BENTHOS AND FOOD SUPPLY STUDIES IN FEEDING GROUNDS OF THE OKHOTSK-KOREAN GRAY WHALE POPULATION IN 2006

V. I. FADEEV

MARINE BIOLOGY INSTITUTE OF THE FAR EAST BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES

VLADIVOSTOK

Email: vfadeev@mail.primorye.ru]

Research Vessel *Akademik Oparin*, September 2006 (Photo by Yu. M. Yakovlev)

VLADIVOSTOK
2007

R U S S I A N   A C A D E M Y   O F   S C I E N C E S
FAR EAST BRANCH

MARINE BIOLOGY INSTITUTE

RELEASED BY:
Institute Director
MARINE BIOLOGY INSTITUTE, FAR EAST BRANCH,
RUSSIAN ACADEMY OF SCIENCES

___________A. V. Adrianov
Academician of the Russian Academy of Sciences

RESEARCH REPORT

BENTHOS AND FOOD SUPPLY STUDIES IN FEEDING GROUNDS OF THE OKHOTSK-KOREAN GRAY WHALE POPULATION IN 2006

Research Supervisor,
V. I. Fadeev

Laboratory Director, PhD in Biological Sciences

VLADIVOSTOK
2007

RUSSIAN ACADEMY OF SCIENCES
FAR EAST BRANCH

MARINE BIOLOGY INSTITUTE

RELEASED BY:
Institute Director
MARINE BIOLOGY INSTITUTE, FAR EAST BRANCH,
RUSSIAN ACADEMY OF SCIENCES
_______________ A. V. Adrianov
Academician of the Russian Academy of Sciences

RESEARCH REPORT

BENTHOS AND FOOD SUPPLY STUDIES IN FEEDING GROUNDS OF THE OKHOTSK-KOREAN GRAY WHALE POPULATION IN 2006

Research Supervisor,
V. I. Fadeev
Laboratory Director, Candidate of Biological Sciences

VLADIVOSTOK
2007

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TEXT PHOTOGRAPHS

LIST OF APPENDICES

INTRODUCTION

General information[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 et al. 2005), and the western Pacific or Korean–Okhotsk population, numbering about 120 animals (Cooke et al. 2006, Yakovlev and Tyurneva 2007).

After commercial whaling was halted in the 1940's, the eastern gray whale population has likely reached carrying capacity, although its estimated size decreased from 26,000 in 1998 (Rugh et al. 1999) to 18,000 in 2001 (Rugh et al. 2005). Although an increase in the death rate, a low birth rate, and deterioration of the physical condition of some 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 experts' estimates did not exceed 2,000–2,500 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. For several years, the whale population was estimated between 120 and 250, however in 2006, the IBM observed 120 individuals and recent models have also estimated the population to be ~120 individuals (Cooke et al. 2006; Yakovlev and Tyurneva 2007). It is hypothesized that there are fewer than 50 remaining individuals capable of reproduction (Weller et al. 2001). Because of low reproduction rates, genetic uniqueness (LeDuc et al. 2002), and low total population (Weller et al. 2000; Vladimirov 2000), the Korean–Okhotsk gray whale has been classified as critically endangered on the IUCN List of Threatened Species (USFWS 1997; Hilton-Taylor 2000; Weller and Brownell 2000) and placed in category I of the Russian Federation Red Book (2000).

[1] Because more detailed information about the history of benthos studies, data on benthos distribution in the Eastern Sakhalin area, and the feeding of the California-Chukotka gray whale population is available in the report Kusakin, O.G., Sobolevskii, E.I., and Blokhin, S.A., 2001, Review of Benthos Research Literature for the Northeast Sakhalin Shelf. Interim Report of IBM DVO RAN and TINRO, Vladivostok, the present authors did not attempt a literature review herein. Published works are cited by us when discussing our findings and in other necessary circumstances. Also, the above cited report (Kusakin et al. 2001) is available on the Internet at 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 North 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 Biodiversity Conservation 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 “Okhotsk–Korean Gray Whale Population Monitoring and Research Program,” which was approved by the Russian State Committee on Environmental Protection (Goskomekologiya) 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 Piltun gray whale feeding area – the area seaward 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 many years, 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 working aboard a seismic research support ship en route to refueling observed seven gray whales feeding seaward from Chayvo Bay. Subsequent aerial and ship-based surveys of the area resulted in the discovery of a second gray whale feeding area (the Offshore area) (Maminov and Yakovlev 2002). This area is located on a traverse from the middle of Chayvo Bay to southern Niyskiy Bay at a distance of 20–45 km from the latter at depths of 30–50 m. Whales were observed to feed here from September through November 2001 (Blokhin et al. 2002) in numbers ranging from 48 to 83 individuals. In subsequent years, whales continued to use this area, although the numbers in 2003 and 2004 were lower than those in 2001 and 2002 (Blokhin et al. 2003, 2004). Numbers in 2005 and 2006 have been intermediate (Vladimirov et al. 2006, 2007).

A proposal was developed in 2002 for a comprehensive study of gray whales in the previously known Piltun shallow-water feeding area (seaward of Piltun Bay) and in the new deep-water Offshore area. The fieldwork for the study was done in 2002–2006 (Fadeev 2003, 2004, 2005, 2006) during expeditions on the marine tug *Nevel'skoy* and the research vessel *Akademik Oparin*. The 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). Amphipods of the genus *Ampelisca* are the most widespread and best-known food item in the gray whale feeding locations (Zimushko and Lenskaya 1970; Blokhin and Pavlyuchkov 1988; Bogoslovskaya 1996; Zenkovich 1937; Kusakin et al. 2001; 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 2003, 2004, 2005, 2006).

The objective of this survey was to study quantitative distribution and status of benthos in the Piltun and Offshore gray whale feeding areas and at feeding sites of individual whales based on field data from 2006 to understand the nature of gray whale distribution and movement in response to prey distribution.

This work was done under the Okhotsk-Korean Gray Whale Population Monitoring and Research Program funded by the Sakhalin II project (operated by Sakhalin Energy Investment Company Ltd. (SEIC) and Sakhalin-1 project (operated by Exxon Neftegas Ltd. (ENL)).

Tasks of the study. This report was prepared based on the results of benthos studies conducted in August–October 2006 on two standard traverses in the coastal waters of northeastern Sakhalin during an expedition of the research vessel *Akademik Oparin* from the Marine Biology Institute (IBM) of the Russian Academy of Sciences (RAN) Far East Branch (DVO).

The tasks of the study were:

- conduct benthos studies in the Piltun and Offshore whale feeding areas by collecting bottom grab samples;
- study benthos in the near-shore zone (to a depth of 12 m) of the Piltun traverse using diving equipment and underwater videography;
- investigate the benthos composition at gray whale feeding sites;
- 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;
- assess the composition and abundance of macrobenthos in the whale feeding areas and outside the feeding zones;
- perform a morphometric analysis of the common species of amphipods to assess the size distributions;

- obtain data on the particle size distribution of sediments in feeding grounds and at feeding sites of gray whales; and
- compare the benthos distributions in the Piltun and Offshore areas based on materials for 2006 and 2005.

MATERIALS AND METHODS

1. Materials and Methods for Field Studies

1.1. Material

Time periods of the studies. Field work to study benthos and the food supply of gray whales was performed by a field team from the Marine Biology Institute of the Far East Branch, Russian Academy of Sciences, aboard the research vessel *Akademik Oparin* from 19 August to 10 October 2006.

Distinguishing features of fieldwork in 2006. The fieldwork in 2004–2006 was somewhat different than the work done in 2002–2003. These differences were due to primarily to the whale distribution during 2004–2006.

1. In contrast to 2002-2003, gray whales were absent from the Offshore area in July and August 2004–2005. A few feeding whales were observed only in September. Photo identification work in 2003, 2004, 2005 and 2006. respectively, in the Offshore area showed that there were 35, 8, 7 and 33 individual gray whales, respectively (Yakovlev and Tyurneva 2004, 2005, 2006, 2007).

2. In the northern Piltun area in 2004–2005, there was a larger proportion of whales feeding at depths greater than 15 m. Shore-based and vessel counts in 2006 showed fewer whales feeding at depths greater than 15 m in the northern Piltun area. This difference prompted a more detailed study of benthos at the whale feeding sites at depths greater than 15–20 m, including the collection of plankton and epibenthos samples there.

3. During 2006 fieldwork, shore-based and vessel observers for the first time observed a group of feeding whales near Chayvo Bay. This necessitated an immediate benthic study in this area.

In addition, certain features of the studies were conditioned by the technical characteristics of the 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 2004–2006 limited the opportunities to collect samples at depths less than 10–12 m. Hence three diving transects were sampled in the Piltun area in 2005 at depths of 3–12 m from a Zodiac motor launch. The lightweight bottom grab sampler used for benthos sampling from the Zodiac in 2003–2004 was not very effective (Fadeev 2003).

Characteristics of field collections. Two gray whale feeding areas were studied in 2006: 1) Piltun area (coastal zone from Odoptu Bay to southern Piltun Bay) and 2) Offshore area (30–45 km from the coast from middle Chayvo Bay to southern Niyskiy Bay). Also investigated in 2006 was an area in the vicinity of Chayvo Bay 40 km from inlet to Piltun lagoon at locations where gray whales were observed feeding.

A consistent approach was used in planning the locations of benthos stations in the two previously studied (Piltun and Offshore) areas in 2006 and 2002-2005. 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. Figure 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 2005, with the clients' consent, the decision was made to not use a random stratified approach and it was decided to sample at the same stations as 2004, due to the distribution of some whales in 2004-2005 in the northern Piltun area. This decision was made because the stations of 2002 and 2003 were a significant 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 (average 2.34±0.18 km). It was felt that re-sampling at the same station each year would provide more valuable information in regards to potential changes in the abundance and distribution of potential gray whale prey. The accuracy of vessel positioning in 2006 at the 2005 stations was determined by the navigation conditions and amounted to 130±20 m. Because of the vessel length (75 m), the accuracy of repeated positioning at 2003 sites in 2005–2006 can be regarded as satisfactory.

During the initial planning of the work in 2002, the waters of the Offshore area were divided into 36 sectors (four blocks), each with an area of about 115 sq km (Appendix 1. Figure P1.2). There were 36 stations here during the expeditions in 2002 and 2003. The individual sectors in the Offshore area have a larger area than those in the Piltun area, and the distances between the same stations within a sector in 2003 and 2002 accordingly are substantially greater there – from 0.33 to 10.75 km (average 5.08±0.48 km). In 2003, gray whales were observed further east outside of the Offshore sampling grid (Maminov 2004). In accordance with the statement of work for 2004, the station grid in the Offshore area was expanded eastward (compared with 2002 and 2003) in order to determine the size of the sector having the greatest abundance of forage benthos; i.e., ampeliscid amphipods. A network of stations covering the entire Offshore area was studied in 2006 (Appendix 1, Figure P1.2).

The locations of benthos stations in 2006 are shown in Figure 1. Bottom grab benthos sample collections were taken from 153 stations (Table 1). In addition to sampling at standard benthos stations (108 stations), collections of benthos (45 stations, 135 samples) and epibenthos and plankton (80 samples) were made where gray whales were observed feeding (gray whale feeding sites). The following samples were taken to study the characteristics of bottom sediments: 174 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. Characteristics of Materials Collected in 2006.

Area	van Veen grab	Diving collections	Epibenthic net	Bongo plankton net
	Stations/samples	Stations/samples	samples	samples
Piltun area	60/198	14/56	0	0
Offshore area	48/144	0	0	0
Whale feeding sites	45/135	15/68	30	50
Totals	**153/459**	**29/124**	**30**	**50**

As in 2002–2005, bottom grab sample collections in 2006 were taken from the vessel, 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 vessels were 11 m in 2002, 8 m in 2003, 10 m in 2004, 11 m in 2005, and 12 m in 2006 (Table 2).

Table 2. Distribution of Collecting Stations by Depth in Piltun area for 2001–2006.

Depth Range	Number of Stations					
	2006	2005	2004	2003	2002	2001
1–5 m*	5	6	6	0	0	5
6–10 m*	6	7	7	10	0	5
11–15 m	16	15	6	19	16	5
16–20 m	14	12	13	7	13	5
21–25 m	14	27	14	12	18	5
26–30 m	13	15	13	10	11	5
31–35 m	3	5	5	5	2	0
Totals	74	87	64	63	60	30

Note: * denotes diving collections.

As indicated by diving data from 2001 and 2003 (Fadeev 2002, 2004), the sections of the Piltun area with the most abundant food organisms are at depths up to 15–20 m. Therefore, benthos grab collections were made from a Zodiac boat on three traverses at depths of 3–12 m. The southern traverse was very close to the diving traverses of 2001 and 2003. As stipulated by the statement of work for 2005–2006, more detailed benthic studies were made by dives along 6 traverses in the shallow-water whale feeding zone in Piltun area at depths of 3–12 m.

Benthos collections were taken at seven stations in the Piltun area (with the highest prey biomass) at the start (last 10 days of August) and end of the expedition (first 10 days of October) to study the size distribution and assess the growth rates of common amphipod species. The micro- and mesodistributions of forage macrobenthos were studied by taking from 6 to 10 consecutive bottom grab samples as the vessel drifted at three stations in the Piltun area. The position of each bottom grab sampler at the moment of contact with the seabed was recorded by GPSMAP, which will make it possible to compute the distance between samples and accordingly to assess the aggregation and size of prey patches.

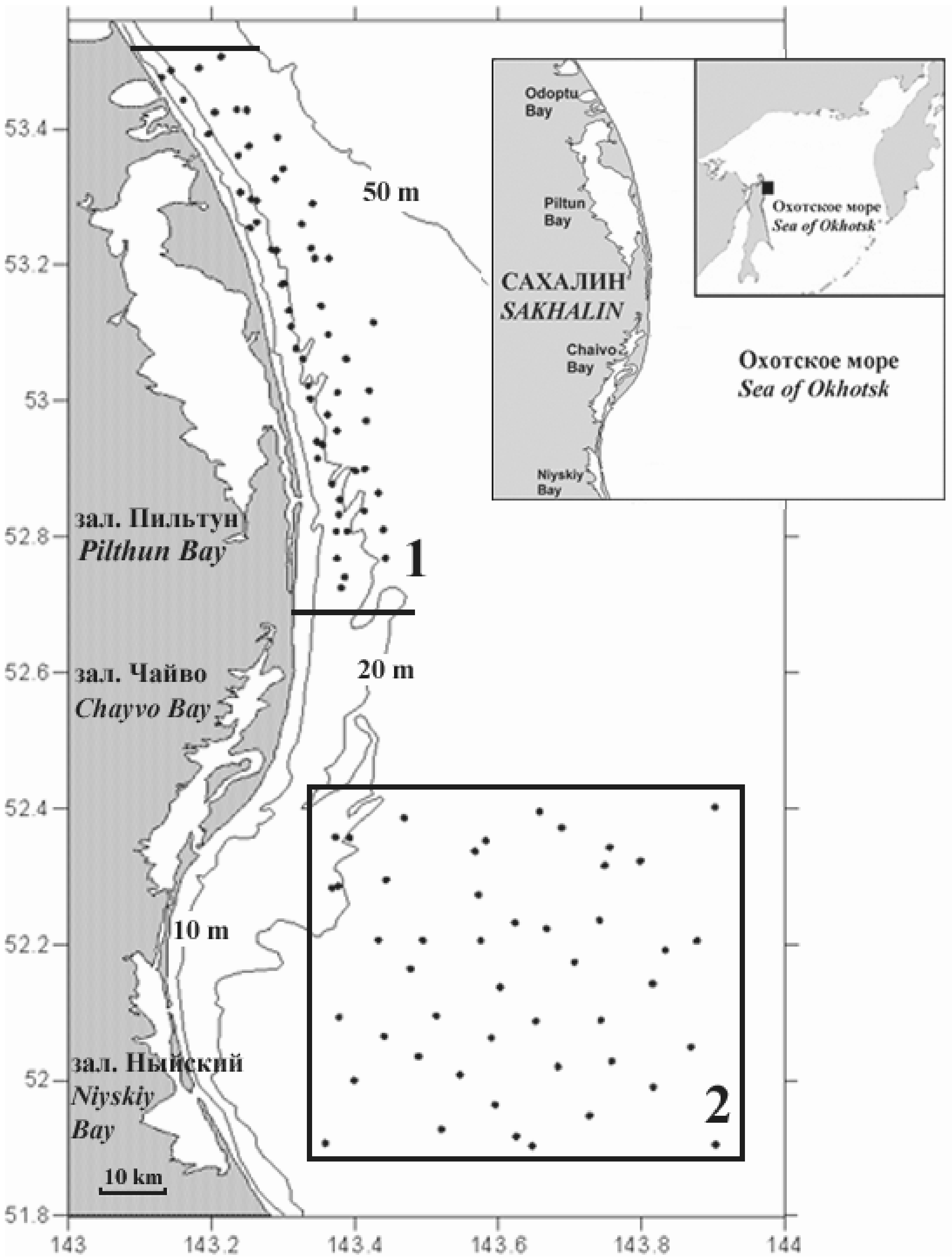


Figure 1. Bottom grab station locations in two areas in 2006.

1) Piltun feeding area.
2) Offshore feeding area.

1.2. Field Work Methods

All benthos samples taken from the expedition vessel were obtain using a van Veen bottom grab sampler (grab area 0.2 m^2, weight 57 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 bottom surface at each station, the location was determined by GPS, and the water depth was recorded, along with the water surface and bottom temperatures and salinities. Water temperature and salinity were recorded using a MultiLine P4 hydrologic probe (Germany) at depths to 20 m and a Valeport SV EXTRA probe at depths beyond that. This probe was equipped with sensors for pressure, temperature, electrical conductivity, and dissolved oxygen concentration (England).

Aboard the ship, all 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, such as sand dollars and mollusks), 1 mm, and 0.5 mm (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.

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

Soil types were determined according to the sediment classification by mechanical composition (Table 3).

Table 3. Bottom Sediment Classification Used in the Report.
(Bezrukov and Lisitsyn 1960; Shepard 1976).

Sediment group	Types of sediments	Abbreviation in text	Predominant particle size, mm	Md, mm
Coarsely clastic (psephites)	Pebbles	Peb	>10	
Coarsely clastic (psephites)	Gravel: coarse medium fine	 Grc Grm Grf	 10-5 5-2 2-1	
Sandy (psammites)	Sand: 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 given type of sediment.

2.2. 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). All animals were sorted. Large organisms were counted visually, and small ones were counted with an 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. Then the 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 also was determined with the same precision. The colony density of organisms per square meter was 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 clearly (because of fragmentation or aggregation of colonies, etc.), the number was indicated by a question mark "?" in the table. Taxonomic identification of the sample collections was done by qualified expert taxonomists[2] having many years of experience with the given animal group. If the species was represented by juvenile individuals (young without clear taxonomic features) so that it was impossible to identify the species, the designation *sp. juv.* was used for the taxon name. The rate of occurrence (incidence) of species in sandy bottom sediments was assessed by determining the species incidence frequency (P, %), which is the percentage ratio of the number of quantitative samples containing the species to the total number of quantitative samples in the area. This parameter is important primarily as a characteristic of food organisms, since it characterizes their availability to the consuming species.

The communities were described using traditional single-factor methods as well as 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). The primary basis for the analysis was a tetragonal data matrix in the form of a list of benthic species for each station,

[2] The following colleagues from IBM DVO RAN and ZIN RAN took part in taxonomic identification of the major macrobenthos groups: Cand. L. L. Budnikova (amphipods), Cand. M. V. Malyutina (isopods), Cand. G. M. Kamanev (bivalve mollusks), Cand. V. V. Gul'bin (brachiopods), Cand. E. V. Bagaveeva (polychaetes), Cand. S. F. Chaplygina (hydrozoa), Cand. V. N. Romanov (ascidians), Cand. A. V. Chernyshov (nemertini), and Dr. V. S. Levin (holothuroidea).

with quantitative characteristics of the species. The Bray–Curtis similarity coefficient for each pair of samples was calculated based on the data matrix. Dendrograms were constructed using the mean-link method (Clarke and Green 1988; UNEP 1995). Empirically, the quantitative characteristics of benthos abundance (number of individuals and biomass) typically do not follow a normal distribution. Therefore, to compare samplings using parametric criteria, the source data were transformed based on the nature of the empirical distribution (Elliott 1977).

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

Standard procedures of the SURFER 7 cartographic system (Surface Mapping System) were used to construct distribution maps of bottom-sediment and water-column parameters, pollutant concentrations, and indices of quantitative abundance of macrobenthos. The cartographic system was used only for illustrating the general nature of the parameter distributions in the study area. Therefore, the "simple planar surface" version of the polynomial regression method was used to calculate isolines. This method is good for identifying large-scale trends in spatial distributions of data. The ideology of this method has been described in detail (Draper and Smith 1981). On the whole, the procedure for obtaining, 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

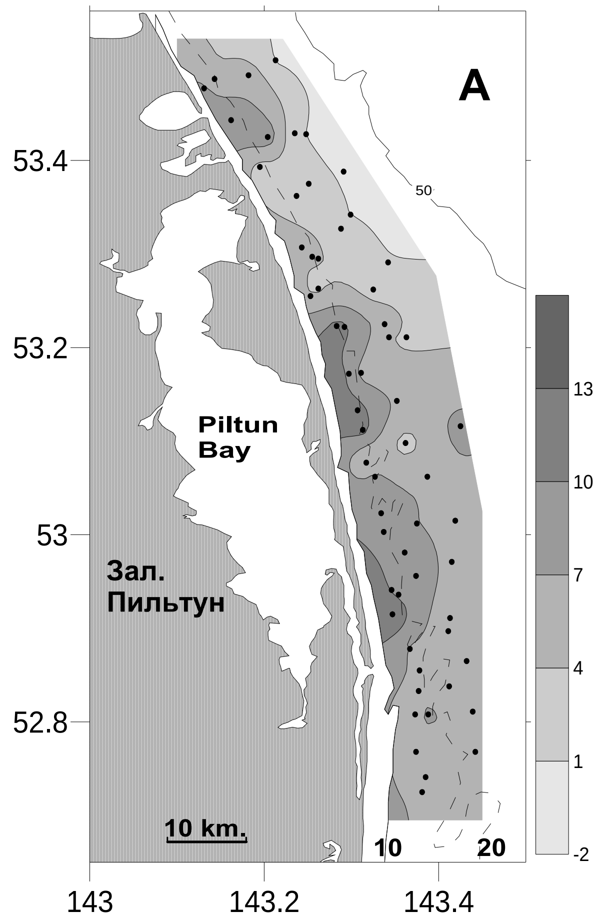
The water surface temperature and salinity were measured in the waters studied during the period from 26 August to 9 October 2006. The measurement results from individual stations are presented in Appendix 2. The spatial distribution of temperature fields in the Piltun and Offshore areas is shown in Figure 2, and the salinity distribution is shown in Figure P1.3.

Water temperature. In September 2006, the water surface temperature in the Piltun area varied from 6.8 to 13.2 °C and bottom water temperature varied from 0.6 to 12.8 °C. Bottom water temperature averaged 5.92± 0.38 °C. Surface water temperatures in the Piltun area were consistent between 2006 and 2005 (Table 4).

Table 4. Surface Water Temperatures (°C) in the Areas.

