BENTHOS AND FOOD SUPPLY STUDIES IN FEEDING AREAS OF THE OKHOTSK-KOREAN GRAY WHALE POPULATION

REPORT

BASED ON RESULTS OF FIELD WORK
ABOARD THE RESEARCH VESSEL *AKADEMIK OPARIN*
IN 2004

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FINAL REPORT

ON MATERIALS FROM FIELD STUDIES ON THE
RESEARCH VESSEL OPARIN IN 2004

BENTHOS AND FOOD SUPPLY STUDIES IN FEEDING GROUNDS OF THE OKHOTSK-KOREAN GRAY WHALE POPULATION IN 2004

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INTRODUCTION

General overview[1]. We know that two independent gray whale (*Eschrichtius robustus*) populations (LeDuc et al., 2002) reside in the Pacific Ocean: the eastern or California-Chukotka population, which reached a size of about 18,000 animals in 2001 (Rugh et al., 1999; Le Boeuf et al., 2000; Rugh, 2003), and the western Pacific or Korean-Okhotsk population, numbering about 100 animals (Weller et al., 2004).

After commercial whaling was halted during the 1940's, the eastern gray whale population has fully restored, although its estimated size decreased from 26,000 in 1998 (Rugh et al., 1999) to 17,000 in 2001 (Rugh, 2003). Despite the fact that an increase in the death rate, a low birth rate and deterioration of the physical condition of some of the animals were observed in the eastern population in 1999 and 2000 (Moore et al., 2001), the status of the population was reasonably stable due to its large size (LeBoeuf et al., 2000).

In contrast to the eastern population, the Korean-Okhotsk gray whale population has never been large and according to the estimates of experts did not exceed 2,000 – 2,500 thousand individuals at its peak (Berzin, 1974; Yablokov and Bogoslovskaya 1984). Many years of whaling brought the population to the brink of practical extinction, and it was only in the early 1970's that gray whales began to be sighted off northeastern Sakhalin (Berzin, 1974; Brownell and Chun, 1977; Blokhin et al., 1985). A 40-year ban on whaling (beginning in the 1960's) failed to produce a substantial restoration of the whale population. According to optimistic estimates, the whale population numbers between 100 and 250 animals, although most researchers estimate the population as not more than 100 whales (Blokhin, 1996; Blokhin and Burdin, 2001; Vladimirov, 2000; Sobolevsky, 1999, 2000; Sobolevsky, 2000, 2001; Weller et al., 1999, 2000, 2001, 2002, 2004). It is hypothesized that there are fewer than 50 remaining individuals capable of reproduction (Weller et al., 2001). The low reproduction rate, genetic uniqueness (LeDuc et al., 2002) and small overall size of the Korean-Okhotsk gray whale population (Weller et al., 2000; Vladimirov, 2000) have prompted inclusion of the species in category I of the IUCN Endangered Species List (USFWS, 1997; Hilton-Taylor, 2000; Weller and Brownell, 2000) and the Russian Federation Red Book (2000).

[1] Since the history of benthos studies and data on the benthos distribution in the Eastern Sakhalin area and on the feeding of the California-Chukotka gray whale population have been analyzed and summarized in detail in the report: Kusakin, O. G., E. I. Sobolevsky and S. A. Blokhin. Survey of Benthos Studies on the Northeastern Sakhalin Shelf. Interim Report of the Marine Biology Institute of the Far East Branch of the Russian Academy of Sciences (IBM DVO RAN) and the Pacific Research Institute of Fisheries and Oceanography (TINRO). Vladivostok, 2001, 89 pp., we have not undertaken a survey of the literature on these issues in this section. We shall merely cite published data in a discussion of the results and elsewhere as necessary, especially since the report (Kusakin et al., 2001) is available on the website www.sakhalinenergy.com.

The startup of offshore commercial oil and gas development on the eastern Sakhalin Shelf in the mid-1990's necessitated comprehensive study of the Western Pacific gray whale population to assess the possible anthropogenic impact on the population and to develop approaches to minimize the effects of negative factors (Berzin and Vladimirov, 1996; Vladimirov, 2000). In particular, in development of the joint declaration of the Gore-Chernomyrdin Commission "On Measures to Ensure the Preservation of Biodiversity in the Sakhalin Island Area" dated 7 February 1997, in connection with the development of oil and gas fields on the island shelf, the Russian and American sides in 1998 prepared a joint "Korean-Okhotsk Gray Whale Population Monitoring and Research Program," which was approved by the State Committee on Environmental Protection (Goskomekologiya) of Russia and the U. S. Fish and Wildlife Service (Weller et al., 2001). The program proposed multidisciplinary studies of the Okhotsk-Korean population during the whales' feeding season off eastern Sakhalin: abundance and distribution surveys, acoustic studies, and a study of benthos as the key component in the diet of gray whales.

In 2001, 10 diving transects were sampled in the northeastern Sakhalin coastal zone in an area from Niyskiy Bay in the south to Tront Bay in the north. Four transects were sampled in the traditional Piltun gray whale feeding area – the area of Piltun Bay. It was demonstrated that at depths of 5 to 15 m, this area is characterized by a great abundance of forage benthos, primarily amphipods and isopods (Fadeev, 2002).

For a long time, the Piltun Area was considered the only gray whale feeding location off the east coast of Sakhalin Island during the summer and fall period, although small groups of animals were also sighted at a considerable distance from shore and at significant depths (Sobolevsky, 1999; Miyashita et al., 2001). On 10 September 2001, however, observers M. Maminov and Y. Yakovlev, while working aboard a seismic research support ship during bridging for refueling, observed seven gray whales feeding out to sea from Chayvo Bay. The aerial and ship-based surveys of the area that followed resulted in the discovery of a second gray whale feeding area (the Offshore Area) (Maminov and Yakovlev, 2002). The area is located on a line from the middle part of Chayvo Bay to the southern part of Niyskiy Bay 20-45 km from the latter in a depth zone of 30-65 m. In 2001, whales were present there on a regular basis from June to November (Blokhin et al., 2002), and the counts varied from 48 to 83 animals.

A work statement was developed in 2002 for a multidisciplinary study of gray whales, both in the well-known shallow-water feeding area (the Piltun Area off Piltun Bay) and the new deep-water area (the Offshore Area). The field phase of the work was conducted in 2002

(Fadeev, 2003), 2003 (Fadeev, 2004) and 2004 within the scope of three expeditions aboard the seagoing tug *Nevelskoy* and the research vessel *Akademik Oparin*. The complex of studies included gray whale prey/benthos surveys.

The first data obtained in 2002 on the benthos composition and distribution in the Offshore Area indicated that gray whales feed there in areas of ampeliscid amphipod dominance (Fadeev, 2003). *Ampelisca* amphipods are the most common and best known prey in gray whale feeding grounds (Zimushko and Lenskaya, 1970; Blokhin and Pavlyuchkov, 1980, 1996, 1999; Bogoslovskaya, 1996; Zenkovich, 1937; Kusakin et al., 2001; Bogoslovskaya et al., 1981, 1982; Jones and Swartz, 2002; Nerini, 1984; Oliver et al., 1983, 1984). Whales feed in the Piltun Area in shallow coastal areas dominated by amphipods that differ from ampeliscid amphipods in both ecology and type of diet (Sobolevsky et al., 2000; Fadeev, 2002, 2003).

The objective of this survey was to study quantitative distribution and status of benthos in the Piltun and Offshore gray whale feeding area and at feeding sites of individual whales based on field data from 2004 to understand the nature of gray whale distribution and movement in response to prey distribution.

The work was done under the "Korean-Okhotsk Gray Whale Population Monitoring and Research Program" funded by Sakhalin Energy Investment Company Limited (SEIC). and Exxon Neftegas Limited (ENL).

This report was prepared based on the results of benthos studies conducted, in July-October 2004, by an expedition of the Marine Biology Institute (IBM) of the Far East Branch (DVO) of the Russian Academy of Sciences (RAN) aboard the research vessel *Akademik Oparin*.

The tasks of the study were:

- to conduct benthos studies in the Piltun and Offshore whale feeding areas by collecting bottom grab samples;
- to investigate the benthos composition where gray whales are observed feeding (whale feeding sites);
- to obtain information on the species composition and abundance (colony density and biomass) of individual taxonomic groups and common species of benthos from analysis of macrobenthos collections;
- to assess the composition and abundance of macrobenthos in the whale feeding areas and outside the feeding zones;
- to perform a morphometric analysis of the common species of amphipods to assess the size compositions;

- to obtain data on the particle size distribution of sediments in the feeding areas and whale feeding sites and the concentrations of petroleum hydrocarbons and heavy metals in the bottom sediments; and
- to perform a comparative analysis of the benthos distribution in the Piltun and Offshore areas based on materials from 2004 and 2002-2003.

MATERIALS AND METHODS

1. Materials and Methods for Field Studies

1.1. Material

Timing for performance of the studies. Field work to study benthos and the food supply of gray whales was performed by a field team from the Institute of Marine Biology of the Far East Branch, Russian Academy of Sciences, aboard the research vessel *Akademik Oparin* from 27 July to 7 October 2004.

Special features of the field work in 2004. The field work from 2004 differed in certain aspects from the work in 2003. The distinguishing features of the work from 2004 (increased number of stations at whale feeding sites at depths greater than 15-20 m and larger numbers of epibenthos and plankton collections at the whale feeding sites) were prompted primarily by the nature of the whale distribution:

1. In contrast to 2002-2003, gray whales were absent from the Offshore Area in July and August 2004. It was only in the first ten days of September that two feeding whales were observed. In 2002-2003, however, from 48 to 83 animals were recorded there.

2. The proportion of whales feeding at depths greater than 15 m increased somewhat in the Piltun Area in July 2004. The proportion of such whales was less than 10% in 2002-2003. This difference prompted more detailed study of benthos at the whale feeding sites at depths greater than 15-20 m and collection of plankton and epibenthos samples there. Extensive plankton collection was also prompted by the fact that spots of elevated density of pteropod mollusks were observed among the plankton of the Piltun Area in September 2004.

In addition, certain features of the studies in 2004 were conditioned by the technical characteristics of the field research vessel *Akademik Oparin* (draft 4.5 m). A vessel with a draft of 1.5 m was used in 2002-2003. The deeper draft of the vessel used in 2004 limited the opportunities to collect samples at depths less than 10-12 m. Hence three transects were sampled in the Piltun Area at depths of 3-12 m from a Zodiac motor launch.

Characteristics of field collections. Two gray whale feeding areas were studied in 2004: 1 – the Piltun Area (the near-shore zone in the section from Odoptu Bay to the southern part of Piltun Bay); 2 – the Offshore Area (30-45 km from the coastline in the section from the middle part of Chayvo Bay to the southern part of Niyskiy Bay).

A consistent approach was used in planning the locations of benthos stations in the two areas in 2004 and 2002-2003. During planning of the studies in 2002, the waters of the Piltun Area were divided into 60 sectors of equal area making up five blocks corresponding to the aerial survey sectors (Appendix 1. Fig. P1.1). Within each sector, the locations of the stations were determined according to a random number table in 2002 (60 stations) and 2003 (60 stations). In 2004, with the clients' consent, the decision was made to repeat the station layout from 2003, which was prompted by feeding of some of the whales in 2004 at depths greater than in 2003. The stations of 2002 and 2003 were some distance apart, even within the same sector. The distances between the same stations in the same sectors in 2002 and 2003 varied from 0.06 to 5.3 km (2.34±0.18 km, on the average). The station grid from 2003 was repeated in 2004. The accuracy of the vessel's positioning at 2003 stations in 2004 was determined by the navigation conditions and amounted to 110±10 m. In light of the size of the vessel (length 75 m), the accuracy of repeated positioning at 2003 sites in 2004 can be regarded as satisfactory.

During planning of the work in 2002, the waters of the Offshore Area were divided into 36 sectors (4 blocks), each with an area of about 115 sq. km (Appendix 1. Fig. P1.2). During the expeditions in 2002 and 2003, there were 36 stations in the Offshore Area. The area of individual sectors in the Offshore Area is larger than in the Piltun Area, and the distances between the same stations of the same sector in 2003 and 2002 accordingly are substantially greater there – from 0.33 to 10.75 km (5.08±0.48 km, on the average). In accordance with the statement of work from 2004, the station grid in the Offshore Area was expanded eastward (compared to 2002 and 2003) to define the size of the section with the greatest abundance of forage benthos – ampeliscid amphipods.

Combined diagrams of the layout of stations in 2002-2003 in the Piltun and Offshore areas are presented in Appendix 1 (Figs. P1.1 and P1.2).

The locations of benthos stations in 2004 are shown in Fig. 1. Bottom grab benthos samples were collected at 148 stations (Table 1). In addition to sampling at standard benthos stations (96 stations, 291 samples), collection of benthos (52 stations, 156 samples) and epibenthos and plankton (210 samples) was performed at gray whale feeding sites. The following samples were taken to study the characteristics of bottom sediments: 148 samples to determine the particle size distribution of the sea bottom, and 60 samples to assess the concentrations of heavy metals and petroleum hydrocarbons.

A complete record of the samples, including coordinates and water temperature and salinity characteristics is given in Appendix 2 (Table P2.1).

Table 1. Description of Materials Collected Aboard Research Vessel *Akademik Oparin* in 2004.

Area	Bottom grab sampler	Epibenthic net	Bongo plankton net
	Stations (samples)	Stations (samples)	Stations (samples)
Piltun Area	64(195)	13(26)	41(82)
Offshore Area	32(96)	0	0
Whale feeding sites	52(156)	22(58)	22(44)
Total	148(447)	35(84)	63(126)

As in 2002-2003, bottom grab sample collections in 2004 were taken from aboard the ship, which imposed restrictions on the minimum depth for benthos collection. Specifically, this limited the opportunity to study the most abundant sections of the Piltun Area at depths of 5-15 m. The shallowest depths for bottom grab sample collections from the ships were 11 m in 2002, 8 m in 2003 and 11 m in 2004 (Table 2).

Table 2. Distribution of stations in the Piltun Area by depths in collections from 2004 and 2001-2003.

Depth Range	Number of Stations			
	2004	2003	2002	2001
1 - 5 m	**6**	0	0	5
6 -10 m	**7**	10	0	5
11-15 m	**6**	19	16	5
16-20 m	**13**	7	13	5
21-25 m	**14**	12	18	5
26-30 m	**13**	10	11	5
31-35 m	**5**	5	2	0
Total	**64**	63	60	30

As indicated by diving data from 2001 (Fadeev, 2002) and 2003 (Fadeev, 2004), the sections of the Piltun Area with the most abundant food organisms are at depths up to 15-20 m. Therefore, in 2004 bottom grab sample collection was performed on three transects in a depth range of 3-12 m from a Zodiac. The south transect (Fig. 1) was located in direct proximity to the diving transects of 2001 and 2003.

Benthos collections were taken at three stations in the Piltun Area (with the highest prey biomass) at the start (July) and end of the expedition (late September) to study the size composition and assess the growth rates of common amphipod species.

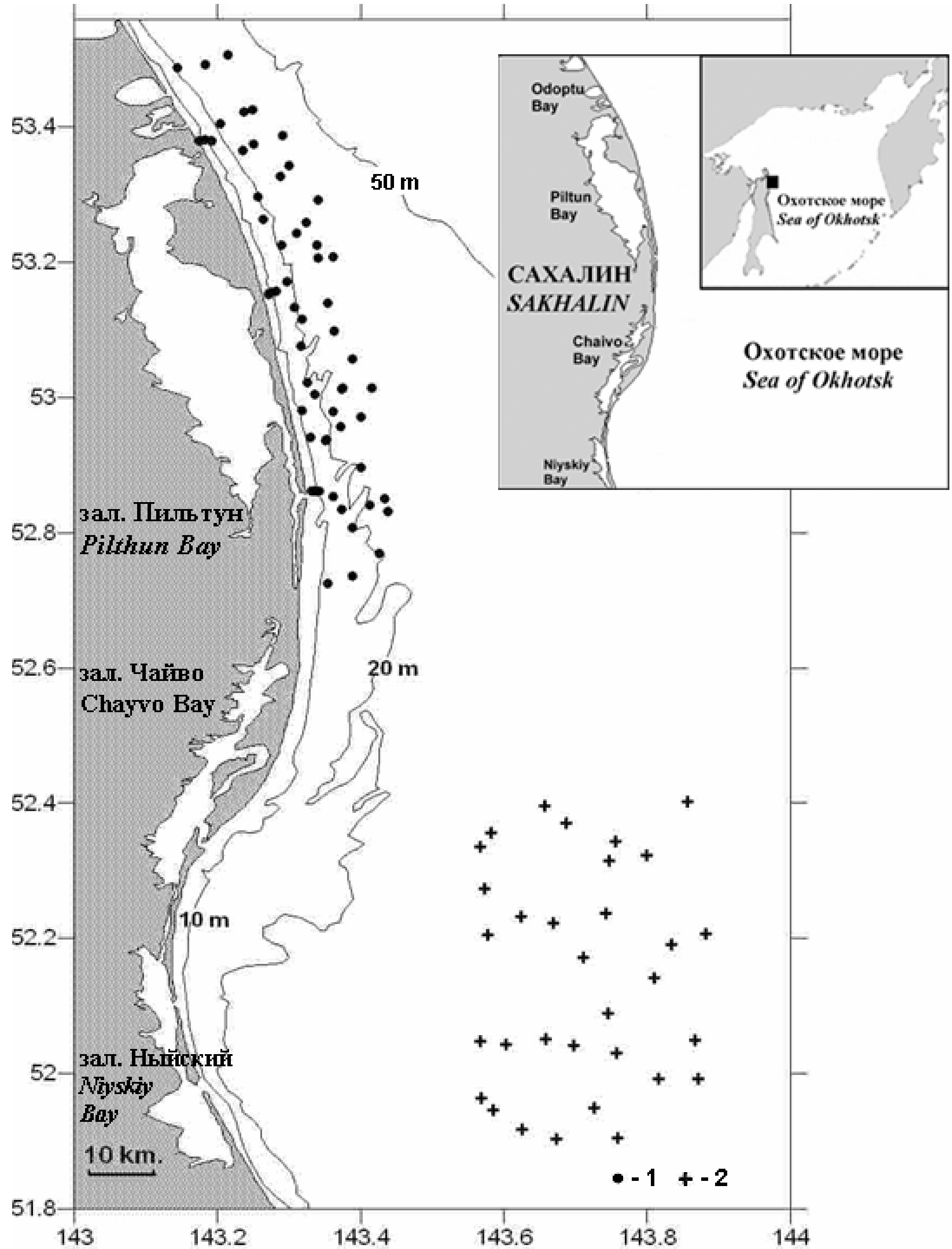


Figure 1. Station locations in the study area in 2004.

1 – stations in the **Piltun Area**;

2 – stations in the **Offshore Area**.

1.2. Field Study Methods

All benthos sampling from the ship on the 2004 expedition was performed with a Van Veen bottom grab sampler (grab area 0.2 m^2, weight 57 kg). In the work from aboard the Zodiac, a heavy model of the Petersen bottom grab sampler was used (grab area 0.025 m^2, weight 12 kg). Three replicate samples were taken at each station. Before the start of grab sampling, an underwater video recording was made of the water column and the bottom surface at each station to obtain information on the presence of plankton accumulations in the water column or of epibenthos in the bottom water layers. An *epibenthic net* with an area of 0.25 m^2 was used to assess the quantity and composition of epibenthos, and a double *Bongo net* was used for plankton. Underwater video was taken of the water column and the bottom surface at each station, the location was recorded by GPS, and the depth, water surface temperature and salinity were recorded. The water temperature and salinity were measured with a MultiLine P4 hydrologic probe.

Aboard the ship, the *macrobenthos* samples were washed on a washing table through a system of three sieves – 5 mm (to remove coarse bottom fractions and large animals – flat sea urchins and mollusks), 1 mm, and 0.5 mm (the bottom sieve) – and fixed with 4% formalin. Then all the benthos and epibenthos samples were transferred to 75% alcohol. The washed benthos samples were photographed with an Olympus digital camera. To analyze the *particle size distribution* and the concentrations of *petroleum hydrocarbons* and *heavy metals*, a sample was taken from the surface sediment layer using a Teflon pipe sampler. The samples were placed in plastic packets and special dishes and left in a cooler until they could be sent to the laboratory for analysis.

Large zooplankton samples were collected in the Piltun Area 24-28 September 2004. Plankton was collected with a double Bongo net (25 cm inlet, 1 mm mesh), so that there were two samples in each capture. At stations Bon 1-27, 1-2 vertical surface captures (5-0 m in most cases, and 2-0 m at one station) and in a few cases another total capture (bottom-0 m) were performed; 1 total capture each, from the bottom to the surface, was performed at stations Pil 5-13. A total of 63 samples were taken: Bon – 45, and Pil – 18 (Table 2A). The samples were fixed with a 4% formaldehyde solution and subsequently transferred to alcohol. Laboratory processing of the zooplankton samples was performed at a permanent laboratory. The samples were examined in a Borogov chamber under the MBS-10 stereoscopic binocular microscope, and all the organisms were identified and counted. Since a coarse-mesh net was used, only data on large organisms (body sizes larger than 1 mm) were analyzed. Small and medium-sized plankters (copepods and cladocerans, meroplankton and young of other groups), although they were common forms, were captured in the Bongo net by chance, hence their presence was noted, but they were not included in the estimates.

Table 2A. List of large zooplankton samples (capture depth, m) collected in the Piltun Area in September 2004. Captures reaching the bottom are marked with an asterisk.

Station No.	Sample No.					
	1	2	3	4	5	6
Bon-1	5-0	5-0	-	-	-	-
Bon-2	5-0	5-0	-	-	-	-
Bon-3	5-0	5-0	-	-	-	-
Bon-5	2-0	-	-	-	-	-
Bon-6	5-0	5-0	-	-	-	-
Bon-7	5-0	5-0	-	-	-	-
Bon-8	5-0	5-0	-	-	-	-
Bon-17	5-0	5-0	-	-	-	-
Bon-18	5-0	5-0	5-0	5-0	18*-0	18*-0
Bon-20	5-0	5-0	12*-0	12*-0	-	-
Bon-21	5-0	5-0	-	-	-	-
Bon-22	5-0	5-0	-	-	-	-
Bon-24	5-0	5-0	5-0	5-0	32*-0	32*-0
Bon-26	5-0	5-0	5-0	5-0	19*-0	19*-0
Bon-27	5-0	5-0	5-0	5-0	-	-
Pil-5	3*-0	3*-0	-	-	-	-
Pil-6	5*-0	5*-0	-	-	-	-
Pil-7	7*-0	7*-0	-	-	-	-
Pil-8	10*-0	10*-0	-	-	-	-
Pil-9	3*-0	3*-0	-	-	-	-
Pil-10	5*-0	5*-0	-	-	-	-
Pil-11	7*-0	7*-0	-	-	-	-
Pil-12	10*-0	10*-0	-	-	-	-
Pil-13	12*-0	12*-0	-	-	-	-

2. Laboratory Analysis of Materials

2.1. Analysis of Particle Size Distribution of Bottom Sediments

The particle size distribution of bottom sediments was analyzed at the *Shelf Problems Laboratory of the Far East State University* (DVGU) by two standard Russian methods: screen and areometric. The analysis determined the percentage concentrations in the sea bottom of fractions of the following sizes: larger than 10 mm; 10-5; 5-2; 2-1; 1-0.5; 0.5-0.25; 0.25-0.1; 0.1-0.05; 0.05-0.01; 0.01-0.005; and smaller than 0.005 mm. The moisture content (W) and specific gravity of the bottom soil samples were determined preliminarily by the standard Russian method. The bottom sample was then dried and sifted through a set of screens with mesh sizes of 10, 5, 2 and 1 mm. The soil fractions remaining on the screens and the fraction that passed through the screen with a 1 mm mesh were weighed. The sediment that passed through the screen with a mesh size of 1 mm was transferred to a porcelain cup that had been weighed in advance and then was weighed. The soil sample was poured into a flask with a capacity of 1000 cm^3, which was then filled with distilled water (approx. 300 ml). The soil with water added was allowed to stand for one day. After standing for a day, 1 cm^3 of a 25% ammonia solution was added to the sample, and the flask with the sample was boiled for one hour and then cooled to room temperature. The suspension obtained was poured into a 1-liter glass cylinder through a sieve with a mesh size of 0.1 mm. The soil particles left in the sieve with a mesh size of 0.1 mm were dried, sifted through a set of screens with mesh sizes of 0.5, 0.25 and 0.1 mm, and then weighed separately. The suspension was agitated for one minute, until the sediment was stirred up completely from the bottom of the cylinder. An areometer was introduced, and its readings were determined one minute after the agitation stopped for the fraction smaller than 0.05 mm, after 30 minutes for the fraction smaller than 0.01 mm, and after three hours for the fraction smaller than 0.005 mm.

The Classification of sediments according to mechanical composition (Table 3) has been used to designate soil types.

Table 3. Classification of bottom sediments used in the report (Bezrukov and Lisitsin, 1960; Shepard, 1976).

Sediment Group	Types of Sediments	Abbreviation in Text	Predominant Particle Size, mm	Md, mm
Coarsely fragmented (psephites)	Pebbles	**Peb**	>10	
Coarsely fragmented (psephites)	Gravel Coarse Medium Fine	 **Grc** **Grm** **Grf**	 10-5 5-2 2-1	
Sandy (psammites)	Sands Coarse Medium Fine	 **Sc** **Sm** **Sf**	 1-0.5 0.5-0.25 0.25-0.1	 1-0.5 0.5-0.25 0.25-0.1
Silt (aleurites)	Coarse aleurites Fine aleurite silt	**Ac** **Af**	0.1-0.05 0.05-0.01	0.1-0.05 0.05-0.01
Clay (pelites)	Coarse pelite	**Pec**	<0.01	0.01-0.005

Note: Md, mm, is the median diameter of the soil particles. Numbers in the column are the range of values for the type of sediment in question.

2.2. Analysis of the Concentrations of Heavy Metals, Petroleum Hydrocarbons and Organochlorine Pesticides in Bottom Sediments

Heavy metals. The concentrations of iron, zinc, chromium, copper and lead were measured on a Nippon Jarrell-Ash AA-855 atomic absorption spectrophotometer. A single-slot burner was used as the atomizer, with an acetylene-air gas mixture. A deuterium lamp was used for background correction. The test sensitivity (μg/ml) was 2 for iron; 0.02 for zinc; 0.005 for copper; and 0.02 for chromium. Aluminum and barium concentrations were measured with an acetylene-nitrous oxide gas mixture. The test sensitivity was 2 μg/ml for aluminum and 1 μg/ml for barium. Cadmium, lead and arsenic concentrations were determined on a Hitachi 170-70 atomic absorption spectrophotometer with a graphite-tube atomizer. Zeeman effect background correction was used. The test sensitivity (μg/ml) was: 0.0002 for cadmium; 0.005 for lead; and 0.02 for arsenic. Mercury concentrations were determined by the flameless atomic absorption method using a Hiranuma Hg-1 microanalyzer. The test sensitivity was 0,0001 μg/ml.

The samples were prepared for atomic absorption analysis by the accepted Russian methods, namely the procedures developed by the Azov Fishery Research Institute (RD-15-229-91 – Cd; RD-15-241-91 – Cu; RD-15-227-91 – As; RD-15-231-91 – Pb; RD-15-228-91 – Cr; RD-15-232-91 – Hg), as follows: bottom sediment samples were dried at 105°C. A 1 g specimen weighed with a accuracy of 0.01 g, was transferred to a glass beaker, and 10 ml of concentrated HNO_3 was added. The beaker was kept at room temperature for 24 hours, after which 5 ml of bidistilled H_2O was added, and the beaker was heated at 120 °C for three hours (during which the beaker was covered with watch glass). Then 3 ml of concentrated $HClO_4$ was added to the cooled solution, and the mixture was heated at 180 °C until HCl vapor appeared. The residue was filtered and brought up to a volume of 25 ml with bidistilled H_2O in a measuring flask. Acid-soluble forms of the heavy metals (with the exception of mercury) were determined in the mineralization product.

Samples were prepared as follows for mercury assay: 1 g of a carefully homogenized specimen with natural moisture content was treated with 50% sulfuric acid and 6% potassium permanganate, with subsequent reduction of mercury with stannous chloride, according to the procedure "Determination of Total Mercury in Bottom Sediments by the Flameless Atomic Absorption Method," RD-15-226-91, developed by the Azov Fishery Research Institute.

The laboratory glassware used in the decomposition process was washed with diluted nitric acid and rinsed three times with bidistilled water.

Upon arrival of the bottom sediment samples, they were checked for possible contamination due to unsealing of the packaging, as well as for the acceptability of the transfer conditions, and were checked for adequate sample size, after which the sample labels were checked against the accompanying documents. The sample characteristics were logged. The samples were prepared for analysis according to the procedures described above. The standard solutions used were solutions prepared from reference specimens of metals listed in the State Registry of Measures which had passed GSORM official tests.

Every spectrophotometer used had passed initial calibration according to the manufacturer's instructions. Before the analyses of bottom sediment samples, three-point calibration of the instruments was performed, and the linearity of response factors for each of the metals to be measured was checked. The relative standard deviations for the initial calibration and the subsequent calibrations were within limits of 3 to 5%. Three dummy samples were prepared for each procedure for sample preparation for atomic absorption assays of metals.

<u>Chlorinated pesticides</u>. The sediments were dried at 70 °C and analyzed for concentrations of chlorinated hydrocarbons (*p,p′*-DDT , *p,p′*-DDD and *p,p′*-DDE, and α- and γ-isomers of HCH). Chlorinated hydrocarbons were analyzed by gas-liquid chromatography according to the standard procedures of the Russian Meteorological Service (Guide 1979; Methodological Guidelines 1996) on an LSM-8 gas chromatograph with a glass column (1 m × 3 mm, stationary phase SE–30, column temperature 220 °C, detector temperature 250 °C).

The method is based on extracting chlorinated hydrocarbons with a mixture of organic solvents (acetone-hexane), isolating the extracts with sulfuric acid and an aqueous solution of sodium sulfite in the presence of tetrabutyl ammonium (TBA) sulfate, and subsequent determination of the chlorinated hydrocarbons in the concentrated extract by gas-liquid chromatography. The substances are identified according to the retention time relative to DDE. The quantities of the substances are calculated according to the respective peak heights. When polychlorinated biphenyls (PCBs) are present in a sample, they are separated from the organochlorine pesticides (OCP) by alkaline dehydrochlorination (in alcohol solution).

The minimum detectable quantity (MDQ) was 0.3-0.5 ng/g of dry bottom sediment for DDT, DDD and DDE, and 0.1 ng/g of dry sediment for α-HCH and γ-HCH.

<u>Petroleum hydrocarbons</u>. The sediments were dried at 70 °C and analyzed for the total (gross) concentration of petroleum hydrocarbons. Petroleum hydrocarbons were extracted with n-hexane, and their concentration was determined by IR spectrophotometry

according to the standard procedures of the Russian Meteorological Service (Guide 1979; Methodological Guidelines 1996).

The method is based on extracting petroleum hydrocarbons from bottom sediment samples with a basic ethanol solution, with transfer of the component under analysis to hexane, removal of extraneous compounds by sorption onto aluminum oxide, replacement of the solvent with carbon tetrachloride, and subsequent measurement of the concentration of petroleum hydrocarbons by IR spectrophotometry. The minimum detectable quantity of petroleum hydrocarbons is 5 μg/g of dry bottom sediment.

2.3. Analysis of Benthos Samples

Laboratory processing of *macrobenthos* consisted of determining the benthos species composition and quantitative characteristics in the sample (biomass and count for each species and for individual taxonomic groups, and total biomass and count of macrobenthos in the sample). A total sorting of the animals was performed. Large organisms were counted visually, and small ones were counted with the MBS-10 binocular microscope. The gross weight of large benthic organisms was determined with a VLKT-100 electronic scale accurate to 10 mg, and the gross weight of small organisms was determined on a torsion scale accurate to 1 mg. Before weighing, the organisms were dried on filter paper for one minute. Afterward, specific biomass per square meter was calculated based on the capture area of the sampler and rounded to 0.01 g. The average biomass error was determined with the same degree of accuracy. The population density of organisms per square meter was also calculated and rounded to the nearest whole number.

For colonial animals (*Hydroidea, Bryozoa, Spongia*), the number of individual colonies was counted; when it was not possible to determine the number of colonies without ambiguity (presence of fragments of colonies, aggregation of colonies, etc.), the number was indicated by a question mark "?" in the table. Taxonomic processing of the sample collections was performed by qualified expert taxonomists[2] with many years' experience with the animal group in question. In a case where the species was represented by juvenile individuals (young without clear taxonomic features), i.e., it was not possible to identify the

[2] The following associates of the IBM DVO RAN, the DVGU and the Zoological Institute of the Russian Academy of Sciences (ZIN RAN) took part in the taxonomic processing of the main groups: Candidate of Biological Sciences L. L. Budnikova (Amphipoda), Candidate of Biological Sciences M. V. Malyutina (Isopoda), Candidate of Biological Sciences G. M. Kamenev (bivalve mollusks), Candidate of Biological Sciences V. V. Gulbin (gastropods), Candidate of Biological Sciences E. V. Bagaveyeva (marine worms), Candidate of Biological Sciences S. F. Chaplygina (hydroids), Candidate of Biological Sciences V. N. Romanov (Ascidia), Candidate of Biological Sciences A. V. Chernyshev (nemertines) and doctor of biological sciences V. S. Levin (Apoda).

species, the designation *sp. juv.* was used for the taxon name. It was impossible to identify the species in some cases due to severe damage; in that case, the designation *sp.* was used for the taxon name.

The index "frequency of occurrence of the species" (P, %) – the ratio of the number of quantitative samples in which the species was encountered to the total number of quantitative samples in the area, expressed as a percentage – was used to assess the rate of occurrence (incidence) of species in the sandy bottom sediment. This index is important primarily as a characteristic of food organisms, since it characterizes their availability to the consuming species.

Traditional single-factor methods as well as the methods of multidimensional statistical analysis, including classification and ordination methods (Afifi and Eyzen, 1982) using the statistical software package Statistica 6.0 (Borovikov, 2001) and Primer v5 (Clarke and Gorley, 2001), were used to describe the communities. A tetragonal data matrix in the form of a list of benthic species for each station, with quantitative characteristics of the species, served as the primary basis for the analysis. The Bray-Curtis similarity coefficient for each pair of samples was calculated based on the data matrix. Dendrograms were constructed by the mean-link method (Clarke and Green, 1988; UNEP; 1995). Quantitative characteristics of benthos (abundance and biomass) normally have an empirical distribution that differs from the norm. Therefore, in comparison of samplings using parametric criteria, the source data were transformed based on the nature of the empirical distribution (Elliott, 1977).

The entropic index of sorting of sediments was used to assess the classification of bottom sediment soils. The *entropic index of sorting* of sediments (H_s) was calculated based on the Shannon-Wiener Species Diversity Index (H) by the formula: $H_s = -\sum p_i \times (\ln p_i)$, where p_i is the proportion of the i fraction in the sediment; and n is the number of fractions in the analysis. This measure is independent of the type of distribution function of sediment particles by sizes and is determined solely by the divisibility of the particle size distribution analysis and the fraction size scale selected. The *normalized sorting index* (H_s/H_{max}, where $H_{max} = \ln n$) takes on a value from 0 (ideally graded sediments) to 1 (absolutely nongraded).

For plotting charts of the distribution of the characteristics of bottom sediments and the water column, concentrations of contaminants and indices of quantitative abundance of macrobenthos, standard procedures of the SURFER 7 cartographic system (Surface Mapping System) were used. The cartographic system was used only for illustrating the general nature of the distribution of parameters in the water area studied. Therefore, the “simple planar surface” version of the polynomial regression method was used in calculating isolines. This method produces good results when large-scale trends in the spatial distribution of data need to be identified. The ideology of the method has been described in detail (Draper and Smith, 1981). On the whole, the procedure for taking, processing and analyzing samples was consistent with generally accepted methods (Bilyard and Becker, 1987).

RESULTS AND DISCUSSION

3. Characteristics of Water Column and Bottom Sediments

3.1. Distribution of Water Temperature and Salinity during the Study Period

The water surface layer temperature and salinity were measured in the waters studied during the period from 4 August to 30 September 2004. The water temperature and salinity measurement results from individual stations are presented in Appendix 2, the spatial distribution of water temperature fields in the Piltun and Offshore areas is shown in Fig. 2, and the water salinity distribution is shown in Fig. P1.3.

Water temperature. During the study period, the temperature of the water surface layer in the Piltun Area varied to a significant degree: from 5.1 °C in August to 10.7 °C in September (Table 4). It was observed during analysis of the materials from 2003 that there was a statistically significant difference in the water temperature in August 2003 and 2001 (Fadeev, 2004). The water temperature was lower in September 2003 than during the analogous period in 2002. The water temperature in the area was 8.78±0.8°C in August 2001 and 4.01±0.82 °C in August 2003. It is possible that the lower temperatures in 2003 were associated with features of the ice conditions that year. The water temperature in August 2004 was significantly higher than in August 2003 (7.48±0.6 °C compared to 4.01±0.82 °C, respectively).

Table 4. Water surface layer temperatures (°C) in 2004 and 2003.

Parameter	Piltun Area					Offshore Area		
	Aug 2004	**Sep 2004**	Jul 2003	Aug 2003	Sep 2003	**Aug 2004**	Aug 2003	Sep 2003
Average	**7.48**	**8.58**	2.96	4.01	9.87	**10.15**	7.95	11.38
Standard deviation	**0.6**	**0.1**	0.3	0.82	0.32	**0.23**	0.27	0.12
Minimum	**5.1**	**7.7**	0.4	0.6	8.2	**6.7**	4.5	10.2
Maximum	**9.2**	**10.7**	7.2	14.1	11	**12.4**	12.2	12.5
Observations	**43**	**66**	38	24	11	**32**	40	35

A spot of colder water was observed in the northern part of the Piltun Area in 2001-2003, which could have been caused by a persistent upwelling of deep waters in the area (Krasavtsev et al., 2000). The average water temperatures were similar in September 2004 and 2003 (Table 4). The temperature of the surface water layer in the Offshore Area did not differ substantially from the data from 2003. The distributions of temperature and salinity were more regular than in the Piltun Area (Figures 2 and P1.3).

A detailed analysis was performed within the seasonal dynamics of water temperature and salinity in September 2004 in the study area by associates of the Pacific Oceanographic Institute (POI) of the DVO RAN (Rutenko, 2005). It was established that temperature and salinity characteristics of the water along Piltun in August and September differ substantially (Fig. 2A). The average characteristics for August:

1. The temperature in the relatively mixed near-shore zone is 5.5 – 8 °C, and the salinity is 28 – 30 psu. The waters of the shelf water mass are within the 20-meter isobath.
2. A section with depths of 20 – 30 m occupies the shelf front, with a sharper temperature differential of 1 – 8.4 °C and a salinity differential of 28 – 31.5 psu.
3. Beyond the 30-meter isobath is the impact zone of the water masses of the Sea of Okhotsk, with a temperature of 0.5 – 8.6 °C and salinity of 28.7 – 32.6 psu.

The average characteristics for September:

1. The temperature of the shelf waters is 7.7 – 9.4 °C, and the salinity is 29.55 – 29.95 psu as far as the 20-meter isobath, with values of 6.3 – 9.2 °C and 30 – 31.2 psu as far as the 30-meter isobath. Hence, there was an increase in the area occupied by shelf water masses in September. The reason was intensification of wind activity, which resulted in significant mixing and the formation of a thick upper quasihomogeneous layer (UQL). In addition, due to the intensification of Ekman transfer of waters of the UQL away from shore, upwelling intensified, leading to the penetration of the littoral shelf by water from the Sea of Okhotsk at levels near the bottom.
2. Accordingly, the shelf front moved toward the 40-meter isobath, and the area occupied by the marine water structure decreased. The range of average temperatures of this structure is 3 – 9.2 °C, and average salinity range is 30.2 – 32.3 psu.

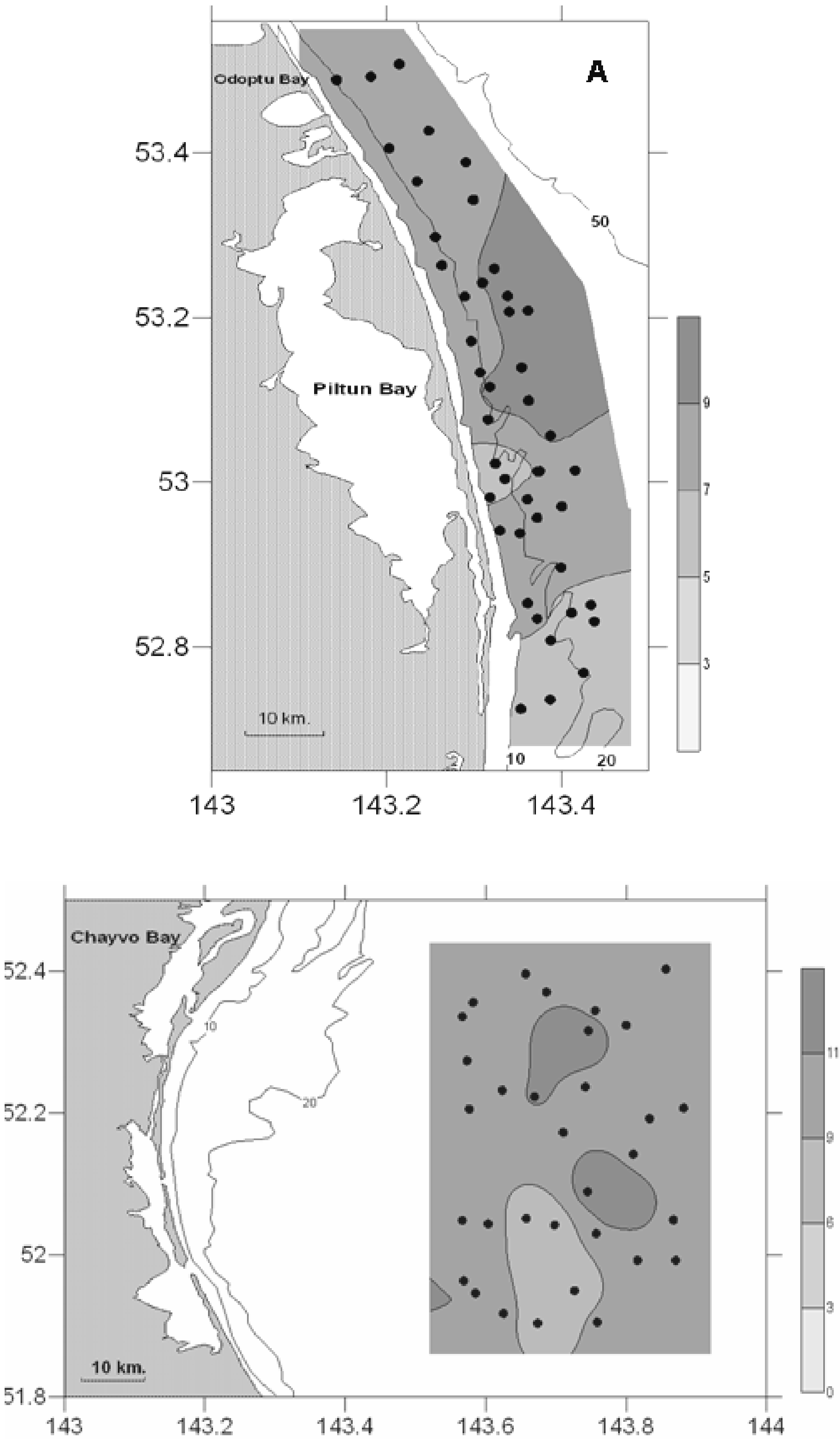


Figure 2. Water temperature distribution (T° C) of the surface water layer in the Piltun (A) and Offshore (B) areas in September 2004.

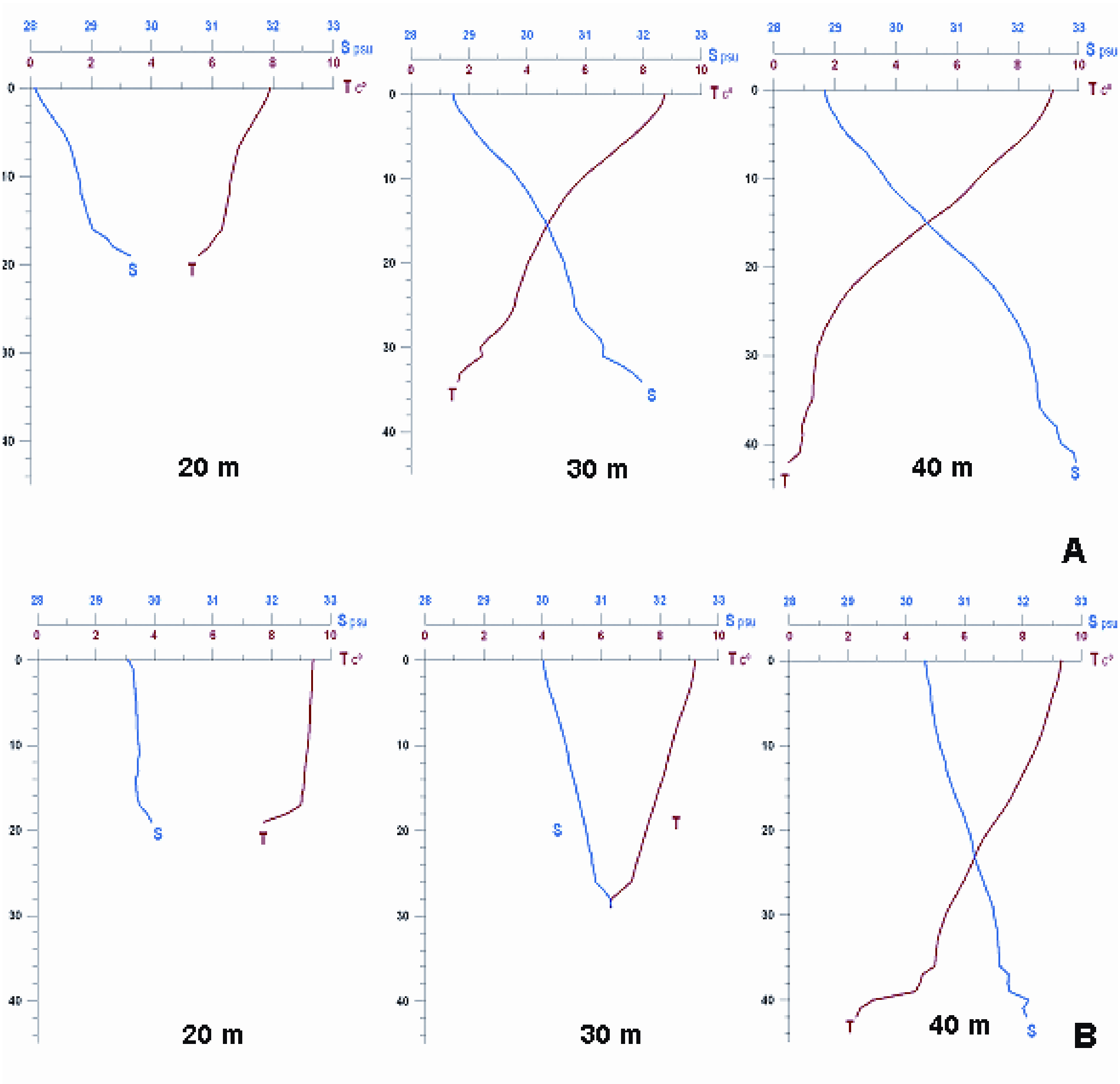


Figure. 2A. Vertical temperature and salinity profiles averaged for August (A) and September (B) as far as 20-, 30- and 40-meter isobaths (per Rutenko, 2005).

3.2. Particle Size Distribution of Bottom Sediments in the Areas

The particle size distribution of bottom sediments was studied based on laboratory analyses of 145 soil samples taken at benthos stations and whale feeding sites. The grain size distribution of the sea bottom is given in Appendix 2 (Table P2.2). The distribution of the main bottom sediment fractions (coarse aleurite and sand: fine, medium and coarse, and small gravel) is shown in Figures 4-6 for the Piltun Area and Figures 8-10 for the Offshore Area. Figures 3 and 7 show the distribution of depths in the Piltun and Offshore areas according to the data from stations in these areas.

A sharp prevalence of sandy (psammite) fractions at most of the stations is characteristic of the bottom sediments throughout the area. Of 145 stations in all areas, sands (fine – 55%; medium – 12%) are prevalent at 80% of the stations, and gravel-pebble bottoms mixed with sands of various grain sizes account for 16%. The proportion of the fine sand fraction is in excess of 60% at most of the stations.

Piltun Area. In the process of describing the distribution of soils according to field data from 2001-2003, it was observed that fine sandy bottoms are prevalent at depths up to 10-15 m throughout the area. As the depth increases, they are replaced by medium and coarse sands and gravel-pebble bottom areas mixed with sands of various grain sizes (Fadeev 2002, 2003, 2004).

According to data of the 2004 expedition, fine sands were prevalent at 52% of the stations in this area, and medium sands were prevalent at 27% of the stations. Gravel-pebble bottoms, often mixed with sands of various grain sizes, are encountered in patches at depths greater than 15-20 m (Figure 4). The highest proportion (more than 30%) of the aleurite-pelite fraction in the sea bottom is observed in a local area at depths greater than 20 m in the channel areas of the Piltun Lagoon. The active hydrodynamics of the area probably promotes the transfer of fine soil fractions to greater depths. The effect of lagoons on the accumulation of aleurite-pelite fractions can be seen in two areas: off Odoptu Bay and Piltun Bay (Figure 6). A similar trend was observed in the data from 2001-2003.

Offshore Area. The depths in the Offshore Area increase smoothly from 20 to 50 m (Figure 7). The proportion of the fine sand fraction in the sea bottom increases with depth (Figure 10D). On the whole, fine sands were prevalent at 85% of the stations in the Offshore Area. Gravel bottoms and coarse-grained sand have a patchy distribution (Figures 8 and 9).

