Title	The Intertidal Biota of Volcanic Yankich Island (Middle Kuril Islands)
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Citation	PUBLICATIONS OF THE SETO MARINE BIOLOGICAL LABORATORY (1996), 37(3-6): 201-225
Issue Date	1996-12-25
URL	http://hdl.handle.net/2433/176267
Right	
Type	Departmental Bulletin Paper
Textversion	publisher

The Intertidal Biota of Volcanic Yankich Island (Middle Kuril Islands)

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Abstract A description of the intertidal biota of volcanic Yankich Island (Ushishir Islands, Kuril Islands) is given. The species composition and vertical distribution pattern of the intertidal communities at various localities are described in relation to environmental factors, such as nature of the substrate, surf conditions and volcanic vent water. The macrobenthos is poor in the areas directly influenced by high temperature (20-40°C) and high sulphur content. There are no marked changes in the intertidal communities in the areas of volcanic springs that are characterised by temperature below 10°C and by the absence of sulphur compounds. In general, the species composition and distribution of the intertidal biota are ordinary for the intertidal zone of the middle Kuril Islands. But there are departures from the typical zonation of the intertidal biota. Also, mass populations of *Balanus crenatus* appear.

Key words: Kuril Islands, intertidal, macrobenthos, volcanic springs

Introduction

The purpose of this report is to describe the intertidal biota of Yankich Island, a volcanic island in the Ushishir Islands of the middle Kuril Islands. This island is influenced by wave action of various intensities and gaso-hydrothermal activity.

The Ushishir Islands are a group of two small volcanic islands, Yankich Island and its smaller neighbour Reponkich Island. They are situated nearly in the middle of the Kuril Islands chain between Ketoy Island and Rashua Island (Fig. 1) and represent the summits of Ushishir Volcano that became partly submerged several (probably 10) thousand years ago (Gavrilenko et al., 1989). The Ushishir Islands lie at 47°30' N and the cold currents running along the middle Kuril Islands lower the sea temperature so much (3-4°C in August) that the summer hydrographic conditions correspond to those in the Bering Strait. Tides are irregularly diurnal, with the maximum range of fluctuation of sea level about 2.1 m.

Yankich Island reaches an altitude of 401 m and its coastline consists mainly of intrusive igneous rocks, forming tall, abrupt cliffs. On the south, Kraternaya Bight cut deeply into the island. This bight is a caldera, a submerged crater connected with the open sea by a long, narrow and shallow passage. At the mouth of the passage lie five stony reefs and sandbanks that separate the bight from the open sea, and a shallow channel which is about 0.2-0.3 m deep at the lowest low water.

The open craggy coast of the Ushishir Islands is subjected to strong wave action. The wave action is reduced by stony reefs; therefore, in Kraternaya Bight the water is usually calm without surf.

The waters around the Ushishir Islands are usually homogenous and rich in nutrients (N-NO_3 to 30 μM, P- PO_4 to 2 μM). Chlorophyll *a* concentrations are about 0.2 mg m^{-3} or less (Tarasov et al., 1990).

The Ushishir Islands and especially Kraternaya Bight were intensively investigated in 1985-1992 by expeditions of the Institute of Marine Biology, Vladivostok, headed by V. Tarasov. The results of this survey concerning the marine ecosystem of the caldera of

Kraternaya Bight have been published in many papers (e.g., in English, Tarasov et al., 1990; Zhirmunsky & Tarasov, 1990). But as for the intertidal biota, these publications only briefly noted observations on barnacles and littorinids.

The present report is based on observations made during short visits to Yankich Island in June-July, 1988, by E. Kostina and in August-September, 1992, by O. Kussakin. Field trips were made along the southern coast of the island and all around Kraternaya Bight in order

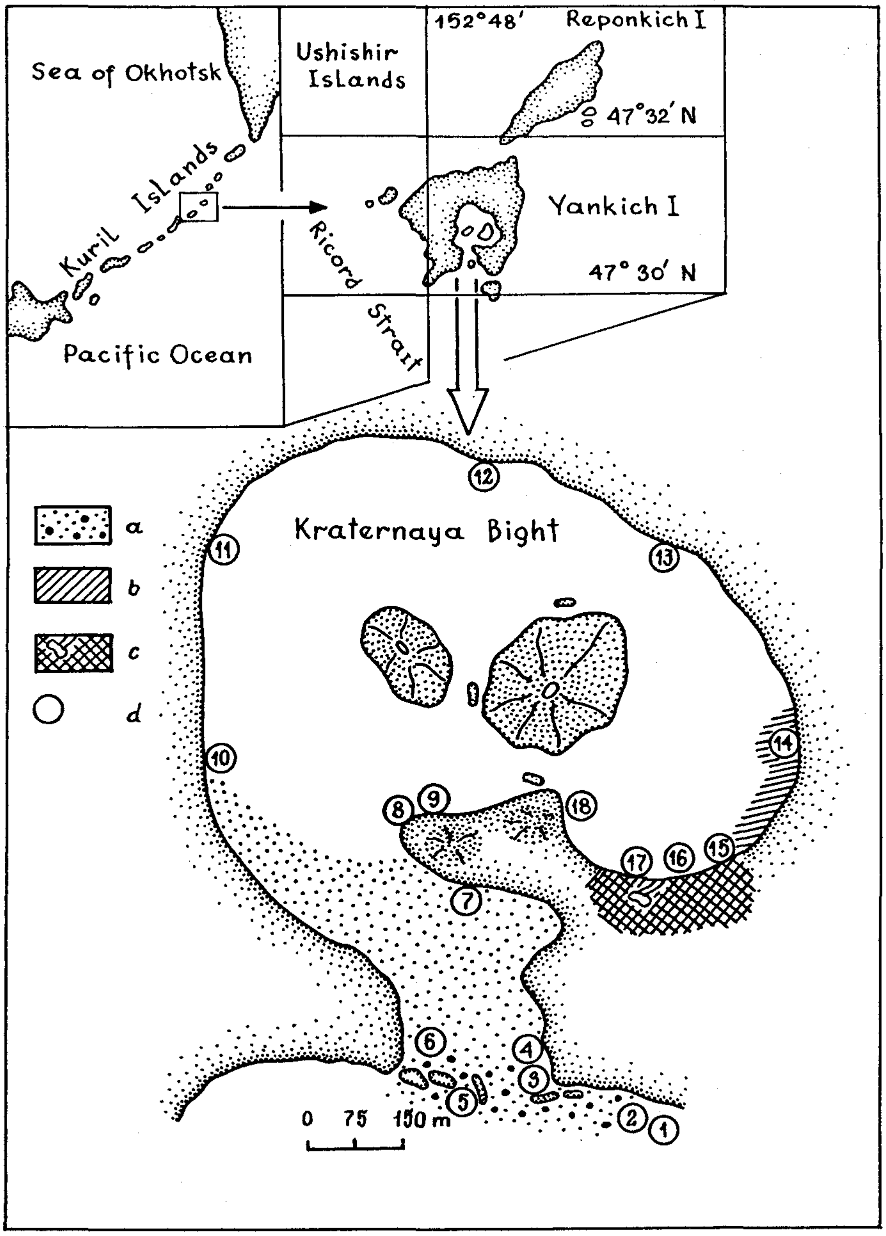

Fig. 1. Map of the investigated area and locations of sampling transects. a - sand bank and stones in the bight entrance; b - area of volcanic water seeps; c - terrestrial hydrosolfatar field, boiling volcanic water seeps; d - sampling transects.

to gain broader information of the shore conditions and intertidal biota. Areas representing the major intertidal habitats were selected for more intensive study (Fig. 1, d), namely transect surveys across the intertidal zone. Altogether, 42 quantitative and 24 qualitative samples of macrobenthos were taken from 18 transects in the studied areas. The quantitative samples were collected using 0.01, 0.25 and 0.5 m^2 square metal frames along each transect.

Table 1. Biomass (B, g wet wt m^{-2}) and numbers (N, m^{-2}) of intertidal macrobenthos on the open coast (Transects 1 & 2)

Taxa	Taxonomic group*	H. High intertidal		M. Middle intertidal		L. Low intertidal	
		B	N	B	N	B	N
PLANTS							
Urospora penicilliformis	Ch	185.2	–	–	–	–	–
Acrosiphonia duriuscula (with epiphytic diatoms)	Ch	–	–	350.0	–	–	–
Palmaria stenogona	Rh	–	–	451.0	–	–	–
Iridaea cornucopiae	Rh	–	–	1518.3	–	–	–
Monostroma grevillei	Ch	–	–	20.8	–	–	–
Alaria sp.	Ph	–	–	6.5	–	–	–
Neoptilota asplenioides	Rh	–	–	0.3	–	–	–
Laminaria longipes	Ph	–	–	–	–	23,153.0	–
Kallymeniaceae gen. sp.	Rh	–	–	–	–	105.0	–
Ptilota filicina	Rh	–	–	–	–	8.0	–
Total plants		185.2		2346.9		23,266.0	
ANIMALS							
Littorina sitkana	Ga	2317.5	8400	10.25	420	34.0	600
Nucella freycinettii	Ga	–	–	53.75	25	–	–
Parallorchestes ochotensis	Am	–	–	13.2	2800	14.3	500
Nemertini	Ne	–	–	1.5	375	11.0	2100
Turtonia minuta	Bi	–	–	0.75	325	1.0	100
Idotea gurjanovae	Is	–	–	6.5	750	–	–
Nereis pelagica	Po	–	–	2.95	275	14.0	100
Pontogeneia makarovi	Am	–	–	0.5	550	–	–
Boccardia sp.	Po	–	–	2.1	50	–	–
Cucumaria vegae	Ho	–	–	2.0	75	645.0	8600
Amphiglena pacifica	Po	–	–	0.75	50	–	–
Allorchestes malleolus	Am	–	–	0.15	50	–	–
Leptasterias alaskensis asiatica	Ast	–	–	–	–	3.0	200
Sycon sp.	Sp	–	–	–	–	37.0	–
Eteone longa	Po	–	–	–	–	2.2	100
Typosyllis ehlersioides japonica	Po	–	–	–	–	9.4	3700
Sabellidae gen. sp.	Po	–	–	–	–	5.6	100
Actiniidae gen. sp.	Ac	–	–	–	–	5.0	100
Cirratulus wladislavi	Po	–	–	–	–	1.0	100
Abietinaria filicula filicula	Hy	–	–	–	–	1.0	–
Lepidopecreum sp.	Am	–	–	–	–	1.9	600
Ischyrocerus tzvetkovae	Am	–	–	–	–	1.4	400
Phascolosoma sp.	Si	–	–	–	–	1.0	100
Dysponetus pygmaeus	Po	–	–	–	–	1.0	2400
Naineris quadricuspida	Po	–	–	–	–	0.8	100
Turbellaria	Tu	–	–	–	–	0.4	100
Phyllodocidae gen.sp.	Po	–	–	–	–	0.4	100
Paraphoxus longirostris	Am	–	–	–	–	0.8	700
Ampithoe djakonovi	Am	–	–	–	–	0.4	100
Total animals		2317.5		94.4		792.0	

