulids and sipunculans (Labai, 2000) were represented by only one species each. Total population density varied within the range of 80 to 106400 ind/m^{2,} making on the average 14440 ind/m^2

(Table 3.4). Cumaceans, represented by only one species Diastylis bidentata, were dominant. Their population density reached 105600 ind/m^2. Amphipods were second in population density, first of all, Wecomedon minusculus with maximal density 4300 ind/m^2, and after them Protomedeia sp. and Eohaustorius eous eous. Bivalve mollusks were represented by 20 species and comprised 26% of total population density without regard for cumaceans. Mysella kurilensis kurilensis reached maximal population density (to 13440 ind/m^2), and Crenella decussata decussata was the second in population density (to 620 ind/m^2). Out of echinoderms, that comprised 14% population density, the sand dollar Echinarachnius parma was dominant, which population density at some stations exceeded 1000 ind/m^2. Population density of polychaetes comprised 8%, that of sea anemones Halcampa sp. and Epiactis lewisi – 3% (Pecheneva, 2000).

A completely different proportion of the groups we have as regards biomass, which is quite natural considering different size of the representatives of these groups. Echinoderms were dominant in biomass because of Echinarachnius parma (to 17001 g/m^2). The character of bottom sediments, among which the sites with moderate or fine sands without any admixture or with a very slight silting prevail, explains this predominance of sand dollar.

It is at such ground that sand dollar is dominant. Cumaceans comprised only 6% total macrobenthos biomass, and the mean biomass of other animal groups did not exceed 1% total biomass. On the whole, macrobenthos biomass at the Piltun-Astokhskii testing ground varied from 9.7 to 17062 g/m^2 with an average of 1337 g/m^2 with cumaceans and 1266 g/m^2 without them (Table 3.4).

Table 3.3

Proportion of main groups of macrobenthos in g/m^2 and % (in brackets) at 3 testing grounds of FERIHS on the shelf of the northeastern Sakhalin in 1994 (Belan et al., 1996)

Group	Testing grounds		
	1	2	3
Actiniaria	50(4)	57(4)	43(6)
Bivalvia	-	99(7)	93(13)
Crustacea	31(2)	31(2)	35(5)
Echinoidea	1146(86)	1195(80)	552(75)
Gastropoda	8(<1)	20(1)	1(<1)
Ophiuroidea	-	44(3)	1(<1)
Polychaeta	15(1)	19(1)	8(1)

Table 3.4

Population density (ind.per 1 m^2) and biomass of dredged samples of benthos at the Piltun-Astokhskii testing ground in September 1998. (Pecheneva, 2000).

Characteristics	Minimum	Maximum	Mean
Population density	80	106400	14440
Population density without cumaceans	60	14120	1007
Biomass	9.7	17062.33	1336.8
Biomass without cumaceans	3.12	17060.3	1266.02

As regards occurrence frequency, the leading species (occurrence frequency over 50%) at the Piltun-Astokhskii testing ground are represented by the cumacean Diastylis bidentata and the sand dollar Echinarachnius parma. The group of secondary species with occurrence frequency 25-50% was represented by three amphipod species (Eohausforius eous, Wecomedon minuseulus and Orchomenella pinguis), the priapulid Priapulus caudatus and polychaete Glyceia capitata.

Density indices of bottom organisms ranged from 0.021 to 2933.85 and added up to 550.869. The sand dollar Echinarachnius parma and the cumacean Diastylis bidentata were leading in density index. The priapulida Priapulus caudatus fits into the common forms of the first order, and other species with density index over 4 – to typical species of the second order. Taking into account the occurrence frequency and density index of the species, the dominant species at the Piltun-Astokhskii testing ground were Echinarachnius parma, Diastylis bidentata and Priapulus caudatus (Pecheneva, 2000). The quantitative characteristics of zoobenthos of that biocenosis are presented in Table 3.5.

Some additional information was obtained as a result of an analysis of 8 dredged samples, collected in the same expedition along the route of the Piltun-Astokhskii pipeline "A", in which 43 benthos species were registered. There the population density of the dredged benthos varied from 440 to 10720 ind/m^2, making on the average 2195 g/m^2. Amphipods were dominant; their population density reached 4880 ind/m^2 with an average value of 935 ind/m^2 (Table 3.6). Out of them the highest population density was observed in Pontoporeia sp., Eohaustorius eous eous and Monoculodes sp. The second in population density were cumaceans that were represented by 3 species there. The third were the bivalves with an average density of 220 ind/m^2, out of which Mysella kurilensis kurilensis was dominant (to 1500 ind/m^2).

Table 3.5

The quantitative characteristics of macrobenthos community of Echinarachnius parma + Diostylis bidentata (Labai, 2000)

Species	Group	Average population density, ind/m^2	Average biomass, g/m^2	Relative biomass, %	Occurrence frequency, %	Density index
Dominant Echinarachnius parma	Ech	112	1180.39	88.5	73.1	6472.4
Common Diastylis bidentata Of the 1st order	Cu	13433	69.45	5.2	94.0	489.6
Common Priapulus caudatus Of the 2nd order	Pr	23	17.64	1.3	37.3	49.4
Secondary Wecomedon minusculus Of the 1st order	Am	116	2.94	0.2	44.8	9.9
Nephthys longosetosa	Po	4	8.52	0.6	14.9	9.5
Halcampa sp.	Ac	27	7.12	0.5	10.4	5.6
Goldia myalis	Bi	4	6.56	0.5	10.4	5.1
Anonyx kurilicus	Am	14	2.77	0.2	19.4	4.0
Mya priapus	Bi	7	2.81	0.2	14.9	3.1
Nephthys sp.(fr.)	Po	4	2.71	0.2	14.9	3.0
Epiactis lewisi	Ac	5	8.66	0.6	3.0	1.9
Travisia forbesii	Po	5	1.45	0.1	14.9	1.6
Ophelia limacina	Po	9	0.86	0.1	22.4	1.4

Anonyx sp.	Am	21	0.81	0.1	22.4	1.4
Phascolosoma Japonica	Si	19	0.74	0.1	23.9	1.3
Hyas coarctatus	De	3	2.20	0.2	7.5	1.2
Glycera capitata	Po	18	0.37	< 0.1	37.3	1.0
Total: 14	-	254	48.52	3.6	-	50.3
Secondary Of the 2nd order 100	-	592	17.78	1.3	-	6.8
Total: 117	-	14413	1333.78	100.0	-	7068.4

Legend: Ech –sea urchins; Cu - cumaceans Pr - priapulids; Am - amphipods; Po - polychaetes; Ac - sea anemones; Bi - bivalve molluscs; Si - sipunculans; De - decapods.

The values of benthos biomass along the route of the pipeline A varied from 60.8 to 2724.3 g/m^2 making on the average 842.83 g/m^2. Echinarachnius parma was dominant, its biomass reaching 2724 g/m^2, making on the average 768.8 g/m^2. Bivalve mollusks, represented by 8 species, were on the second place (53.28 g/m^2); out of them the highest biomass was observed in Siliqua alta. Amphipods were on the third place (39.3 g/m^2). Population density and mean biomass of the main groups of macrobenthos of that region is shown in Table3.6.

In 9 dredging samples of benthos from the route of the Piltun-Astokhskii pipeline"B" bivalve mollusks were dominant in population density, and sand dollars - in biomass. The population density of the mollusks Mysella kurilensis kurilensis reached 40800 ind/m^2 with an average of 5005 ind/m^2. The second in population density were cumaceans, represented by only one species Diastylis bidentata (1644 ind/m^2), and in biomass – amphipods Euchaustorius eous eous, Pontoporeia affinis Eogammarus schmidti. The average biomass of benthos at the route of the pipeline "B" was 712.94 g/m^2. Out of this value the major part was contributed by the biomass of Echinarachnius parma (on the average, 567.5 g/m^2 with a maximum to 3192 g/m^2). The second and third in biomass were amphipods and bivalve mollusks. Amphipods, sand dollars, polychaetes and cumaceans were dominant as regards occurrence frequency (Pecheneva, 2000).

Table 3.6.