Characteristic	Piltun area					Offshore area		
	Sep. 2006	Aug. 2005	Sep. 2005	Aug. 2004	Sep. 2004	Sep. 2006	Aug. 2005	Sep. 2005
Average	11,03	8,08	11,77	7,48	8,58	10,5	12,4	12,2
Standard deviation	0,16	0,52	0,12	0,6	0,1	0,18	0,34	0,11
Minimum	6,78	0,5	9	5,1	7,7	8,52	11	11
Maximum	14,39	13,0	14,1	9,2	10,7	13,04	14	13
Observations	60	34	64	43	66	48	10	37

A spot of colder water observed in the northern Piltun area in 2001–2005 might be due to persistent upwelling of deep waters in the area (Krasavtsev et al. 2000; Rutenko 2006). This cold-water spot in the northern Piltun area is clearly seen in the bottom water temperature distribution for September 2006 (Figure 2). In September 2006 the bottom water temperature in the northern Piltun area at depths beyond 10 m averaged 3.9±0.4 °C, which is significantly different from the average bottom temperature in the southern part of the area, which is 6.9±0.4 °C. The surface temperature in the Offshore area in September 2006 (10.5± 0.18 °C) was lower than in 2005 (12.2± 0.11 °C). The bottom temperature in this area averaged 1.56± 0.3 °C and varied from –0.87 to + 6.74 °C. In the Offshore area, depth clearly



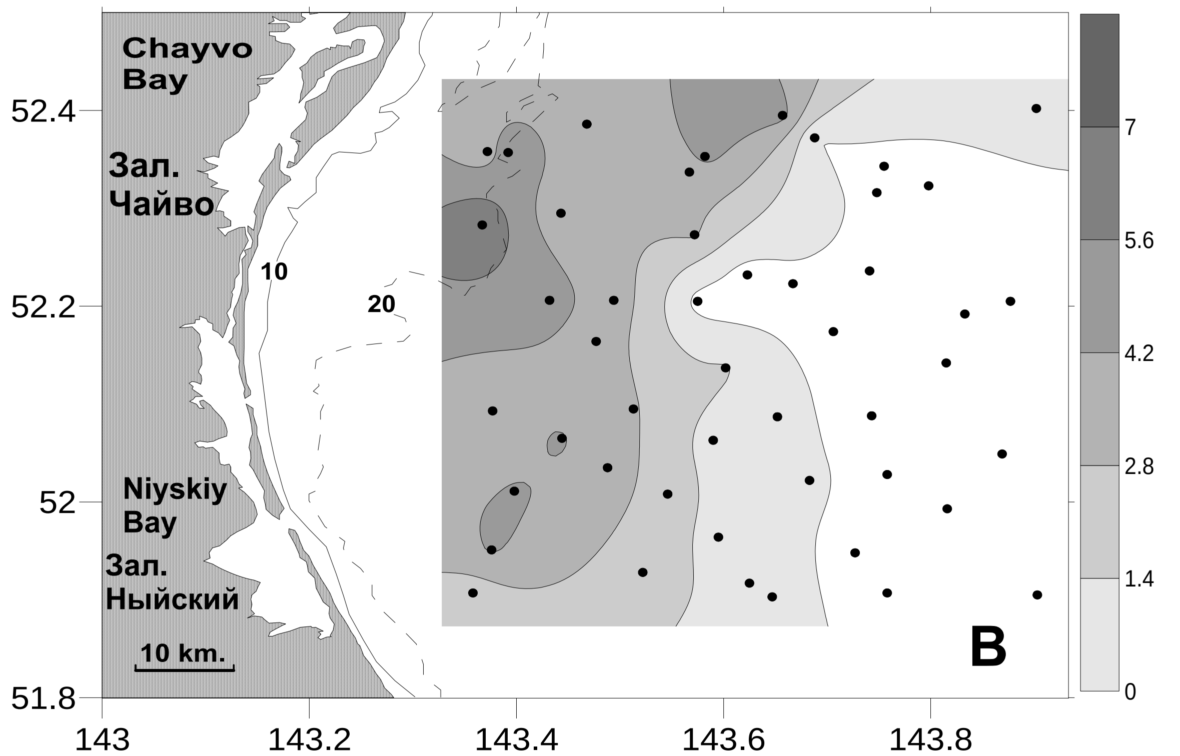


Figure 2. Distribution of bottom water temperature (T °C) in the Piltun (A) and Offshore (B) areas in September 2006.

correlates with bottom salinity and water temperature. With increasing depth, bottom water temperature decreases and salinity increases (Figure 2B, Figure P1.3).

A detailed analysis was performed within the seasonal dynamics of water temperature and salinity in August–September 2004 and 2005 in the study area by researchers at the Pacific Oceanographic Institute (TOI) of DVO RAN (Borisov et al. 2005; Kruglov et al. 2006). This analysis showed that the thermohaline characteristics of the water are quite different between August and September. Average characteristics for August:

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

Average characteristics for September:

1. The shelf waters have a temperature of 7.7–9.4 °C, and salinity of 29.55–29.95 psu to the 20-m isobath, with values of 6.3–9.2 °C and 30–31.2 psu to the 30-m isobath. Thus the area occupied by shelf water masses increased in September. The reason was intensified 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 UQL waters away from shore, upwelling intensified, leading to the penetration of the littoral shelf by water from the Sea of Okhotsk at the near-bottom levels.
2. Accordingly, the shelf front moved toward the 40-m 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 is 30.2–32.3 psu.

According to oceanographers, the water temperature in the near-shore zone of the Piltun area can vary by 8–10 °C within 2–3 days due to wind surge, and salinity can vary by 5 psu (Kruglov et al. 2006).

In addition to seasonal changes in water temperature in a study area, there are substantial changes in hydrologic conditions between years.

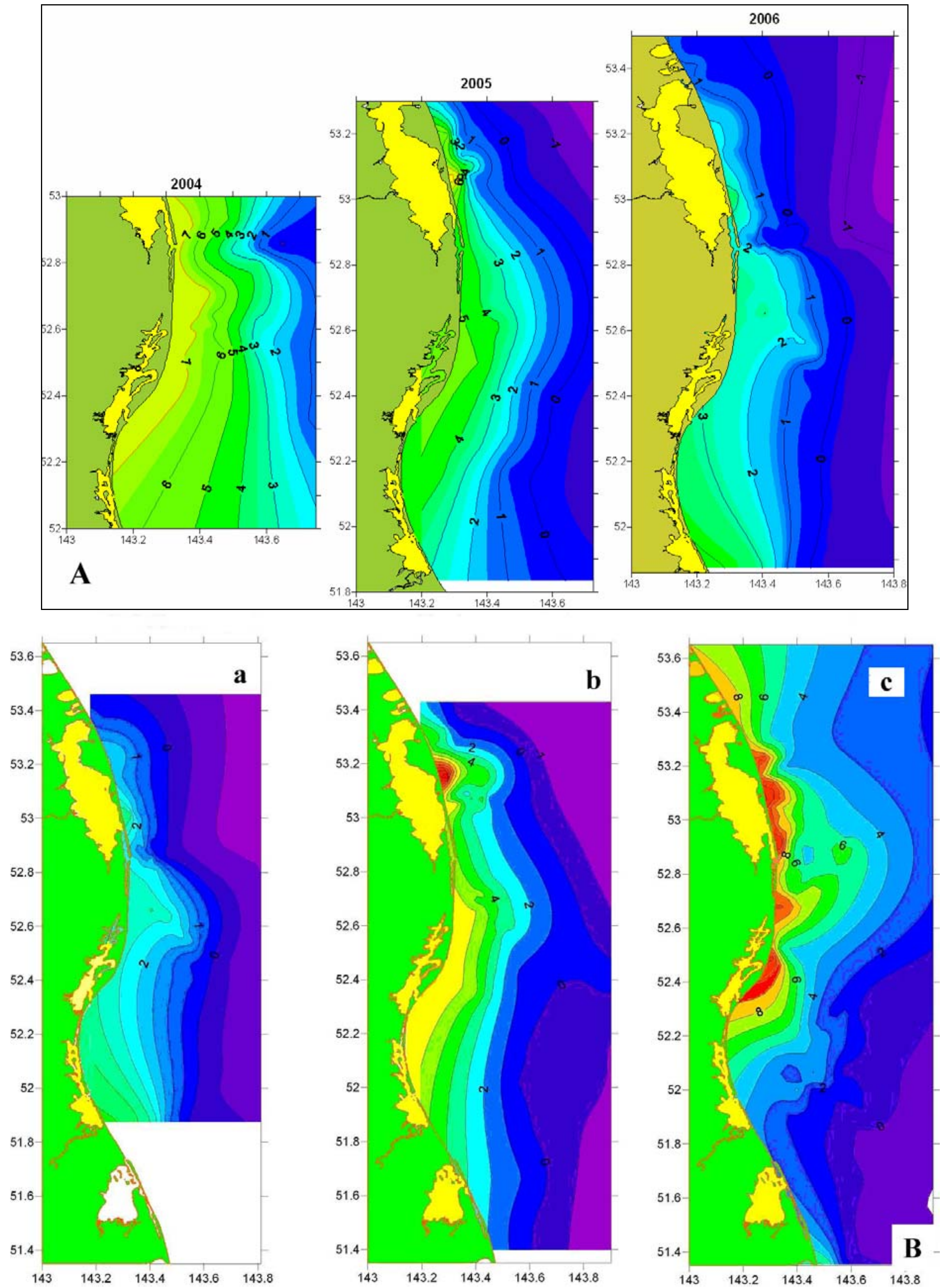


Figure 3. Distribution of bottom water temperature in the first half of August, 2004–2006 (A) and (B) in the first half (a), in the third 10 days of August (b), and in the middle of September 2006 (c).

Annual changes in bottom water temperature in the Piltun area of Niyskiy Bay from 2004 through 2006 were studied by F.F. Khrapchenkov of TOI DVO RAN. Biological productivity in the shallow-water shelf of northeast Sakhalin, particularly in Chayvo and Piltun bays, is particularly influenced by the cold, high-density bottom water layer that forms in winter on the shelf due to convection and salinification (brine discharge) during ice formations, the dynamics of which depends on the following factors. The first is wind mixing, especially during southerly and northerly winds, which results in coastal upwelling and wind surge. The second is vertical and horizontal mixing due to tidal phenomena. The intensity of these mixing processes increases during syzygial tides, when stratification can be completely destroyed. The third factor is the dimensions of dynamics of the Amur River drainage lens, where the water temperature is higher and salinity lower than in the Sea of Okhotsk shelf waters, resulting in the formation of frontal separations on the boundaries of this lens.

As a result of all these factors, during the entire summer in the coastal region from Chayvo Bay to Odoptu Bay, there are brief (diurnal) changes in surface water temperature and salinity as a result of tidal phenomena, and long-term changes (several days) as a result of upwellings. Because of these fluctuations, the coastal region alternately receives Amur waters with a high dissolved oxygen content and bottom waters rich in nutrients, resulting in favorable conditions for phytoplankton development.

During the first half of August 2006, during a prolonged upwelling, cold water filled the entire coastal strip from Chayvo Bay to Okha. During this period, there was cold (1.5–2.5 °C) and saline (over 31.2–31.4 psu) water along the entire Piltun feeding area to at least the 30-m isobath. The prolonged action of lower-temperature water at the bottom could result in a slower rate of benthos growth and correspondingly to a reduction in whale prey biomass.

Depending on the meteorological conditions during cold period of the year and the corresponding ice formation conditions along the Sakhalin coast, the temperature of the cold bottom layer can differ substantially between years. Unfavorable temperature conditions, especially during the spawning period, can sharply limit the populations of subsequent generations of bottom benthos communities. Bottom water temperature distributions from measurements during the first half of August in 2004, 2005, and 2006 are shown in Figure 3A.

This figure clearly shows that the bottom water temperature by the middle of August in 2005 was about 2 degrees colder in the southern Offshore area and about 4 degrees colder in the Piltun feeding area, compared with 2004. In 2006, the water was even colder (by 2–3 degrees) in the entire coastal region. In mid-August 2004, water with negative temperature was found only opposite the outlet from seaward Piltun Bay at depths greater than 40 m. At the same time at 2005, waters with negative temperatures were observed along the entire coast beginning at a depth of 35 m. In 2006, the 0 and –1 °C isotherms in the area of the Piltun Bay mouth were even closer to the coast.

The change in bottom water temperature along the coast in August and September 2006 is shown in Figure 3B. The lowest temperatures were observed during the first half of August as a result of prolonged upwelling. By the end of the month, bottom water temperatures were somewhat higher along the coast than in 2005, and the zero isotherm was farther from shore. In mid-September negative bottom water temperatures were observed only in areas more than 60 km south of Chayvo Bay. During August and September, the zero isotherm at Nabil' Bay was at a distance of about 30 km.

A comparison of bottom water temperatures in September 2005 and 2006 (Figure 4) shows that the bottom water temperature distributions were about the same in the Piltun feeding area. Along Chayvo Bay and southward in 2005, the strip of bottom water temperature above 8 degrees was 30 km, vs. not more than 10 km in 2006. In September 2005 there were practically no bottom waters with negative temperature, while in September 2006 such waters were observed south of Chayvo Bay and came up to 20 km from the coast at Nabil' Bay.

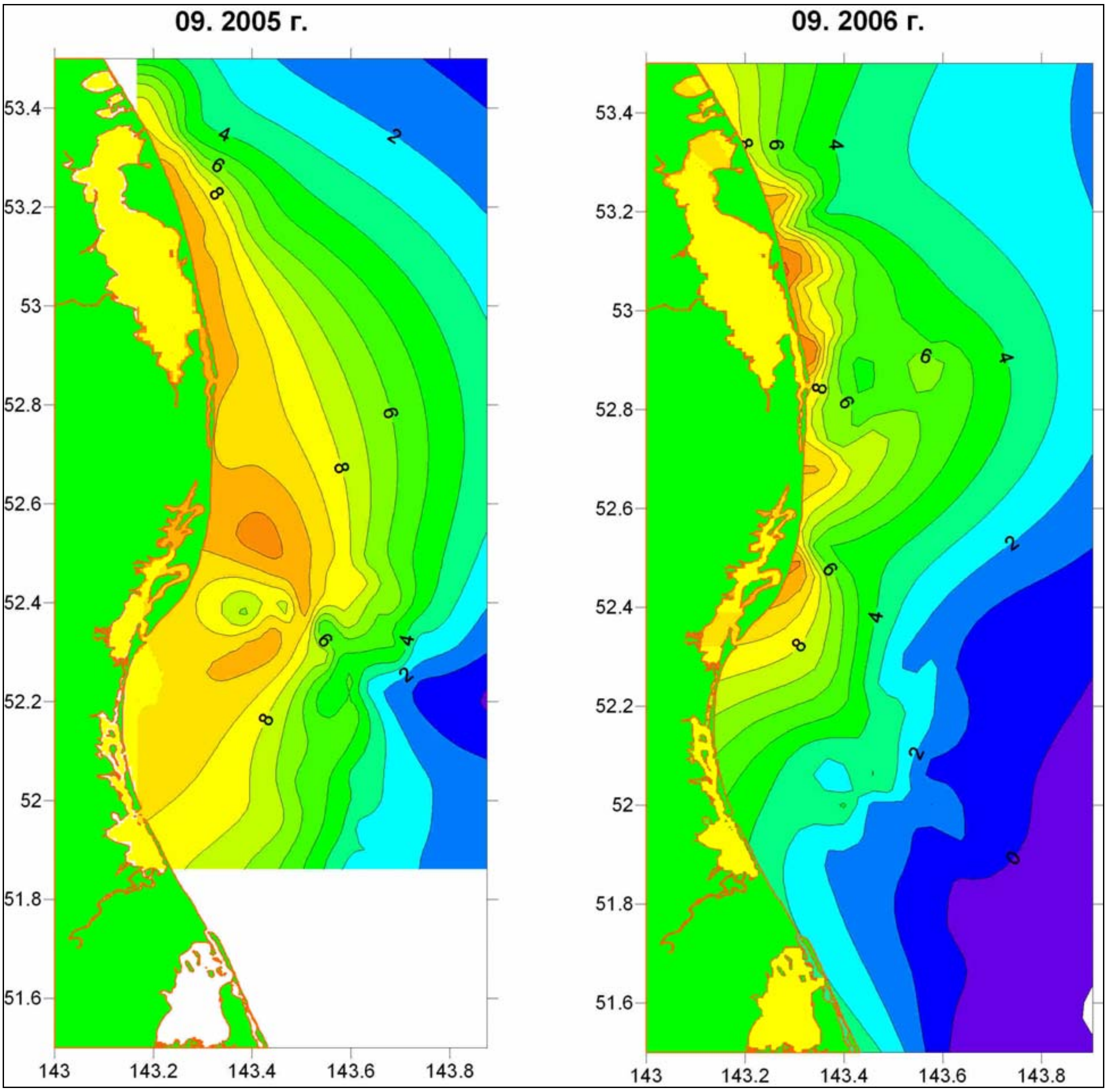


Figure 4. Bottom water temperatures in September 2005 and mid-September 2006.

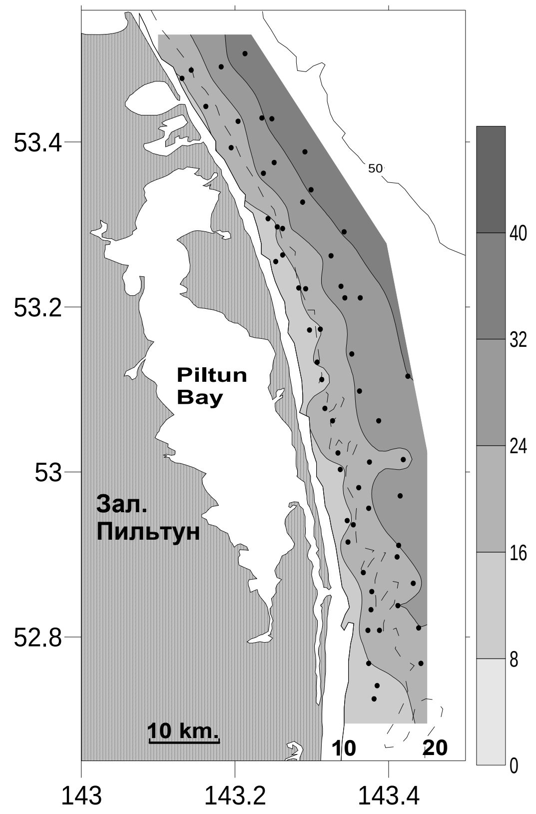
3.2. Particle Size Distribution of Bottom Sediments in the Areas

The particle size distribution of bottom sediments was studied based on laboratory analyses of 174 soil samples taken at benthos stations and whale feeding sites. The grain size distribution of the soil is given in Appendix 2 (Table P2.2). The distributions of the main bottom sediment fractions (coarse aleurite; fine, medium, and coarse sand; and gravel) in the Piltun and Offshore areas are shown in Figures 5–7 and 8–10, respectively. Depth distributions in the Piltun and Offshore areas from bottom grab station data are shown in Figures 5 and 8. The bottom sediments at most stations throughout the area are characterized by great predominance of sandy (psammite) fractions. Of the 174 stations in all areas, 87% have predominately sands (fine – 67%; medium – 20%), while 13% have gravel–pebble soils containing some sands of various grain sizes. The proportion of the fine sand fraction exceeds 60% at most stations.

Piltun Area. Field data on soil distribution gathered during 2001–2005 showed that fine sandy soils predominate at depths up to 10–15 m throughout the area. With increasing depth, these are replaced by medium- and coarse-grained sands and areas with gravel–pebble soils containing some sands of varying grain size.

The 2006 field data showed that fine sands predominate at 45% of the stations in this area, with medium sands predominating at 19% of the stations. Gravel–pebble bottoms, often containing some sands of various grain sizes, occur in patches at depths greater than 15–20 m (Figure 5). The highest proportion (more than 15%) of aleurite–pelite fraction in the soil is observed in a local area at depths below 20 m in the channel area of 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: at Odoptu and Piltun bays. A similar trend was observed in the data from 2001–2005.

Offshore Area. The depths in the Offshore area increase gradually from 20 to 60 m (Figure 8). The proportion of fine sand fraction in the soil increases with depth (Figure 10D). Overall, fine sands predominate at 85% of the stations in the Offshore area. Gravel soils and coarse-grained sands occur in places (Figures 8 and 9).



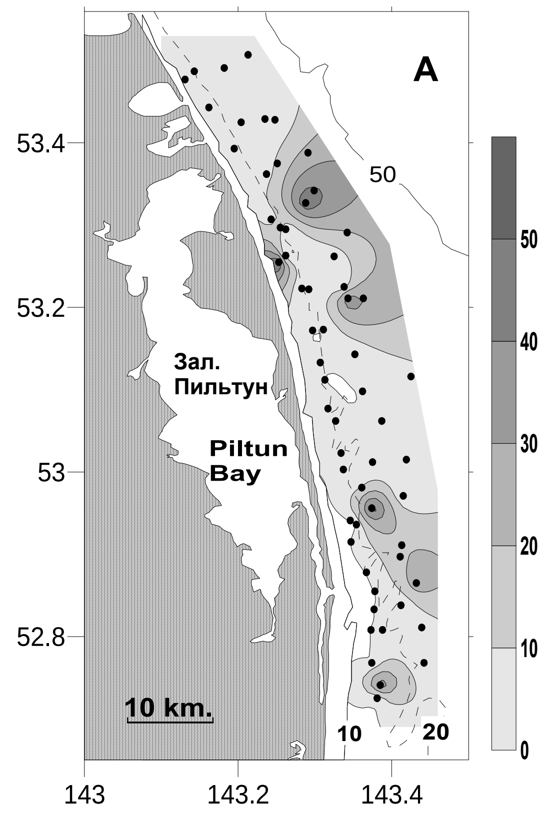


Figure 5. Distribution of bottom sediment fractions (% of dry sediment weight) in the Piltun area: gravel–pebble fraction (A; > 1 mm).

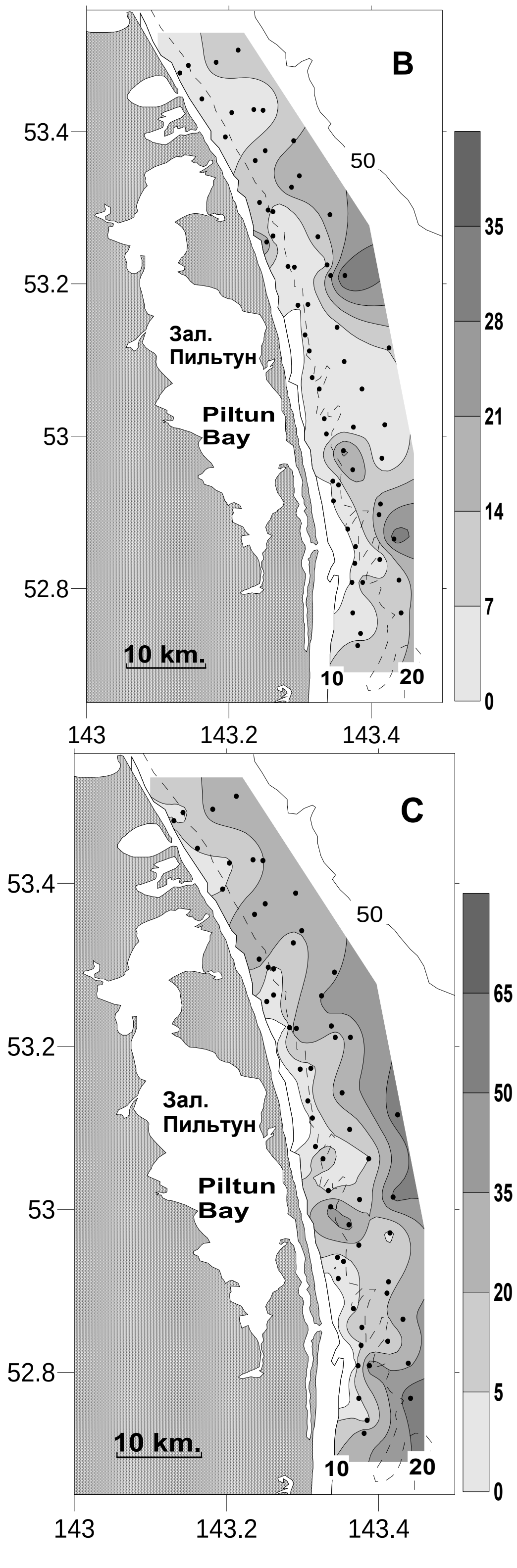


Figure 6. Distribution of bottom sediment fractions (% of dry sediment weight) in the Piltun area: coarse sand (B; 0.5 – 1 mm); medium sand (C; 0.25 – 0.5 mm).

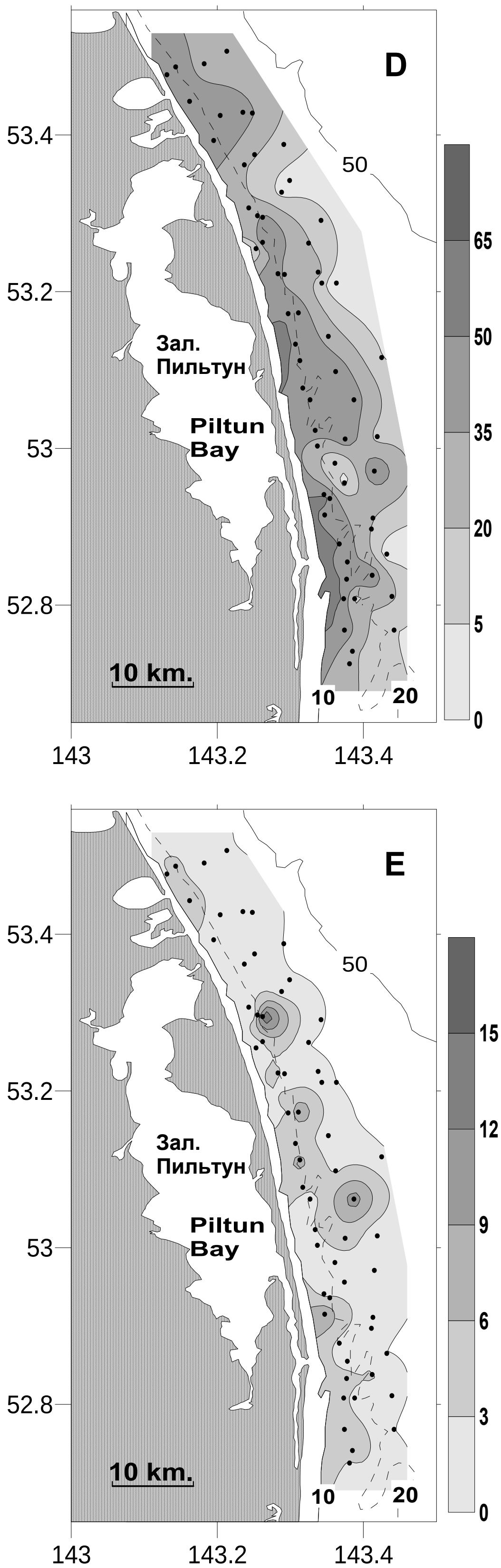


Figure 7. Distribution of bottom sediment fractions (% of dry sediment weight) in the Piltun area: fine sand (D; 0.1 – 0.25 mm); aleurite (E; < 0.1 mm).