*) Ch - Chlorophycota; Ph - Phaeophycota, Rh - Rhodophycota; Sp - Spongia; Hy - Hydrozoa; Ac - Actiniaria; Tu - Turbellaria; Ne - Nemertini; Si - Sipunculida; Po - Polychaeta; Ol - Oligochaeta; Ci - Cirripedia; Le - Leptostraca; Am - Amphipoda; Is - Isopoda; Ga - Gastropoda; Bi - Bivalvia; Ast - Asteroidea; Ech - Echinoidea; Ho - Holothuroidea; As - Ascidia.

The number of individuals and biomass of each species were calculated for 1 m^2 area. The biomass of each species was determined as blotted wet weight. This procedure was necessary because the material was needed for subsequent taxonomic work.

The Open Coast

The substrate varies little along the open coast of Yankich Island. Abrupt rocky shores stretch all along the coast of this island. The rocky walls are mostly vertical and difficult for investigators to approach because of the surges, but at some places a narrow boulder beach is formed between the rocky headlands, consisting of relatively hard volcanic rocks. We studied one such boulder beach on the south-eastern coast of the island near the entrance to Kraternaya Bight (Transects 1 and 2). The wave action here was nearly constant and sometimes severe. Therefore, most of the intertidal zone proper, an area about 30-50 m wide, was occupied purely by lower intertidal laminarians with *Laminaria longipes* as the dominant species. The mean algal biomass was comparatively high (Table 1, L), but the number of species was very low, and the macroalgal flora included only two other species of red algae, *Ptilota filicina* and Kallymeniacea gen. sp. Animals were more diverse. The dominant species was the small sea cucumber *Cucumaria vegae*, which attained high densities along the sides of stones, beneath boulders, and among algae. Various polychaetes and amphipods were commonly found in holdfasts of laminarian growths.

The mid-intertidal fucoid community of *Fucus evanescens* is poorly developed in this area, mainly because of the strong surf, and it comprised the large algae *Iridaea cornucopiae* and *Palmaria stenogona* with an admixture of other small algae, especially a green alga *Acrosiphonia duriuscula*. The biomass of the algae in this community was about 1/10, and the biomass of animals about 1/8.5, of that in the lower intertidal community (Table 1, M). Common animals were the gastropods *Nucella freycinettii* and *Littorina sitkana*, an amphipod *Parallorchestes ochotensis*, and an isopod *Idotea gurjanovae*. The main breadth of the mid-intertidal belt in this area was about 5 m.

The common upper-intertidal community of *Littorina sitkana* here was often replaced by patches of the small filamentous green alga *Urospora penicilliformis*, with a low biomass of about 200 g m^{-2} (Table 1, H).

Entrance to Kraternaya Bight

The entrance to Kraternaya Bight (Transects 3-7) is somewhat sheltered from the open sea by stony reefs that are exposed at low water and are divided into two groups by a shallow and narrow, turbulent channel. These reefs are composed of boulders and rocks from 0.5 to 3 m in diameter. Besides these boulders, there are several high vertical rocks leaning against each other on the western reef. The shaded niches under these rocks are well protected from the surf. Between the stones are numerous tide pools of various sizes situated at different levels above the sea. Most of the tide-covered reefs are subject to the influence of strong tidal currents. Due to the considerable width of these reefs (several tens of metres), the wave action across the reefs is diminished. The water in this area appears to be unusually rich in nutrient salts and microelements, partly due to an inflow from Kraternaya Bight.

The heterogeneity of the substrate, with open and sheltered spaces, tide pools, and shaded niches, the turbidity of the water with good aeration but without shocking surf and very strong wave action, and, probably, the presence of small amounts of products of gaso-hydrothermal activity create extremely favourable conditions for rich intertidal biota. In fact, this environment supports a large number of plant and animal species, more than in all other parts of the island and even exceeding the number of species in many other regions of the high-boreal subzone. In particular, we found here such unusual forms for the boreal littoral zone as the polychaete *Spinther* sp., the echiurid *Bonellia* sp., and the brachiopod *Diestothyris frontalis*. Only in this area did we find *Undariella*, a recently described new genus of laminarian algae. The senior author has been studying the intertidal biota of the boreal region for more than 40 years, but he has never found as many as eight species of chitons living together at anywhere but here.

The richness and diversity of the intertidal life in this area are strongly pronounced only in the lower part of the intertidal zone (the infra-littoral fringe according to Stephenson & Stephenson, 1972). Here, in the low intertidal zone, the laminarian belt, as is typical for the boreal zone, was well developed. In this area, *Laminaria longipes, Alaria angusta*, and *A. marginata* predominated. Other common algae were the laminarians *Thalassiophyllum clathrus* and *Arthrothamnus kurilensis* and small specimens of *Laminaria bongardiana*. The red algae *Neoptilota asplenioides* and *Ptilota filicina* formed an undergrowth. On *Thalassiophyllum*, encrustations of the red algae *Hildenbrandtia prototypus* and *Titanoderma dispar* occurred. Besides these algae, in the lower tide pools and niches, the moderate-sized brown alga *Desmarestia aculeata*, the red algae *Constantinea rosa-marina, Iridaea cornucopiae, Palmaria stenogona, Odonthalia floccosa, Velatocarpus pustulosus*, and the green algae *Ulvaria splendens*, *Codium ritteri*, and *Acrosiphonia duriuscula* were most common. A certain amount of the pink lithothamnion *Clathromorphum loculosum* and small patches of the brown encrusting alga *Ralfsia fungiformis* were also present in caves, tide pools, and shady places. Only in such shady niches with moderate wave exposure did we find a medium-sized laminarian alga that belongs to a new genus, *Undariella* (Petrov & Kussakin, 1996). This alga has a thallus with an entire blade about 0.5 m long and fringed laterally with several rows of semicircular laminae.

Above the laminarian belt, these large brown seaweeds gradually disappeared and were replaced by red algae, predominantly *Palmaria stenogona, Iridaea cornucopiae, Porphyra tasa, Halosaccion glandiforme, Ptilota filicina, Neoptilota asplenioides*, and *Velatocarpus pustulosus*, with an admixture of a green alga *Ulvaria splendens* and a brown alga *Fucus evanescens*.

In the lower part of the mid-intertidal subzone, the most common algae were *Iridaea cornucopiae* and *Fucus evanescens*. In the upper part, Porphyra tasa with patches of *Acrosiphonia saxatilis* also occurred.

In the pools and under stones at the lowest tide level, a wealth of animal life was observed. Besides lithothamnion encrusting the bottoms of pools and the slopes, the stones were covered with various sponges and tunicates. Among the sponges, the amorphous, yellowish-green *Halichondria panicea*, pale grey *Haliclona gracilis*, and red *Lissodendorix amaknakensis* were usually abundant. Whitish calcareous sponges *Sycon* spp. occurred not only on the bottom, but on the holdfasts of various algae. Tunicate species were represented by a colonial *Amaroucium* sp. that formed amorphous masses, and *Dendrodoa aggregata*.

Among the stones, the gastropods *Nucella freycinettii* and *Buccinum baeri*, the green sea-urchin *Strongylocentrotus droebachiensis*, and the small six-rayed seastars *Leptasterias alaskensis asiatica* and *L. camtschatica* were common. The stones and holdfasts sheltered many shelled protozoans *Gromia oviformis*, brown turbellarians, brown and cream-coloured nemerteans, a sipunculid *Phascolosoma japonicum*, the polychaetes *Nereis pelagica, Eteone longa, Cirratulus wladislawi, Amphiglena marita*, and *Harmothoe imbricata*; an echiurid *Bonellia* sp., pycnogonids, a leptostracan *Nebalia bipes*, the amphipods *Ischyrocerus tzvetkovae, Paracalliopiella pacifica, Pontogeneia makarovi, Caprella parapaulina*, and many others; the isopods *Gnorimosphaeroma noblei* and *Idotea aleutica*; the chitons *Spongioradsia aleutica, Schizoplax brandtii, Tonicella beringensis beringensis*, and *Placiphorella borealis;* the gastropods *Astyris kobai*, *Volutharpa ampullacea*, and *Onchidoris bilamellata*; and the sea cucumber *Eupentacta pseudoquinquesemita*. Large holdfasts of brown algae, especially *Thalassio-*

phyllum clathrus, were covered with small animals, such as various sponges, hydroids, bryozoans, chitons, the brachiopod *Diestothyris frontalis*, and the bivalve *Turtonia minuta*. On the laminarian blades various amphipods, the gastropods *Margarites helicina* (with egg masses) and *Epheria porrecta* (with egg capsules), and *Lacuna minor* occurred.