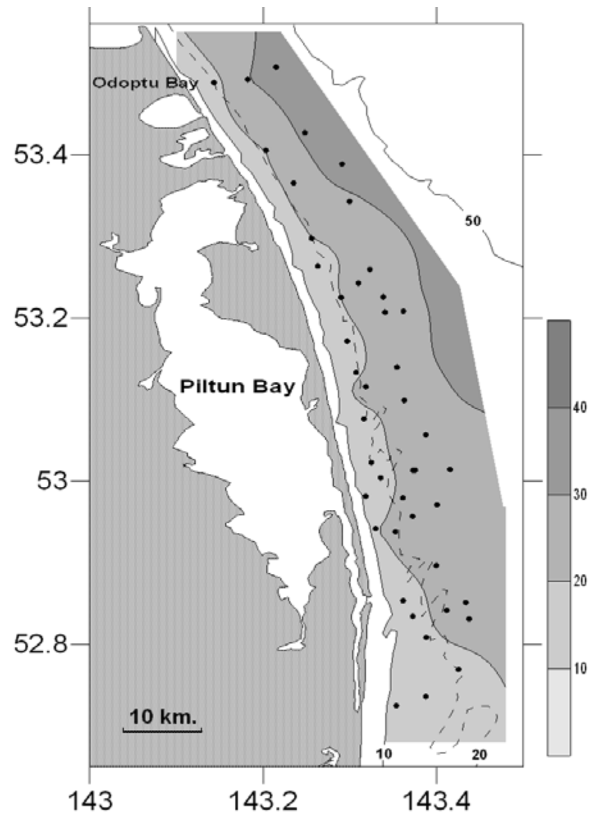


Figure 3. Distribution of depths (m) in the Piltun Area.

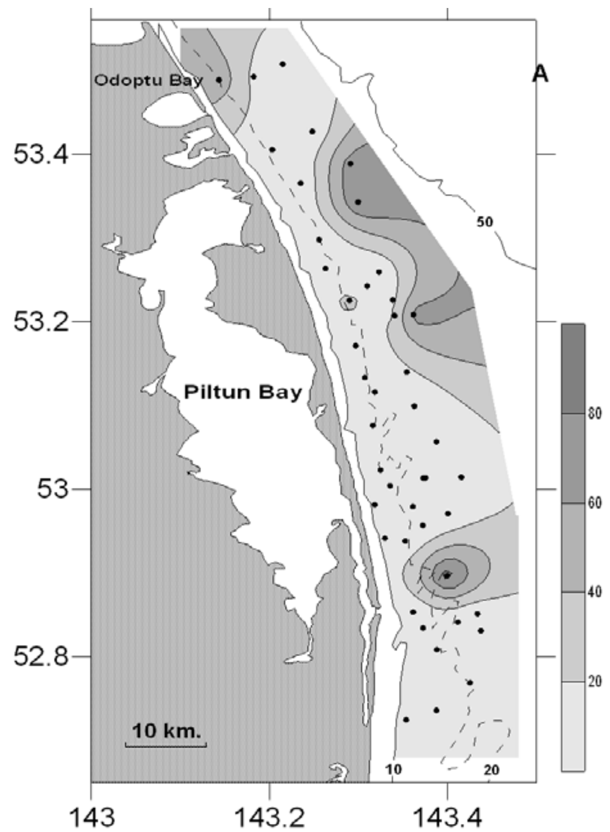


Figure 4. Distribution of bottom sediment fractions (% of dry sediment weight) in the Piltun Area: gravel-pebble fraction (A; > 1 mm).

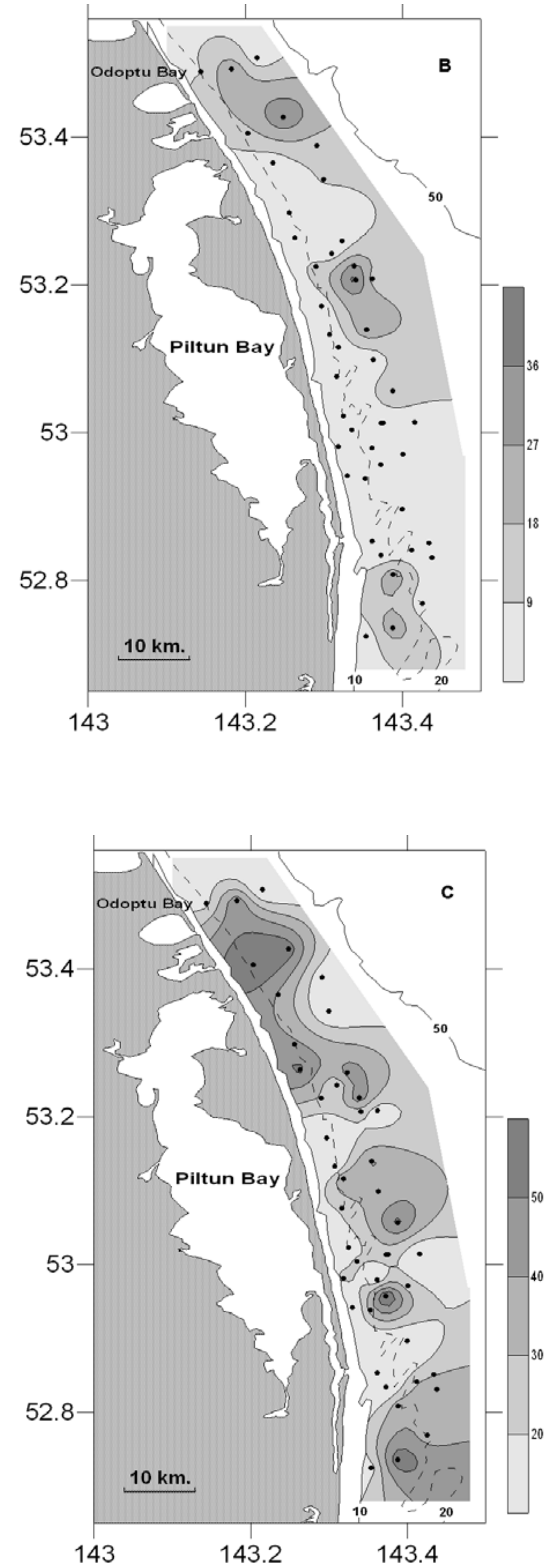


Figure 5. Distribution of bottom sediment fractions (% of dry sediment weight) in the Piltun Area: coarse sand (B; 0.5 – 1 mm); medium sand (C; 0.25 – 0.5 mm).

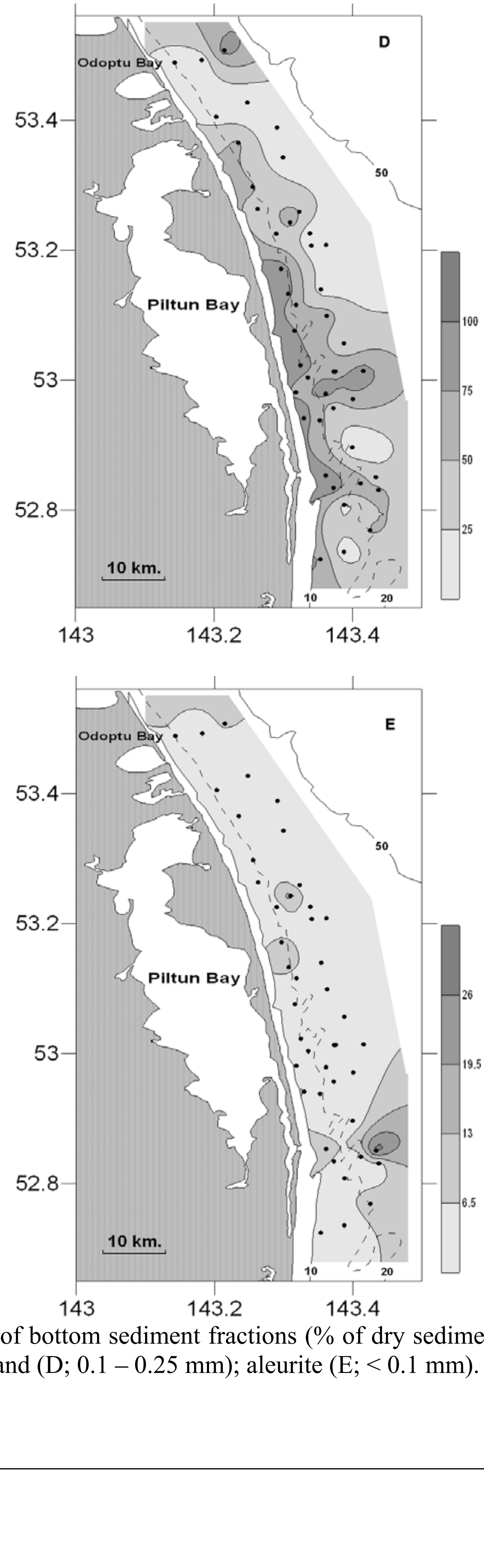


Figure 6. Distribution of bottom sediment fractions (% of dry sediment weight) in the Piltun Area: fine sand (D; 0.1 – 0.25 mm); aleurite (E; < 0.1 mm).

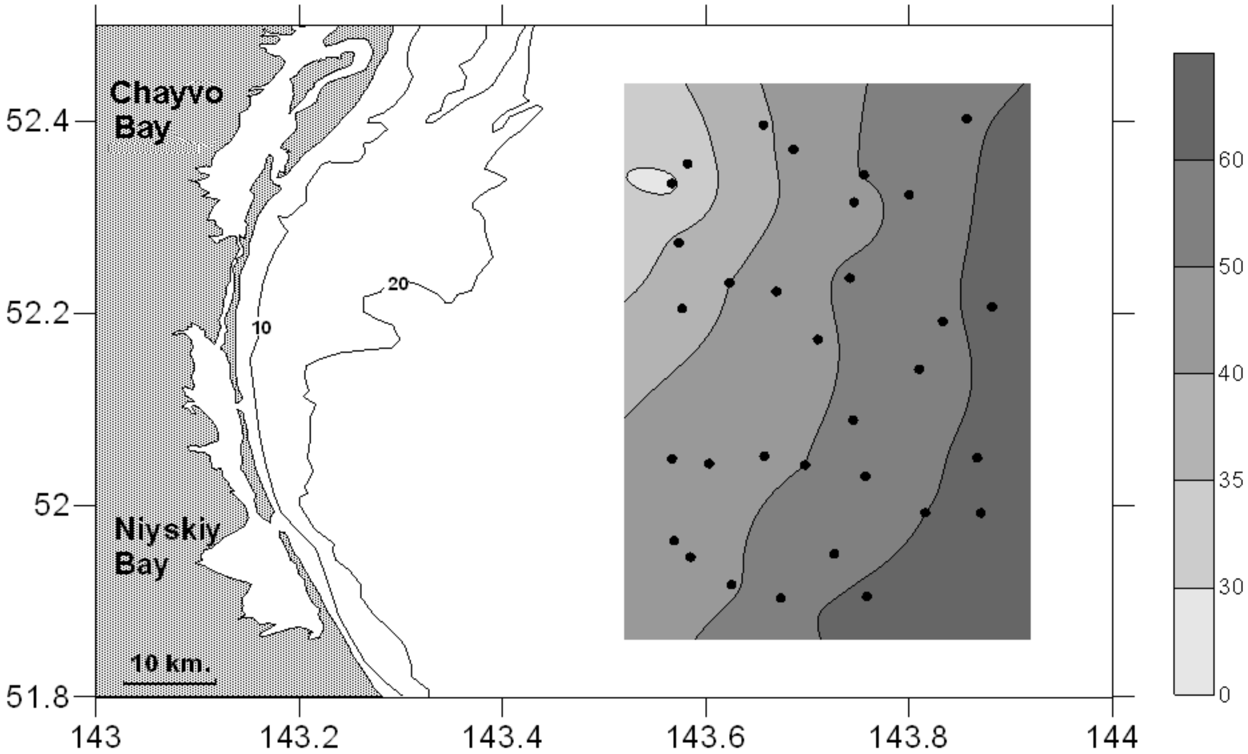


Figure 7. Distribution of depths (m) in the Offshore Area.

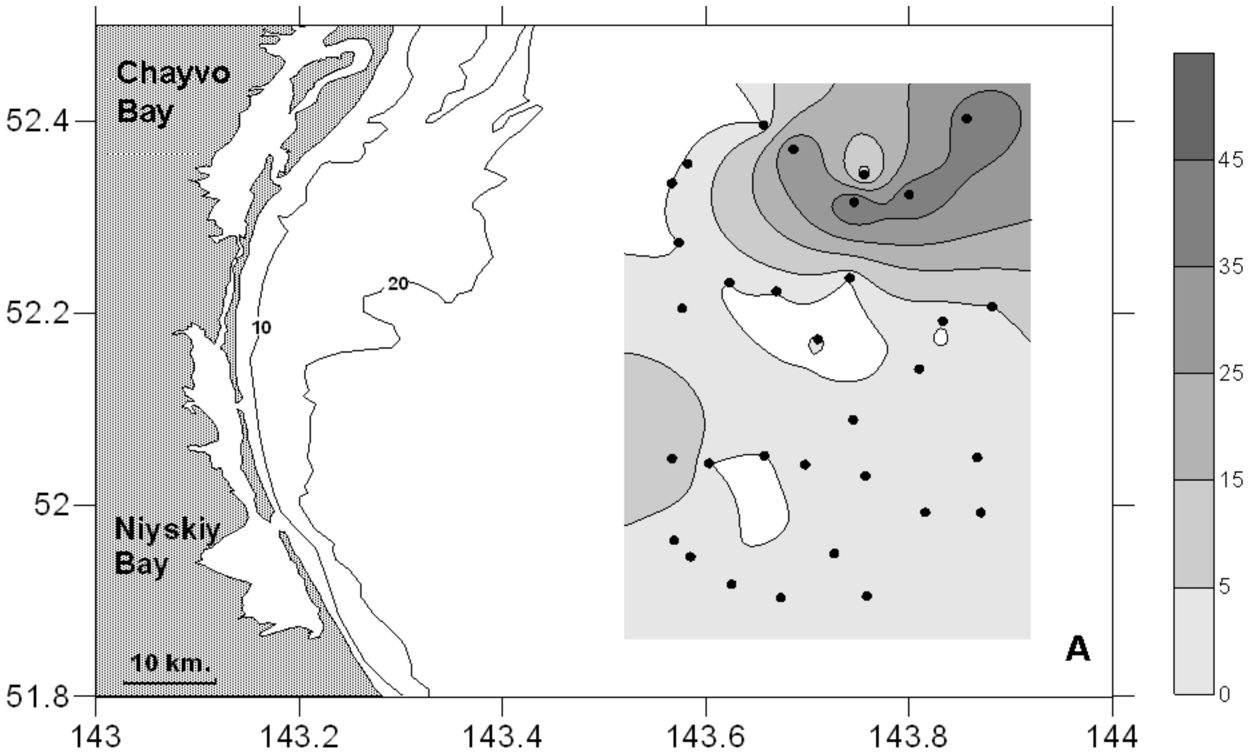


Figure 8. Distribution of bottom sediment fractions (% of dry sediment weight) in the Offshore Area: gravel-pebble fraction (A; > 1 mm).

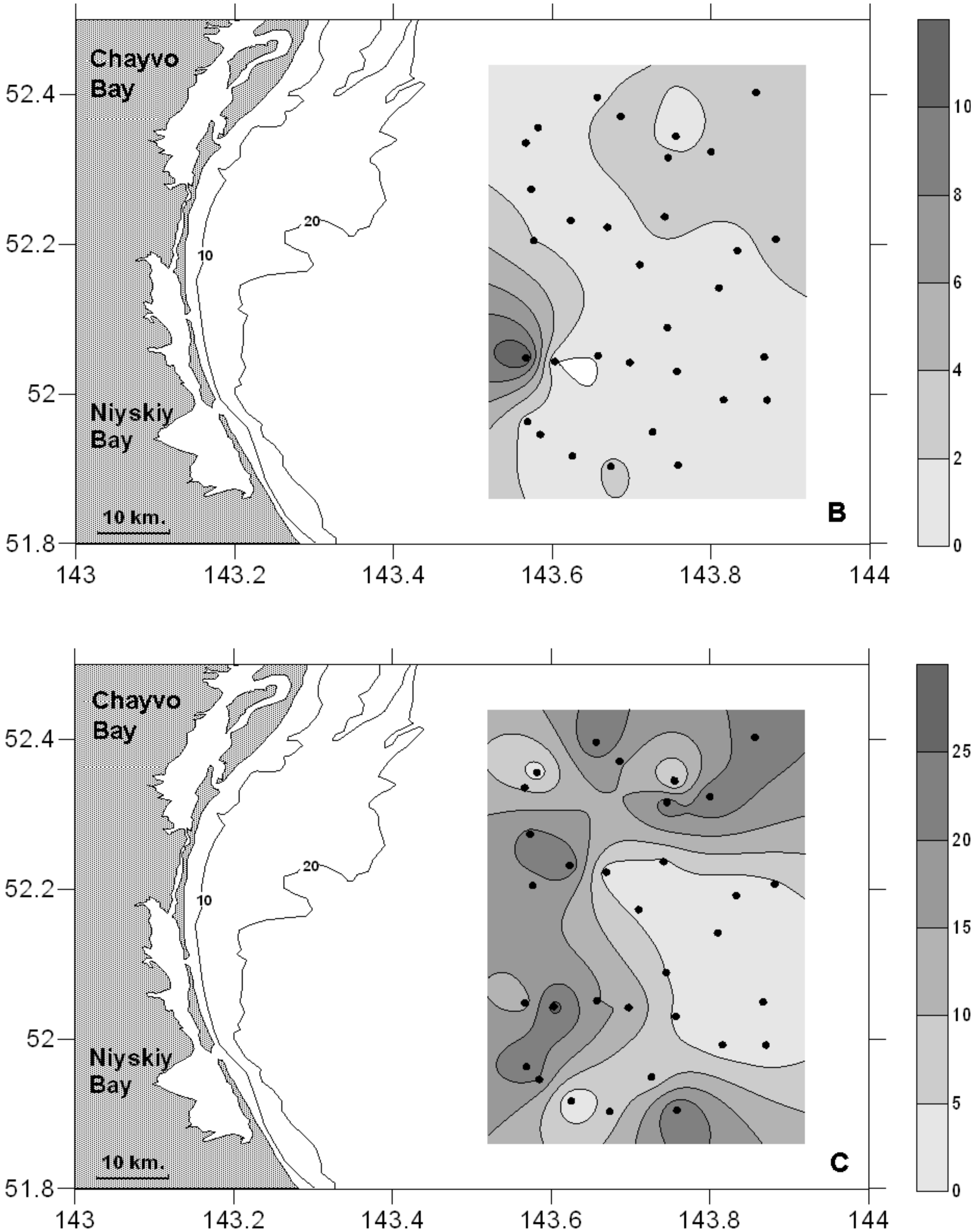


Figure 9. Distribution of bottom sediment fractions (% of dry sediment weight) in the Offshore Area: coarse sand (B; 0.5 – 1 mm); medium sand (C; 0.25 – 0.5 mm).

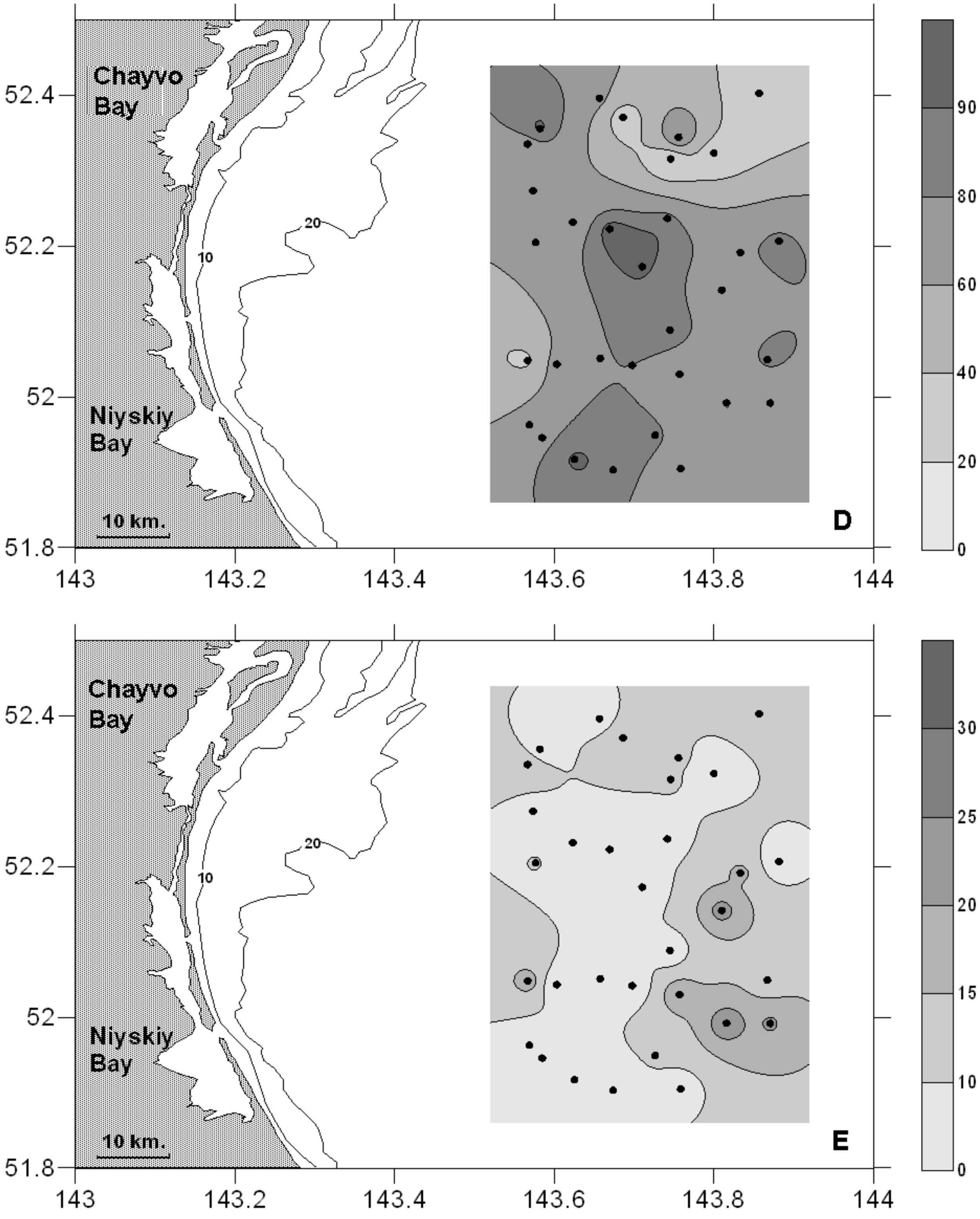


Figure 10. Distribution of bottom sediment fractions (% of dry sediment weight) in the Offshore Area: fine sand (D; 0.1 – 0.25 mm); aleurite (E; < 0.1 mm).

3.3. Classification of Stations According to Similarity of Particle Size Distribution

Data on the 10-fraction compositions of bottom sediments at stations in the Piltun and Offshore areas and at whale feeding sites have been grouped (classified) by cluster analysis procedures (Ward's clustering method, Euclidean distance). Dendrograms are shown in Fig. 11.

It follows from the dendrograms that three to four groups of stations can be distinguished in all areas based on similarity of particle size distribution – A, B, C and D. Table 5 gives averaged characteristics for each of the sediment groups for the Piltun and Offshore areas based on data from 2004 and 2001-2003.

Group A in all areas is made up of stations with a sharp prevalence of the 0.1-0.25 mm fraction (fine sand) in the sediment. According to 2001-2003 data, the proportion of this fraction varies from 75.5 to 89.5% of dry sediment weight in sediments of the Piltun Area. The normalized entropic index of sorting is 0.43 (ideally graded sediment has an index of 0). The average depth of occurrence of sediments of this group in the Piltun Area is 19 m.

Group B includes stations where medium-grained sand is prevalent in the bottom, mixed with up to 20% coarse sand. The value of the entropic index of sorting varies from 0.6 to 0.68. The average depth of the sediments of this group in the Piltun Area is 20.4 m.

Group C is made up of stations without clear dominance of any of the fractions. The bottom is a gravel fraction mixed with sand fractions. Fractions of 0.5-1.0 mm (coarse sand) and 1.0-2.0 mm (small gravel) have the highest values. The entropic index of sorting varies from 0.6 to 0.68 (absolutely nongraded sediment has a value of 1). The average depth of the stations of this sediment group in the Piltun Area is 26 m.

Hence ***group A*** corresponds to well-sorted fine-grained sands, ***group B*** to medium-sorted sands of varying grain size (a mixture of fine and medium sands), and ***group C*** corresponds to poorly sorted gravel bottoms mixed with sands of varying grain size, pebbles and exposed detritus. The composition of the sediment groups in the Piltun Area described according to 2004 data matches the results of bottom sediment analysis based on the materials of the 2001-2003 studies well (Table 5). Based on 2004 data, a fourth group, ***group D***, in addition to ***groups A-C***, has been distinguished in the Offshore Area (Figure 11.3, Table 5). The group includes stations where fine sand is prevalent, mixed with a significant amount of the aleurite fraction (28%).

Table 5. Characteristics of sediment groups in Piltun and Offshore areas.

Sediment groups	Sediment fractions						H_s	H_s/H_{max}	Code
	Peb	Gr	Sc	Sm	Sf	A+Pe			
Piltun Area according to data of 2004									
A	0	0.52	1.56	19.6	**72.89**	5.45	0.75	0.43	Sf
B	0.00	10.69	20.65	**56.76**	7.82	4.08	1.21	0.67	Smc
C	8.56	49.16	24.08	10.16	5.00	3.04	1.29	0.69	Gr+Scm
Piltun Area according to data of 2003 (Fadeev, 2004)									
A	0.83	1.98	2.12	10.93	**75.48**	8.66	0.81	0.42	Sf
B	0	4.81	13.61	**63.85**	17.12	0.6	1.5	0.64	Sm+Sf
C	5.01	44.3	20.28	16.8	11.88	1.74	2.16	0.84	Gr+Scmf
Offshore Piltun Area according to data of 2002 (Fadeev, 2003)									
A	0.39	1.21	0.77	11.41	**84.52**	1.7	0.82	0.32	Sf
B	0.26	8.11	9.64	**47.81**	32.64	1.54	1.77	0.68	Sm+Sf
C	1.05	37.28	14.81	17.49	25.96	3.41	2.12	0.82	Gr+Sfmc
Piltun Area according to data of 2001 (Fadeev, 2002)									
A	0	1	0.8	5.9	**89.5**	2.8	0.65	0.28	Sf
B	0.2	3.4	5.6	40.8	**48.4**	1.6	1.55	0.6	Sf+Sm
C	9.7	46.8	18.8	12	8.9	3.9	2.15	0.83	Gr+Scm
Offshore Area according to data of 2004									
A	0.00	0.65	1.32	3.68	**88.14**	6.21	0.5	0.33	Sf
B	0.00	0.29	1.06	21.41	**71.22**	6.02	0.8	0.45	Sf+Sm
C	7.40	28.06	5.08	19.76	25.14	14.56	1.65	0.87	Gr+Sf
D	0.00	0.35	0.55	3.30	**67.60**	28.20	0.78	0.44	Sf+A
Offshore Area according to data of 2003 (Fadeev, 2004)									
A	0	0.31	0.31	3.32	**90**	6.06	0.6	0.26	Sf
B	0	0.05	0.75	33.65	**64.7**	0.85	1.05	0.45	Sf+Sm
C	3	**50.6**	20.35	20.05	5.55	0.45	1.85	0.71	Gr+Scm
D	0.18	0.38	0.44	1.81	**72.75**	24.43	1.02	0.39	Sf+A
Offshore Area according to data of 2002 (Fadeev, 2003)									
A	0.71	2.74	2.4	15.65	**75.4**	3.1	1.2	0.47	Sf
B	0.31	3.49	5.41	**52.03**	37.55	1.21	1.52	0.59	Sm+Sf
C	0.44	18.49	21.83	36.69	20.66	1.89	2.07	0.86	Gr+Scmf

Notes to Tables 5 and 6: for abbreviations of sediment fractions, see Table 3. H_s is the entropic index of sorting of bottom sediments, and H_s/H_{max} is the normalized entropic index of sorting. **Boldface** indicates the dominant bottom fractions; values for fractions that make up the bottom base, in the absence of dominant bottom fractions, are **shaded**.

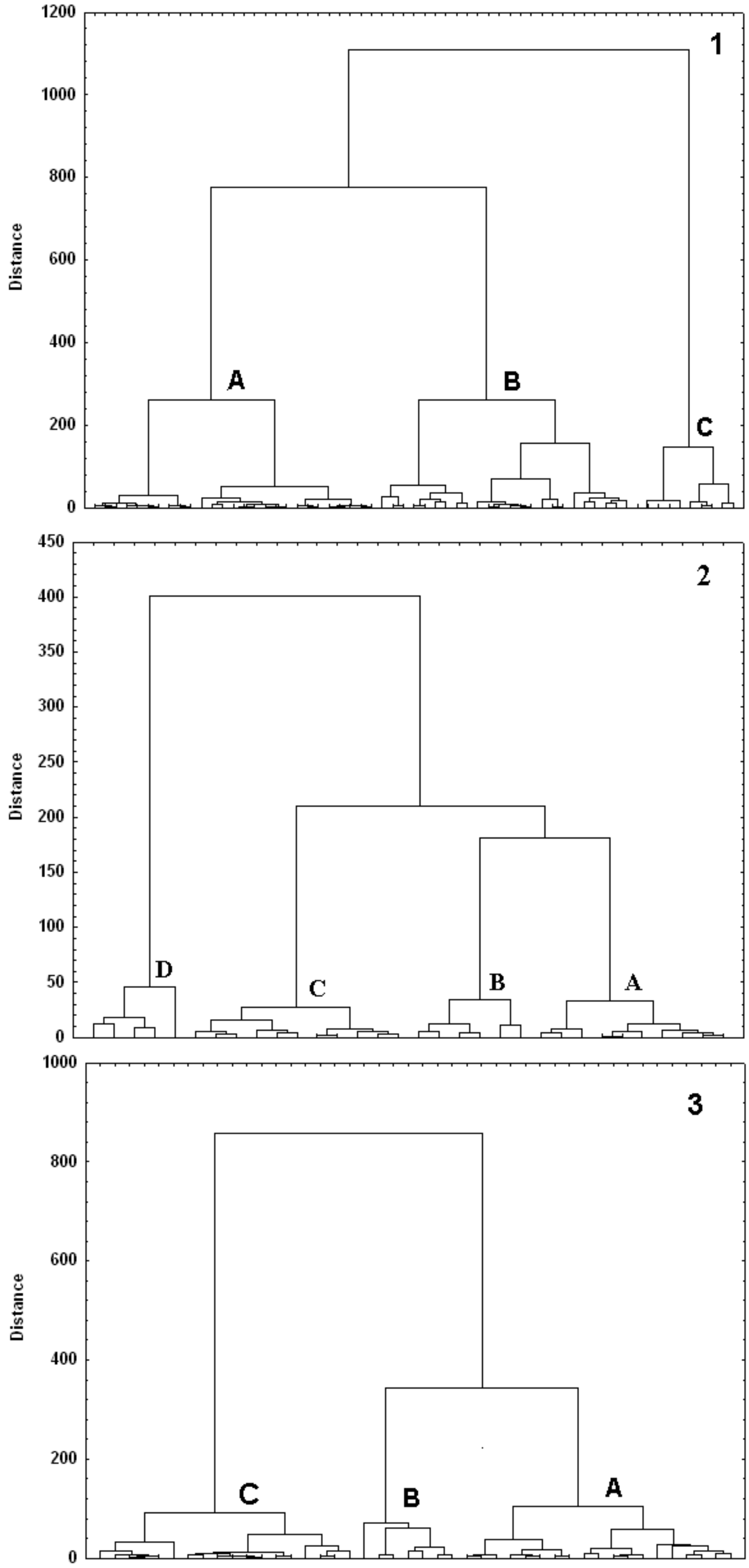


Figure 11. Classification of stations according to the 10-fraction sediment composition in the areas.

1 – Piltun Area;
2 – Offshore Area;
3 – Stations at gray whale feeding sites;
A, B, C – sediment groups.

3.4. Particle Size Distribution of Bottom Sediments at Gray Whale Feeding Sites

The sediment composition at gray whale feeding sites in the Piltun and Offshore areas was considered based on data from 2001-2003 (Fadeev, 2002, 2003, 2004). Bottom sediments were sampled at nine gray whale feeding sites in the Piltun Bay area in 2001. The average depth of the feeding sites was 9±0.9 m. Analysis indicated that the bottoms at the feeding sites were fine-grained sands in all cases (proportion of the fraction of 0.1-0.25 mm, from 73.95 to 94.34%); i.e., the bottoms are classified as *group A*.

In 2002, bottom sediments were sampled at 46 whale feeding sites in the Piltun Area (21 stations; average depth 12±0.7 m) and the Offshore Area (25 stations; average depth 41±0.9 m). Sandy bottoms were prevalent at all the feeding sites in the Piltun Area. Fine-grained sands were prevalent at 53% of the stations, medium sands at 38%, and a mixture of fine and medium sands was observed at 9% of the stations. Sandy bottoms were also prevalent at the whale feeding sites in the Offshore Area. Medium sands and a mixture of fine and medium sands were prevalent at 36% of the stations, and 12% of the stations had fine and coarse sands (Fadeev, 2003). In 2003, bottom sediment samples were taken at 51 whale feeding sites in the Piltun (12 stations; average depth 18.6±1.6 m) and Offshore areas (39 stations; average depth 50.8±0.9 m). Well-sorted fine sands (*sediment group A*) were prevalent at all gray whale feeding sites in both areas. About 15% of the whale feeding sites had medium-sorted mixed sandy bottoms (medium and fine sands). A small number of whale feeding sites in the Offshore Area had a fine sandy bottom mixed with aleurite fraction (up to 25%) (*sediment group D*).

Most of the whale feeding sites in 2004 were in the Piltun Area. Only two feeding whales were observed in the Offshore Area. Most of the whales in 2004, as in 2002 and 2003, fed in the Piltun Area, in a zone of fine- and medium-grained bottoms.

Table 6. Characteristics of sediment groups at whale feeding sites.

Sediment groups	Sediment fractions						H_s	H_s/H_{max}	Code
	Peb	Gr	Sc	Sm	Sf	A+Pe			
Whale feeding sites (2004 stations)									
A	0	0.85	2.17	13.77	75.49	7.72	0.81	0.45	Sf
B	0	2.25	10.51	**57.43**	28.54	1.27	1.05	0.57	Sm
C	1.14	15.33	15.51	38.18	27.52	2.32	1.44	0.7	Smfc+Gr
Whale feeding sites (2003: Fadeev, 2004)									
A	0.85	1.07	1.48	4.62	**85.02**	6.96	0.87	0.38	Sf
B	0.34	1.28	3.37	22.91	**66.61**	5.49	1.37	0.59	Sf+Sm
C	0	6.58	18.7	**59.47**	14.73	0.52	1.61	0.69	Sm+Scf
D	0	0.16	0.27	1.63	**73.00**	24.94	0.97	0.42	Sf+APe

3.5. Concentrations of Petroleum Hydrocarbons, Heavy Metals and Organochlorine Pesticides (OCP)

Assessment of the concentrations of high-priority pollutants – petroleum hydrocarbons, heavy metals and organochlorine pesticides – in the sea bottom of the gray whale feeding area is important from the point of view of the impact of pollution on both gray whale food resources (the accumulation of toxic substances in prey tissues) and the habitat conditions in the feeding area. The first studies of the distribution of pollutants in the Piltun Area were performed based on data from diving work in 2001. During field work in 2001, 30 bottom sediment samples were collected on 10 transects (at depths of 5–10–20 m), i.e., in the zone of most intense feeding of the whales, to assess the concentrations of petroleum hydrocarbons and 10 heavy metals (copper, aluminum, arsenic, barium, cadmium, chromium, iron, mercury, lead and zinc). At 10 stations in the gray whale habitat in the Piltun Bay – Odoptu Bay area, 10 bottom sediment samples were taken to determine the OCP concentration. It was established that during the study period in 2001, the main pollutants had low concentrations and were distributed relatively evenly in the study waters; i.e., no significant effect of pollutants on benthos was observed (Fadeev, 2002).

In 2004, 50 bottom sediment samples were collected for analysis of the concentrations of petroleum hydrocarbons and 10 heavy metals in the Piltun (43 samples) and Offshore areas (17 samples). Samples were taken at 2001 sampling points on three transects to assess possible year-to-year changes in the pollutant distribution. In the Piltun Area, seven samples were taken at depths of 10-15 m to study the concentration of organochlorine pesticides in the bottom sediments. Samples were taken in the same depth range in 2001.

Petroleum hydrocarbons. Appendix 4 and Table 9 give data on the concentration of petroleum hydrocarbons in the bottom sediments of the Near-Shore and Offshore areas. The petroleum hydrocarbon concentration at stations of the Piltun Area varied from 0.3 to 5.3 μg/g of dry sediment weight and averaged 2.5±0.1 μg/g of dry sediment weight, which is less than the natural background values of the petroleum hydrocarbon concentration at greater depths. The spatial distribution of petroleum hydrocarbons is shown in Figure 12. The lower petroleum hydrocarbon concentrations in the Piltun Area are associated with the Near-Shore zone. In the Offshore Area, while a low petroleum hydrocarbon concentration is preserved, some increase in the petroleum hydrocarbon concentration is observed in the northern part of the area.

Organochlorine pesticides. Chlorinated hydrocarbons get into the waters off northeastern Sakhalin with the Amur River flow and are entrained from the waters of coastal lagoons. The presence of pesticides in the bottom deposits is a distinguishing feature of the northeast shelf of the Sea of Okhotsk. The data of Table 7 show that the DDT concentration and the total concentration of DDT and its metabolites in the bottom sediments vary only slightly and do not exceed the background levels for the northeastern Sakhalin area.

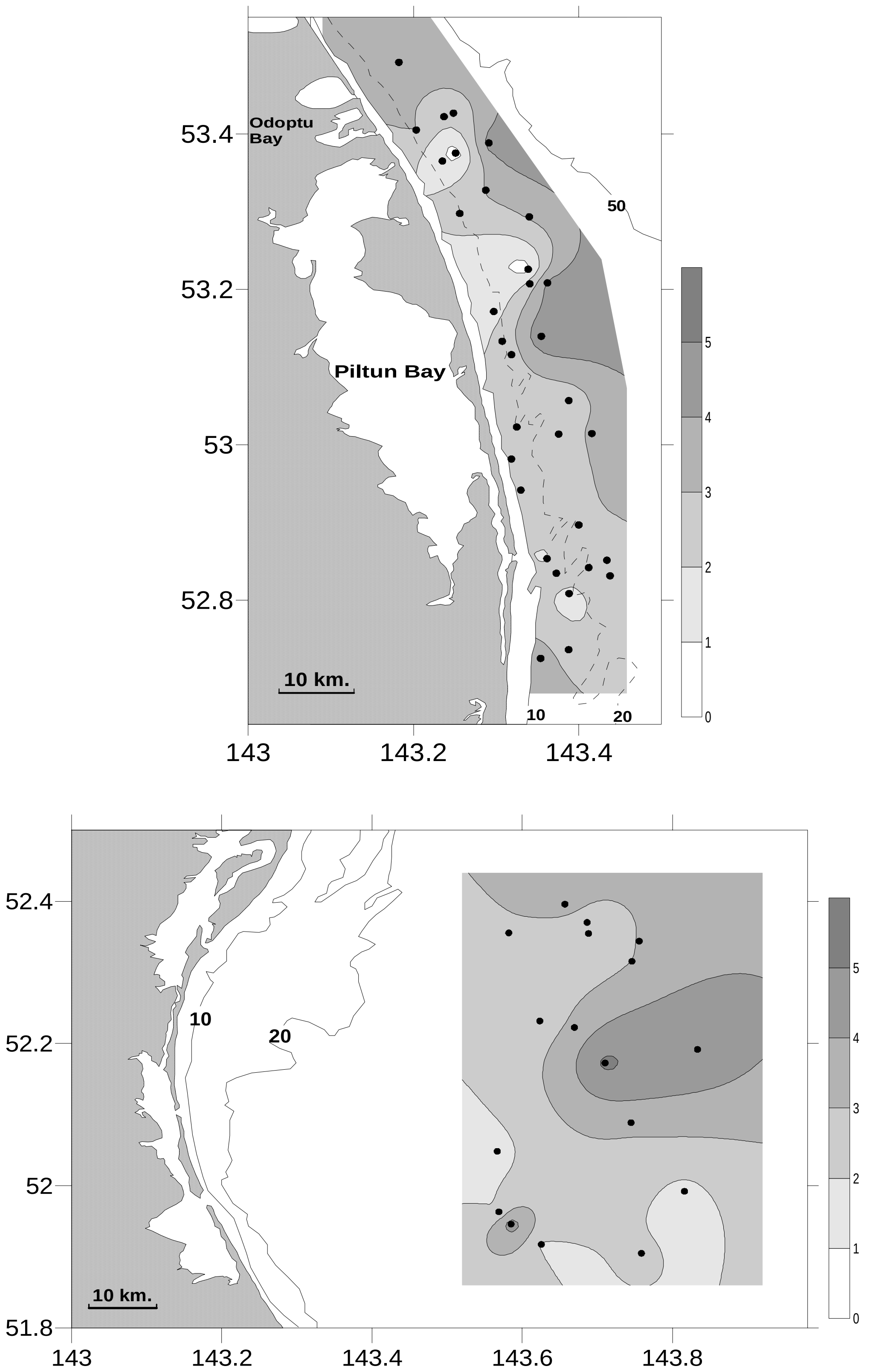


Figure 12. Distribution of petroleum hydrocarbon concentrations (μg/g) in bottom sediments in the Piltun and Offshore areas in 2004.

Table 7. Organochlorine pesticide concentrations (ng/g) in bottom sediments at 7 stations in the Piltun Area.

Station	Depth	DDT	DDE	DDD	**∑DDT**	α-HCH	γ-HCH	**∑HCH**
PIL-4	10	1	0.2	0.3	**1.5**	0.1	0.1	**0.2**
PIL-8	10	2.8	0.6	0.5	3.9	0.1	0.1	**0.2**
PIL-12	10	1.4	0.3	0.5	**2.2**	0	0.1	**0.1**
2-2N	15	1	0.3	0.4	**1.7**	0.1	0.2	**0.3**
2-3M	16	0.6	0.2	0.2	**1**	0	0.2	**0.2**
2-4M	15	1.3	0.2	0.2	**1.7**	0.3	0.1	**0.4**
4-1S	16	1.1	0.2	0.3	**1.6**	0.1	0.1	**0.2**

Heavy metals. We know that the heavy metal concentrations in bottom deposits of the seas and oceans depend on a large number of factors. Differences in concentration levels can be conditioned by the mineralogical composition and particle size distribution of the sea bottom. Sandy bottoms, for example, due to their lower sorption capacity, typically have lower concentrations of heavy metals than aleurite-pelite deposits. Hydrodynamic conditions, physical and chemical processes and biogenic sedimentation processes affect the accumulation and distribution of microelements. All these factors show up in the constant variation of the concentrations of many chemical elements in the surface layer of bottom deposits.

Results of the analysis of 60 sediment specimens for concentrations of 10 heavy metals (copper, aluminum, arsenic, barium, cadmium, chromium, iron, mercury, lead and zinc) are given in Appendix 4. The sediment specimens collected at depths of 3-10-20 m (30 samples) are distinguished by low concentrations of toxic heavy metals, which is consistent with the natural geochemical background of the area. Similar values of heavy metal concentrations were determined in the bottom deposits of different areas of the northeast shelf of the Sea of Okhotsk. In addition, the distribution of practically all heavy metals is characterized by minimum concentrations at depths up to 15-20 m, i.e., in the zone of the most intense feeding of gray whales.

Published data (Status of the Environment in the Piltun-Astokh Field Area 1996, 1997) on the heavy metal concentrations in the area of the Piltun – Astokh field (Table 8) fully confirm our conclusion concerning the low concentrations of heavy metals in the study area.

Table 8. Heavy metal concentrations in the area of the Piltun – Astokh field based on published data* and in the study area based on data from 2001 and 2004.

Elements	**Concentration, µg/g**			
	Published data	**PAC****	**2001**	**2004**
As (µg/g)	2.5 – 14.8	-	1.25 – 4.8	0.47 – 2.07
Ba (µg/g)	268 – 763	-	46.7 – 89.6	0.96 – 22.55
Cd (µg/g)	<0.01 – 0.13	4.2 – 9.6	0.001 – 0.006	0.001 – 0.3
Cr (µg/g)	0.6 – 121	160 – 370	1.32 – 8.91	1.61 – 37.35
Cu (µg/g)	0.6 – 6.7	108 – 270	0.23 – 1.46	0.26 – 6.6
Hg (µg/g)	0.001 – 0.047	–	0.013 – 0.125	0 – 0.025
Pb (µg/g)	5.1 – 19.5	112 – 218	0.17 – 0.39	0.001 – 6.4
Zn (µg/g)	3.1 – 29.1	271 – 410	2.0 – 7.18	0.88 – 37.6

Note: * - published data: Status . . ., 1996, 1997.
PAC** – probable active concentration of toxic metals (Belan 2001)

Table 9. Concentrations of DDT and its metabolites (∑DDT), α- and γ-isomers of hexachlorocyclohexane (∑HCH) and petroleum hydrocarbons in bottom sediments of different areas of the Gulf of Peter the Great (Sea of Japan) and the study area.

Area	**Petroleum hydrocarbons**, mg/g dry weight*	**∑HCH**, ng/g dry weight**	**∑DDT,** ng/g dry weight**
Zolotoi Rog Bay (Sea of Japan)	5.4–16.7	<0.2–5.5 (1.66)	0.8–22.7 (9.01)
Amur Bay (Sea of Japan)	0.03–2.72	<0.2–1.3 (0.58)	4.4–14.8 (7.59)
Ussuriysk Gulf (Sea of Japan)	0.03–0.25	<0.2–1.1 (0.32)	4.4–9.1 (6.01)
Piltun Area, 2001	0–0.03 (0.007)***	<0.1– 0.6 (0.29)***	1.3–4.8 (2.31)***
Piltun Area, 2003	0.004–0.016 (0.008)***	–	–
Piltun Area, 2004	0–0.005 (0.002)***	<0.1– 0.4 (0.23)***	1.0–3.9 (1.91)***
Offshore Area, 2004	0.002–0.005 (0.003)***	–	–

Note:
* According to: Belan, 2001 (data from 1986–1994; concentration range given);
** According to: Tkalin, 2001 (data from 1994; concentration range given with average values – in parentheses);
*** - our data.

Comparing the petroleum hydrocarbon and OCP concentrations in the study area to published data from the waters of Far East seas that have been studied most extensively is no less significant. It follows from the table that for all the pollutants considered, their maximum concentrations in the study area are in line with the minimum concentrations in the Gulf of Peter the Great (Sea of Japan).

Therefore, analysis of the concentrations and distribution of the main pollutants – petroleum hydrocarbons, heavy metals and organochlorine pesticides – in the bottom sediments of the water area studied makes it possible to conclude that no significant effect of pollutants on benthos was observed during the study period. These results might have been promoted by the active hydrodynamic conditions of the waters in question and the movement of waters of the eastern Sakhalin Current along the coast, which prevent the accumulation of pollutants in sandy sediment.

4. Benthos Composition and Quantitative Distribution in the Areas

In light of the fact that the areas in question differ considerably with regard to both environmental conditions and the nature of the bottom population, the benthos distribution is considered separately in each of the areas: Piltun and Offshore.

Benthos studies were performed in the Piltun Area in 2001-2003 and in the Offshore Area in 2002-2003. Diving surveys in 2001 indicated that the highest forage benthos biomass levels are observed in a zone immediately adjacent to the coast in the Piltun Area, at depths less than 15 m. Bottom grab collecting was performed from the ship on expeditions in 2002 and 2003, and no material could be obtained in the areas with the highest forage benthos biomass levels, in a depth range of 5-10 m.

4.1. Piltun Area

There were 60 stations within the area during the 2002 expedition at depths of 11 to 35 m (181 bottom grab samples, average depth 20.4±0.8 m). In 2003, there were 63 bottom grab sampling stations in the area at depths of 8 to 33 m (189 bottom grab samples, average collection depth 18.7±0.9 m). There were 10 stations that year in the range of 8-10 m.

There were a total of 64 bottom grab sampling stations in the Piltun Area in 2004: 51 stations with sampling from the ship in the range from 11 to 35 m, and 13 stations from a motor launch at depths from 3 to 10 m. The locations of the ship stations in 2004 coincided in most cases with the stations from 2003. A diagram of the locations of the stations is shown in Figure 13, and a combined map of the stations from 2002 and 2003 is shown in Figure P1.1 (Appendix 1).

The benthos distribution is considered below based on materials from field work in 2004 and 2001–2003 (Fadeev, 2002, 2003,2004).

4.1.1. Quantitative Abundance and Distribution of Benthos Based on Data from 2004 and 2001-2003

Total benthos biomass. Based on materials from 2001-2002, similar trends were noted in the distribution of total benthos biomass in the Piltun Area: an increase in total biomass with depth is observed throughout the area. The increase in total biomass with depth is defined by the course of biomass variation of a flat sea urchin, the sand dollar *Echinarachnius parma*; their proportion in the total biomass of the area is from 61 to 70% and increases to 85-95 % at depths of 25-30 m. The proportion of other groups in the total biomass is significantly lower: crustaceans – from 9 to 17%; bivalve mollusks – from 8 to 13%; isopods – 4-5%. The proportion of key forage benthos (amphipods, isopods) in the total biomass decreases with depth: from 40-59% at 5-15 m to 1-4% at 20-30 m (Fadeev, 2002, 2003).