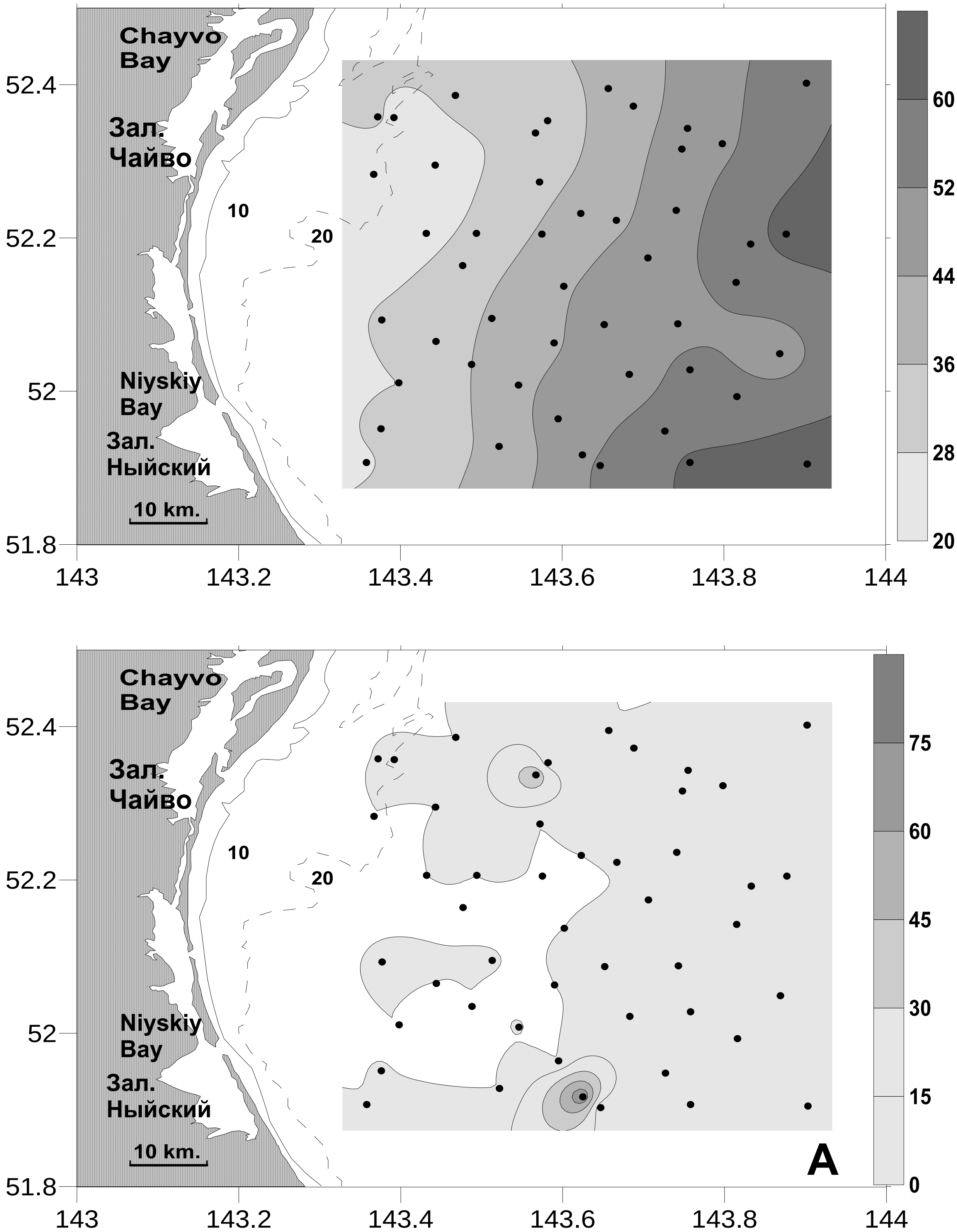


Figure 8. Distribution of bottom sediment fractions (% of dry sediment weight) in the Offshore area: gravel–pebble fraction (A; > 1 mm).

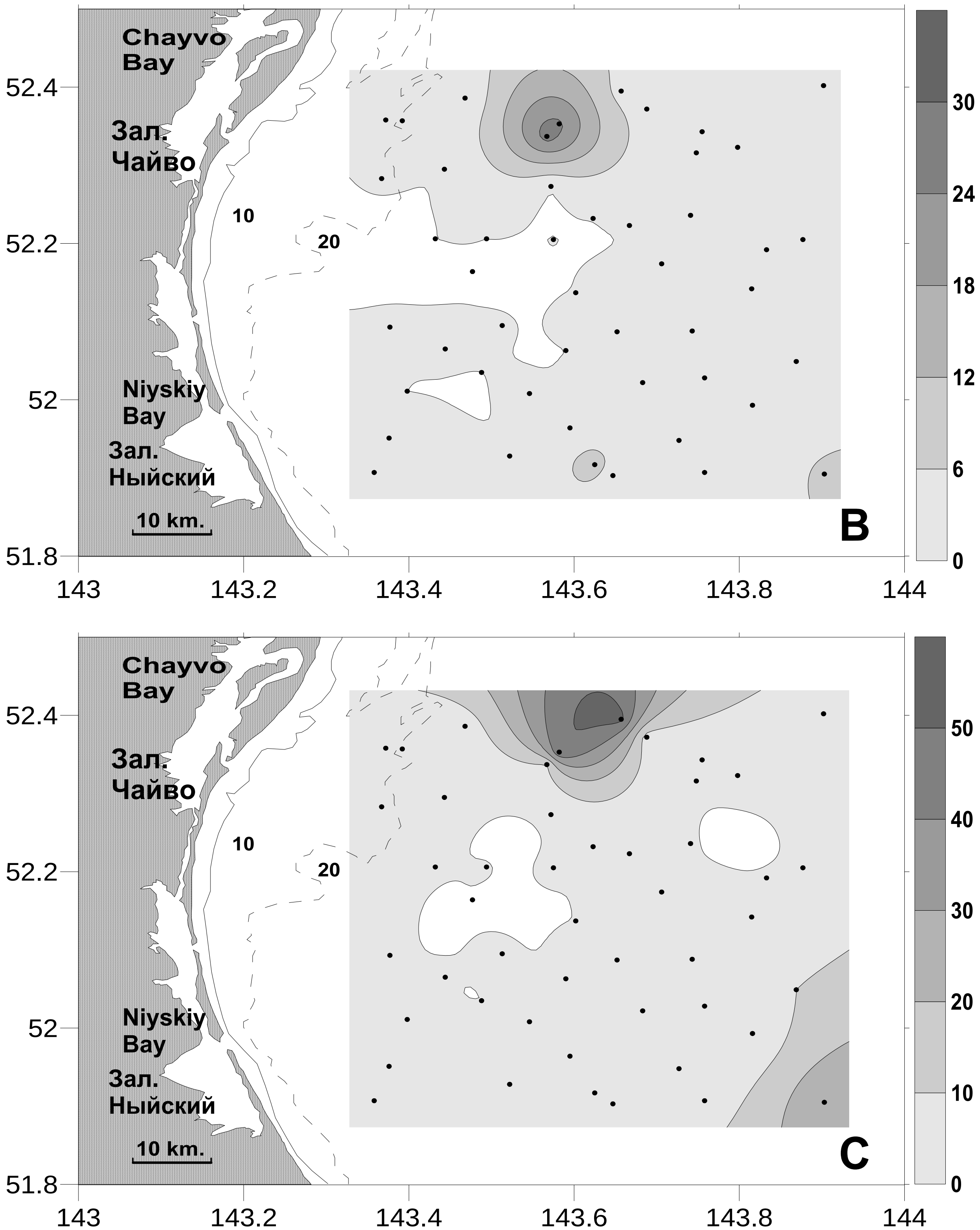


Figure 9. Distribution of bottom sediment fractions (% of dry sediment weight) in the Offshore area: coarse sand (B; 0.5 – 1 mm); medium sand (C; 0.25 – 0.5 mm).

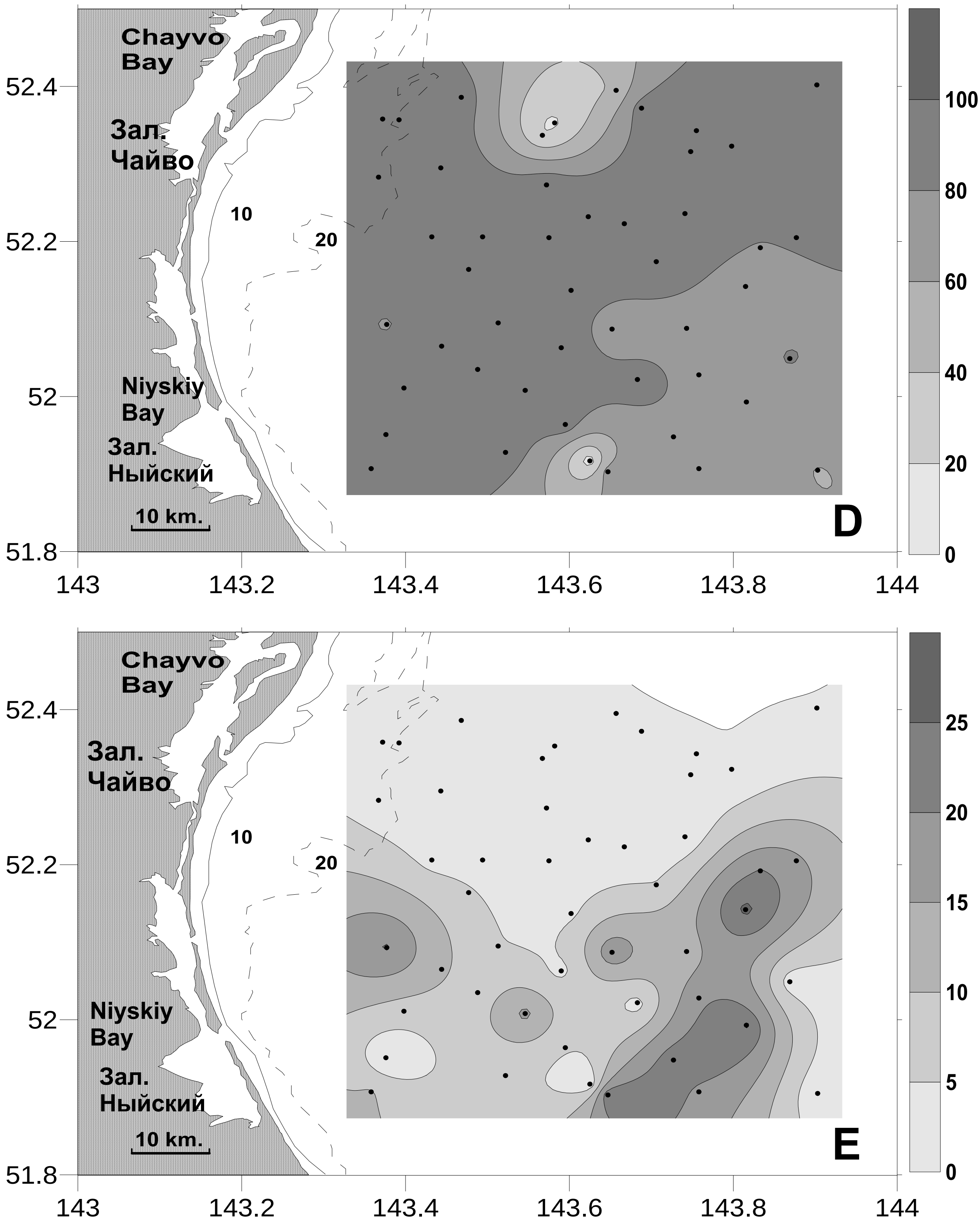


Figure 10. Distribution of bottom sediment fractions (% of dry sediment weight) in the Offshore area: fine sand (D; 0.1 – 0.25 mm); aleurite (E; < 0.1 mm).

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 Figure 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 sediment group for the Piltun and Offshore areas based on data from 2002–2006. No group D soils were found in 2005–2006.

Group A in all areas consists of stations where the 0.1–0.25 mm fraction (fine sand) greatly predominates. According to 2001–2006 data, the proportion of this fraction varies from 60 to 96% of dry sediment weight in sediments of the Piltun area. The normalized entropic index of sediment sorting is 0 for the coastal zone from Odoptu Bay to southern Piltun Bay (an ideally sorted sediment has a value of 0). The average depth at which this sediment group occurs in the Piltun area is 19 m.

Group B includes stations where the soil is predominately medium-grained sand with up to 20% coarse sand. The entropic index of sorting varies from 0.6 to 0.74. The average depth of the sediments of this group in the Piltun area is 22 m.

Group C comprises stations without clear dominance of any one fraction. The soil is gravel mixed with sand fractions. The major fractions are 0.5–1.0 mm (coarse sand) and 1.0–2.0 mm (small gravel). The entropic index of sorting varies from 0.79 to 0.87 (absolutely ungraded sediment has a value of 1). The average depth of this group of stations in the Piltun area is 26 m.

Hence group A is well-sorted fine-grained sands, group B comprises medium-sorted sands of varying grain size (a mixture of fine and medium sands), and group C corresponds to poorly sorted gravel soils containing some sands of varying grain size, pebbles, and shell detritus. The sediment groupings in the Piltun area from 2006 data are in good agreement with the soil analysis based on the 2002–2005 data (Table 5). Three sediment groups have been identified in the Offshore area based on 2006 data (Figure 11.3 Table 5).

Table 5. Characteristics of Sediment Groups in Piltun and Offshore Areas.

Sediment group	Sediment fractions						H_s	H_s/H_{max}	Code
	Peb	Grav	Sand coarse	Sand med	Sand fine	Aleu+Pel			
Piltun area, 2006 data									
A	0	0,7	0,71	3,84	**90,36**	4,39	0,42	0,26	Sf
B	0	6,73	9,17	34,97	47,84	1,29	1,18	0,73	Sfm
C	1,88	38,83	24,98	18,13	15,5	0,68	1,42	0,79	Gr+Sc
Piltun area, 2005 Data (Fadeev, 2006)									
A	0	4,1	5,07	12,25	**74,48**	4,1	0,89	0,55	Sf
B	0	9,75	29,04	**54,2**	4,72	2,29	1,15	0,71	Smc
C	6,1	36,15	22,02	20,48	11,68	3,57	1,57	0,87	Gr+Scm
Piltun area, 2004 data (Fadeev 2005)									
A	0	0,52	1,56	19,6	**72,89**	5,45	0,8	0,5	Sf
B	0,00	10,69	20,65	**56,76**	7,82	4,08	1,21	0,75	Smc
C	8,56	49,16	24,08	10,16	5,00	3,04	1,39	0,78	Gr+Scm
Piltun area, 2003 data (Fadeev, 2004)									
A	0,83	1,98	2,12	10,93	**75,48**	8,66	0,87	0,48	Sf
B	0	4,81	13,61	**63,85**	17,12	0,6	1,04	0,64	Smf
C	5,01	44,3	20,28	16,8	11,88	1,74	1,46	0,81	Gr+Scmf
Piltun area, 2002 data (Fadeev, 2003)									
A	0,39	1,21	0,77	11,41	**84,52**	1,7	0,57	0,32	Sf
B	0,26	8,11	9,64	**47,81**	32,64	1,54	1,23	0,68	Smf
C	1,05	37,28	14,81	17,49	25,96	3,41	1,47	0,82	Gr+Sfmc
Offshore area, 2006 data									
A	0	0,39	0,5	1,96	**94,39**	2,76	0,27	0,17	Sf
B	0	0,71	1,14	2,84	**76,56**	18,75	0,71	0,44	Sf+Al
C	3,28	22,72	14,34	28,8	29,96	0,9	1,49	0,83	Sfc+Gr
Offshore area, 2005 data (Fadeev, 2006)									
A	0	0,75	1,01	10,38	**82,67**	5,19	0,63	0,39	Sf
B	0	2,87	2,6	19,31	**66**	9,22	1,01	0,63	Sfc
C	5,32	30,93	11,73	18,32	29,38	4,32	1,58	0,88	Gr+Sfmc
Offshore area, 2004 data (Fadeev, 2005)									
A	0,00	0,65	1,32	3,68	**88,14**	6,21	0,5	0,31	Sf
B	0,00	0,29	1,06	21,41	**71,22**	6,02	0,8	0,5	Sfm
C	7,40	28,06	5,08	19,76	25,14	14,56	1,65	0,92	Gr+Sf
D	0,00	0,35	0,55	3,30	**67,60**	28,20	0,78	0,49	Sf+Al
Offshore area, 2003 data (Fadeev, 2004)									
A	0	0,31	0,31	3,32	**90**	6,06	0,41	0,25	Sf
B	0	0,05	0,75	33,65	**64,7**	0,85	0,73	0,45	Sfm
C	3	**50,6**	20,35	20,05	5,55	0,45	1,28	0,71	Gr+Scm
D	0,18	0,38	0,44	1,81	**72,75**	24,43	0,7	0,39	Sf+Al
Offshore area, 2002 data (Fadeev, 2003)									
A	0,71	2,74	2,4	15,65	**75,4**	3,1	0,83	0,47	Sf
B	0,31	3,49	5,41	**52,03**	37,55	1,21	1,05	0,59	Smf
C	0,44	18,49	21,83	36,69	20,66	1,89	1,44	0,8	Gr+Scmf

Notes for Tables 5 and 6: for abbreviations of sediment fractions, see Table 3. H_s is the entropic index of sediment sorting, and H_s/H_{max} is the normalized entropic index of sorting. **Boldface** indicates the dominant soil fractions; values for major soil fractions in the absence of a predominant fraction are shaded.

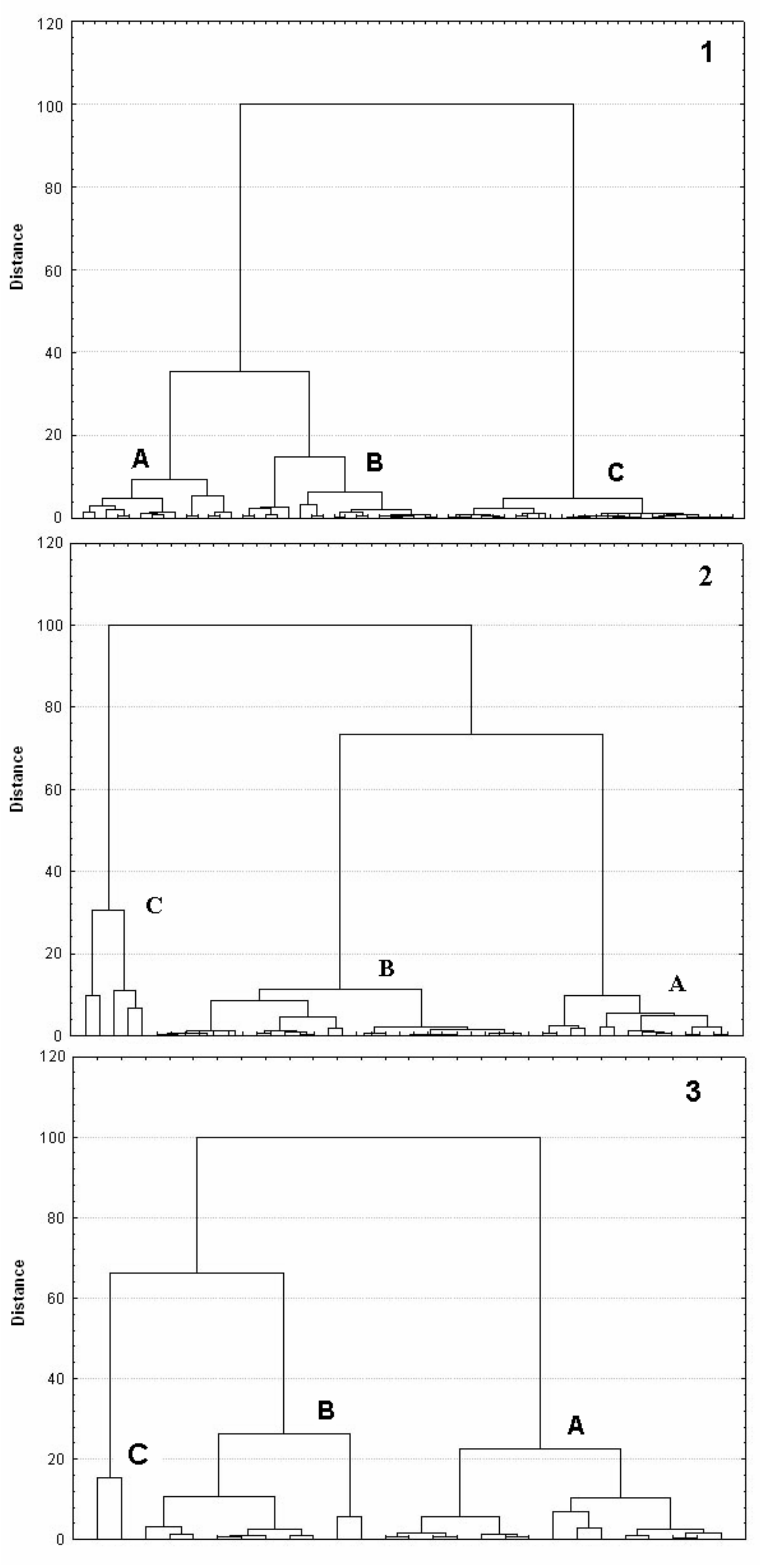


Figure 11. Classification of stations by 10-fraction sediment composition in the areas.
1 – Piltun area;
2 – Offshore area;
3 – Stations at gray whale feeding sites;
A, B, C – sediment groups.

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 studied from data obtained in 2001–2006 (Fadeev 2002–2006). In 2001, bottom sediments were sampled at nine gray whale feeding sites in the Piltun feeding area. The average depth of the feeding sites was 9±0.9 m. The analysis showed that the soils at the feeding sites were fine-grained sands in all cases (proportion of 0.1–0.25 mm fraction ranging from 73.95 to 94.34%); i.e., the soils are classified as group A.

In 2002, bottom sediments were sampled at 46 whale feeding sites: 21 stations in the Piltun area (average depth 12±0.7 m) and 25 stations in the Offshore area (average depth 41±0.9 m). Sandy soils were prevalent at all the feeding sites in the Piltun area. Fine-grained sands predominated at 53% of the stations, medium sands at 38%, while mixed fine and medium sands were found at 9% of the stations. Medium sands and mixed fine–medium sands predominated at 36% of the stations, while 12% of the stations had fine and coarse sands (Fadeev 2003). In 2003, bottom sediment samples were taken at 51 whale feeding sites: 12 stations in the Piltun area (average depth 18.6±1.6 m) and 39 stations in the Offshore area (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 soils (medium and fine sands). A small number of whale feeding sites in the Offshore area had a fine sandy soil mixed with aleurite fraction (up to 25%) (sediment group D). Most of the whale feeding sites in 2004 and 2005 were in the Piltun area. Only eight whale feeding sites were investigated in the Offshore area in 2005 (in 2004 - only two feeding whales were observed).

Most of the whales in 2006, as in previous years 2002-2005, fed in the Piltun and Offshore feeding areas, in the zone of fine- and medium-grained soils.

Table 6. Characteristics of Sediment Groups at Whale Feeding Sites.

Sediment group	Sediment fractions						H_s	H_s/H_{max}	Code
	Peb	Grav	Sand coarse	Sand med	Sand fine	Aleu+Pel			
Whale feeding sites (2006 stations)									
A	0	0,44	0,35	1,32	**90,48**	7,41	0,37	0,23	Sf
B	0	0	0,59	11,45	87,66	0,3	0,41	0,3	Sfc
C	0	11,45	9,1	48,05	31,3	0,1	1,19	0,74	Smf+Gr
Whale feeding sites in 2005 (Fadeev 2006)									
A	0	0	0,27	3,36	**92,37**	4	0,54	0,27	Sf
B	0	3,64	1,27	**65,22**	22,2	7,67	1,2	0,56	Sc
C	0	38,22	22,26	19,28	14,42	5,82	1,35	0,64	Gr+Scmf

4. Benthos Composition and Quantitative Distribution in the Areas

Because the study areas differ considerably with regard to both environmental conditions and the nature of the bottom population, the benthos distribution is considered separately in each area: Piltun and Offshore.

Benthos studies were conducted in the Piltun area in 2001–2006 and in the Offshore area in 2002–2006. Diving data from 2001 showed that the greatest biomass of food benthos is in the near coastal zone of the Piltun area at depths less than 15 m.

4.1. Piltun Area

There were 60 stations in this 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). Ten of the stations that year were between 8 and 10 m. There were a total of 64 bottom grab sampling stations in the Piltun area in 2004: 51 stations were sampled from the vessel at depths of 11 to 35 m, and 13 stations were sampled from a zodiac at depths of 3 to 10 m.

In 2005, a total of 87 bottom grab samples were collected in the Piltun area: 72 bottom grab stations (229 samples) taken from the *Oparin* at depths >12 m, and 15 dive stations (60 samples) at depths of 3–12 m. Most of the vessel stations in 2006 were in the same locations as the 2005 stations. In 2006, 60 vessel-based bottom grab stations (180 samples) were sampled, in addition to 14 diving stations in waters <11 m (56 samples) accessed using a zodiac A diagram of station locations is shown in Figure 12.