High-littoral life was developed only on the largest stones. In this subzone, three belts of *Fucus evanescens, Porphyra tasa*, and *Urospora penicilliformis* were usually discernible. In the lower part, besides the growths of *Fucus evanescens* we found patches of barnacles. Barnacles were the dominant inhabitants on the tops of big stones. It is characteristic that while one of the barnacles, *Semibalanus cariosus*, is common throughout the Kuril Islands, the second one, *Balanus crenatus*, does not occur intertidally anywhere else in this region. The animal community in the lowest part of the *Fucus* belt was about the same as in the laminarian belt; in the uppermost part *Nucella, Littorina, Gnorimosphaeroma, Idotea*, and amphipods occurred. The *Porphyra* belt was densely populated by *Littorina sitkana*, but this species was sparse on *Urospora* mats.

To collect valuable qualitative samples in an area with such a variety and abundance of life during these short visits was a laborious task. Therefore, our qualitative data for this area are especially fragmentary and not well-founded. The mean biomass value in the belts of *Littorina sitkana* was 666 g m^{-2} (N=6300 m^{-2}); for the *Fucus evanescens* belt it was 10.902 gm^{-2}; for the *Iridaea cornucopiae* belt it was 1432 g m^{-2}, and for the *Balanus crenatus* belt it was 9.200 g m^{-2} (N=15,100 m^{-2}).

Inside the west stone reef (Transect 6), where the wave action was weaker, the stones had a dense cover of *Fucus evanescens*. The most interesting feature was a rather frequent occurrence of *Alaria* spp. overlying thalli of *Fucus evanescens*. Therefore, the typical zonal patterns here was broken, and *F. evanescens* was often found over *Alaria*. We have not observed this phenomenon anywhere else.

North of these reefs, the inner part of the entrance presented a small basin protected from wave action, where boulders and stones alternated with sandy beaches inhabited by the polychaetes *Abarenicola vagabunda oceanica, Nereis pelagica, Eteone longa, Capitella capitata, Naineris quadricuspida*, and *Microspio* sp. and the amphipods *Allorchestes carinata, Anonix affinis, Anisogammarus spasskii, Paraphoxus robusta*, and *P. longirostris*.

In the lowest part of the sheltered stony intertidal zone, in the belt of *Alaria marginata* and *A. angusta*, another alariacean alga, *Pleuropterum paradiseum*, appeared. The mid-intertidal subzone was markedly divided, and *Fucus evanescens* formed a conspicuous belt. In addition to *Fucus*, among the usual constituents were *Porphyra tasa, Semibalanus cariosus*, and *Nucella freycinettii*. In many places, the sponges *Halichondria panicea*, a green alga *Codium ritteri*, and a brown alga *Desmarestia aculeata* occurred among stones. The most common red algae between the laminarian and fucoid belts were *Iridaea cornucopiae, Palmaria stenogona, Halosaccion glandiforme*, and *Neorhodomela aculeata*. An unusual feature for the West-Pacific boreal littoral zone was a dense growth of the barnacle *Balanus crenatus* on thalli of *Fucus evanescens* and on the shells of *Nucella freycinettii*. Sometimes *B. crenatus* formed such dense masses that the animals were forced to grow into a columnar shape. As a result, very high and thin, narrow-cylindrical shells were formed.

Kraternaya Bight

Kraternaya Bight is about 0.7 square kilometres in area, with a mean depth of about 25 m and a maximum depth of 63 m. The bight is surrounded by abrupt rocky walls, with a strip of low coastal platform partly covered by high tide, between the walls and the sea. Thus, the intertidal zone is everywhere easily accessible for field investigations.

In contrast to the open sea around Yankich Island, the hydrographical and hydrochemical regime of Kraternaya Bight (Transects 6-11) is characterised by a well-pronounced water stratification with respect to temperature, carbon dioxide content, pH value, and the concentration of oxygen, nutrients, and chlorophyll *a*. Three vertical water layers are noted in the bight: surface, intermediate (4-20 m), and deep-water (Tarasov et al., 1990). Of these layers, only the first actually interacts with the intertidal zone. According to these authors, the surface layer (0-3 m) has a slightly lowered salinity (31-32 ‰) and contains high concentrations of volcanogenic carbon dioxide and oxygen. Carbon dioxide is the main component of gas inflow from hydrothermal vents. Hydrogen sulphide and ammonia have been found only over the hydrothermal vents, particularly in the southeastern part of the bight (Zhirmunsky & Tarasov, 1990). The oxygen content depended mostly on photosynthesis, which was most intense in August. In this month, oxygen oversaturation of up to 200% and a very high chlorophyll *a* content were recorded, with pronounced daily variations in concentration (Tarasov et al., 1990). The temperature of the surface waters varies from 9 to 12.5°C in August and is particularly warm in the southeastern parts of the bight, where underwater vents with temperatures of 30°C and land solfatars are concentrated and produce more than 20,000 m^3 of hydrothermal water per day (Zhirmunsky & Tarasov, 1990). These hydrothermal vents issue solutions of manganese, iron, zinc, copper, nickel, and cadmium with 2 to 3 orders of magnitude higher concentrations than in the open sea around the island (Shulkin, 1989).

The average content of dissolved organic matter in the bight is 5 to 8 times higher than in the open sea (5 to 8 mg l^{-1} and 1 mg l^{-1}, respectively) (Khristoforova, 1989). The biomass of plankton is high (up to 1 g m^{-3}) from the surface down to 40 m (Zhirmunsky & Tarasov, 1990). These authors also stated that a rich and diverse subtidal macrobenthos flourished on the bottom of this bight. The highest plant biomass (up to 30 kg wet wt m^{-2}) is contributed by *Alaria* at a depth of 5-8 m in the vicinity of cold effluents free of hydrogen sulphide but high in N-NH_4, P-PO_4, iron, and manganese. The highest biomass of bottom invertebrates (up to 10 kg m^{-2}) was observed in a muddy community dominated by *Cerianthus lloydii*, sedentary polychaetes and burrowing bivalves (Tarasov et al., 1990).

On the whole, Kraternaya Bight is a semi-closed, eutrophic, small sea basin with obviously recent volcanic activity. This activity and numerous gaso-hydrothermal vents influence the species diversity and the composition and structure of all marine communities in the bight. The influence of volcanic activity in this bight is accompanied by a reduction in species number and a significant increase in the population density and biomass of one or several species adapted to unusual hydrochemical regimes (Tarasov et al., 1988). When considering particularly energetic dynamics of environmental conditions in the intertidal zone, it is very interesting to trace the influence of gaso-hydrothermal activity on the littoral biota in different areas of this bight.

Kraternaya Bight is well protected from wind from practically all directions and is separated from the open sea; therefore, it is well sheltered from surf and wave action. On the other hand, strong tidal currents assist the inflow of clean water from the open sea and remove the products of gaso-hydrothermal activity from the inland waters of the bight. The rise and fall of the tides are not affected by surf, so the zonation between the tide-marks coincides generally with the basic tidal levels.

The sheltered shore of Kraternaya Bight consists of a gently sloping pebbly-boulder beach underlain by sand. In some places, it is interrupted by sandy beaches with detached boulders. These beaches are more common in the lower intertidal zone. Only in the southeastern, innermost part of the bight, which is partly closed by two islets, is the intertidal biota subject to the influence of complex variations of temperature and hydrochemical characteristics caused by gaso-hydrothermal vents. However, tidal stirring decreases any harmful influence of volcanic activity in this area.

Along most of the coastline, the lowest part of the intertidal zone, essentially the laminarian belt, was dominated by *Alaria marginata, A. angusta*, and *Pleuropterum paradiseum*. The biomass of these three species (26,472 g m^{-2}) was responsible for more than 90% of the total plant biomass (Table 2, AP). Associated with these algae were the subsidiary species *Ulvaria splendens, Velatocarpus pustulosus*, and *Fucus evanescens*. The barnacles *Balanus crenatus* and *Semibalanus cariosus*, the gastropods *Nucella freycinettii* and *Littorina sitkana*, and the bivalve *Turtonia minuta* were the most common animals. Among the conspicuous elements of the fauna were the sponge *Halichondria panicea*, a sea anemone *Bunodactis* sp., the polychaetes *Harmothoe imbricata, Nereis pelagica, Eteone longa*, and *Naineris quadricuspida*, an isopod *Idotea gurjanovae*, the amphipods *Anisogammarus locustoides* and *Ischyrocerus chamissoi*, the gastropods *Nucella freycinettii, Cartilagovelutina beringensis*, and *Onchidoris bilamellata*, the echinoderms *Leptasterias* spp., *Cucumaria vegae*, and *Eupentacta pseudoquinquesemita*, and an ascidian *Ascidia collosa*.

The sea-urchin *Strongylocentrotus droebachiensis* and the polychaetes *Polydora vulcanica* and *Abarenicola vagabunda* were the most conspicuous among the animals on sandy bottoms in the lowest intertidal.

Above the laminarian belt, two communities were discernible (Table 2, BN and BU). The most typical usually was a belt dominated by *Balanus crenatus* and *Nucella freycinettii*, with a scanty growth of small algae. *Balanus crenatus* was crowded not only on the tops of stones but also on the blades of *Fucus*. The most common animals besides *Balanus* and *Nucella* were a nemertean *Nepemplectonema* sp., the polychaetes *Nereis pelagica* and *Eteone longa*, a gastropod *Littorina sitkana*, a bivalve *Turtonia minuta*, a seastar *Leptasterias alaskensis* asiatica, and an ascidian *Ascidia callosa*.

The community of *Balanus crenatus* and *Ulvaria splendens* was found only in some places. Besides *Ulvaria*, there were small brown algae, *Melanosiphon intestinalis* and *Pilayella litoralis*, and the green alga *Acrosiphonia duriuscula*. The animals and their biomass were about the same as in the *Balanus* community (Table 2, BU). Also there were populations of the polychaete *Polydora vulcanica* with a biomass of up to 10 kg m^{-2}.