According to materials from 2003, the average benthos biomass in the Piltun Area at depths of 8–30 m (minimum collection depth, 8 m) was 555.7±69.4 g/m^2 at a colony density of more than 6000 spec./m^2. The sand dollar *E. parma* accounts for the largest proportion (70%) in the benthos biomass. The proportion of sea urchins in the total benthos biomass increased as the depth increased, from 20% at 15 m to 95% at 25-30 m. The biomass of the main whale food component – amphipods – decreased from 146 g/m^2 (74% of the total benthos biomass) at a depth of 8-11 m to 9 g/m^2 (1.2%) in the range of 26-30 m. The sharpest changes in the quantitative abundance of benthos were observed in a range of 15 – 20 m (Fadeev, 2004).

Based on bottom grab collections in 2004, the average benthos biomass in the area was 501.2±93.8 g/m^2 and did not differ substantially from the data from 2003 (555.7±69.4 g/m^2). As in previous years, flat sea urchins account for the main proportion of biomass, at 75%, and the proportion of sea urchins at depths greater than 20 m reaches 85%. The quantitative abundance of the main forage benthos component – amphipods – decreased from 111 g/m^2 (48% of total benthos biomass) at depths of 11-15 m to 39 g/m^2 (5%) in the depth range of 26-30 m. Since the station locations were the same in most cases in 2004 and 2003 in the depth range of 11-30 m, one can conclude that no substantial changes were observed in total benthos biomass. The most substantial changes in total benthos biomass are seen at depths of 8-10 m. Benthos biomass in this range reached 202.5 g/m^2 in 2003 and 49.4 g/m^2 in 2004 (Table 10). Possible causes of the change will be considered in analysis of the distribution of the key macrobenthos groups.

Biomass of basic taxonomic groups and common species of benthos. Crustaceans (amphipods, isopods, decapod crustaceans and cumaceans), bivalve mollusks and marine worms are of the greatest interest for assessing food supplies for the diet of the gray whale in the water area studied.

Crustaceans (*Crustacea*). The main crustacean groups had high frequencies of occurrence in 2004 collections: amphipods – 100%; isopods – 60%; and cumaceans – 50%. Despite the high frequency of occurrence of crustaceans in the Piltun Area, their proportion in benthos biomass varies considerably within the water area and with the depth.

Based on materials from 2001-2003, the overall proportion of crustaceans in macrobenthos biomass in the Piltun Bay area was from 40 to 55% at depths of 5–10 m and only 3-10% at 26-30 m. Three types of crustacean biomass changes were observed with increasing depth. Amphipods and isopods had maximum biomass at 5-15 m; it decreased sharply at depths greater than 20 m. The change in cumacean biomass was in the opposite direction. It was at a minimum at depths less than 20 m and increased with depth. Decapod biomass was low at all depths and varied only slightly.

Table 10. Macrobenthos biomass distribution (g/m^2) in the Piltun Area based on materials of field studies in 2004 and 2003.

Groups	Depth										Entire Area	
	8-10 m		11-15 m		16-20 m		21-25 m		26-30 m			
	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003
Amphipoda	21.4	**146.6**	**111.2**	**88.7**	61.1	5.2	22.3	23.2	39.6	9.2	47.4±7.7	54.6±8.7
Isopoda	2.8	15.7	10.7	10.3	18.5	45.6	19.3	12.8	23.3	33	18.5±5.6	23.5±3.7
Bivalvia	19.8	27.9	39.3	21.9	22.4	56.8	16	13.7	19.2	120.8	23.1±4.1	48.2±11.9
Cumacea	0.2	1.3	1.1	1.7	0.1	0.1	0.1	4.2	2.5	2.5	1.1±0.4	2.1±0.9
Echinoidea	0	6.7	44.5	29.4	**161.3**	**684.1**	**489.1**	**718.7**	**640.9**	**511.4**	377.1±94.8	390.1±64.7
Polychaeta	4.1	0.9	3.3	2.5	2.3	4.5	12.2	36	9.2	48	7.5±1.9	18.4±5.3
Pisces	0	1.9	22	4.4	2.9	18.3	25.2	9.6	29.1	2.6	14.8±4.8	4.6±1.6
Rest	1.1	3.3	0.6	6.7	0.1	4.1	2.1	35	6.1	32	2.6±0.8	16.2±3.2
Total	**49.4**	**202.5**	**234.8**	**161**	**270.5**	**800.6**	**594.7**	**849.7**	**778.33**	**764.5**	**501.2±93.8**	**555.7±69.4**

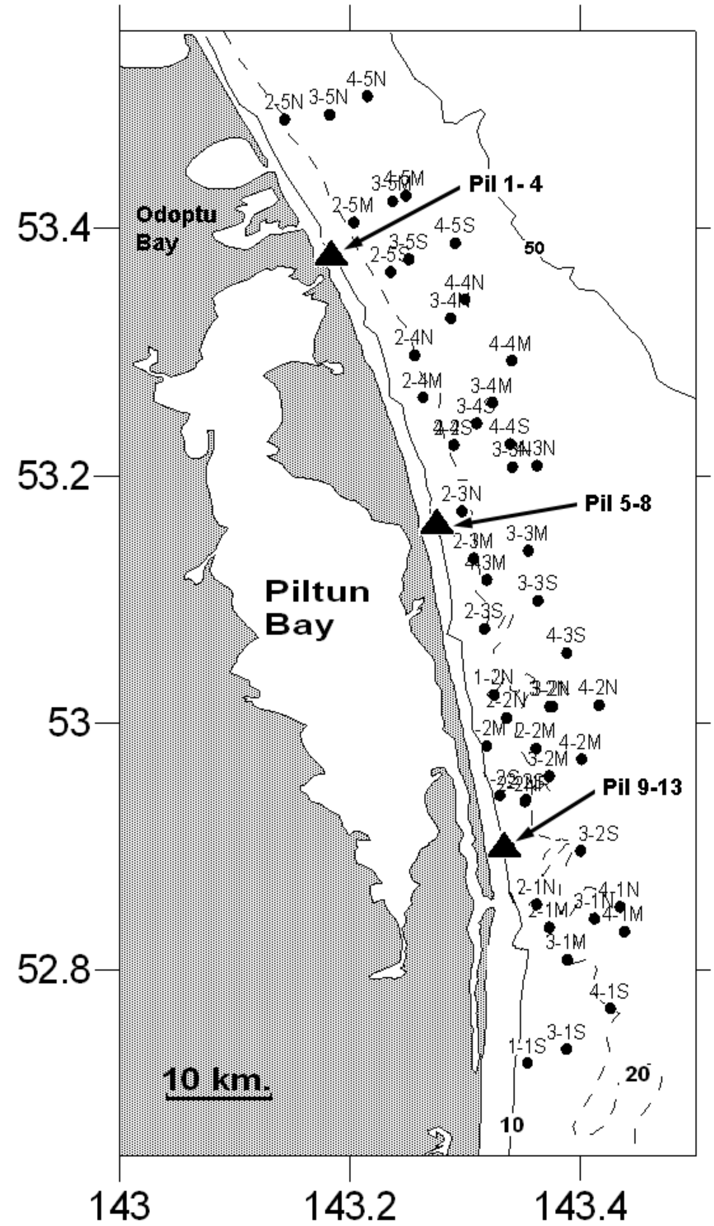


Figure 13. Locations of stations in the Piltun Area in 2004. Triangles indicate near-shore transects at depths of 3-10 m.

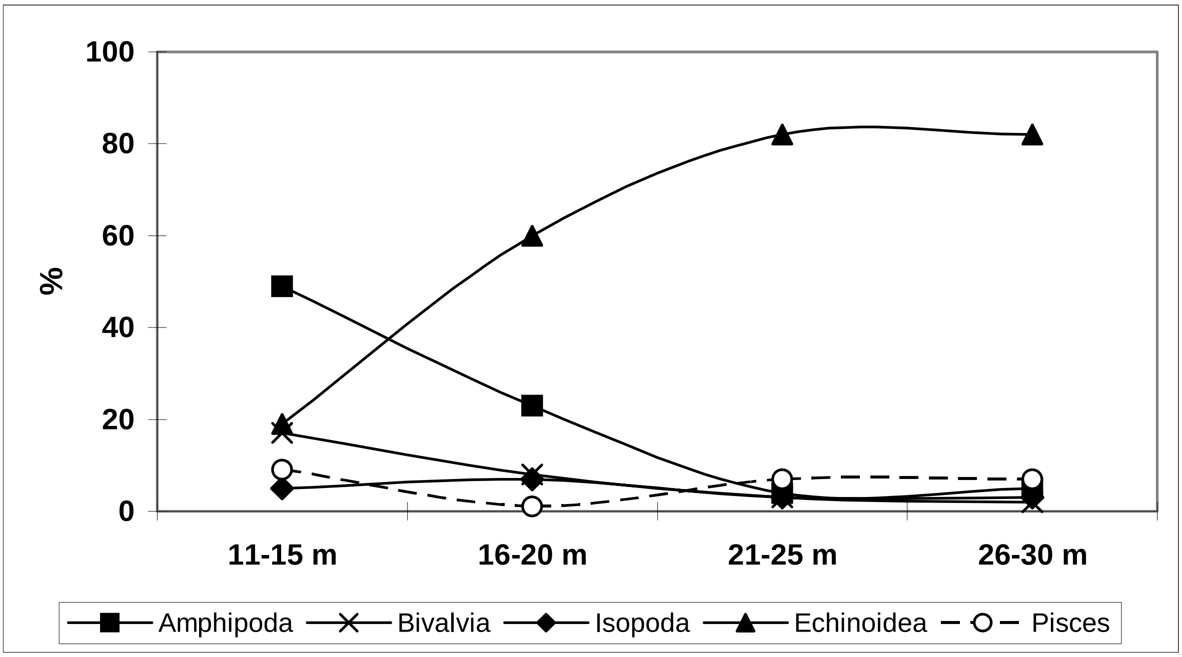


Figure 14. Variation in the proportions (%) of 5 benthos groups in the total benthos biomass by depth in the Piltun Area in 2004.

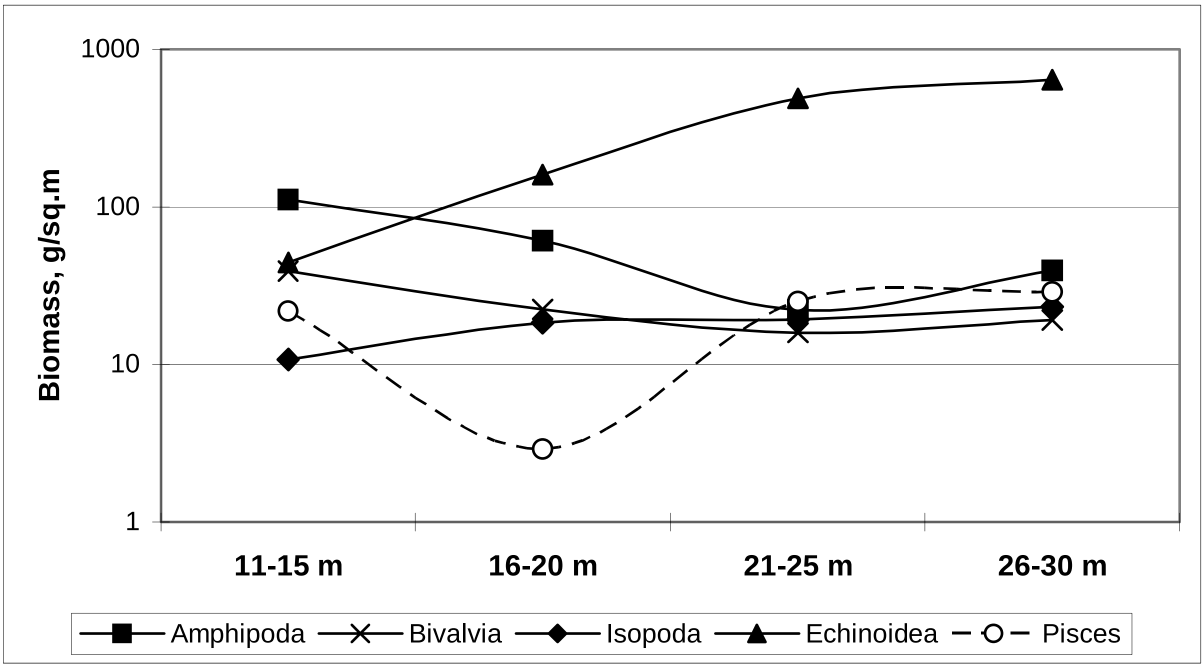


Figure 15. Variation in biomass (g/m^2) of 5 benthos groups by depth in the Piltun Area in 2004.

Based on materials from 2004, the proportion of crustaceans in the total biomass reached 49% at depths of 11-15 m and decreased to 8% in the range of 26-30 m. The trend of benthos biomass proportion decreasing with depth is clearest for amphipods (Table 10; Figure 14). The spatial distribution of crustaceans in the Piltun Area according to materials from 2004 is shown in Figure P1.6 (Appendix 1). Some patchy areas of high crustacean biomass are observed in the coastal zone. The largest crustacean accumulations in the area are observed in the coastal zone of Piltun Bay, in the southern and northern parts. These shallow-water accumulations are made up of amphipods and isopods. At the same time, a clear declining trend in the proportion of crustaceans in the total benthos biomass with increasing depth is observed. Spots of high biomass at depths greater than 20 m are made up of cumaceans.

Isopods (*Isopoda*). According to materials from diving studies in 2001, the relative proportion of isopods in the total macrobenthos biomass was 14.1% at depths of 5–10 m and only 2.4% at 11–30 m. The average isopod biomass in this range was 25.0 g/m^2. It was demonstrated that the small isopod *Synidotea cinerea* (average body weight 0.02 g) has the greatest significance in the benthos biomass of the Piltun Area. This isopod had the highest rate of occurrence of all macrobenthos species – 86% - in the study areas at depths of 5-30 m. Maximum biomass values for this species were observed at depths less than 15 m. Only individuals of *S. cinerea* were encountered in deeper waters. According to the materials of diving studies, the greatest colony density of *S. cinerea* (up to 5000 spec./m^2) is associated with tube mats of the sea worm *Onuphis shirikishinaiensis*.

The second species – the large isopod *Saduria entomon* (body weight up to 5 g, average weight 2.1 g) – is encountered significantly less frequently in the Piltun Area (P = 25%). In the zone of mass sand dollar development, this species can form local accumulations, which made it possible to consider this isopod, along with other crustaceans, as potential prey for gray whales (Photo 1). The biomass of this species increases with depth (Fadeev, 2002). The isopod *S. entomon* had a 16% frequency of occurrence in 2002 collections. The biomass of this species at depths of 11 to 30 m varied from 1.5 to 56 g/m^2.

The isopod distribution in the Piltun Area in 2003 had a distinctly patchy nature (Figure 16A). The patchy nature of the isopod biomass distribution in the shallow zone was conditioned by local accumulations of the small isopod *Synidotea cinerea*. The density of this species in the accumulations reached 3600 spec./m^2 with biomass of 55 g/m^2. At depths greater than 15 m, areas of elevated isopod biomass were conditioned by accumulations of the large isopod *Saduria entomon*. The biomass of this species in local accumulations reached

Photo 1. Large isopods *Saduria entomon* and young crabs *Hyas coarctatus* in an epibenthos sample (diving survey site of 1 m^2; depth 15 m; fine sand mixed with medium-grained sand; in depressions between sand wave ridges: Fadeev, 2002).

Photo 2. Sand lance *Ammodytes hexapterus* in a benthos sample (diving bottom grab sampler; depth 15 m; fine sand: Fadeev, 2002).

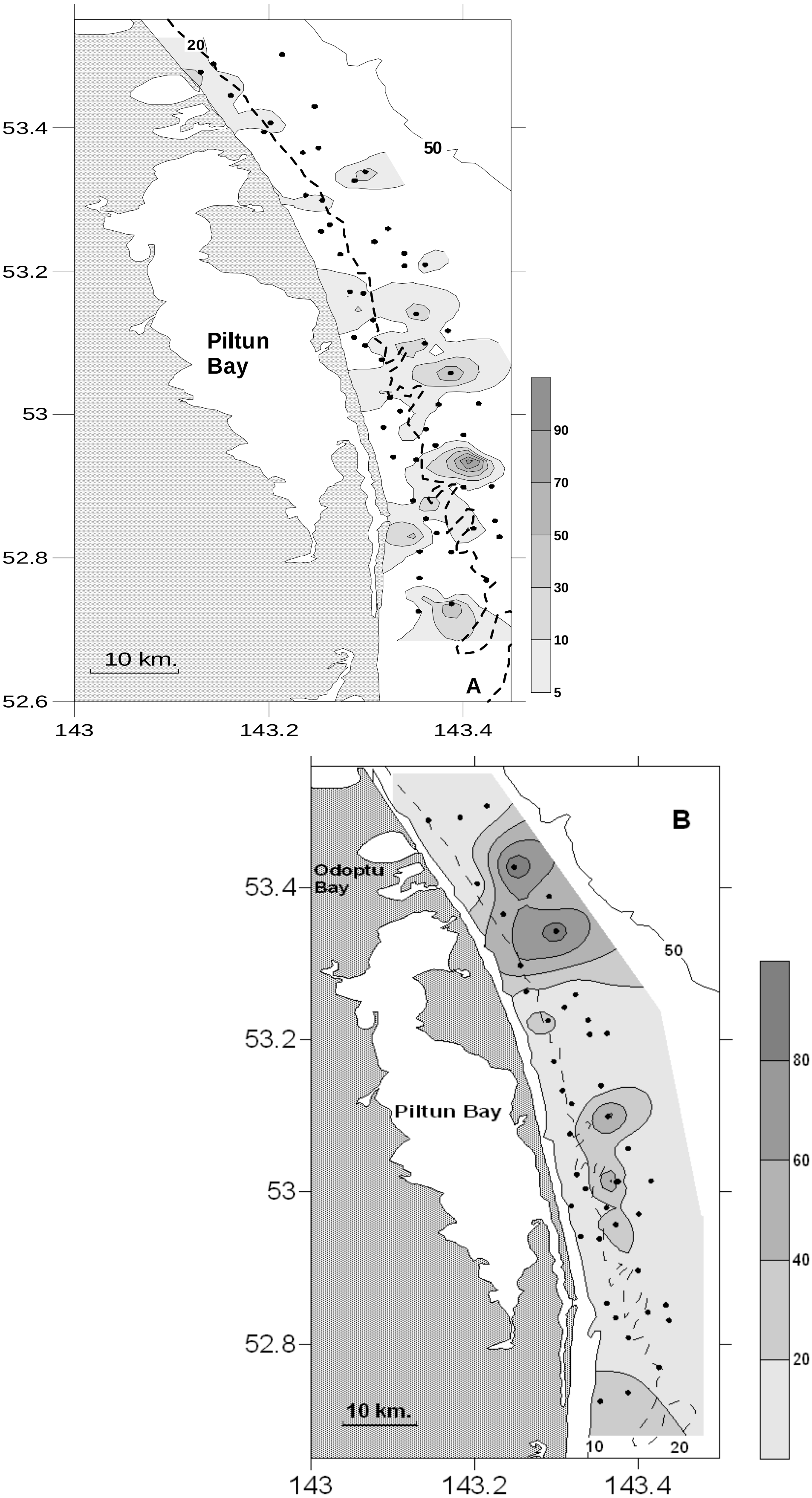


Figure 16. Isopod biomass distribution (g/m^2) in the Piltun Area according to materials from 2003 (A) and 2004 (B).

128 g/m^2 at a colony density of 75 spec./m^2. However, analysis of the spatial distribution of biomass of this species indicated that such accumulations are rare and occupy a small area in the sand dollar zone (Fadeev, 2004). For example, accumulations of *Saduria entomon* with a biomass greater than 30 g/m^2 were observed at 6 stations in 2003. The isopods were present at each station in only one bottom grab sample out of three taken at the station. Flat sea urchins without isopods, with biomass up to 1200 g/m^2, were prevalent in the other two samples at these stations. The proportion of samples with isopod dominance in the biomass was only 6% at depths greater than 15-20 m in 2003 and was less than 3% when bottom grab sample collections from 2002 were included. Despite the low frequency of occurrence of local accumulations of large isopods at depths greater than 15-20 m, they can be used in feeding of individual whales, but they cannot serve as a regular food resource.

The proportion of isopods in benthos biomass at depths of 11-30 m in 2004 was 4% at an average biomass of 18.5±5.6 g/m^2, which is not substantially different from the data of 2003: 4% and 23.5±3.7. No clear trend in the change in isopod biomass is observed with increasing depth (Table 10, Figure 14). As in 2003, the highest biomass levels (more than 120 g/m^2) were observed at depths greater than 18 m within local accumulations of the large isopod *Saduria entomon*. The spatial distribution of isopods in the Piltun Area was different in nature in 2004 and 2003 (Figures 16A and 16B). The isopod biomass distribution is distinctly patchy. Some differences are observed in the zone immediately adjacent to the shore, at depths less than 15 m. The number of areas of elevated isopod biomass there in 2004 was lower than in 2003. At depths greater than 15-20 m, local isopod accumulations in 2004 can be charted in the northern and southern parts of the Piltun Area (Fig. 16B).

Characteristics of the dominant isopod species. The large isopod *Saduria entomon* is a saltwater Pan-Arctic circumpolar species represented by relic populations in the boreal zone. It resides throughout a broad depth range: 0-44 m in the Arctic (Crimmon and Bray, 1962), and 1-270 m in the Baltic Sea (Jarvekulg, 1979). According to published data, the maximum habitat temperature in the Arctic and the seas of the Far East is 10 °C (Crimmon and Bray, 1962). The species reaches sexual maturity at the age of 3-4 years (Jarvekulg, 1979). It inhabits the lagoons of eastern Sakhalin and is encountered throughout the Piltun lagoon, where it is the only predator among the epibenthic invertebrates (Kafanov et al., 2003). This isopod is an active cannibal predator (Leonardsson, 1991; Sparrevik and Leonardsson, 1998), and its accumulations are temporary in nature.

Amphipods (*Amphipoda*). According to diving data from 2001, 10 species of amphipods had a frequency of occurrence higher than 25% at depths of 5–30 m in the water area studied, and three species had a frequency of occurrence higher than 50% (*Eohaustorius eous eous* – 81%; *Grandifoxus longirostris* – 75%; and *Pontoporeia affinis* – 71%). The average amphipod biomass for the entire area at depths of 11–30 m was 114.1±15.7 g/m^2. It was noted that the most substantial changes in biomass and frequency of occurrence of common amphipod species occur in the range of 15-20 m in the Piltun Area (Fadeev, 2002). In 2002-2003 collections at depths of 8–30 m, 37 amphipod species were recorded (Appendix 4). Of these, six species have a frequency of occurrence (P) higher than 50%: *Eohaustorius eous eous* (P = 100%), *Pontoporeia affinis* (98%), *Grandifoxus longirostris* (86%), *Eogammarus schmidti* (81%), *Anisogammarus pugettensis* (78%), and *Westwoodilla sp.* (65%). Of the species with a frequency of occurrence higher than 25%, nine species had the highest biomass levels: *Grandifoxus longirostris, Eohaustorius eous eous, Pontoporeia affinis, Eogammarus schmidti, Atylus collingi, Pontharpinia robusta, Anonyx nugax,* and *Westwoodilla sp.* The average amphipod biomass levels for the entire area were similar in 2002 and 2003. It was demonstrated based on data from 2001-2003 that the most substantial change in amphipod biomass occurred at depths of 15-20 m (Fadeev, 2003, 2004).

In materials from 2004, the average amphipod biomass was 47.4±7.7 g/m^2 for the entire depth range studied in the Piltun Area, which is comparable to the data from 2002 – 42.7 g/m^2 – and 2003 – 54.6 g/m^2. As in 2003, the average amphipod biomass amounts to about 9% of the total benthos biomass. More than 95% of amphipod biomass is accounted for by two species: *Pontoporeia affinis* (62% of the total amphipod biomass) and *Eogammarus schmidti* (34%). Amphipods have their highest quantitative abundance levels at depths less than 15 m. The sharpest decrease in the abundance of amphipods occurs in the range of 15-20 m (Table 10; Figures 14 and 15). The proportion of amphipods is 47% of the total benthos biomass at depths of 11-15 m and less than 5% at depths greater than 20 m.

The nature of the spatial distribution of amphipod biomass in the Piltun Area shows similar trends in 2004 and 2003: the zone of high biomass is associated with the parts of the water area nearest the shore, and the amphipod distribution is patchy (Figure 17). The amphipod biomass distribution was more regular in 2003 (Figure 17A) than in 2004 (Figure 17B), and local spots of elevated biomass can be seen in the northern and middle parts of the area. According to materials from 2002, a spot of elevated biomass was located only in the southern part of the area. In 2004, areas of elevated amphipod biomass are seen in the middle and northern parts of the area and are more pronounced than in 2003. The section in the northern part of the Piltun Area is larger in area and has higher amphipod quantitative abundance levels.

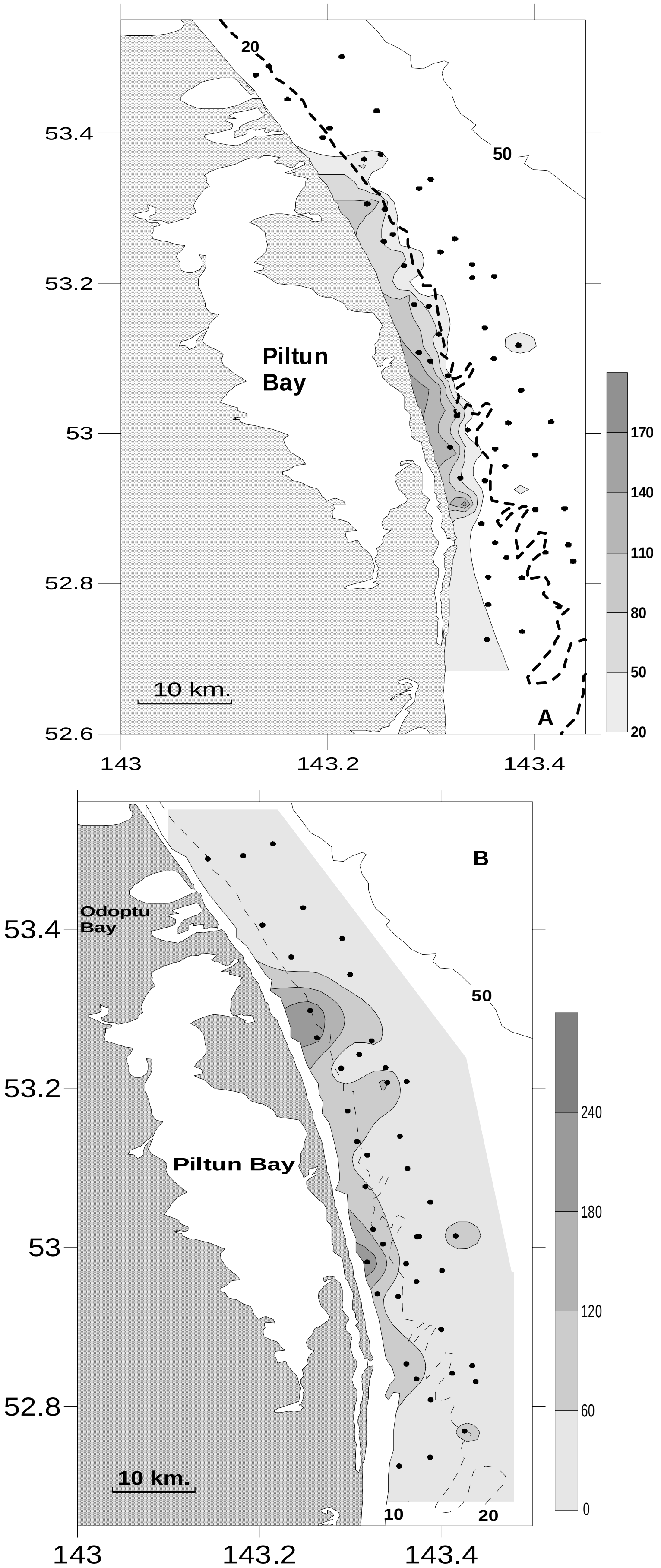


Figure 17. Amphipod biomass distribution (g/m^2) in the Piltun Area based on materials from 2003 (A) and 2004 (B).

Characteristics of the dominant amphipod species. The amphipod *Pontoporeia affinis* **(**= *Monoporeia affinis***)** is a saltwater Pan-Arctic circumpolar species represented by relic populations in the boreal zone. It inhabits the northern arctic seas and lakes of Northern Europe and North America. In the Baltic Sea, it lives at depths of 0.5-300 m with salinity of 1.5-18‰ and temperatures up to 12.8 °C (Jarvekulg, 1979). In the Piltun Area, the species is encountered both in freshened Piltun lagoon areas and in offshore areas with normal salinity. With respect to feeding type, it is a burrowing deposit feeder. In digging up the top layer of the bottom and stirring up the bottom sediment during feeding, *P. affinis* has a significant impact on bivalve mollusk juveniles (Segestrale, 1973), meiobenthic animals (Olafsson and Elmgren, 1991) and even zooplankton (Albertsson and Leonardsson, 2001). It breeds in winter, and juveniles emerge from the hatching pouch in spring; individuals die after the first breeding (Jarvekulg, 1979). In cold waters, the species reaches sexual maturity in the second year of life, while in warmer waters, it has a one-year life cycle (Segerstrale, 1967). In the Baltic Sea, *P. affinis* is among the highly productive benthic species (Andersin et al., 1984).

Cumaceans (*Cumacea*). Based on materials from 2001, the average biomass of cumaceans at depths of 5–30 m was 17.1±3.5 g/m^2. The biomass of cumaceans increased with depth. A similar relationship could be traced in the materials from 2002. The biomass of cumaceans was 5.35 g/m^2 in the range of 11–15 m and increased to 48.9 g/m^2 at a depth of 30 m. The average biomass was 10.9±2.8 g/m^2. The maximum colony density of cumaceans of 24,800 to 37,600 spec./m^2 with a biomass of 84 to 113 g/m^2 was observed at depths of 30-32 m (Fadeev, 2002, 2003).

Cumaceans had a high frequency of occurrence – 50% – in the 2004 collections. As in 2003, four cumacean species were observed: *Lamprops affinis, Lamprops quadriplicata, Diastylopsis dawsoni* and *Diastylis bidentata.* The first three species were encountered in small numbers at depths less than 15 m. Only *Diastylis bidentata* is encountered at all depths; it accounts for more than 98% of the total cumacean biomass. The average cumacean biomass for the entire area in 2004 was 1.1 g/m^2, which is not substantially different from the data from 2003: 2.1 g/m^2. Cumacean biomass levels from 2003 and 2004 are significantly lower than the biomass levels of 2001 and 2002 (17.1 and 10.9 g/m^2). The differences in biomass in different years are explained by the fact that the station layout in 2003-2004 differed from the 2002 layout; i.e., cumacean accumulations inspected in 2002 were not covered in the studies in 2003 and 2004.

Bivalve mollusks (*Bivalvia*). Based on data from diving studies in 2001, only three bivalve mollusk species had a frequency of occurrence higher than 25% and were dominant in regard to biomass in the Piltun Bay area in 2001: *Siliqua alta, Macoma lama* and *Megangulus luteus*. For the water area as a whole, the biomass of *Bivalvia* increased somewhat from 5 m to 10–15 m, with a subsequent decrease at depths greater than 20 m. The average biomass value for bivalve mollusks for the entire water area at depths of 11–30 m was 103.2±25.15 g/m^2. The average biomass of bivalve mollusks in the range of 11–30 m in 2002 was 40.36±8.81 g/m^2. Four species make up the basis of bivalve mollusk biomass: *Megangulus luteus* (frequency of occurrence P = 56%), *Macoma lama* (P = 45%), *Siliqua alta* (P = 31%) and *Mactromeris polynyma* (P = 1%). The spatial distribution of bivalve mollusks in the Piltun Area was similar in 2001 and 2002. Areas of elevated biomass had a spotty distribution and were associated with the southern, middle and northern parts of the area (Fadeev, 2002, 2003).

In the materials from 2004 and 2003, 30 species of bivalve mollusks were recorded (Appendix 5). Of these, five species had a frequency of occurrence higher than 25%: *Megangulus luteus* (frequency of occurrence P = 60-71%), *Macoma lama* (P = 25-35%), *Siliqua alta* (P = 30-32%), *Mysella kurilensis* (P = 28-30%) and *Mactromeris polynyma* (P = 25-27%). The average bivalve mollusk biomass in the Piltun Area is 23.1±4.1 g/m^2 (Table 7). The bivalve mollusk biomass varies only slightly throughout the depth range studied (Figures 14 and 15). The spatial distribution of bivalve mollusks from 2002-2004 had a distinctly aggregated nature (Figure P1.7). This conclusion is also supported by the nature of the spatial distribution of the bivalve mollusk complex in the Piltun Area (Figure 21).

Sand lance *Ammodytes hexapterus*. The materials from 2004 are distinguished from 2003 by a significantly higher proportion of the fish *Ammodytes hexapterus* in the total benthos biomass of the Piltun Area. The frequency of occurrence of the sand lance in bottom grab sample collections in 2002-2003 was 5-8% at an average biomass of 4.6-6.2 g/m^2. The frequency of occurrence of the sand lance in 2004 was 14.8% at an average biomass of 14.8±4.8 g/m^2. Within local accumulations, the sand lance biomass varied from 68 to 166 g/m^2, which amounted to 25 to 48% of the biomass in the samples. The densest accumulations in 2004 were observed in the northern and middle parts of the Piltun Area (Figure 18A).

Sand lance accumulations were observed for the first time in the Piltun Area during diving work in 2001 (Fadeev, 2002). The sand lance was observed in a zone of fine-grained and medium sandy bottoms, mainly in the southern and middle sections of the Piltun Area, at depths greater than 10 m. The frequency of occurrence of this species was 32% in the samples collected with a diving bottom grab sampler. A distinguishing feature of the ecology

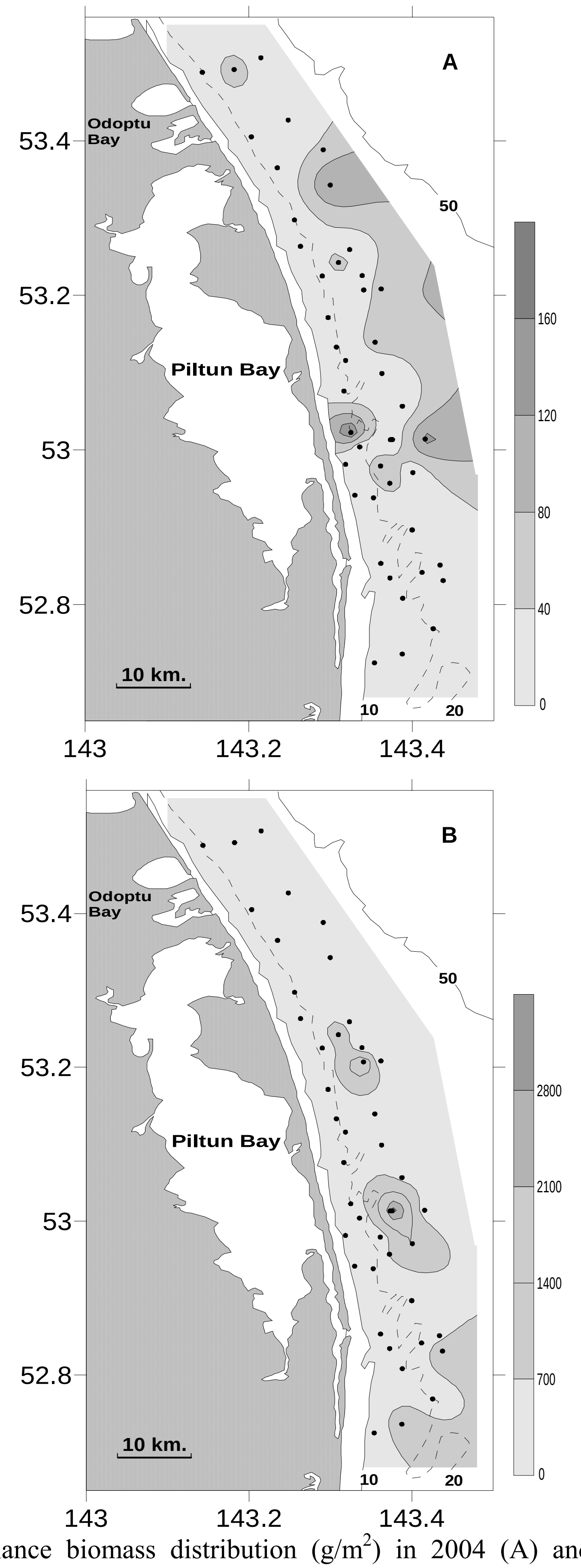


Figure 18. Sand lance biomass distribution (g/m^2) in 2004 (A) and total macrobenthos biomass in 2004 (B) in the Piltun Area.

of the sand lance is the fact that individuals of the species bury themselves in the surface layer of sand during the day, which makes it possible to count the species in accumulations with reasonable accuracy. Juvenile sand lances were prevalent in the 2001 collections at depths up to 20 m (Photo 2). The sand lance density in the densest accumulations reached 40-60 spec./m^2. Sand lance accumulations in the Piltun Area were not associated with any macrobenthos community; the nature of the sea bottom is the determining factor. Based on the high sand lance biomass levels in accumulations and their high fuel value, the sand lance was considered supplementary prey for whales in the Piltun Area (Fadeev, 2002), especially since this species has already been noted as prey for gray whales from stomach contents (Zimushko and Lenskaya, 1970).

4.1.2. Size Composition of Common Amphipod Species

Analysis of data on the benthos composition at gray whale feeding sites obtained in the Piltun Area in 2002-2003 indicated that amphipods have high quantitative abundance levels there (Fadeev, 2003, 2004). Analysis of the size composition in the whale feeding areas makes it possible to assess the proportion of amphipods potentially suitable for the whale's diet. The threshold value is assumed to be 6 – 8 mm (Rice and Wolman, 1973; Nerini, 1984). In addition, the degree of replenishment of amphipod colonies with juveniles, the growth rates of individuals and, accordingly, the productive potential of the whale feeding grounds can be assessed based on the size composition.

A preliminary analysis was performed in 2001-2002 on the size composition of 10 common species from the Piltun (seven species) and Offshore areas (three species): *Anonyx nugax pacificus, Pontoporeia affinis, Protomedeia fasciata, Grandifoxus longirostris, Anisogammarus pugettensi, Eogammarus schmidti, Eohaustorius eous eous, Ampelisca eschrichti, Photis reinchardi.* It was noted that the presence of a significant proportion of juvenile individuals was characteristic of all species, which attests to the absence of any pronounced negative impact on the amphipod colonies. The proportion of individual specimens with a body length greater than 6 mm, i.e., individuals accessible for whale feeding, varied among the different species from 58 to 100% (Fadeev, 2003).

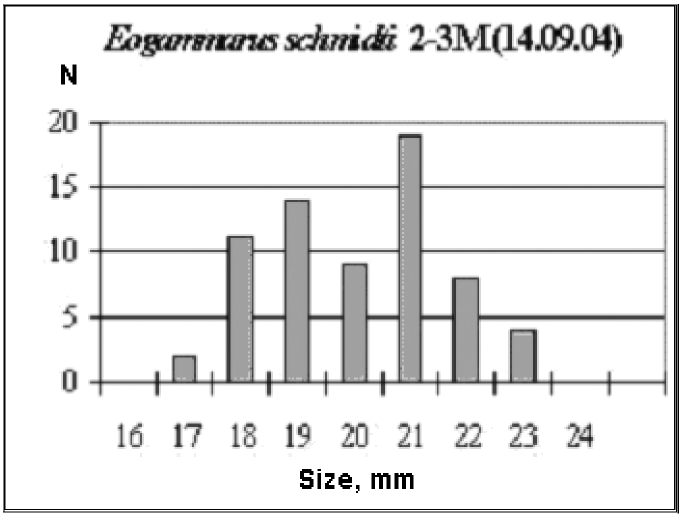
Of the 43 amphipod species recorded in the Piltun Area, seven species have a high frequency of occurrence: *Anonyx nugax pacificus, Protomedeia fasciata, Pontoporeia affinis, Eogammarus schmidti, Eohaustorius eous eous, Grandifoxus longirostris* and *Anisogammarus pugettensis.* Materials from 2002-2003 demonstrated that three species account for most of the amphipod biomass in the whale feeding zone: *Pontoporeia affinis,* *Eogammarus schmidti* and *Eohaustorius eous eous.* It is these species that were used for the size composition analysis in 2003 and 2004.

Extensive material for analysis of the size composition of amphipods was collected at three stations in 2003: 1-3M, 2-3M and 1-4S, in the fine sand zone at depths of 10-14 m. The amphipod biomass at the stations varied from 70 to 85 g/m^2. Of the 12 species recorded at the stations, three species (*Pontoporeia affinis, Eogammarus schmidti* and *Eohaustorius eous eous*) accounted for 95 to 99% of the amphipod colony density and 78 to 99% of the average biomass at the stations. The proportion of individuals exceeding the threshold size of 6 mm was 100% for *Eogammarus schmidti*, 86% for *Pontoporeia affinis* and 48% for *Eohaustorius eous eous*. Analysis of the size composition of amphipod samples made it possible to analyze the age composition. According to materials from 2003, the amphipods *Eogammarus schmidt* were divided into three size groups: with a modal value of 7 mm – age group 0+; with a mode of 14 mm – group 1+; and with a mode of 20 mm – group 2+. As in the 2002 sampling, two size groups can be distinguished for *Pontoporeia affinis*: with modal value of 9 mm (age group 1+) and 4 mm (group 0+).

The total amphipod biomass at station 2-3M in 2004 was 80.1 g/m^2 (81.5 g/m^2 in 2003); all three common amphipod species were observed there in numbers sufficient for morphometric analysis. In addition, collections were performed at this station in September 2004 and July 2003, which makes it possible to consider changes in the size composition of the sampling for the two months. It follows from Figure 19 and Table 11 that juvenile growth among *Eogammarus schmidti* amphipods is finished by mid-September, and all the individuals are sexually mature. More than 95% of the individuals reach sizes larger than 6 mm beginning in July. For *Pontoporeia affinis*, the proportion of individuals larger than 6 mm is 73% in July and reaches 100% by September. In contrast to 2003, when the proportion of individuals larger than 6 mm for the amphipod *Eohaustorius eous eous* was 48%, practically all individuals were smaller than 6 mm in 2004 (Table 11, Figure 20).

Table 11. Statistical characteristics of the size composition of common amphipod species.

Parameter	***Pontoporeia affinis***			***Eogammarus schmidti***		***Eohaustorius eous eous***	
	2004	2002	2003	**2004**	2003	**2004**	2003
Average, mm	**12.53**	10.68	8.69	**20.11**	14.41	**3.44**	5.1
Standard deviation	**0.11**	0.24	0.06	**0.21**	0.13	**0.16**	0.07
Min	**7.3**	3	1.7	**17.1**	2.6	**1.6**	1.9
Max	**14.8**	17.5	16.8	**23.6**	29.2	**5.2**	9.3
n , spec.	**650**	1035	2052	**480**	754	**196**	522



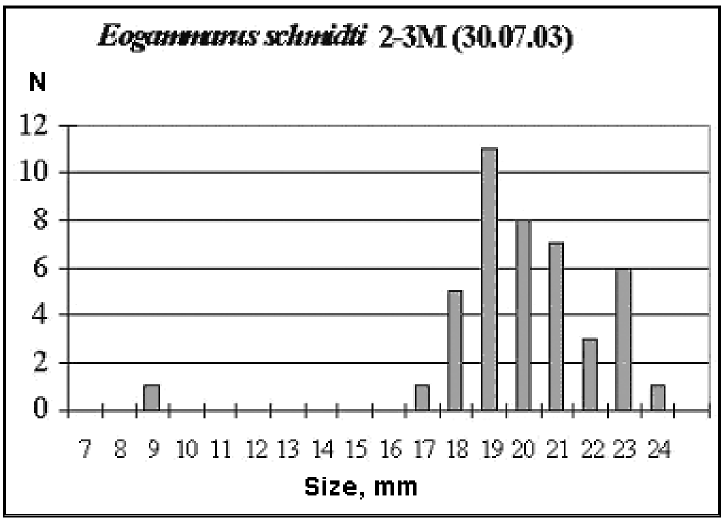


Figure 19. Histograms of the body length distribution for common amphipod species.

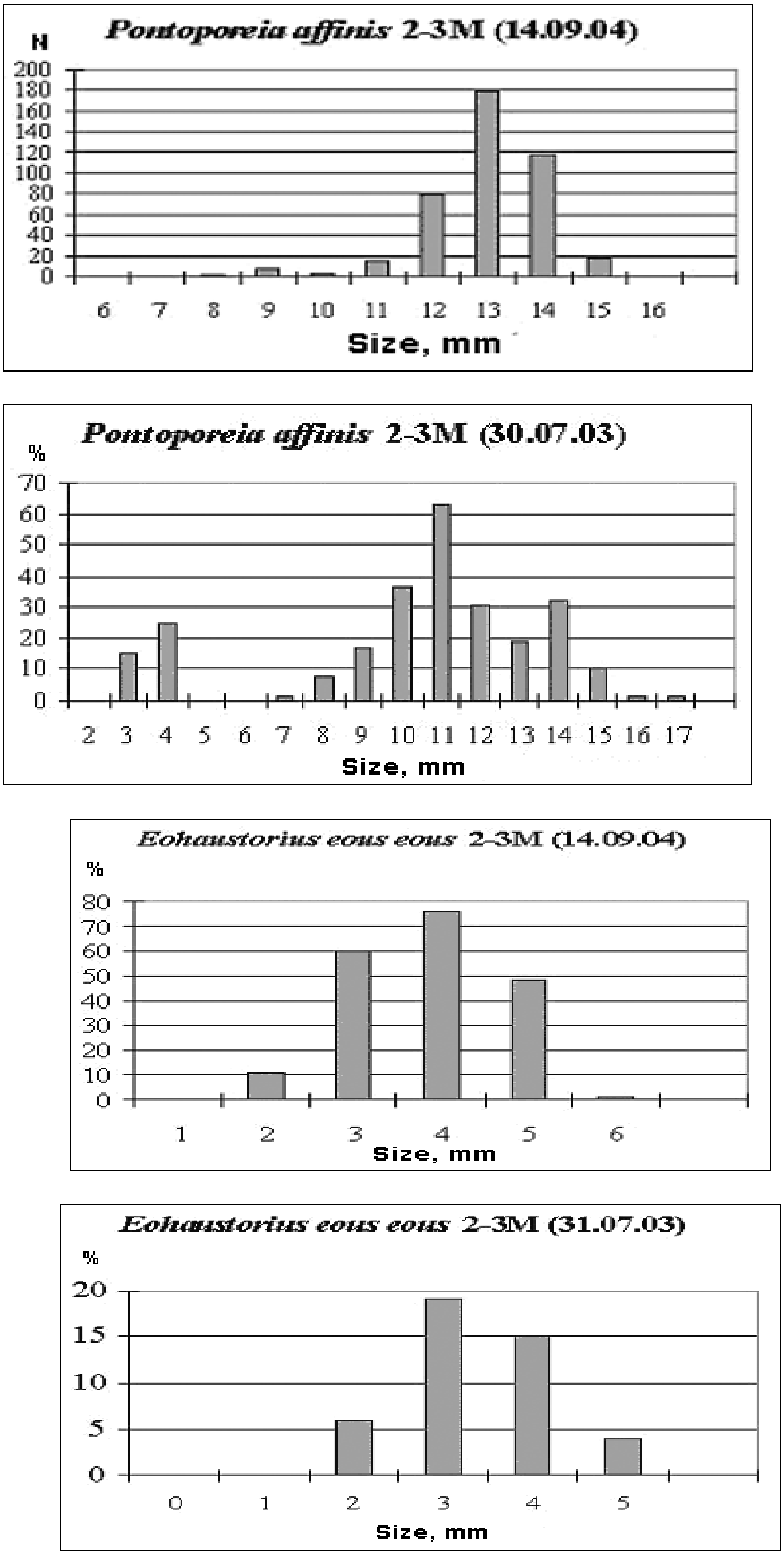


Figure 20. Histograms of the body length (mm) distribution for common amphipod mass species.

4.1.3. Composition and Distribution of Benthos Complexes According to 2004 and 2002 Data

Cluster analysis was used to identify irregularities in the benthos distribution – the 163 stations (2002-2004) were grouped according to similarity of the quantitative ratios of benthos taxonomic groups. The classification results are presented in a dendrogram (Figure 22). The groups of stations with the greatest similarity within the groups in regard to benthos complexes are not, strictly speaking, biocoenotic units. In further detailing, the complexes are further divided into a number of complexes which are smaller but have greater similarity of units within the groups – communities. Figure 21 shows the locations of stations assigned to each complex in the Piltun Area. The benthos complexes differ in both the composition and the abundance of the taxonomic groups (Table 12).

Table 12. Composition of benthos complexes of the Piltun Area.

Group	*Amphipoda* complex		*Bivalvia* complex		*Echinoidea* complex	
	A, spec./m^2	B, g/m^2	A, spec./m^2	B, g/m^2	A, spec./m^2	B, g/m^2
Amphipoda	7401	**113.72**	2512	42.56	240	26.49
Bivalvia	111	19.88	420	**97.72**	62	40.73
Cumacea	84	1.28	163	1.67	247	1.32
Decapoda	0	0	2	1.76	3	3.31
Echinoidea	2	2.66	13	33.07	139	**839.97**
Gastropoda	3	2.82	6	2.78	2	12.91
Isopoda	420	22.75	222	14.64	17	25.31
Pisces	3	8.77	2	5.22	3	14.13
Polychaeta	86	2.62	93	16.66	98	20.33
Total	8185	177.09	3455	221.14	863	988.68

Amphipoda complex includes 39 stations at depths of 8 to 23 m (average depth 15 m) in the fine- and medium- sand zone. The complex is distributed in a belt along the coast in the Piltun Area (Fig. 21). The average biomass of the complex (**177.1** g/m^2) is made up primarily of amphipods – 64%; isopods – 14%; and bivalve mollusks – 13% (Photo 3). The complex includes 29 amphipod species with a total biomass of 113.7±14.5 g/m^2 at a colony density of 7410±1170 spec./m^2. Four species have the greatest quantitative abundance: *Pontoporeia affinis, Eogammarus schmidti, Eohaustorius eous eous* and *Anisogammarus pugettensis*. They account for 95% of the average biomass and colony density of amphipods in the complex.