Population density (ind/m^2) and biomass (g/m^2) of main groups of dredged benthos at the route of the Piltun-Astokhskii pipeline "A" in September 1998 (From: Pecheneva, 2000)

Group	Average density	Average biomass
Polychaeta	95	4.6
Cumacea	335	1.18
Amphipoda	935	39.29
Gastropoda	15	1.71
Bivalvia	220	53.28
Echinoidea	105	768.8

Unfortunately, benthos collections in the expeditions of IOAS and PRIFO were conducted only at a depth over 16-20 m, therefore, smaller depths of the open sea of the Eastern Sakhalinian shelf (without taking into account lagoons) remained almost non-studied until recently. Data of the expeditions of the Institute of Marine Biology (IMB) at the expedition vessel "Oparin" have not been published yet, even though they were conducted in Piltun Bay, where gray whales of the Okhotsk-Korean population mainly feed off Sakhalin in summer. Only data obtained by an expedition of IMB at R/V "Vulkanolog" in August 1995 were published (Sobolevskii et al., 2000). The collections were made by use of bottom hydrobiological trawl as well as by SCUBA-diving biologists in the immediate area of feeding of whales at a depth of 7-12 m. The bottom there was even, sandy, silting non-significant. Quite a big amount of empty shells of various bivalve mollusks was found on the bottom, out of which live Spisula (Mactromeris) voyi were found in trawls in mass, and Megangulus lutea, Macoma lama and Siliqua alta were more rare. Out of other large representatives of macrobenthos the helmet crab Telmessus cheiragonus was registered there. Off-bottom fishes were very diverse there – sand lace Ammodytes hexapterus, juvenile sculpin Myoxocephalus jaok and flatfishes - Pleuronectes proboscideus, Bering Sea Hipoglossoides elassodon and Sakhalinian Pleuronectes sakhalinensis were observed. Amphipods numerous in number of species and number of individuals were abundant there, isopods and cumaceans were observed in quite a big number (Sobolevskii , Yakovlev, Kussakin, 2000).

Quantitative SCUBA-diving collections, though single, nevertheless, gave some idea of the macrobenthos of that part of the eastern Sakhalinian shelf.

At a depth of 7 m average macrobenthos biomass was 427 g/m^2. Almost half of the biomass (212.1 g/m^2 at a density population 16 ind/m^2) was comprised by the bivalve mollusk Siliqua alta. The biomass of other bivalves was also rather high – Spisula voyi (57.4 g/m^2 at 4 ind/m^2), Macoma lama (35.4 g/m^2 at 20 ind/m^2) and Meganculus sp.juv. (3.1 g/m^2 at 4 ind/m^2). The second in

biomass group consisted of amphipods numerous in species number (75 g/m^2 at 5488 ind/m^2). The third in biomass were polychaetes (40.6 g/m^2) with predominance of Ohuphis shirikishinaensis.

At a depth of 10-20 m community composition on similar sandy bottom significantly changed, mainly, due to a sharp decrease of bivalve mollusks and all benthos biomass. At a depth of 10 m various amphipods and isopod Synidotea cinerea were most dominant, polychaetes were fairly abundant, the mollusk Siliqua alta, shrimp Crangon septemspinosa and Cumucea were found in small number. At a depth of 20 m bivalve mollusks were not registered, the number of Synikobea cinerea abruptly decreased, and a large isopod Saduria entomon became dominant.

At a depth of 12 m, where SCUBA-diving quantitative collections were made directly in the midst of eating whales, benthos biomass was unexpectedly low-and varied within the range of 85-137 g/m^2. Various amphipods were significantly dominant (4360-26800 ind/m^2 at biomass 72.4-85.1 g/m^2). The second was the isopod Synidotea cinerea (biomass 0.4-11.2 g/m^2), the third –the bivalve mollusc Siliqua alta 0.1-0.2 g/m^2. Among other invertebrates rare isopods Saduria entomon, polychaetes Ohuphis shrikishinaensis, cumaceans Diastylopsis dowsoni typica and Lamprops quadriplicata krasheninnikov were found (Sobolevskii , Yakovlev, Kussakin, 2000).

Therefore, in trawl and SCUBA-diving collections at a depth of 7-20 m amphipods were most abundant and diverse in species composition in the studied area. Thirty-four species of these animals were observed. Their maximal registered biomass was 75 g/m^2 at a depth of depth 7 m and 85.1 g/m^2 at a depth of 12 m with population density 5488 and 26880 ind/m^2, correspondingly. Pontoporeia affinis was dominant comprising 63-95% total biomass of amphipods and about 89% amphipod population density. Anisogammarus pugettensis, Eohaustorius eous eous, Eogammarus schmidti and Pontharpinia longirostris were also found in significant quantity. Other amphipod species

(Anonyx nugax pacificus, Melita dentate, etc.) were found not regularly and were represented by individual specimens.

In accordance with data of PRIFO and IOAS, in the upper part of the shelf at a depth over 16 m the sand dollar Echinarachnius parma was always dominant, which was almost not observed at a depth of 7-12 m. According to materials of PRIFO, Isopoda did not form any significant groups of organisms anywhere (Table 3.1 and 3.2), while at a depth of 7-12 m large isopods Saduria entomon and Synidotea cinerea were numerous forms, together with amphipods. Undoubtedly, the food value of large amphipods, isopods, cumaceans and polychaetes with their thin skeleton per weight unit was significantly higher than that of sand dollars and even bivalve mollusks.

The shelf of the northeastern Sakhalin contains a significant number of commercial invertebrates, fishes and sea beasts. According to the calculations of the researchers of PRIFO (Borets, 1985; Shuntov, 1985; Rodin, 1985, etc.) their stocks are abundant (Table 3.7).

Table 3.7.

Total biomass of commercial animals on the shelf of the northeastern Sakhalin (data by V.P. Shuntov, 1985, Borts, 1985 et al.)

Group	Biomass, thous. tons
Wall-eyed pollack	600-800
Salmons	50-80
Bottom fishes (flatfishes, navaga, gobies, eelpouts)	150-200
Ridgeless sand lances	100-120
Herring	20-50
Crabs	40-50
Gastropod mollusks – buccinids	50
Squids	50
Sardine	100
Seals	100 thous. ind.

4. Production of zoobenthos on the shelf of the northeastern Sakhalin

From the work of Dulepova and Borts (1990) on the composition, trophic structure and productivity of all the shelf of the Okhotsk Sea, it is possible to distinguish data on the northeastern coast of Sakhalin southward to Terpeniya Cape. In addition to data on total biomass and biomass of individual groups, these authors made an interesting attempt to calculate the production of particular trophic levels and communities. As far as no special investigations on the evaluation of specific production of particular species of zoobenthos in that region were made, the authors used published data on **P/B**-coefficients for specific groups. They divided all animals of macrobenthos into trophic levels. The second trophic level relatively included motile and non-motile sestonophages, collecting and non-selective detritophages, and the third trophic level – predators. The predators included sea anemones, nemertines, decapods, starfishes and bottom fishes – benthophages and predators. The second trophic level included most groups of invertebrates, while polychaetes, amphipods and gastropods were divided to those belonging to the second level (70% biomass of polychaetes and 90% biomass of gastropods and amphipods) and to the third one (the remaining part of these groups).

In such approximation out of total zoobenthos number at the shelf of the northeastern Sakhalin 14.1 mln tons, 12.7 mln tons were the animals of the second trophic level and 1.4 mln tons were the animals of the third trophic level. Total production of animals of the second trophic level – 15.1 mln tons, and the third level – 1.5 mln tons. These values comprise 6.81% total biomass of zoobenthos of the Okhotsk Sea (206.7 mln tons) and 5.5% production of both levels of zoobenthos. The role of individual groups of zoobenthos of both levels is presented in Tables 4.1 and 4.2.

Taking into account the fact that total production of community is formed by total production of different levels that comprises its composition, except the part that is assimilated by predators, in accordance with the

calculations of Dulepova and Borts the total production at the shelf of the northeastern Sakhalin was 12.9 mln tons or 336 g/m^2. Therefore, total production per area unit in that region was much lower (by 1.4 times) than the average value of total production of macrozoobenthos (477 g/m) at all the shelf of the Okhotsk Sea.

Table 4.1

Biomass (A) and production of the 2-nd trophic level of benthos on the shelf of the northeastern Sakhalin (From: Dulepova, Borets, 1990).