Most of the mid-littoral zone was covered with a dense growth of *Fucus evanescens*, with an admixture of the red algae *Iridaea cornucopiae* and *Palmaria stenogona* of the lowest levels. The plant biomass was very high, which was typical of the *Fucus* community in sheltered areas of the boreal zone (Table 3, A). Among the most common animals, there were masses of the gelatinous colonial ascidian *Amaroucium* sp., the polychaete *Nereis vexillosa*, the barnacle *Balanus crenatus*, and the gastropods *Littorina sitkana* and *Nucella freycinettii*. The total amount of animals achieved a biomass of up to 4 kg wet wt m^{-2} (Table 3, F).

In the mid-littoral subzone, we did not observe any true balanoid belt, but encountered populations of *Semibalanus cariosus* as patches of up to 1-2 m^2 between fucoid growth. In these patches the algae were rare (65.5 g m^{-2}), but the total animal biomass was more than one hundred times higher (Table 3, S). In a few places, brilliant green patches of small *Acrosiphonia duriuscula* and *Blidingia minut*a (Table 3, AB) or brown tufts of *Analipus japonicus* were found (Table 3, A). The fauna include numerous *Balanus crenatus, Nucella freycinettii, Littorina sitkana, Onchidoris bilamellata, Turtonia minuta, Idotea gurjanovae*, and nemerteans. Total plant and animal biomass in the *Analipus* tufts were both very high and nearly equal in value (Table 3, A). The patches of green algae were populated by rare *Littorina sitkana* and sparse *Balanus crenatus, Gnorimosphaeroma noblei*, and *Modiolus phenax*. The total biomass of plants and animals was small (Table 3, S).

The upper intertidal subzone (the supra-littoral fringe) had a population of the small gastropod *Littorina sitkana* with an average biomass of 1376 g m^{-2}. There were also irregular patches of the green alga *Urospora penicilliformis*. The sandy areas were populated by the beach hoppers *Talorchestia ochotensis*.

Comparatively cool gaso-hydrothermal vents with a temperature of 10–34°C occurred all along the northern shore of the bight. These waters contained no hydrogen sulphide, but CO_2 and high concentrations of dissolved manganese, iron, zinc, and other metals were present. Vent gases contained CO_2, N_2, He, CH_4, and H_2 (Tarasov et al., 1990).

In this area (Transect 7) with a temperature of 10°C, algae and some animals were

Table 2. Biomass (B, wet wt m^{-2}) and numbers (N, m^{-2}) of intertidal macrobenthos in the low intertidal zone in the bight (Transects 8-13)

Taxa	Taxonomic group*	AP. *Alaria*+ *Pleuropterum* belt		BN. *Balanus*+ *Nucella* belt		BU. *Balanus*+ *Ulvaria* patches	
		B	N	B	N	B	N
PLANTS							
Alaria marginata (with epiphytic *Rhodymenia pertusa)*	Ph	10,576.0	–	–	–	–	–
Pleuropterum paradiseum	Ph	9303.0	–	–	–	–	–
Aralia angusta (with epiphytic *Ectocarpus* sp.)	Ph	6593.0	–	–	–	–	–
Ulvaria splendens	Ch	–	–	–	–	780.8	–
Melanosiphon intestinalis f. *complanatus* (with epiphytic *Pilayella litoralis*)	Ph	–	–	–	–	388.0	–
Analipus japonicus	Ph	258.0	–	–	–	–	–
Acrosiphonia duriuscula	Ch	229.0	–	0.3	–	522.0	–
Fucus evanescens	Ph	–	–	186.3	–	–	–
Palmaria stenogona	Rh	80.5	–	–	–	–	–
Pilayella litoralis	Ph	9.5	–	–	–	–	–
Rhodophycota indet.	Rh	–	–	1.5	–	–	–
Total plants		27,049.7		188.1		1690.8	
ANIMALS							
Balanus crenatus	Ci	1793.5	27,517	2505.7	17,300	3690.0	19,925
Nucella freycinetii	Ga	269.0	167	1164.6	450	588.75	150
Polydora vulcanica	Po	231.8	22,133	–	–	–	–
Semibalanus cariosus	Ci	621.2	33	0.5	17	–	–
Turtonia minuta	Bi	132.5	18,167	19.5	2153	8.25	700
Littorina sitkana	Ga	127.5	4533	80.0	2150	28.75	475
Nemertini	Ne	80.5	14,450	93.8	29,183	172.3	36,600
Nereis pelagica	Po	29.7	1067	111.3	3150	1.85	150
Leptasterias alaskensis asiatica	Ast	–	–	38.5	17	–	–
Anisogammarus (*Eogammarus*) *locustoides*	Am	10.1	550	–	–	–	–
Cucumaria vegae	Ho	8.9	33	–	–	–	–
Eteone longa	Po	5.8	650	28.5	6833	0.1	25
Gnorimosphaeroma noblei	Is	1.3	283	0.3	33	1.5	50
Idotea gurjanovae	Is	0.8	17	–	–	–	–
Onchidoris bilamellata	Ga	0.8	17	–	–	–	–
Ischyrocerus chamissoi	Am	0.6	500	–	–	4.2	2750
Bunodactis sp.	Ac	–	–	2.5	33	–	–
Eupentacta pseudoquinquesemita	Ho	–	–	4.3	17	–	–
Cirratulus wladislavi	Po	–	–	3.6	50	–	–
Orbiniella nuda	Po	0.1	33	0.6	100	12.2	8025
Ischyrocerus dezhnevi	Am	–	–	–	–	1.25	1050
Naineris quadricuspida	Po	–	–	0.5	50	–	–
Pontogenea makarovi	Am	0.02	17	–	–	0.7	175
Modiolus phenax	Bi	–	–	0.3	33	–	–
Ampithoe djakonovi	Am	–	–	–	–	0.4	100
Ischyroceras anguipes	Am	–	–	–	–	0.2	75
Harmothoe imbricata	Po	0.2	33	–	–	0.3	50
Falsicingula sp.	Ga	0.2	17	–	–	–	–
Corophium steinegeri	Am	0.1	100	0.25	117	0.05	50
Total animals		3324.6		4054.8		4510.8	

*) See Table 1.

covered with rusty deposit of ferric oxide. In others respects, the intertidal biota in this area was about the same as elsewhere in such sheltered localities along the coast of the bight. The laminarian belt extended from well above the mean low water of spring tide to the infralittoral zone. Only one species, *Alaria angusta*, was dominant (biomass up to 25 kg m^{-2}). Among the growths of this plant was an undergrowth of the small algae *Ulvaria splendens*, *Acrosiphonia duriuscula*, and *Melanosiphon* sp., and various animals, usually *Balanus crenatus, Nucella freycinettii*, the amphipods *Ischyrocerus anguipes, I. deshnevi*, and *I. chamissoi*, nemerteans, and the polychaetes *Nereis pelagica, Harmothoe imbricata* and *Orbiniella nuga*.

The biomass of *Fucus evanescens* in the middle intertidal subzone was 23 kg m^{-2}. The most conspicuous animals here were about the same as in the laminarian belt.

The upper intertidal subzone had a definite *Littorina* belt with a biomass of 482 g m^{-2}.

Finally, the intertidal biota of the southeastern part of the bight (Transects 14-17), which is under the influence of hot gaso-hydrothermal vents, was examined. In that area, a great

Table 3. Biomass (B, g wet wt m^{-2}) and numbers (N, m^{-2}) of intertidal macrobenthos in the middle intertidal zone in the bight (Transects 8-13)

Taxa	Taxonomic group*	F. *Fucus* belt		A. *Analipus* patches		AB. *Acrosiphonia*+ *Blidingia* patches		S. *Semibalanus* settlings	
		B	N	B	N	B	N	B	N
PLANTS									
Fucus evanescens	Ph	25,111.6	–	–	–	4.5	–	4.0	–
Analipus japonicus	Ph	–	–	3692.0	–	–	–	–	–
Acrosiphonia duriuscula+ diatoms	Ch	–	–	–	–	372.75	–	61.0	–
Blidigia minima	Ch	–	–	–	–	233.75	–	–	–
Iridaea cornucopiae	Rh	1109.4	–	–	–	1.3	–	0.5	–
Palmaria stenogona	Rh	735.8	–	–	–	167.0	–	–	–
Total plants		26,956.8		3692.0		779.3		65.5	
ANIMALS									
Semibalanus cariosus	Ci	–	–	38.3	100	–	–	6052.5	200
Amaroucium sp.	As	2002.0	–	–	–	–	–	–	–
Balanus crenatus	Ci	279.1	28,100	1388.0	26300	30.5	1750	30.0	2200
Nucella freycinettii	Ga	283.1	125	1088.0	200	–	–	3.0	50
Nereis vexillosa	Po	705.0	2700	–	–	–	–	–	–
Littorina sitkana	Ga	343.9	7235	323.0	72	208.5	860	60.5	2400
Nemertini	Ne	28.1	5520	256.0	17,200	–	–	132.5	17,250
Strongylocentrotus droebachiensis	Ech	–	–	–	–	–	–	196.0	25
Turtonia minuta	Bi	11.4	1663	133.01	12,100	–	–	73.0	17,150
Modiolus phenax	Bi	89.0	9350	–	–	0.5	50	38.0	8950
Cucumaria vegae	Ho	83.5	300	–	–	–	–	–	–
Onchidoris bilamellata	Ga	5.6	200	62.0	1000	–	–	–	–
Idotea gurjanovae	Is	–	–	42.2	100	–	–	–	–
Allorchestes carinata	Am	41.1	100	–	–	–	–	–	–
Harmothoe imbricata	Po	32.5	900	0.8	100	–	–	–	–
Flabelligera affinis	Po	4.7	100	–	–	–	–	–	–
Ampithoe volki	Am	5.9	300	–	–	–	–	–	–
Bunodactis sp.	Ac	3.75	25	–	–	–	–	–	–
Gnorimosphaeroma noblei	Is	1.25	725	–	–	0.75	100	4.0	1750
Naineris quadricuspida	Po	1.6	200	–	–	–	–	–	–
Nereis pelagica	Po	0.6	35	9.6	1600	–	–	–	–
Anisogammarus (*Eogammarus*) *locustoides*	Am	–	–	–	–	–	–	0.6	250
Orbiniella nuda	Po	0.6	100	–	–	–	–	–	–
Turbellaria	Tu	0.5	50	–	–	–	–	–	–
Pontogeneia makarovi	Am	0.3	30	1.4	500	–	–	–	–
Eteone longa	Po	3.4	155	0.2	100	–	–	–	–
Total animals		3926.9		3342.5		240.25		6590.1	

*) See Table 1.

land hydrosolfatar field that consists of thick sulphur deposits with fumaroles is located (Fig. C). The solfatar effluents with a water temperature 92-96°C and also a warm spring enter the bight. The temperature of the surface waters in this area was high in August at 20- 22°C, compared to 10-13°C elsewhere in the bight and only 2.5-3.5°C around the island. These hydrothermal waters with pH of 3.5 to 4 contained hydrogen sulphide, other sulphur compounds, silicon, phosphorus, and high concentration of manganese, iron, zinc, copper, nickel, and cadmium: 2 to 3 orders of magnitude more than in the waters surrounding the bight (Shulkin, 1989; Zhirmunsky & Tarasov, 1990).