The benthos distribution is discussed below based on field data from 2006 and 2001–2005.

4.1.1. Quantitative abundance and distribution of benthos

<u>Total benthos biomass.</u> The 2001–2002 data showed similar trends 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 determined by the biomass variation of the sand dollar *Echinarachnius parma*; which comprises 61 to 70% of the total biomass of the area, increasing to 85–95 % at depths of 25–30 m. The proportion of other groups in the total biomass is significantly lower: crustaceans, 9–17%; bivalve mollusks, 8–13%; and isopods, 4–5%. The proportion of key forage benthos (amphipods and

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).

From 2003–2004 data, the average benthos biomass in the Piltun area at depths of 8–30 m (minimum collection depth, 8 m) was more than 500 g/m^2 with a colony density of more than 6000 individ./m^2. The sand dollar *E. parma* comprises the largest proportion (70%) of the benthos biomass. The proportion of sand dollars in the total benthos biomass increased with depth, from 20% at 15 m to 95% at 25–30 m. The biomass of amphipods, which are the main whale food component, decreased from 146 g/m^2 (74% of total benthos biomass) at depths of 8–11 m to 9 g/m^2 (1.2%) at 26–30 m. The sharpest changes in the quantitative abundance of benthos were observed between 15 and 20 m. From bottom grab samples taken in 2005, average benthos biomass in the region was 392.4±63.3 g/m^2, which was not significantly different from the 2004 data (501.2±93.8) (Fadeev, 2005, 2006).

In 2006, the average benthos biomass in the Piltun area was 434.3± 64.5 g/m^2, which was not significantly different from the 2005 data (392.4±63.3 g/m^2). The observed increase in average total biomass in 2006 was due to the increased proportion of sand dollars in the benthos biomass. As in the previous years, sand dollars are the major element (77%) of total biomass, reaching 83% at depths greater than 20 m. The quantitative abundance of the main forage benthos components, amphipods and isopods, decreased from 77 g/m^2 (75% of total benthos biomass) at 11–15 m depths to 17 g/m^2 (3%) at 26–30 m. Most of the station locations for depths 11–30 m were the same in 2006 and 2005, so there were no substantial changes in total observed benthos biomass (Table 7).

Biomass of basic taxonomic groups and common benthos species. Crustaceans (amphipods, isopods, decapods. and cumaceans), bivalve mollusks, and marine worms are of greatest interest for assessing food supplies for gray whales in the study area.

Crustaceans (*Crustacea*). The main crustacean groups had high frequencies of occurrence in the 2006 collections: amphipods comprised 90% and isopods 58%, which were not substantially different from the 2005 data. Despite the frequent occurrence of crabs in the Piltun area, the percentage of these animals in benthos biomass vary considerably within the study area, and with depth. Based on data from 2001–2004, the overall proportion of crustaceans in the macrobenthos biomass in Piltun feeding area was 40–55% 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, decreasing sharply at depths greater than 20 m. The change in cumacean biomass was the opposite. It was minimum at depths less than 20 m and increased with depth. Decapod biomass was low at all depths and varied only slightly.

Table 7. Macrobenthos Biomass Distribution (g/m^2) in the Piltun Area Based on Field Data from 2006 and 2005.

Depth	Depth								Entire area.		
	11–15 m		16–20 m		21–25 m		26–30 m				
	2006	2005	**2006**	2005	**2006**	2006	**2006**	2005	**2006**	2005	2004
Amphipoda	59,8	64,7	25,5	23,0	19,8	20,1	9,4	18,1	28,5±3,8	38,8±7,2	47,4±7,7
Isopoda	17,3	8,7	10,6	15,6	12,4	26,1	7,7	13,3	11,6±1,6	15,3±2,2	18,5±3,6
Bivalvia	6,4	31,0	19,6	120,6	32,2	84,7	56,2	10,7	30,1±7,1	59,0±13,9	23,1±4,1
Cumacea	0,3	1,7	0,3	2,2	0,4	2,1	9,1	2,7	2,7±1,1	1,7±0,6	1,1±0,4
Echinoidea	4,5	8,3	110,7	51,4	620,2	498,3	523,8	482,2	335,4±65,3	257,6±58,6	377,1±94,8
Polychaeta	4,1	1,8	4,6	7,7	3,2	16,5	9,1	18,7	5,3±1,2	10,6±2,5	7,5±1,9
Pisces	7,5	6,8	9,1	8,1	17,6	21,4	34,1	31,5	17,7±9,9	16,3±4,4	14,8±4,8
Rest	2,6	3,5	3,4	4,3	4,1	2,6	8,6	1,1	4,8±1,3	3,2±1,2	2,6±0,8
Totals	102,5	126,7	183,8	222,8	709,9	651,8	658,2	568,2	434,3±64,5	392,4±63,3	501,2±93,8

For 2005–2006, the proportion of crustaceans in the overall biomass was 54% at depths of 11–15 m, decreasing to 8% at 26–30 m. Amphipods have the strongest declining trend in proportion of benthos biomass with increasing depth (Table 7; Figures 13 and 14).

The spatial distribution of crustaceans in the Piltun area from 2005 data is shown in Figure P1.6 (Appendix 1). As in 2005, some patchy areas of high crustacean biomass were observed in the coastal zone. The largest areas of crustacean accumulations in the Piltun area were observed in the southern and northern portions. These shallow-water accumulations consist of amphipods and isopods. At the same time, the proportion of crustaceans in total benthos biomass clearly decreases with increasing depth. Spots of high biomass at depths greater than 20 m consist of cumaceans.

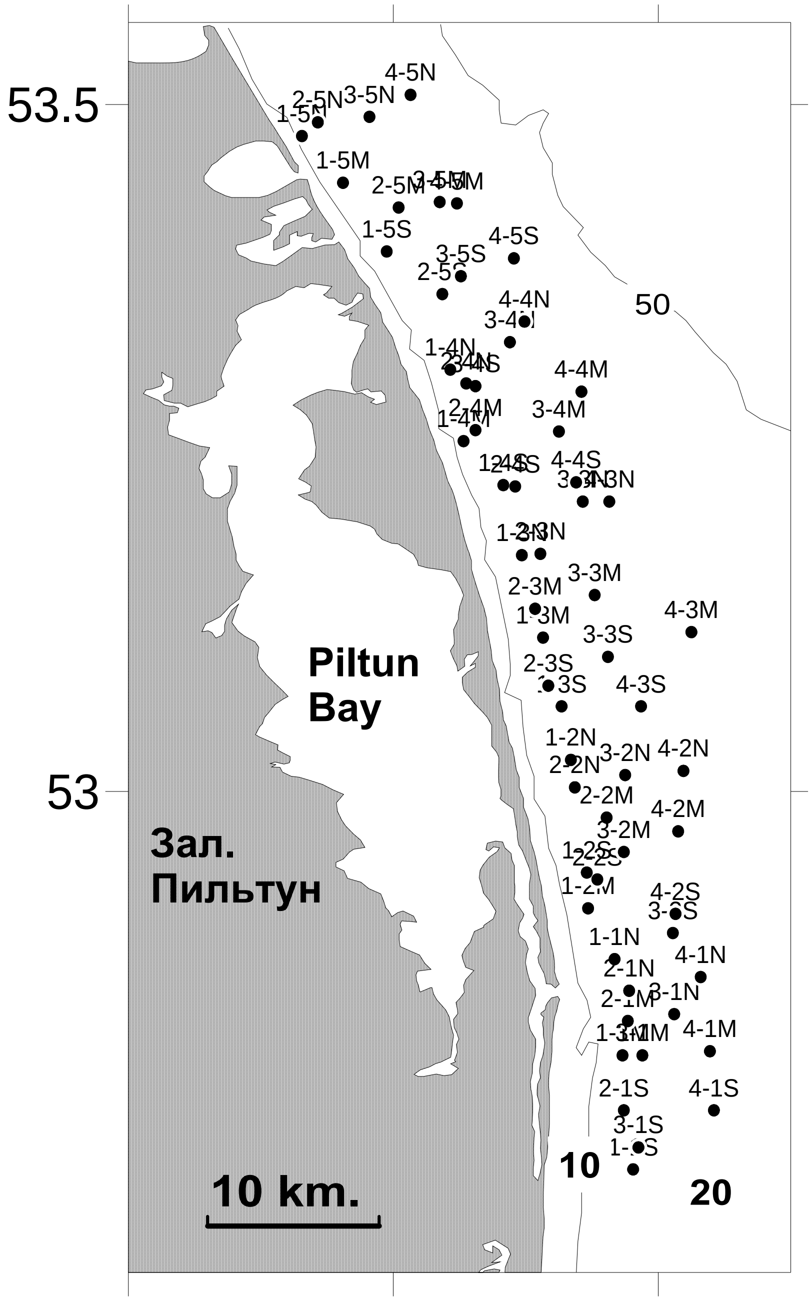


Figure 12. Locations of stations in the Piltun area in 2006.

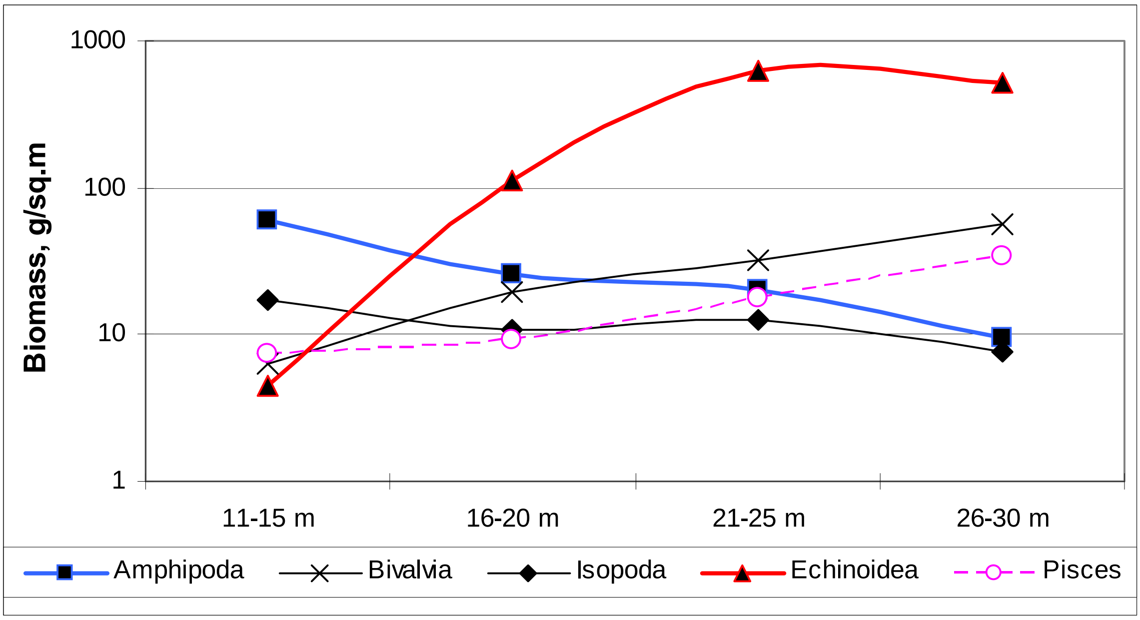


Figure 13. Variation in biomass (g/m^2) of 5 benthos groups by depth in the Piltun area in 2006.

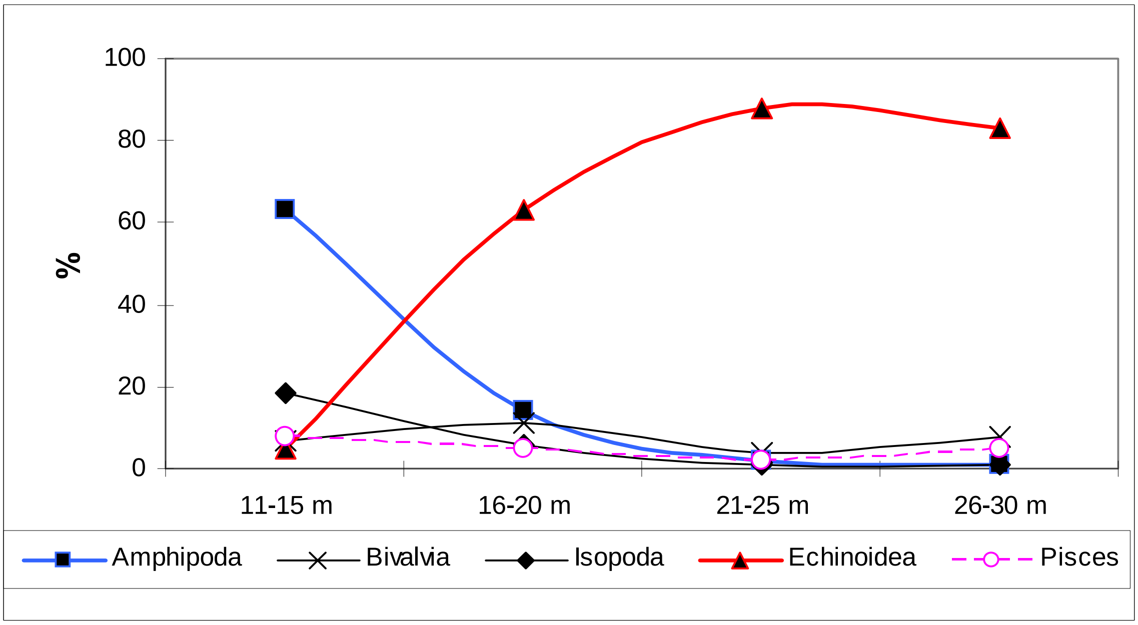


Figure 14. Variation in the proportions (%) of 5 benthos groups in the total benthos biomass by depth in the Piltun area in 2006.

Isopods (*Isopoda*). According to the 2001 diving studies, 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 shown that the small isopod *Synidotea cinerea* (average body weight 0.02 g) is the most significant component of benthos biomass in 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 a few individuals of *S. cinerea* were encountered in deeper waters. According to the diving studies, the greatest colony density of *S. cinerea* (up to 5000 individ./m^2) is associated with tube mats of the sea worm *Onuphis shirikishinaiensis* (Photo 1A).

The second species – the large isopod *Saduria entomon* (body weight up to 5 g, average weight 2.1 g) – is encountered much less frequently in the Piltun area (P = 25%). In the zone of prolific sand dollar development, this species can form such large local accumulations that it, along with other crustaceans, can be considered 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 the 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 was distinctly patchy. This patchiness of isopod biomass distribution in the shallow zone was due to local accumulations of the small isopod *Synidotea cinerea*. The density of this species in the accumulations reached 3600 individ./m^2 with a biomass of 55 g/m^2. At depths greater than 15 m, areas of elevated isopod biomass were due to accumulations of the large isopod *Saduria entomon*. The biomass of this species in local accumulations reached 128 g/m^2 with a colony density of 75 individ./m^2. However, analysis of the spatial biomass distribution 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 six stations in 2003. The isopods were present at each station in only one bottom grab sample out of three taken at the station. The other two samples at these stations were predominantly sand dollars with a biomass of up to 1200 g/m^2, with no isopods. The proportion of samples with isopod dominance in the biomass was only 6% at depths greater than 15–20 m in 2003 and less than 3% if bottom grab sample collections from 2002 are included. Despite the infrequent occurrence at depths greater than 15 m, there are local accumulations of large isopods.

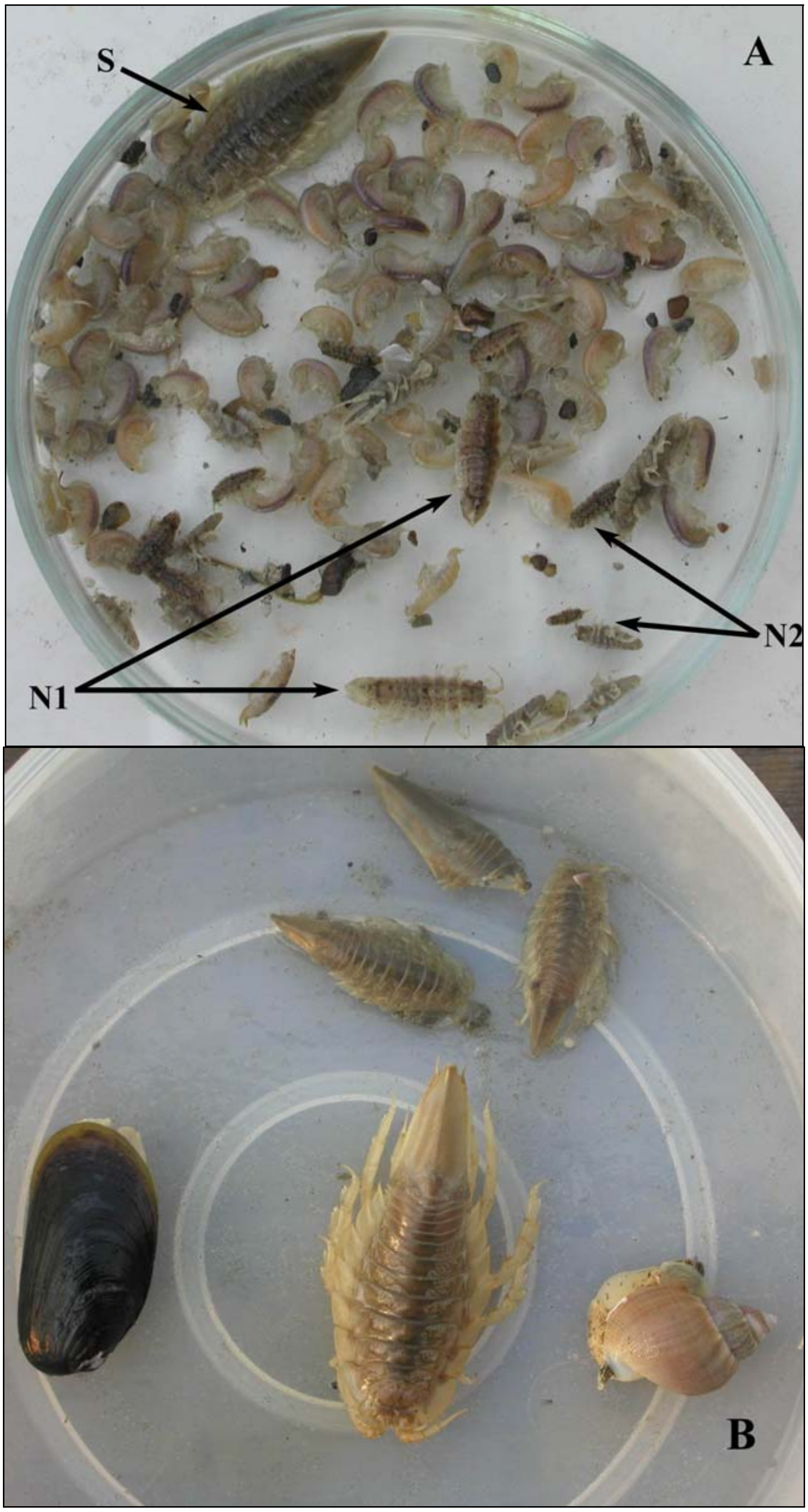


Photo 1. A) Isopod *Saduria entomon* (S), adult (N1) and young (N2) individuals of the isopod *Synidotea cinerea* from bottom grab sample.
B) Young and adult individuals of the isopod *Synidotea cinerea* (station 4-5M, depth 25 m) from the sand dollar zone.

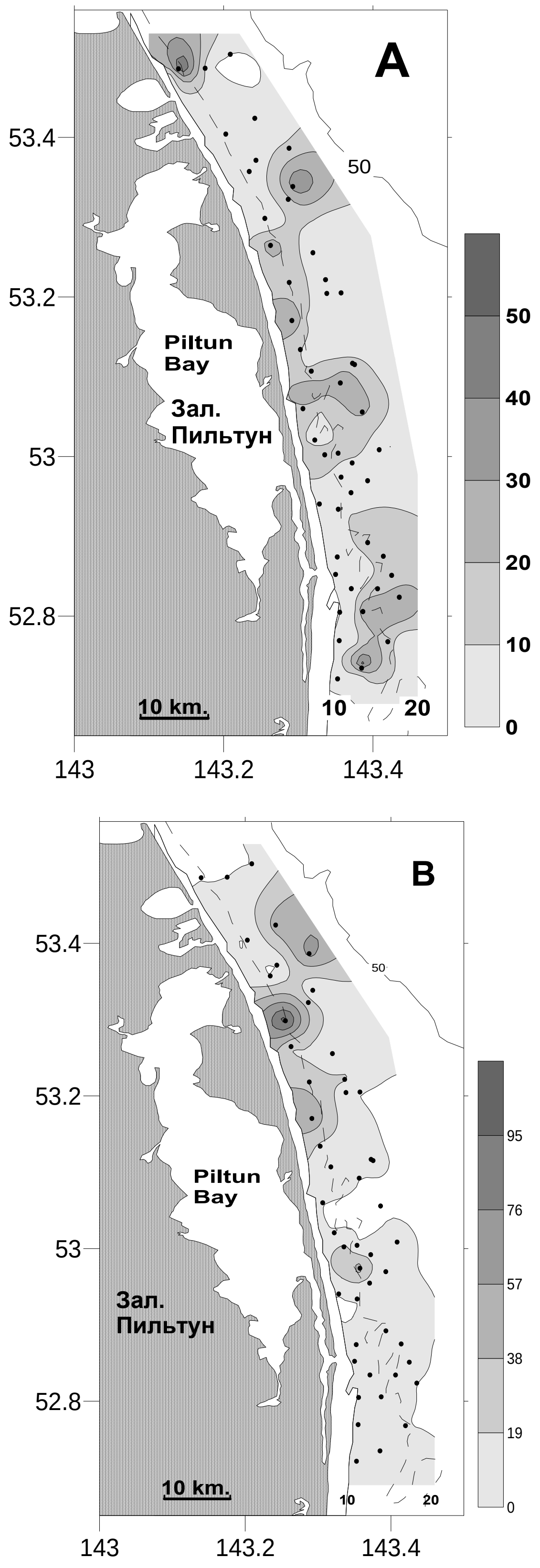


Figure 15. Isopod biomass distribution (g/m^2) in the Piltun area according to materials from 2006 (A) and 2005 (B).

Isopods can be eaten by individual whales but do not constitute a permanent food source. A similar nature of the isopod distribution was observed in the Piltun area in 2004-2005 (Fadeev 2005, 2006).

The proportion of isopods in benthos biomass at depths of 11-30 m in 2006 collections was 17% at an average biomass of 17.3±8.7 g/m^2, which is not substantially different from the data of 2005. No clear trend in the change in isopod biomass is observed with increasing depth (Table 7, Figure 14) As in 2005, the highest biomass levels (more than 45 g/m^2) were observed at depths greater than 20 m within local accumulations of the large isopod *Saduria entomon*.(Photo 1B).

The spatial distribution of isopods in the Piltun area was similar in nature in 2006 and 2005 (Figures 15A and 15B). 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 2005 was lower than in 2006. At depths greater than 15-20 m, local isopod accumulations in 2005 and 2006 can be charted most clearly in the northern part of the Piltun area (Figures 15A, B).

Characteristics of the dominant isopod species. The large isopod *Saduria entomon* is a brackish-water 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 ºC (Crimmon and Bray 1962). The species reaches sexual maturity at the age of 3-4 years (Yarvekyulg 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, ten 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 2005, the average amphipod biomass in the Piltun area was 38.8±7.2 g/m^2, which is comparable to the data from 2002 – 42.7 g/m^2 – and 2003 – 54.6 g/m^2 (Fadeev 2005, 2006)

In 2006, the average amphipod biomass was 28.5±3.8 g/m^2 for the entire depth range studied in the Piltun area, which does not differ significantly from the data from 2005 – 38.8±7.2 g/m^2. (Table 7). As in 2004-2005, 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* (more than 60% of the total amphipod biomass) and *Eogammarus schmidti* (more than 30%). Amphipods have their highest quantitative abundance levels at depths under 15 m. The sharpest decrease in the abundance of amphipods occurs in the range of 15-20 m (Table 7; Figures 13, 14). The proportion of amphipods is more than 58% of the total benthos biomass at depths of 11-15 m and decreases to 1.5% at depths greater than 20 m. The decrease in the average amphipod biomass in the Piltun area from 38.8±7.2 g/m^2 in 2005 to 28.5±3.8 g/m^2 in 2006 was due a signifiacnt decline in amphipod biomass at depths greater than 25 m (18.1 g/m^2 in 2005 and 9.4 g/m^2 in 2006). The decline in amphipod biomass at these depths does not have a decisive impact on the gray whale feeding base in the Piltun area, since at depths greater than 25 m aphipods account for less than 2% of the average benthic biomass and do not form heavy accumulations.

As data from 2001-2006 studies demonstrated, the largest amphipod accumulations occurred in the near-shore zone of the Piltun area at depths less than 15-20 m. In 2006, the average amphipod biomass in 15-m (or less) depths was 59.8±11.8 g/m^2, which is comparable to the data from 2005 – 64.7±10.2 g/m^2 (Table 7). However, amphipod biomass distribution along the Piltun area coastline in 2006 was somewhat different from that in 2005.

The nature of the spatial distribution of amphipod biomass in the Piltun area has similar trends in 2006 and 2005 – a zone of elevated biomass is associated with the near-shore sections of the water area, and the amphipod distribution is patchy. (Figures 16A, B).