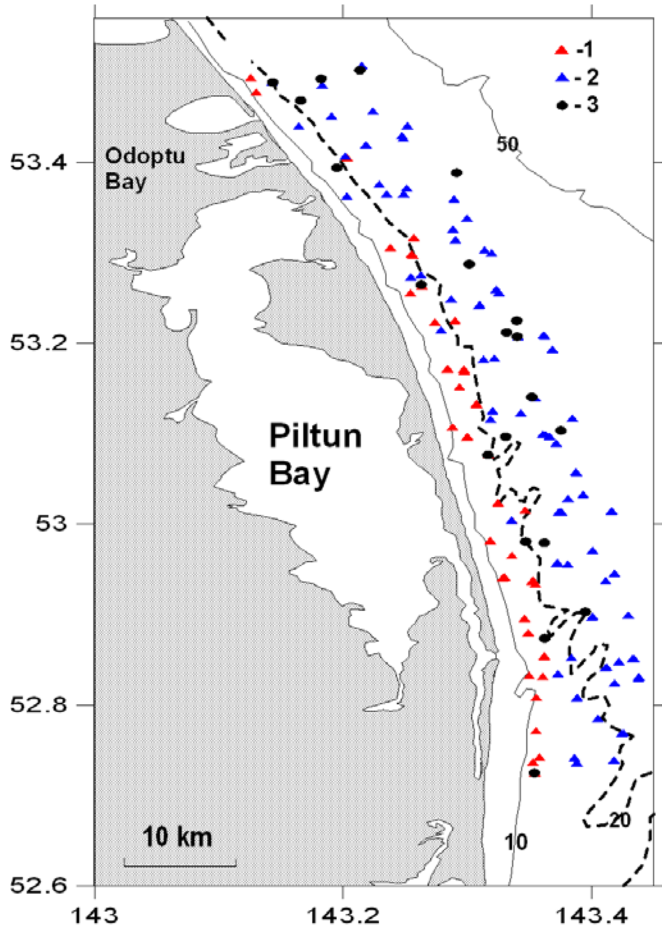


Figure 21. Distribution of complexes in the Piltun Area based on 2002-2004 data.

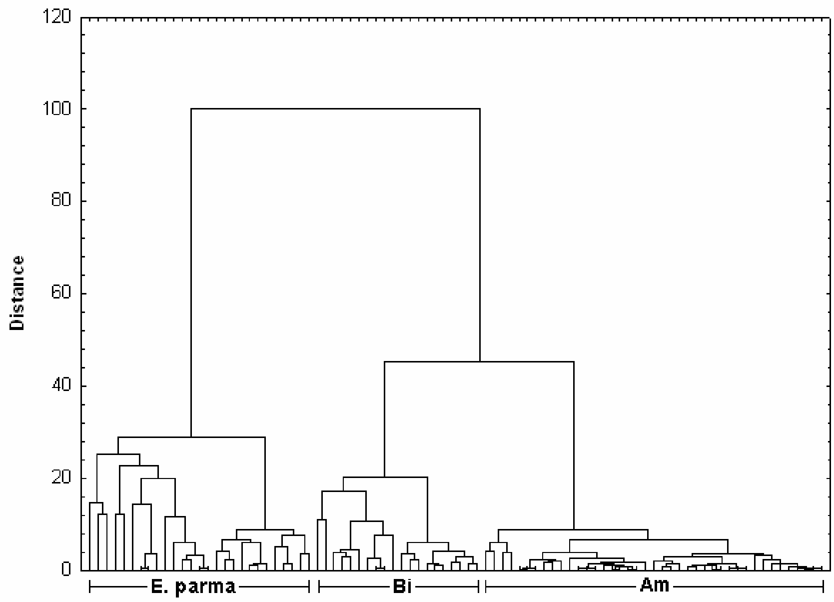


Figure 22. Dendrogram of the similarity of stations (bottom) and diagram of the distribution of complexes (top) in the Piltun Area based on materials from 2002-2004.

In dendrogram: Am – amphipod complex; Bi – bivalve mollusk complex; E. parma – sand dollar complex.

Complex designations in diagram: 1 – amphipods; 2 – sand dollars; 3 – bivalve mollusks.

Photo 3. Bottom grab sample (0.2 m^2) from *Amphipoda* complex.

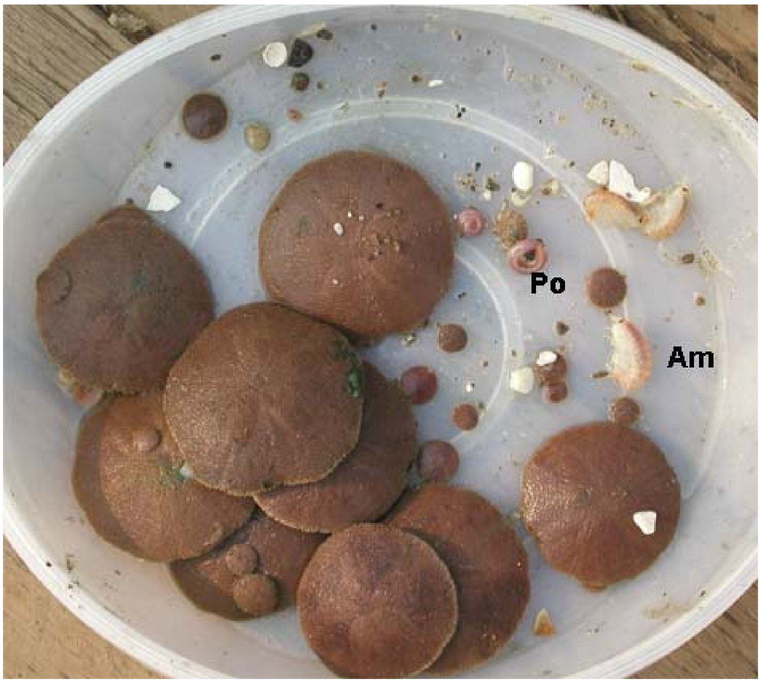


Photo 4. Bottom grab sample (0.2 m^2) from sand dollar complex.
Am – amphipods *Anonyx nugax*;
Po – polychaetes *Ophelia limacina.*

This group of species, in turn, is dominated by *Pontoporeia affinis,* which makes up 85% of biomass and 80% of colony density of the complex. Second in significance in the complex is the isopod group, represented by two species: *Synidotea cinerea* and *Saduria entomon*. The dominant species, *S. cinerea*, has a frequency of occurrence in the complex of 95%, and it accounts for 94% of the total isopod biomass. The complex includes 10 species of mollusks, of which five species have a frequency of occurrence greater than 50%: *Megangulus luteus, Siliqua alta, Tridonta borealis, Liocyma fluctuosum, Macoma lama.* These species account for more than 92% of the biomass of bivalve mollusks (19.9 g/m^2).

Based on diving data from 2001, the bottom areas having dominance of similar compositions of amphipods and isopods are located in the near-shore zone of the Piltun Area at depths of 5-17 m (Fadeev, 2002). The amphipods *Pontoporeia affinis* had the greatest abundance in the coastal amphipod complex in 2001-2004.

Bivalvia complex includes 25 stations at depths of 9 to 29 m (21 m, average) on fine sands and mixed gravel and sand bottoms. In contrast to the amphipod complex, it has a distinctly spotty distribution in the area (Figure 21). The composition of the complex includes 18 bivalve mollusk species with a biomass of 97.8±46.2 g/m^2 at an average complex biomass of 221.14 g/m^2. Eight species have the highest frequency of occurrence: *Megangulus luteus, Astarte arctica, Macoma lama, Tridonta borealis, Siliqua alta, Mysella kurilensis, Liocyma fluctuosum* and *Mactromeris polynyma*. They account for more than 98% of the total biomass of the complex. The bivalve mollusk complex is not homogeneous: *Megangulus luteus* is dominant in the shallow areas, and *Astarte arctica* is dominant in deeper waters (deeper than 20-25 m). Within the complex, the total amphipod and isopod (primarily *Saduria entomon*) biomass is more than 50% of the biomass of bivalve mollusks. Analysis of the data from whale feeding sites in 2002-2003 indicates that whale feeding occurs in areas occupied by the *Bivalvia* complex.

Sand dollar *Echinarachnius parma* complex (Photo 4) has been described in detail based on materials from 2001-2003 (Fadeev, 2002, 2003, 2004) and is not covered in this report.

In resuming the analysis of the distribution of macrobenthos complexes based on materials from 2003 and 2004, we note that most of the sea bottom in the Piltun Area is occupied by two complexes: a shallow-water coastal amphipod complex with a high proportion of forage components, and a deeper-water sand dollar complex with an extremely low proportion of prey in its biomass. The provisional boundary between complexes is at depths of about 20 m (Fig. 21).

4.2. Offshore Area

4.2.1. Quantitative Abundance and Distribution of Benthos Based on Data from 2004 and 2002

There were 32 stations (96 bottom grab samples) at depths from 16 to 63 m (average depth 49.3±2.3 m, n=32; in 2003, 35.9±1.7 m, n=36) in the Offshore Area in 2003. Diagrams of station locations and depths in the Offshore Area are shown in Figure 23.

There are sandy bottoms in most of the Offshore Area: well-sorted fine sand at 28 stations, and sands of varying grain size mixed with gravel and pebbles at five stations. The proportion of the aleurite-pelite fraction is more than 25% of the dry sediment weight at a number of stations.

There were 18 benthos taxonomic groups recorded in the collections; they differ substantially in their frequency of occurrence at the stations (Table 13).

Table 13. Frequency of occurrence of benthos taxonomic groups in the Offshore Area.

Frequency of Occurrence (P, %) of Taxonomic Groups, n=32							
P>50%		P = 25-50%		P = 10-25%		P<10%	
Group	P,%	Group	P,%	Group	P,%	Group	P,%
Amphipoda	100	*Sipunculida*	49	*Holoturoidea*	22	*Bryozoa*	9
Polychaeta	100	*Gastropoda*	47	*Pisces*	12	*Caprellida*	6
Bivalvia	100	*Hydroidea*	44			*Ophiuroidea*	6
Actinia	91	*Nemertinea*	38			*Isopoda*	3
Cumacea	84	*Echinoidea*	25			*Ascidiacea*	3
Decapoda	66						

As in 2003, groups with a frequency of occurrence greater than 50% form the basis of the benthos biomass throughout the waters of the Offshore Area: amphipods, cumaceans, bivalve mollusks, marine worms and sea anemones. There are also groups with a lower frequency of occurrence throughout the area which nevertheless form local sections with very high biomass – sand dollars *E. parma* (P = 28%). For the Offshore Area as a whole, these taxonomic groups account for more than 95% of the average total benthos biomass – 899.1±85.8 g/m^2 (n=32). Figures for the quantitative abundance of benthos for the Offshore Area in 2004 are given in Table 14.

Analysis of the total average benthos biomass and the biomass of individual groups for the 2004 and 2003 collections indicates that statistically significant differences in the average values are observed in a number of cases. The average total benthos biomass was reliably higher in 2004 than in 2003 (899.1±85.8 g/m^2 and 630.1±64.3 g/m^2, respectively; t-test, t = 3.46, df = 62, $p < 0.05$). Statistically significant differences in the overall distribution of total biomass are due to the fact that the study area was expanded eastward in 2004 in response to the observed distribution of whales in 2003. This was done to outline the area of elevated amphipod biomass. Accordingly, quite a few stations with high biomass were sampled.

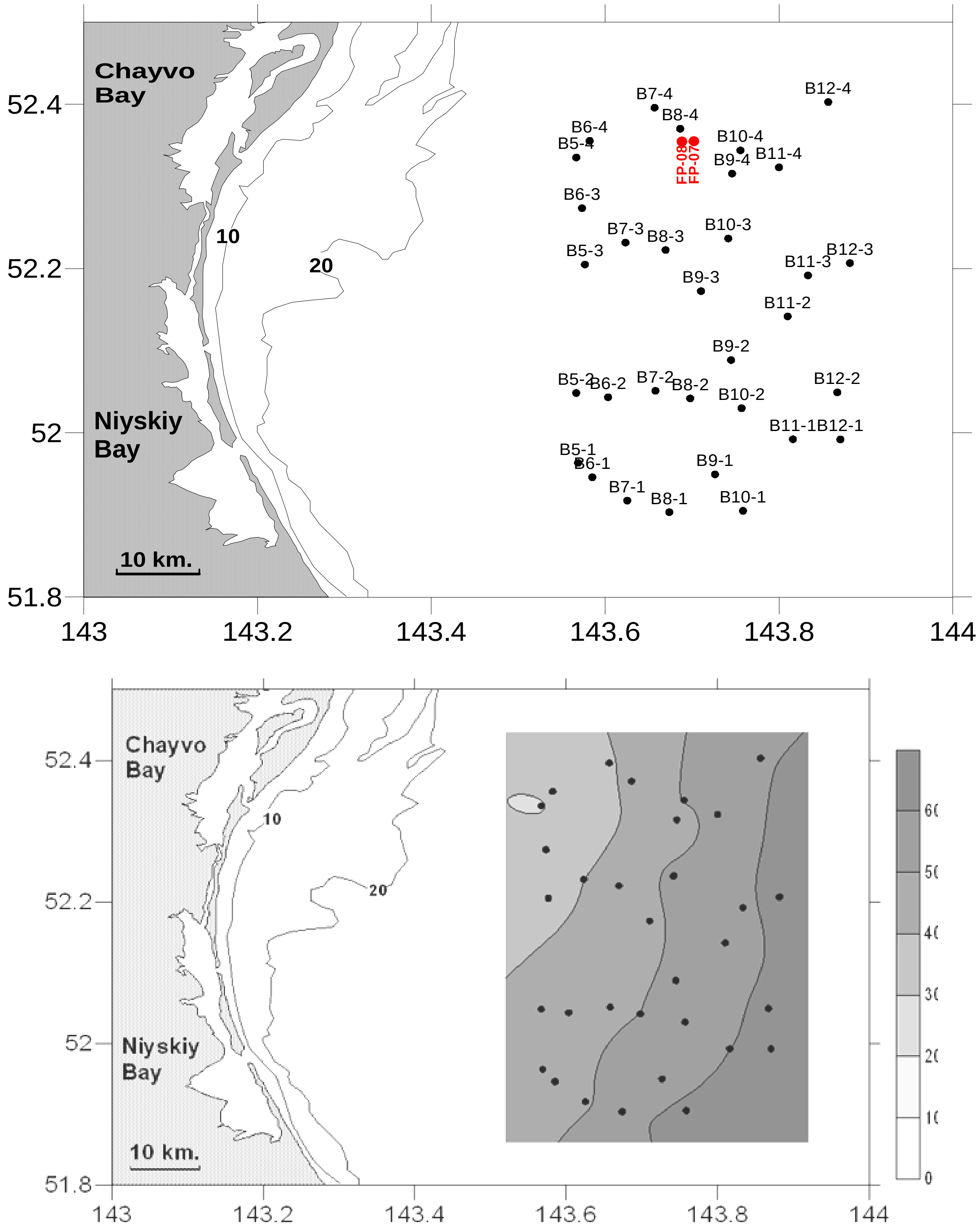


Figure 23. Diagram of station locations in the Offshore Area (top) FP are whale feeding points) and depth distribution (m) of individual stations (bottom) in 2004.

The biomass of the main groups (amphipods, bivalve mollusks, sea anemones and cumaceans) in 2004 was comparable to the 2003 data. The biomass of amphipods – the most important component in the diet of whales in the Offshore Area – was 328.5±41.2 g/m^2 and 343.8±52.8 g/m^2, respectively, in 2004 and 2003. Year-to-year variations in the average amphipod biomass are not statistically significant ($p = 0.11 > 0.05$).

Table 14. Macrobenthos biomass distribution (B, g/m^2) in the Offshore Area based on materials from 2003-2004 field work.

Groups	Depth										Entire Area (**Bsumm**)	
	Amphipoda		*Actinia*		*Bivalvia*		*Echinoidea*		*Polychaeta*			
	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003
Average B	**328.5**	**343.8**	184.6	83.6	114.1	73.7	164.2	50.9	42.7	15.6	899.1	630.1
Standard deviation	41.2	52.8	42.1	17.3	19.5	12.8	74.2	14.4	22.8	7.8	85.8	64.3
Proportion, % of **Bsumm**	36.5	54.6	20.5	13.3	12.7	11.7	18.3	8.1	4.7	2.5	100%	100%
Minimum	0.4	2.7	0	0	5.4	0	0	0	0.1	0	196	63.6
Maximum	1094	1237	1169	453	370.4	296.2	1548	457	739.8	282.5	2204	15514
P, %	100	100	91	60	100	93	25	26	100	90		
Number of stations	32	36	32	36	32	36	32	36	32	36		

The spatial distribution of benthos biomass was similar in 2004 and 2003. Amphipod biomass increases in moving from shore toward deeper water (Figs. 26, 27). A similar trend was observed in 2002. The 2004 expedition succeeded in outlining the zone of the highest amphipod biomass levels (Figure 27A). In moving eastward from the maximum biomass zone, there is a sharp decrease in the quantitative abundance of amphipods. There is a parallel gradual increase in the proportion of aleurite-pelite fractions.

The other groups (sea anemones, bivalve mollusks and cumaceans) that make up most of the biomass have a distinctly spotty distribution.

As in 2002-2003, accumulations of bivalve mollusks, sea anemones, cumaceans and sand dollars have the most aggregated distribution. Higher biomass areas of these groups are on the edge of the amphipod mass development zone (Figures P1.9 and P1.12). The nature of the distribution of total benthic colony density is determined by specific features of the distribution of cumaceans and amphipods. The macrobenthos high-density zone coincides with cumacean colonies in the eastern part of the area and with areas of amphipod mass development in the western part.

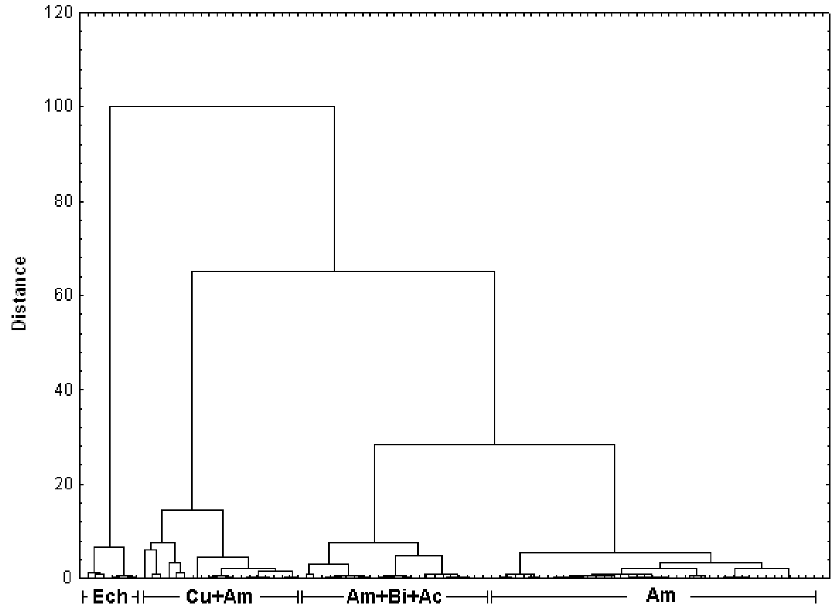


Figure 24. Dendrogram of the similarity of stations in the Offshore Area in 2002-2004 according to macrobenthos structure.

Table 15. Quantitative characteristics (g/m^2) of macrobenthos complexes in the Offshore Area based on materials from 2002-2004 (72 stations)

Parameter	Taxonomic Group					Average total biomass (**Bsumm**)
	Amphipoda	*Actinia*	*Bivalvia*	*Echinoidea*	*Cumacea*	
1. Complex *Ampelisca eschrichti* (Am)						
Average biomass	**733.38**	197.66	154.52	6.26	30.91	1123.81
Standard deviation	42.56	35.21	32.31	4.09	5.86	68.9
Proportion in **Bsumm**, %	65.3	17.6	13.8	0.6	2.8	100%
2. Complex *Diastylis bidentata* + *Amphipoda* (Cu+Am)						
Average biomass	**150.3**	14.64	18.12	20.89	**245.69**	455.72
Standard deviation	53.48	10	8.13	14.37	59.18	94.26
Proportion in **Bsumm**, %	33	3.2	4	4.6	53.9	100%
3. Complex *Ampelisca eschrichti* + *Bivalvia* + *Actinia* (Am+Bi+Ac)						
Average biomass	**356.06**	**259.77**	**237.44**	0	27.55	927.56
Standard deviation	55.12	60.47	59.91	0	7.13	124.7
Proportion in **Bsumm**, %	33.4	23.3	32.4	0	11	100%
4. Complex *Echinarachnius parma* (E. parma)						
Average biomass	59.68	120.2	50.47	**724.18**	48.67	1015.32
Standard deviation	20.31	54.7	24.09	117.23	22.22	155.54
Proportion in **Bsumm**, %	5.9	11.8	5	71.3	4.8	100%

4.2.2. Composition and Distribution of Benthos Complexes in the Offshore Area Based on Materials from 2004 and 2003

Based on materials from 2002-2003 (72 stations), three macrobenthos complexes were distinguished in the Offshore Area: the sand dollar complex, the cumacean and amphipod complex, and the ampeliscid amphipod complex. The latter occupies the largest part of the water area and is of great importance as an active feeding ground for gray whales (Fadeev, 2004).

All the stations of 2004 and 2003 were grouped according to similarity of the quantitative relationships among benthos taxonomic groups. A similar approach was used in classifying the stations of the Piltun Area (Section 4.1.3). The classification results are illustrated with a dendrogram (Figure 24). Based on materials from 2002-2004, four benthos complexes are distinguished in the Offshore Area (Table 13):

I. Complex with dominance of <u>sand dollars *Echinarachnius parma*</u>. The average depth was 31.5±1.8 m (12 stations at depths of 18-47 m). Sand dollars are dominant at all stations, with an average biomass of 724 g/m^2 (more than 85% of the total biomass of the complex).

This complex was described in the Piltun Area at depths greater than 20 m based on data from 2001-2003. According to materials from 2002-2003, it occupies local sections in the Offshore Area in the northern part of the water area (Figure 25).

Based on published data (Averintsev et al., 1979), there is a gigantic subarctic-latitude association of the sand dollar *Echinarachnius parma* in the area of northeastern Sakhalin Island at depths of 15-120 m which occupies an area of about 13,000 km^2, i.e., about 40% of the shelf area, off eastern Sakhalin. The *E. parma* community is associated with shallow sandy bottoms and silted sands, where bottom currents with sufficiently high speeds are present (Koblikov, 1983a,b). As the current speed decreases southward along the eastern Sakhalin shelf and bottom silting increases, the sand dollars replaced by other species. Mobile seston-feeders (flat sea urchin, etc.) settle primarily on sands and coarse silts, with an organic matter content of 0.5-1.0% and a concentration of suspended matter in the seabed water of about 20 mg/l (Kuznetsov, 1964). According to observations conducted in 1995-1996, the content of suspended matter in the water column varied from 0.93 to 11.8 mg/l, with suspended matter of biological origin prevalent (CSA, 1996, 1997). Significant bottom areas occupied by the *E. parma* community have been discovered on the western Kamchatka shelf (Neyman, 1988), and, as researchers note, the northern boundary of the *E. parma* area has advanced more than 20 miles to the north. They connect the cause of such changes with an indirect anthropogenic effect – over harvesting of the Kamchatka crab and flounder (which feed on the sand dollars, which has resulted in disruption of the balance in the "predator-prey" system.

II. Complex with dominance of <u>cumaceans *Diastylis bidentata*</u> and <u>amphipods *Ampelisca eschrichti*</u>. The average depth is 28.6±1.8 m (14 stations at depths of 24-31 m). The average total biomass of the complex is 455.72±94.3 g/m^2, and the dominant species account for more than 80% of the biomass (cumaceans – 58.7%; and amphipods – 23%). The complex occurs in patches at depths of 24 to 31 m in the western part of the area, on fine-grained and mixed sands. Amphipod *A. eschrichti* is a subdominant species with biomass of 151 g/m^2.

The distribution of cumaceans was considered in describing the Piltun Area (section 4.1.1), also based on data from 2001 (Fadeev, 2002). Based on materials from 2002, the relationship between the colony density of cumaceans *D. bidentata* and amphipods *A. eschrichti* in the Offshore Area was examined. The amphipod colony density decreased, while the cumacean colony density increased, as the depth increased (Fadeev, 2003). Ampeliscid amphipods and cumaceans are seston-feeders and filter-feeders; i.e., both species obtain nutrition by filtering the seabed water. In areas of greatest abundance, their density reaches enormous values: cumaceans, up to 87,000 spec./m^2; and amphipods, more than 31,000 spec./m^2. It could be expected that competition for food supplies would result in a spatial separation between accumulations with the highest biomass levels of amphipod *A. eschrichti* and cumacean *D. bidentata*.

Analysis of benthos at gray whale feeding sites in the Offshore Area based on materials from 2002 indicated that the whales fed in areas where this complex was dominant in a number of cases (Fadeev, 2003). However, the question of the possibility of gray whales' using cumaceans for their diet remains unsettled. It is known that there is a threshold amphipod body size (6-8 mm, according to: Rice and Wolman, 1973; Nerini, 1984) below which they cannot be used for feeding. If this principle is valid for other crustaceans as well, it is worth noting that the cumaceans in collections from the Offshore Area are significantly smaller. The relationship between the sizes of cumaceans and amphipods can be judged based on the bottom grab sample fragment in Photo 4.

On the other hand, quite a high ampeliscid biomass level was observed in this complex (based on data from 2002-2003, more than 150 g/m^2). Gray whales may feed in the areas of this complex within the ampeliscid pockets.

III. Complex with dominance of amphipod *Ampelisca eschrichti*. The average depth is 52.6±1.9 m (43 stations in the range of 30-65 m). The complex occupies the eastern part of the Offshore Area. The average biomass is 1123±68 g/m^2, and the biomass of the dominant group – amphipods – is more than 730 g/m^2 (65% of total biomass). The complex includes 35 species, of which 14 species are found only in the Offshore Area. One species – *A. eschrichti* – is distinctly dominant in regard to frequency of occurrence, colony density and biomass. Its biomass makes up 95-100% of the total amphipod biomass at certain individual stations. The maximum ampeliscid biomass had similar values in 2002 and 2003: 1312 and 1237 g/m^2, respectively, at 100% frequency of occurrence in the collections.

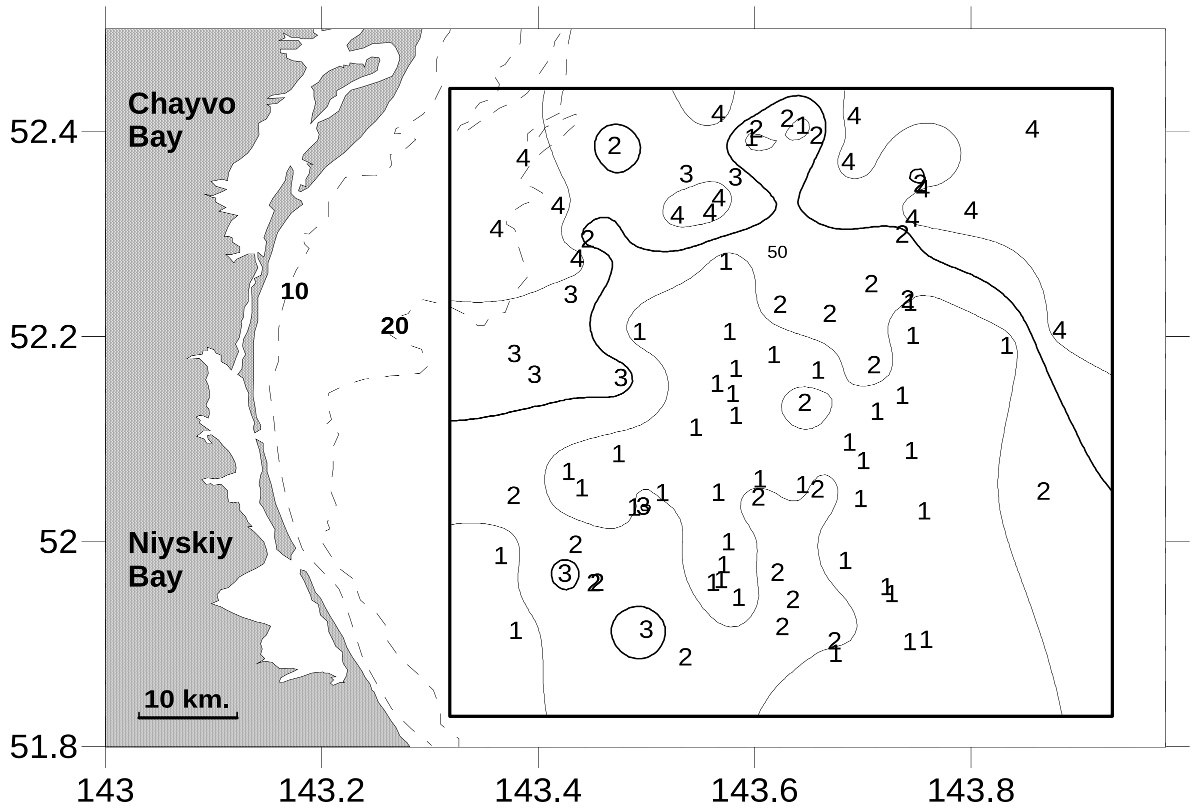


Figure 25. Distribution of benthic complex in the Offshore Area. The numbers follow the numbering of the complex in Table 16.

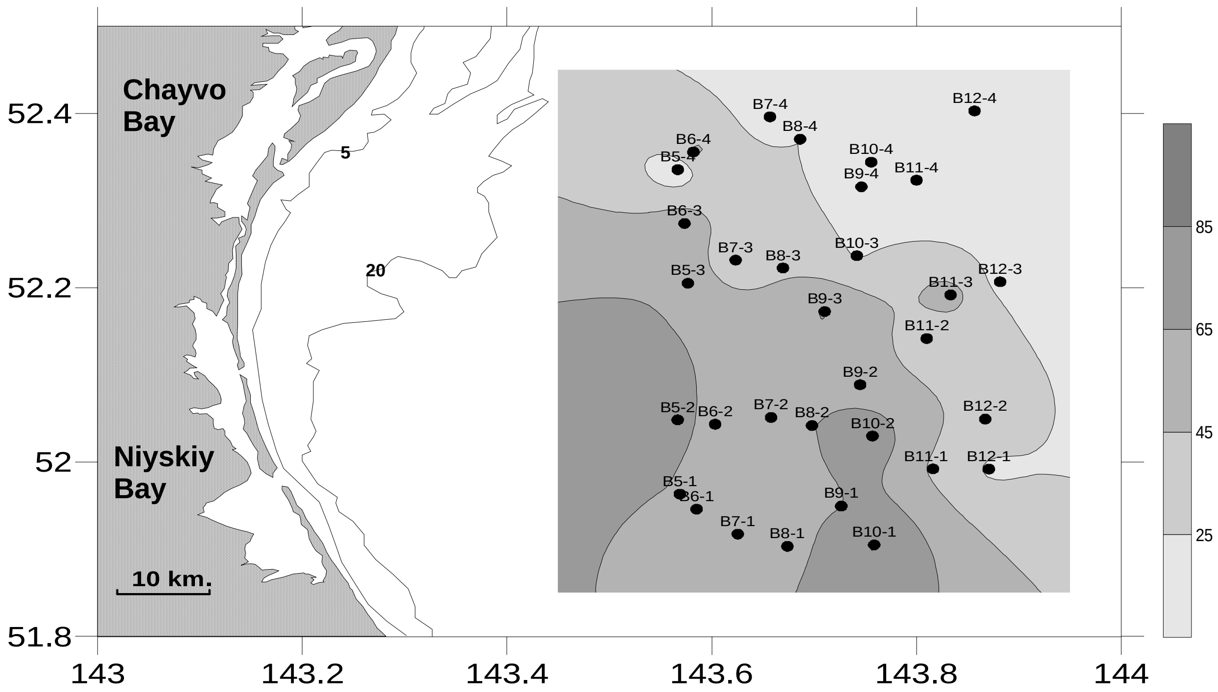


Figure 26. Proportion of ampeliscid amphipods in the total benthos biomass in the Offshore Area based on 2004 data.

Materials from 2003 and 2004 from the Offshore Area (Table 15) make possible to conclude that quantitative abundance levels for *A. eschrichti* are high. The ampeliscid colony density and biomass in the area are comparable to, and in some cases exceed, the values in benthos of other highly productive areas of the North Pacific (Kuznetsov, 1964; Koblikov, 1983a, b, 1986; Makarov, 1937) and eastern gray whale feeding grounds (Stoker, 1981; Nerini and Oliver, 1983; Oliver et al., 1983; Dunham and Duffus, 2001, 2002). In contrast to the dominant species in the amphipod complex of the Piltun Area, the ampeliscids live in tubes attached to the bottom in areas with significant bottom currents (Mills, 1967; Wildish and Kristmans, 1997).

The ampeliscid size composition was analyzed based on materials from 2004 and 2001-2003. The average body length was 11.38±0.43 mm in 2001 (n = 210) and 13.78±0.31 mm in 2002 (n = 2015). More than 90% of the individuals have a body size larger than 6 mm, which supports the suitability of the ampeliscid colonies in the Offshore Area for gray whale feeding. The average body length in 2003 was 14.1±0.26 mm (n = 592). The distribution of ampeliscid body sizes was similar in 2003 and 2004. The average ampeliscid body length in 2004 was 13.91±0.41 mm (n = 610), and the proportion of individuals with body sizes larger than 6 mm is 83%.

IV. Complex with dominance of amphipod *A. eschrichti*, bivalve mollusks and sea anemones. Photo 5 shows a fragment of a bottom grab sample taken within the complex. The average depth was 37.1±2.2 m (19 stations in a range of 23-47 m). The complex occurs in patches on the edge of the ampeliscid complex. The average biomass of the complex is 927 g/m^2. Ampeliscids, bivalve mollusks and sea anemones account for about 95% of the biomass of the complex. The complex includes 20 recorded species of bivalve mollusks. Two species have the highest frequency of occurrence: *Serripes groenlandicus* (P = 52%) and *Liocyma fluctuosum* (41%).

The dominant species in regard to biomass in the benthos complex – amphipods *Ampelisca eschrichti* and bivalve mollusks *S. groenlandicus* and *L. Fluctuosum* – are classified according to feeding type as seston-feeders and filter-feeders of the seabed water and are associated with hydrodynamically active sections of the shelf. A high seston concentration in the seabed water and the presence of steady bottom currents that facilitate seston transfer are necessary conditions for their existence. Sea anemones, which are predators according to feeding type, are also involved with the transfer of food particles by bottom currents. Active seabed hydrodynamics promotes the transfer of larvae from existing sestonophage colonies to new areas and leads to a patchy (spotty) distribution.

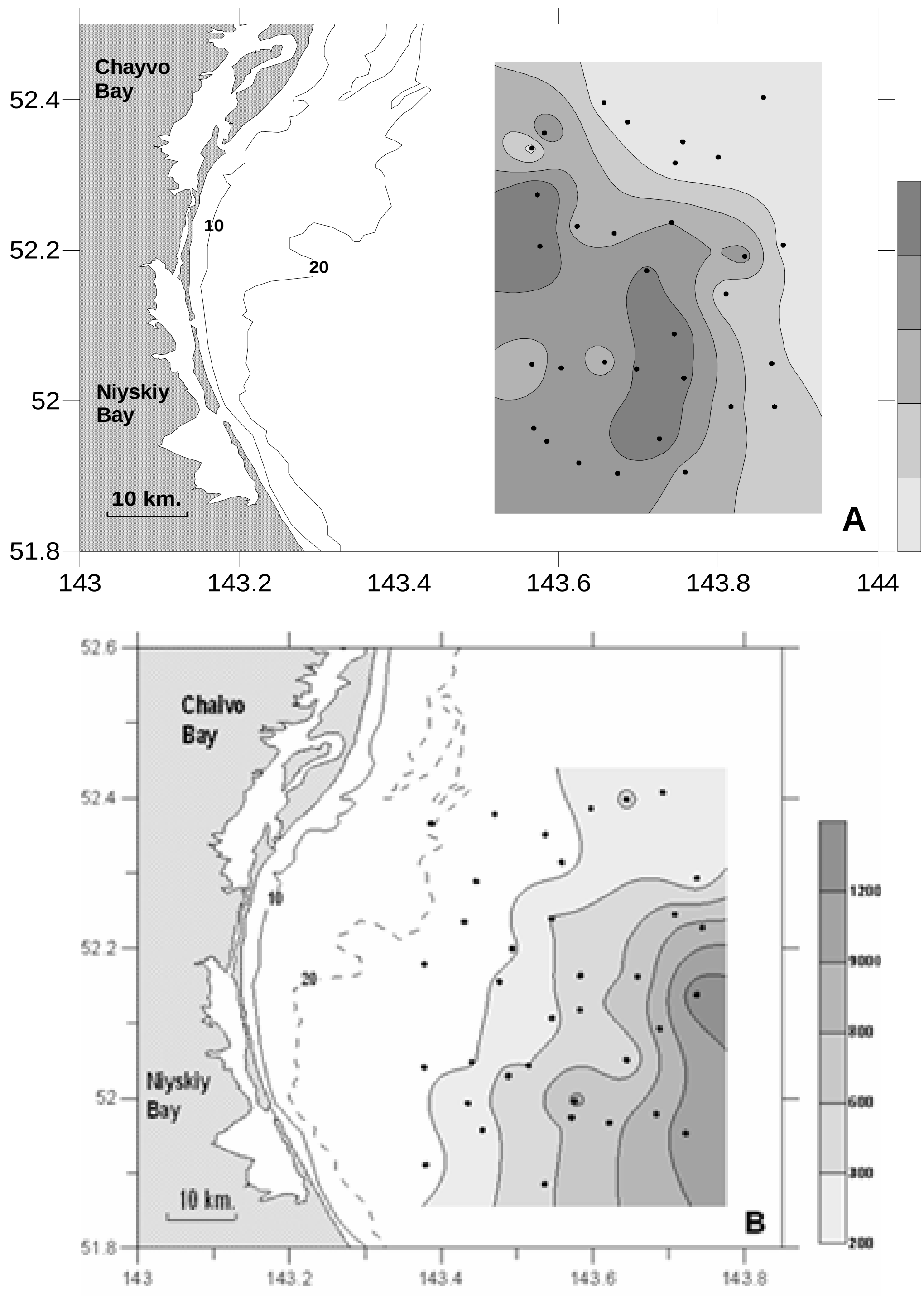


Figure 27. Ampeliscid amphipod biomass distribution (g/m^2) in the Offshore Area in 2004 (A) and 2003 (B).

Photo 5. Bottom grab sample (0.2 m^2) from the cumacean and ampeliscid complex.

Photo 6. Bottom grab sample (0.2 m^2) with sea anemones and ampeliscids.

4.3. Benthos at Gray Whale Feeding Sites

Bottom grab samples were collected at gray whale feeding sites in the Piltun and Offshore areas for the first time in 2002. There were 46 sampling stations: 21 stations in the Piltun Area, and 25 stations in the Offshore Area. The average biomass at whale feeding sites in the Piltun Area was 234.4 g/m^2. Amphipods and isopods accounted for more than 50% of the total biomass. Whale feeding sites in the Offshore Area were located at depths of 33 to 45 m. The average biomass was 1228 g/m^2, with ampeliscids accounting for up to 560 g/m^2 (Fadeev, 2003). There were 51 stations at whale feeding sites in 2003: 12 stations in the Piltun Area, and 39 stations in the Offshore Area. Based on 2003 data, the average depth of the feeding sites in the Piltun Area was 18.6±1.6 m. The average benthos biomass at feeding sites was 164.2 g/m^2, with amphipods and isopods accounting for 79% of the biomass. Most of the whales foraged at depths less than 20 m in 2002 and 2003 (Fadeev, 2004).

4.3.1. Whale Feeding Sites in the Piltun Area

In 2004, 50 whale feeding sites were studied in the Piltun Area at depths of 14-35 m (Figure 28). The average depth of the whale feeding sites inspected in 2004 was 23.5±0.9 m, which differs substantially from the data for 2003 – 18.6±1.6 m – and 2002 – 19.5±1.5 m.

The whale feeding sites inspected in 2004 were selected by two methods: some of the sites were identified during observation of whales from the ship (stations PP1-28 according to the sample Log), and the rest were identified during photoidentification work from aboard the Zodiac motorboat (stations FP 01-30 according to the sample Log). It was primarily sites at depths greater than 20 m that were investigated in this process, due to redistribution of some of the whales to these depths during the study period. All the sites were identified during work from the motorboat in 2002-2003, and sampling covered all depth ranges and reflected the distribution of feeding whales in the survey waters.

Therefore, the sampling of feeding sites for 2004 was artificially "shifted" to greater depths and does not reflect the actual distribution of feeding whales throughout the water area. As in previous years, most of the whales in the Piltun Area foraged at depths less than 20 m. The "shift" of the whale feeding site sampling to depths greater than 20 m in 2004 can easily be traced in histograms of the distribution of stations by depths (Fig. 28). Bear in mind in analyzing the materials from the 2004 feeding sites that the errors in determination of the coordinates of whale feeding sites by a vessel-based observer were inevitable. A vessel-based observer cannot visually record "prey patches," and whales diving in search of a prey patch can be classified as "feeding whales" in this case. The distance to a diving (feeding) whale is determined visually, after which the coordinates of the feeding site are defined according to a navigation chart. The visually determined distance to the whale is from 1 km (minimum distance for the vessel's approach to the whale) to 3-6 km; naturally, there can be substantial errors in the feeding site coordinates obtained as a result. Keep in mind, in addition, that errors are inevitable in positioning the vessel at the feeding site to perform bottom grab sampling based on the coordinates. Both "prey patches" at a whale feeding site and the coordinates of the site can be recorded more clearly in identifying whale feeding sites from the Zodiac during photo-ID work. In this process, sampling can be performed either from the ship or directly from the Zodiac, depending upon the depth.

Materials from 39 (111 samples) of 59 stations were used for analysis of benthos at gray whale feeding sites. The sea bottom at 13 stations in the depth range of 25-35 m, based on underwater videography data and bottom grab samples, is made up of dense gravel/pebble fields. Benthos in such soils has the form of sessile epibenthic fauna – sponges, hydroids, etc. According to video data and samples of the epibenthic system, there are no accumulations of planktonic or epibenthic fauna in the bottom layers or the water column.

Practically all the stations at whale feeding sites in 2004 at depths of 15-20 m (14 stations, 42 samples) are classified as associated with the coastal amphipod complex in regard to the benthos structure (see section 4.1.3). The average benthos biomass there is 139.5±30.5 g/m^2, with the following accounting for most of the biomass: ampihpods (78.6±8.5 g/m^2), isopods (15.2±4.3 g/m^2) and bivalve mollusks (33.5±11.5 g/m^2). More than 95% of the amphipod biomass is made up of *Eogammarus schmidti.*

Data from 23 bottom sampling stations (69 samples) and underwater video of the bottom water layer and the surface of bottom sediments at these stations were used to analyze the benthos composition at feeding sites at depths greater than 20 m. Two complexes are widespread in the Piltun Area at depths greater than 20 m: 1 – bivalve mollusks, and 2 – flat sea urchins (Fadeev, 2003, 2004). It follows from Figure 21 that most of the bottom area is occupied by the complex of flat sea urchins, the sand dollar *Echinarachnius parma,* which is characterized by low levels of quantitative abundance of prey benthos (Table 12). Benthos prey groups are unevenly distributed within the flat sea urchin community. For example, local areas with high biomass of large isopods *Saduria entomon* (more than 30 g/m^2) were found within the sea urchin community based 2003 data. Such accumulations were observed at six stations, but at each of the stations, isopods were present in only one bottom grab sample of the three taken at the station. Flat sea urchins without isopods, with biomass up to 1200 g/m^2, were dominant in the other two samples at these stations. The proportion of samples with isopod dominance in the biomass is only 6% in the zone deeper than 15-20 m in

2003 and less than 3% including the bottom grab collections from 2002. It was concluded that despite the low frequency of occurrence of local accumulations of large isopods at depths greater than 15-20 m, they can be used for feeding by individual whales; however, they are not a regular food resource (Fadeev, 2004).

The average biomass of individual benthos groups at a station, calculated based on three bottom grab samples, yields an approximate assessment of the variability of quantitative abundance figures for benthos. At the same time, due to microscale aggregation of benthos, each individual sample can characterize a specific section of the bottom within the community. Therefore, we analyzed benthos in 69 separate bottom grab samples from whale feeding sites at depths greater than 20 m. In 52 of the 69 samples (75%), flat sea urchins were dominant in regard to biomass (dominance index of 50 to 99%). Of the other 17 samples (24.6%), bivalve mollusks were prevalent in nine (13%); i.e., the composition of biota there was similar to the bivalve mollusk complex. Of the other eight samples, the fish Pacific sand lance *Ammodytes hexapterus* has the greatest biomass (from 72 to 392 g/m^2) in four (5.8%), the amphipod *Eogammarus schmidti* is dominant in two samples (122-153 g/m^2), and the isopod *Saduria entomon* is dominant in two (87.8 and 69.7 g/m^2). Hence 11% of the samples within the dominance zone of flat sea urchins had high prey benthos levels, which reflects microaggregation in the macrobenthos distribution. The isopod *Saduria entomon* and the amphipod *Eogammarus schmidti* also have high abundance levels at whale feeding sites in the shallow-water zone of the Piltun Area (Fadeev 2003, 2004). A significant increase was observed in the frequency of occurrence and biomass in accumulations of the Pacific sand lance *Ammodytes hexapterus* in 2004 (compared to 2001-2003), primarily in the northern part of the Piltun Area (Photos 6 and 7). Macroaggregation of the distribution of amphipod, isopod and sand lance accumulations in the Piltun Area based on 2004 materials is illustrated in Figure 29. The distribution of local accumulations of these groups in the northern part of the area has a definite similarity to the locations of points at which whales were recorded during the summer period in 2004.

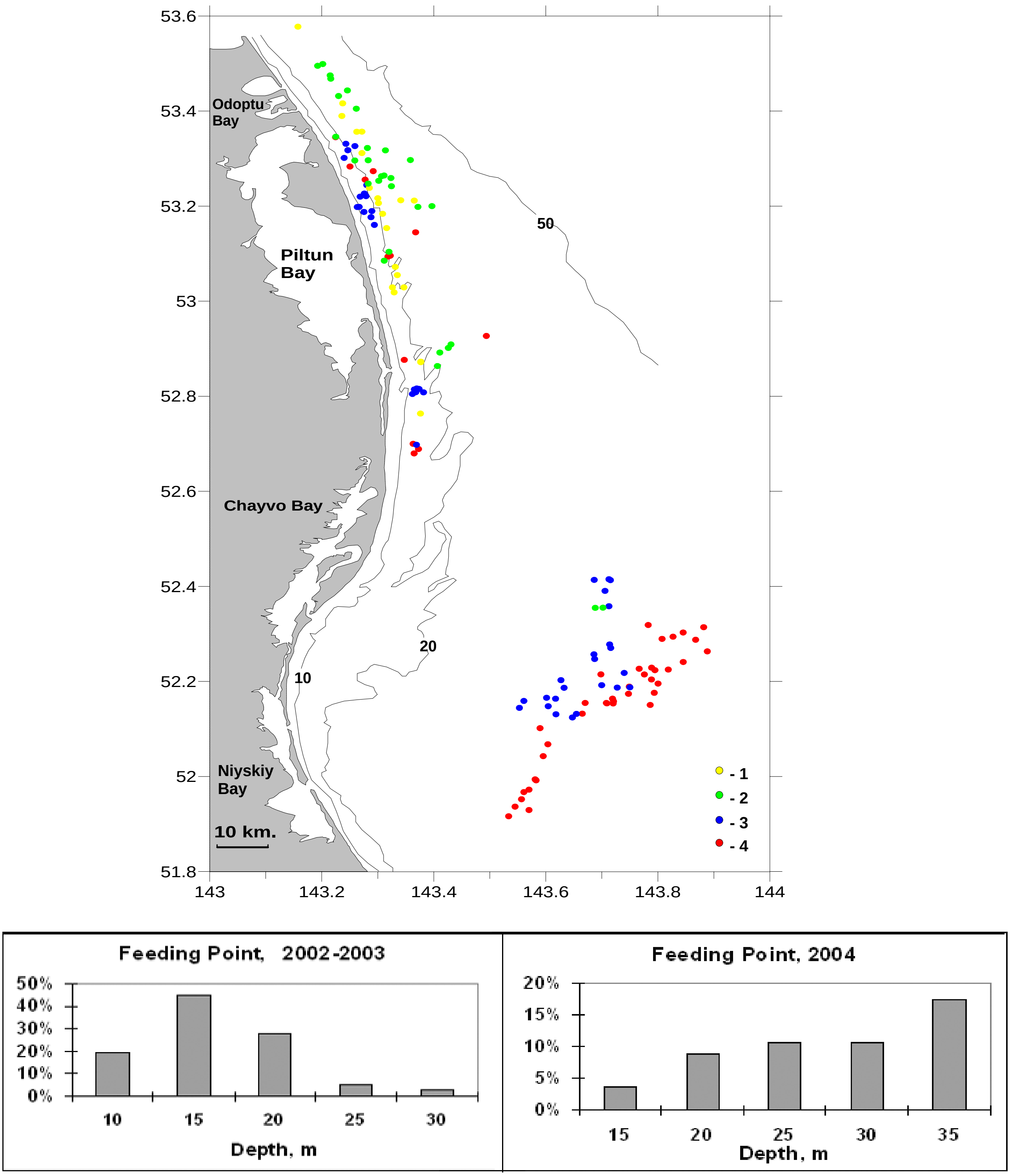


Figure 28. Chart of the locations of gray whale feeding sites studied in 2002-2004 and the distribution of feeding sites by depths in the Piltun Area in 2002-2004.