The number of intertidal species here was much lower than in other parts of the bight, but plant and especially animal biomasses were high. Some species that are well adapted to the extreme conditions of life in the vicinity of gaso-hydrothermal vents were plentiful only in this area. The most common species of animal was the white barnacle *Balanus crenatus*.

The hot spring intertidal biota along a transect 100 metres west of the area of volcanic activity differed from that found under usual condition in the bight. The surface of the sand, pebbles, and boulders here was covered with a reddish-brown film. In the lower part of the intertidal zone, the laminarian belt still remains, although this belt often alternated with irregular patches of the burrowing polychaete *Polydora vulcanica* with a biomass of up to 18 kg m^{-2} or populations of *Balanus crenatus* (average biomass about 4.9 kg m^{-2}) (Table 4, Po and Ba).

In the laminarian belt, *Pleuropterum paradiseum* and *Alaria marginata* were dominant, but neither alga was abundant, with an average biomass of less than 1.5 kg m^{-2}. The blades of *Pleuropterum* were often covered with the brown epiphytic alga *Pilayella litoralis*. Animal life was scanty in the laminarian belt (Table 4, Pl), but much more abundant in the *Balanus* and *Polydora* patches (Table 4, Po and Ba). Boulders were covered with dense masses of *Balanus crenatus*. In places, barnacles were replaced by the brown algae, *Fucus evanescens* and *Punctaria plantaguinea*, or the red alga *Mastocarpus pacificus*. Conspicuous animals in the *Balanus* belt were *Halichondria panicea, Nereis pelagica, Phyllodoce groenlandica, Littorina sitkana, Nucella freycinettii, Onchidoris bilamellata, Nebalia bipes, Bunodactis* sp., *Idotea aleutica*, and *Eupentacta pseudoquinquesemita*. The animal biomass was about 5 kg m^{-2}, while the plant biomass was only 120 g m^{-2} (Table 4, Ba).

The populations of *Polydora vulcanica* were uniform; algae were absent and other animals, such as *Nereis pelagica, Eteone longa, Phyllodoce* sp., and *Littorina sitkana*, were rare. The mean biomass (8.7 kg m^{-2}) was predominantly composed of the single dominant species.

Most of mid-littoral subzone supported growths of *Fucus evanescens* and *Mastocarpus pacificus*. Because these algae occurred only on the boulders scattered on the sandy beach, the plant biomass was relatively small (Table 4, Fu). Animals in this belt were the same as in the lower intertidal zone, but the amphipods *Anisogammarus locustoides* and *Corophium steinegeri* were more numerous.

The upper part of the mid-littoral and the upper intertidal subzone were populated only by *Littorina sitkana* with an average biomass of almost 3 kg m^{-2}.

Around the inflow of gaso-hydrothermal water into the bight, the water temperature was 38°C and macrobenthos was absent. Near this place, sterile *Fucus evanescens* appeared. The sea floor and fucoid thalli were covered with a yellowish-white film of sulphur compounds.

A short distance away of the warm inflow (Transect 16), *Balanus crenatus* appeared settled on boulders, shells of *Nucella*, and especially on thalli of *Fucus*. Fucoid blades free from *Balanus* growth were covered with a small green alga, *Acrosiphonia duriuscula*. On the tops of low-level boulders and among the algae, *Littorina sitkana* and *Nucella freycinettii* were common, and beneath them were found abundantly the polychaetes, *Harmothoe imbricata, Nereis pelagica*, and *Eteone longa*, the amphipod *Corophium steinegeri*, the gastropod *Onchidoris bilamellata*, the bivalve *Hiatella arctica* and the fishes *Myoxocephalus brandtii, M.*

Table 4. Biomass (B, g wet wt m^{-2}) and numbers (N, m^{-2}) of the intertidal macrobenthos near the hydrosolfatar field (Transects 16–17)

Taxa	Taxonomic group*	Po. *Polydora* population B	N	Ba. *Balanus* belt B	N	Pl. *Pleuropterum* belt B	N	Fu. *Fucus* belt B	N
PLANTS									
Pleuropterum paradiseum (with epiphytic *Pilayella litoralis*)	Ph	–	–	120.0	–	905.0	–	–	–
Fucus evanescens	Ph	–	–	–	–	–	–	1276.8	–
Mastocarpus pacificus	Rh	–	–	–	–	–	–	580.0	–
Alaria marginata	Ph	–	–	–	–	531.7	–	–	–
Total plants				120.0		1436.7		1856.8	
ANIMALS									
Polydora vulcanica	Po	8624.9	105,300	–	–	–	–	–	–
Balanus crenatus	Ci	–	–	4500.0	4046	222.0	4000	424.0	3733
Littorina sitkana	Ga	25.0	100	8.3	163	–	–	55.0	893
Anisogammarus (*Eogammarus*) *locustoides*	Am	–	–	17.9	950	–	–	270.7	7885
Nereis pelagica	Po	19.0	1000	125.9	627	38.2	400	3.8	40
Turtonia minuta	Bi	–	–	111.3	4505	2.0	400	34.0	4370
Nucella freycinettii	Ga	–	–	66.0	40	–	–	10.0	50
Corophium steinegeri	Am	–	–	0.3	310	5.1	4950	25.1	6925
Phyllodoce (*Anaitides*) *groenlandica*	Po	–	–	25.9	30	–	–	–	–
Nemertini	Ne	–	–	10.0	10,800	2.0	300	1.4	530
Turbellaria	Tu	–	–	1.6	200	–	–	9.0	200
Eteone longa	Po	5.1	500	3.8	110	–	–	0.6	30
Phyllodoce sp.	Po	4.0	100	–	–	–	–	–	–
Nebalia bipes	Le	–	–	2.0	80	–	–	–	–
Spionidae gen. sp.	Po	1.3	67	–	–	–	–	–	–
Terebellidae gen. sp.	Po	–	–	1.5	10	–	–	–	–
Ampithoe sp.	Am	3.7	100	–	–	0.9	30	–	–
Naineris quadricuspida	Po	1.0	200	–	–	–	–	–	–
Anisogammarus (*Spinulogammarus*) *ochotensis*	Am	–	–	–	–	0.7	20	–	–
Naineris jacutica	Po	–	–	0.7	50	–	–	–	–
Bunodactis sp.	Ac	–	–	0.5	20	–	–	–	–
Orbiniella nuda	Po	–	–	0.4	67	–	–	–	–
Oligochaeta	Ol	–	–	–	–	–	–	–	–
Capitella capitata	Po	–	–	0.02	10	–	–	–	–
Ampithoe djakonovi	Am	–	–	–	–	0.03	100	–	–
Total of animals		8684.0		4876.1		270.9		833.8	

*) See Table 1.

stelleri, *M. polyacanthocephalus*, *Ascoldia variegata*, and *Krusensterniella* sp. These fishes, although abundant, were very small (22-64 mm in length). The mean biomass was 235 g m^{-2} for polychaetes, 17 g m^{-2} for amphipods, and 5 g m^{-2} for littorinids, while the biomass of *Balanus crenatus* was much greater and reached 4850 g m^{-2}.

There were no laminarians in the lower intertidal and no littorinids in the upper intertidal subzones.

Discussion and Conclusions

A comparison of the characteristic species composition and zonal patterns between Yankich Island and other Kuril Islands reveals four essential types of features.

1. Features common to all Kuril Islands.

The basic zonation pattern common to all of them includes: the presence of laminarian, *Fucus evanescens*, *Semibalanus cariosus*, and *Littorina sitkana* belts; the development of undergrowths of various red algae, *Palmaria stenogona*, *Halosaccion glandiforme*, *Neoptilota* *asplenioides, Ptilota filicina*, and others, in the laminarian belt and between the laminarian and fucoid belts. A considerable affinity between the high-boreal middle and northern Kurils and the low-boreal islands is demonstrated by the presence of many plant and animal species in common. These species are usually distributed widely throughout the boreal zone, such as *Mytilus edulis, Hiatella arctica, Halichondria panicea, Eulalia viridis, Eteone longa, Harmothoe imbricata, Nereis pelagica, Ulothrix flacca, Blidingia minima*, and *Urospora penicilliformis*, or widely within the boreal Pacific, such as *Ulvaria splendens, Analipus japonica, Ptilota filicina, Neoptilota asplenioides, Nereis vexillosa*, and *Semibalanus cariosus*, or only along the Asian coast, such as *Anisogammarus locustoides, A. spasskii, Idotea ochotensis, I. gurjanovae*, and *Buccinum percrassum*.