The amphipod biomass distribution was more regular in 2006 (Figure 16A) than in 2005 (Figure 16B), and local spots of elevated biomass (more than 120 g/m^2) can be seen in the northern parts of the area.

In the southern Piltun area, the average amphipod biomass in the 11-15 m depth range was 33.5 g/m^2 in September 2006. In 2005, in the same area in similar depths, the average amphipod biomass sometimes reached 69.4 g/m^2. These significant variations in average biomass numbers at the same stations in 2005 and 2006 may have been due to a number of factors. In 2005, in the area's southern section, sampling was performed in the second decade of July, i.e., at the beginning of the feeding season, while in 2006 samples were collected in the second or third decade of September, i.e., at the end of the feeding season. The biomass decline in September 2006 may be due to the decimation of amphipod accumulations by foraging whales during the feeding season. Observations show that the gray whale feeding season in the Piltun area starts exactly in the southern section, with relatively high whale numbers observed throughout the feeding season. (Vladimirov et al. 2006).

Meanwhile, the analysis of perennial changes in the hydrologic regimen, provided in section 3.1, shows that in the summer season of 2006 the southern sections of the Piltun area exhibited the lowest benthic water temperatures over the period from 2004 through 2006. This can be assumed to have affected the growth rate of common species of amphipods, which represent the feeding base for gray whales in this region.

To determine the most likely causes of the amphipod biomass decline in September 2006 in the southern Piltun area, efforts are currently underway to analyse the data on length composition of amphipods and quantitative distribution of benthos obtained in a similar period from 2001 through 2005.

Characteristics of the dominant amphipod species. The amphipod *Pontoporeia affinis* (= *Monoporeia affinis*) is a brackish-water 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 12.8ºC (Yarvekyulg 1979).

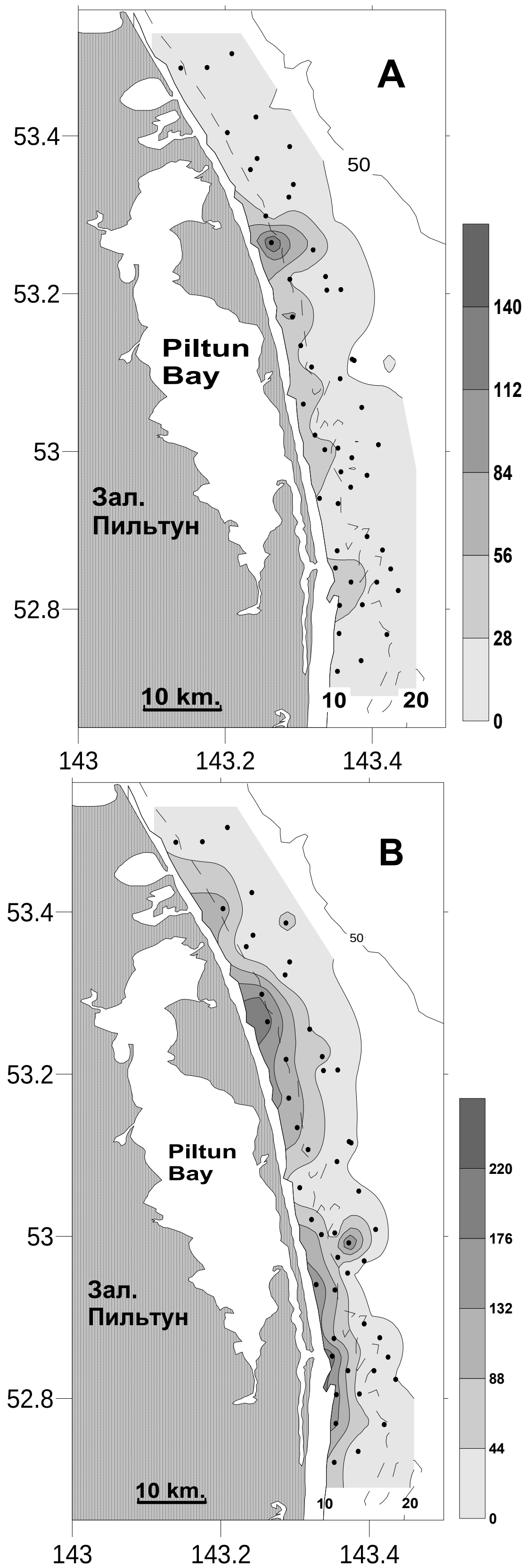


Figure 16. Amphipod biomass distribution (g/m^2) in the Piltun area based on materials from 2006 (A) and 2005 (B). (B) In the Piltun area.

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).

<u>Cumaceans (*Cumacea*).</u> 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 2002-2004. 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 highest cumacean colony density of 24,800 to 37,600 spec./m^2 with a biomass of 84 to 113 g/m2 was observed at 30-32-m depths. The average cumacean biomass for the entire area in 2005 was 1.7 g/m^2, which is comparabe to the 2004 data – 1.1 g/m^2 (Fadeev 2002, 2006).

Cumaceans had a high frequency of occurrence – 79% – in the 2006 collections. As previously, four cumacean species were observed at depths up to 30 m: *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 2006 was 2.7 g/m^2, which is not substantially different from the data from 2005 (1.7 g/m^2). Furthermore, the cumacean biomass levels in 2006 and 2005 are reliably lower than the biomass levels in 2001 and 2002 (17.1 and 10.9 g/m^2, respectively). The differences in biomass in different years are explained by the fact that the station layout in 2005-2006 differed from the 2002 layout; i.e., cumacean accumulations inspected in 2002 were not covered in the studies in 2006 and 2005.

<u>Bivalve mollusks *(Bivalvia).*</u> 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: *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 made 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 = 31%). 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 for 2003-2006, thirty species of bivalve mollusks were recorded (Appendix 4). Of these, five species had a frequency of occurrence higher than 25%: *Megangulus luteus* (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 in 2006 was 30.1±7.1 g/m^2 (Table 7). The bivalve mollusk biomass varies only slightly throughout the depth range studied (Figures 14 and 15).

Sand lance *Ammodytes hexapterus*. The difference between materials from 2004-2006 and 2002-2003 is the significantly larger proportion of *Ammodytes hexapterus* in the total benthos biomass of the Piltun area. 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. 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.

In 2005, the sand lance was encountered in low numbers throughout the Piltun area, but the densest accumulations were found in the northern and middle parts of the area, typically at depths greater than 20 m in the sand-dollar zone. Very few sand lance accumulations were encountered at shallow depths (the minimum depth being 12 m) within the near-shore complex of amphipods (Photo 2). While the average biomass was 16.3±4.4 g/m^2 for the whole area, the sand lance biomass within local accumulations sometimes reached 150 – 236 g/m^2. In 2005, the average frequency of occurrence of the sand lance in the Piltun area was 15%, while in the northern part it reached 40-60%. Sand lance accumulations were observed for the first time in the Piltun area during diving operations in 2001. 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. Based on the high sand lance biomass levels in accumulations and their high fuel value, according to the results of 2001 studies, the sand lance was considered potential 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).

Photo 2. Sand lance *Ammodytes hexapterus* in a bottom grab sample from a gray whale feeding site in the near-shore amphipod complex at a 12 m depth (above) and from the sand-dollar complex at a 30 m depth.

Adult sand lances were prevalent in the 2006 collections at depths greater than 20 m at gray whale feeding sites in the northern part of the Piltun area (Photo 2, Figure 17). The sand lance density in the densest accumulations reached 140-160 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.

An increase was observed in the frequency of occurrence and biomass of the sand lance in the northern part of the Piltun area from 2004 through 2005. This process occurred concurrently with a decrease in the number of whales in the Offshore area and the appearance of a grouping of whales feeding at depths greater than 20 m in the northern part of the Piltun area (Vladimirov at al. 2006; Yakovlev and Tyurneva 2006). An analysis of the 2004-2005 materials on sand lance distribution provided grounds for the assumption that the Offshore area represents a secondary feeding ground for gray whales and is used by them when forage benthos biomass declines (as a result of decimation by predators, seasonal or year-on-year biomass changes) in Piltun, the principal feeding area (Fadeev 2006). Therefore, the emergence of the sand lance as an additional available food resource in the northern Piltun area in 2003-2005 likely resulted in a reristribution of whales between the Piltun and Offshore areas. Notably, the largest sand lance accumulations in the northern Piltun area (at depths more than 20 m) are loacted 5-7 km from the shallow near-shore amphipod complex (at depths less than 15-20 m). Gray whales are capable of traveling this distance in 1-1.5 hours, i.e., the same animals can use both amphipod-dominated near-shore areas and deeper offshore sites in which sand lancers dominate.

In 2006 and 2005, the average sand lance biomass in the Piltun area was characterized by similar levels (Table 7), with a significant decline in the frequency of occurrence in the northern part of the area (from 40-60% in 2005 to 20-25% in 2006). This may have been caused by either the departure of adolescent sand lances for deeper waters in September 2006 (according to published data, this occurs in September) or the beginning of a long-term decline in its numbers (according to published data, an irruption of the sand lance typically lasts three or four years).

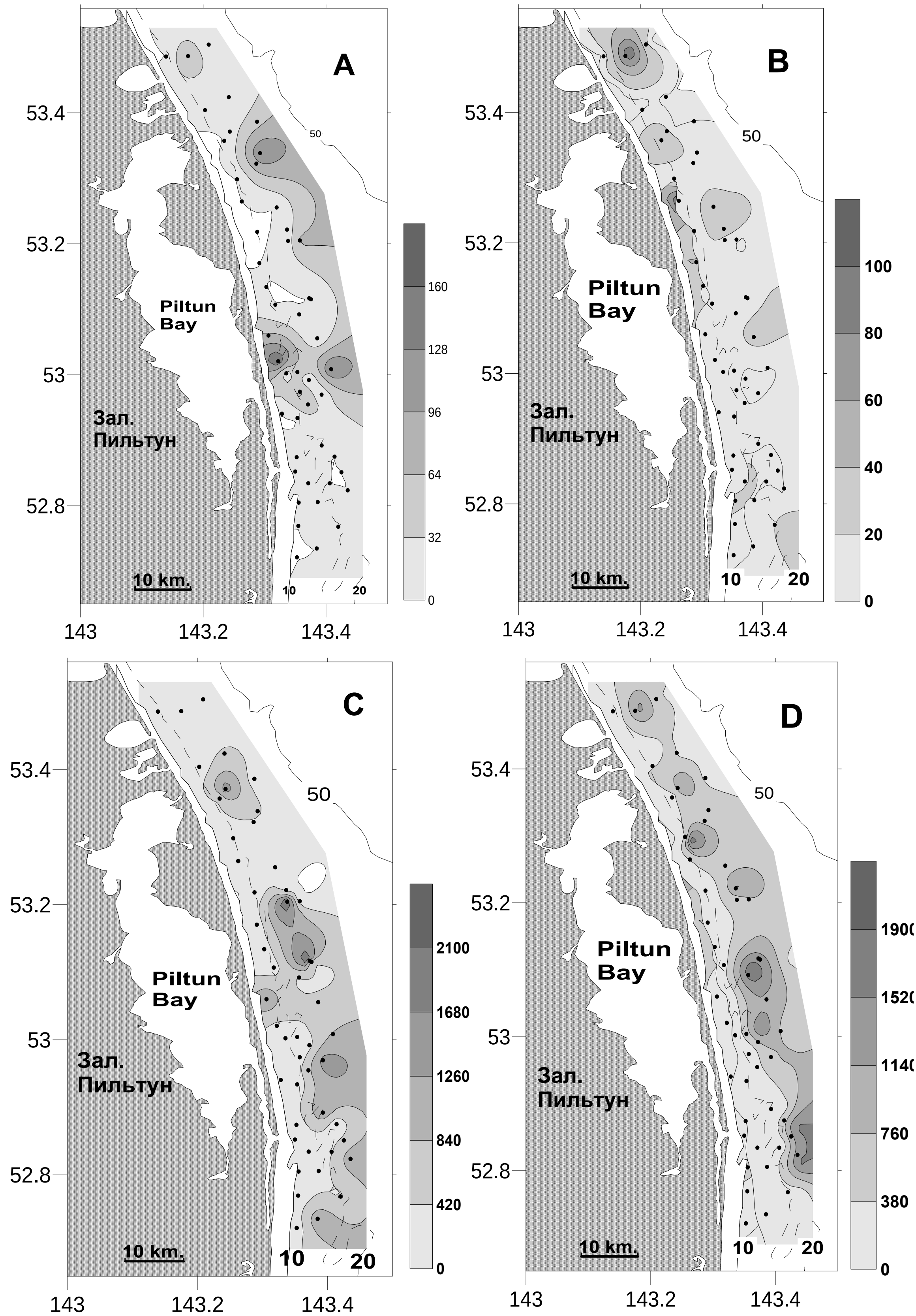


Figure 17. Sand lance biomass distribution (g/m^2) (A – 2005; B – 2006) and total macrobenthos biomass (C – 2005; D – 2006) in the Piltun area.

4.1.2. Composition and Distribution of Benthos Complexes

Cluster analysis was used to identify irregularities in the benthos distribution – the 256 stations (2002-2006) were grouped according to the similarity of quantitative relationships among benthos taxonomic groups. The classification results are presented in a dendrogram (Figure 19). 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 that are smaller but have greater similarity of units within the groups – communities. Figure 18 shows the locations of stations assigned to each complex in the Piltun area. The benthos complexes differ in both the composition and the quantitative abundance of the taxonomic groups (Table 8).

Table 8. Composition of benthos complexes of the Piltun area.

Taxonomic 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	5283	**90,21**	1077	20,35	419	25,35
Bivalvia	74	17,56	377	**162,45**	67	46,32
Cumacea	120	1,58	74	0,68	1196	7,63
Decapoda	0	0	1	2,06	2	3,54
Echinoidea	1	1,34	10	30,52	167	**914,3**
Isopoda	312	18,47	254	11,71	16	20,52
*Pisces**	2	7,09	1	5,91	3	17,23
Polychaeta	66	2,57	79	14,79	90	24,54
Totals	2663	138,82	1874	248,47	1960	1059,43

Note: * - temporarty community component.

The *Amphipoda* complex includes 68 stations at depths of 5 to 23 m (average depth 15 m) in the fine- and medium-grained sand zone. The complex is distributed in a belt-like pattern along the coast in the Piltun area (Figure 18). The average biomass of the complex (138.8 g/m^2) is made up primarily of amphipods – 65%; isopods – 13%; and bivalve mollusks – 13%. The complex includes 34 amphipod species with a total biomass of 90.2 ±18.5 g/m2 at a colony density of 5,280±1,300 spec./m^2. Four species have the greatest quantitative abundance: *Pontoporeia affinis, Eogammarus schmidti, Eohaustorius eous eous* and *Anisogammarus pugettensis*. They account for 92% of the average biomass and colony density of amphipods in the complex. (Photo 3).

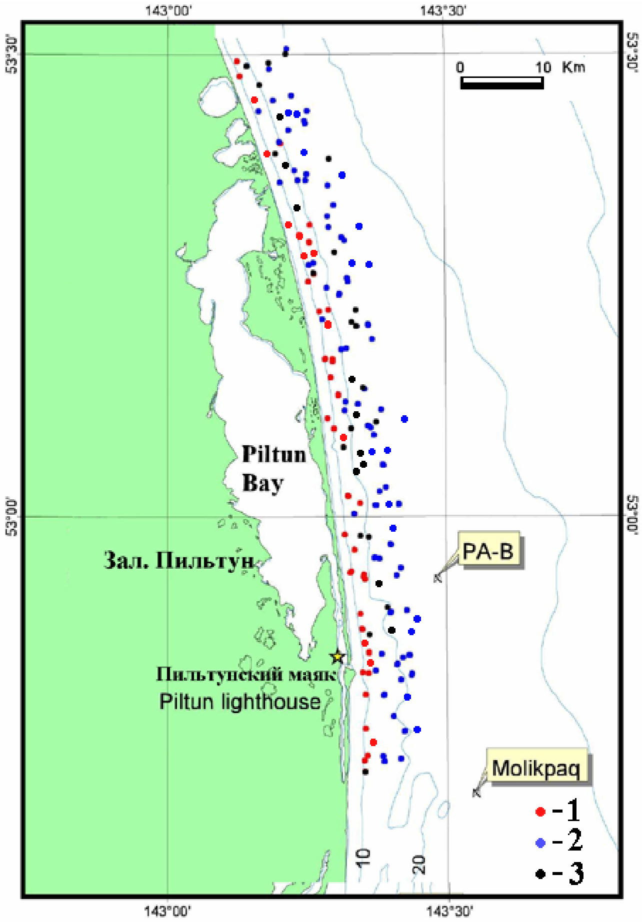


Figure 18. Distribution of complexes in the Piltun area based on 2002-2006 data.

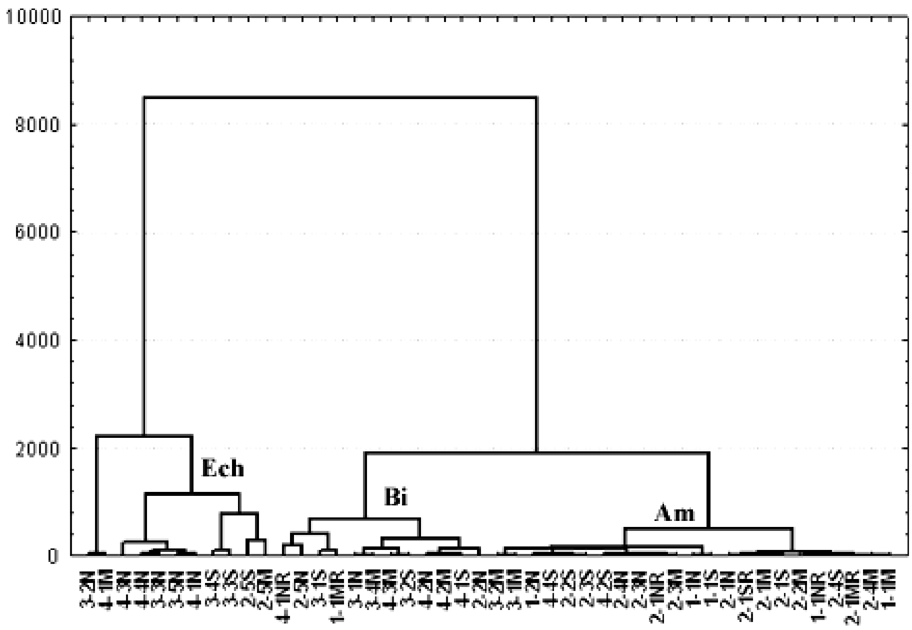


Figure 19. Dendrogram of the similarity of stations in the Piltun area based on collections from 2006-2005.

In dendrogram: Am – amphipod complex; Bi – bivalve mollusk complex; Ech – flat sea urchin complex.

Figure 19 complex designations: 1 – amphipods; 2 – flat sea urchins; 3 – bivalve mollusks.

Photo 3. Bottom grab sample (0.2 m^2) from the amphipod complex.

Photo 4. Bottom grab sample (0.2 m^2) from the sand dollar complex.

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* and *Macoma lama.* These species account for more than 95% of the biomass of bivalve mollusks (17 g/m^2).

Based on diving data from 2001, the bottom areas where similar compositions of amphipods and isopods dominate 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 2001–2006.

The *Bivalvia* complex includes 48 stations at depths of 9 to 31 m (22 m on average) on fine sands and mixed gravel and sand bottoms. In contrast to the amphipod complex, it has a distinctly spotty distribution across the area (Figure 18). The composition of the complex includes 18 bivalve mollusk species with a biomass of 162.45± 53.4 g/m^2 at an average complex biomass of 248.5 g/m^2. Seven 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, while *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.

The 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.

Summarizing the analysis of the distribution of macrobenthos complexes based on materials from 2002-2006, 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 the complexes lies at depths of about 20 m (Figure 18).

4.2. Offshore area

4.2.1. Quantitative abundance and distribution of benthos

In the Offshore area in 2006, there were 48 stations (144 bottom grab samples) at depths from 20 to 63 m. (The average depth was 42.1±1.7 m, n=48 in 2006; 42.5±1.7 m, n=48 in 2005 and 49.3±2.3 m, n=32 in 2004.) Diagrams of station locations in the Offshore area are presented in Figures 20 and P1.2. In contrast to the diagrams of station locations in 2002-2004, there was a full grid of stations (48 stations) throughout the Offshore area during the 2005-2006 expeditions (Figure P1.2).

Most of the Offshore area features sandy bottom soils: well-graded fine sand at 40 stations and differently-grained sand with admixtures of gravel and pebbles at eight stations. The proportion of the aleurite-pelite fraction is more than 20-26% 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 9).

Table 9. Frequency of occurrence of benthos taxonomic groups in the Offshore area.

Frequency of Occurrence (P, %) of Taxonomic Groups, n=48							
P>50%		P = 25-50%		P = 10-25%		P<10%	
Group	P,%	Group	P,%	Group	P,%	Group	P,%
Amphipoda	100	*Gastropoda*	44	*Echinoidea*	21	*Bryozoa*	9
Polychaeta	79	*Nemertinea*	27	*Sipunculida*	19	*Hydroidea*	9
Bivalvia	73	*Decapoda*	27	*Caprellida*	17	*Pisces*	8
Cumacea	73			*Holoturoidea*	12	*Ophiuroidea*	5
Actinia	68			*Isopoda*	10		

As in 2004-2005, 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, such as sand dollars *E. parma* (P = 21%). For the Offshore area as a whole, these taxonomic groups account for more than 95% of the average total benthos biomass – 654±60 g/m^2 (n=48). Figures for the quantitative abundance of benthos for the Offshore area in 2006 are given in Table 10.

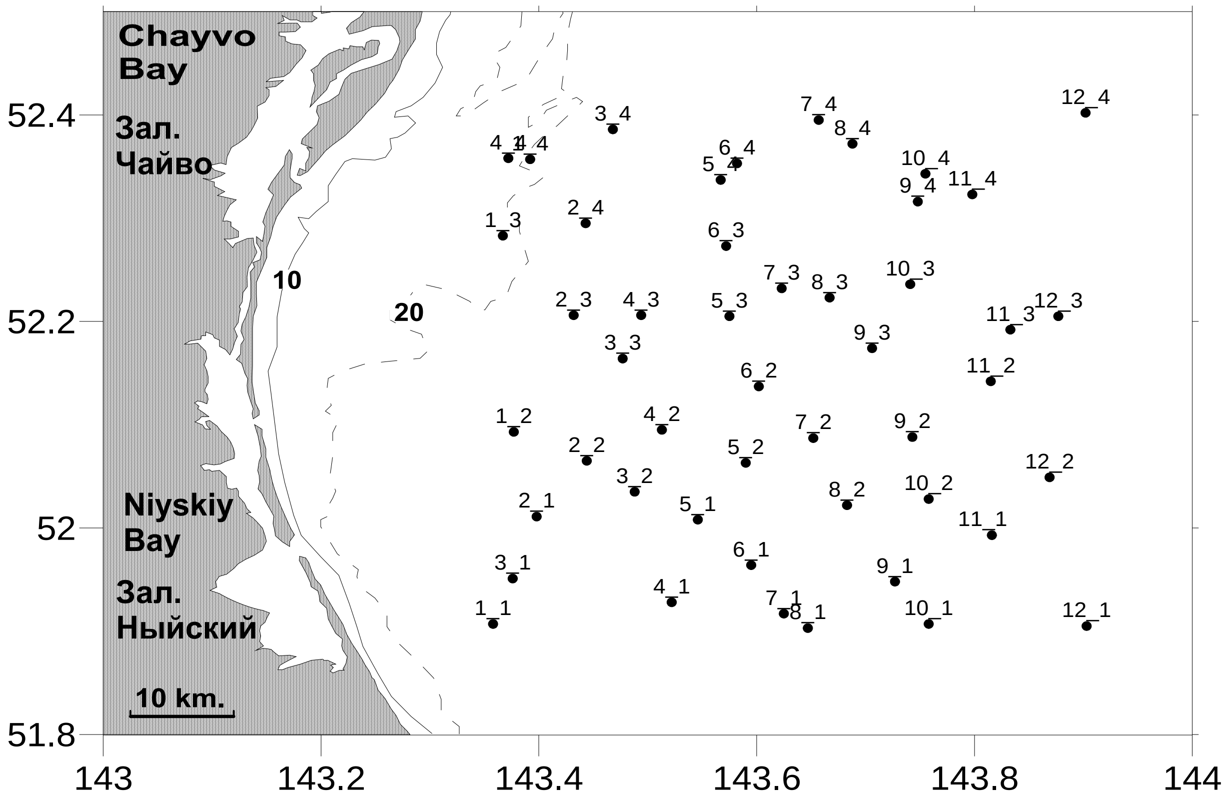


Figure 20. Diagram of station locations in the Offshore area in 2006.

Field data from 2006 and 2005 were collected under a similar sampling procedure (performed on 48 stations) and within similar calender timelines, which helped offset the impact of interseasonal benthos variability on analysis data.

Analysis of the total average benthos biomass of the Offshore area based on 2006 and 2005 collections indicates a statistically insignificant difference in the average biomass levels. The average total benthos biomass was 654.7±59.9 g/m^2 in 2006 and 526.6±52.3 g/m^2 in 2005.