Group	A	B
Foraminifera	4.2	9.2
Porifera	1.4	3.8
Hydroidea	1.0	2.9
Priapulida	+	+
Polychaeta	6.4	19.5
Echiurida	1.8	3.9
Sipuncula	7.4	17.6
Bryozoa	1.5	2.2
Gastropoda	3.9	2.6
Bivalvia	6.3	5.0
Amphipoda	7.5	7.9
Cirripedia	3.8	2.6
Brachiopoda	+	+
Ophiuroidea	1.1	0.7
Echinoidea	50.3	18.5
Holothuroidea	0.6	0.2
ASdiae	1.9	2.3
Others	1.1	1.1
Total (mln. tons)	12.7	15.1

Table 4.2

Biomass (A) and production (B) of the 3-rd trophic level of different groups of benthos on the shelf of the northeastern Sakhalin (From: Dulepova, Borets, 1990)

Group	A	B
Actiniaria	27.2	21.0
Nemertini	1.6	1.2
Polychaeta	24.2	42.2
Gastropoda	3.8	3.0
Amphipoda	7.4	9.0
Decapoda	15.9	12.5
Asteroidea	12.5	9.7
Pisces	7.4	1.4
Total (mln.t)	1.4	1.5

Production of macrobenthos organisms was calculated by Labai (2000) for the area of Piltun-Astokhskii oil-field. According to this author, it comprised, on the average, 725.747 g/m^2. Main production values are given in Table 4.3.

Table 4.3

Main calculated values macrobenthos production in the area of the Piltun-Astokhskii oil field (From: Labai, 2000)

Group	Biomass, g/m^2	**P/B** coefficient	Production, g/m^2
Actinia	15.787	0.77	12.156
Amphipoda	8.732	0.75	6.549
Bivalvia	17.834	0.3	5.350
Cumacea	69.449	0.9	62.504
Decapoda	2.197	0.3	0.659
Echinoidea	1180.393	0.44	519.373
Gastropoda	2.918	0.3	0.875
Hydroidea	0.126	2.5	0.316
Isopoda	0.001	2.5	0.004
Nematoda	0.001	2.5	0.001
Ophiuroidea	0.575	0.44	0.253
Pantopoda	0.006	2.5	0.016
Polychaeta	16.619	3.65	60.658
Priapulida	17.641	3	52.924
Sipuncula	0.737	3	2.211
Tunicata	0.760	25	1.899
Total:	1333.775	-	725.747

Therefore, the main contribution to the total production is made by the sand dollar Echinarachnius parma.

An analysis of trophic structure made by Labai showed that motile sestonophages comprise most of the community composition, making 94% total macrobenthos biomass. The most valuable food species belong to this group.

5. FEEDING OF GRAY WHALE

5.1. Feeding of gray whales in summer-autumn at the south-eastern coast of Chukchi Peninsula

First data on the feeding pattern of gray whales in summer-autumn in the Bering and Chukchi Seas were obtained by B.A. Zenkovich (1934, 1937), who established that this whale was a typical benthophage, and amphipods comprised the basis of their food consisted of. Hereafter, the works by A.G. Tomilin (1937, 1957), M.M. Sleptsov (1952) and G. C. Pike (Pike, 1962) contributed additional information on this issue. Sometime later, S.S. Klumov (1963) generalized data on feeding of gray whales off the coast of the Far East and gave a list of food items including 17 species, of which amphipods are the main.

Later, V.V. Zimushko, S.A. Lenskaya (1970) studied the stomach content of 70 gray whales, caught in 1965 – 1969 in the Chukchi Sea, Bering Channel and Anadyrskii Bay. Among the food items of gray whale they distinguished 70 representatives of bottom fauna, among which six amphipod species were dominant (from 23). In 1979 – 80 L.S. Bogoslovskaya et al (Bogoslovskaya et al., 1981, 1982; Yablokov and Bogoslovskaya, 1984) studied the species composition of food of 230 gray whales caught in different parts of the coastal waters of Chukchi Peninsula from Anadyrskii Bay to the Chukchi Sea. They gave a list of food items including 30 species of amphipods and other representatives from 12 orders of invertebrates. Therefore, it was established that, the food base of gray whales almost everywhere consists of amphipods, but their species composition in food is different in different fattening grounds.

Despite the information available from the literature on feeding of gray whale, there was a lack of data on food composition in many important fattening grounds of the whales off the coast of the Far East, which stimulated a continuation of studies in that direction.

The materials presented below generalize the results of the studies of feeding of gray whales in their hunting areas off the southeastern coast of Chukchi

Peninsula in 1980 – 1982 and 1998 – 1999 (Blokhin, Pavlyuchkov, 1981, 1996, 1999; Blokhin 1990).

An analysis of the samples of stomach content of the studied whales did not reveal any differences in feeding of females and males, which can be explained by their common fattening grounds off the coast of Chukchi Peninsula. Therefore, in future the feeding of female and male specimens will be examined together.

In the stomachs of the studied whales 150 species of benthos and nectobenthos organisms, belonging to 32 orders were found (Table 5.1). The most abundant among them were amphipods (49 species), out of which the first in occurrence frequency were Ampelisca macrocephala, Lembos arcticus, Pontoporea femorata femorata and Byblis longicornis (Tables 5.1, 5.2 and5.3). As far as gray whales inhabit a large aquatorium of coastal waters, different parts of which are characterized by different conditions, including composition of bottom fauna, it is very natural that the role of different organisms in feeding of animals in different localities varies. Thus in the stomachs of the whales caught in the adjacent waters of Provideniya Bay (locality I, Fig. 5.1), P. f. femorata was dominant, making 90-95 % their content. This representative of amphipods was dominant in food of all the whales caught in that area (Table 5.4). In Mechigmenskii Bay and the adjacent waters the species composition of food items of whales was more diverse, although in III and V localities P. f. femorata were also dominant in their food: their specific weight in the samples was 53.8 and 39.0 %. They were dominant in the stomachs of whales in I, III and V localities (Table 5.4). A. macrocephala (48.1 %) and A. eschrichti (22.0 %) were dominant in the food of gray whale in the most remote from the coast locality VI. They were dominant in the stomachs of the animals caught there 35.3 and 23.5 % correspondingly (Table 5.4).

Table 5.1

Species composition of food items gray whale in coastal waters of the northeastern coast of Chukchi Peninsula (1980-1982)

Species	Occurrence frequency					
	1980.(n=38)		1981. (n=37)		1982. (n=51)	
	n	%	n	%	n	%
1. **Spongia**	6	15.7	2	5.4	5	9.8
Hydrozoa						
2.Sertularella tricuspidata	5	13.1	9	24.3	4	7.8
3. Actinieria	4	10.5	1	2.7	-	-
4. Nemertini			1	2.7		
5. Ampharetidae gen. sp			1	2.7		
6. Lumbriconereis sp.			1	2.7		
7. Maldane sp.					1	1.9
8. Nephthys malmgreni					1	1.9
9. Nephthys sp.	3	7.9			1	1.9
10. Onuphis sp.			3	8.1		
11. Oweniidae gen. sp.	12	31.5	27	71.0	32	62.7
12. Pectinaria granulata	13	34.2	3	8.1	5	9.8
13. P. Hyperborea	1	2.6	1	2.7		
14. Potamilla neglecta					1	1.9
15. Potamilla sp.			1	2.7		
16. Sabellidae gen. sp.	1	2.6	3	8.1		
17. Travisia forbesii	1	2.6				
18. Terebellidae gen. sp.			2	5.4		
19. Fam. gen. sp.					3	5.9
Echiurida						
20. Echiurus echiurus	2	5.2				
Sipunculida						
21. Golfingia sp.	1	2.6				
Cirripedia						
22. Balanus sp.	2	5.2	2	5.4	6	11.8
Cumacea						
23. Diastylis aspera	1	2.6	1	2.7		
24. D. Alabcehtis	6	15.7				
25. D. Bidentata	3	7.9				
26. D. dalli	1	2.6				
27. Diastylis sp.			1	2.7		
Isopoda						
28. Idothea sp.	1	2.6	2	5.4		
29. Synidothea bicuspida					1	1.9
30. S. nebulosa					3	5.9
31. Synidothea sp.	1	2.6				
Amphipoda						
32. Ampelisca derjugini	1	2.6				
33. A. Eschrichti	10	26.3	20	54.1	18	35.3
34. A. Macrocephala	21	55.3	22	59.5	32	62.7

Table 5.1 (continued 1)