2. Features common to the middle and northern Kurils.

Many of these features are typical of the high-boreal biota: the absence of low-boreal *Pelvetia babingtonii*, sargassacean, and *Phyllospadix iwatensis* belts; the absence of subtropic-boreal and low-boreal species, such as the crabs *Hemigrapsus* spp. and *Cancer gibbosulus*, the isopods *Excirolana japonica* and *Cymodoce japonica*, the chiton *Ischnochiton hakodatensis*, the gastropods *Notoacmaea* spp. and *Batillaria cumingii*, the seastar *Lysastrosoma anthosticta*, and many other species. Some common low-boreal species, such as *Margarites pilsbryi, Epheria turrita, Strongylocentrotus intermedius, Laminaria japonica*, and *Kjellmaniella gyrata*, are replaced by their high-boreal vicariants or ecological counterparts, such as *Margarites helicina, Epherria porrecta, Strongylocentrotus polyacanthus, Laminaria longipes*, and *L. bongardiana*. The brown algae *Pleuropterum paradiseum* and *Cymathaere triplicata*, the isopod *Neastacilla littoralis*, the gastropod *Mitrella kobai*, and the bivalve *Mysella kurilensis litoralis*, which are common to the middle and north Kurils, are also typical of the intertidal zone of the high-boreal Kuril province.

3. Although the intertidal biota of the middle Kurils has strong affinities to that of the northern Kurils, some essential differences exist between these two areas. First, there are many species that occur in the southern and northern Kurils but are absent from the middle Kurils, such as the polychaetes *Eulalia viridis* and *Syllis fasciata* (Khlebovitch, 1961), the gastropods *Collisella* spp. and *Testudinalia scutum* (Golikov & Kussakin, 1962), pagurids, and the cirriped *Chthamalus dalli* (Kussakin, 1976). It is interesting that three common species of *Collisella* and two common species of *Pagurus* are found at Paramushir Island in the northern Kurils and in the southern Kurils but are absent from Urup Island to Onekotan Island. The authors once explained this phenomenon as due to the low summer sea temperature (3-7°C) in the middle Kurils. Our recent visits to the shores of Urup, Ushishir, and Shiashkotan Island have confirmed these observations. On the contrary, some cold-water, high-boreal species, such as *Cymathaere triplicata, Vilasina vernicosa, Modiolus phenax, Cucumaria vegae*, and *Eupentacta pseudoquinquesemita*, flourish in the middle Kurils. Both the species composition and intertidal zonation at Ushishir and Shiashkotan Island are more similar to those at Urup (Kussakin et al., 1974) and Simushir Island (Kussakin, 1976) than to those at Paramushir Island (Kussakin et al., 1974). Therefore, the separation of the middle Kuril district within the Kuril province (Gulbin, 1974) is well-founded.

4. Some features peculiar to Yankich Island are noticeable, but most of them are encountered only in Kraternaya Bight, not on the open coasts. The characteristic disturbance of the usual zonal pattern and the uniqueness in species composition are apparently caused by gaso-hydrothermal vents and other forms of volcanic activity and are not attributable to usual physical factors such as temperature, salinity, and so on. It is, however, quite difficult to determine exactly how much influence these volcanic activities exert on the intertidal biota of Kraternaya Bight because there are no similar semi-enclosed bights lacking such activity in the middle Kurils. Brouton Bay at Simushir Island is the only semi-enclosed protected area comparable to Kraternaya Bight, but it is also a caldera with apparent

volcanic activity.

Brouton Bay was visited by O. Kussakin in August, 1957. The temperature of the surface waters was about 13°C, compared to 3.5–5°C in the open sea around this island. The shoreline in the inner part of this bay is formed of boulder-gravel and pebble-sandy beaches. Here and there a small issue of gaso-hydrothermal vents was observed. The substrate and mollusk shells were covered with rusty films. Four belts ranging from the lowest intertidal to the lower supra-littoral could be distinguished along this shore: 1 - an *Alaria angusta* belt with an admixture of *Palmaria stenogona* and other red algae; 2 – a rhodophycean belt with a predominance of *Iridaea cornucopiae* and *Mastocarpus pacificus* in the lower part and *Halosaccion glandiforme* in the upper part; 3 – a well-developed, mid-littoral *Fucus evanescens* belt partly spreading into the lower intertidal; 4 – an upper-littoral *Littorina sitkana* belt with *Anisogammarus locustoides* and *Gnorimosphaeroma noblei* beneath the stones. *Pleuropterum paradiseum, Balanus crenatus*, and *Onchidoris bilamellata* were not found. On the other hand, in the lowest part of the rocky intertidal, a narrow belt of the sea-grass *Phyllospadix iwatensis*, a low-boreal species, was found, representing its northern limit of distribution.

The most remarkable feature of the intertidal biota of Kraternaya Bight was dense populations of the white barnacle, *Balanus crenatus*. This widely distributed amphi-boreal species is common in the infra-littoral and lowest intertidal zones along south-east Kamchatka with a biomass up to 35 kg m^{-2} (List, 1989), but had not been yet recorded for the intertidal zone of the Kuril Islands. Kraternaya Bight represents the only exception and, furthermore, in this bight *B. crenatus* is a common species in the lower and middle intertidal subzones and is common not only on stones and shells of *Nucella*, but it also forms dense masses on the thalli of large brown and red algae, especially on *Fucus* evanescens. It is difficult for the authors to understand the factors affecting the presence of this barnacle in the bight and its larval ecology. Probably, a high biomass of plankton (up to 1 g m^{-3}) in the bight (Zhirmunsky & Tarasov, 1990) favours the flourishing of the sestonophagous *Balanus crenatus* and benefits the creation of a surplus larval pool. This pressure of an enormous larval pool and a lack of shore stones results in the settling of barnacles on algal thalli. This is an indirect influence of gaso-hydrothermal activity that favours the eutrophication of the bight.

The arrangement of *Fucus evanescens*, which may spread into the lower intertidal zone, and the settlement of *Alaria* on *Fucus* blades show lesser significant deviations from the typical zonation. Besides *Balanus crenatus*, in Kraternaya Bight the alariacean alga *Pleuropterum paradiseum*, the spionid polychaete *Polydora vulcanica*, the nudibranch *Onchidoris bilamellata*, the holothurian *Psolus fabricii*, and the sea urchin *Strongylocentrotus droebachiensis* are especially plentiful. *Pleuropterum paradiseum* is distributed from Urup Island to Alaid Island (Miyabe & Nagai, 1933; Nagai, 1941), is an endemic species of the Kuril province. *Onchidoris bilamellata* is a widely distributed amphi-boreal species, but it had not been observed before anywhere in the intertidal zone of the Kuril Islands. *Strongylocentrotus droebachiensis* is also an amphi-boreal species. In Kraternaya Bight it forms isolated populations consisting only of small but mature specimens, and it is replaced outside the bight by the common high-boreal Pacific sea urchin, *S. polyacanthus*. *Polydora vulcanica* has so far been found only in Kraternaya Bight and is therefore an endemic species there. Some authors (Tarasov et al., 1988; Zhirmunsky & Tarasov, 1990) also considered *Psolus* sp. as presumably a species new to science, and the bivalve *Macoma lukini* Kamenev, as endemic in Kraternaya Bight. But Kamenev (1989), describing his new species of bivalve, reported it as well from Brouton Bay at Simushir Island. Kafanov (1991) considered this species as a probable synonym of *M. obliqua* (Sowerby) from Pleistocene deposits in England. A large collection of *Psolus* spp. from the Kuril Islands deposited in the Zoological Institute (St.-Petersburg) needs further revision. A preliminary identification of 43 specimens from Kraternaya Bight allows us to conclude that this is the widely distributed amphi-boreal species *Psolus fabricii*

(Smirnov, 1995).

It is very doubtful that independent species could arise in Kraternaya Bight during the 10 thousand years of its existence. However, the denial of the independent establishment of endemism in Kraternaya Bight can by no means wipe out the problem of high endemism of the shore biota of the middle Kurils, and discussion concerning the possible influence of volcanic activity on speciation is highly relevant. Actually, the volcanic middle Kurils constitute a unique region of the far-eastern seas of Russia. Just for laminarians and gastropods, five endemic genera are recognised: the three laminarian genera *Costularia* Ju. Petrov & Gussarova, and *Feditia* Ju. Petrov & Gussarova from Simushir Island, and the new genus *Undariella* Petrov & Kussakin from Yankich Island; the gastropod genus *Lacunitunica* Golikov & Gulbin and, in addition, the subgenus *Neomargarites* (Gussarova, 1975; Golikov & Gulbin, 1978; Petrov & Kussakin, 1996). If we add to these genera the alariacean genus *Pleuropterum* and the gastropod genus *Corneobuccinum* (Golikov & Gulbin, 1977), which are endemic to the middle and northern Kurils, the resultants are even more impressive.

Tarasov with co-authors, already cited above, proclaimed a very high biomass as the second remarkable feature of the biota of Kraternaya Bight connected with volcanic activity. Population densities and biomasses of the intertidal communities within Kraternaya Bight are, in general, relatively but not extremely high. The maximum animal biomass in the intertidal zone occurs in the community dominated by the polychaete *Polydora vulcanica* (mean biomass 8.6 kg m^{-2}, maximum biomass up to 18 kg m^{-2}). The *Polydora natrix* community at Urup Island (total animal biomass 5640 g m^{-2} with *Polydora* at 4400 g m^{-2}: Kussakin et al., 1974) has a similar mean biomass. The biomasses of other animals (240 to 6600 g m^{-2}) and plants (66 g to 27 kg m^{-2}) in the intertidal zone of Kraternaya Bight by no means exceed the ordinary values typical of the boreal sheltered or moderately protected littoral (Kussakin, 1963; Kussakin et al., 1974; Tarakanova, 1978).