The biomass of the main groups (amphipods, bivalve mollusks, sea anemones and cumaceans) in 2006 was comparable to the 2005 data. The biomass of amphipods – the most important component in the diet of whales in the Offshore area – was 184.9±29.6 g/m^2 in 2006 and 200.2±35.7 g/m^2 in 2005. The year-to-year variations in the average amphipod biomass are statistically insignificant. Analysis of data from the central part of the Offshore area (20 stations, Figure P 1.2), where benthic samples were taken in 2003, 2004, 2005 and 2006, shows that the differences between the years in the total biomass of benthos and the total biomass of the main prey item - *Ampelisca eschrichti* - were statistically insignificant.

The spatial distribution of benthos biomass was similar in 2006 and 2005. The biomass and proportion of amphipods in the total benthos biomass of the Offshore area increases in moving from shore toward deeper water (Figures 23 and 24A). A similar trend was observed in 2002-2004. The 2004 expedition succeeded for the first time in outlining the zone of the highest amphipod biomass levels (Figure 24A). 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 in the seabed. The other groups (sea anemones, bivalve mollusks, cumaceans and flat sea urchins) that make up most of the biomass have a distinctly spotty distribution. (Appendix 1: Figures P1.6. – P1.8).

As in 2002-2004, accumulations of bivalve mollusks, sea anemones and flat sea urchins have the most aggregated distribution. Higher-biomass areas of these groups are on the edge of the amphipod mass development zone (Appendix 1: Figures P1.6 and P1.8).

Table 10. Macrobenthos biomass distribution (B, g/m^2) in the Offshore area based on materials from 2005-2006 field work.

Indicator	Taxonomic Group								Entire Area (Bsumm)	
	Amphipoda		*Actinia*		*Bivalvia*		*Echinoidea*			
	2006	2005	**2006**	2005	**2006**	2005	**2006**	2005	**2006**	2005
Average B	184,9	200,2	127,2	76,5	102,3	91,7	138,7	85,5	654,7	526,6
Standard deviation	29,6	35,7	21,9	13,7	24,8	15,7	46,2	36,2	59,9	52,3
Proportion, % of **Bsumm**	28,2	35,7	19,4	13,7	15,6	15,7	21,2	36,2	100	100
Minimum	0,9	0,3	0	0	0	0	0	0	92,4	100,8
Maximum	953,1	1334	659,3	396,9	710,4	427	1218	1238	1642	1806
P, %	48	48	48	48	48	48	48	48		
Number of stations										

Notes: **Bsumm** is the average total benthos biomass, g/m^2

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 its western part. In the second half of September 2006, mass occurrence of juvenile cumacean crustaceans *Diastylis bidentata* was observed (prevalent modal class 1-2 mm). During this period, colony density of cumaceans at some stations exceeded 270,000 spec./m^2 with a biomass of more than 300 g/m^2 (Photo 6).

4.2.2. Composition and Distribution of Benthos Complexes in the Offshore area

Based on materials from 2002-2004 (118 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, 2005).

All the stations of 2006 and 2002-2005 were grouped according to the similarity of 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 21). Based on materials from 2002-2005, four benthos complexes were distinguished in the Offshore area (Table 11).

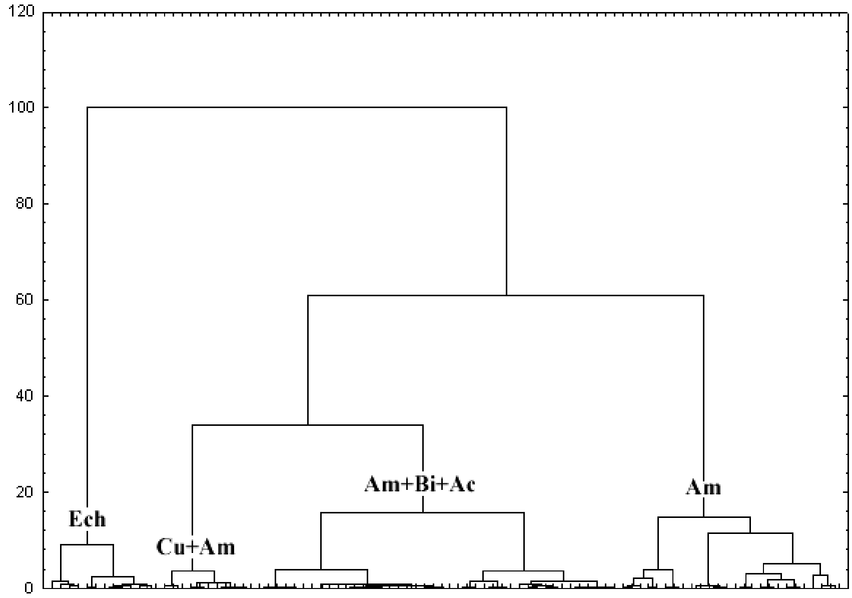


Figure 21. Dendrogram of the similarity of Offshore area stations in regard to benthos structure.

Table 11. Quantitative characteristics (B, g/m^2) of macrobenthos complexes in the Offshore area.

Parameter	Taxonomic Group					Average total biomass (**Bsumm**)
	Amphipoda	*Actinia*	*Bivalvia*	*Echinoidea*	*Cumacea*	
1. Complex *Echinarachnius parma* (Ech)						
Average biomass	54,8	72,7	75,5	**674,9**	52,5	931,6
Standard deviation	20,4	32,3	36,5	125	26,1	162,2
Proportion in **Bsumm**, %	5	7	8	72	5	100%
2. Complex *Diastylis bidentata* + *Amphipoda* (Cu+Am)						
Average biomass	**131,6**	25,4	24	25,4	**230,7**	436,3
Standard deviation	34,7	14,9	11,4	14,1	35,4	62,9
Proportion in **Bsumm**, %	30	5	5	5	52	100%
3. Complex *Ampelisca eschrichti* + *Bivalvia* + *Actinia* (Am+Bi+Ac)						
Average biomass	**226**	**140**	**126,5**	0,8	42,2	522,3
Standard deviation	26,8	36,9	26,9	0,8	11,9	49,7
Proportion in **Bsumm**, %	43	26	24	0	8	100%
4. Complex *Ampelisca eschrichti* (Am)						
Average biomass	572,2	136,6	93,4	0	22,7	810,6
Standard deviation	64	35,7	22,8	0	6,1	98,3
Proportion in **Bsumm**, %	70	16	11	0	2	100%

Note: Abbreviated names of complexes used in Figure 24 are given in parentheses.

I. A complex with dominance of sand dollars *Echinarachnius parma*. The average depth was 31.5±1.8 m (18 stations at depths of 18-47 m). Sand dollars are dominant at all stations, with an average biomass of 670 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 2001-2004 (Fadeev, 2003, 2004). According to materials from 2002-2006, it occupies local sections in the Offshore area in the northern part of the water area (Figure 22).

Based on 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. This site 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, 1983 a, b). As the current speed decreases southward along the eastern Sakhalin shelf and bottom silting increases, the sand dollars are 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). 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 human impact – over-harvesting of the Kamchatka crab and flounder (which feed on the sand dollars), which has resulted in a disruption of the balance in the "predator-prey" system.

II. A complex with dominance of cumaceans *Diastylis bidentata* and amphipods *Ampelisca eschrichti.* The average depth is 28.6±1.8 m (21 stations at depths of 24-31 m). The average total biomass of the complex is 338±44 g/m^2, and the dominant species account for more than 80% of the biomass (cumaceans – 58%; 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 a biomass of 134 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 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). Nevertheless, 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 food. 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. On the other hand, quite a high ampeliscid biomass level was observed in this complex (based on data from 2002-2005, more than 130 g/m^2). Gray whales may feed in the areas of this complex within the ampeliscid pockets.

III. A complex with dominance of amphipod *Ampelisca eschrichti*. The average depth is 52.6±1.9 m (64 stations in the range of 30-65 m). The complex occupies the eastern part of the Offshore area. The average biomass is 644±145 g/m^2, and the biomass of the dominant group – amphipods – is more than 510 g/m^2 (79% of total biomass). The complex comprises 35 amphipod 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 2005 and 2006: 1,237 and 1,334 g/m^2, respectively, at 100% frequency of occurrence in the collections.

Materials from 2006 and 2005 from the Offshore area (Table 10) support the conclusion that 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 benthic values of other highly productive areas of the North Pacific (Kuznetsov, 1964; Koblikov, 1983 a, 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).

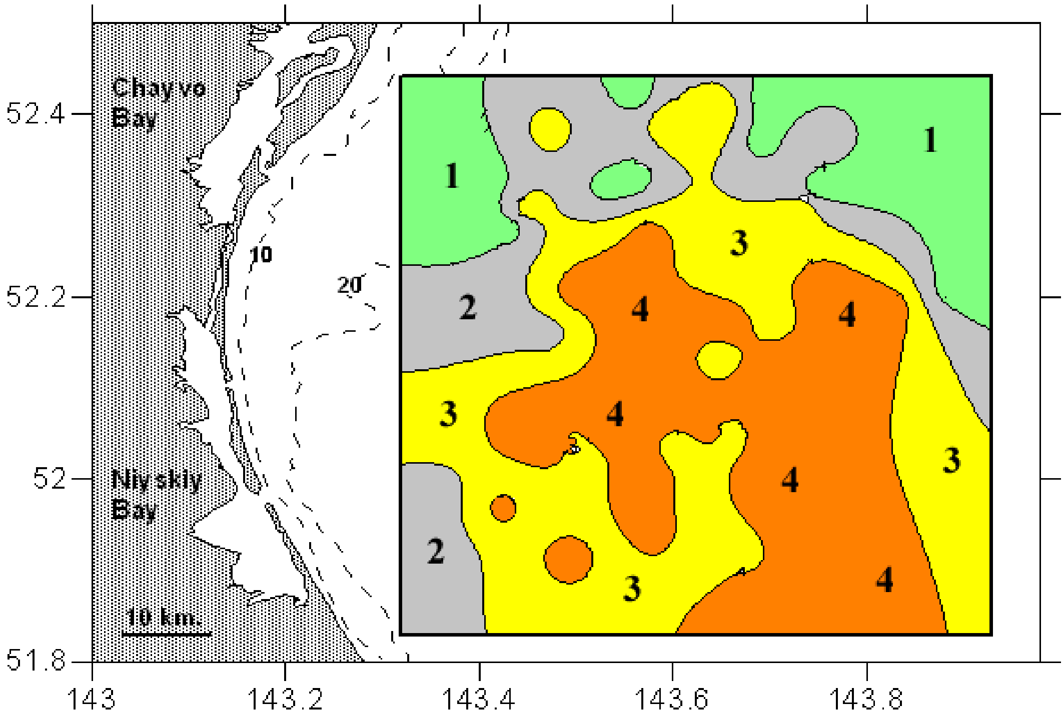


Figure 22. Distribution of benthic complexes in the Offshore area in 2004-2006. The numbers of the complexes are given in Table 11.

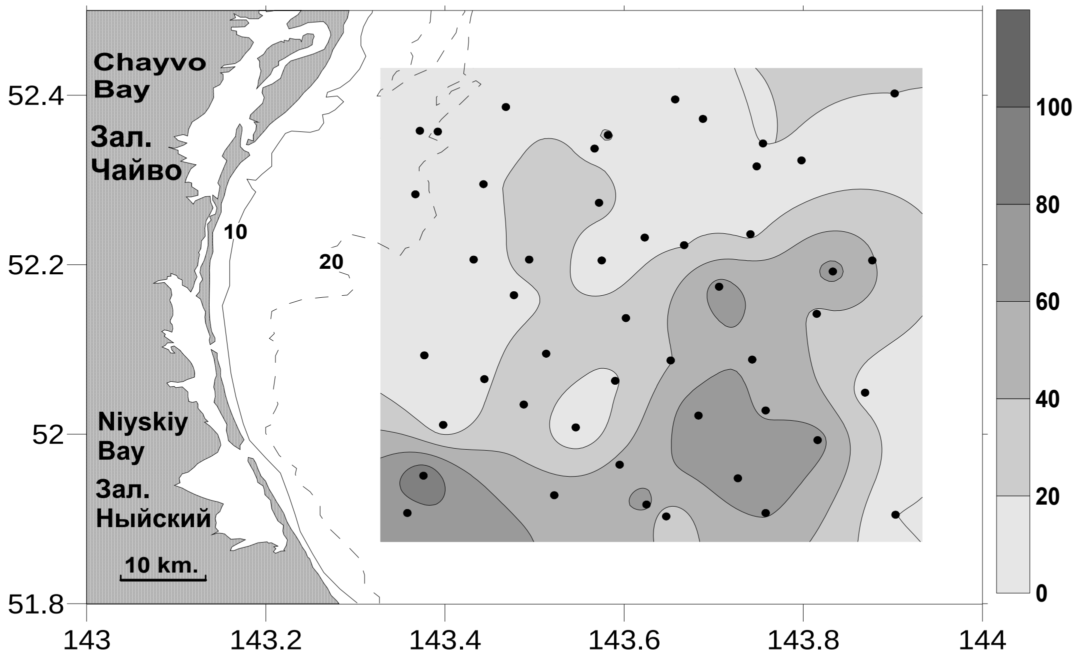


Figure 23. Proportion of ampeliscid amphipods in the total benthos biomass in the Offshore area based on 2006 data.

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 size composition of ampeliscids was analyzed on the basis of materials from 2004 and 2002-2003. The average body length was 11.38±0.43 mm in 2002 (n = 210) and 13.78±0.31 mm in 2003 (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 was 83%.

IV. A 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 (49 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 622±48 g/m^2. Ampeliscids, bivalve mollusks and sea anemones account for about 95% of the biomass of the complex. The complex includes 18 recorded species of bivalve mollusks. Two species have the highest frequency of occurrence: *Serripes groenlandicus* (P>50%) and *Liocyma fluctuosum* (P>30%).

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 in seabed water and are associated with hydrodynamically active sections of the shelf. A high seston concentration in 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.

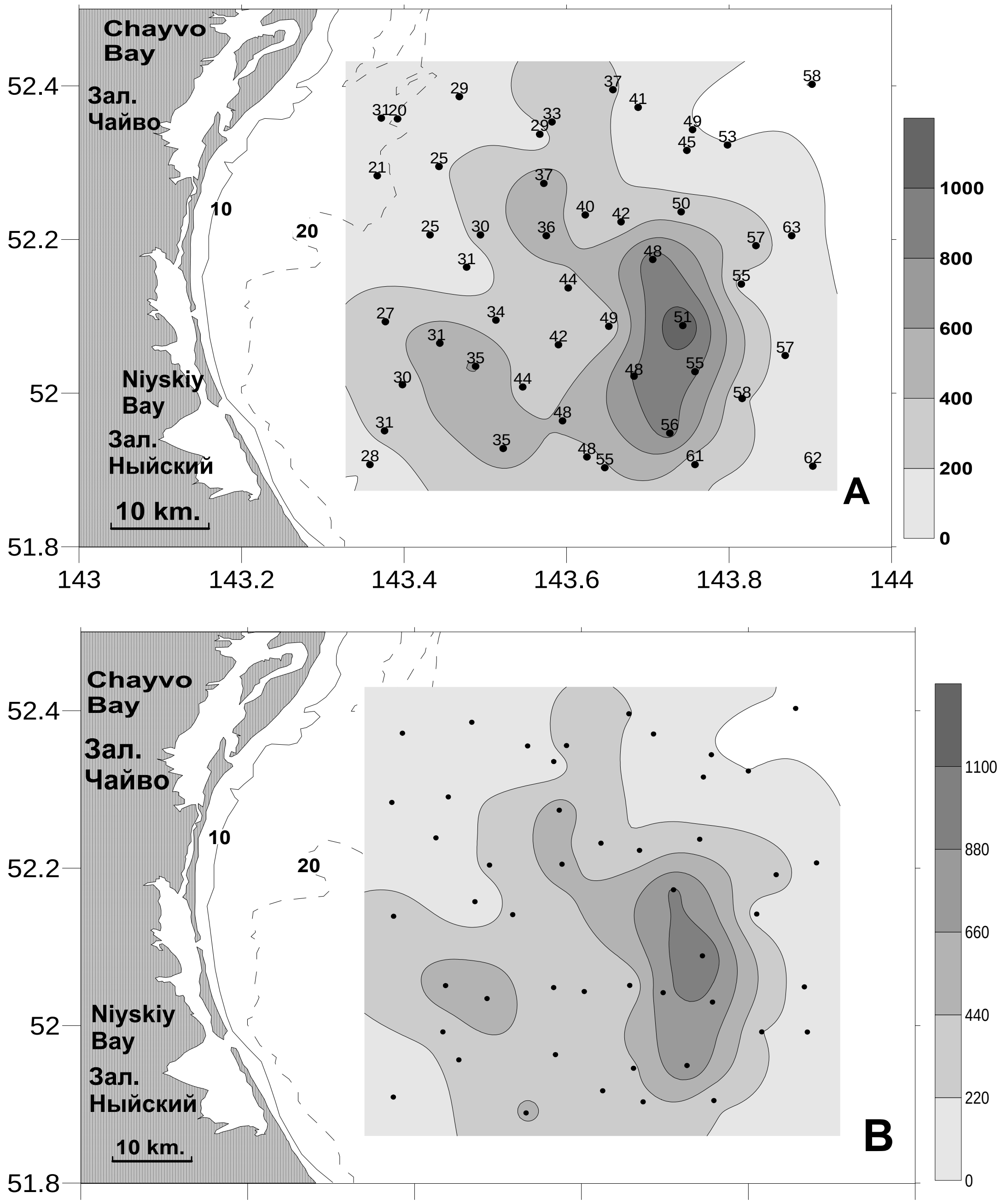


Figure 24. Ampeliscid amphipod biomass distribution (g/m^2) in the Offshore area in 2006 (A) and 2005 (B). In Figure A, the numbers indicate station depth.

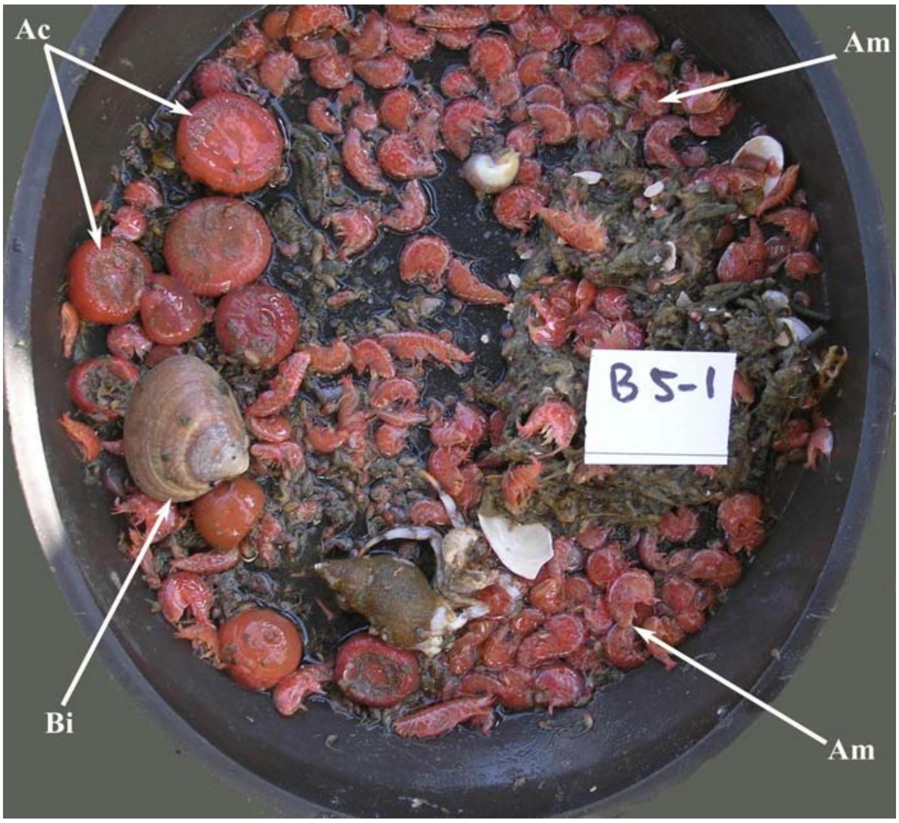


Photo 5. Bottom grab sample (0.2 m^2) from the ampeliscids (Am), bivalve mollusks (Bi) and actinia (Ac) complex.

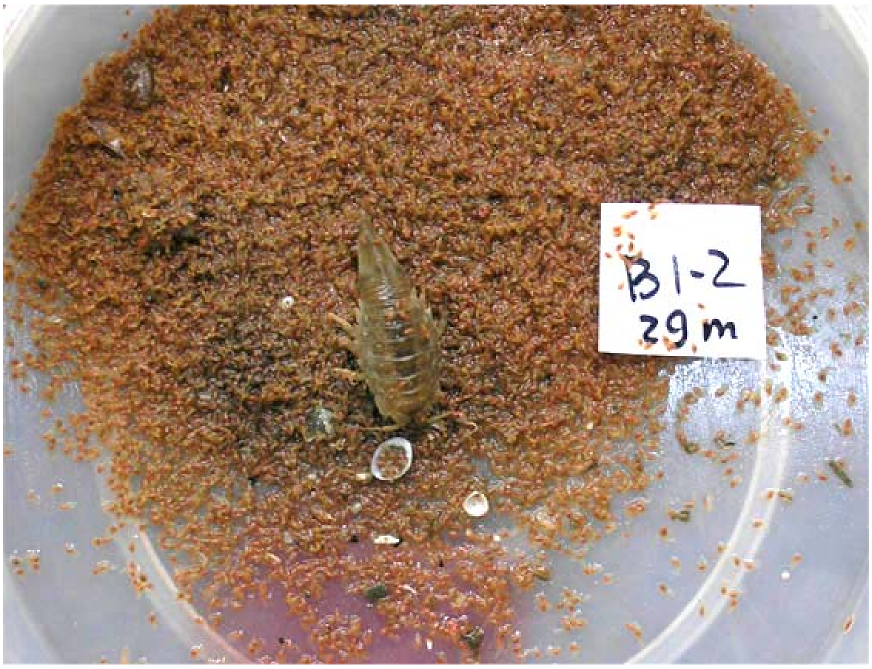


Photo 6. Bottom grab sample (September 18, 2006) with juvenile cumaceans.

.

4.3. Benthos at Gray Whale Feeding Sites

During the 2006 field season, there were 45 benthos sampling stations in gray whale feeding locations: 14 stations in the Offshore area, 12 stations in the Chayvo Bay area, and 14 stations in the Piltun area. In addition, during vessel idle time due to inclement weather, five stations were sampled in the Sakhalin Bay area at the whale feeding site within Severny Bay in 2005.

4.3.1. Whale Feeding Sites in the Piltun Area

Bottom grab samples were collected at gray whale feeding sites in the Piltun area for the first time in 2002. There were 21 sampling stations (the average depth of the feeding sites in this area was 19.5±1.5 m).

The average benthos biomass was 234.4 g/m^2. Amphipods and isopods accounted for more than 50% of the total biomass (Fadeev 2003). In 2003, 12 locations were studied (average depth - 18.6±1.6 m). The average benthos biomass at feeding sites was 164.2 g/m^2. Most of the whales foraged at depths less than 20 m in 2002 and 2003 (Fadeev 2004).

In 2004, 50 whale feeding sites were studied at depths of 14-35 m (average depth being 23.5±0.9 m). The increase in the average whale feeding depth was due to the fact that beginning in 2004, in the northern part of the area, the whales began using locations deeper than 15-20 m in the flat sea urchin complex.

In 2005, 74 feeding sites were studied (average depth – 18.5±1.1 m). As in previous years, most of the whales foraged at depths less than 20 m within the coastal amphipod complex. Analysis of 2004-2005 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. In these samples, sand lance *Ammodytes hexapterus*, amphipod *Eogammarus schmidti* and isopod *Saduria entomon* had the highest frequency of occurrence and biomass.

Photo-identification data were used in 2006 to determine the coordinates of whale feeding sites. A total of 14 stations were studied: eight stations in the northern Piltun area in 20-m to 27-m depths (average depth – 24.1±1 m) and eight stations in the southern part of the area in 11-m to 16-m depths (average depth - 14±0.9 m).

These stations are located 16 km south of the Piltun Bay mouth abeam the Molikpaq platform (Figure 25). As Figure 25 shows, foraging whales were sighted in this location each year in 2002-2006. In all of these years, the whales foraged at this site in the last decade of August or in September. The total area of the feeding site is approximately 16 km^2. The number of whales feeding at the site simultaneously typically did not exceed 3-4 animals, with seven simultaneously feeding whales observed only in 2004.

The average total benthos biomass at the whale feeding sites was 57.9±7.5 g/m^2, while amphipod biomass was 35.2±3.2 g/m^2 (or 60.7% of the total biomass). By benthos composition and structure, this site is classifiable as a near-shore amphipod complex. Based on 2005 data, amphipod biomass at this site reached 59 g/m^2 at the end of August.

Therefore, the near-shore whale feeding sites in the southern Piltun area exhibited a lower amphipod biomass in 2006 compared with 2005, and its level (35.2±3.2 g/m^2) was virtually identical to the amphipod biomass at locations adjacent to the Piltun Bay exit (33.5±6.1 g/m^2). Possible causes of the decline of amphipod biomass during observations in the southern section of the Piltun area were discussed in section 4.1.1.