Species	1980		1981		1982.	
	n	%	n	%	n	%
35. A. Furcigera			1	2.7		
36. Ampelisca sp.	1	2.6				
37. Anonyx lilljeborgi	8	21.0	8	21.6	11	21.6
38. A. Nugax pacificus	19	50.0	22	59.5	32	62.7
39. A. Makarovi	15	39.5	18	48.6	2	3.9
40. A. Ochotieus	7	18.4	1	2.7		
41. A. Pavlovskii			4	10.8		
42. A. schokalskii			4	10.8		
43. Anonyx sp			6	16.2	2	3.9
44. Acanthostepheia behringiensis			6	16.2	1	1.9
45. Atylus bruggeni	12	31.5	10	27.0	15	29.4
46. A. atlassovi	1	2.6				
47. A. collingi					1	1.9
48. Amphithoe sp.			1	2.7		
49. Byblis gaimardi	3	7.9	2	5.4	1	1.9
50. B. Longicornis	23	60.5	16	43.2	21	41,2
51. Bathymedon sp	1	2.6				
52. Echinogammarus atchrnsis					1	1.9
53. Erictonius grebnitzki					1	1.9
54. E. tolli			1	2.7	1	1.9
55. Eusirus cuspidatus	1	2.6				
56. Haploops sibirica	4	10.5	4	10.8	3	5.9
57. Hippomedon abyssi	1	2.6				
58. H. holbolli			1	2.7		
59. H. propinquus eous	5	13.1	5	13.5		
60. H. minusculus					2	3.9
61. Ischyrocerus commensalis	1	2.6	6	16.2	8	15.7
62. I. latipes	7	18.4			1	1.9
63. I. pachtusovi					5	9.8
64. Ischyrocerus sp.	8	21.1			2	3.9
65. Lembos arcticus	16	42.1	20	54.1	28	54.9
66. Lepidepecreum sp.			1	2.7	1	1.9
67. Melita formosa	4	10.6				
68. M. Quadrispinosa			3	8.1		
69. Melita sp.	3	7.9				
70. Maera prionochira			5	13.5		
71. Maera sp.			4	10.8	1	1.9
72. Monoculodes zernovi	1	2.6				
73. Monoculodes sp.	3	7.9				
74. Orchomene sp.			1	2.7		
75. Orchomenella intermedia			9	24.3		
76. O. minuta	1	2.6	1	2.7	4	7.8
77. O. pacifica	12	31.5	2	5.4		
78. O. pinguis	12	31.5	4	10.8	5	9.8
79. Orchomenella sp.	1	2.6	2	5.4		
80. Odius kelleri			4	10,8		

Table 5.1 (continued 2)

Species	1980		1981.		1982.	
	n	%	n	%	n	%
81. Photis reinchardi	1	2.6				
82. Pontoporeia affinis affinis	2	5.2			2	3.9
83. P. femorata femorata	26	68.4	18	48.6	17	33.3
84. Protomedeia fASata	1	2.6	3	8.1		
85. P. grandimana					1	1.9
86. P. gurjanovae					3	5.9
87. Rhachotropis aculeata			2	5.4		
88. Socarnes bidenticulatus			2	5.4		
89. Stegocephalus inflatus	3	7.9			1	1.9
90. Sympleustes suberitobius					1	1.9
91. Caprella sp.	1	2.6	2	5.4	1	1.9
Decapoda						
92. Chionoecetes opilio opilio			3	8.1	6	11.8
93. Eualus suckleyi					1	1.9
94. Eualus sp.			1	2.7		
95. Hyas coarctatus alutaceus	13	34.2	3	8.1	9	17.6
96. Nectocrangon lar lar	1	2.6				
97. Nectocrangon sp.	1	2.6				
98. Pagurus sp.			2	5.4		
99. Spirontocaris sp.			1	2.7		
Mollusca **Gastropoda** **Hamiglossa**						
100. Boreotrophon sp.	1	2.6				
101. Beringion sp. (shells and eggs)	6	15.8				
102. Buccinum angulosum (shells, eggs)	14	36.8	1	2.7	4	7.8
103. B. Acutispiratum (shells and eggs)	4	10.5				
104. B. bajani minor (shells and eggs)			4	10.8		
105. B. Ciliatum					1	1.9
106. B. ectomicina beringiense (shell)	12	31.5	1	2.7	1	1.9
107. B. Elatior	3	7.9			1	1.9
108. B. glaciale L. (eggs)	3	7.9	2	5.4		
109. B. mirandum picturatum (shell)			1	2.7	8	15.7
110. B. maltzani (shells and eggs)						
111. B. marchianum	13	34.2			1	1.9
112. B. Pemphigus (shells and eggs)					10	19.6
113. B. strigilatum (shells)			1	2.7		
114. Buccinum sp.			6	16.2	4	7.8
115. Cryptonatica aleutica			1	2.7		
116. Margarites helicina					1	1.9
117. Margarites sp.	1	2.6	2	5.4		
118. Neptunea lyrata (shell)	2	5.2				
119. N. ventricosa (eggs)	1	2.6				
120. Neptunea sp. (shell)			5	13.5	2	3.9
121. Plycifusus sp.	1	2.6				
122. Pyrolofusus deformis (eggs)	1	2.6	6	16.2	1	1.9

Table 5.1 (continued 3)

Species	1980		1981		1982	
	n	%	n	%	n	%
123. Volutopsis middendorffii (eggs)	3	7.9			2	3.9
124. Volutopsis sp. (eggs)	2	5.2				
125. Trichotropis bicarinata (Soverbi)	2	5.2	4	10.8		
126. Trichotropis sp.	2	5.2			4	7.8
Bivalvia						
127. Musculus laevigatus					1	1.9
128. M. Nigra	1	2.6				
Lucinida						
129. Hiatella arctica (Linne)					1	1.9
Cardiida						
130. Macoma baltica (Linne)	1	2.6	9	33.3		
131. M. calcarea (Gmelin)			1	2.7		
132. M. moesta (Deshayes)	2	5.2			1	1.9
133. Macoma sp.	2	5.2			1	1.9
134. Mya priapus Tilesius					1	1.9
135. M. truncata Linne	1	2.6	1	2.7		
136. Mya sp.	1	2.6			1	1.9
137. Serripes groenlandicus (Chemnitz)					1	1.9
Bryozoa						
138. Borgella tumulosa Kluge					1	1.9
Cheilostomata						
139. Bugulopsis peache v. beringia Kluge					1	1.9
140. Caberea sp.					1	1.9
141. Celepora nordenskjoldi Kluge					1	1.9
142. Smithina beringia Kluge					1	1.9
143. Fam. gen. sp.	4	10.5	3	8.1	1	1.9
Holothuroidea						
144. Cucumaria calcigera (Stimpson)	3	7.9			1	1.9
145. Cucumaria sp.	1	2.6			1	1.9
ASdiacea						
146. Boltenia echinata Linne					1	1.9
147. B. Ovifera (Linne)					1	1.9
Stolidobranchiata						
148. Molgula griffithsii (MacLevy)					3	5.8
149. Pelonaia corrugata Forbes et Goods	7	18.4	3	8.1	3	5.8
150. SinASdia sp.	1	2.6	1	2.7	1	1.9

Table 5.2

Occurrence frequency, dominance and specific weight of main food items of gray whales (n = 126), caught off Chukchi Peninsula in 1980 – 1982, %

Species	Occurrence frequency	Dominance	Specific weight
Amphipoda			
Ampelisca macrocephala	61.4	15.0	15.6
Ampelisca eschrichti	37.7	6.7	8.1
Pontopore femorata f.	48.1	30.0	29.9
Byblis longicornis	47.2	3.3	6.7
Lembos arcticus	50.4	1.7	3.8
Atylus bruggeni	28.9	10.0	9.7
Polichaeta			
Oweniidae	55.9	5.8	10.2

Table 5.3

Specific weight of main food items of gray whale outside the areas of its highest abundance off the southeastern coast of Chukchi Peninsula , %