1 – whale feeding sites in 2004 (based on observations from the Zodiac during photo-ID of whales);
2 – whale feeding sites in 2004 (based on observations from the ship);
3 – whale feeding sites in 2002; and
4 – whale feeding sites in 2003.

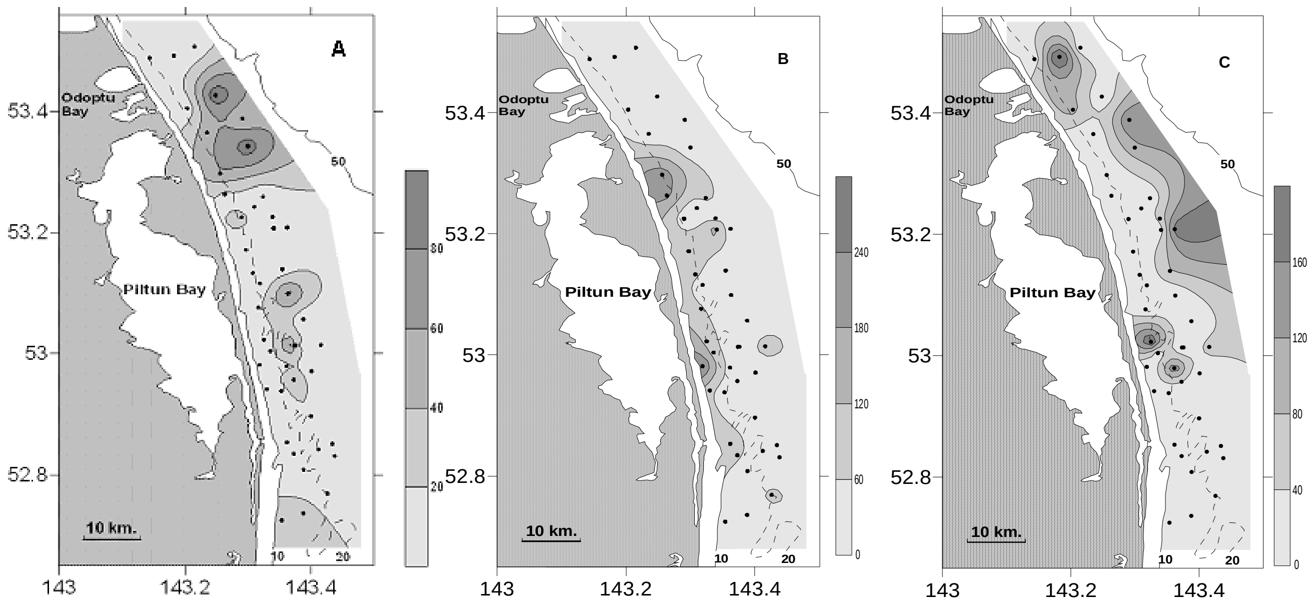


Figure 29. Charts of the locations of local accumulations of isopods (A), amphipods (B) and the Pacific sand lance *Ammodytes hexapterus* (C) in the Piltun Area in 2004.

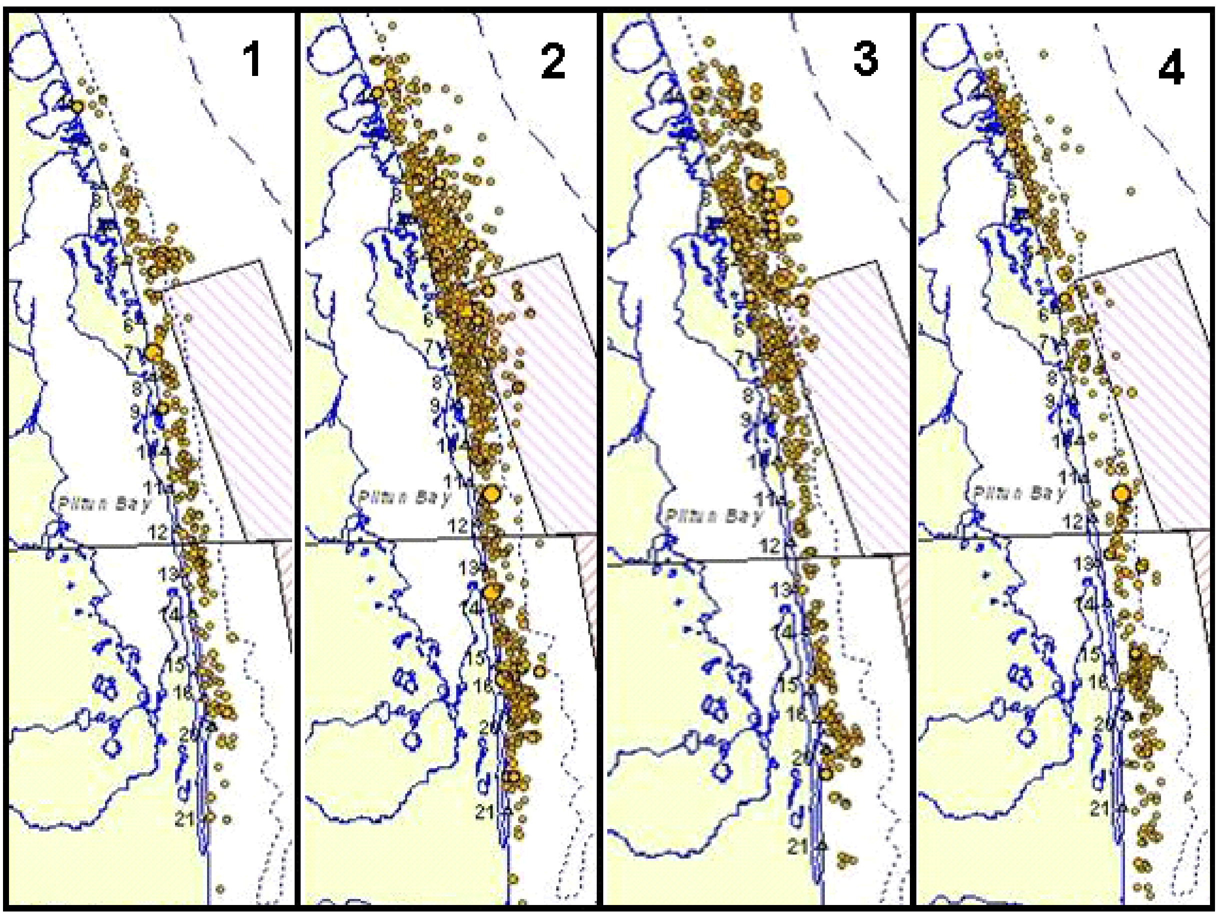


Figure 30. Distribution of whale sightings based on shore-based observation data (Vladimirov, 2005).

1 – up to July 24;
2 – July 25 – September 5;
3 – September 5 – September 23;
4 – after September 30.

4.3.2. Whale Feeding Sites in the Offshore Area

Based on 2003 data, gray whales foraged in the Offshore Area at depths of 41-63 m (50.8±0.9 m, on the average) in the ampeliscid amphipod dominance zone. Benthos at whale feeding locations had high biomass values (up to 1351 g/m^2) and averaged 605 g/m^2. Six benthos groups had a frequency of occurrence higher than 75%: amphipods, sea anemones, bivalve mollusks, polychaeta, decapoda, crustaceans and cumaceans. These groups accounted for 98% of the average biomass at whale feeding sites. The proportion of ampeliscids in total amphipod biomass varied from 95 to 100% (Fadeev, 2004).

Only two feeding whales were observed in the Offshore Area in 2004; the locations of the feeding sites are shown in Figure 23. As indicated in section 3.2, the quantitative abundance levels of benthos in the Offshore Area in 2004 did not differ substantially from the 2003 data. Taking into account the data on the low concentrations of key pollutants in the sediments of the Offshore Area (section 3.4), one can conclude that the very small number of gray whales feeding in the Offshore Area in 2004 is not related to the benthos status.

Table 16. Benthos Colony Density (A, spec./m^2) and Biomass (B, g/m^2) at Gray Whale Feeding Sites in the Offshore Area in 2004.

Parameter	***Amphipoda***		***Actinia***		***Bivalvia***		***Polychaeta***		***Decapoda***		***Cumacea***		***Total Average***	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Average	1005	270.1	220	215.7	60	113.9	10	25.7	5	20.4	5270	32.1	6576	751.5
Standard deviation	285	25.4	30	50.3	25	102.8	5	12.1	0	11.1	3480	21.5	674	131.9
Minimum	235	42.3	130	203.5	0	0	0	0	0	0	45	0.21	0	0
Maximum	2280	431	295	492.5	130	604.5	30	78	15	69	22160	136.5	22160	604.5

All the benthos groups found at the two whale feeding sites are common in the benthos of the Offshore Area and are included in the complex *A. eschrichti + Bivalvia + Actinia* (Table 14). Feeding of gray whales within on benthos characterized by this complex was observed in 2002 and 2003.

The sharp decrease in the number of whales feeding in the Offshore Area in 2004, while high prey benthos abundance levels were preserved, can may indicate that the Offshore Area is a secondary feeding ground and is used by the gray whales during periods of reduced prey benthos biomass (consumption or seasonal or year-to-year changes in biomass) in the main feeding ground – the Piltun Area, or it could indicate that the gray whales capitalized on a larger than normal biomass of available preysand lance in the Piltun Area..

4.3.3. Locations of Gray Whale Feeding Sites in Relation to Benthos Distribution

Piltun Area. In preparation of the chart in Figure 31, data of aerial observations on the locations of 446 whale feeding sites in the Piltun Area in 2001-2004 were used. The data were obtained by TINRO-Center associates S. A. Blokhin and N. V. Doroshenko. The chart also includes 82 whale feeding sites from vessel-based observations in 2002-2004 at which bottom grab samples were collected to study the benthos composition. Hence, the chart combines data on 528 gray whale feeding sites in the Piltun Area for the period 2001-2004.

Analysis of the distribution of benthos and the whale feeding sites according to aerial and vessel-based observations in 2001-2002 indicated that most of the whale feeding sites were located between the shoreline and the 20 m isobath, mainly along the 10 m isobath. The distribution of most of the feeding sites at depths less than 20 m is entirely consistent both with the results of the benthos study from 2002-2003 using the standard station grid and the benthos study results from the actual whale feeding sites (Fadeev, 2003, 2004). It was shown based on diving data from 2001 that the absolute biomass levels for gray whale prey benthos and the proportion of prey benthos in total benthos biomass are at a maximum at depths of 5-15 m (Fadeev, 2002). The results of bottom grab sampling in 2002-2003 confirmed that the greatest changes in the benthos distribution occur in the range of 15-20 m; a zone with prevalence of flat sea urchins is situated at depths greater than 20 m in the Piltun Area (Fadeev, 2004). Based on data from 2002 and 2003, three benthos complexes have been distinguished within the Piltun Area: a coastal amphipod complex, a complex with dominance of bivalve mollusks, and a flat sea urchin complex. The 20 m isobath was taken as the provisional boundary (Fadeev, 2004; section 4.1.3 of this report).

Including additional results from aerial surveys in the Piltun Area in 2003-2004 (Figure 31) hardly changes the conclusion that most of the whale feeding sites are located at depths less than 20 m. On the other hand, some feeding whales were observed at greater depths during the 2004 study period. This is supported by the data of shore-based observations (Figure 30). It was primarily feeding sites at depths greater than 20 m that were studied in 2004 (Figure 31). All these points are in the dominance zone of flat sea urchins. An extremely low proportion of prey organisms is characteristic of the flat sea urchin complex. According to bottom grab sampling results for 2002-2003, however, samples with quite high isopod biomass, caused by accumulations of the large isopod *Saduria entomon*, were observed in a number of cases at depths greater than 15-20 m (Fadeev 2004). The number of such stations did not exceed 6% of the total number of stations in 2003. Analysis of bottom grab samples from whale feeding sites in 2004 indicated that local accumulations of the

Pacific sand lance *Ammodytes hexapterus* may be observed, in addition to local patches of high isopod and amphipod biomass (Figure 29; Photos 6,and 7). The total proportion of such stations was 11% in 2004. The frequency of occurrence and biomass of the sand lance were significantly lower in 2001-2003 than in 2004. One can assume that year-to-year variations in the abundance of this species were observed in 2004. Based on diving results from 2001, this species was considered as potential prey (Fadeev, 2002). There are data indicating that the sand lance is used by gray whales in other areas (Zimushko and Lenskaya, 1970).

Hence, the limited number of feeding sites at depths greater than 20 m in the Piltun Area can be explained by feeding of whales in on local patches of crustaceans and potentially the sand lance.

Offshore Area. The chart of the locations of whale feeding sites in the Offshore Area (Figure 33) includes points from aerial observations in 2001-2004 and vessel-based observations in 2002-2004. Bottom grab samples were collected from the ship at these points to study the benthos composition. The chart of whale feeding sites was compared to a chart of the distribution of biomass of the main prey component in the Offshore Area – ampeliscid amphipods.

A zone of dominance of amphipod *Ampelisca eschrichti* was charted and the distribution of benthos complexes in the Offshore Area was defined (Figures 32 and 33) as a result of the eastward expansion of the sampling grid in 2004. Two complexes – ampeliscid amphipods, and ampeliscids+sea anemones+bivalve mollusks – occupy most of the sea bottom in the Offshore Area. Of the total area of the Offshore Area (2160 km^2), they occupy 35 and 33% (747 and 706 km^2). These complexes have the highest average caloric content of prey benthos at 946 and 515 $kcal/m^2$. Comparison of the chart the distribution of biomass for amphipod *Ampelisca eschrichti* and the feeding sites shows that most of the gray whale feeding locations in the Offshore Area (96%) are associated with sections with amphipod biomass of 200-300 g/m^2 or more (Fig. 33). It is noteworthy in this regard that most of the feeding sites are located north and west of the section with the highest prey benthos biomass levels. This distribution could be due to the fact that the sections with the highest biomass are located in a zone of maximum depths of 50 to 65 m; i.e., the whales feed primarily in a zone with biomass of 200-300 g/m^2 at depths of 35-45 m. Possibly the energy expenditures for reaching the food are optimized in this way.

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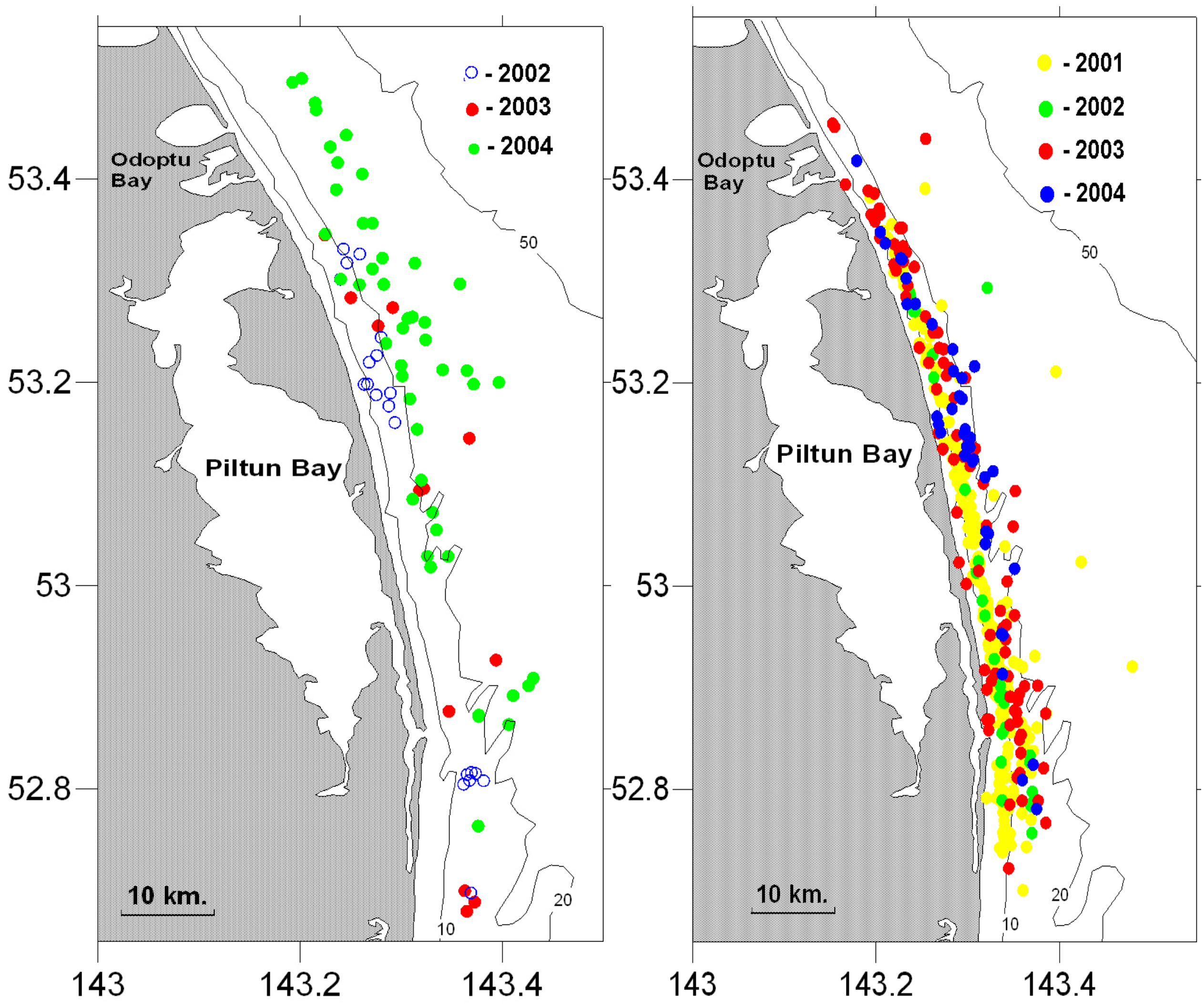

Figure 31. Chart of the locations of whale feeding sites in the Piltun Area:
- whale feeding sites according to aerial observations (right);
- whale feeding sites according to vessel-based observations and benthos collection stations at whale feeding sites (left).

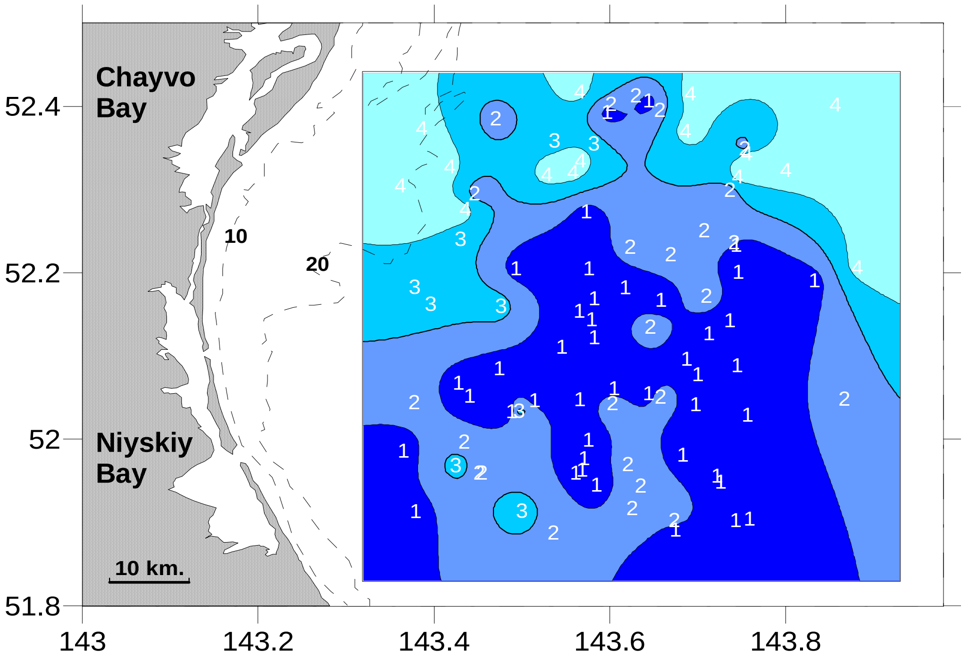

Figure 32. Distribution of macrobenthos complexes in the Offshore Area. The numbers correspond to the complex numbers in Table 15. Color gradations correspond to changes in the average caloric content of the complex.

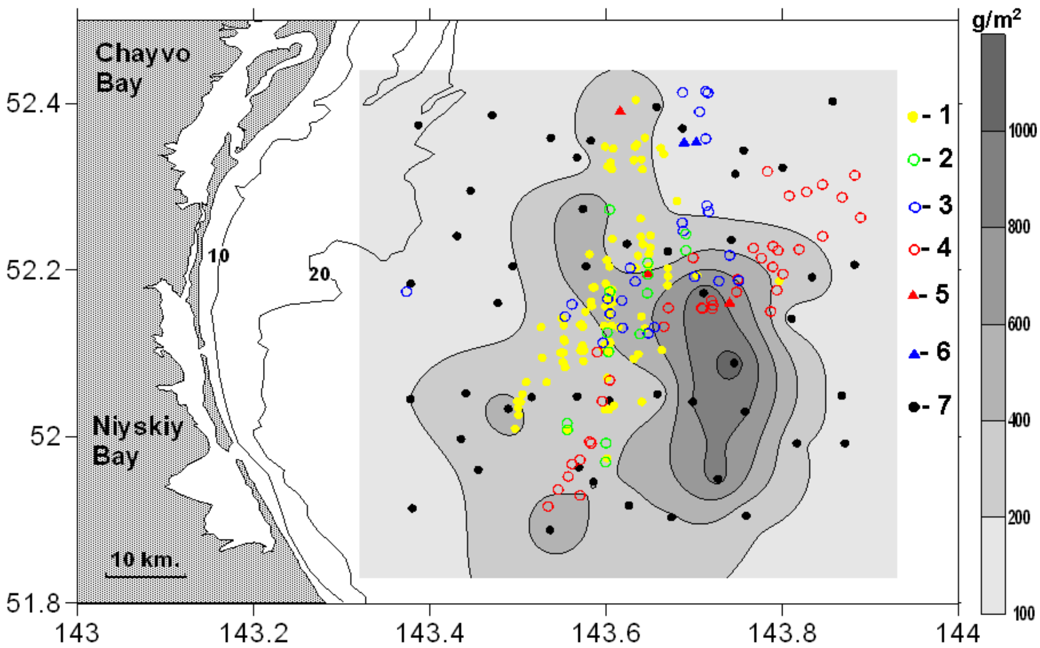

Figure 33. Chart of the biomass distribution for amphipod *Ampelisca eschrichti* (g/m^2) and whale feeding sites in the Offshore Area.

1, 2 – whale feeding sites according to aerial observations in 2001 and 2002;

3, 4 – benthos collection stations at whale feeding sites in 2002 and 2003;

5 – whale feeding sites according to aerial observations in 2004;

6 – benthos collection stations at whale feeding sites in 2004;

7 – standard benthos collection stations in 2004.

Photo 7. Bottom grab sample with Pacific sand lance *Ammodytes hexapterus* from the flat sea urchin zone in the Piltun Area.

Photo 8. Three bottom grab samples with dominance of the large isopod *Saduria entomon,* the Pacific sand lance *Ammodytes hexapterus* and young toad crabs *Hyas coarctatus* from the zone of the flat sea urchin complex in the Piltun Area.

5. Composition and Quantitative Distribution of Large Zooplankton in Whale Feeding Areas

Composition. Representatives of 16 hydrobiological groups of zooplankton were found in Bongo plankton net catches conducted along the Sakhalin coast (Figure 34): holoplankton and benthopelagic organisms, ichthyoplankton (fish roe and larvae) and larvae of benthic invertebrates (Table 17).

Coelenterata were represented by at least eight species of the Class Hydrozoa, of which only three species could be identified with certainty. Of Ctenophora, in addition to two normal species for the Sea of Okhotsk, *Beroe cucumis* and *Pleurobrachia pileus*, a ctenophore of the warm-water genus Bolinopsis was found.

Of Copepoda, 10 species were found. Large neritic species (genera Epilabidocera, Centropages, Tortanus) were represented only by mature individuals, while oceanic species (genera Calanus, Neocalanus) were represented only by stage V copepods. Small species were represented by adult individuals and copepodites.

The two Cladocera species, *Podon leuckarti* and *Evadne nordmanni*, were in the final stage of the active period: most of the population were gamogenetic females with winter eggs formed inside the body. Cladoceran crustaceans were also observed individually and laying eggs.

Of Pteropoda, two normal species for the Sea of Okhotsk were found; *Clione limacina* was represented only by adults, while *Limacina helicina* was represented by various size and age groups, from veliger up (the table only gives the density of individuals with diameters greater than 1 mm; the presence of young is indicated with plus signs).

Structure of zooplankton. A distinguishing feature of the status of zooplankton during the study period was the abundance (and prevalence in regard to count and biomass in the samples) of ctenophores, medusas and pteropod mollusks, along with the relative poverty of the species composition of other large holoplankton groups. According to community structure, three sample groups can be distinguished (Table 17, Figure 36): 1) samples taken in areas of accumulations ("patches," "strips") of the pteropod mollusk *Clione limacina*; 2) samples from outside such accumulations; 3) samples from the shallow littoral zone.

The pteropod mollusk *Clione limacina* formed the basis for count and biomass (the density of the species numbered thousands of spec./m^3) (Figure 35, Photos 9-11); the proportion of other organisms totaled less than 3% (in regard to count), and the number of taxons (species richness, variety) was minimal. In group 2 samples (stations Bon 6-27), *C.*

limacina (with a total density of a few spec./m^3) and hydromedusas were dominant in regard to count, and cumaceans, ctenophores, gammarids, copepods and mysids were subdominant; the community had greater species richness and variety. Hydromedusas (mainly due to *Aglantha digitale*) and ctenophores (due to *Pleurobrachia pileus*) were dominant in regard to count in group 3 samples, *C. limacina* was totally absent, and its main food – the pteropod mollusk *Limacina helicina* – was a subdominant species. In addition, the community in the near-shore zone was characterized by a high count of limacid young, greater copepod variety (both large and small) and high abundance of meroplankton (especially larval pluteus echinoderms) and cladoceran crustaceans.

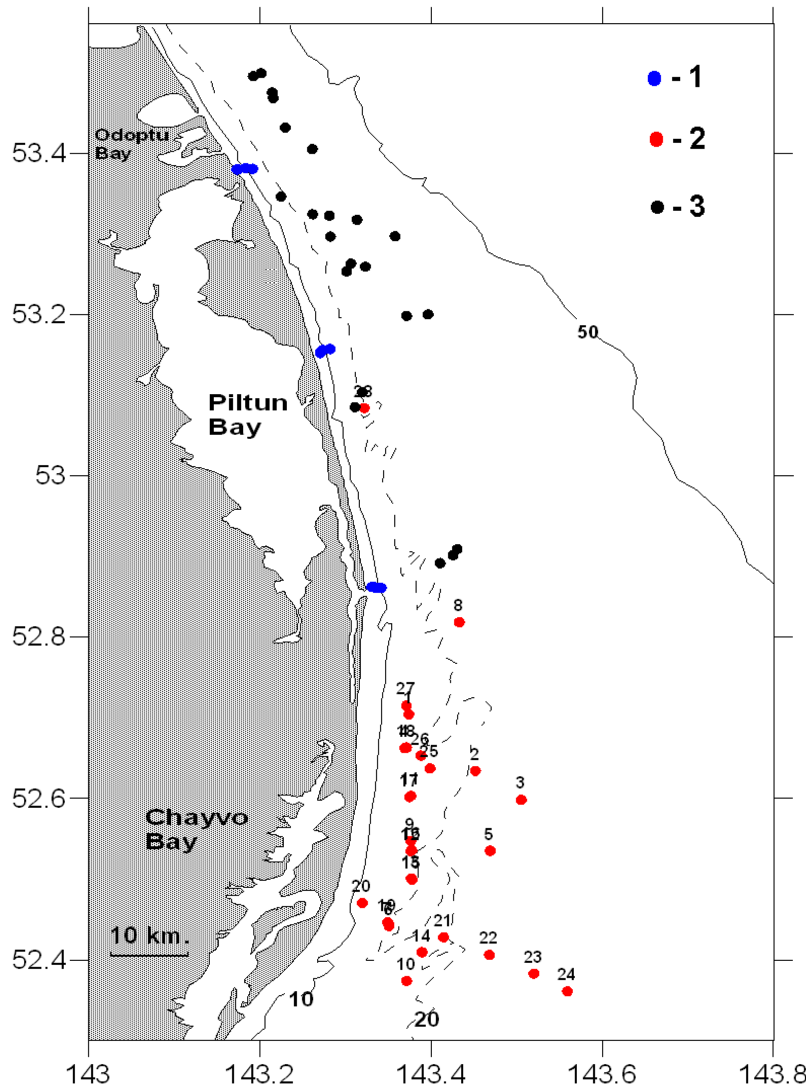

Figure 34. Sampling stations for large plankton (Bongo net) and epibenthos (epibenthic net) for the 2004 expedition.
1 – near-shore stations Pil 1-13 (collection: epibenthos, plankton);
2 – plankton stations Bon 1-28 (collection: plankton);
3 – whale feeding points FP (collection: epibenthos, plankton).
Characteristics of the stations are presented in Appendix 2.

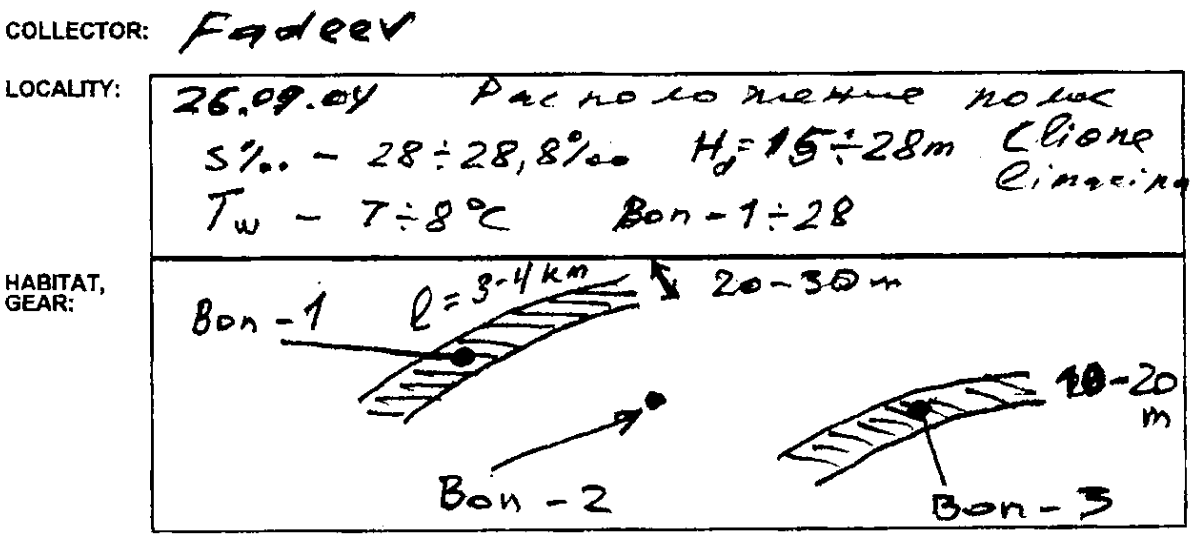

Figure 35. Locations of plankton stations Bon-1 – Bon-3 (Bongo net) in the zone of elevated *Clione limacina* concentration "strips."

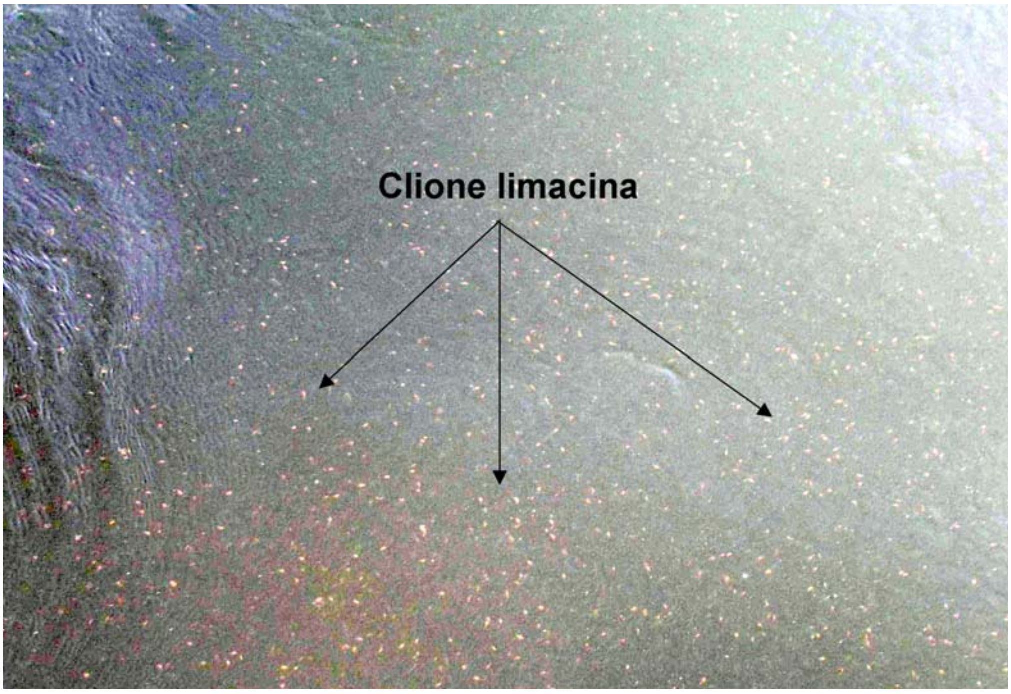

Photo 9. *Clione limacina* accumulation within "strips."

Photo 10. *Clione limacina* in Bongo net bucket. Bon-1 sample from 0-5 m range.

Photo 11. Pteropod mollusk (“sea angle”) *Clione limacina*. Body length – 17 mm.

Table 17. Zooplankton composition (by three groups of stations) off the coast of Eastern Sakhalin (Sea of Okhotsk) in September 2004. AverD – average density (spec./m^3), ID – density index (%).

Taxons	Bon 1-5		Bon 6-28		Pil 5-13	
	AverD	ID, %	AverD	ID, %	AverD	ID, %
Copepoda	3.06	0.12	1.48	5.97	2.32	2.29
Calanus glacialis					1.06	1.05
Centropages abdominalis	2.04	0.08	0.56	2.24		
Epilabidocera amphitrites	1.02	0.04	0.93	3.73	0.68	0.67
Neocalanus plumchrus s.l.					0.34	0.33
Tortanus discaudatus					0.24	0.24
Acartia spp. (hudsonica, longiremis)	+		+		+	
Eurytemora spp. (americana, herdmani)			+		+	
Paracalanus spp. (minutus, newmani)			+		+	
Cladocera (specimens, ova)	+		+		+	
Podon leuckarti	+		+		+	
Chaetognatha			0.93	3.73	1.87	1.84
Ctenophora	2.04	0.08	1.85	7.46	25.06	24.72
Beroe cucumis	1.02	0.04	0.19	0.75	1.13	1.12
Pleurobrachia pileus	1.02	0.04	1.67	6.72	23.93	23.61
Bolinopsis sp.			+			
Coelenterata	62.64	2.46	6.57	26.49	50.72	50.04
Aglantha digitale	61.62	2.42	1.94	7.84	45.09	44.48
Obelia longissima			0.09	0.37	0.24	0.24
Melicertum campanula	0.51	0.02	0.19	0.75	2.20	2.17
Spp. (5 or more species)	0.51	0.02	4.35	17.54	3.19	3.15
Euphausiacea (furcilia)					0.24	0.24
Pteropoda	2477.21	97.14	5.83	23.51	17.24	17.01
Limacina helicina	2.55+	0.10	0.56+	2.24	17.24+	17.01
Clione limacina	2474.67	97.04	5.28	21.27		
Gammarida	2.04	0.08	1.85	7.46	3.16	3.11
Mysidacea			1.48	5.97	0.41	0.41
Pisces (ova, larvae)			0.19	0.75		
Decapoda	3.06	0.12	0.19	0.75	0.34	0.33
Macrura (larvae)			0.19	0.75	+	
Anomura (zoea)	2.55	0.10				
megalopa	0.51	0.02			0.34	0.33
Echinodermata (pluteus, auricularia)					+	
Cirripedia (nauplii, cypris)	+		+		+	
Bivalvia (larvae)					+	
Ostracoda (benthic)			+		+	
Total	**2550.04**	**100**	**24.82**	**100**	**101.37**	**100**

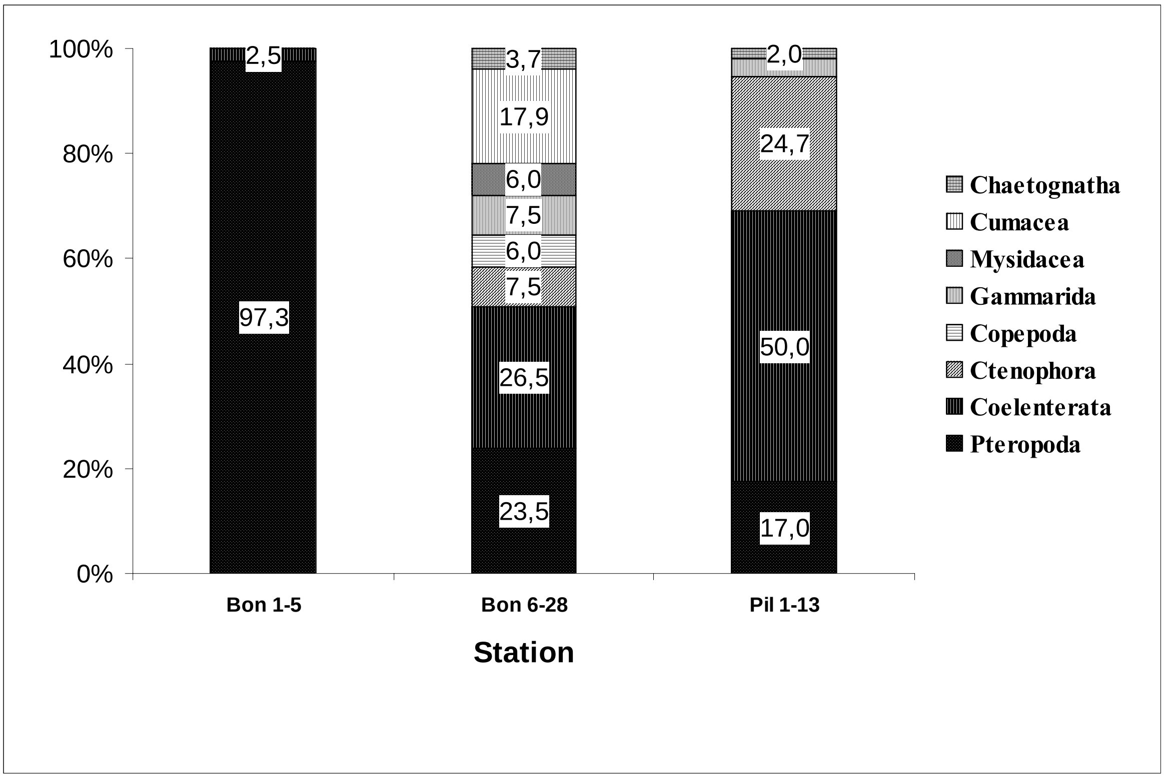

Figure 36. Structure of large fraction zooplankton community off the coast of eastern Sakhalin in September 2004. For map of stations, see Figure 34.

Studies in the same area in early October (i.e., two weeks later) indicated that some zooplankton characteristics (samples were collected with a Juday net) were similar to those presented above. On the whole, mass development of small species of copepods, cladocerans and larval plankton was observed in the presence of pronounced "blossoming" of system phytoplankton; ctenophores and hydromedusas (especially *Aglantha digitale*) were the basis of the large (as well as the medium) fraction, and *Limacina helicina* (both young and large) reached enormous density. Adult *Clione limacina*, however, were rarely encountered; the population of this species was made up mainly of polytrochal larvae (early and late) and individuals at the metamorphosis stage. In addition, a significantly larger number of large and medium copepod species (especially oceanic) was observed, and their density was higher.

Hence, there were no groups of organisms among large plankton in the gray whale feeding grounds in the Piltun Area during the study period which are used by whales as an alternative food source in a forage benthos shortage. Analysis of underwater video of the water column at whale feeding sites yields a similar conclusion.

CONCLUSION

1. Bottom grab collections of benthos taken in August-September 2004 in the coastal waters of northeastern Sakhalin in the section between Odoptu Bay and Niyskiy Bay served as material for the study. Benthos studies were performed in two gray whale feeding areas: Piltun (Piltun Bay) and Offshore (an areas with depths of 30 – 60 m at a distance from the shoreline in the Piltun Bay – Niyskiy Bay area). Bottom grab collections of benthos were performed at 148 stations (447 samples). In addition, the benthos collections included 52 stations from gray whale feeding sites in the Piltun (50 stations) and Offshore (two stations) areas. Three bottom sampling transects were run from a motorboat at depths of 3-12 m in the shallows of the Piltun Area. Due to feeding of some of the whales at depths greater than 20 m in 2004, it became necessary to assess alternative food sources – large plankton and sea-bed epibenthos. For this purpose, epibenthos collection was performed from the water layer near the bottom with an epibenthic net (35 stations, 84 samples) and a Bongo plankton net (65 stations, 126 samples). The water column and the surface of the sea bed were photographed at all the stations with an underwater television system.

2. During the study period, the temperature of the water surface layer in the Piltun area varied considerably: from 5.1 °C in August to 10.7 °C in September. The water temperature was reliably higher in August 2004 than in August 2003 ((7.48 ± 0.6 °C and 4.01 ± 0.82 °C, respectively). In contrast to the data from 2001-2003, no upwelling of deep water was observed in the northern part of the Piltun Area in 2004. As in 2002-2003, the temperature and salinity of the surface layer of water in the Offshore Area were more evenly distributed than in the Piltun Area.

3. Analysis of the particle size distribution of 145 bottom sediment samples indicated that prevalence of sandy (psammite) bottom fractions is characteristic of both areas. Fine sands were prevalent at 52% of the stations in the Piltun Area, and medium sands were prevalent at 27% of the stations. Patches of gravel-pebble bottoms, often mixed with sands of varying grain size, are encountered at depths greater than 20-25 m. The highest proportion (more than 30%) of aleurite-pelite sediments in the sea bed is observed in a local area at depths greater than 20 m in the area of the channels of Piltun Lagoon. A similar tendency was found in materials from 2001-2003. Fine sands were prevalent at 85% of the stations in the Offshore Area. Gravel bottoms and coarse-grained sand have a patchy distribution in the northern part of the area.

4. The bottom sediments at gray whale feeding sites were investigated at 52 stations. Most of the whales in 2004, as in 2002 and 2003, fed in the Piltun Area, in a zone of fine- and medium-grained bottoms. The sediments at whale feeding sites can be classified according to three groups with respect to particle size distribution: fine- and medium-grained sands, and sands with varying grain size mixed with small gravel.

5. Analysis of the concentrations of key pollutants – petroleum hydrocarbons, heavy metals and organochlorine pesticides – in the sediments and their distribution in the waters in question makes it possible to conclude that there is no substantial pollutant impact on benthos at present. This situation may be the result of the active hydrodynamic conditions in these waters and the movement of water along the shore by the Eastern Sakhalin Current, which prevent the accumulation of pollutants in sandy sediments.

6. There were 64 bottom sampling stations in the **Piltun Area** in 2004: 51 stations from the ship in the depth range of 11 to 35 m, and 13 stations from a motorboat at depths of 3 to 12 m. The locations of the ship-based stations for 2004 were the same in most cases as in 2003.

The average benthos biomass for bottom grab collections in 2004 was 501.2±93.8 g/m^2, which did not differ substantially from 2003 data (555.7±69.4 g/m^2). As in previous years, flat sea urchins, the sand dollar *Echinarachnius parma*, accounted for most of the biomass at 75%, and the proportion of the sea urchin reaches 85% at depths greater than 20 m. The quantitative abundance of the main forage benthos component – amphipods – decreased from 111 g/m^2 (48% of total benthos biomass) at depths of 11-15 m to 39 g/m^2 (5%) at depths of 26-30 m. Since the locations of the stations in the depth range of 11-30 m was the same in most cases in 2004 and 2003, one can conclude that there were no substantial changes in total benthos biomass. The sharpest changes in the quantitative abundance of benthos occur in the range of 15-20 m. At most of the stations in the Piltun Area, it is at these depths that a sharp decrease in the biomass of amphipods, isopods and bivalve mollusks and an increase in flat sea urchin biomass occur. Materials from 2004 confirm the basic trends in the distribution of total benthos biomass in the Piltun Area observed in analysis of the collections from 2001-2003.

The proportion of crustaceans in the overall biomass was 49% at depths of 11-15 m and decreased to 8% in the range of 26-30 m. Amphipods have the clearest declining trend in the proportion in benthos biomass with increasing depth. Several areas of higher biomass of crustaceans (amphipods and isopods) with a patchy distribution were observed in the shallow zone of the Piltun Area. The largest crustacean accumulations in the area are in the southern and northern parts of the Piltun Area.

The average amphipod biomass for the entire depth range studied in the Piltun Area was 47.4±7.7 g/m^2, which is comparable to the data from 2002 – 42.7 g/m^2 – and 2003 – 54.6 g/m^2. More than 95% of amphipod biomass is accounted for by two species: *Pontoporeia affinis* (62% of total amphipod biomass) and *Eogammarus schmidti* (34%). The highest quantitative abundance levels for amphipods occur at depths less than 15-20 m.

The nature of the spatial distribution of amphipod biomass in the Piltun Area shows similar trends in 2004 and 2003: the zone of high biomass is associated with the parts of the area near the shore, and the amphipod distribution is patchy. Sectors of high amphipod biomass are found on the 2004 chart in the middle and northern parts of the area and are more distinct than in 2003. The sector in the northern part of the Piltun Area has a larger area and higher quantitative abundance levels than in 2003. Analysis of the size composition of common amphipod species indicated that the proportion of individuals with a body size larger than 6 mm in July ranged from 75 to 95% for different species. Most of the individuals of the common amphipod species are accessible for feeding of the whales.

According to some materials, the Pacific sand lance *Ammodytes hexapterus* made up a significantly larger proportion of the total benthos biomass of the Piltun Area in 2004 than in 2003. In 2002-2003 the frequency of occurrence of the sand lance in bottom grab collections was 5-8%, with an average biomass of 4.6-6.2 g/m^2. The frequency of occurrence of the sand lance in 2004 was 14.8%, with an average biomass of 14.8±4.8 g/m^2. The sand lance biomass varied from 68 to 366 g/m^2 within local accumulations, which was 25 to 48% of the biomass in the samples. Accumulations with the greatest density in 2004 were found in the northern and middle parts of the Piltun Area at depths of 20-30 m.

Based on the materials of bottom grab collections from 2002-2004 (163 stations), three macrobenthos complexes have been distinguished in the Piltun Area. In regard to biomass, two groups of benthic organisms occupy most of the bottom area for biomass: a shallow-water coastal amphipod complex with a high proportion of prey, and a deeper-water flat sea urchin complex with an extremely low proportion of prey. The provisional boundary between the complexes is located at depths of about 20 m. The average biomass of the amphipod complex (177.1 g/m^2) is accounted for primarily by amphipods – 64%, isopods – 14%, and bivalve mollusks – 13%. The complex includes 29 amphipod species with a total biomass of 113.3±14.5 g/m^2 at a colony density of 7410±1170 spec./m^2. Four species have the greatest quantitative abundance: *Pontoporeia affinis, Eogammarus schmidti,* *Eohaustorius eous eous* and *Anisogammarus pugettensis,* which account for 95% of the average biomass and colony density of amphipods in the complex. High quantitative abundance figures for the amphipod complex in the Piltun Area are conditioned by its highly eurybiontic nature, short life cycle and high growth rates of the dominant amphipod species – *Pontoporeia affinis*.

7. In the **Offshore Area** in 2004, there were 32 stations (96 bottom grab samples) at depths from 28 to 63 m (average depth 49.3±2.3 m, n=32; in 2003 – 35.9±1.7 m, n=36). Analysis of the total average benthos biomass and the biomass of individual groups for collections of 2004 and 2003 indicates that significant differences in the average values are observed in a number of cases. The average total benthos biomass was reliably higher in 2004 than in 2003 (899.1±85.8 g/m^2 and 630.1±64.3 g/m^2, respectively; t-test, $t = 3.46$, $df = 62$, $p < 0.05$). The statistically significant differences in the distribution of total biomass are due to the fact that the study area was extended eastward in 2004. The purpose was to chart a patch of high amphipod biomass. Accordingly, many new stations with high biomass levels were included in the sampling. The biomass of amphipods – the most important whale prey component in the Offshore Area – in 2004 and 2003 was 328.5±41.2 g/m^2 and 343.8±52.8 g/m^2, respectively. Year-to-year variations in the average amphipod biomass are not statistically reliable ($p = 0.11 > 0.05$).

Based on materials from 2002-2004, four benthos complexes were distinguished in the Offshore Area. Complexes with the amphipod *Ampelisca eschrichti* as the dominant species have the greatest importance for assessing the food potential of the area. A zone with dominance of the amphipod *Ampelisca eschrichti* was charted in 2004 as a result of the eastward expansion of the sampling grid, and the distribution of benthos complexes in the Offshore Area was defined. Two complexes – ampeliscid amphipods, and ampeliscids+sea anemones+bivalve mollusks – occupy most of the bottom in the Offshore Area. Of the area of the Offshore Area (2160 km^2), the occupy 35 and 33% (747 and 706 km^2). These complexes have the highest average caloric content of forage benthos at 946 and 515 kcal/m^2.