4.3.2. Whale Feeding Sites in the Chayvo Bay Area in 2006

In 2006, the south coast observation team reported whale sightings throughout the observation period in the Chayvo Bay near-shore zone. As shown by the aggregated whale distribution charts for this area (Vladimirov 2007), the largest number of whales was reported in September 2006 (Figures 26A and 26B). The site in question lies 40 km south of the entry to the Piltun lagoon. In the second and third decades of September, the study team conducted shipboard counts, photographed the whales for subsequent photo-identification and collected benthos samples opportunisticaly where whales were observed feeding. In benthic station locations, video observations of the water column and bottom surface were undertaken, and plankton and epibenthos samples were collected.

In the whale feeding area, 33 samples were taken at 11 bottom grab stations. In addition, benthos samples were taken outside the whale feeding zone in the direction of the Orlan platform (sampling depth - 18 m). Whale feeding site coordinates were determined using the photo-identification technique. The stations were located in depths ranging from 10 m to 15 m (average depth – 12.4 m) on well-graded fine (eight stations) and coarse (three stations) sands. Video imaging did not reveal any accumulations of plankton animals in the water column. Plankton samples (Bongo plankton net) and epibenthos samples (epibenthos net) came up with insignificant numbers of euphausiids. At the whale feeding sites, benthos can be assigned to the near-shore amphipod complex, abundant in the Piltun area at depths up to 15-20 m. Amphipod biomass stands at 41.1±7.9 g/m^2, or 45% of the average total benthic biomass.

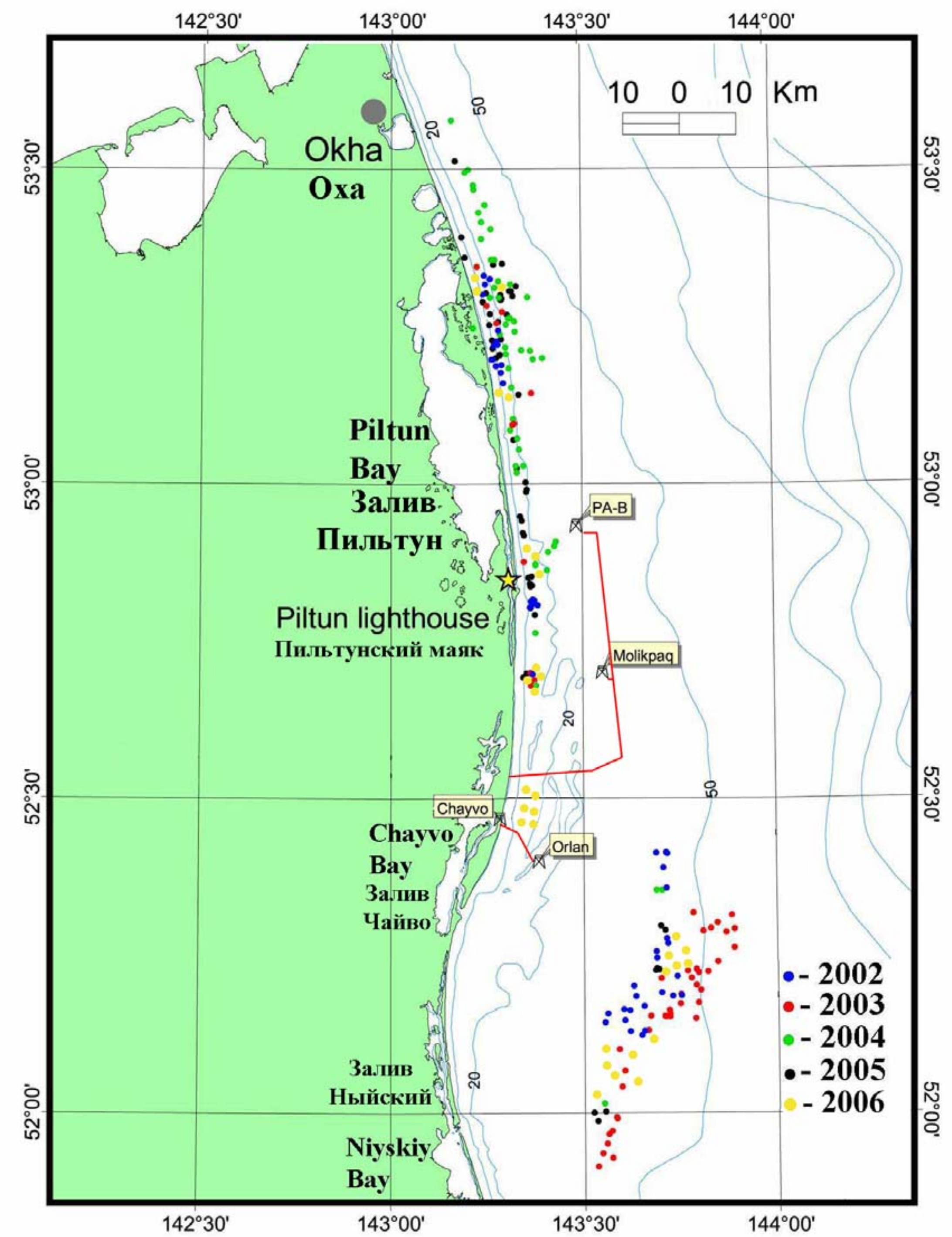


Figure 25. Chart of the locations of gray whale feeding sites studied in 2002-2006.

The species composition of amphipods, isopods and bivalve mollusks is typical of the amphipod complex (see section 4.2.1).

In 2001, scuba diving benthic surveys were conducted at two transects over the range of depths from 5 m to 30 m (transects South1 and South2 in Figure 26C). The 2006 whale feeding area was located between these transects. In 2001, the average amphipod biomass in the 10-15 m range was 35.7±9.8 g/m^2, which is not significantly different from the biomass level in 2006 - 41.1±7.9 g/m^2 (Fadeev 2002).

Thus, no amphipod biomass increase was observed in the Chayvo Bay area in 2006. On the other hand, 2006 saw an increase in the number of foraging whales here, particularly visible in the fall season. This can be attributable to the following factors. First, lower amphipod biomass levels were reported during this period in the southern part of the Piltun area: In 2006, the average amphipod biomass in the 11-15 m depth range was 33.5 g/m^2, while in 2005 it was 69.4 g/m^2. Second, in 2006 observers in the northern part of the Piltun area reported a decrease in the frequency of occurrence of the sand lance whose accumulations were likely used by whales during the 2004-2005 feeding season.

In other words, gray whales likely foraged in the Chayvo Bay area in 2006 not so much because of better feeding conditions here, but because of deteriorating feeding conditions in the Piltun feeding area. The increasing numbers of foraging whales in the Offshore feeding area in 2006 were likely also a reflection of deterioration of the prey base in the Piltun feeding area.

4.3.3. 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±1 m, on average) in the ampeliscid amphipod dominance zone. In contrast to 2003, fewer whales were sighted in the Offhore area in summers of 2004-2005. A small number of foraging whales was reported only in September. Photo-identification programs in the Offshore area in 2003, 2004, 2005 and 2006 identified 35, 8, 7 and 33 individual gray whales, respectively (Yakovlev and Tyurneva 2007). In 2002-2003, when the number of feeding whales was high, the team studied 64 whale feeding sites. Three feeding sites were studied in 2004 and eight were studied in 2005. In 2006, the team studied 14 feeding sites (average depth – 47 m).

The quantitative abundance levels of benthos in the Offshore area in 2005 did not differ substantially from the figures for 2003-2004. This has led to the conclusion that the very small number of gray whales feeding in the Offshore area in 2004-2005 is not related to the status of benthos as a source of food supply. In 2005, ampeliscid biomass at the whale feeding sites averaged 366.3±168.3 g/m^2, in 2006 – 247.7±43 g/m^2. This supports a previous conclusion that gray whales feed in the Offshore area primarily where ampeliscid biomass is more than 200-300 g/m^2. All the benthos groups found at whale feeding sites in 2004-2006 are common in the benthos of the Offshore area and are included in the complex *Ampelisca eschrichti* and the complex *A. eschrichti + Bivalvia + Actinia* (Table 12). In 2006, gray whales were feeding at the same feeding sites within the Offshore area as in 2002 and 2003 (Figure 25). In some cases, feeding points in 2006 were reported 2-5 km from the feeding points in 2003-2005. Since the whale feeding sites for all years of observations have remained within an area of about 1,000 km^2, one can conclude that forage benthos accumulations are stable at a mesoscale level (accumulations spanning tens of square kilometers in area).

Figure 27 presents a chart of biomass distribution for ampeliscid amphipods, the whales' principal food item in the Offshore area. It shows all whale feeding sites based on aerial surveys and feeding sites surveyed from vessels in 2002-2006. 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 are associated with areas with amphipod biomass of 200-300 g/m^2 or more and sites lying to the north of the area with the highest biomass of forage benthos. Such a distribution may be associated with the fact that the highest-biomass locations are found in maximum depths of 50 m to 65 m, i.e., the whales tend to feed in areas with lower biomass levels but in shallower water (a depth range of 35 m - 45 m). The whales may do so to save energy while searching for food.

Table 12. Benthos Colony Density (A, spec./m^2) and Biomass (B, g/m^2) at Gray Whale Feeding Sites in the Offshore Area in 2006.

Characteristic	***Amphipoda***		***Actinia***		***Bivalvia***		***Polychaeta***		***Cumacea***		***Average***	
	A	B	A	B	A	B	A	B	A	B	A	B
Average	4376	247,72	41	92,22	17	51,71	62	25,4	3176	28,82	7695	478,6
Standard deviation	959	42,99	14	27,07	4	19,4	16	7,07	606	5,83	1044	64,7
Minimum	1558	105	5	8,67	0	0	18	1,52	11	0,13	1815	210,7
Maximum	12760	626,5	200	322,3	45	220,72	206	71,07	6613	71,35	15341	1048,4

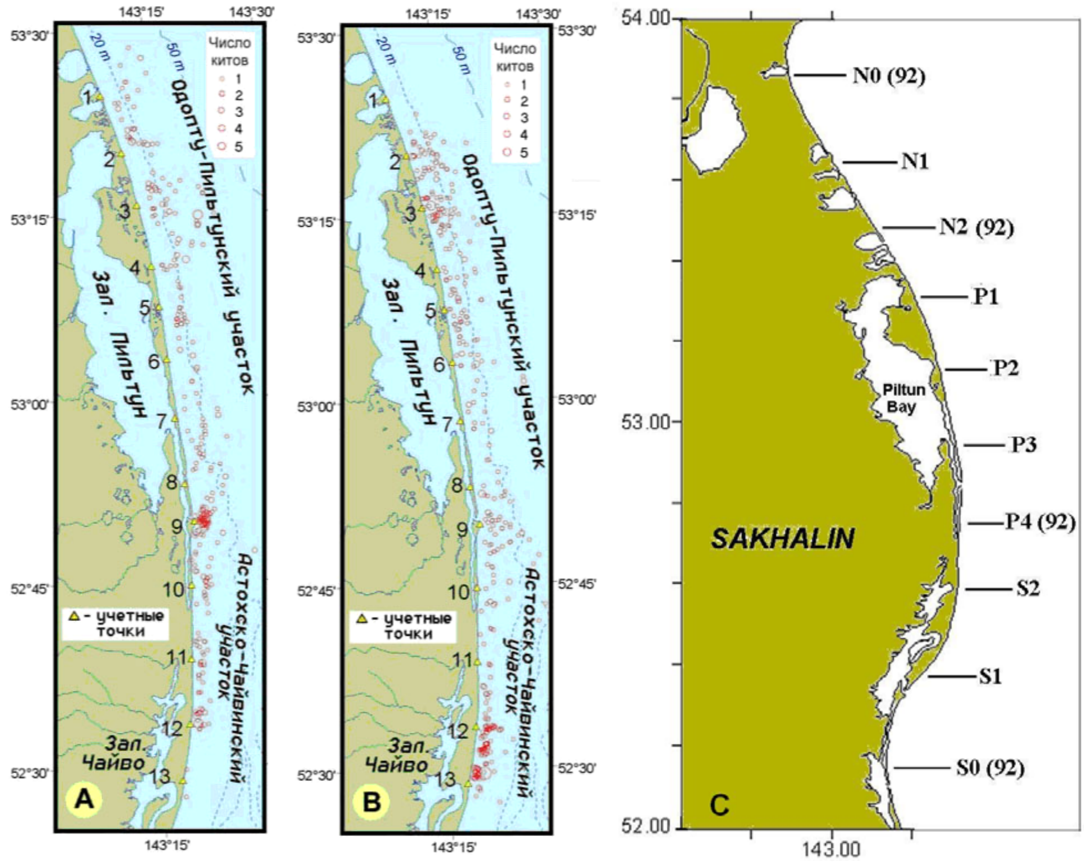


Figure 26. Chart of gray whale distribution in the Piltun area based on onshore surveys in June-July (A) and September (B) (Vladimirov et al. 2007) and scuba diving transects in 2001 (Fadeev 2002).

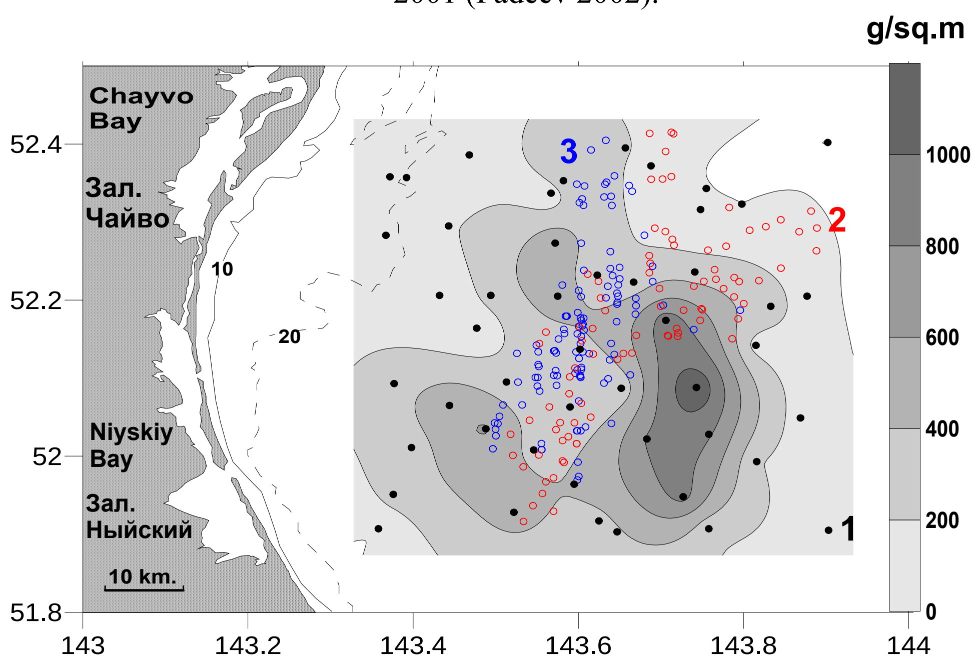


Figure 27. Chart of the biomass distribution for amphipod Ampelisca eschrichti (g/m^2) in 2006 and whale feeding sites in the Offshore area.
1 – benthos stations 2006, 2 – benthos sampling locations at whale feeding sites in 2002-2006, and
3 – whale feeding sites according to aerial observations in 2001-2004.

CONCLUSION

1. Bottom grab collections of benthos taken from 26 August through 9 October 2006, 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 feeding area (a near-shore area between Odoptu Bay and the southern sector of Piltun Bay) and Offshore feeding area (an area with depths of 30 – 60 m located at a distance from the shoreline along the Chayvo Bay – Niyskiy Bay area). Bottom grab collections of benthos were performed at 108 stations (342 samples). In addition, the benthos collections included 45 stations from gray whale feeding points in the Piltun (14 stations) and Offshore (14 stations) feeding areas; in the Chayvo feeding site (12 stations) and in the whale feeding sites in Severny Bay in 2005 (five stations). To assess alternative food sources at the whale feeding sites in the Chayvo Bay area and northern part of the Piltun area, the team gathered epibenthos samples from the water layer near the bottom with an epibenthic net (30 samples) and a Bongo plankton net (50 samples). The water column and the surface of the seabed were documented at all the stations with an underwater camera system.

2. In September 2006, near-bottom water temperatures in the Piltun area varied from 0.6 to 12.8 °C, averaging 5.92 °C. The presence of a colder-water pocket in the area's northern section is clearly reflected in the distribution of the bottom water temperatures. In September 2006, water temperatures near the seabed at depths greater than 10 m averaged 3.9±0.4 °C in the northern Piltun area and 6.9±0.4 °C in the area's southern sector. The average bottom temperature in the Offshore area in September was 1.56±0.3 °C, varying from -0.87 to + 6.74 °C.

F.F. Khapchenokov of TOI DVO RAN (Pacific Institute of Oceanology, Far East Branch of the Russian Academy of Sciences) performed an analysis of year-to-year differences in bottom water temperatures in the Piltun Bay - Niyskiy Bay area over the period from 2004 through 2006. It demonstrated that bottom temperature in the Piltun area in summer 2006 was [consistently] colder than in 2004-2005. For instance, bottom temperature in the middle of August 2005 was approximately two degrees colder in the Offshore area and four degrees colder near the Piltun Bay than it was in 2004. In 2006, it was even colder (by 2-3 degrees) throughout the near-shore area. In the middle of August 2004, below-freezing water temperatures were reported only at the Piltun Bay exit in more than 40-m depths. In the same period of 2005, below-freezing water temperatures were observed along the entire coast, beginning from a 35-m depth. In 2006, the 0 and -1 ºC isotherms came even closer to the coast in the area near the Piltun Bay exit.

3. In 2006, bottom sediment samples from gray whale feeding locatios were studied at 45 stations. Based on soil analysis from the 2002-2006 whale feeding sites, three sediment groups were identified: fine- and medium-grained sands, and sands with varying grain size mixed with small gravel. All three sediment groups were found in the Offshore and Piltun areas, while fine- and medium-grained sands are common in the Chayvo Bay area. In all of the areas the whales foraged predominanlty at sites with well-graded fine-grained sandy bottoms.

4. In the **Piltun area,** the average benthos biomass in 2006 was 434.3±64.5 g/m^2, which did not differ substantially from 2005 data (392.4±63.3 g/m^2).

Flat sea urchins, the sand dollar *Echinarachnius parma*, accounted for most of the biomass at 77%, and the proportion of the sea urchin reaches 90% at depths greater than 20 m. The sharpest changes in the quantitative abundance of benthos occur in the range of 15-20 m. The largest amphipod colonies pursued by gray whales during the feeding season are found in the near-shore zone in depths under 15-20 m. In 2006, in 15-m depths for the entire Piltun area the average amphipod biomass was 59.8±11.8 g/m^2, which is generally consistent with the 2005 data (64.7±10.2 g/m^2). The nature of the spatial distribution of amphipod biomass in the Piltun area has similar trends in 2006 and 2005 – zones of elevated biomass are associated with the near-shore sections of the water area, and the amphipod distribution is quite patchy. The differences relate to the size of amphipod accumulations and their position along the coast of the Piltun area. In contrast to 2005, locations of elevated biomass (more than 120 g/m^2) in the near-shore zone in 2006 were confined to the northern section of the area.

In the southern Piltun area (sections adjacent to Piltun Bay exit), the average amphipod biomass in September 2006 in the 11-15-m depth range was 33.5 g/m^2. In 2005, in the same area in similar depths, the average amphipod biomass was 69.4 g/m^2. The differences in average biomass numbers at the same stations in 2005 and 2006 are attributable to a number of factors. In 2005, in the area's southernmost section, sampling was performed in the second decade of July, i.e., at the beginning of the feeding season, while in 2006 samples were collected in the second or third decade of September, i.e., at the end of the feeding season. The biomass decline in September 2006 may be due to decimation of amphipod accumulations by whales during the feeding season. The gray whale feeding season in the Piltun area starts exactly in the southern section, with relatively high whale numbers observed throughout the feeding season. (Vladimirov et al. 2006). Meanwhile, the analysis of perennial changes in the hydrologic regimen shows that in the summer period of 2006, the southern sections of the Piltun area exhibited the lowest benthic water temperatures over the period from 2004 through 2006. Prolonged exposure to low temperatures may cause slower growth rates in common species of amphipods, which represent the primary feeding base for gray whales in this region.

To determine the most likely causes of the amphipod biomass decline in September 2006 in the southern Piltun area, efforts are currently underway to analyse the data on length composition of amphipods and quantitative distribution of benthos obtained in a similar period from 2001 through 2005.

An increase was observed in the frequency of occurrence and biomass of the sand lance *Ammodytes hexapterus* in the northern part of the Piltun area from 2004 through 2005. This process occurred concurrently with a decrease in the number of whales in the Offshore area and the appearance of a grouping of whales feeding at depths greater than 20 m in the northern part of the Piltun area (Vladimirov at al. 2006; Yakovlev and Tyurneva 2006). Researchers assumed that the emergence of an additional available food source, the sand lance, in northern Piltun area in 2004-2005 resulted in a redistribution of whales between the Piltun and Offshore areas. In 2004-2006, the sand lance was encountered throughout the Piltun area, but it exhibited the highest biomass levels and frequency of occurrence in the area's northern section in depths greater than 20 m, in the flat sea urchin zone. The largest sand lance accumulations in the northern Piltun area (at depths more than 20 m) are located 5-7 km from the shallow coastal amphipod complex (depths less than 15-20 m). Gray whales are capable of traveling this distance in 1-1.5 hours, i.e., the same animals can use both amphipod-dominated coastal areas and deeper offshore areas in which sand lances dominate.

In 2006 and 2005, the average sand lance biomass in the Piltun area was characterized by similar levels, with a significant decline in the frequency of occurrence in the northern part of the area (from 40-60% in 2005 to 20-25% in 2006). The decline in the frequency of occurrence of the sand lance in September 2006 may be associated with certain biological features of this species. First, after the summer feeding season, juvenile sand lances tend to migrate to deeper areas in September-October. Second, an eruption of the sand lance typically lasts three to four years. Naturally, whichever of these phenomena occurred in fall of 2006 will define the sand lance numbers during the whale feeding season in 2007.

5. **Offshore area.** In the Offshore area in 2006, there were 48 stations (144 bottom grab samples) at depths from 20 to 63 m (average depth 42 m). Field data from 2006 and 2005 were collected under a similar sampling procedure and within similar calender

timelines, which helped offset the impact of interseasonal benthos variability on data analysis. Analysis of the total average benthos biomass of the Offshore area based on 2006 and 2005 collections indicates a statistically insignificant difference in the average biomass levels. The average benthos biomass was 654.7±59.9 g/m^2 in 2006 and 526.6±52.3 g/m^2 in 2005. The biomass of the main groups (amphipods, bivalve mollusks, sea anemones and cumaceans) in 2006 was comparable to the 2005 data. The biomass of ampeliscid amphipods – the most important component in the diet of whales in the Offshore area – averaged 184.9±29.6 g/m^2 in 2006 and 200.2±35.7 g/m^2 in 2005.

The spatial distribution of benthos biomass was similar in 2006 and 2005. The biomass and proportion of amphipods in the total benthos biomass of the Offshore area increases moving from the shore toward deeper water. A similar trend was observed in 2002-2004. 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 in the seabed. The other groups (sea anemones, bivalve mollusks, cumaceans and sand dollars) that make up most of the biomass have a distinctly spotty distribution). Based on materials from 2002-2006, 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. Two complexes – ampeliscid amphipods, and ampeliscids+sea anemones+bivalve mollusks – occupy most of the bottom in the Offshore area. It is within these complexes that most gray whale feeding locations are found.

6. **Whale feeding sites.** <u>Piltun feeding area.</u> The team surveyed gray whale feeding sites in an area located 16 km south of the entry to the Piltun Bay. Sightings of foraging whales were reported in this area every year in the last decade of August or in September over 2002-2006. The site occupies an area of 12 km^2. The total average benthos biomass at the whale feeding locations was 57.9±7.5 g/m^2, while amphipod biomass was 35.2±3.2 g/m^2 (or 60.7% of the total biomass). By benthos composition and structure, this site is classifiable as a near-shore <u>amphipod complex</u>. Based on 2005 data, amphipod biomass at this site reached 59.0 g/m^2 at the end of August. Therefore, the near-shore whale feeding sites in the southern Piltun area exhibited a lower amphipod biomass in 2006 compared with 2005, and its level (35.2±3.2 g/m^2) was virtually identical to the amphipod biomass at locations adjacent to the Piltun Bay exit (33.5±6.1 g/m^2).

<u>Chayvo feeding site.</u> In 2006, the south coast observation team reported whale sightings throughout the study period in the Chayvo Bay coastal zone. As shown by the

aggregated whale distribution charts for this area, the largest number of whales was reported in September 2006 (Vladimirov 2006). The site in question lies 40-45 km south of the entry to the Piltun lagoon. In this area, benthos at the whale feeding sites can be assigned to the near-shore amphipod complex, also abundant in the Piltun area within 15-20-m depths. Amphipod biomass was 41.1±7.9 g/m^2, or 45% of the total average benthic biomass.