Area of whale hunting (Fig. 27)	List of species							
	I*	II	III	IV	V	VI	VII	VIII
1	-	-	-	75.0	-	-	-	-
2	5.0	5.0	50.0	30.0	-	-	-	-
3	-	-	-	-	+	-	70.0	20.0
4	-	-	-	20.0	-	-	70.0	+
5	-	-	90.0	-	-	-	4.0	+
6	+	-	95.0	-	-	-	+	-
7	11.5	-	40.0	30.0	17.3	-	-	-
8	57.0	14.7	-	-	27.4	-	-	-
9	-	-	+	70.0	-	-	-	-
10	+	-	45.0	44.0	-	-	-	-
11	31.0	30.0	-	10.0	-	15.0	-	-
12	80.0	+	-	15.0	+	+	-	-
13	20.0	70.0	-	-	-	+	-	-
14	63.4	6.2	-	-	25.5	2.0	-	-
15	30.0	30.0	-	-	-	+	-	+
16	46.0	44.0	-	-	-	+	-	+
17	25.0	24.0	-	+	26.0	20.0	-	+
18	24.4	58.2	-	-	14.1	+	-	+
19	+	-	62.7	24.0	+	-	-	+
20	+	+	***95.0***	-	-	+	-	-
21	91.7	-	-	+	4.4	3.3	-	+
22	+	-	98.0	-	+	-	+	+
23	70.0	-	-	-	-	20.0	-	+
24	-	-	-	25.0	30.0	-	-	-
25	25.0	70.0	-	+	-	+	-	-
26	70.0	-	-	-	5.0	5.0	-	15.0
27	25.0	25.0	-	+	25.0	20.0	-	+
28	73.0	10.0	+	-	+	9.0	+	+
29	60.0	-	-	+	20.0	20.0	-	-
30	35.0	-	-	-	60.0	5.0	-	-
31	50.0	5.0	-	-	-	-	-	+

Note. * I – Ampelisca macrocephala; II – A. eschrichti; III – Pontoporea femorata f.; IV – Polechaeta Oweniidae; V - Byblis longicornis; VI – Lembos arcticus;
VII – Atylus bruggeni; VIII – Anonyx nugax pacificus;
95.0 – ASdiacea; "+" – single occurrence

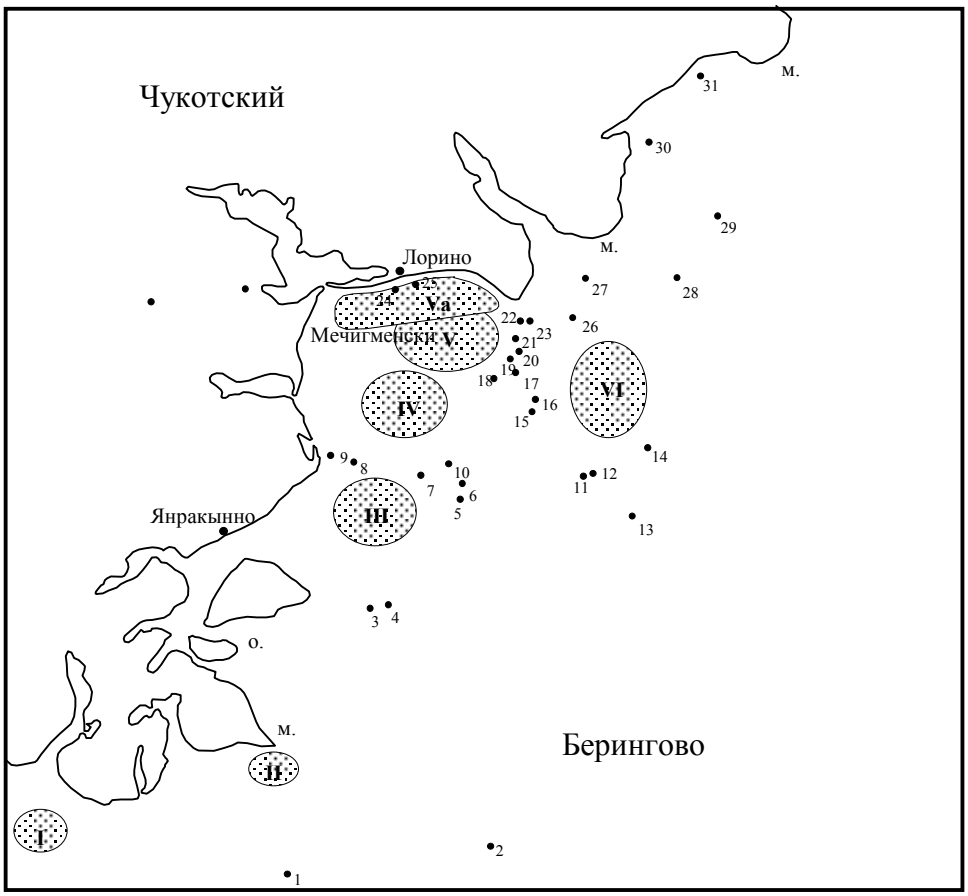

Рис. 5.1
Районы и места добычи серого кита, у определён видовой состав
1980-1982 гг. - Районы I- V, точки 1-31
1998-1999 гг. - Район Va

Table 5.4

Dominance and specific weight of main food items of gray whale in different fattening grounds off south-eastern coast of Chukchi Peninsula, %

Species	Dominance						Specific weight					
	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Amphipoda												
Am. macrocephala			10.0			3.6			5.8	9.3	13.5	48.1
Am. eshcrichti				7.7		23.5				9.6	2.1	22.0
Pontoporea f. f.	100		55.0	7.7	39.3		93.0		53.8	12.3	39.0	
Byblis longicornis										6.9	6.3	10.1
Atylus bruggeni		50.0	20.0	23.1		5.9		60.0	16.0	25.0		5.5
Polichaeta												
Oweniidae		25.0	15.0	7.7	3.6			20.0	20.6	4.6	9.1	1.7
Number of stomachs	8	4	20	14	28	15	8	4	20	14	28	15

Note. I -VI - area number (Fig. 27)

In locality IV on the first place as regards the significance for feeding of whales was Atylus bruggeni (25.6 %), while the proportion of A. eschrichti, P. f. femorata, A. macrocephala, Byblis longicornis and Lembos arcticus in the stomachs was non-significant and approximately the same (Table 5.4). In feeding of whales in locality II on the first place as regards significance was A. bruggeni that was dominant in the stomachs of two out of four caught whales.

Feeding range of gray whales differed not only in different parts of their summer habitat area**,** but also in the same areas in different years. Although in the stomachs of the whales caught in locality V P. f. Femorata was dominant, but its percentage in the total food composition varied: in 1980 – 61.8 %, in 1981 – 37.7 %, and in 1982 – only 25.6 %. In the animals caught in 1980 in locality III, only one specimen contained polychaetes of the family Oweniidae, while in 1981 - 1982 these polychaetes were found in the stomachs of almost all the whales that were caught there in large quantities (40 – 95 %). These data allow assuming that a particular representative of bottom fauna can play a different role in feeding of gray whales in different years.

Despite the abundance of species composition of food items found in the stomachs of gray whales, as a rule, only one of them was dominant. Only in some cases several species contributed approximately equal parts to stomach content. Most often in the studied samples of the food of P. f. femorata and A. Macrocephala were dominant, which, correspondingly, occupied a most important place in feeding of gray whales off Chukotka, with specific weight 45.5 % (Table 5.2 and 5.4). At the same time, we observed two cases of feeding of gray whale with the polar cod Boreogadus saida (1985 and 1987, V locality). The different degree of its digestion as well as the absence of other food items in the stomachs testified that the whale caught the fish not just once but fed on them regularly.

Let us consider more fully the feeding characteristics of gray whale in the coastal waters of Mechigmenskii Bay (Fig. 5.1, locality Va) as far as this is the first case of the information on that locality during all period of research.

Polychaetes, amphipods and cumaceans form the basis of food ratio of gray whale in that locality (Table 5.5). However, species composition and proportion of main organisms consumed by the animals in the bay in 1998 and 1999 were different. Only polychaetes, mainly the representatives of the family Oweniidae, were dominant in feeding of whales in both years (Table 5.5). However, in 1999 their specific weight was significantly higher (1998 - 34.5 %, 1999 - 48.7 %). As regards the representatives of amphipod order that are the favorite food of gray whales, their significance in feeding in these two years was different. In 1998 the representatives of the family Ampeliscidae were in the second place (26.8 %), while in 1999 their significance decreased significantly - 3.1 % (Table 5.5). Moreover, in 1999 another amphipod species - P. f. femorata was almost lacking in the feeding of whales (0.3 %), while in 1998 it was in the third place as regards specific weight (8.7 %; Table 5.5). Of special interest is the appearance of a large number of cumaceans (сем. Diastilidae), mainly Diastylis alabcehtis, in the food of whales in 1999 (22.8 %). This representative of benthos was not registered as a food item of the whales caught in 1998 (Table 5.5).