On the whole, the influence of gaso-hydrothermal products results in the same picture of high biomass along with decreased species diversity as that observed under the influence of any other pollutant. In reality, we have observed extraordinarily large animal biomasses in places slightly or moderately polluted by waste products of fish or whale processing, e.g. the biomass of *Littorina sitkana* up to 15.5 kg m^{-2} and *Semibalanus cariosus* up to 22 kg m^{-2} in Kasatka Bay, Iturup Island (Kussakin et al., 1974).

Acknowledgements

The authors thank the following colleagues for kindly identifying the algae and some of the animals: Dr. I. Levenets, Algae; Dr. S. Chaplygina, Hydrozoa; Drs. A. Ozolinsh and E. Bagaveeva, Polychaeta; Dr. A. Kubanin, Bryozoa; Drs. G. Evseev and M. Ivanova, Bivalvia; Dr. T. Sokolovskaya, Pisces (Institute of Marine Biology, Vladivostok); Dr. V. Kudrjashov, Amphipoda (Far-East University, Vladivostok); Prof. V. Koltun, Spongia; Dr. B. Sirenko, Loricata; Dr. V. Romanov, Ascidia (Zoological Institute, St.-Petersburg). Their valuable help is highly appreciated. We give our sincere thanks to Dr. V. Tarasov for kind invitations and help during our surveys in the expeditions under his leadership. We are also very thankful to Ms. Irina Barsegova for help in preparing of the English manuscript.

The present publication was supported by the Russian Science Program "Biodiversity" project N2.3 45 and the Russian Foundation of Fundamental Research, project N 96-04-48076.

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Appendix Table

List of Macrobenthic Species of the Intertidal Zone of Yankich Island

Since the middle Kuril Islands were poorly represented in our list of intertidal animals (Kussakin et al., 1974; Kussakin, 1976) and a list of macrophytes (Zinova & Perestenko, 1974) from the intertidal zone of the Kuril Islands, we consider it useful to give the complete list of plants and animals collected by the authors from the intertidal zone of Yankich Island.

Species	Areas and Transects			
	Inner part: near hydrosolfatar field (Transects 14-17)	Middle part of bight (Transects 8-13)	Entrance to bight (Transects 3-6)	Open coast (Transects 1 & 2)
PLANTS				
Division CHLOROPHYCOTA				
Class ULOTRICHOPHYCEAE				
Order ULOTRICHALES				
Family Ulotrichaceae				
Ulothrix flacca (Dillw) Thurner			+	
U. pseudoflacca Wille			+	
Order ACROSIPHONALES				
Family Acrosiphonaceae				
Acrosiphonia duriuscula (Ruprecht) Yendo	+	+	+	+
A. saxatilis (Rupr.) Vinogradova			+	
Urospora penicilliformis (Roth) Areschough				+
Order ULVALES				
Family Monostromataceae				
Monostroma grevillei (Thurner) Wittrock			+	+
Kornmannia zostericola (Tilden) Bliding			+	
Blidingia minima (Nageli et Kutzing) Kylin		+		
Family Ulvaceae				
Ulvaria splendens Ruprecht		+	+	
Class SIPHONOPHYCEAE				
Order SIPHONALES				
Family Codiaceae				
Codium ritteri Setchell et Gardner			+	
Division PHAEOPHYCOTA				
Class PHAEOSPOROPHYCEAE				
Order ECTOCARPALES				
Family Ectocarpaceae				
Pilayella litoralis (Linnaeus) Kjellman	+	+	+	
Ectocarpus confervoides (Roth) Le Jols		+		
Order RALFSIALES				
Family Ralfsiaceae				
Analipus japonicus (Harvey) Wynne	+	+		
Ralfsia fungiformis (Gunn.) Setchell et Gardner			+	
Order DICTYOSIPHONALES				
Family Punctariaceae				
Punctaria plantaginea (Roth) Greville	+		+	
Family Asperococcaceae				
Melanosiphon intestinalis (Saund.) Wynne f. *complanata* (Woron) Wynne		+		
Family Dictyosiphonaceae				
Coilodesme fucicola (Yendo) Nagai			+	
Order SCYTOSIPHONALES				
Family Scytosiphonaceae				
Colpomenia peregrina (Sauvageau) Hamel			+	
Order DESMARESTIALES				
Family Desmarestiaceae				
Desmarestia aculeata (Linnaeus) Lamouroux		+	+	

Order LAMINARIALES				
Family Laminariaceae				
Laminaria longipes Bory f. *angustifolia* (Postels et Ruprecht) Miyabe et Nagai in Nagai			+	+
L. bongardiana Postels et Ruprecht			+	
Arthrothamnus kurilensis Ruprecht			+	
Thalassiophyllum clathrus (Gmelin) Postels et Ruprecht			+	
Family Alariaceae				
Alaria marginata Postels et Ruprecht		+	+	
A. angusta Kjellm. emend. Yu. Petrov		+	+	
Alaria sp.		+		+
Pleuropterum paradiseum Miyabe et Nagai in Nagai	+	+	+	+
Undariella kurilensis Petrov et Kussakin			+	+
Order FUCALES				
Family Fucaceae				
Fucus evanescens C. Agardh	+	+	+	+
Division RHODOPHYCOTA				
Class BANGIOPHYCEAE				
Order BANGIALES				
Family Bangiaceae				
Porphyra tasa (Yendo) Ueda		+	+	
? P. aff. *umbilicalis*			+	
Class FLORIDEOPHYCEAE				
Order CRYPTONEMIALES				
Family Dumontiaceae				
Constantinea rosa-marina (Gmelin) Postels et Ruprecht			+	
Family Hildenbrandtiaceae				
Hildenbrandtia prototypus Nardo			+	
Family Corallinaceae				
Clathromorphum loculosum (Kjellman)			+	
Titanoderma sp.			+	
Family Kallymeniaceae				
Callophyllis rhynchocarpa Ruprecht			+	
Family Crossocarpaceae				
Velatocarpus pustulosus Perestenko		+	+	
Order GIGARTINALES				
Family Nemastomataceae				
Schizymenia pacifica Kylin			+	
Family Gigartinaceae				
Mastocarpus pacificus (Kjellman) Perestenko	+			
Iridaea cornucopiae Postels et Ruprecht		+	+	+
Order RHODYMENIALES				
Family Rhodymeniaceae				
Rhodymenia pertusa (Postels et Ruprecht) J. Agardh		+		
Palmaria stenogona (Perestenko) Perestenko		+	+	+
Halosaccion glandiforme (Gmelin) Ruprecht		+	+	
Order CERAMIALES				
Family Ceramiaceae				
Ptilota filicina J. Agardh		+	+	+
Neoptilota asplenioides (Turner) Kylin			+	+
Family Delesseriaceae				
Congregatocarpus pacificus (Yamada) Mikami			+	
Micamiella sp.			+	
Family Rhodomelaceae				
Symphyocladia marchantioides (Harvey) Falkenb.			+	
Polysiphonia morrowii Harvey			+	
? Odontalia floccosa (Esp.) Falkenberg		+	+	

Rhodomela sibirica A. Zinova et Vinogradova			+	
?Neorhodomela aculeata Masuda			+	
Kingdom ANIMALIA				
PHYLUM SPONGIA				
Class CALCAREA				
Order SYCETTIDA				
Family Sycettidae				
Sycon ensiferum Denoby			+	
S. arctica (Haeckel)			+	
S. utriculus (Schmidt)			+	
Family Grantidae				
Leucandra valida Lambe			+	
Class DEMOSPONGIA				
Order POECILOSCLERIDA				
Family Myxillidae				
Lissodendoryx amaknekensis (Lambe)			+	
Order HALICHONDRIDA				
Family Halichondriidae				
Halichondria panicea (Pallas)	+	+	+	
Order HAPLOSCLERIDA				
Family Haliclonidae				
Haliclona sp.			+	
PHYLUM CNIDARIA				
Class HYDROZOA				
Order LEPTOLIDA				
Family Corynidae				
Coryne pusilla Gaertner			+	
Family Sertulariidae				
Sertularella pinnata Clark			+	
Abietinaria inconstans (Clark)			+	
A. filicula filicula (Ellis et Solander)				+
Order THECAPHORA				
Family Bonneviellidae				
Bonneviella regia (Nutting)			+	
Class SCYPHOZOA				
Order STAUROMEDUSA				
Family Haliclystidae				
Haliclystus steinegeri Kishinoye			+	
Class ANTHOZOA				
Order ACTINIARIA				
Family Condylanthidae				
Charisea saxicola Torrey		+		
Family Actiniidae				
Cnidopus japonicus (Verrill)		+	+	+
Epiactis arctica (Verrill)			+	
Bunodactis sp.	+	+	+	
Family Metridiidae				
Metridium senile fimbriatum Verrill		+	+	
PHYLUM NEMERTINI				
Class ENOPLA				
Order HOPLONEMERTINI				
Family Emplectonematidae				
Paranemertes peregrina Loe			+	
Emplectonematidae gen sp.		+	+	
Family Tetrastematidae				
Antarctonemertes (Kurileonemertes) sp.			+	
Family Amphiporidae				
Amphiporus fuscosparus Korotk.			+	
PHYLUM ANNELIDA				
Class POLYCHAETA				
Order PHYLLODOCIDA				
Family Phyllodocidae				