8. In the Piltun Area, 50 whale feeding sites at depths of 14-35 m were investigated in 2004. The average depth of the whale feeding sites sampled in 2004 was 23.5±0.9 m, which differs from the data for 2003 – 18.6±1.6 m; and 2002 – 19.5±1.5 m. Whales feeding sites in 2004 were examined primarily at depths greater than 20 m, which was the result of the redistribution of some of the whales to these depths during the study period. As in previous years, most of the whales in the Piltun Area foraged at depths less than 20 m within the coastal amphipod complex. Analysis of bottom grab samples from whale feeding sites at

depths greater than 20 m in the zone of the flat sea urchin complex indicated that 11% of the samples had high abundance of prey organisms. The Pacific sand lance *Ammodytes hexapterus* (72 to 392 g/m^2), the amphipod *Eogammarus schmidti* (122-153 g/m^2) and the isopod *Saduria entomon* (87.8 and 69.7 g/m^2) have the highest biomass in these samples.

In contrast to 2003, only two feeding whales were observed in the Offshore Area in 2004. Since the figures for quantitative abundance of benthos in the Offshore Area did not differ substantially from the 2003 season, one can conclude that the drop in the number of gray whales is not related to the benthos status. The sharp drop in the number of whales in the Offshore Area in 2004 can suggest that this area is a secondary feeding ground and is used by the gray whales during periods of reduce forage benthos biomass (consumption or seasonal or year-to-year changes in biomass) in the main feeding ground – the Piltun Area. This hypothesis needs further confirmation.

9. The locations of gray whale feeding sites according to data of aerial and vessel-based observations in the Piltun and Offshore areas in 2001-2004 match the benthos distribution in these areas well. The vast majority of the whale feeding sites in the Piltun Area according to aerial surveys are located between the shoreline and the 20 m isobath, mainly along the 10 m isobath. This is entirely consistent with the distribution of the coastal complex with dominance of amphipods in the Piltun Area. On the other hand, some of the feeding whales were observed at greater depths during the study season in 2004. Analysis of bottom grab samples from whale feeding sites in 2004 indicated that local accumulations of the Pacific sand lance *Ammodytes hexapterus* may occur in addition to patches of high isopod and amphipod biomass. One can assume that there were year-to-year variations in the abundance of the species in 2004. Hence, a small number of feeding sites at depths greater than 20 m in the Piltun Area can be explained by feeding of whales in local patches of crustaceans and potentially the sand lance.

Comparison of the chart of biomass distribution for amphipod *Ampelisca eschrichti* and the feeding sites shows that most of the gray whale feeding locations in the Offshore Area (96%) are associated with sections with amphipod biomass of 200-300 g/m^2 or more. It is noteworthy in this regard that most of the feeding sites are located north and west of the section with the highest forage benthos biomass levels. This distribution could be due to the fact that the sections with the highest biomass are located in a zone of maximum depths of 50 to 65 m; i.e., the whales feed primarily in a zone with biomass of 200-300 g/m^2 at depths of 35-45 m. Possibly the energy expenditures for reaching the food are optimized in this way.

10. The large zooplankton in gray whale feeding grounds in the Piltun Area during the study period did not include groups of organisms used by the whales as an alternative food source when benthic prey is in short supply. Analysis of underwater video of the water column at whale feeding sites yields a similar conclusion.

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APPENDICES 1 – 11

TO REPORT

BENTHOS AND FOOD SUPPLY STUDIES
IN FEEDING GROUNDS OF THE OKHOTSK-KOREAN GRAY WHALE
POPULATION

APPENDIX 1. ADDITIONAL FIGURES

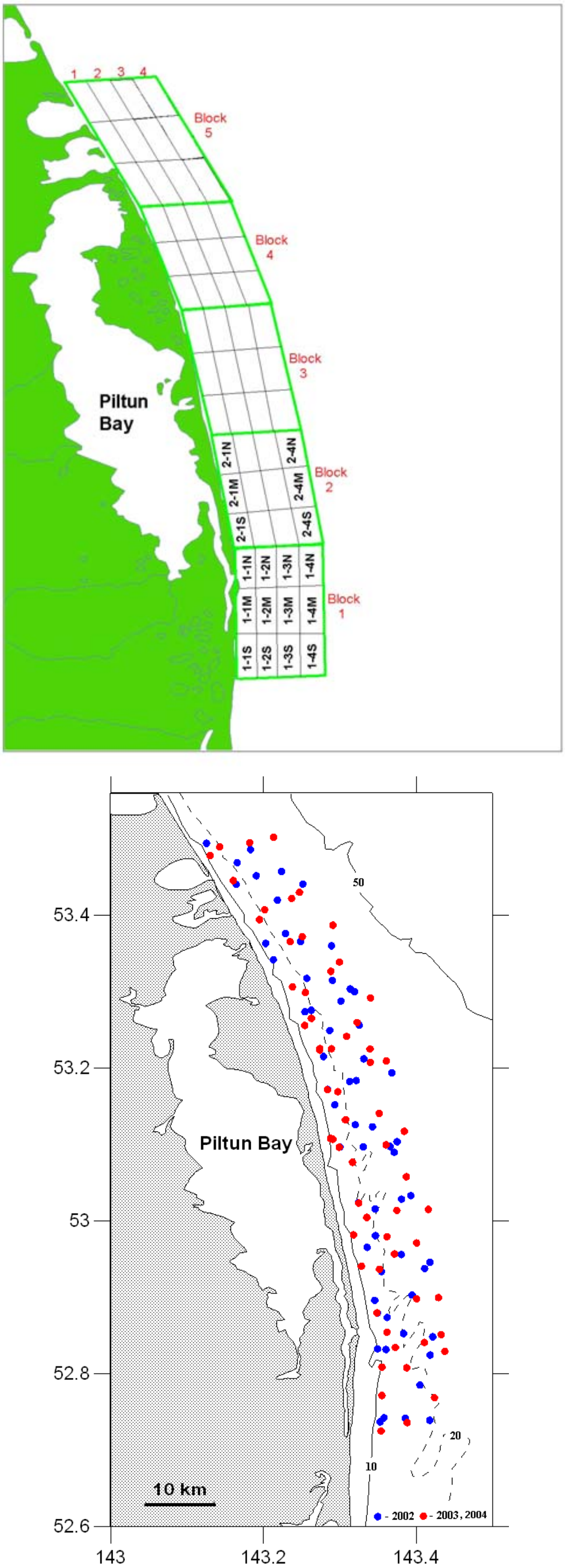


Figure P1.1. Chart of blocks in the Piltun Area and stations in 2002 and 2003-2004.

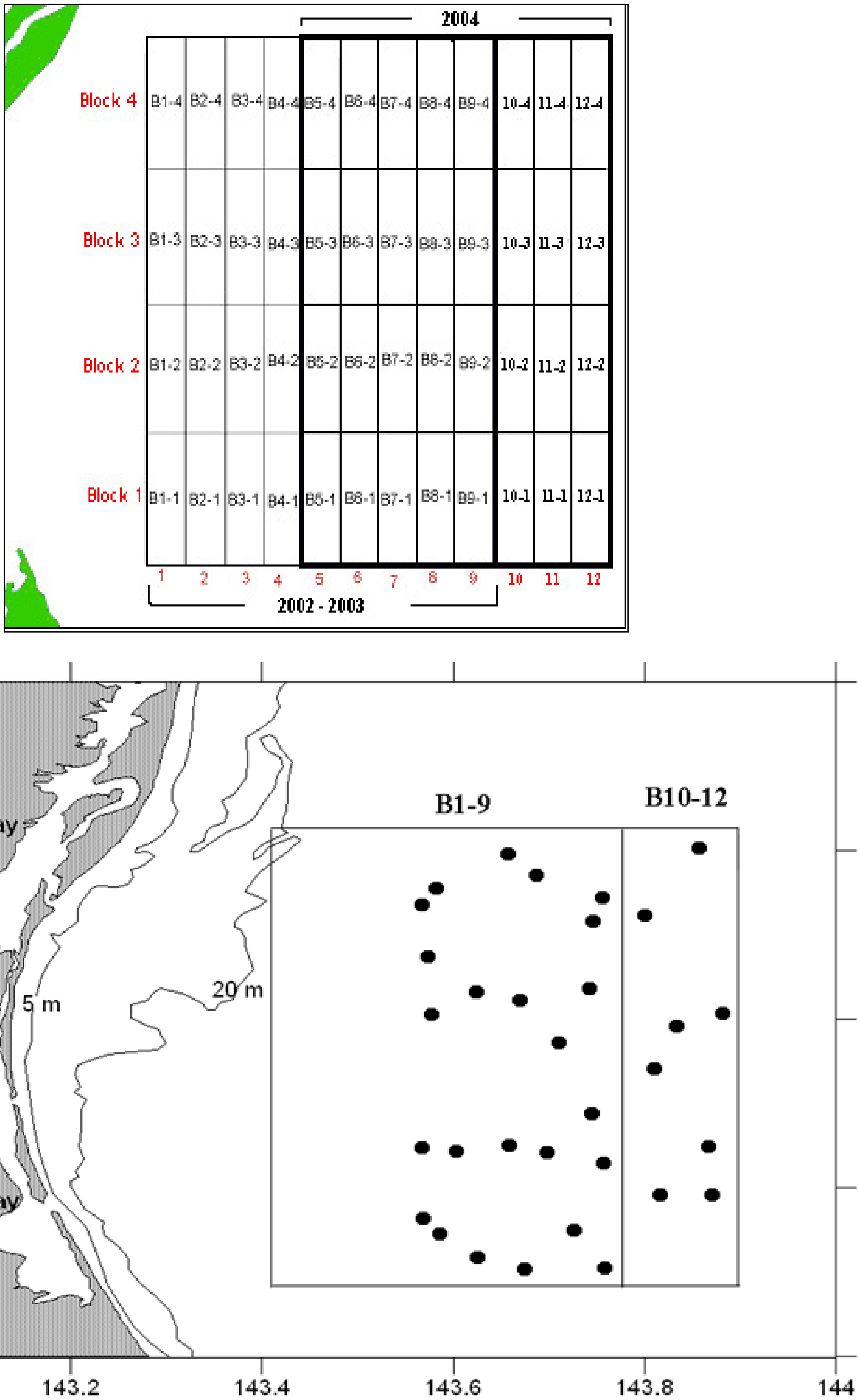


Figure P1.2. Chart of blocks in the Offshore Area and stations in 2004. B10-12 – additional stations for 2004

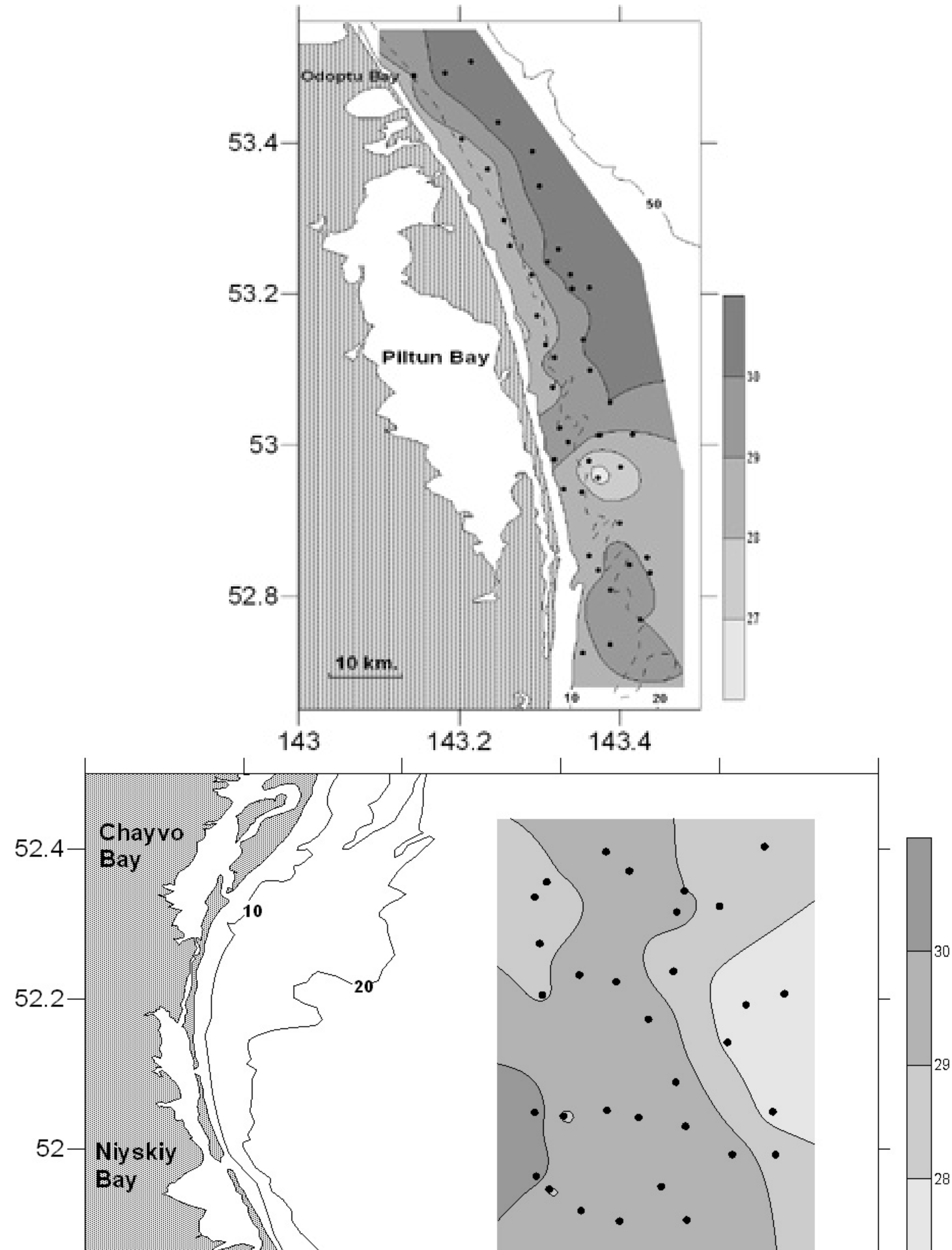


Figure P1.3. Distribution of salinity (S, %) of the surface water layer in the Piltun and Offshore areas during the study period.

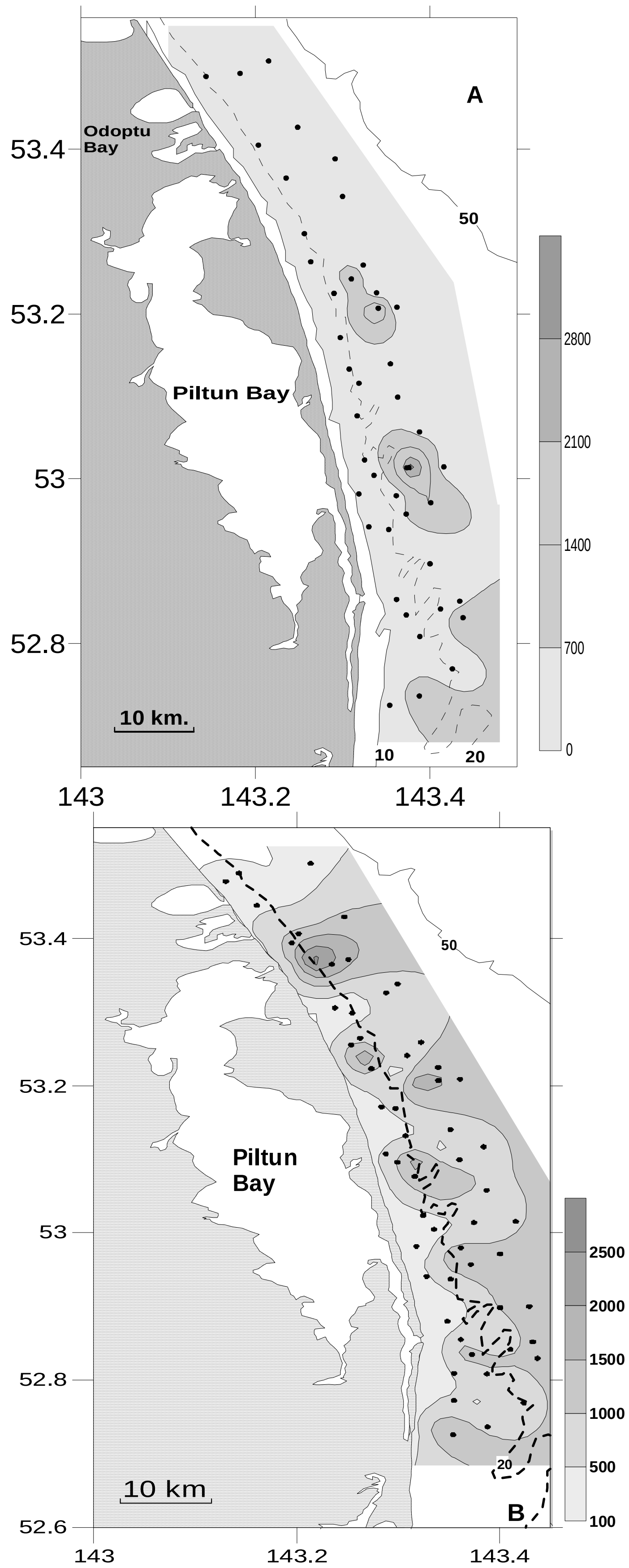


Figure P1.4. Distribution of total biomass (g/m^2) of macrobenthos in the Piltun Area in 2004 (A) and 2003 (B).

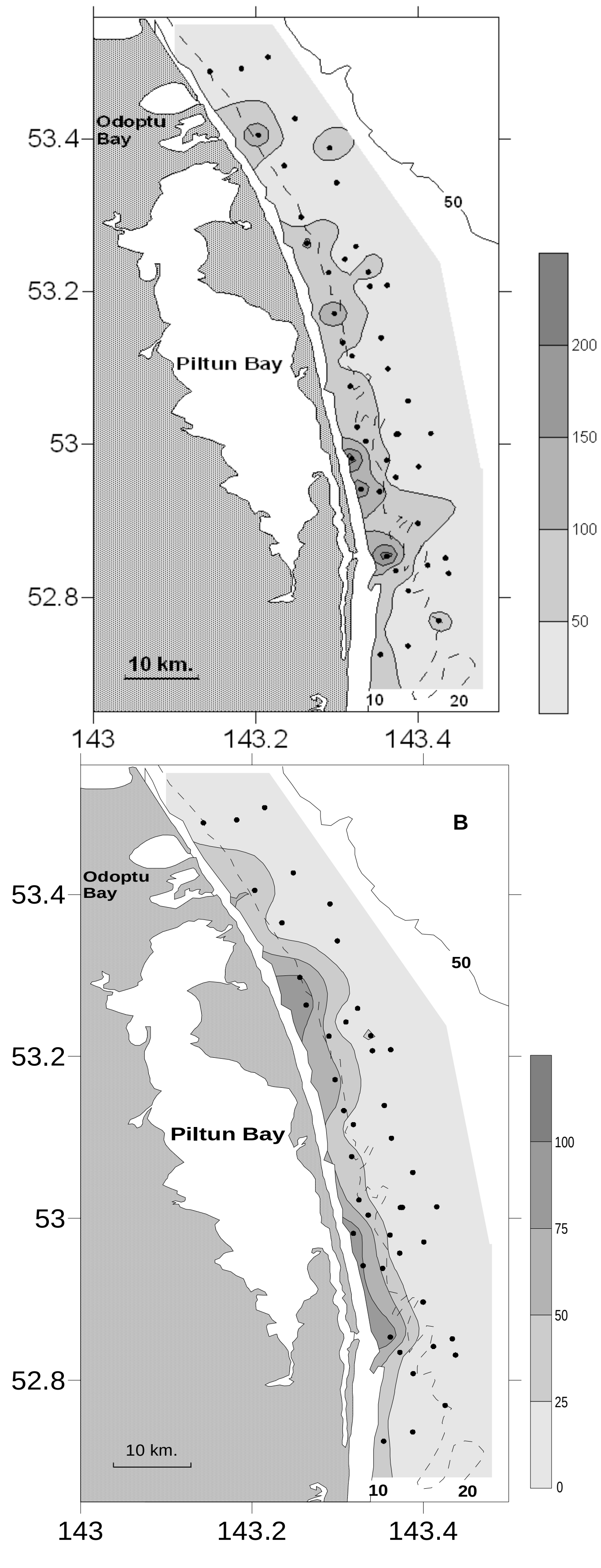


Figure P1.5. Distribution of total biomass (g/m^2) of amphipods and isopods (A) **and proportion of amphipods (%) in benthos biomass** in the Piltun Area in 2004.

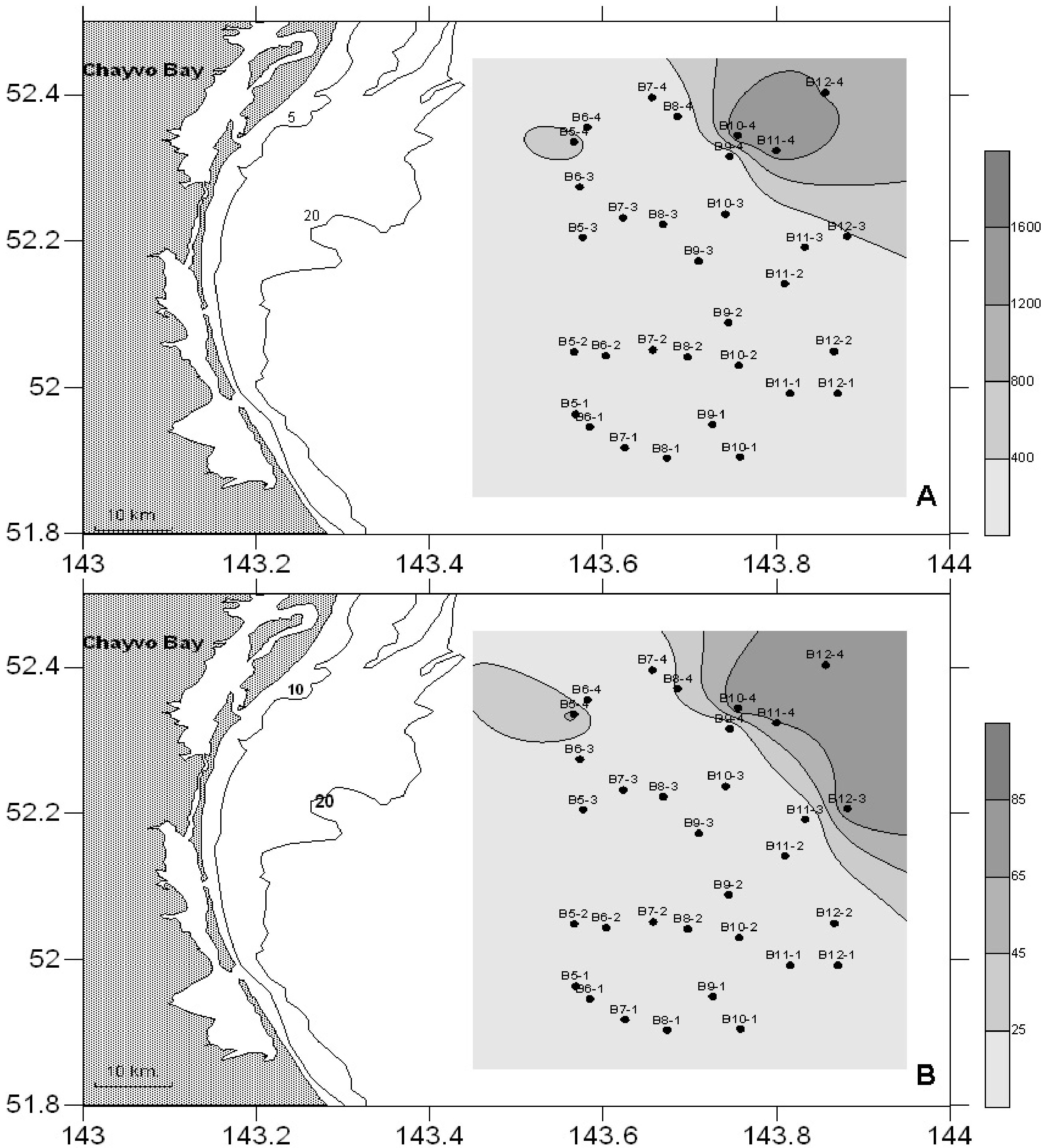
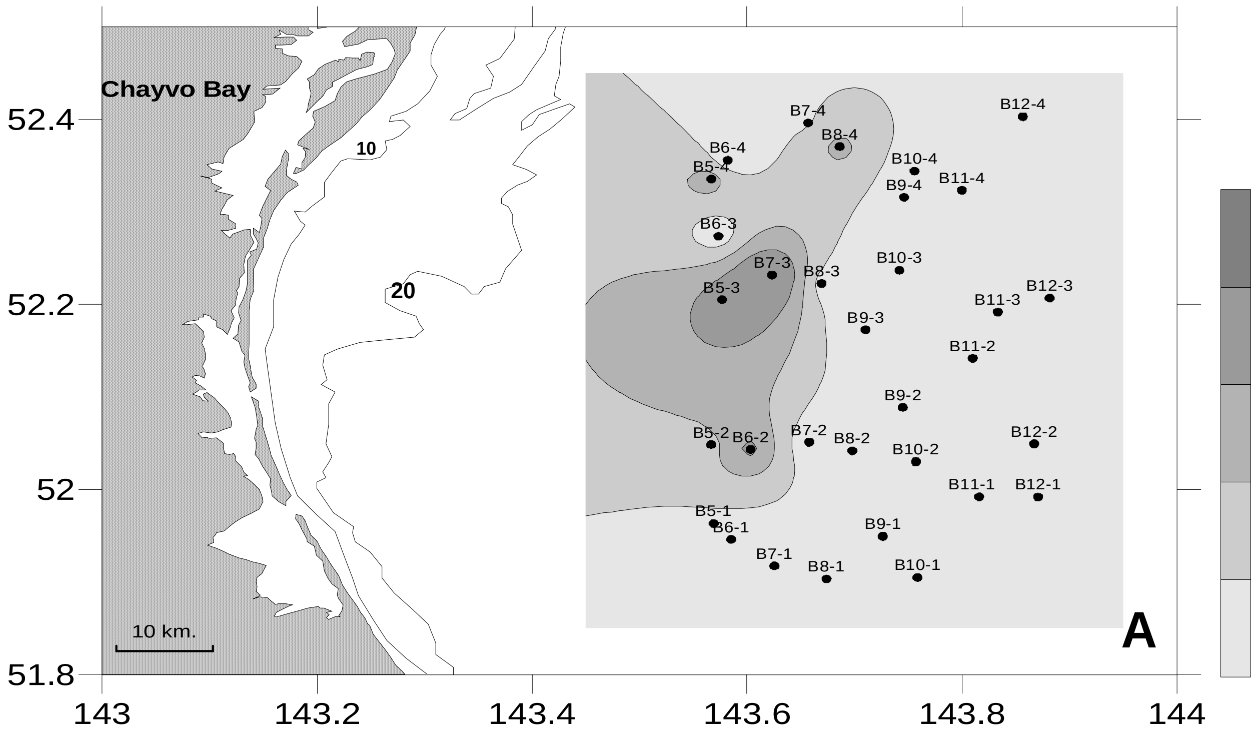


Figure P1.6. Distribution of biomass (A; g/m^2) and proportion (%) of flat sea urchins in the total benthos biomass in the Offshore Area in 2004.



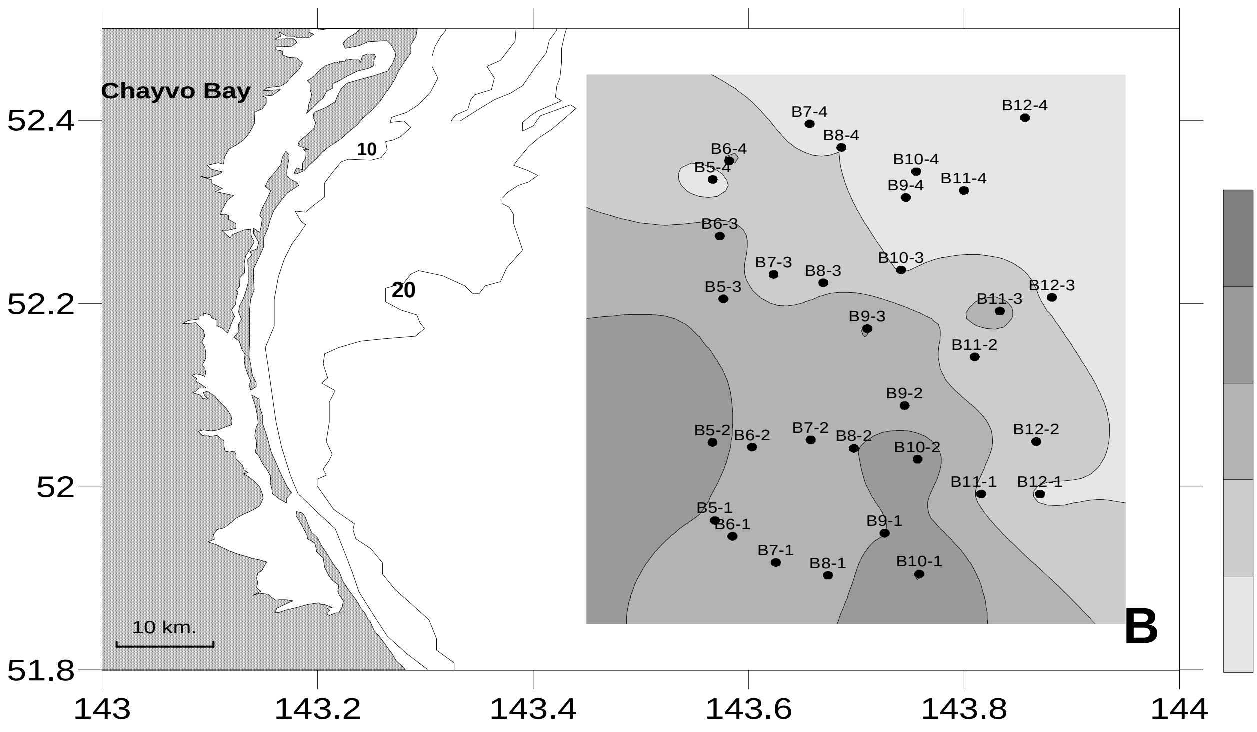


Figure P1.7. Proportion (%) of **cumaceans** (A) and **amphipods** (B) in the average benthos biomass (g/m^2) in the Offshore Area in 2004.

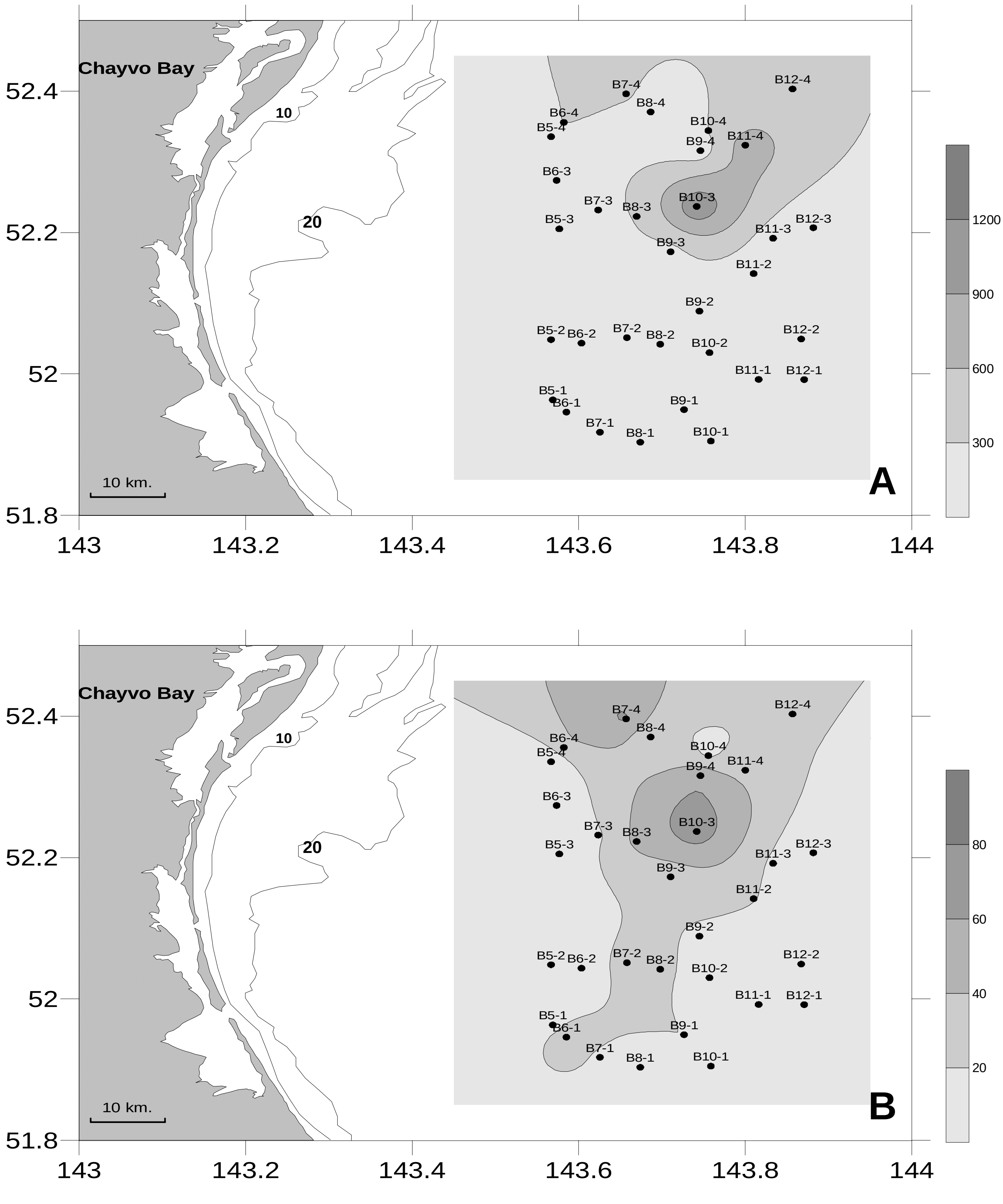


Figure P1.8. Biomass (g/m^2) and proportion (%) of sea anemones in the total benthos biomass in the Offshore Area in 2004.

APPENDICES 2 – 11

APPENDIX 2. Sampling log for July-September 2004 for the expedition of the Institute of Marine Biology of the Far East Branch of the Russian Academy of Sciences aboard the research vessel *Academic Oparin*

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
1	1	PIL-01	Piltun	53,379550	143,173383	53º 22,773	143º 10,403	24.09.2004	10:55	3	16,0	10,5	27,2	3	2	2	+
2	2	PIL-02	Piltun	53,379850	143,175150	53º 22,791	143º 10,509	24.09.2004	11:10	5	16,0	10,5	27,2	3	2	2	+
3	3	PIL-03	Piltun	53,381367	143,183467	53º 22,882	143º 11,008	24.09.2004	11:30	7	16,0	10,6	27,2	3	2	2	+
4	4	PIL-04	Piltun	53,380500	143,191917	53º 22,830	143º 11,515	24.09.2004	11:35	10	16,0	10,6	27,2	3	2	2	+
5	5	PIL-05	Piltun	53,152183	143,270867	53º 09,131	143º 16,252	29.09.2004	10:40	3	14,0	7,7	27,0	3	2	2	+
6	6	PIL-06	Piltun	53,153933	143,271600	53º 09,236	143º 16,296	29.09.2004	10:50	5	14,0	8,0	27,0	3	2	2	+
7	7	PIL-07	Piltun	53,155883	143,273733	53º 09,353	143º 16,424	29.09.2004	11:00	7	14,0	8,0	27,0	3	2	2	+
8	8	PIL-08	Piltun	53,157167	143,282267	53º 09,430	143º 16,936	29.09.2004	11:10	10	14,0	8,0	27,0	3	2	2	+
9	9	PIL-09	Piltun	52,862150	143,330750	52º 51,729	143º 19,845	01.10.2004	8:30	3	11,0	8,1	27,1	3	2	2	+
10	10	PIL-10	Piltun	52,862250	143,333150	52º 51,735	143º 19,989	01.10.2004	9:40	5	11,0	8,1	27,0	3	2	2	+
11	11	PIL-11	Piltun	52,861517	143,334867	52º 51,691	143º 20,092	01.10.2004	9:50	7	11,0	8,1	27,0	3	2	2	+
12	12	PIL-12	Piltun	52,861550	143,338483	52º 51,693	143º 20,309	01.10.2004	10:00	10	11,5	8,0	27,0	3	2	2	+
13	13	PIL-13	Piltun	52,860900	143,342150	52º 51,654	143º 20,529	01.10.2004	10:10	12	11,0	8,1	27,1	3	2	2	+
14	1	1-1S	Piltun	52,724833	143,353833	52º 43,49	143º 21,23	20.08.2004	22:23	13	12,2	5,8	28,8	3	-	-	+
15	2	1-2M	Piltun	52,981500	143,318500	52º 58,89	143º 19,11	21.08.2004	20:47	10	11,2	6,7	29,2	3	-	-	+
16	3	1-2N	Piltun	53,022667	143,325000	53º 01,36	143º 19,5	21.08.2004	0:34	16	9,1	5,4	29,5	3	-	-	+
17	4	1-2S	Piltun	52,941517	143,329900	52º 56,491	143º 19,794	15.09.2004	10:40	20	16,0	8,0	28,9	3	-	-	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
18	5	2-1M	Piltun	52,834500	143,372767	52º 50,070	143º 22,366	27.08.2004	18:04	16	11,4	8,2	28,8	3	-	-	+
19	6	2-1N	Piltun	52,853333	143,361667	52º 51,2	143º 21,7	27.08.2004	15:54	16	13,5	8,2	28,8	3	-	-	+
20	7	2-2M	Piltun	52,979333	143,361333	52º 58,76	143º 21,68	21.08.2004	21:19	23	10,5	8,6	27,3	3	-	-	+
21	8	2-2N	Piltun	53,004000	143,335833	53º 00,24	143º 20,15	21.08.2004	0:00	15	9,2	5,4	29,9	3	-	-	+
22	9	2-2NR	Piltun	52,936667	143,351667	52º 56,2	143º 21,1	27.08.2004	14:00	16	14,4	8,5	28,7	3	-	-	+
23	10	2-2S	Piltun	52,938233	143,352683	52º 56,294	143º 21,161	15.09.2004	9:50	21	16,0	8,0	28,7	3	-	-	+
24	11	2-3M	Piltun	53,133083	143,307333	53º 07,985	143º 18,440	14.09.2004	10:35	16	17,5	8,6	28,1	3	-	-	+
25	12	2-3N	Piltun	53,171283	143,297167	53º 10,277	143º 17,830	14.09.2004	11:05	15	15,0	8,1	28,3	3	-	-	+
26	13	2-3S	Piltun	53,076267	143,316500	53º 04,576	143º 18,990	14.09.2004	9:30	15	17,0	8,7	28,6	3	-	-	+
27	14	2-4M	Piltun	53,263333	143,263333	53º 15,8	143º 15,8	14.09.2004	15:15	15	17,0	8,1	28,8	3	-	-	+
28	15	2-4N	Piltun	53,297517	143,256000	53º 17,851	143º 15,360	14.09.2004	16:00	20	17,0	8,0	28,8	3	-	-	+
29	16	2-4S	Piltun	53,225000	143,290000	53º 13,5	143º 17,4	14.09.2004	14:35	20	16,0	8,1	28,7	3	-	-	+
30	17	2-5M	Piltun	53,405000	143,203333	53º 24,3	143º 12,2	12.09.2004	14:45	20	14,0	7,9	28,8	3	-	-	+
31	18	2-5N	Piltun	53,488333	143,143333	53º 29,3	143º 08,6	12.09.2004	13:55	17	15,0	8,1	29,0	3	-	-	+
32	19	2-5S	Piltun	53,364933	143,235100	53º 21,896	143º 14,106	14.09.2004	16:45	22	16,0	8,0	28,5	3	-	-	+
33	20	3-1M	Piltun	52,808350	143,388333	52º 48,501	143º 23,300	20.08.2004	19:54	18	8,8	5,4	29,3	3	-	-	+
34	21	3-1N	Piltun	52,841733	143,412017	52º 50,504	143º 24,721	20.08.2004	18:55	24	10,1	5,1	29,7	3	-	-	+
35	22	3-1S	Piltun	52,736083	143,387783	52º 44,165	143º 23,267	20.08.2004	21:45	19	8,8	5,3	29,2	3	-	-	+
36	23	3-2M	Piltun	52,957000	143,372667	52º 57,42	143º 22,36	21.08.2004	21:54	27	10,1	8,3	26,4	3	-	-	+
37	24	3-2N	Piltun	53,013333	143,373333	53º 00,8	143º 22,4	27.08.2004	12:05	25	14,0	9,0	28,5	3	-	-	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
38	25	3-2N	Piltun	53,013500	143,375667	53º 00,81	143º 22,54	21.08.2004	23:29	27	9,4	7,1	29,0	3	-	-	+
39	26	3-2S	Piltun	52,896667	143,400000	52º 53,8	143º 24,0	27.08.2004	15:20	23	23,0	8,2	28,8	3	-	-	+
40	27	3-2SR	Piltun	52,896667	143,400000	52º 53,8	143º 24,0	27.08.2004	15:02	23	13,6	8,7	28,5	3	-	-	+
41	28	3-3M	Piltun	53,139433	143,354617	53º 08,366	143º 21,277	19.09.2004	11:07	28	13,3	9,3	30,0	3	-	-	+
42	29	3-3N	Piltun	53,206967	143,340717	53º 12,418	143º 20,443	18.09.2004	13:34	29	20,0	9,5	30,2	3	-	-	+
43	30	3-3S	Piltun	53,098967	143,362900	53º 05,938	143º 21,774	19.09.2004	10:03	25	13,1	9,4	29,9	3	-	-	+
44	31	3-4M	Piltun	53,259300	143,323483	53º 15,558	143º 19,409	18.09.2004	11:55	23	14,2	9,4	30,2	3	-	-	+
45	32	3-4N	Piltun	53,327433	143,287467	53º 19,646	143º 17,248	17.09.2004	16:30	30	11,0	8,7	30,6	3	-	-	+
46	33	3-4S	Piltun	53,242467	143,309867	53º 14,548	143º 18,592	18.09.2004	12:29	26	18,2	9,1	30,3	3	-	-	+
47	34	3-5M	Piltun	53,422100	143,236933	53º 25,326	143º 14,216	17.09.2004	9:28	33	14,0	8,4	30,7	6	-	-	+
48	35	3-5N	Piltun	53,492100	143,182317	53º 29,526	143º 10,939	13.09.2004	16:30	30	16,0	8,0	30,6	3	-	-	+
49	36	3-5S	Piltun	53,375217	143,250983	53º 22,513	143º 15,059	17.09.2004	15:05	25	11,4	8,5	30,6	3	-	-	+
50	37	4-1M	Piltun	52,831167	143,437833	52º 49,87	143º 26,27	20.08.2004	18:00	25	13,7	6,1	28,9	3	-	-	+
51	38	4-1N	Piltun	52,851233	143,434067	52º 51,074	143º 26,044	20.08.2004	18:26	22	12,0	6,1	28,5	3	-	-	+
52	39	4-1S	Piltun	52,769033	143,425600	52º 46,142	143º 25,536	20.08.2004	20:50	16	9,1	5,7	29,0	3	-	-	+
53	40	4-2M	Piltun	52,970833	143,400833	52º 58,25	143º 24,05	21.08.2004	22:23	27	9,9	7,8	27,6	3	-	-	+
54	41	4-2N	Piltun	53,014333	143,415833	53º 00,86	143º 24,95	21.08.2004	23:00	23	9,7	7,3	28,9	3	-	-	+
55	42	4-2S	Piltun	53,225000	143,290000	53º 13,5	143º 17,4	15.09.2004	13:45	22	19,0	8,0	28,9	3	-	-	+
56	43	4-3M	Piltun	53,115800	143,318583	53º 06,948	143º 43,115	19.09.2004	10:30	28	12,9	9,4	30,0	3	-	-	+
57	44	4-3N	Piltun	53,208233	143,362083	53º 12,494	143º 21,725	19.09.2004	11:55	28	17,4	9,4	30,1	3	-	-	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
58	45	4-3S	Piltun	53,056717	143,387967	53º 03,403	143º 23,278	19.09.2004	9:20	29	15,0	9,5	30,0	3	-	-	+
59	46	4-4M	Piltun	53,293167	143,340133	53º 17,590	143º 20,408	18.09.2004	11:10	34	16,0	8,5	30,5	3	-	-	+
60	47	4-4N	Piltun	53,342633	143,299783	53º 20,558	143º 17,987	17.09.2004	16:00	28	11,0	8,7	30,7	3	-	-	+
61	48	4-4S	Piltun	53,225683	143,338767	53º 13,541	143º 20,326	18.09.2004	13:00	29	18,6	9,3	30,2	3	-	-	+
62	49	4-5M	Piltun	53,426667	143,248333	53º 25,6	143º 14,9	13.09.2004	13:45	32	14,0	8,7	30,6	3	-	-	+
63	50	4-5N	Piltun	53,507167	143,215000	53º 30,43	143º 12,90	13.09.2004	15:45	33	15,0	8,1	30,7	3	-	-	+
64	51	4-5S	Piltun	53,388267	143,291250	53º 23,296	143º 17,475	17.09.2004	14:19	36	11,9	8,7	30,7	3	-	-	+
65	1	B5-1	Offshore	51,963167	143,568833	51º 57,79	143º 34,13	08.08.2004	16:10	45	20,0	10,8	30,6	3	-	-	+
66	2	B5-2	Offshore	52,048333	143,566667	52º 02,9	143º 34,0	08.08.2004	14:31	44	18,6	10,6	30,6	3	-	-	+
67	3	B5-3	Offshore	52,205000	143,576667	52º 12,3	143º 34,6	08.08.2004	13:06	37	18,7	10,3	28,9	3	-	-	+
68	4	B5-4	Offshore	52,335367	143,566767	52º 20,122	143º 34,006	08.08.2004	10:32	29	18,1	10,0	28,5	3	-	-	+
69	5	B6-1	Offshore	51,945833	143,585167	51º 56,75	143º 35,11	08.08.2004	16:45	47	18,3	11,0	28,9	3	-	-	+
70	6	B6-2	Offshore	52,043333	143,603333	52º 02,6	143º 36,2	08.08.2004	15:11	47	19,0	11,0	28,8	3	-	-	+
71	7	B6-3	Offshore	52,273567	143,573383	52º 16,414	143º 34,403	08.08.2004	11:21	36	18,3	10,0	28,9	3	-	-	+
72	8	B6-4	Offshore	52,355617	143,582083	52º 21,337	143º 34,925	08.08.2004	9:50	33	19,8	10,0	28,9	3	-	-	+
73	9	B7-1	Offshore	51,917267	143,625417	51º 55,036	143º 37,525	24.08.2004	9:22	48	16,1	10,1	29,3	3	-	-	+
74	10	B7-2	Offshore	52,051067	143,657817	52º 03,064	143º 39,469	14.08.2004	11:12	48	11,1	6,7	29,7	3	-	-	+
75	11	B7-3	Offshore	52,231667	143,623333	52º 13,9	143º 37,4	08.08.2004	12:29	40	19,0	10,4	29,3	3	-	-	+
76	12	B7-4	Offshore	52,396000	143,656833	52º 23,76	143º 39,41	04.08.2004	11:50	39	16,0	10,7	29,3	3	-	-	+
77	13	B8-1	Offshore	51,903217	143,673850	51º 54,193	143º 40,431	14.08.2004	8:27	59	12,2	7,5	29,3	3	-	-	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
78	14	B8-2	Offshore	52,041833	143,697867	52º 02,510	143º 41,872	14.08.2004	10:30	50	11,8	7,0	29,5	3	-	-	+
79	15	B8-3	Offshore	52,222567	143,669517	52º 13,354	143º 40,171	04.08.2004	15:50	43	14,1	11,2	29,5	3	-	-	+
80	16	B8-4	Offshore	52,370333	143,686317	52º 22,220	143º 41,179	04.08.2004	12:57	42	16,0	10,7	29,0	3	-	-	+
81	17	B9-1	Offshore	51,949350	143,726433	51º 56,961	143º 43,586	14.08.2004	9:20	57	11,1	7,0	29,5	3	-	-	+
82	18	B9-2	Offshore	52,088633	143,744917	52º 05,318	143º 44,695	04.08.2004	18:07	52	15,2	12,3	29,5	3	-	-	+
83	19	B9-3	Offshore	52,172533	143,710300	52º 10,352	143º 42,618	04.08.2004	16:57	48	13,5	10,5	29,8	3	-	-	+
84	20	B9-4	Offshore	52,315650	143,746117	52º 18,939	143º 44,767	04.08.2004	14:18	42	16,8	12,4	29,3	3	-	-	+
85	21	B10-1	Offshore	51,904833	143,758667	51º 54,29	143º 45,52	23.08.2004	20:36	61	13,2	9,8	29,5	3	-	-	+
86	22	B10-2	Offshore	52,029900	143,757017	52º 01,794	143º 45,421	23.08.2004	18:00	56	13,6	10,5	29,7	3	-	-	+
87	23	B10-3	Offshore	52,236667	143,741667	52º 14,2	143º 44,5	23.08.2004	13:10	53	12,3	10,4	28,3	3	-	-	+
88	24	B10-4	Offshore	52,344000	143,755667	52º 20,64	143º 45,34	23.08.2004	11:00	51	12,7	10,3	29,0	3	-	-	+
89	25	B11-1	Offshore	51,992067	143,816033	51º 59,524	143º 48,962	23.08.2004	18:47	60	13,8	10,6	29,5	3	-	-	+
90	26	B11-2	Offshore	52,141667	143,810000	52º 08,5	143º 48,6	23.08.2004	15:50	55	12,9	10,6	27,8	3	-	-	+
91	27	B11-3	Offshore	52,191667	143,833333	52º 11,5	143º 50	23.08.2004	14:49	58	12,8	10,2	27,3	3	-	-	+
92	28	B11-4	Offshore	52,323333	143,800000	52º 19,4	143º 48	23.08.2004	12:06	55	12,6	9,8	28,8	3	-	-	+
93	29	B12-1	Offshore	51,991883	143,870667	51º 59,513	143º 52,240	23.08.2004	19:26	61	13,2	10,6	28,6	3	-	-	+
94	30	B12-2	Offshore	52,049217	143,867100	52º 02,953	143º 52,026	23.08.2004	17:00	62	14,5	10,8	27,6	3	-	-	+
95	31	B12-3	Offshore	52,206667	143,881667	52º 12,4	143º 52,9	23.08.2004	14:04	63	14,1	10,6	27,3	3	-	-	+
96	32	B12-4	Offshore	52,402833	143,856667	52º 24,17	143º 51,40	23.08.2004	10:13	59	15,0	10,3	28,6	3	-	-	+
97	1	FP-01	Piltun	53,443400	143,245767	53º 26,604	143º 14,746	05.09.2004	10:00	35	16,0	9,0	29,4	3	-	-	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
98	2	FP-02	Piltun	52,863533	143,406433	52º 51,812	143º 24,386	05.09.2004	13:20	20	20,0	10,7	24,6	3	-	-	+
99	3	FP-03	Piltun	53,301560	143,240363	52º 16,02	143º 21,10	05.09.2004	14:10	20	19,8	9,2	28,9	3	-	-	+
100	4	FP-04	Piltun	53,241867	143,324383	53º 14,512	143º 19,463	05.09.2004	17:10	25	17,0	9,0	28,7	3	-	-	+
101	5	FP-05	Piltun	53,264433	143,311200	53º 15,866	143º 18,672	05.09.2004	17:45	26	15,0	9,0	28,8	3	-	-	+
102	6	FP-06	Piltun	53,296000	143,258967	53º 17,760	143º 15,538	05.09.2004	18:25	19	15,2	9,1	28,7	3	-	-	+
103	7	FP-07	Offshore	52,355117	143,701983	52º 21,307	143º 42,119	06.09.2004	17:15	47	17,5	10,5	28,8	3	-	-	+
104	8	FP-08	Offshore	52,354800	143,688267	52º 21,288	143º 41,296	06.09.2004	17:50	43	14,0	11,0	28,7	3	-	-	+
105	9	FP-09	Piltun	53,322333	143,281500	53º 19,34	143º 16,89	10.09.2004	9:15	27	12,0	8,4	28,6	3	2	2	+
106	10	FP-10	Piltun	53,317333	143,313667	53º 19,04	143º 18,82	10.09.2004	9:45	29	13,0	8,1	28,8	3	2	2	+
107	11	FP-11	Piltun	53,296500	143,282833	53º 17,79	143º 16,97	10.09.2004	10:20	25	15,0	8,0	28,7	3	2	2	+
108	12	FP-12	Piltun	53,263000	143,306667	53º 15,78	143º 18,40	10.09.2004	11:10	25	16,0	8,1	28,8	3	2	2	+
109	13	FP-13	Piltun	53,253333	143,301667	53º 15,2	143º 18,1	10.09.2004	13:05	23	17,0	8,0	29,4	3	2	2	+
110	14	FP-14	Piltun	53,198333	143,371667	53º 11,9	143º 22,3	10.09.2004	13:50	30	18,0	7,9	24,6	3	2	2	+
111	15	FP-15	Piltun	53,200000	143,396667	53º 12,0	143º 23,8	10.09.2004	14:10	31	18,0	7,9	28,9	3	2	2	+
112	16	FP-16	Piltun	53,103850	143,320000	53º 06,231	143º 19,200	10.09.2004	17:45	20	15,2	7,8	28,7	3	2	2	+
113	17	FP-17	Piltun	53,085200	143,311517	53º 05,112	143º 18,691	10.09.2004	18:30	15	15,0	8,0	28,8	3	3	2	+
114	18	FP-18	Piltun	52,891917	143,410750	52º 53,515	143º 24,645	11.09.2004	8:20	24	15,0	8,1	28,0	3	3	2	+
115	19	FP-19	Piltun	52,901650	143,425917	52º 54,099	143º 25,555	11.09.2004	8:45	25	14,9	8,0	28,1	3	3	2	+
116	20	FP-20	Piltun	52,909033	143,430700	52º 54,542	143º 25,842	11.09.2004	9:10	26	15,0	8,0	28,8	3	3	2	+
117	21	FP-21	Piltun	53,346000	143,225000	53˚20,700	143˚ 13,470	11.09.2004	11:20	14	15,0	8,0	28,7	3	3	2	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
118	22	FP-22	Piltun	53,431667	143,230000	53º 25,9	143º 13,8	11.09.2004	13:50	31	15,0	7,8	27,8	3	3	2	+
119	23	FP-23	Piltun	53,475000	143,215000	53º 28,5	143º 12,9	11.09.2004	14:25	33	15,0	8,0	27,1	3	3	2	+
120	24	FP-24	Piltun	53,495183	143,192650	53º 29,711	143º 11,559	12.09.2004	10:05	33	15,2	8,7	27,1	3	3	2	+
121	25	FP-25	Piltun	53,498983	143,201767	53º 29,939	143º 12,106	12.09.2004	10:30	35	15,0	8,0	27,3	3	3	2	+
122	26	FP-26	Piltun	53,468083	143,216050	53º 28,085	143º 12,963	12.09.2004	10:50	33	15,0	8,0	27,1	3	3	2	+
123	27	FP-27	Piltun	53,247383	143,213600	53º 14,843	143º 12,816	13.09.2004	9:35	32	16,0	8,8	27,1	3	3	2	+
124	28	FP-28	Piltun	53,259133	143,323483	53º 15,548	143º 19,409	13.09.2004	10:15	26	16,0	8,7	27,0	3	3	2	+
125	29	FP-29	Piltun	53,296983	143,358200	53º 17,819	143º 21,492	13.09.2004	11:05	34	14,0	8,0	27,0	3	3	2	+
126	30	FP-30	Piltun	53,405000	143,261667	53º 24,3	143º 15,7	13.09.2004	14:20	33	14,0	8,0	27,1	3	3	2	+
127	31	PP-01	Piltun	52,872683	143,376850	52º 52,361	143º 22,611	26.08.2004	9:26	15	12,0	7,7	28,7	3	-	-	+
128	32	PP-1R	Piltun	52,871667	143,376667	52º 52,3	143º 22,6	26.08.2004	13:55	15	14,0	8,0	28,8	3	-	-	+
129	33	PP-02	Piltun	52,872500	143,376667	52º 52,35	143º 22,6	26.08.2004	14:21	15	12,6	7,8	28,8	3	-	-	+
130	34	PP-03	Piltun	53,054883	143,334900	53º 03,293	143º 20,094	26.08.2004	16:00	22	13,1	9,1	28,5	3	-	-	+
131	35	PP-04	Piltun	53,072117	143,331200	53º 04,327	143º 19,872	26.08.2004	16:40	19	11,7	8,9	28,6	3	-	-	+
132	36	PP-05	Piltun	53,153833	143,315833	53º 09,230	143º 18,950	26.08.2004	17:48	23	11,9	9,2	28,3	3	-	-	+
133	37	PP-06	Piltun	53,183817	143,308633	53º 11,029	143º 18,518	26.08.2004	18:27	21	12,1	9,2	28,3	3	-	-	+
134	38	PP-07	Piltun	53,206333	143,301183	53º 12,380	143º 18,071	26.08.2004	19:09	21	11,8	9,0	28,1	3	-	-	+
135	39	PP-08	Piltun	53,211633	143,365117	53º 12,698	143º 21,907	26.08.2004	20:00	31	11,0	8,5	28,0	3	-	-	+
136	40	PP-09	Piltun	53,212300	143,341000	53º 12,738	143º 20,46	26.08.2004	20:28	32	10,8	8,8	28,1	3	-	-	+
137	41	PP-10	Piltun	53,216667	143,300000	53º 13	143º 18	31.08.2004	13:30	23	15,0	6,4	29,9	3	-	-	+