Therefore, the studies revealed a significant difference in the food range of gray whales in Mechigmenskii Bay in 1998 and 1999, which is evidently connected with their distribution dynamics in this aquatorium. In the 1980-ies a large number of gray whales used the bay as a fattening ground, most of which stayed more than 5-7 km from the coast (Blokhin, 1996). In 1994-96 the number of whales in the bay decreased significantly (Blokhin, 1998), and in 1998-99 it increased again. In our opinion, the observed dynamics of the number of whales in the bay was connected with the changes in their feeding base there (Blokhin, 1998, 1999). However, we had no data bearing witness to the truth of this suggestion.

Table 5.5

Stomach content of the gray whales caught in Mechigmenskii Bay in July-September 1998 (n=27) and 1999 (n=34), %

Species	Occurrence frequency		Specific weight	
	1998 г.	1999 г.	1998 г.	1999 г.
Amphipoda				
Ampeliscidae				
Am. macrocephala	48.1	15.0	22.6	1.6
Am. Eschrichti	22.2	6.0	3.1	0.94
Haploops sibirica	-	20.6	-	3.3
Ampelisca sp.	14.8	3.0	1.04	0.24
Lysianassidae				
Anonyx nugax pacificus	44.4	20.6	7.7	2.88
Anonyx ochoticus	7.4	11.8	0.37	0.44
Hipomedon sp.	-	15.0	-	1.76
Orchomenella sp	-	8.8	-	1.53
Atyllidae				
Atylus cfrinatus	-	3.0	-	0.1
Nototropis brugeni	-	6.0	-	0.65
Nototropis collingi	-	3.0	-	0.6
Photidae				
Fotis fishmfni	-	6.0	-	1.2
Ischyroceridae				
Ischyrocerus latipes	-	6.0	-	1.2
Ischyrocerus sp	7.4	3.0	0.55	0.6
Gammaridae				
Melita formosa	-	6.0	-	0.74
Haustoriidae				
Pontopore femorata f.	22.2	3.0	8.7	0.3
Amphipoda varia	14.8	6.0	1.04	0.94
Cumacea				
Diastilidae				
Diastylis alabcehtis		51.0		21.6
Diastylis sp.	14.8	44.0	0.74	1.2
Decapoda				
Hyas coaretausaluteceus	3.7		+	
Hydroidea sp.	18.5	-	8.5	-
Isopoda sp.	-	3.0	-	+
Polychaeta				
Oweniidae	70.4	58.0	30.4	30.74
Terebellidae	7.4	-	1.67	-
Chloraemidae				
Brada sp.	7.4	-	0.74	-
Polychaeta varia	14.8	44.0	1.67	17.94
Bivalvia				
Tellinidae				
Macoma sp.	3.7	-	0.37	-
Spongia sp.	-	6.0	-	+
ASdia				

Styelidae				
Pelonaia corrugata	-	3.0	-	+
Sand	22.2	6.0	8.4	0.6

The distribution of the whales in the bay in 1998 – 1999 also varied. In 1998 the majority of the animals inhabited and, correspondingly, were caught further than 5-7 km from the coast, while in 1999 the majority of the whales observed in the bay were distributed closer to the coast (from 1 to 5 km). In both cases the behavior of the whales (a prolonged dwelling in a small aquatorium, prolonged sinking into water with their tails protruded from the water) testified of their active feeding.

The studies conducted in 1980 – 1982 showed that in the area situated on the eastern border of the bay and in the open waters of the Bering Channel, (locality V) in the feeding of whales the first place as regards specific weight was occupied by the polychaetes of the family Oweniidae (39. 0 %), the second one – by the representatives of the amphipod A. macrocephala (13.5 %), and the third one - by P. f. femorata (9.1 %). Such proportion almost fully coincides with species composition of the main food items in the animals caught in Mechigmenskii Bay in 1998 (Table 5.5). However, in 1999 as it was mentioned above, the gray whales there stayed closer to the coast, which, obviously, explained the significant difference in the feeding of the animals in these two years. Of special interest was the fact that the representatives of the family Diastilidae, which occupied the second place as regards specific weight (22.8 %) in the food of the whales caught in 1999 (Table 5.5), earlier were not mentioned in literature as their food item, and in the stomachs of the animals studied by us in 1980-1982 only individual specimens were found (Table 5.1). It is possible that the distribution of this representative of bottom fauna is adjusted to the shallow waters of Chukchi Peninsula, where the whales had not been caught till 1992 during their hunting by whaling ships.

The presence of gray whales at different fattening grounds depends on the stocks of feeding benthos in them (Berzin, Rovnin, 1966; Blokhin, 1988). Therefore, the difference that we observed in the feeding and distribution of the animals in Mechigmenskii Bay might indirectly testify of a possible decrease of

food resources of the areas that are most remote from the coast of this aquatorium by 1999.

V.V. Zimushko and S.A. Lenskaya (1970) analyzed the stomach content of 70 gray whales and did not find any significant differences in food range of the animals in different parts of their summer habitat area. According to their data, the first in occurrence frequency in the stomachs of the whales examined was Anonyx nugax, (80.0 %) which occupied the second place as regards weight after P. f. femorata. Unfortunately, the authors did not mention the catch areas of the whales studied by them. In our collections Anonix nugax was found in 50.5 % samples, but in none of them it was dominant and did not play a significant role as a food item of gray whale (Table 5.1). A.G. Tomilin (1957) mentioned that in the stomach of one gray whale caught in the waters of the Chukchi Sea, polychaete Travisia forbesii was observed in mass, which in our samples was almost lacking. In the material of V.V. Zimushko and S.A. Lenskaya (1970) among polychaetes on the first place as regards occurrence frequency were the representatives of the family Pectinariidae (38,8 %), individual specimens of which were found in the stomachs of the whales caught in 1980 – 1982. At the same time, the most numerous polychaetes in feeding of whales in that period were the representatives of the family Oweniidae, that in occurrence frequency were on the second place, and in the specific weight – on the third place (Table 5.2). The most significant in the feeding of whales they were in II and III localities (Fig. 5.1).

In works by Bogoslovskaya et al. (1981, 1982) data are presented that testify of different food ranges of gray whales in different localities, which has been confirmed by our studies. Besides, there is a definite similarity of their data on food composition of animals with our material. For example, in the samples of the whales studied by them from Provideniya Bay (locality I), P. f. femorata was significantly dominant, and in Mechigmenskii Bay P, f. femorata, A. macrocephala and A. bruggeni occupied the leading place. The same representatives of bottom played an important role in the feeding of the whales from IV and V localities studied by us (Fig. 5.1, Table 5.4). Moreover, it is interesting that in our samples

polychaetes were the third as regards specific weight (Table 5.2), while in the work by Bogoslovskaya et al. (1982) they were just mentioned as a food item of the animals only in two out of nine areas studied by them.

Therefore, a comparative analysis of available and our own data makes it possible to assume that a changeability exists in food range of gray whales both as regards different years, and different localities off Chukotka. These data as well as the fact of a discovery of bottom fish in the stomachs of the animals testify of a certain plasticity, which can be exhibited by gray whale in the feeding process.

The studies conducted in 1980 – 1982 showed that despite the abundance of the species found in the stomachs of gray whales, only a small number of them plays the main role in feeding of the animals off the south-eastern coast of Chukchi Peninsula, among which the most significant are P. f. femorata A. macrocephala and polychaetes of the family Oweniidae. Based on the fact that these food items were dominant more often than other speciesin the stomachs of the whales examined by us (Table 5.2, 5.5), it can be assumed that they form dense aggregations in the coastal waters of the peninsula and as a food item are most available to gray whale. Therefore, the distribution of whales in their summer habitat area is determined by the presence and high density of the aggregations formed by these organisms, and in some localities – such representatives as A. bruggeni, A. eschrichti, B. longicornis and L. arcticus.