Phyllodoce (Anaitides) groenlandica Oersted		+		
Phyllodoce sp.	+			
Eteone longa (Fabricius)	+	+	+	+
? Eumida minuta (Ditlevsen)			+	
Family Polynoidae				
Lagisca rarispina (Sars)		+		
Harmothoe imbricata Linné	+	+	+	
Family Chrysopetalidae				
Dysponetus pygmaeus (Levinsen)				+
Family Syllidae				
Typosyllis ehlersioides japonica Buzhinskaja			+	
T. pulchra occidentalis Buzhinskaja				+
Typosyllis sp.			+	
Exogone gemmifera Pagenstecher			+	
Family Nereidae				
Nereis vexillosa Grube		+		
N. pelagica Linné	+	+	+	+
Order SPINTHERIDA				
Family Spintheridae				
Spinther hystrix Uschakov			+	
Order EUNICIDA				
Family Eunicidae				
Lumbrineris japonica (Morenzeller)			+	
Order ORBINIIDA				
Family Orbiniidae				
Naineris quadricuspida (Fabricius)	+	+	+	+
N. jacutica Annenkova	+			
Orbiniella nuda Hobson	+	+	+	
Order SPIONIDA				
Family Spionidae				
Microspio sp.		+		
Polydora vulcanica Radashevski	+	+		
Boccardia sp.			+	+
Nerine sp.				+
Order CIRRATULIDA				
Family Cirratulidae				
Cirratulus wladislavi Buzhinskaja	+	+	+	
Order FLABELLIGERIDA				
Family Flabelligeridae				
Flabelligera affinis Sars		+		
Order CAPITELLIDA				
Family Capitellidae				
Capitella capitata (Fabricius)	+		+	
Family Arenicolidae				
Abarenicola vagabunda oceanica Healy et Wells		+		
Arachniomaldane vincenti Langerhans			+	
Family Maldanidae				
Nicomache sp.			+	
Order TEREBELLIDA				
Family Terebellidae				
Terebella ehrenbergi Grube			+	
Amphitrite cirrata Müller		+		
Order SABELLIDA				
Family Sabellidae				
Amphiglena pacifica (Annenkova)				+
A. marita Chlebovitsch		+	+	
Asabellides sibirica (Wirén)			+	
Potamilla torelli Malmgren			+	
Class ECHIURIDA				
Order ECHIUROINEA				
Family Bonelliidae				
Bonellia sp.			+	
PHYLUM ARTHROPODA				

Class CRUSTACEA				
Subclass COPEPODOIDEA				
Order THORACICA				
Family Balanidae				
Balanus crenatus Brugière	+	+	+	
Semibalanus cariosus (Pallas)	+	+	+	
Subclass MALACOSTRACA				
Order LEPTOSTRACA				
Family Nebaliidae				
Nebalia bipes (Fabricius)	+	+	+	
Order DECAPODA				
Family LITHODIDAE				
Hapalogaster grebnitzkii Schalfeev		+	+	
Order AMPHIPODA				
Family Ampithoidae				
Ampithoe djakonovi Gurjanova	+			+
A. volki Gurjanova		+	+	
A. eoa Bruggen	+			
A. mea Gurjanova	+			
Ampithoe sp.	+		+	
Family Anisogammaridae				
Anisogammarus (Eogammarus) locustoides (Brandt)	+	+		
A. (Spinulogammarus) spasskii (Bulycheva)			+	
A. (Spinulogammarus) ochotensis (Brandt)	+			
Family Calliopiidae				
Paracalliopiella pacifica Tzvetkova et Kudrjaschov			+	
Family Corophiidae				
Corophium steinegeri Gurjanova	+	+	+	
Corophium sp.	+	+	+	
Paracerapus polutovi (Gurjanova)	+	+	+	
Family Hyalidae				
Allorchestes malleolus Stebbing				+
A. carinata Iwasa	+	+	+	
Parallorchestes ochotensis (Brandt)			+	+
Family Ischyroceridae				
Ischyrocerus anguipes Krøyer	+	+	+	
I. chamissoi Gurjanova	+	+	+	
I. dezhnevi Gurjanova		+		
I. tzvetkovae Kudrjaschov	+		+	+
I. krascheninnikovi Gurjanova		+	+	
? *I. pachtusovi* Gurjanova			+	
Ischyrocerus sp.			+	
Jassa oclairi Conlan	+		+	
Family Lysianassidae				
Anonyx affinis Ohlin			+	
A. japonicus Gurjanova	+			
Orchomenella japonica Gurjanova			+	
Stomacontion sp.			+	
Lepidopecreum sp.			+	
Family Melitidae				
Melita sp.			+	
Family Phoxocephalidae				
Paraphoxus longirostris (Gurjanova)			+	+
P. robusta (Gurjanova)			+	
Family Pontogeneiidae				
Pontogeneia makarovi (Gurjanova)		+	+	+
Pontogeneia sp.			+	
Tethygeneia rostrata (Gurjanova)			+	
Family Pleustidae				
Pleustes behningi (Gurjanova)			+	
Pleusymtes sp.			+	

Sympleustes glaber (Boeck)			+	
Family Stenothoidae				
Mesostenothoides slastnikovi (Gurjanova)			+	
Family Talitridae				
Talorchestia crassicornis Derzhavin			+	
Family Caprellidae				
Caprella parapaulina Vassilenko			+	
C. cristibranchium Mayer			+	
C. distalis Mayer		+		
C. laeviuscula Mayer		+		
Order ISOPODA				
Family Sphaeromatidae				
Gnorimosphaeroma noblei Menzies		+	+	
Family Idoteidae				
Idotea gurjanovae Kussakin		+		+
I. aleutica Gurjanova	+	+	+	
PHYLUM MOLLUSCA				
Class POLYPLACOPHORA				
Subclass LORICATA				
Order LEPIDOPLEURIDA				
Family Leptochitonidae				
Leptochiton assimilis (Thiele)				
Order CHITONIDA				
Family Lepidochitonidae				
Spongioradsia aleutica (Dall)			+	
Yuvenichiton albocinnamomensis Sirenko			+	
Mucichiton grandispina Sirenko			+	
Family Tonicellidae				
Tonicella beringensis beringensis Yakovleva			+	
T. submarmorea Middendorff				+
Family Schizoplacidae				
Schizoplax brandtii (Middendorff)			+	
Family Mopaliidae				
Placiphorella borealis Pilsbry			+	
Class GASTROPODA				
Subclass PECTINIBRANCHIA				
Order ANISOBRANCHIA				
Family Trochidae				
Margarites helicina (Phipps)			+	
Order DISCOPODEA				
Family Lacunidae				
Lacuna minor (Dall)			+	
Epheria divaricata (Fabricius)			+	
Family Littorinidae				
Littorina sitkana Philippi	+	+	+	+
Family Falsicingulidae				
Falsicingula sp.	+			
Order ECHINOSPIRIDA				
Family Velutinidae				
Cartilagovelutina beringensis (Derjugin)		+	+	
Limneria (*Conivelutina*) *prolongata* (Carpenter)			+	
Order HAMIGLOSSA				
Family Pyrenidae				
Astyris kobai Golikov et Kussakin			+	
Family Buccinidae				
Volutharpa ampullacea (Middendorff)			+	
Buccinum baeri (Middendorff)			+	
Family Thaididae				
Nucella freycinettii (Deshayes)	+	+	+	+
Subclass OPISTHOBRANCHIA				
Order NUDIBRANCHIA				

Family Onchidorididae				
Onchidoris bilamellata Linné	+	+	+	
Family Aeolididae				
Aeolidia papillosa Linné			+	
Class BIVALVIA				
Order MYTILIDA				
Family Mytilidaé				
Modiolus phenax (Dall)		+	+	
Vilasina vernicosa (Middendorff)			+	
Order LUCINIDA				
Family Turtoniidae				
Turtonia minuta (Fabricius)	+	+	+	+
Order ADAPEDONTA				
Family Hiatellidae				
Hiatella arctica (Linné)		+	+	+
PHYLUM BRYOZOA				
Class STENOLAEMATA				
Order TUBULIPORIDA				
Family Crisiidae				
Crisia eburnea (Linné)			+	
Class EURYSTOMATA				
Order STENOSTOMIDA				
Family Flustrellidridae				
Flustrellidra conriculata (Smith)			+	
Order FLUSTRIIDA				
Family Flustriidae				
Carbasea nordenskjoldii (Kluge)			+	
Order BUGULIDA				
Family Buguliidae				
Dendrobeania murrayana (Johnston)			+	
D. levinseni (Kluge)			+	
Order CELLEPORIDA				
Family Hippothoidae				
Celleporella hyalina (Linné)		+	+	
PHYLUM BRACHIOPODA				
Class ARTICULATA				
Order TEREBRATULIDA				
Family Dallinidae				
Diestothyris frontalis (Middendorff)			+	
PHYLUM ECHINODERMATA				
Class HOLOTHUROIDEA				
Order DENDROCHIROTA				
Family Cucumariidae				
Cucumaria vegae Theel	+	+		
Eupentacta pseudoquinquesemita Deichmann	+	+	+	
Family Psolidae				
Psolus fabricii Düben et Koren			+	
Class ASTEROIDEA				
Order SPINULOSA				
Family Echinasteridae				
Henricia sp. (3)			+	
Order FORCIPULATA				
Family Asteriidae				
Leptasterias hirsuta Djakonov		+		
L. alaskensis asiatica Fischer		+	+	+
L. camtschatica (Brandt)		+	+	
Class ECHINOIDEA				
Order CAMARODONTA				
Family Strongylocentrotidae				
Strongylocentrotus droebachiensis Müller		+	+	
PHYLUM CHORDATA				
Class ASCIDIACEAE				
Order APLOUSOBRANCHIA				

Family Polyclinidae			
Amaroucium sp. 1 (sp. n.?)			+
Amaroucium sp. 2		+	
Order PHLEBOBRANCHIA			
Family Ascidiidae			
Ascidia callosa Stimpson		+	
Order STYELIDAE			
Family Styelidae			
Styela coriaceae (Alder et Hancock)			+
Dendrodoa aggregata (Rathke)			+
Class TELEOSTOMI			
Order PERCIFORMES			
Family Stichaeidae			
Ascoldia variegata Knipowich et Soldatov	+		
Family Zoarcidae			
Krusensterniella sp.	+	+	
Order SCORPAENIFORMES			
Family Cottidae			
Myoxocephalus stelleri Tilesius		+	
M. polyacanthocephalus (Pallas)	+		
M. brandti (Steindachner)	+	+	