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
138	42	PP-11	Piltun	53,238333	143,285000	53º 14,3	143º 17,1	31.08.2004	13:56	26	11,4	6,5	29,9	3	-	-	+
139	43	PP-14	Piltun	53,311667	143,271667	53º 18,7	143º 16,3	31.08.2004	14:54	27	11,4	6,8	29,8	3	-	-	+
140	44	PP-15	Piltun	53,356667	143,271667	53º 21,4	143º 16,3	31.08.2004	15:50	30	10,6	6,6	30,0	3	-	-	+
141	45	PP-16	Piltun	53,356450	143,262433	53º 21,387	143º 15,746	31.08.2004	16:15	28	10,5	6,6	29,9	3	-	-	+
142	46	PP-17	Piltun	53,389667	143,235900	53º 23,380	143º 14,154	31.08.2004	16:55	26	10,6	6,4	30,1	3	-	-	+
143	47	PP-18	Piltun	53,416217	143,237333	53º 24,973	143º 14,240	31.08.2004	17:30	31	11,0	7,6	29,5	3	-	-	+
144	48	PP-19	Piltun	53,577533	143,157417	53º 34,652	143º 09,445	31.08.2004	18:50	27	10,0	6,7	29,8	3	-	-	+
145	49	PP-25	Piltun	53,029000	143,326067	53º 01,74	143º 19,564	27.08.2004	9:47	15	15,4	9,0	28,6	3	-	-	+
146	50	PP-26	Piltun	53,018500	143,329200	53º 01,11	143º 19,752	27.08.2004	10:12	17	12,7	8,7	28,8	3	-	-	+
147	51	PP-27	Piltun	53,029000	143,346633	53º 01,74	143º 20,798	27.08.2004	10:40	17	12,5	8,7	28,7	3	-	-	+
148	52	PP-28	Piltun	52,763567	143,376200	52º 45,814	143º 22,572	27.08.2004	20:21	17	11,2	8,4	28,8	3	-	-	+
149	1	BON-1	Piltun	52,704350	143,374233	52º 42,261	143º 22,454	24.09.2004	17:10	15	16,0	8,0	28,0	-	-	2	-
150	2	BON-2	Piltun	52,634350	143,452033	52º 38,061	143º 27,122	24.09.2004	19:05	24	16,0	7,8	28,1	-	-	2	-
151	3	BON-3	Piltun	52,598333	143,505633	52º 35,900	143º 30,338	24.09.2004	20:10	28	15,0	7,8	28,8	-	-	2	-
152	4	BON-4	Piltun	52,662467	143,369633	52º 39,748	143º 22,178	25.09.2004	9:45	19	15,9	9,9	28,7	-	-	2	-
153	5	BON-5	Piltun	52,535283	143,469317	52º 32,117	143º 28,159	25.09.2004	16:40	20	16,0	7,9	27,8	-	-	2	-
154	6	BON-6	Piltun	52,442067	143,351233	52º 26,524	143º 21,074	25.09.2004	19:00	21	12,0	8,0	27,0	-	-	2	-
155	7	BON-7	Piltun	52,443533	143,351000	52º 26,612	143º 21,060	25.09.2004	20:30	20	11,0	9,0	27,1	-	-	2	-
156	8	BON-8	Piltun	52,818600	143,433133	52º 49,116	143º 25,988	26.09.2004	8:10	25	16,0	8,0	27,9	-	-	2	-
157	9	BON-9	Piltun	52,547500	143,376500	52º 32,85	143º 22,59	26.09.2004	11:20	20	16,0	8,1	28,0	-	-	2	-

Item	Number	Station	Area	Coordinates (decimal form)		Coordinates (canonical form)		Date	Time	Depth (m)	Temperature (ºC)		Salinity	Bottom Grab Sampler	Epibenthic Net	Bongo Net	Granulometry
				longitude	latitude	longitude	latitude				Air	Water					
158	10	BON-10	Piltun	52,374000	143,371667	52º 22,44	143º 22,30	26.09.2004	14:30	19	14,0	8,0	27,0	-	-	2	-
159	11	BON-11	Piltun	52,603333	143,376667	52º 36,2	143º 22,6	26.09.2004	15:00	20	15,0	7,9	27,2	-	-	2	-
160	12	BON-12	Piltun	52,535000	143,376667	52º 32,1	143º 22,6	26.09.2004	15:30	18	15,0	8,0	27,1	-	-	2	-
161	13	BON-13	Piltun	52,501117	143,377067	52º 30,067	143º 22,624	26.09.2004	16:10	19	15,0	8,0	27,1	-	-	2	-
162	14	BON-14	Piltun	52,409650	143,389733	52º 24,579	143º 23,384	26.09.2004	16:40	15	15,0	7,9	27,1	-	-	2	-
163	15	BON-15	Piltun	52,499767	143,378017	52º 29,986	143º 22,681	26.09.2004	19:30	20	14,0	7,7	27,1	-	-	2	-
164	16	BON-16	Piltun	52,535700	143,377833	52º 32,142	143º 22,670	26.09.2004	22:00	20	12,0	7,7	27,1	-	-	2	-
165	17	BON-17	Piltun	52,601983	143,375067	52º 36,119	143º 22,504	26.09.2004	22:40	22	13,0	8,0	27,1	-	-	2	-
166	18	BON-18	Piltun	52,663333	143,371667	52º 39,8	143º 22,3	26.09.2004	23:30	18	11,0	7,7	27,1	-	-	2	-
167	19	BON-19	Piltun	52,446467	143,349533	52º 26,788	143º 20,972	27.09.2004	18:00	19	16,0	7,6	27,2	-	-	2	-
168	20	BON-20	Piltun	52,470667	143,319933	52º 28,240	143º 19,196	27.09.2004	21:00	12	12,0	8,0	27,1	-	-	2	-
169	21	BON-21	Piltun	52,428250	143,414733	52º 25,695	143º 24,884	27.09.2004	21:30	20	12,0	8,0	27,2	-	-	2	-
170	22	BON-22	Piltun	52,406133	143,468350	52º 24,368	143º 28,101	27.09.2004	22:00	20	12,0	8,0	27,0	-	-	2	-
171	23	BON-23	Piltun	52,383117	143,520200	52º 22,987	143º 31,212	27.09.2004	22:35	28	12,0	8,0	27,1	-	-	2	-
172	24	BON-24	Piltun	52,361200	143,559433	52º 21,672	143º 33,566	27.09.2004	22:50	32	12,0	8,0	27,1	-	-	2	-
173	25	BON-25	Piltun	52,637267	143,399000	52º 38,236	143º 23,940	28.09.2004	10:00	20	14,0	8,0	27,0	-	-	2	-
174	26	BON-26	Piltun	52,653333	143,388333	52º 39,2	143º 23,3	28.09.2004	12:20	19	16,0	7,7	27,0	-	-	2	-
175	27	BON-27	Piltun	52,715183	143,371467	52º 42,911	143º 22,288	28.09.2004	16:01	15	14,0	7,7	27,1	-	-	2	-
176	28	BON-28	Piltun	53,084000	143,322267	53º 05,040	143º 19,336	28.09.2004	16:50	20	14,0	7,8	27,0	-	-	2	-

APPENDIX 3. Granulometric Composition of Bottom Sediments.

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
1	1	PIL-1	Piltun	53,379550	143,173383	3	0,0	0,0	36,0	3,3	3	17,6	21,4	2,1	3,9	5,1	Gr+Sfm
2	2	PIL-2	Piltun	53,379850	143,175150	5	1,6	4,8	3,3	2,2	14,5	26,2	27,9	4,6	10,1	4,8	Sfmc
3	3	PIL-3	Piltun	53,381367	143,183467	7	0,0	0,0	0,1	0,1	2,5	27,9	**65,7**	2,8	0,5	0,4	Sf
4	4	PIL-4	Piltun	53,380500	143,191917	10	0,0	0,0	0,0	0,3	1,7	33,2	**61,4**	3,3	0,1	0,0	Sf
5	5	PIL-5	Piltun	53,152183	143,270867	3	0,0	8,7	4,8	2,0	5,8	29,3	37,2	1,9	3,8	6,5	Sfm
6	6	PIL-6	Piltun	53,153933	143,271600	5	0,0	0,1	0,2	0,6	2,2	31,6	**62,2**	2,3	0,5	0,3	Sf
7	7	PIL-7	Piltun	53,155883	143,273733	7	0,0	0,0	0,1	0,2	2,2	20,5	**72,0**	4,0	0,5	0,5	Sf
8	8	PIL-8	Piltun	53,157167	143,282267	10	0,0	0,0	0,1	0,2	2,0	24,4	**69,1**	2,9	0,7	0,6	Sf
9	9	PIL-9	Piltun	52,862150	143,330750	3	1,1	10,6	6,4	3,6	3,3	31,8	27,4	2,3	5,8	7,7	Smf
10	10	PIL-10	Piltun	52,862250	143,333150	5	10,6	9,9	5,9	1,8	2,5	26,3	35,0	3,8	2,2	2,0	Sfm
11	11	PIL-11	Piltun	52,861517	143,334867	7	0,0	0,0	0,0	0,0	1,6	27,2	**64,4**	4,6	1,3	0,9	Sf
12	12	PIL-12	Piltun	52,861550	143,338483	10	0,0	0,0	0,0	0,3	2,1	26,4	**65,9**	3,9	0,7	0,7	Sf
13	13	PIL-13	Piltun	52,860900	143,342150	12	0,0	0,0	0,0	0,1	2,1	**54,4**	41,8	1,2	0,2	0,2	Sm
14	14	1-1S	Piltun	52,724833	143,353833	13	0,0	0,0	0,4	2,0	1,3	14,8	**75,2**	5,3	0,8	0,3	Sf
15	15	1-2M	Piltun	52,981500	143,318500	10	0,0	0,0	0,0	0,0	2,0	22,6	**70,4**	3,0	1,1	0,9	Sf
16	16	1-2N	Piltun	53,022667	143,325000	16	0,0	0,0	0,0	0,4	0,6	11,0	**85,6**	2,4	0,0	0,0	Sf
17	17	1-2S	Piltun	52,941517	143,329900	20	0,0	0,4	1,8	0,6	1,5	3,2	**85,8**	6,4	0,3	0,0	Sf
18	18	2-1M	Piltun	52,834500	143,372767	16	0,0	0,2	0,1	0,2	0,3	2,5	**90,8**	5,6	0,3	0,0	Sf
19	19	2-1N	Piltun	52,853333	143,361667	16	0,0	0,0	0,1	0,1	0,1	0,2	**90,2**	8,7	0,6	0,0	Sf
20	20	2-2M	Piltun	52,979333	143,361333	23	0,0	0,0	0,2	0,7	1,4	9,5	**83,9**	3,9	0,4	0,0	Sf

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
21	21	2-2N	Piltun	53,004000	143,335833	15	0,0	0,0	0,0	0,0	1,5	22,1	**69,4**	5,8	1,2	0,0	Sf
22	22	2-2S	Piltun	52,938233	143,352683	21	0,0	0,0	0,0	0,0	2,4	34,9	**59,5**	2,0	0,7	0,5	Sf
23	23	2-3M	Piltun	53,133083	143,307333	16	0,0	0,0	0,1	0,1	0,6	4,3	**85,8**	8,6	0,5	0,0	Sf
24	24	2-3N	Piltun	53,171283	143,297167	15	0,0	0,0	0,0	0,2	0,2	1,0	**91,4**	7,2	0,0	0,0	Sf
25	25	2-3S	Piltun	53,076267	143,316500	15	0,0	0,0	0,0	0,0	0,5	21,7	**76,1**	1,7	0,0	0,0	Sf
26	26	2-4M	Piltun	53,263333	143,263333	15	0,0	0,0	0,0	0,1	4,7	**52,6**	41,0	1,0	0,4	0,2	Sm
27	27	2-4N	Piltun	53,297517	143,256000	20	0,0	0,0	0,0	0,0	3,0	42,5	**52,5**	0,5	0,8	0,7	Sf
28	28	2-4S	Piltun	53,225000	143,290000	20	0,0	3,9	13,5	10,6	12,0	29,7	27,8	2,5	0,0	0,0	Smf
29	29	2-5M	Piltun	53,405000	143,203333	20	0,0	0,0	0,8	7,9	15,2	**60,2**	15,3	0,4	0,2	0,0	Smc
30	30	2-5N	Piltun	53,488333	143,143333	17	0,0	2,5	30,6	21,0	8,7	15,7	15,2	3,2	1,8	1,3	Gr+Smf
31	31	2-5S	Piltun	53,364933	143,235100	22	0,0	0,0	0,0	0,3	2,2	38,9	**54,4**	3,4	0,7	0,1	Sf
32	32	3-1M	Piltun	52,808350	143,388333	18	0,0	0,0	6,4	12,6	24,5	36,8	15,1	4,3	0,3	0,0	Smf+Gr
33	33	3-1N	Piltun	52,841733	143,412017	24	0,0	0,0	0,0	0,0	1,6	29,1	**65,5**	2,5	0,8	0,5	Sf
34	34	3-1S	Piltun	52,736083	143,387783	19	0,0	0,0	1,8	6,6	24,9	**59,1**	7,4	0,2	0,0	0,0	Sm
35	35	3-2M	Piltun	52,957000	143,372667	27	0,0	0,0	0,0	0,0	4,2	**65,2**	29,4	0,4	0,4	0,4	Sm
36	36	3-2N	Piltun	53,013500	143,375667	27	0,0	0,0	0,0	0,3	1,8	25,5	**69,8**	2,1	0,5	0,0	Sf
37	37	3-2S	Piltun	52,896667	143,400000	23	47,3	36,4	4,2	3,5	2,0	4,4	2,2	0,0	0,0	0,0	Peb+Gr
38	38	3-3M	Piltun	53,139433	143,354617	28	0,0	1,9	4,2	10,2	25,4	41,8	13,5	1,6	1,0	0,4	Scm
39	39	3-3N	Piltun	53,206967	143,340717	29	0,0	0,0	2,7	18,2	40,5	25,4	10,0	3,1	0,1	0,0	Scm
40	40	3-3S	Piltun	53,098967	143,362900	25	0,0	0,0	0,0	0,0	1,7	27,5	**64,2**	3,9	1,5	1,2	Sf
41	41	3-4M	Piltun	53,259300	143,323483	23	0,0	0,0	0,0	0,1	1,9	45,0	**50,8**	1,7	0,3	0,2	Sf
42	42	3-4N	Piltun	53,327433	143,287467	30	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
43	43	3-4S	Piltun	53,242467	143,309867	26	0,0	0,0	0,1	0,2	1,6	18,3	**62,8**	16,1	0,9	0,0	Sf

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
44	44	3-5M	Piltun	53,422100	143,236933	33	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
45	45	3-5N	Piltun	53,492100	143,182317	30	0,0	0,1	4,7	9,7	26,2	48,9	6,9	3,4	0,1	0,0	Smc
46	46	3-5S	Piltun	53,375217	143,250983	25	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
47	47	4-1M	Piltun	52,831167	143,437833	25	0,0	0,0	0,0	0,0	3,0	38,2	**55,7**	2,1	1,0	0,0	Sf
48	48	4-1N	Piltun	52,851233	143,434067	22	0,0	0,0	0,2	1,0	6,6	29,1	31,8	30,6	0,7	0,0	Sfm+Al
49	49	4-1S	Piltun	52,769033	143,425600	16	0,0	0,0	0,0	0,1	1,8	34,5	**52,9**	7,2	3,5	0,0	Sf
50	50	4-2M	Piltun	52,970833	143,400833	27	0,0	0,0	0,0	0,3	1,8	25,5	**69,7**	2,1	0,5	0,1	Sf
51	51	4-2N	Piltun	53,014333	143,415833	23	0,0	0,0	0,4	0,5	2,1	5,9	**86,9**	4,2	0,0	0,0	Sf
52	52	4-2S	Piltun	53,225000	143,290000	22	0,0	0,0	0,3	1,3	2,5	11,2	**80,8**	3,9	0,0	0,0	Sf
53	53	4-3M	Piltun	53,115800	143,718583	28	0,0	0,0	0,0	0,0	2,6	41,6	**53,5**	1,2	0,6	0,5	Sf
54	54	4-3N	Piltun	53,208233	143,362083	28	10,0	9,2	27,6	21,9	11,5	12,3	4,4	3,1	0,0	0,0	Gr+Scm
55	55	4-3S	Piltun	53,056717	143,387967	29	0,0	0,0	0,0	5,2	17,9	**53,8**	23,1	0,0	0,0	0,0	Sm
56	56	4-4M	Piltun	53,293167	143,340133	34	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
57	57	4-4N	Piltun	53,342633	143,299783	28	1,1	8,3	41,2	28,6	9,9	7,9	1,4	1,6	0,0	0,0	Gr
58	58	4-4S	Piltun	53,225683	143,338767	29	0,0	0,0	2,1	11,8	30,5	48,6	5,7	1,3	0,0	0,0	Scm
59	59	4-5M	Piltun	53,426667	143,248333	32	0,0	0,1	0,6	2,0	35,9	56,7	4,7	0,0	0,0	0,0	Smc
60	60	4-5N	Piltun	53,507167	143,215000	33	0,0	0,0	0,2	0,8	1,6	2,7	**87,3**	7,2	0,2	0,0	Sf
61	61	4-5S	Piltun	53,388267	143,291250	36	9,4	12,9	27,4	20,5	13,3	10,5	1,8	4,1	0,1	0,0	Gr+Sc
62	1	B5-1	Offshore	51,963167	143,568833	45	0,0	0,0	0,0	0,0	1,2	22,7	**69,3**	4,1	1,4	1,3	Sf
63	2	B5-2	Offshore	52,048333	143,566667	44	0,0	1,1	3,2	11,0	12,0	12,8	35,6	8,6	4,4	11,3	Sfmc
64	3	B5-3	Offshore	52,205000	143,576667	37	0,0	0,1	0,8	0,8	2,0	18,0	**68,2**	9,8	0,3	0,0	Sf
65	4	B5-4	Offshore	52,335367	143,566767	29	0,0	0,0	0,0	0,0	0,4	9,5	**72,6**	13,8	1,9	1,8	Sf
66	5	B6-1	Offshore	51,945833	143,585167	47	0,0	0,0	0,4	0,1	1,4	20,1	**74,5**	3,0	0,4	0,3	Sf

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
67	6	B6-2	Offshore	52,043333	143,603333	47	0,0	0,0	0,0	0,0	0,0	27,1	**70,0**	2,4	0,2	0,3	Sf
68	7	B6-3	Offshore	52,273567	143,573383	36	0,0	0,0	0,0	0,0	1,5	21,2	**69,4**	5,8	1,2	0,9	Sf
69	8	B6-4	Offshore	52,355617	143,582083	33	0,0	0,0	0,1	0,3	0,4	1,9	**92,7**	2,9	1,2	0,5	Sf
70	9	B7-1	Offshore	51,917267	143,625417	48	0,0	0,0	0,0	0,1	0,1	0,4	**92,2**	6,2	1,0	0,0	Sf
71	10	B7-2	Offshore	52,051067	143,657817	48	0,0	0,0	0,0	0,0	0,1	15,1	**78,3**	3,7	0,7	2,1	Sf
72	11	B7-3	Offshore	52,231667	143,623333	40	0,0	0,0	0,0	0,0	1,2	23,8	**66,7**	4,1	2,2	2,0	Sf
73	12	B7-4	Offshore	52,396000	143,656833	39	0,0	0,0	0,0	0,0	1,1	25,6	**67,9**	3,0	1,3	1,1	Sf
74	13	B8-1	Offshore	51,903217	143,673850	59	0,0	0,0	0,2	0,5	2,5	7,6	**85,1**	4,1	0,0	0,0	Sf
75	14	B8-2	Offshore	52,041833	143,697867	50	0,0	0,0	0,5	0,2	1,2	15,1	**79,9**	3,0	0,1	0,0	Sf
76	15	B8-3	Offshore	52,222567	143,669517	43	0,0	0,0	0,0	0,1	0,5	2,3	**95,3**	1,5	0,3	0,0	Sf
77	16	B8-4	Offshore	52,370333	143,686317	42	4,8	14,3	10,0	6,6	4,1	15,6	25,2	5,6	7,3	6,5	Gr+Smc
78	17	B9-1	Offshore	51,949350	143,726433	57	0,0	0,0	0,0	0,2	0,4	5,4	**83,9**	6,5	1,5	2,1	Sf
79	18	B9-2	Offshore	52,088633	143,744917	52	0,0	0,0	0,2	0,4	1,7	4,9	**89,2**	3,4	0,2	0,0	Sf
80	19	B9-3	Offshore	52,172533	143,710300	48	0,0	0,0	0,0	0,2	1,3	4,0	**91,3**	2,9	0,3	0,0	Sf
81	20	B9-4	Offshore	52,315650	143,746117	42	7,9	21,9	13,3	3,9	2,9	23,6	16,2	2,1	3,8	4,4	Gr+Sm
82	21	B10-1	Offshore	51,904833	143,758667	61	0,0	0,0	0,0	0,0	0,9	25,4	**68,0**	3,0	1,4	1,3	Sf
83	22	B10-2	Offshore	52,029900	143,757017	56	0,0	0,0	0,0	0,4	1,4	4,2	**66,2**	5,8	4,0	18,0	Sf
84	23	B10-3	Offshore	52,236667	143,741667	53	0,0	0,0	0,0	0,0	3,0	4,1	**86,2**	5,7	0,4	0,6	Sf
85	24	B10-4	Offshore	52,344000	143,755667	51	0,0	0,0	0	0	0,3	3,1	**86,1**	5,6	1,5	3,4	Sf
86	25	B11-1	Offshore	51,992067	143,816033	60	0,0	0,0	0,0	0,2	0,4	2,2	**59,4**	12,0	6,4	19,4	Sf
87	26	B11-2	Offshore	52,141667	143,810000	55	0,0	0,0	0,3	0,7	0,5	1,7	**63,0**	9,6	7,0	17,2	Sf
88	27	B11-3	Offshore	52,191667	143,833333	58	0,0	0,0	0,0	0,1	0,2	0,7	**77,7**	5,9	4,2	11,2	Sf
89	28	B11-4	Offshore	52,323333	143,800000	55	15,3	12,2	10,4	3,5	3	24,7	25,7	1,7	1,8	1,7	Sfm

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
90	29	B12-1	Offshore	51,991883	143,870667	61	0,0	0,0	0,1	0,3	0,4	1,5	**66,7**	9,2	5,9	15,9	Sf
91	30	B12-2	Offshore	52,049217	143,867100	62	0,0	0,0	0	0,1	0,3	2,4	**82,9**	7,3	2,1	4,9	Sf
92	31	B12-3	Offshore	52,206667	143,881667	63	0,0	0,0	2,4	2,4	4,0	4,4	**84,6**	1,2	1,0	0,0	Sf
93	32	B12-4	Offshore	52,402833	143,856667	59	9	14,3	10	4,6	3,4	22,1	23	4,1	4,9	4,6	Sfm
94	1	FP-01	Piltun	53,443400	143,245767	35	0,0	0,0	4,3	8,8	16,9	30,1	36,0	3,6	0,3	0,0	Sfm
95	2	FP-02	Piltun	52,863533	143,406433	20	0,0	0,0	1,1	8,1	28,2	**49,7**	12,6	0,3	0,0	0,0	Sm
96	3	FP-03	Piltun	52,017000	143,351667	20	0,0	0,0	0,0	0,0	0,2	2,4	**94,3**	3,1	0,0	0,0	Sf
97	4	FP-04	Piltun	53,241867	143,324383	25	0,0	0,0	0,2	1,4	9,6	46,2	42,3	0,3	0,0	0,0	Smf
98	5	FP-05	Piltun	53,264433	143,311200	26	0,0	0,1	1,0	14,2	27,8	36,1	20,6	0,2	0,0	0,0	Smcf
99	6	FP-06	Piltun	53,296000	143,258967	19	0,0	0,0	0,3	0,9	4,5	15,5	**75,6**	2,9	0,3	0,0	Sf
100	7	FP-07	Offshore	52,355117	143,701983	47	0,0	0,0	0,3	1,2	4,2	20,2	**54,0**	4,4	2,8	12,9	Sf
101	8	FP-08	Offshore	52,354800	143,688267	43	0,0	0,0	0,0	0,2	0,4	0,6	**76,4**	4,6	2,0	15,8	Sf
102	9	FP-09	Piltun	53,322333	143,281500	27	0,1	0,1	1,0	3,7	14,5	31,8	**48,8**	0,0	0,0	0,0	Sf
103	10	FP-10	Piltun	53,317333	143,313667	29	0,0	0,0	0,0	0,1	2,3	45,0	46,6	4,8	0,7	0,5	Sfm
104	11	FP-11	Piltun	53,296500	143,282833	25	0,0	0,0	0,9	4,4	10,8	44,8	38,8	0,3	0,0	0,0	Smf
105	12	FP-12	Piltun	53,263000	143,306667	25	0,0	0,0	3,2	7,0	12,9	39,6	35,1	1,9	0,3	0,0	Smf
106	13	FP-13	Piltun	53,253333	143,301667	23	3,2	4,3	13,1	14,8	22,4	36,1	4,8	0,4	0,5	0,4	Smc
107	14	FP-14	Piltun	53,198333	143,371667	30	1,1	1,4	6,2	8,4	13,7	34,8	29,6	4,0	0,5	0,3	Smf
108	15	FP-15	Piltun	53,200000	143,396667	31	0,0	0,0	0,0	0,6	2,6	11,6	**76,8**	8,0	0,4	0,0	Sf
109	16	FP-16	Piltun	53,103850	143,320000	20	0,0	0,0	0,2	0,1	2,1	25,6	**68,3**	2,9	0,8	0,0	Sf
110	17	FP-17	Piltun	53,085200	143,311517	15	0,0	0,0	0,0	0,2	1,4	12,6	**77,2**	8,4	0,2	0,0	Sf
111	18	FP-18	Piltun	52,891917	143,410750	24	0,0	0,0	0,1	0,7	1,8	23,8	**70,3**	2,3	0,6	0,4	Sf
112	19	FP-19	Piltun	52,901650	143,425917	25	0,0	0,0	0,1	0,2	0,4	14,0	**78,2**	5,2	1,2	0,7	Sf

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
113	20	FP-20	Piltun	52,909033	143,430700	26	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
114	21	FP-21	Piltun	53,346000	143,225000	14	0,0	0,0	0,0	3,0	0,8	27,2	**66,9**	0,7	0,7	0,7	Sf
115	22	FP-22	Piltun	53,431667	143,230000	31	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
116	23	FP-23	Piltun	53,475000	143,215000	33	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
117	24	FP-24	Piltun	53,495183	143,192650	33	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
118	25	FP-25	Piltun	53,498983	143,201767	35	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
119	26	FP-26	Piltun	53,468083	143,216050	33	0,0	0,0	3,0	6,8	15,5	43,0	28,9	2,2	0,4	0,2	Smf
120	27	FP-27	Piltun	53,247383	143,213600	32	0,0	0,1	0,0	4,2	16,1	**55,9**	23,0	0,7	0,0	0,0	Sm
121	28	FP-28	Piltun	53,259133	143,323483	26	3,2	4,2	14,2	16,3	22,0	29,4	6,2	3,5	0,6	0,4	Scm+Gr
122	29	FP-29	Piltun	53,296983	143,358200	34	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
123	30	FP-30	Piltun	53,405000	143,261667	33	0,0	0,0	0,2	1,6	10,4	**55,4**	31,2	0,5	0,3	0,4	Sm
124	31	PP-01	Piltun	52,872683	143,376850	15	0,0	0,1	0,8	0,8	2,0	18,0	**68,3**	9,8	0,2	0,0	Sf
125	32	PP-02	Piltun	52,872500	143,376667	15	0,0	0,0	0,2	1,0	4,8	11,0	**75,2**	4,8	1,6	1,4	Sf
126	33	PP-03	Piltun	53,054883	143,334900	22	0,0	0,0	0,0	0,3	1,8	10,3	**79,8**	7,4	0,4	0,0	Sf
127	34	PP-04	Piltun	53,072117	143,331200	19	0,0	0,0	0,1	0,6	1,2	5,2	**83,6**	8,8	0,5	0,0	Sf
128	35	PP-05	Piltun	53,153833	143,315833	23	0,0	0,0	0,2	0,2	0,1	2,0	**86,8**	9,5	1,2	0,0	Sf
129	36	PP-06	Piltun	53,183817	143,308633	21	0,0	0,0	0,1	0,7	7,1	**60,7**	30,4	0,5	0,2	0,3	Sm
130	37	PP-07	Piltun	53,206333	143,301183	21	0,0	0,0	0,3	0,8	1,3	15,8	**78,5**	3,2	0,1	0,0	Sf
131	38	PP-08	Piltun	53,211633	143,365117	31	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
132	39	PP-09	Piltun	53,212300	143,341000	32	0,0	0,0	0,0	2,9	18,1	**54,0**	22,4	2,6	0,0	0,0	Sm
133	40	PP-10	Piltun	53,216667	143,300000	23	0,0	0,0	4,5	7,8	22,6	**50,0**	11,7	3,3	0,1	0,0	Sm
134	41	PP-11	Piltun	53,238333	143,285000	26	**100,0**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	Peb
135	42	PP-14	Piltun	53,311667	143,271667	27	0,0	0,0	0,8	11,2	36,8	39,3	11,3	0,5	0,1	0,0	Smc

Item	Number	Station	Area	Coordinates (decimal form)		Depth, m	Bottom Type										Bottom Code
							Peb	Grc	Grm	Grf	Sc	Sm	Sf	Ac	Af	Pec	
							Size of Prevalent Fraction, mm										
				longitude	latitude		> 10	10-5	5-2	2-1	1-0,5	0,5-0,25	0,25-0,1	0,1-0,05	0,05-0,01	< 0,01	
136	43	PP-15	Piltun	53,356667	143,271667	30	12,9	32,9	27,1	7,7	4,7	7,6	5,9	0,9	0,3	0,0	Gr
137	44	PP-16	Piltun	53,356450	143,262433	28	0,0	0,0	1,3	3,3	11,0	**51,7**	30,3	2,2	0,2	0,0	Sm
138	45	PP-17	Piltun	53,389667	143,235900	26	0,0	0,0	0,3	2,9	15,0	**53,0**	28,2	0,6	0,0	0,0	Sm
139	46	PP-18	Piltun	53,416217	143,237333	31	0,0	0,0	1,3	3,3	9,7	44,4	37,8	2,5	0,7	0,3	Smf
140	47	PP-19	Piltun	53,577533	143,157417	27	0,0	0,0	0,0	0,0	2,7	**53,2**	42,1	0,9	0,5	0,6	Sm
141	48	PP-1R	Piltun	52,871667	143,376667	15	0,0	0,0	0,0	0,3	3,1	**66,2**	30,0	0,4	0,0	0,0	Sm
142	49	PP-25	Piltun	53,029000	143,326067	15	0,0	0,0	0,1	0,2	3,7	22,7	**69,5**	3,1	0,7	0,0	Sf
143	50	PP-26	Piltun	53,018500	143,329200	17	0,0	1,3	15,3	10,5	6,1	26,1	36,3	2,1	1,6	0,7	Smf
144	51	PP-27	Piltun	53,029000	143,346633	17	0,0	0,0	0,0	0,1	3,4	**62,5**	32,8	0,5	0,7	0,0	Sm
145	52	PP-28	Piltun	52,763567	143,376200	17	0,0	0,0	0,2	1,2	5,8	9,5	**79,1**	3,9	0,3	0,0	Sf

APPENDIX 4, Concentrations of Petroleum Hydrocarbons (mcg/g dry sediment) and 10 Toxic Metals (mcg/g dry sediment) in Bottom Sediments of the Piltun and Offshore Areas Based on 2004 Field Study Results

Station	Depth	Concentrations of Substances in Bottom Sediments, mcg/g dry sediment										
		PH	**Al**	**As**	**Ba**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Pb**	**Zn**
1-1S	13	3,74	2128	1,15	4,00	0,160	37,35	2,51	6424	0,0019	0,00	7,40
1-2N	16	2,53	1042	1,78	1,78	0,022	13,90	2,25	4895	0,0022	0,84	7,80
2-1M	16	3,06	2460	1,11	3,45	0,001	8,71	2,20	5647	0,0031	3,00	10,60
2-1N	16	1,82	2331	1,25	2,18	0,001	9,54	1,62	7435	0,0002	0,00	3,60
2-2M	23	1,94	1658	1,05	2,90	0,001	7,98	1,30	6621	0,0026	1,20	8,60
2-2N	15	3,52	1827	0,88	4,42	0,096	9,54	2,40	6245	0,0030	0,48	6,40
2-2NR	16	2,89	1770	0,69	2,61	0,048	9,54	1,30	6581	0,0031	0,03	2,40
2-2S	21	3,08	2331	0,69	2,18	0,036	32,42	1,90	6092	0,0025	0,03	5,60
2-3M	16	2,36	750	1,34	10,23	0,006	6,43	3,20	6430	0,0020	2,80	4,20
2-3N	15	1,55	1254	0,52	3,13	0,001	31,12	1,40	4798	0,0016	3,40	7,00
2-3S	15	2,55	2128	1,39	4,37	0,001	6,24	2,60	2355	0,0180	4,20	7,00
2-4M	15	2,17	2523	1,58	2,14	0,096	7,47	2,20	4356	0,0034	3,20	3,60
2-4S	20	3,03	1820	2,07	3,01	0,081	3,35	5,00	6890	0,0002	1,70	7,00
2-5N	17	2,18	771	1,39	4,51	0,078	4,70	0,96	6894	0,0200	3,40	9,80
2-5S	22	1,39	1808	1,23	1,90	0,088	28,57	3,00	6224	0,0013	0,01	8,60
3-1M	18	1,49	1465	1,15	3,61	0,006	7,40	3,00	4339	0,0025	4,60	8,60
3-1N	24	3,11	826	0,83	3,81	0,025	9,13	4,60	6224	0,0024	6,40	3,60
3-2M	27	3,70	2910	0,66	5,83	0,001	9,71	1,98	5021	0,0018	1,70	5,60
3-2N	27	3,11	432	1,22	3,13	0,001	8,94	1,76	6088	0,0110	1,14	8,60
3-3M	28	4,80	750	1,46	5,12	0,001	36,27	2,20	6304	0,0002	2,19	15,10
3-3S	25	2,36	919	0,92	2,57	0,036	7,40	3,00	2355	0,0125	2,00	4,80
3-4M	23	4,30	1320	1,38	2,48	0,040	8,92	1,42	5349	0,0240	1,10	7,80
3-4S	26	2,85	1769	1,37	2,79	0,001	8,71	3,40	7356	0,0002	1,23	7,80
3-5S	25	0,33	1844	1,66	6,27	0,080	8,30	1,64	7435	0,0023	1,90	8,60
4-1M	25	2,89	2592	0,83	1,85	0,001	8,30	4,60	6304	0,0023	3,00	3,60
4-1N	22	2,49	2072	1,04	2,33	0,001	31,12	1,98	7365	0,0022	2,60	2,27
4-1S	16	3,33	2562	1,05	3,04	0,005	8,50	2,20	6424	0,0035	1,90	15,80
4-2M	27	4,49	1163	0,80	20,42	0,001	13,90	2,60	5091	0,0020	1,96	9,00
4-2S	22	2,29	2986	1,91	2,04	0,048	15,10	3,60	4118	0,0200	4,80	7,00
4-3M	28	2,53	2141	1,66	2,75	0,170	26,97	6,60	7665	0,0026	2,60	7,80
4-3N	28	2,36	1875	1,22	1,90	0,130	8,50	2,60	6177	0,0019	0,00	13,40
4-4N	28	2,56	1916	1,05	3,58	0,130	8,17	3,00	4135	0,0020	0,68	6,40
4-4S	29	0,58	1488	0,91	0,96	0,081	13,75	1,64	4797	0,0020	2,40	8,60
4-5N	33	2,25	1793	1,35	3,66	0,170	6,63	3,40	5647	0,0019	1,32	9,20
PIL-1	3	1,61	1362	1,75	5,83	0,096	13,75	3,40	6730	0,0110	4,60	8,58
PIL-2	5	1,50	1916	1,35	4,89	0,016	12,24	1,42	4475	0,0002	1,64	5,60
PIL-4	10	0,39	1717	1,53	3,10	0,270	8,50	0,86	7163	0,0035	1,11	0,88
PIL-5	3	1,85	2045	0,69	2,33	0,078	10,48	0,86	2824	0,0002	0,48	8,60
PIL-6	5	1,78	2353	0,96	2,48	0,080	24,90	2,51	4570	0,0002	2,80	12,80
PIL-8	10	0,74	1495	0,95	5,92	0,032	33,20	3,20	4135	0,0110	0,12	7,00
PIL-9	3	0,33	1559	0,50	4,42	0,001	1,61	1,30	4890	0,0230	3,40	4,40
PIL-10	5	1,08	1522	1,15	16,77	0,300	10,99	1,64	6177	0,0036	1,12	13,40
PIL-12	10	0,88	1808	0,89	2,71	0,001	13,28	1,36	4465	0,0002	1,98	5,60
B5-3	37	2,09	1769	0,85	2,17	0,300	12,24	3,60	5918	0,0037	1,02	12,60

Station	Depth	Concentrations of Substances in Bottom Sediments, mcg/g dry sediment										
		PH	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Pb	Zn
B5-4	29	2,59	1875	0,85	1,90	0,270	37,35	2,60	5557	0,0002	1,94	6,40
B6-2	47	2,35	1343	0,83	4,00	0,090	20,75	1,36	7665	0,0019	2,19	13,40
B6-3	36	2,08	1786	1,61	5,37	0,080	12,65	0,26	5317	0,0025	1,14	5,60
B7-2	48	5,22	2986	0,47	1,85	0,026	9,54	2,40	6520	0,0250	1,06	37,60
B8-1	59	1,89	1899	0,95	22,55	0,072	4,98	0,98	5194	0,0018	1,80	5,00
B8-2	50	1,74	1974	0,99	4,51	0,001	13,07	2,40	3103	0,0015	4,20	7,12
B9-1	57	4,70	2530	0,91	4,51	0,074	8,92	4,60	4890	0,0020	0,24	5,00
B10-2	56	4,58	1666	1,53	5,37	0,001	6,05	1,84	5918	0,0018	6,40	3,60
B10-3	53	3,34	1343	0,89	2,71	0,001	10,99	1,42	6430	0,0002	1,06	9,00
B11-2	55	3,28	1720	1,37	2,37	0,074	3,35	2,20	4798	0,0002	5,20	15,80
B11-4	55	1,67	2523	0,69	2,14	0,100	12,65	1,50	3103	0,0027	2,00	7,12
B12-1	61	3,29	2016	0,83	3,61	0,130	13,07	3,60	3192	0,0019	0,01	5,60
B12-2	62	3,01	2353	2,07	4,37	0,024	15,10	3,20	3504	0,0038	0,00	5,00
B12-3	63	2,86	826	0,49	2,90	0,001	12,92	1,50	5349	0,0190	3,40	4,20
B12-4	59	3,06	1465	1,22	1,90	0,001	12,92	2,44	3504	0,0020	1,42	13,00
FP-7	47	2,09	771	0,50	2,18	0,001	8,71	6,60	5655	0,0030	0,30	8,60
	Mean	**2,5**	**1768**	**1,1**	**4,23**	**0,06**	**13,5**	**2,5**	**5452**	**0,005**	**2**	**8,08**
	St. Dev.	0,1	76,2	0,1	0,51	0,01	1,17	0,2	176	0,001	0,2	0,66
	MIN	0,3	432	0,5	0,96	0	1,61	0,3	2355	0,0002	0	0,88
	MAX	5,2	2986	2,1	22,6	0,3	37,4	6,6	7665	0,025	6,4	37,6

APPENDIX 5. Taxonomic List of Benthic and Nektobenthic Species Observed in the Piltun and Offshore Areas in 2001-2004.