The studies conducted in 1986 (Blokhin, Pavlyuchkov, 1986) showed that total stocks of food benthos (amphipods and polychaetes) of gray whale in the main fattening grounds off the Far East coast comprise about 10 mln. tons (Table 5.6). The richest in this respect is the southern part of the Chukchi Sea, where the proportion of the feeding benthos is 62.0 % its total stock in the localities distinguished by us (Table 5.6). As a result, in this aquatorium the greatest number of gray whales fattened (54.6 %). The second as regards food benthos stocks (20.0 %) is the area from Chaplin Cape to Dezhnev Cape, which was the third as regards the number of feeding whales in it. The third as regards food stocks was (12.3 %) the area between Anastasii Bay and Navarin Cape (Koryakskii coast), which was

the second as regards the number of whales in it. Other localities small in area were characterized by the smallest stocks of feeding benthos and, respectively, by the smallest number of the animals feeding in it (Table 5.6).

In spite of the mentioned connection between the distribution of gray whales with their food stocks, in each individual locality the whales not always were attached to the places of highest concentration of their food items: sometimes the greatest amount of the animals was observed in the areas where benthos density was the lowest. In some areas during the repeated survey the whales were absent in the places where they were numerous previously and, on the other hand, they were observed in the places where they were previously absent. Such distribution pattern of gray whales was observed by other researchers Rovnin, 1966; Zimushko, Lenskaya, 1970). In accordance with data by A.A. Berzin and A.A. Rovnin (1966) the feeding animals were found only in the places where benthos biomass reached 100 g/m^2 and more, but, unfortunately, they did not describe species composition. We agree with the assumption of V.V. Zimushko and S.A. Lenskaya (1970) that «…characterizing the distribution of gray whales, it is not enough to use only total biomass of benthos», because in many places it is formed mainly by echinoderms and mollusks (Zenkevich, 1963), which are not food items of whales. In accordance with our data in the coastal waters of the Far East in 1986 the feeding benthos in the distinguished localities comprised from 6.6 to 33.4 % total benthos stock in each of them. Its value was highest in the coastal waters of the northwestern part of Anadyrskii Bay, and it was lowest in the southern and northeastern parts of the bay. For example, at the south-eastern coast of Chukchi Peninsula, between Chaplin and Dezhnev Capes, 60 % total bottom area is occupied by bottom organisms, the biomass of which reaches 500 – 1000 g/m^2 (average - 744.3 g/m^2). Polychaetes and amphipods comprise only 93.2 g/m and 104.2 g/m^2, correspondingly. The main amphipod species that are most often eaten by gray whales are A. macrocephala, A. eschrichti and P. f. femorata. The highest biomass of feeding benthos (over 200 g/m^2) is concentrated in the central part of this auatorium (V and VI localities, Fig.

5.1), mainly on fine aleurite and aleurite-clay grounds. The average biomass of feeding macrobenthos there was 270.8 g/m^2 (Blokhin, Pavlyuchkov, 1986).

Based on data mentioned above, it can be assumed that for the fattening of a certain number of gray whales in a specific area the average biomass of feeding benthos in it should be non less than 40-50 g/m^2.

In 1967 V.V. Zimushko and S.A. Lenskaya 3 (1970) having found sand and gravel in the stomachs of 24 % whales examined by them, expressed an opinion that a great number of the animals, in which stomachs non-food items were found, are connected with the condition of their feeding base. However, even in the 1930-ies in the stomach of almost every whale caught by a whaler vessel «Aleut», gravel was found in large amount (Zenkovich, 1937). As far as gray whale is a benthophage, it is quite natural that in the feeding process the animal can engulf from the bottom a certain amount of ground. For example, in the stomachs of many animals examined by us foreign bodies, such as pieces of wood, stones, gravel, sand and silt were found. The studies that we conducted in 1980 – 1991showed that the stomachs of 85 % examined whales were full or half-full and only in the stomachs of 5 % animals there was nothing except sand, gravel and silt. In 1994-96 in the stomachs of almost all the animals examined by us together with food items there was sand and small gravel occupying from 10 to 80 % its content (Blokhin, 1996). However, in the whales' catch of 1998 there were significantly less whales with such stomachs (Blokhin, 1998), and 1999 there were no such whales.

One of the indicators of the feeding conditions (fattening) of large whales is their fatness (Sliper, 1954). Our studies showed that the index of fat thickness varied in gray whales of different sexes and females of different physiological state (Blokhin, 1990). It is reasonable that pregnant females show the highest fatness, and barren ones that recently stopped feeding calves - the lowest one (Table 5.7). At the same time, this index in the whales caught in the period from 1980 to 1999 was not permanent but its changes till 1990 did not show any specific tendency.

And only from 1989 a significant decrease in fatness index of caught males was observed, and from 1990 – sexually immature animals (Table 5.7). Based on

this data, an assumption appears about the worsening of fattening conditions of some groups of whales in the coastal waters of Chukchi Peninsula after 1990. In accordance with data of American researchers the Californian Chukchi population of gray whales now (1997 – 1998) exhibits the maximal level of its abundance as compared with the whole research period in that century (26.6 thousand, Hobss a. Rugh, 1999). For this reason, it can be assumed that the stocks of feeding benthos under the active consumption by whales and other representatives of bottom fauna at present are, possibly, not in their best condition. It is not inconceivable that at present, the optimal abundance of this population of gray whales exceeds the level, which the present feeding base is able to satisfy. As an indirect confirmation of this suggestion can serve the information on the extraordinary number of gray whales (300 specimens), found dead on the western coast of the North America at the end of 1999. In the opinion of some American researchers the mass mortality of the whales could be caused by starvation (a personal communication of an Australian ecologist Sue Arnold). However, we do not have any objective evidence testifying in favor of that version. Moreover, in 1999 only one case of finding a dead young whale on the coast of Mechigmenskii Bay was registered, while in previous years it was a common case for that area.

Table 5.6

Abundance of gray whales and their feeding benthos stocks (amphipods and polychaetes) in the main fattening grounds in the Bering and Chukchi Seas (1986)

№№ localities		**I**	**II**	**III**	**IV**	**V**	**VI**	**Total**
Number of whales	heads	1380	200	202	7	761	3030	5540
Feeding benthos biomass	Thous. tons	736	106	217	5	1200	8000	10264
	%%	12.3	1.8	3.6	0.08	20.0	62.1	100
Average feeding benthos biomass	g/m^2	72.7	49.8	57.4	31.7	144.6	114.7	
Correlation of average biomass of feeding and total benthos	%	21.2	6.6	33.4	6.6	17.2	17.8	
Number of benthos stations								179

Table 5.7

Fatness indices of gray whales caught off the coast of Chukchi Peninsula in 1981-1999, %

Year(month)	Females			Males
	Sexually immature	Barren	Pregnan	
1981 (IX)	1.09 (14)*	0.95 (9)	1.15 (9)	1.04 (13)
1982 (VIII-X)	1.11 (7)	0.93 (18)	1.18 (11)	1.08 (33)
1983 (VIII-X)	1.02 (15)	0.93 (20)	1.09 (10)	1.00 (15)
1984 (VIII-X)	1.04 (20)	0.97 (21)	0.98 (5)	0.98 (23)
1985 (VII-X)	1.03 (13)	0.94 (19)	1.12 (15)	1.04 (18)
1987 (IX)	1.01 (17)	0.93 (17)	1.18 (5)	0.99 (17)
1988 (VIII-X)	1.07 (3)	0.98 (40)	1.21 (4)	0.99 (22)
1989 (VII-X)	1.01 (9)	0.92 (30)	1.03 (1)	0.90 (22)
1990 (VIII-X)	0.94 (5)	0.98 (29)	1.21 (4)	0.91 (24)
1994-95 (X)	0.84 (16)**	-	-	-
1998 (VII-VIII)	0.93 (25)**	-	-	-
1999 (VIII-X)	0.88 (26)**	-	-	-

Notre: * - in brackets number of measurements; ** - together with males

5.2 Feeding of gray whales of the Okhotsk-Korean population on the shelf of the northeastern Sakhalin

The gray whales of the Okhotsk-Korean population were not specially caught at the fattening grounds in the Okhotsk Sea, which explains the lack of data

on their feeding off the coast of the northeastern Sakhalin until recently. However, on analogy with the animals from the Californian-Chukchiii population it was assumed that its food base consisted of the representatives of bottom biotopes – amphipods and polychaetes. These representatives of bottom fauna are present on the shelf of the Okhotsk Sea (Koblikov, Pavlyuchkov, 1990).