Item	Species Count	Taxon/Species Name	Code
		Actiniaria – sea anemones*	
1	1	*Epiactis lewisi*	Act
212	2	*Halcampoides purpurea*	Act
		Amphipoda – amphipod crustaceans	
2	1	*Acanthostepheia behringiensis*	Am
172	2	*Acanthostepheia malmgreni*	Am
173	3	*Ampelisca eoa*	Am
3	4	*Ampelisca eschrichti*	Am
188	5	Ampelisca macrocephala	Am
4	6	*Anisogammarus pugettensis*	Am
174	7	*Anisogammarus schmidti*	Am
189	8	Anonyx compactus	Am
5	9	*Anonyx kurilicus*	Am
190	10	Anonyx lilljeborgi	Am
6	11	*Anonyx nugax pacificus*	Am
7	12	*Anonyx ochoticus*	Am
191	13	Anonyx pavlovskii	Am
8	14	*Anonyx sp.*	Am
192	15	Atylus carinatus	Am
9	16	*Atylus collingi*	Am
175	17	*Bathymedon langsdorfi*	Am
10	18	*Bathymedon obtusifrons*	Am
193	19	Bathymedon sp.	Am
194	20	Bathymedon subcarinatus	Am
11	21	*Bathymedon tilessii*	Am
12	22	*Boeckosimus derjugini*	Am
176	23	*Boeckosimus simus*	Am
195	24	Boeckosinus krassini	Am
177	25	*Byblis erythrops*	Am
13	26	*Caprella cristibrachium*	Am
196	27	Dulichia spinosissima	Am
14	28	*Eogammarus schmidti*	Am
15	29	*Eohaustorius eous eous*	Am
16	30	*Ericthonius tolly*	Am
197	31	Eyakia simplex	Am
178	32	*Harpiniopsis kobjakovae*	Am
198	33	Harpiniopsis similis	Am
199	34	Harpiniopsis simplex	Am
179	35	*Hippomedon denticulatus orientalis*	Am

Item	Species Count	Taxon/Species Name	Code
200	36	Ischyrocerus anguipes	Am
17	37	*Ischyrocerus chamiossi*	Am
201	38	Ischyrocerus cristatus	Am
18	39	*Ischyrocerus elongatus*	Am
19	40	*Ischyrocerus krascheninnikovi*	Am
20	41	*Ischyrocerus sp.*	Am
202	42	Jyrrhoe crenulata	Am
180	43	*Lembos arcticus*	Am
203	44	Lepidepecreum kasatka	Am
21	45	*Maera loveni*	Am
22	46	*Melita sp.*	Am
23	47	*Melitoides makarovi*	Am
24	48	*Metopa clypeata*	Am
25	49	*Metopa layi*	Am
26	50	*Metopa majuscula*	Am
27	51	*Metopa sp.*	Am
28	52	*Metopa spitzbergensis*	Am
29	53	*Monoculodes crassirostris*	Am
30	54	*Monoculodes sp.*	Am
31	55	*Monoculodes zernovi*	Am
181	56	*Onisimus krassini*	Am
32	57	*Orchomene gurjanovae*	Am
33	58	*Orchomenella japonica*	Am
204	59	Orchomenella nana	Am
34	60	*Orchomenella pinguis*	Am
205	61	Paraphoxus simplex	Am
35	62	*Parapleustes tricuspis*	Am
182	63	*Parapleustes vasinae*	Am
183	64	*Paronesimus barentsi*	Am
36	65	*Photis baekmannae*	Am
206	66	Photis fischmanni	Am
37	67	*Photis reinchardi*	Am
38	68	*Photis sp.*	Am
207	69	Pleustomesus japonicoides	Am
39	70	*Pleusymtes sp.*	Am
208	71	Pleusymtes sp.	Am
40	72	*Pleusymtes vasinae*	Am
209	73	Podoceropsis nitida	Am
41	74	*Pontharpinia longirostris*	Am
42	75	*Pontharpinia nasuta*	Am
43	76	*Pontharpinia robusta*	Am
44	77	*Pontoporeia affinis*	Am
210	78	Protomedeia epimerata	Am

Item	Species Count	Taxon/Species Name	Code
48	79	*Protomedeia fasciata.*	Am
45	80	*Protomedeia macrocarpa*	Am
46	81	*Protomedeia microdactila*	Am
47	82	*Protomedeia popovi*	Am
211	83	*Protomedeia sp.*	Am
49	84	*Psammonyx kudrjaschovi*	Am
50	85	*Rhachotropis oculata*	Am
51	86	*Synchelidium gurjanovae*	Am
52	87	*Wecomedon minusculus*	Am
184	88	*Wecomedon wirketis*	Am
53	89	*Weswoodilla sp.*	Am
54	90	*Weswoodilla sp.1*	Am
		Ascidiacea – ascidians	
185	1	*Ascidia vegae*	Asc
55	2	*Pelonaia corrugata*	Asc
		Bivalvia – bivalve mollusks	
56	1	*Arvella japonica*	Bi
57	2	*Arvella manshurica*	Bi
213	3	*Astarte arctica*	Bi
214	4	*Astarte sp.*	Bi
58	5	*Crenella decussata decussata*	Bi
215	6	*Diplodonta aleutica*	Bi
216	7	*Ennucula fenuis*	Bi
59	8	*Hiatella arctica*	Bi
60	9	*Liocyma fluctuosa*	Bi
61	10	*Macoma balthica*	Bi
62	11	*Macoma calcarea*	Bi
217	12	*Macoma cuneipyga*	Bi
218	13	*Macoma golikovi*	Bi
63	14	*Macoma lama*	Bi
64	15	*Macoma middendorffi*	Bi
65	16	*Macoma sp.*	Bi
66	17	*Mactromeris polynyma = Spisula voji*	Bi
67	18	*Megangulus luteus = Peronidia lutea*	Bi
68	19	*Musculus niger*	Bi
219	20	*Musculus sp.*	Bi
69	21	*Mya (Mya) priapus*	Bi
70	22	*Mya sp.*	Bi
220	23	*Mya truncata*	Bi
71	24	*Mysella planata*	Bi
72	25	*Mysella gurjanovae*	Bi
73	26	*Mysella kurilensis*	Bi
74	27	*Panomya sp. (juv.)*	Bi

Item	Species Count	Taxon/Species Name	Code
75	28	*Serripes groenlandicus*	Bi
76	29	*Siliqua alta*	Bi
186	30	*Spisula sachalinensis*	Bi
221	31	*Thracia myopsis*	Bi
77	32	*Tridonta borealis*	Bi
78	33	*Tridonta montaqui*	Bi
79	34	*Tridonta rollandi*	Bi
80	35	*Vilasina vernicosa*	Bi
81	36	*Yoldia (Cnesterium) seminuda*	Bi
82	37	*Yoldia (Yoldia) myalis*	Bi
		Cirripedia – barnacles*	
83	1	*Chthamalus dalli*	Ci
84	2	*Solidobalanus hesperius*	Ci
85	3	*Balanus cariosus*	Ci
		Cumacea – cumaceans	
86	1	*Diastylis bidentata*	Cu
87	2	*Diastylopsis dowsoni*	Cu
88	3	*Lamprops quadriplicata*	Cu
		Decapoda – decapod crustaceans	
89	1	*Hyas coarctatus (juv.)*	De
90	2	*Pagurus ochotensis*	De
91	3	*Pagurus pubescens*	De
92	4	*Crangon septemspinosa*	De
93	5	*Telmessus cheiragonus*	De
		Echinoidea – sea urchins	
94	1	*Echinarachnius parma*	Ech
		Euphausiacea – krills	
95	1	*Thysanoessa raschii*	Euph
		Gastropoda – gastropod mollusks	
222	1	*Ancistroleis beringianus*	Ga
223	2	*Buccinum lichkeanum*	Ga
96	3	*Buccinum middendorffi*	Ga
97	4	*Buccinum percrassum*	Ga
98	5	*Buccinum sakhalinense*	Ga
224	6	*Cryptonatica aleutica*	Ga
99	7	*Cryptonatica clausa*	Ga
100	8	*Cryptonatica janthostoma*	Ga
225	9	*Cylichna alba*	Ga
101	10	*Cylichna consobrina*	Ga
102	11	*Lunatia pallida*	Ga
103	12	*Neptunea bulbacea*	Ga
104	13	*Piliscus radiatus*	Ga
105	14	*Pseudolimesus nassula*	Ga

Item	Species Count	Taxon/Species Name	Code
106	15	*Solariella obscura intermedia*	Ga
		Holoturioidea – sea cucumbers	
254		*Chiridota ochotensis*	Ho
		Hydroidea – hydroids*	
107	1	*Abietinaria thujarioides*	Hy
108	2	*Calicella syringa*	Hy
109	3	*Campanularia volubilis*	Hy
110	4	*Halecium reversum*	Hy
111	5	*Lafoea fruticosa*	Hy
112	6	*Obelia longissima*	Hy
113	7	*Sertularella plumosa*	Hy
114	8	*Sertularella similis*	Hy
115	9	*Sertularella tricuspidata*	Hy
116	10	*Sertularella gigantea*	Hy
117	11	*Sertularia similis*	Hy
118	12	*Thuiaria breitfussi*	Hy
119	13	*Thuiaria cylindrica*	Hy
120	14	*Thuiaria gonorhiza*	Hy
121	15	*Thuiaria triserialis*	Hy
		Isopoda – isopod crustaceans	
122	1	*Saduria entomon*	Is
123	2	*Synidotea bicuspida*	Is
124	3	*Synidotea cinerea*	Is
		Mysidacea – mysids	
125	1	*Tenagomysis orientalis*	My
		Ophiuroidea – brittle stars	
126	1	*Ophiura sarsi*	Oph
127	2	*Stegophiura nodosa*	Oph
		Pantopoda – sea spiders	
128	1	*Nymphon striatum*	Pa
		Polychaeta – bristle worms	
129	1	*Ampharete acutifrons*	Po
226	2	*Ampharete crassiseta*	Po
227	3	*Ampharete finmarchica*	Po
130	4	*Ampharete goesi*	Po
228	5	*Ampharete lindstromi*	Po
131	6	*Arabella iricolor*	Po
132	7	*Autolytus prismaticus*	Po
133	8	*Capitella capitata*	Po
134	9	*Chaetozone setosa*	Po
135	10	*Chone teres*	Po
136	11	*Cistenides granulata*	Po

Item	Species Count	Taxon/Species Name	Code
137	12	*Cistenides soldatovi*	Po
138	13	*Demonax fullo*	*Po*
139	14	*Eteone longa*	Po
229	15	*Eteone sp.*	Po
230	16	*Euchone analis*	Po
140	17	*Eumida sanguinea*	Po
141	18	*Euzonus sp.*	Po
231	19	*Exogone gemmifera*	Po
142	20	*Glycera capitata*	Po
143	21	*Glycinde armigera*	Po
144	22	*Goniada maculata*	*Po*
145	23	*Harmothoe imbricata*	Po
146	24	*Idanthyrsus armatus*	Po
232	25	*Laphania boecki*	Po
147	26	*Lumbrineris bifurcata*	Po
233	27	*Lumbrineris heteropoda*	Po
148	28	*Lumbrineris japonica*	Po
149	29	*Lumbrineris minuta*	Po
150	30	*Lumbrineris sp.*	Po
151	31	*Magelona sachalinensis*	*Po*
234	32	*Mediomastus californiensis*	Po
152	33	*Melinna cristata*	Po
235	34	*Microclymene pacifica*	Po
236	35	*Nephthys californiensis*	Po
237	36	*Nephthys longosetosa*	Po
153	37	*Nephtys caeca*	Po
154	38	*Nephtys ciliata*	Po
155	39	*Nephtys longosetosa*	Po
238	40	*Nicomache sp.*	*Po*
239	41	*Onuphis geophiliformis*	Po
157	42	*Onuphis iridescens*	Po
158	43	*Onuphis shirikishinaiensis*	Po
240	44	*Onuphis sp.*	Po
159	45	*Ophelia limacina*	Po
241	46	*Paradiopatra fauchaldi*	Po
160	47	*Pectinaria sp.*	Po
242	48	*Pholoe longa*	Po
243	49	*Phyllodoce (Anaitides) maculata*	Po
161	50	*Phyllodoce groenlandica*	Po
244	51	*Phyllodoce sp.*	Po
245	52	*Pista cristata*	Po
246	53	*Polydora cardalia*	Po
247	54	*Polydora sp.*	Po

Item	Species Count	Taxon/Species Name	Code
248	55	*Potamilla reniformis*	Po
162	56	*Potamilla torelli*	Po
163	57	*Praxillella praetermissa*	Po
249	58	*Proclea graffi*	Po
164	59	*Scalibregma inflatum*	Po
250	60	*Scolelepis sp.*	Po
165	61	*Scoloplos armiger*	Po
251	62	*Sphaerosyllis hirsuta*	Po
166	63	*Spio filicornis*	Po
252	64	*Spio sp.*	Po
167	65	*Spiophanes bombyx*	Po
168	66	*Travisia forbesii*	Po
169	67	*Travisia sp.*	Po
253	68	*Typosyllis oerstedi*	Po
		Sipunculida – peanut worms	
170	1	*Phascolosoma japonicum*	Si
187	2	*Phascolosoma margaritacea*	Si
		Spongia – sponges***	
171	1	*Halichondria panicea*	Sp
		Pisces – fish	
	1	*Ammodytes hexapterus*	Pi

APPENDIX 6. Quantitative Characteristics of Benthos at Stations in the Piltun Area (colony density - A, spec./m^2; biomass - B, g/m^2).

Taxonomic Group	Station											
	1-1S		1-2M		1-2N		1-2S		2-1M		2-1N	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	1207	41,22	9150	248,58	2093	102,33	5177	79,83	1425	74,29	3125	106,17
Bivalvia	160	48,60	7	7,44	5	0,67	23	6,31	2	10,13	0	0
Cumacea	238	5,70	48	0,86	25	0,20	47	0,84	17	0,34	67	1,83
Echinoidea	0	0,00	0	0,00	5	35,00	0	0	12	138,05	0	0
Euphasiacea	7	0,37	18	0,78	10	0,45	38	0,09	12	0,33	3	0,07
Gastropoda	2	0,05	3	0,41	0	0,00	0	0	2	0,23	2	0,03
Isopoda	35	28,78	590	4,76	75	1,85	1488	17,14	35	4,48	48	4,38
Pisces	0	0	0	0	52	166,00	0	0	7	12,1	0	0
Polychaeta	18	8,40	100	0,33	7	0,78	30	1,05	0	0	0	0
Rest	0	0	0	0	0	0	0	0	0	0	0	0
Total	1667	133,12	9916	263,16	2272	307,28	6803	105,26	1512	239,95	3245	112,48

Taxonomic Group	Station											
	2-2M		2-2NR		2-2S		2-3M		2-3N		2-3S	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	272	35,41	780	79,5	205	19,8	923	80,07	1313	87,53	1450	68,17
Bivalvia	10	45,96	7	4,47	10	12,28	7	33,57	28	46,63	35	94,69
Cumacea	32	0	32	0,07	0	0	10	0,05	2	0	2	0,03
Echinoidea	0	0	12	108,75	0	0	0	0	0	0	0	0
Euphasiacea	0	0	8	0,35	0	0	2	0,08	0	0	0	0
Gastropoda	2	10,33	7	0,11	5	0,58	10	59,1	3	7,5	5	11,02
Isopoda	173	13,47	25	1,93	105	9,33	153	10,02	100	7,06	372	16,12
Pisces	17	74,98	3	4,72	0	0	0	0	0	0	0	0
Polychaeta	2	1,18	10	6,83	18	0,54	15	2,17	20	1,29	25	6,93
Rest	0	0	0	0	0	0	0	0	3	1,65	0	0
Total	508	181,33	884	206,73	343	42,53	1120	185,06	1469	151,66	1889	196,96

Taxonomic Group	Station											
	2-4M		2-4N		2-4S		2-5M		2-5N		2-5S	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	4225	198,59	2320	222,08	213	23,23	70	29,32	85	12,85	105	7,68
Bivalvia	13	100,91	7	81,75	0	0	10	8	8	53,06	25	77,21
Cumacea	2	0,03	52	0,03	50	0,03	2	0,02	0	0	7	0,09
Echinoidea	0	0	0	0	0	0	0	0	2	16,07	30	338,33
Euphasiacea	0	0	0	0	0	0	2	0,08	0	0	0	0
Gastropoda	3	0,38	0	0	0	0	0	0	2	0,24	3	1,92
Isopoda	95	14,53	43	57,95	22	27,95	10	2,17	153	13,25	42	52,58
Pisces	0	0	0	0	0	0	2	13,79	0	0	0	0
Polychaeta	28	7,43	7	2,42	0	0	37	3,16	17	0,98	153	7,35
Rest	0	0	0	0	0	0	0	0	0	0	0	0
Total	4366	321,87	2429	364,23	285	51,21	133	56,54	267	96,45	365	485,16

Taxonomic Group	Station											
	3-1M		3-1N		3-1S		3-2M		3-2N		3-2NR	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	72	15,87	180	10,5	150	7,13	50	8,96	20	4,27	242	7,12
Bivalvia	2	9,88	13	7,8	532	4,16	55	0,32	2	1,93	0	0
Cumacea	2	0,02	7	0,01	23	0,04	15	0,05	0	0	0	0
Echinoidea	7	177,17	50	321,17	95	1149,5	65	648,46	115	2150	122	3203,33
Euphasiacea	5	0,16	0	0	2	0,08	0	0	0	0	0	0
Gastropoda	0	0	2	8,73	2	0,02	8	19,75	3	31,33	2	2,03
Isopoda	0	0	3	1,78	45	35,82	13	43,25	65	73,08	3	25,52
Pisces	2	7,63	0	0	0	0	7	28,22	21	68,22	2	9,53
Polychaeta	3	0,04	47	26,03	182	3,92	8	0,02	2	0,21	2	6,67
Rest	2	0,77	12	0,23	0	0	2	7,95	0	0	0	0
Total	95	211,54	314	376,25	1031	1200,67	223	756,98	228	2329,04	373	3254,2

Taxonomic Group	Station											
	3-2S		3-2SR		3-3M		3-3N		3-3S		3-4M	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	87	1,17	655	14,2	8	1,23	1912	152,17	215	8,67	533	77,26
Bivalvia	0	0	2897	7,83	2	0	125	63,65	0	0	8	1,5
Cumacea	2	0,04	3	0,01	0	0	62	0,19	0	0	20	0,02
Echinoidea	268	122,47	10	1,55	88	209,18	393	2006,67	65	164,53	115	303,3
Euphasiacea	0	0	0	0	0	0	5	0,02	0	0	40	0,73
Gastropoda	0	0	23	1,83	3	17,22	8	25,03	3	53,19	0	0
Isopoda	3	20,32	0	0	3	6,18	0	0	20	69,23	3	0,02
Pisces	0	0	0	0	18	59,06	2	12,47	2	4,05	0	0
Polychaeta	22	6,51	38	6,33	17	4,71	210	21,45	62	79,47	80	13,03
Rest	21	12,69	50	2,42	5	4,28	24	23,32	5	1,84	7	2,8
Total	403	163,2	3676	34,17	144	301,86	2741	2304,97	372	380,98	806	398,66

Taxonomic Group	Station											
	3-4S		3-5N		4-1M		4-1N		4-1S		4-2M	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	137	1,37	9168	110,51	23	2,95	150	28,01	282	75,42	138	9,01
Bivalvia	20	36,3	130	40,21	2	11,33	35	8,14	0	0	8	3,29
Cumacea	3	0,02	1263	11,22	2	0,02	128	1,07	0	0	840	1,19
Echinoidea	323	1122,78	32	19,38	248	1109,73	157	478,95	28	240,6	80	1409,9
Euphasiacea	0	0	7	0,18	0	0	0	0	12	0,3	0	0
Gastropoda	0	0	7	28,88	0	0	0	0	0	0	2	7,5
Isopoda	13	0,42	0	0	0	0	2	0,01	0	0	0	0
Pisces	12	69,53	19	70,1	0	0	0	0	8	30,3	2	5,18
Polychaeta	150	7,22	1253	24,69	17	6,21	35	7,59	17	3,82	105	5,09
Rest	0	0	44	9,23	5	0,89	10	3,49	2	0,03	2	5,05
Total	658	1237,64	11923	314,4	297	1131,13	517	527,26	349	350,47	1177	1446,21

Taxonomic Group	Station											
	4-2N		4-2S		4-3M		4-3N		4-3S		4-4N	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	588	90,63	102	10,83	48	14,51	108	7,13	25	7,71	95	8,95
Bivalvia	2	0,01	5	13,58	3	5,43	7	7,21	2	3,38	50	63,39
Cumacea	0	0	2	0,03	0	0	7	0,07	0	0	113	0,11
Echinoidea	67	735,01	0	0	95	399,05	130	69,34	103	437,59	65	129,06
Euphasiacea	0	0	0	0	0	0	2	0,04	0	0	5	0,23
Gastropoda	0	0	2	7,5	5	6,9	2	8,9	7	61,45	2	41,47
Isopoda	0	0	15	30,33	0	0	0	0	0	0	22	93,72
Pisces	25	136,67	0	0	8	6,58	14	71,3	0	0	27	127,78
Polychaeta	13	5,1	18	4,43	23	3,75	27	3,61	7	0,43	45	1,47
Rest	3	0,05	2	5,05	0	0	7	1,44	0	0	8	2,7
Total	698	967,47	146	71,75	182	436,22	304	169,04	144	510,56	432	468,88

Taxonomic Group	Station							
	4-4S		4-5M		4-5N		4-5S	
	A	B	A	B	A	B	A	B
Amphipoda	1095	39,03	85	19,32	3110	26,58	6360	36,9
Bivalvia	43	3,79	7	3,92	37	19,78	60	47,53
Cumacea	277	1,48	475	2,98	853	16,38	748	1,64
Echinoidea	0	0	73	367,83	13	75	0	0
Euphasiacea	0	0	0	0	0	0	0	0
Gastropoda	8	3,13	0	0,85	3	8,92	2	3,58
Isopoda	2	19,12	15	100,16	0	0	10	37,67
Pisces	2	16,75	0	0	0	0	0	0
Polychaeta	108	12,67	720	2,72	143	27,27	570	7,18
Rest	18	26,92	7	0,05	16	0,72	5	3,39
Total	1553	122,89	1382	497,83	4175	174,65	7755	137,89

APPENDIX 7. Quantitative Characteristics of Benthos at Stations in the Offshore Area (colony density - A, spec./m^2; biomass - B, g/m^2).

Taxonomic Group	Station											
	B5-1		B5-2		B5-3		B5-4		B6-1		B6-2	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	7622	340,53	6797	237,2	7200	498,77	1110	41,57	7842	403,4	7040	359,83
Actinia	22	61,07	0	0	20	93,93	0	0	88	315,95	13	48,08
Bivalvia	38	136,44	25	35,63	8	96,96	13	370,43	87	104,13	30	287,78
Cumacea	4218	20,53	4517	25,67	27613	170,73	16957	156,72	775	7,78	22853	143,88
Decapoda	2	1,88	1	1,31	2	8,07	0	0	0	0	0	0
Echinoidea	0	0	0	0	0	0	85	626,43	0	0	0	0
Gastropoda	0	0	2	0,25	3	46,8	0	0	0	0	0	0
Holoturia	0	0	3	2,62	0	0	0	0	2	5,54	0	0
Nemertina	8	3,67	2	0,25	3	2,62	3	0,1	25	1,63	2	2,47
Polycheta	85	18,22	123	9,19	22	3,25	23	1,95	367	71,25	27	9,38
Sipunculida	3	5,57	5	2,35	0	0	0	0	7	3,37	0	0
REST	4	8,97	0	0	0	0	0	0	2	0,13	0	0
Total	12002	596,88	11475	314,47	34871	921,13	18191	1197,2	9195	913,18	29965	851,42

Taxonomic Group	Station											
	B6-3		B6-4		B7-1		B7-2		B7-3		B7-4	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	5493	556,33	5955	281,3	7692	343,73	6948	245,43	9353	237,83	2180	37,1
Actinia	25	69,6	154	331,48	37	120,83	28	168,67	58	175,67	287	362,53
Bivalvia	25	368,27	67	80,57	23	262,92	33	174,12	20	337,88	28	33,46
Cumacea	963	6,55	2802	13,8	497	7,11	40	0,28	41840	262,83	6857	25,83
Decapoda	2	6,6	10	26,76	0	0	3	4,85	0	0	30	80,28
Echinoidea	0	0	2	8,66	0	0	0	0	0	0	5	25,98
Gastropoda	2	0,13	1	0,19	0	0	0	0	0	0	2	0,57
Holoturia	0	0	1	3,69	0	0	0	0	0	0	0	0
Nemertina	3	3,27	17	1,09	2	0,04	2	0,95	3	15,13	0	0
Polycheta	40	21,37	258	50,31	90	18,88	43	7,35	12	2,95	40	8,43
Sipunculida	0	0	5	2,25	0	0	2	3,07	0	0	0	0
REST	3	0,17	7	1,23	10	0,58	8	0,47	7	0,35	17	3,44
Total	6556	1032,29	9279	801,33	8351	754,09	7107	605,19	51293	1032,64	9446	577,62

Taxonomic Group	Station											
	B8-1		B8-2		B8-3		B8-4		B9-1		B9-2	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	7720	378,73	12900	817,84	6115	264,28	3830	39,17	12016	870,5	17215	1093,98
Actinia	20	95,98	28	179,7	230	331,54	30	39,03	35	157,67	28	164,25
Bivalvia	23	226,73	7	58,9	37	63,73	58	30,51	22	69,33	18	163,27
Cumacea	695	4,65	2137	13,52	1405	14,08	4115	23,2	2258	12,58	1413	19,84
Decapoda	2	0,14	2	0,23	8	23,48	0	0	8	9,73	0	0
Echinoidea	0	0	0	0	2	24,77	3	55,98	0	0	0	0
Gastropoda	0	0	2	1,97	2	8,05	0	0	12	30	2	29,68
Holoturia	0	0	0	0	0	0	0	0	0	0	0	0
Nemertina	0	0	3	1,87	0	0	0	0	0	0	0	0
Polycheta	32	16,97	93	19,66	195	4,5	42	8,14	50	4,8	35	94,6
Sipunculida	25	5,72	3	10,63	0	0	0	0	28	33,48	8	5,42
REST	2	0,03	0	0,16	2	1,66	0	0	28	2,22	20	1,12
Total	8519	728,95	15175	1104,48	7996	736,09	8078	196,03	14457	1190,31	18739	1572,16

Taxonomic Group	Station											
	B9-3		B9-4		B10-1		B10-2		B10-3		B10-4	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	19517	913,28	887	28,23	4108	260,5	19649	827,33	3680	299,83	212	5,38
Actinia	77	177,95	113	117,69	12	25,03	8	23,58	70	1169	57	301,83
Bivalvia	18	23,25	17	34,05	12	97,5	13	29,42	5	63,25	15	13,02
Cumacea	103	0,68	275	2,13	0	0	3	0,02	2	0,01	2122	15,68
Decapoda	10	12,19	0	0	5	10,53	3	13,1	13	56,3	0	0
Echinoidea	0	0	0	0	0	0	0	0	0	0	93	1548
Gastropoda	0	0	2	0,11	12	31,83	3	23,33	0	0	0	0
Holoturia	0	0	2	4,13	0	0	0	0	0	0	35	20,78
Nemertina	0	0	0	0	0	0	0	0	0	0	0	0
Polycheta	82	37,1	50	18,67	2	0,09	12	4,07	15	31,13	43	15,74
Sipunculida	2	3,23	0	0	28	13,07	13	3,69	22	12,65	0	0
REST	28	3,87	0	0	35	3,32	0	3,25	1	0,04	0	0
Total	19837	1171,55	1346	205,01	4214	441,87	19704	927,79	3808	1632,21	2577	1920,43

Taxonomic Group	Station											
	B11-1		B11-2		B11-3		B11-4		B12-1		B12-2	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	2206	222,71	4817	107,33	4097	342,67	22	0,35	1545	155,88	1203	121,33
Actinia	12	60,67	18	84	10	111,5	85	735	3	3,63	3	3,63
Bivalvia	7	159,5	5	10,8	5	71,14	5	5,43	5	11,02	32	183,17
Cumacea	2	0,03	18	0,18	0	0	28	0,13	0	0	0	0
Decapoda	37	64,18	5	53,5	10	46,82	2	4,5	2	3,5	2	13,6
Echinoidea	0	0	0	0	0	0	78	1420	0	0	0	0
Gastropoda	3	1,48	2	81,75	2	10,73	2	0,32	0	0	0	0
Holoturia	0	0	0	0	0	0	42	20,28	0	0	8	22,33
Nemertina	0	0	0	0	0	0	0	0	0	0	0	0
Polycheta	50	40,65	17	13,62	28	28,7	7	17,96	833	739,83	15	9,42
Sipunculida	105	56	58	42,85	85	87,08	0	0	0	0	0	0
REST	23	7,39	0	0	15	0,43	0	0	0	0	2	2,17
Total	2445	612,61	4940	394,03	4252	699,07	271	2203,97	2388	913,86	1265	355,65

Taxonomic Group	Station			
	B12-3		B12-4	
	A	B	A	B
Amphipoda	1578	58,03	92	0,51
Actinia	0	0	48	393,04
Bivalvia	7	11,29	22	13,5
Cumacea	0	0	1728	10,28
Decapoda	2	3,5	0	0
Echinoidea	27	373,33	63	1174,86
Gastropoda	0	0	0	0
Holoturia	0	0	0	0
Nemertina	0	0	0	0
Polycheta	20	9,99	37	8
Sipunculida	0	0	0	0
REST	0	0	0	0
Total	1634	456,14	1990	1600,19

APPENDIX 8. Quantitative Characteristics of Benthos at Gray Whale Feeding Points in the Piltun Area (colony density - A, spec./m^2; biomass - B, g/m^2).

Taxonomic Group	Station											
	FP-01		FP-02		FP-03		FP-04		FP-05		FP-06	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	185	68,56	562	138,68	814	22,64	3422	96,53	2263	60,90	30	7,17
Bivalvia	0	0,00	0	0,00	22	0,22	0	0,00	4	18,61	0	0,00
Cumacea	11	0,06	33	0,19	0	0,00	0	0,00	0	0,00	0	0,00
Echinoidea	133	0	185	413,66	30	25,64	0	0,00	0	0,00	4	5,22
Euphasiacea	15	0,26	15	0,00	7	0,07	7	0,19	0	0,00	0	0,00
Gastropoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	0	0,00	0	0,00	0	0,00	0	0,00	11	0,85	0	0,00
Pisces	15	137,97	0	0,00	44	290,34	0	0,00	0	0,00	0	0,00
Polychaeta	44	5,35	52	4,09	70	9,36	22	1,89	0	0,00	4	12,84
Rest	0	0,00	4	0,96	4	0,11	0	0,00	0	0,00	0	0,00
Total	403	212,2	851	557,58	991	348,38	3451	98,61	2278	80,36	38	25,23

Taxonomic Group	Station											
	FP-09		FP-10		FP-11		FP-12		FP-13		FP-14	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	650	48,4	322	47,58	7	0,06	0	0	0	0	44	7,83
Bivalvia	0	0	0	0,00	167	60,79	189	63,94	37	17,63	44	37,02
Cumacea	0	0	0	0,00	0	0,00	0	0	0	0	540	8,51
Echinoidea	11	17,24	11	30,53	0	0,00	0	0	0	0,00	0	0,00
Euphasiacea	0	0	0	0,00	4	0,06	0	0	0	0,00	0	0,00
Gastropoda	0	0	0	0,00	30	98,86	4	11,03	0	0,00	4	16,76
Isopoda	4	21,98	4	4,81	0	0,00	0	0	0	0,00	0	0,00
Pisces	0	0	0	0,00	7	39,33	0	0	4	24,16	0	0,00
Polychaeta	26	5,51	4	2,66	296	19,91	444	54,98	289	37,74	189	29,79
Rest	0	0	0	0,00	26	0,31	22	0,07	11	5,66	19	21,39
Total	691	93,13	341	85,58	537	219,32	659	130,02	341	85,19	840	121,3

Taxonomic Group	Station											
	FP-15		FP-16		FP-17		FP-18		FP-19		FP-21	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	100	1,26	37	7,93	111	17,58	474	83,36	2050	94,35	1358	44,18
Bivalvia	59	7,47	0	0,00	15	158,21	15	32,15	11	32,34	52	4,09
Cumacea	19	0,22	0	0,00	4	0,04	0	0,00	19	0,30	1480	39,29
Echinoidea	0	0	41	79,33	15	8,66	52	13,54	0	0	7	1,04
Euphasiacea	0	0	0	0,00	22	0,48	4	0,09	0	0	0	0,00
Gastropoda	19	110,26	4	21,79	7	37,15	0	0,00	4	0,00	4	3,70
Isopoda	0	0	0	0,00	4	45,95	33	40,00	155	6,77	0	0,00
Pisces	0	0	0	0,00	0	0	0	0,00	0	0	0	0,00
Polychaeta	222	26,2	0	0,00	37	15,36	22	3,44	0	0,00	451	10,08
Rest	0	2,5	0	0,00	19	24,64	0	0,00	0	0	15	0,54
Total	419	147,91	82	109,05	234	308,07	600	172,58	2239	133,76	3367	102,92

Taxonomic Group	Station											
	FP-22		FP-23		FP-30		PP-02		PP-03		PP-04	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	22	0,22	5927	90,24	5398	112,7	545	106,63	25	3,63	55	63,00
Bivalvia	4	1,37	41	11,88	0	0,00	3	0,04	0	0,00	5	0,00
Cumacea	0	0,00	348	2,85	607	7,92	0	0,00	0	0,00	0	0,00
Echinoidea	0	0	0	0	0	0,00	0	0,00	10	167,13	47	2,20
Euphasiacea	0	0	0	0	0	0,00	13	0,51	3	0,12	0	0,30
Gastropoda	0	0	0	0	0	0,00	3	0,05	2	3,27	0	0,10
Isopoda	0	0	0	0	0	0,00	3	0,55	63	6,03	48	0,20
Pisces	0	0	0	0	0	0,00	10	30,44	0	0,00	0	7,10
Polychaeta	104	76,66	292	17,21	174	1,37	0	0,00	0	0,00	0	0,00
Rest	0	0	33	1,44	11	0,20	0	0,00	0	0,00	0	0,00
Total	130	78,25	6641	123,62	6190	122,19	577	138,22	103	180,18	155	72,9

Taxonomic Group	Station											
	PP-05		PP-06		PP-07		PP-09		PP-10		PP-15	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	108	20,68	92	20,35	208	48,59	3	0,03	338	69,68	283	62,22
Bivalvia	2	6,17	0	0,00	10	87,11	20	62,88	8	0,00	0	0,00
Cumacea	0	0,00	0	0,00	2	0,00	0	0,00	0	0,00	98	0,29
Echinoidea	93	127,56	68	1471,67	5	103,38	78	29,69	27	60,32	65	18,95
Euphasiacea	2	0,12	2	0,08	10	0,37	0	0,00	3	0,13	7	0,17
Gastropoda	2	3,93	2	8,63	0	0,00	0	0,00	0	4,60	2	0,32
Isopoda	85	8,92	43	21,90	20	4,08	5	16,28	12	16,02	0	0,00
Pisces	10	23,00	38	90,50	10	68,75	25	175,70	0	0,00	5	18,03
Polychaeta	0	0,00	0	0,00	5	4,72	8	6,56	5	0,21	2	0,23
Rest	0	0,00	0	0,00	0	0,00	0	1,00	3	6,00	0,445	0,00
Total	302	190,38	245	1613,13	270	317	139	292,14	396	156,96	462,445	100,21

Taxonomic Group	Station											
	PP-16		PP-17		PP-18		PP-25		PP-26		PP-27	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	17	0,71	297	61,05	1197	8,06	1793	83,63	632	51,14	643	109,80
Bivalvia	32	50,58	13	5,83	92	203,11	18	41,11	37	12,90	2	4,75
Cumacea	0	0,00	35	0,10	823	6,48	30	0,53	27	0,84	0	0,00
Echinoidea	5	5,20	83	43,67	0	0,00	0	0,00	2	17,78	3	0,88
Euphasiacea	2	0,05	10	0,21	0	0,00	0	0,00	0	0,00	22	0,88
Gastropoda	0	0,00	7	29,17	7	32,84	3	0,32	0	0,00	8	4,98
Isopoda	2	0,13	0	0,00	0	0,00	98	5,38	95	6,50	0	0,00
Pisces	75	225,70	5	18,03	0	0,00	0	0,00	0	0,00	0	0,00
Polychaeta	32	8,52	73	7,52	98	22,67	0	0,00	2	0,03	12	2,02
Rest	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Total	165	290,89	523	165,58	2217	273,16	1942	130,97	795	89,19	690	123,31

APPENDIX 9. Quantitative Characteristics of Epibenthos at Stations in the Piltun Area (colony density - A, spec./m^2; biomass - B, g/m^2).

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Taxonomic Group	Station											
	FP-09		FP-10		FP-11		FP-12		FP-13		FP-14	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	72	4,14	315	13,17	5	0,15	30	1,19	16	0,97	164	7,15
Bivalvia	3	0,03	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Cumacea	0	0,00	0	0,00	0	0,00	1	0,00	0	0,00	0	0,00
Decapoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Euphasiacea	0	0,00	0	0,00	0	0,00	0	0,00	3	0,08	1	0,04
Gastropoda	0	0,00	0	0,00	0	0,00	0	0,00	0	1,01	0	0,00
Hydroidea	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	51	2,36	46	1,15	4	0,13	29	1,73	60	3,24	17	1,22
Pisces	0	0,00	0	0,02	0	0,00	0	0,00	0	0,00	0	0,00
Total	127	6,52	361	14,33	9	0,27	61	2,92	80	5,29	182	8,40

Taxonomic Group	Station											
	FP-15		FP-16		FP-17		FP-18		FP-19		FP-20	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	29	1,91	82	4,48	41	1,32	31	2,09	6	0,07	13	1,23
Bivalvia	1	0,01	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Cumacea	2	0,04	0	0,00	0	0,00	0	0,00	1	0,00	176	0,77
Decapoda	0	0,00	0	0,00	0	0,00	0	0,00	1	1,43	0	0,00
Euphasiacea	0	0,00	1	0,09	3	0,07	0	0,00	0	0,00	0	0,00
Gastropoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Hydroidea	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	42	1,47	110	3,54	33	1,25	57	2,23	16	0,85	18	1,27
Pisces	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Total	74	3,42	193	8,11	77	2,63	88	4,32	25	2,35	207	3,27

Taxonomic Group	Station											
	FP-21		FP-22		FP-23		FP-24		FP-25		FP-26	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	12	0,53	46	0,40	44	0,78	34	0,39	0	0,00	0	0,00
Bivalvia	0	0,00	4	0,06	0	0,00	0	0,00	0	0,00	0	0,00
Cumacea	18	0,04	13	0,19	108	0,50	6	0,02	0	0,00	0	0,00
Decapoda	8	0,72	6	0,62	0	0,00	1	0,57	0	0,00	0	0,00
Euphasiacea	0	0,00	2	0,25	0	0,00	0	0,00	0	0,00	0	0,00
Gastropoda	0	0,00	1	0,01	0	0,00	0	0,00	0	0,00	4	0,53
Hydroidea	4	0,42	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	2	0,17	1	0,05	0	0,00	0	0,00	111	6,08	8	0,70
Pisces	0	0,00	2	1,00	0	0,00	0	0,00	0	0,00	0	0,00
Total	44	1,87	76	2,57	152	1,28	41	0,98	111	6,08	12	1,23

Taxonomic Group	Station											
	FP-27		FP-28		FP-29		FP-30		PIL-01		PIL-02	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	0	0,00	356	3,70	15	1,81	33	0,51	17	0,20	0	0,00
Bivalvia	0	0,00	2	0,03	0	0,00	0	0,00	0	0,00	0	0,00
Cumacea	0	0,00	14	0,11	0	0,00	284	0,82	3	0,01	0	0,00
Decapoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,29	0	0,00
Euphasiacea	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Gastropoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	2	0,27
Hydroidea	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	24	1,93	0	0,00	23	1,65	0	0,01	55	3,04	16	1,32
Pisces	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Total	24	1,93	372	3,84	38	3,46	318	1,33	76	3,53	18	1,58

Taxonomic Group	Station											
	PIL-03		PIL-04		PIL-05		PIL-06		PIL-07		PIL-08	
	A	B	A	B	A	B	A	B	A	B	A	B
Amphipoda	185	2,76	38	0,92	9	0,57	56	4,05	13	0,22	18	1,29
Bivalvia	1	0,02	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Cumacea	7	0,06	1	0,01	0	0,00	0	0,00	0	0,00	177	0,77
Decapoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Euphasiacea	0	0,00	0	0,00	3	0,08	0	0,00	0	0,00	0	0,00
Gastropoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Hydroidea	0	0,00	0	0,01	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	11	0,83	28	1,14	3	0,45	44	2,49	0	0,00	0	0,00
Pisces	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Total	205	3,65	68	2,07	16	1,10	100	6,54	13	0,22	196	2,06

Taxonomic Group	Station									
	PIL-09		PIL-10		PIL-11		PIL-12		PIL-13	
	A	B	A	B	A	B	A	B	A	B
Amphipoda	18	0,72	21	0,67	0	0,00	13	0,03	9	0,38
Bivalvia	0	0,00	5	0,03	0	0,00	8	0,01	3	0,01
Cumacea	18	0,04	108	2,56	57	3,31	7	0,13	36	0,67
Decapoda	14	1,34	5	0,14	0	0,00	19	0,22	0	0,00
Euphasiacea	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Gastropoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Hydroidea	4	0,42	0	0,00	0	0,00	0	0,00	0	0,00
Isopoda	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Pisces	2	1,00	0	0,00	0	0,00	0	0,00	0	0,00
Total	56	3,51	139	3,40	57	3,31	47	0,39	48	1,06

APPENDIX 10. Taxonomic Composition and Characteristics of Zooplankton During the Study Period.

	Taxons	Taxon Characteristics (see Notes)		
		1	2	3
Type	CNIDARIA (=COELENTERATA)			
Class	HYDROZOA			
Order	Trachylida			
Suborder	Narcomedusae			
Family	Aeginidae			
	Cunoctantha tenella Bigelow, 1909	B?	N	0-50
Suborder	Trachymedusae			
Family	Trachynemidae			
	Aglantha digitale (O.F. Muller, 1766)	AB +	NO	0-600
Order	Leptolida			
Suborder	Athecata			
Family	Corynidae			
	Sarsia (*Coryne*) *tubulosa* (M. Sars, 1835	BA	N	
Order	Thecaphora			
Family	Campanulariidae			
	Obelia longissima (Pallas, 1766)	AB	N	
Type	CTENOPHORA			
Class	Atentaculata			
Order	Beroidea			
Family	Beroidae			
	Beroe cucumus Fabricius, 1780	AB	N	EMP
Class	Tentaculifera			
Order	Cydippida			
Family	Pleurobrachiidae			
	Pleurobrachia pileus Vanhoffen			
Type	MOLLUSCA			
Class	BIVALVIA			
	Spp., larvae			P
Class	GASTROPODA			
	Spp., larvae			
Subclass	OPISTOBRANCHIA			
Order	Pneumodermatiformes (=Gymnosomata)			
Family	Clionidae			
	Clione limacina (Phipps, 1774)	BA	O	I
Subclass	DEXTROBRANCHIA			
Order	Cavoliniiformes			
Family	Limacinidae			
	Limacina helicina (Phipps, 1774)	BA	O	UI
Type	ANNELIDA			
Class	POLYCHAETA			
	Magellonida sp., larvae			P
	Lepidonotus sp., larvae			P
Type	ARTHROPODA			
Superclass	CRUSTACEA			
Class	BRANCHIOPODA			
Order	Cladocera			
Family	Podonidae			

		Taxon Characteristics (see Notes)		
	Podon leuckarti (Sars, 1862)	WB, N	N	
	Evadne nordmanni Loven, 1836	WB, N	N	
Class	MAXILLOPODA			
Subclass	Cirripedia			
Order	Thoracica			
Family	Balanidae			
	nauplii, cypris			P
Subclass	COPEPODA			
Order	Calanoida			
Family	Calanidae			
	Calanus glacialis Jaschnov, 1955	A	GN	I
	Neocalanus cristatus (Kroyer, 1848)	WB	O	I
	Neocalanus plumchrus s. l. (Marukawa, 1921)	WB	O	I
Family	Eucalanidae			
	Eucalanus bungii bungii (Giesbrecht, 1892)	WB	O	I
Family	Clausocalanidae			
	Pseudocalanus minutus (Kroyer, 1848) sensu Frost, 1989	AB	O	EP
	P. newmani Frost, 1989	BA	NO	EP
	P. acuspes (Giesbrecht, 1881)	AB	GN	
	Microcalanus pygmaeus (Sars, 1900)	AB, Ant-N	N	I
Family	Aetideidae			
	Jaschnovia (=*Derjuginia*) *tolli* (Linko, 1913)	A	GN	
	сем. Temoridae			
	Eurytemora pacifica Sato, 1913	BA	N	
	E. herdmani Thompson et Scott, 1897	BA	N	
	E. asymmetrica Smirnov	UB	N	
Family	Metridiidae			
	Metridia pacifica Brodsky, 1950	LB	O	I
	M. okhotensis Brodsky, 1950	UB	O	I
Family	Centropagidae			
	Centropages abdominalis Sato, 1913	ST-B	N	
Family	Pontellidae			
	Epilabidocera amphitrites (McMurrich, 1916)	B	N	
Family	Acartiidae			
	Acartia hudsonica Pinhey, 1926	WB	N	
	A. longiremis (Lilljeborg, 1853)	UB	N	
Family	Tortanidae			
	Tortanus discaudatus (Thompson et Scott, 1897)	B	N	
Order	Cyclopoida			
Family	Oithonidae			
	Oithona similis Claus, 1863	BA	O	EP
	O. sp.			
Order	Poecilostomatoida			
	Oncaea borealis G. O. Sars, 1918	B	O	I
Order	Harpacticoida			
Family	Ectinosomatidae			
	Microsetella norvegica (Boeck, 1864)	B	O	EP
	M. rosea (Dana, 1852) ?	ST	O	EP
	Tisbe sp.			B?
Class	MALACOSTRACA			
Order	Cumacea			
	Diastylis sp.			B

		Taxon Characteristics (see Notes)		
Order	Amphipoda			
Suborder	Hyperiidea			
Family	Hyperiidae			
	Parathemisto (=*Themisto*) *japonica* Bovallius, 1887	B	O	I
Suborder	Gammaridea			
Superorder	Eucarida			
Order	Euphausiacea			
Family	Euphausiidae			
	Thysanoessa sp.			
Order	Decapoda			
Suborder	Caridea (=Macrura)			
	larvae			P
Suborder	Brachyura			
	zoea			P
Suborder	Anomura			
	zoea			P
Type	CHAETOGNATHA			
Class	SAGITTODEA			
Order	Aphragmophora			
Family	Sagittidae			
	Parasagitta elegans (Verill, 1873)	AB	O	EP
Type	ECHINODERMATA			
	pluteus, auricularia, brachiolaria larvae			P
Type	PHORONIDA			
	actinotrocha larvae			
Type	CHORDATA			
Subtype	TUNICATA			
Class	APPENDICULARIA			
Family	Fritillaridae			
	Oikopleura labradoriensis (Lohmann)	UB?		
	Fritillaria borealis Lohmann	B	N?	
Subtype	PISCES			
Class	OSTEICHTYES			
	Ova, larvae			

Notes: **Biogeographic characteristics (1):** A – arctic, AB – arctic-boreal, BA – boreal-arctic, B – boreal, UB – upper boreal, LB – lower boreal, WB – widely boreal, ST – subtropical, T – tropical, N – notal, Ant – Antarctic. **Biotopic characteristics – horizontal (2)**: N – neritic, O – oceanic, NO – neritic-oceanic, GN – glacial-neritic; **vertical(3):** EP – epipelagic, EMP – epimesopelagic, I – interzonal, UI – upper interzonal, LI – lower interzonal, B – bottom or near-bottom (benthopelagic), P – pelagic.

APPENDIX 11. Quantitative Characteristics of the Main Zooplankton Taxons in the Lunskoye and Piltun Areas in 2004. P – frequency of occurrence; D – average density; B – average biomass; I – index of dominance in the area community in regard to density and biomass, respectively

Taxons	Lunskoye Area					Piltun Area				
	P, %	D, spec./m^3	I_D, %	B, mg/m^3	I_B, %	P, %	D, spec./m^3	I_D, %	B, mg/m^3	I_B, %
Copepoda	100.0	20398.7	61.0	187.8	33.1	100	27282.6	45.0	269.1	38.2
Calanoida	100.0	4069.2	12.2	112.9	19.9	100	8014.4	13.2	177.4	25.2
Cyclopoida	100.0	9402.4	28.1	49.2	8.7	100	6426.4	10.6	34.2	4.8
Poecilostomatoida	18.2	0.2	0.0006	0.004	0.0007	45.5	2.3	0.004	0.04	0.006
Harpacticoida	100.0	1.4	0.004	0.03	0.005	72.7	1.7	0.003	0.04	0.005
Copepoda nauplii	100.0	6925.3	20.7	25.7	4.5	100	12837.8	21.2	57.3	8.1
Cladocera	100.0	135.4	0.4	7.4	1.3	100	267.2	0.4	41.3	5.9
Appendicularia	100.0	453.2	1.3	120.7	21.2	100	195.9	0.3	42.4	6.0
Chaetognatha	100.0	32.7	0.09	8.1	1.4	100	8.9	0.01	3.4	0.4
Ctenophora	63.6	0.3	0.0008	1.6	0.3	100	12.1	0.02	38.2	5.4
Coelenterata	100.0	102.7	0.3	85.2	14.9	100	228.9	0.4	49.1	6.9
Euphausiacea	36.4	0.09	0.0003	0.05	0.009	100	0.8	0.001	0.2	0.03
Pteropoda	100.0	8930.1	26.7	65.1	11.5	100	14073.4	23.2	152.2	21.6
Hyperiida	72.7	0.2	0.0007	0.2	0.04	9.1	0.03	<0.0001	0.015	0.002
Gammarida	100.0	0.9	0.003	5.4	0.9	63.6	0.32	0.0005	0.5	0.08
Cumacea	100.0	11.6	0.03	54.9	9.7	27.3	0.08	0.0001	0.19	0.03
Isopoda	9.1	0.2	0.0005	0.004	0.0006	9.1	0.02	<0.0001	<0.001	0.0001
Polychaeta	9.1	0.02	0.0001	0.04	0.006	27.3	0.08	0.0001	0.06	0.008
Plathelminthes	18.2	0.06	0.0002	0.004	0.0007	45.5	0.1	0.0002	0.01	0.002
Nemertina	0	0	0	0	0	27.3	0.4	0.0007	0.04	0.006
Pisces	90.9	0.4	0.001	0.5	0.08	9.1	0.03	<0.0001	0.02	0.002
larvae:	0	0	0	0	0	100	18530.7	30.6	106.9	15.2
Macrura	9.1	0.02	0.0001	0.03	0.005	0	0	0	0	0
Brachyura	18.2	0.03	0.0001	0.04	0.007	9.1	0.02	<0.0001	0.02	0.003
Bivalvia	100.0	2677.1	8.0	15.8	2.8	100	8317.3	13.7	49.1	6.9
Gastropoda	18.2	0.4	0.001	0.01	0.0015	45.5	3.2	0.005	0.07	0.01
Echinodermata	90.9	188.4	0.6	2.2	0.4	100	8914.6	14.7	15.1	2.1
Cirripedia	100.0	319.2	0.9	4.9	0.9	100	474.3	0.8	5.8	0.8
Polychaeta	100.0	158.7	0.5	7.8	1.4	100	703.6	1.2	34.6	4.9
Phoronida	0	0	0	0	0	36.4	0.5	0.0008	0.15	0.02
Nemertina	45.5	3.6	0.01	0.06	0.01	100	117.2	0.2	2.04	0.3
Total	**100**	**33414.1**	**100**	**568**	**100**	**100**	**60601.8**	**100**	**704**	**100**