The beginning of the industrial development of oil and gas on the shelf of the eastern Sakhalin attracted the attention of many specialists on its study. As a result, data on the composition of bottom fauna were obtained directly in the places of active fattening of gray whales (Blokhin, Burdin. 2000; Sobolevskii et al. 2000). The studies conducted in 1998 and 1999 in the place of the highest concentration of whales near Piltun Bay allowed to collect the food items that were washed away from the mouth of the animals during their coming to the surface of the sea (Weller et al., 1999). Below, we give their full list in the alphabetic order

1. Coastal area, 1-3 km from the coast

Amphipods: Isopods:

Anisogammarus pugettensis *Saduria entomn*

Anonix sp. *Synidotea nodulosa*

Iocustogammarus hisutimanus *Unidentifed zoea lirva*

Iocustogammarus sp.,

Pontoporea sp.

2. Remote area, 15-16 km from the coast (area of oil platform Molikpak)

Amphipods: **Bivalve molluscs**

Anonix liijeborgi **Gastropods**

Echaustorius eous **Polychaetes**

Ischyrocerus anguipes

Orchomene pacifica

paraphoxus milleri

Data obtained by us from an expedition vessel in 1997 showed that off the north-eastern Sakhalin (at a depth of 10-15 m) gray whales occurred in the areas of bottom biocenoses, in which euryhaline species were dominant s: *Synidotea cinerea* + *Eogammarus schmidti* and *Synidotea cinerea* + *Pontoporea affinis*. The

representatives of such biocenosis with the background species *Synidotea cinerea*, form most dense aggregations in the fattening grounds of gray whales (Labai, 1997) and, obviously, can play an important role as their food item.

Sobolevskii Ye.I. et al. (2000) established that the most abundant species in one of the feeding areas of gray whales (at a depth of 10-12 m) were amphipods (34 species). On the second place as regards the number were the isopods *Synidotea cinerea*. In some places polychaetes (*Onuphis shirikishinaensis*) and a large isopod *Saduria entomon* are numerous, and the shrimp *Crangon septemspinosa* and the representatives of *Cumacea* are found in small number. At a depth of 7-12 m the maximal biomass of amphipods (75 - 85 g/m^2) was observed, among which the species *Pontoporea affinis* was dominant (63-95 %). *Anisogammarus pugettensis, Eonaustorius eous eous, Eogammarus schmidti* and *Pontharpinia longirostris* were usually observed in a large amount. These species in addition with the dominanat one comprise almost total biomass of amphipods in the studied area (Sobolevskii et al., 2000).

Therefore, data available at present allow making an assumption of the similarity in feeding of the animals of the Okhotsk Sea and the northern part of the Bering Sea as regards the main groups of bottom organisms. Of course, the included list of the possible food items of the gray whales off the northeastern coast of Sakhalin is not a complete one, but, obviously, the main role in their feeding also belongs to amphipods. В качестве корма The whales of the Korean-Okhotsk population can use as food polychaetes and cumaceans, which are present in the feeding diet of the animals of the coastal waters of the southeastern coast of Chukotka. However, it is possible that there are significant differences in the species composition of food items of the whales of two populations. For the animals of the Okhotsk-Korean population isopods seem to play a significant role in their food. And yet, in the stomachs of the whales of the Californian Chukchi populations only individual specimens are found.

6. Conclusion

The conducted studies allowed establishing that out of all the diversity of the organisms (150 species of benthos and nectobenthos) that are found in the food of the gray whales 6 species of amphipods and polychaetes play the main role in their feeding in the coastal waters of the southeastern coast of Chukchi peninsula. The most significant among amphipods are P. f. femorata and A. macrocephala that form most dense aggregations in the area of fattening of the animals. At the same time, the gray whales feed on other representatives of bottom fauna, for example, polychaetes from the family Oweniidae, the biomass of which in some parts of the coastal waters (judging from their mass in stomachs) is also large. In the shallow-water bights of the southeastern coast of Chukchi peninsula the cumacean Diastylis alabcehtis can play a significant role as a food item of gray whales. We did not observe the differences in the food range of specimens of different size and sex. Despite that the food base of the animals off the coast of Chukotka is presented by amphipods and polychaetes, their food range can vary depending on their fattening grounds and can change from year to year. This and the observed cases of eating of fish by the whales testify of their plasticity in the ability to feed on different bottom and off-bottom organisms. However, the role of different benthic organisms in feeding of the animals and, therefore, in their distribution in the aquatorium of fattening depends on their stocks, which, in their turn, can change significantly under the influence of feeding pressure from gray whales.

The studies have shown that the feeding base of the gray whales of the Californian-Chukchi population off the coast Chukchi Peninsula in 1980 - 1990 was in a good condition. However, in the 1990-ies the gray whales possibly faced some problems with feeding.

The food range of the gray whales of the Okhotsk-Korean population off the northeastern Sakhalin is quite diverse (amphipods, isopods, polychaetes, cumaceans and other food items). However, off the northeastern Sakhalin the fattening area of the animals in the studied aquatorium is significantly smaller than in the whales of the Chukchi Sea. Therefore, the food stocks near Sakhalin can

serve as a limiting factor in the distribution of the gray whales (Sobolevskii, 1998, 2000). And yet, to make the final conclusions on this issue, it is necessary to conduct a special research on the state of the feeding base of gray whales in that region.

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Legends
«Fig.1.1.Benthic stations of the schooner “Storozh” in 1899-1902.
off the northeastern Sakhalin (From: Ushakov, 1953)
Fig.1.2. Benthic stations off the northeastern Sakhalin
Of the Hydrographic expedition of the Easter Ocean in 1910 (crosses) and in 1918. (ticks) (From: Ushakov, 1953)
Fig.1.3. Benthic stations off the northeastern Sakhalin on **р/т** «Ara» in 1932. (From: Ushakov: Ушаков, 1953)
Fig.1.4. Benthic stations on **р/т** “Gagara” off the northeastern Sakhalin in 1932
Fig.1.5. Map of benthic stations off the northeastern Sakhalin on E/V “Vityaz” in 1949-1954. Black circles – quantitative dredging stations; light triangles – trawling stations (From: Savilov, 1961)
Fig.1.6. Map of benthic stations of PRIFO off the northeastern Sakhalin in 1974-1986. NES – norther part of the eastern Sakhalin; ES –central part of the eastern Sakhalin (From: Koblikov et al., 1990)
Fig.2.1. Distribution of biomass of non-motile sestonophages (%)
Fig.2.2. Distribution of biomass of non-motile sestonophages (g/m2):
1 – less10, 2 – from 10 to 100, 3 – from 100 to 200, 4 – from 200 to 500,
5 –over 500
Fig.2.3. Distribution of biomass of non-motile sestonophages (g/m2):
1 – less 0.1; 2 – over 1000. Other conventional signs as in Fig.2.2.
Fig.2.4. Distribution of biomass of motile sestonophages (%)
Fig.2.5. Distribution of biomass of collecting detritophages (g/m2).
Conventional signs as in Fig.2.2.
Fig.2.6. Distribution of biomass of collecting detritophages (%).
Conventional signs as in Fig.2.2.
Fig.2.7. Distribution of biomass of non-selective detritophages (g/m2).
Conventional signs as in Fig.2.2.
Fig.2.8. Distribution of biomass of non-selective detritophages (%)
Fig.2.9. Dominance areas of food groups of macrobenthos (trophic zones):
1 – of non-motile sestonophages; 2 –motile sestonophages;
3 – collecting detritophages; 4 non-selective detritophages
Fig.3.1. Distribution of total benthos biomass (g/m2, fresh weight) on the shelf of the northeastern Sakhalin (From: Savilov, 1961) 1.300-500 g/m2; 2. 100-300 g/m2; 3. 50-100 g/m2; 4. 10-50 g/m2
Fig.3.2. Quantitative distribution of benthos on the shelf on the eastern Sakhalin (From: Koblikov et al., 1990) 1. 5-100 g/m2; 2. 100-500 g/m2; 3. 500-1000 g/m2; 4. over 1000 g/m2
Fig.3.3. Distribution of benthos biomass (g/m2) in Piltun-Astokhskii area of the north-eastern Sakhalin (From: Tkalin and Belan, 1993)