In 2001, scuba diving benthic surveys were conducted at two transects over the range of depths from 5 m to 30 m. In 2001, the average amphipod biomass in the 10-15-m range was 35.7±9.8 g/m^2. In 2006, this figure was 41.1±7.9 g/m^2.

Thus, no significant amphipod biomass increase was observed in the Chayvo Bay area in 2006. In 2006, an increase in the number of foraging whales was observed, particularly during the fall season. This could be attributed to two factors. First, lower amphipod biomass levels were reported during this period in the southern part of the Piltun area. Second, in 2006 observers in the northern part of the Piltun area reported a decrease in the frequency of occurrence of the sand lance whose accumulations were likely pursued by whales during the 2004-2005 feeding season. In other words, gray whales likely foraged in the Chayvo Bay area in 2006 not so much because of better feeding conditions here, but because of deteriorating feeding conditions in the Piltun feeding area.The increasing numbers of foraging whales in the Offshore feeding area in 2006 was also likely due to deteriorating feeding conditions in the Piltun feeding area.

Offshore area. Photo-identification programs in the Offshore area in 2003, 2004 and 2005 identified 34, 8 and 3 individual gray whales, respectively (Yakovlev and Tyurneva 2006). In 2006, vessel surveys reported 26 animal sightings here (Vladimirov 2007). The quantitative abundance levels of benthos in the Offshore area in 2005 did not differ substantially from the figures for 2003. This has led to the conclusion that the decline in the number of gray whales feeding in the Offshore area in 2004-2005 is not related to the feeding base status.

The team studied 14 feeding points in 2006. Biomass of the main prey, the ampeliscid, at the whale feeding sites in 2006 averaged 247.7±43 g/m^2 compared with 366.3±168.3 g/m^2 in 2005. This supports a previous conclusion that gray whales feed in the Offshore area primarily where ampeliscid biomass is more than 200-300 g/m^2. All the benthos groups found at whale feeding sites in 2006, just as those found in previous years, are common in the benthos of the Offshore feeding area and are included in the ampeliscid amphipod complex. In 2006, gray whales were feeding at the same feeding sites within the

Offshore area as in 2002-2005. In some cases, feeding points in 2006 were located 2-5 km from the feeding points reported in 2003-2005.

ACKNOWLEDGMENTS

Many specialists took part in the early stages of the studies and rendered invaluable assistance in completing the project. We shall mention in particular our colleagues in the field work in 2002-2006: Yu. Yakovlev, N. Prokhorov, V. Zharikov, N. Ivanov, K. Feldman and K. Drozdov, whose professionalism supported the completion of the entire scope of planned field studies. L. N. Khorolskaya, T. A. Krivosheyeva, I. L. Davydkova, N. Demchenko and M. Repina rendered great technical assistance in the laboratory analysis of the collections and the performance of morphometry on the amphipods.

We wish to express special thanks to taxonomists of the IBM DVO RAN, ZIN (Zoological Institute, St. Petersburg) RAN, TINRO-Center, and DVGU (Far East State University, Vladivostok): Professor V. A. Kudryashov, L. L. Budnikova (PhD in Biological Sciences), M. V. Malyutina (PhD in Biological Sciences), G. M. Kamenev (PhD in Biological Sciences), V. V. Gulbin (PhD in Biological Sciences), S. F. Chaplygina (PhD in Biological Sciences), A. V. Chernyshov (PhD in Biological Sciences), and V. N. Romanov (PhD in Biological Sciences) for their meticulous work in determining the benthos species composition.

Sonya K. Meier (LGL Limited, environmental research associates, Canada) and the author developed the Scope of Work for this study. We wish to thank Dr. H. R. Melton and Dr. James Hall (ExxonMobil Upstream Research Company), Vladimir Nechayuk (SEIC) and Sonya K. Meier, Dr. S. R. Johnson, and Lisanne Aerts (LGL Limited) for critical comments at the stage of preparation of the final report. Dr. S. B. Yazvenko (LGL Limited) provided help and support in preparing for the expedition and during the field work and commented on the Russian version of the report. D. Baker (LGL Limited) helped prepare the final version of the report.

REFERENCES

Albertsson J., Leonardsson K. 2001. Deposit-feeding amphipods (Monoporeia affinis) reduce the recruitment of copepod nauplii from benthic resting eggs in the northern Baltic Sea // Marine Biology, 138: 793 – 801.

Andersin, A.B., Lassig, J., and Sandier, H. 1984. On the biology and production of Pontoporeia affinis Lindstr. in the Gulf of Bothnia // Limnologica, 15: 395- 401.

Averintsev, V. G., V. I. Sirenko, A. M. Sheremetevskiy, V. N. Koblikov, V. A. Pavlyuchkov and A. I. Piskunov. Some Patterns in the Distribution of Life on the Eastern Sakhalin Shelf and in the Northwest Part of the Sea of Okhotsk // Summaries of papers of the XIV Pacific Ocean Scientific Congress, Khabarovsk, 1979, pp. 16-17.

Afifi, A., and S. Eyzen. 1982. Statistical Analysis: Approach to Computer Use, Moscow, Mir, 488 pages

Bezrukov, P. L., and A. P. Lisitsin. Classification of Sediments of Modern Bodies of Water // Proc. USSR Academy of Sciences Oceanology Institute, Vol. 32, pp. 3-15.

Berzin A. A 1974. Practical Problems in the study of whales (using the example of Pacific whales) // Vertebrate Zoology, Vol.6, pp. 159-189].

Berzin A. A., Vladimirov V. L. Anthropogenic impact on whales of the Sea of Okhotsk // TINRO Pub. 1996. Vol. 121. Pages 4-8.]

Bilyard G.R., Becker S. 1987. Recommend protocols for sampling subtidal benthic macroinvertebrate assemblages in Puget Sound. US EPA.Washington, 1987. 30 p.

Blokhin S.A. 1996. The Distribution, Abundance and Behavior of the American and Asiatic Populations of Gray Whales (*Eschrichtius robustus)* in their Summer Habitats off the Far East Coasts // Izv. TINRO-Center, Vol. 121, pages 36-53.

Blokhin S.A., Burdin A.M. 2001. Distribution, Numbers, and Certain Behavioral Characteristics of the Asiatic Gray Whale Population (*Eschrichtius robustus*) of the northeastern Sakhalin Coast // Sea Biology, ol.27, No.1, pages 15-20.

Blokhin S. A., Pavlyuchkov V. A. 1981. Feeding of Gray Whales of the California-Chukotka Population in Waters of the Chukotka Peninsula in 1980 // Research on Marine Mammals of the Northern Pacific Ocean in 1980-1981. Moscow, Pp. 88-89.

Blokhin S.A. and V.A. Pavlyuchkov. 1996. Pitanie serykh kitov v letne-osenniy period v pribrezhnykh vodakh Chukotskogo poluostrova (Feeding of gray whales during the summer-fall period in the coastal waters of Chukotka Peninsula) - Bull. of TINRO, Vol. 121, p. 26-35.

Blokhin S.A. and V.A. Pavlyuchkov. 1999. Feeding of Gray Whales of the California-Chukotka Population in Mechigmen Bay) // Bull. of TINRO, Vol. 126, p. 442-446.

Blokhin S.A., Maminov M.K., Kosygin G.M. 1985. On the Korean-Okhotsk Population of Gray Whales // Rep. Int. Whal. Commn 35, p.375-376.

Blokhin, S. A., S. B. Yazvenko, V. L. Vladimirov and S. I. Lagerev. 2002. The Abundance, Distribution and Behavior of Gray Whales (Eschrichtius robustus) in the Coastal Waters of Northeast Sakhalin in the Summer and Fall of 2001 (According to Aerial Observations). Marine Mammals of the Holarctic. Materials from the Second International Conference, Baikal, Russia. pp. 36-38.

Blokhin, S. A., N. V. Doroshenko and P. P. Marchenko. 2003. The Abundance, Distribution and Behavior of Gray Whales (*Eschrichtius robustus*) in the Coastal Waters of Northeast Sakhalin in 2002 (According to Aerial Observations). // Report by TINRO-Center, Vladivostok, Russia, for Exxon Neftegas Limited and Sakhalin Energy Investment Company, Yuzhno-Sakhalinsk, Russia – 67 p.

Blokhin, S. A. , N. V. Doroshenko and S. B. Yazvenko. 2004. The Abundance, Distribution and Behavior of Gray Whales (*Eschrichtius robustus*) in the Coastal Waters of Northeast Sakhalin in 2003 (According to Aerial Observations). // Report by TINRO-Center, Vladivostok, Russia, for Exxon Neftegas Limited and Sakhalin Energy Investment Company, Yuzhno-Sakhalinsk, Russia.

Bogoslovskaya L.C. 1996. The Gray Whale // Priroda, Issue 12. Pages 46-60.

Bogoslovskaya L.S., Votrogov L.M., Semenova T.N. 1981. Feeding habits of gray whales off Chukotka Peniusula // Rep. Int. Whal. Commn. 1981. No. 31. P. 507-510.

Bogoslovskaya L.S., Votrogov L.M., Seraenova T.N. 1982. Distribution and feeding of gray whales off Chukotka in the summer and autumn of 1980 // Rep. Int. Whal. Commn. 1982. No. 32. P. 385-389.

S.V. Borisov, A.V. Gritsenko, Ye.V.Dmitrieva, A.A. Karnoukhov, M.V.Kruglov, A.N.Rutenko 2005 Results of Acoustic and Hydrophysical Studies in Northeastern Sakhalin Offshore, Vol. 1: Equipment, Data and Recommendations / TOI DVO RAN Report, Vladivostok, for Exxon Neftegaz Limited and Sakhlin Energy Investment Company LTD.

V. Borovikov. STATISTICA:The Art of Computer Data Analysis. For Professional Users. St. Petersburg. 2000. 656 pages

Brownell, R.L. (Jr.), and C. Chun. 1977. Probable existence of the Korean stock of gray whales *(Eschrichtius robustus*) // J. Mammalogy 58: 237-239.

Clarke K.R., and R.N. Gorley. 2001. PRIMER v5: User Manual/Tutorial. PRIMER-E: Plymouth. 91 P.

Clarke, K.R., R.N. Green. 1988. Statistical design and analysis for a 'biological effects' study // Mar. Ecol. Prog. Ser. V. 46. No. 1-3. P. 213-226.

Cooke, J.G., D.W. Weller, A.L. Bradford, A.M. Burdin, and R.L. Brownell, Jr. 2006. Population assessment of western gray whales. IWC SC/58/BRG.

Crimmon H. and J. Bray. 1962. Observation on the isopod. Mesidotea entomon in the Western Canadian Arctic Ocean. J. Fish. Res. Board Canada. V. 19, N 3. Pp. 489-496

Draper, N., H. Smith. 1981. Applied Regression Analysis. Wiley-Interscience. 709 p.

Dunham, J.S. and D.A. Duffus. 2001. Foraging patterns of gray whales in central Clayoquot Sound, British Columbia. Marine Ecology Progress Series 223:299-310.

Dunham, J.S. and D.A. Duffus. 2002. Diet of gray whales (Eschrichtius robustus) in Clayoquot Sound, British Columbia, Canada. Marine Mammal Science 18: 419-437.

Elliott, J.M. 1977. Elliott J. M. Statistical analysis of samples of benthic invertebrates // Freshwater Biol. Ass., Sci. Publ., 1977. V. 25. Pp.

Fadeev, V. I. Benthos Studies in the Feeding Grounds of the Okhotsk-Korean Gray Whale Population. Final report. Ин-т биологии моря ДВО РАН. Владивосток. 171 с.

Fadeev, V. I. Benthos Studies in the Feeding Grounds of the Okhotsk-Korean Gray Whale Population. Final report on Materials from Field Work in 2002 Aboard the Research Vessel Nevelskoy. Ин-т биологии моря ДВО РАН. Владивосток. 116 с.

Fadeev, V. I. Benthos Studies in the Feeding Grounds of the Okhotsk-Korean Gray Whale Population. Final report on Materials from Field Work in 2003 Aboard the Research Vessel Nevelskoy. Ин-т биологии моря ДВО РАН. Владивосток. 189 с.

Fadeev, V. I. Benthos Studies in the Feeding Grounds of the Okhotsk-Korean Gray Whale Population. Final report on Materials from Field Work in 2004 Aboard the Research Vessel Nevelskoy. Ин-т биологии моря ДВО РАН. Владивосток. 153 с.

Fadeev, V.I. 2005. Benthos and food supply studies in feeding areas of the Okhotsk-Korean gray whale population. Final Report by the Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Science, Vladivostok, Russia, for Sakhalin Energy and Exxon Neftegas. 150 p.

Fadeev, V.I. (2006). Benthos and food supply studies in feeding areas of the Okhotsk-Korean gray whale population. // Institute of Marine Biology (FEB RAS), Vladivostok, Russia. Final report for Exxon Neftegas Ltd. and Sakhalin Energy Investment Co. 150 p.

Hilton –Taylor, C. 2000. IUCN Red List of Threatened Species, 2000. IUCN/SSC, Gland, Switzerland.

Jarvekulg, Arvi. 1979. Benthic Fauna of the Eastern Baltic Sea. Distributional Composition and Ecology. Tallin: Valgus. 382 pp.

Jones, M.L. and S..L. Swartz. 2002. Gray Whale (*Eschrichtius robustus*). Pp. 524-536 in The Encyclopedia of Marine Mammals, ed. by W.F. Perrin, B. Würsig, and J.G.M. Thewissen, Academic Press, San Diego, CA.

A.I.Kafanov, V.S. Labay and N.V. Pecheneva. Biota and Macrobenthos Communities of Northeastern Sakhalin Lagoons. Yuzhno Sakhalin Fishery and Oceanography Research Institute 2003. 173 pages

V.N.Koblikov 1983a. Quantitative Characteristics of Aquatic Populations of the Sea of Okhotsk. // Quantitative and Qualitative Distribution of Benthos: Food Supply for Benthos-Eating Fish. Moscow: VNIRO Pages 4-21.

V.N.Koblikov 1983b. Composition and Quantitative Distribution of Macrobenthos in the Sea of Okhotsk Sakhalin Shelf // Izv. TINRO, Vol.106, pages 90-97.

V.N.Koblikov 1986. Bethos Communities of the Sea of Okhotsk Continental Shelf and Upper Shoreface off Sakhalin Island. TINRO, Manuscr. deposited with TsNIITEIRKh, 54 pages.

Krasavtsev, V. B., K. L. Puzankov and G. V. Shevchenko. Upwelling Formation on the Northeast Shelf of Sakhalin Island Under the Influence of Wind // Topical Issue of Far East Research and Development Hydrometeorological Institute (DVNIGMI), 2000, No. 3. Vladivostok: Dalnauka. Pages 106-120.

Krasnaya Kniga Rossiiskoi Federatsii (Zhivotnye) [Red Book of the Russian Federation (Animals). 2000. As and Astrel-Balashikha, Aginskoye, 862 pages. (http://nature.ok.ru/redbook.htm).

Kruglov M.V., Rutenko, A.N., Khrapchenkov F.F., 2006. Acoustic Studies on the North East Sakhalin Shelf, 7 July to 7 October, 2005 Volume 3: Analysis, Conclusions and

Recommendations. Prepared for Exxon Neftegas Limited and Sakhalin Energy Investment Company.

Kusakin, O. G., E. I. Sobolevsky and S. A. Blokhin. Survey of Benthos Studies on the Northeastern Sakhalin Shelf // Interim Report of IBM DVO RAN and TINRO, Vladivostok, Russia, for Sakhalin Energy Investment Company, Yuzhno-Sakhalinsk, Russia, 91 pages (published on the Sakhalin Energy Investment Company website).

Kussakin, O.G., E.I. Sobolevsky, S.A. Blokhin. 2001. A review of benthos investigations on the shelf of northeast Sakhalin. Draft Report by the Institute of Marine Biology, Far East Branch of the Russian Academy of Sciences, and the Pacific Research Institute of Fisheries and Oceanography (TINRO), State Comm. for Fish. and Oceanog., Vladivostok. 89 pp.

Kuznetsov, A.P. 1964. Distribution of benthic fauna in the western Bering Sea by trophic zones and general issues of trophic zonation // Trans. Inst. Okeanol. AN SSSP. V. 69, P. 98-177.

Le Boeuf, B.J., M. Perez-Cortes, R. Urban, B.R. Mate, F. Ollervides. 2000. High gray whale mortality and low recruitment in 1999 potential causes and implications // J. of Cetacean Res. and Management. V. 2. P. 85 - 99.

LeDuc, R.G., Weller D.W., Hyde J., Burdin A.M., Rosel P.E., Brownell R.L., Würsig B. and Dizon A.E. 2002. Genetic differences between western and eastern gray whales (Eschrichtius robustus) // J. Cetacean Res. Manage. Vol. 4(1). P. 1 - 5.

Leonardsson, K. 1991. Effects of cannibalism and alternative prey on population dynamics of Saduria entomon (Isopoda) // Ecology. V. 72: 1273 - 1285.

Makarov, V. V. 1937 Materials on Quantitative Accounting of Bottom Fauna of the Northern Part of the Bering and Chukotka Seas" // Studies of the Far Easr Seas of the USSR. Issue 25. Pages 260 – 289.

Maminov, M.K. 2004. Distribution and relative abundance of gray whales of the Okhotsk-Korean population in northeastern Sakhalin waters in July-September, 2003 // Report by TINRO-Center, Vladivostok, Russia, for Exxon Neftegas Limited and Sakhalin Energy Investment Company, Yuzhno-Sakhalinsk, Russia – 72 p. [available on the Sakhalin Energy Investment Company website].

Maminov, M. K., and Yu. M. Yakovlev. "New Data on the Distribution and Abundance of Gray Whales off the Northeast Sakhalin Coast." Marine Mammals of the Holarctic. Materials from the second international conference, Baikal, Russia. pp. 170-171.

Mills, E.L. 1967. Mills E. L. The biology of ampeliscid amphipod crustacean sibling species pair // J. Fish. Res. Board Can. 1967. V. 24. Pp.

Miyashita T., Nishiwaki S., Vladimirov V.A. and Doroshenko N.V. Paper SC/53/RMP5 presented to the IWC Scientific Committee, July 2001 (unpublished). 12, pp.

Moore, S.E. and J.T. Clarke,. 2002. Potential impact of offshore human activities on gray whales // J. Cetacean Res. Manage. 4(1):19-25.

Moore, S.E, W.L. Perryman, F. Gulland, H. Perez-Cortez, P.R. Wade, L. Rojas-Bracho and T. Rowles. 2001. Are gray whales hitting "K" hard? // Mar. Mammal Science 17(4):954-958.

Neyman A. A. Quantitative distribution and trophic structure of World Ocean shelf benthos. VNIRO. 1988. 100 pp.

Nerini, M. 1984. A review of gray whale feeding ecology. In the Gray Whale (Eschrichtius robustus). M.L. Jones, S.L. Swartz, Leatherwood S. (eds). Acad. Press, Inc., Orlando, Florida. P. 451-463.

Nerini M.K., J.S. Oliver. 1983. Gray whales and the structure of the Bering Sea benthos // Oecologia (Berlin). V. 59. P. 224 – 225.

Olafsson E., Elmgren R. 1991. Effects of biological disturbance by benthic amphipods (Monoporeia affinis) on meiobenthic community structure: a laboratory approach // Mar. Ecol. Prog. Ser. V. 74: 99 – 107.

Oliver, J.S., P.N. Slattery, M.A. Silberstein and E.F. O'Connor. 1983. A comparison of gray whale feeding in the Bering Sea and Baja California // Fisheries Bull V. 81. P.:501-512.

Oliver, J. S., P. N. Slattery, M. A. Silberstein and E. F. O'Connor. 1984. Gray whale feeding on dense ampeliscid amphipod communities near Bamfield, British Columbia // Canadian Journal of Zoology V. 62. P:41-49.

Rice, D.W., A.A. Wolman. 1973. Rice D. W., Wolman A. A. The life history and ecology of the gray whale (Eschrichtius robusttus) // Spec. Publ. –Amer. Soc. Mammal. 1973. V. 3. Pp.

Rugh, D.J., M.M. Muto, S.E. Moore, and D.P. DeMaster. 1999. Status review of the eastern North Pacific stock of gray whales. U.S. Dep. of Comm. NOAA Tech. Memo. NMFS-AFC-103. 96 p.

Rugh, D.J. 2003. Gray whale census 2001/2002. U.S. Department of Commerce. National Marine Mammal Laboratory. http://nmml.afsc.noaa.gov/CetaceanAssessment/GrayWhale/GrayCensus01-02.htm

Rugh, D.J., R.C. Hobbs, J.A. Lerczak and J.M. Breitwick. 2005. Estimates of abundance of the eastern North Pacific stock of gray whales (*Eschrichtius robustus*) 1997-2002. Journal of Cetacean Research and Management 7(1): 1-12, 2005.

Rutenko, A.N. (2006). Acoustic Studies on the North East Sakhalin Shelf, Volume 1: Objectives and Data; 7 July to 7 October, 2005; Sakhalin, Russian Federation // Pacific Oceanological Institute (FEB RAS) report for Exxon Neftegas Ltd. and Sakhalin Energy Investment Co.

Segestrale S.G. 1967. Observations of summer breeding in populations of the glacial relict Pontoporeia affinis (Lindstrom) (Crustacea, Amphipoda) living at greater depths in the Baltic Sea // J. Exp. Mar. Biol. Ecol. 1: 55-64.

Segestrale S.G. 1973. Results of bottom fauna sampling in certain localities in the Tvarminne area (Inner Baltic) with special reference to the so-called Macoma-Pontoporeia theory // Comm. Biologica. 67: 1-12.

Shepard F. P. Marine Geology. Leningrad: Недра. 488 pages

Sobolevsky, E. I. Observations of the Behavior of Gray Whales (Eschrichtius robustus) on the Northeastern Sakhalin Shelf // Ekologiya, 1999. № 2. Pages 121-126.

Sobolevsky, E. I., Yu. M. Yakovlev and O. G. Kusakin. Some Data on the Macrobenthos Composition in Gray Whale (Eschrichtius gibbosus Erxl., 1877) Forage Areas on the Northeastern Sakhalin Shelf // Ekologiya, 2000, № 2. Pages 144-146.

Sobolevskiy E. I. Current population and nature of the distribution of gray whales on the Northeastern Sakhalin shelf // Marine mammals of the Holarctic region. Archangelsk. 2000. Pp.

Sobolevsky, E.I. 2000. Sobolevsky, E. I. Marine mammal studies offshore northeast Sakhalin, 1999. Final Report by the Institute of Marine Biology, Far East Branch of Russian Academy of Sciences, Vladivostok, for Sakhalin Energy Investment Company, Yuzhno-Sakhalinsk. 149 p.

Sobolevsky, E.I. 2001. Sobolevsky, E. I. Marine mammal studies offshore northeast Sakhalin, 2000. Final Report by the Institute of Marine Biology, Far East Branch of Russian Academy of Sciences, Vladivostok, for Sakhalin Energy Investment Company, Yuzhno-Sakhalinsk. 199 p.

Sparrevik E., Leonardsson K. 1998. Recruitment in the predacious isopod Saduria entomon (L.): alternative prey reduces cannibalism // J. Exp. Mar. Biol. V. 221: 117-130.

Stoker, S. W. 1981. Benthic invertebrate microfauna of the eastern Bering/Chuckchi continental shelf. // In: In the eastern Bering Sea shelf: oceanography and resources, vol. 1, (eds.) D. W. Hood and J. A. Calder. Off. Marine Pollution Assessment, NOAA. Distributed by University of Washington Press, Seattle.

UNEP. 1995. Statistical analysis and interpretation of marine community data. Reference Methods for Marine Pollution Studies. UNEP. 1995. No 64. 54 p.

USFWS (U.S. Fish and Wildlife Service). Endangered and threatened wildlife and plants. U.S. Dep. of Interior, U.S. Government Printing Office, Washington, DC.

V.A. Vladimirov 2000, Problems in Protecting a Population of Polar and Gray Whales of the Sea of Okhotsk on the Verge of Extinction // Marine Mammals of the Holarctic Region. Archangelsk

V.A.Vladimirov. 2006. Information Report on the Results of the Program for Study and Monitoring of the Okhotsk-Korean Gray Whale Population Off Northeartern Sakhalin Island in 2006. Information Report to the Ministry of Natural Resources of the Russian Federation, VNIRO, Moscow, 35 pages.

V.A.Vladimirov, S.A.Blokhin, A.V.Vladimirov, M.K.Maminov S.P.Starodymov, Ye.P.Shvetsov. 2006. Distribution and Numbers of Gray Whales of the Okhotsk-Korean Population off Northeastern Sakhalin Island in June-November 2005 / VNIRO Report, Moscow, and TINRO-Center, Vladivistok, Russia, for Exxon Neftegaz Limited and Sakhlin Energy Investment Company, Yuzhno-Sakhalinsk, Russia, 199 pages

Vladimirov, V.A.,S.A. Blokhin, A.V. Vladimirov, V.L. Vladimirov, N.V. Doroshenko, and M.K. Maminov. 2007. Distribution and abundance of gray whales of the Okhotsk-Korean population in Northeastern Sakhalin waters in July-November 2004 (based on shore, aerial, and vessel-based surveys. Final report to Exxon Neftegas and Sakhalin Energy Investment Company. Yuzhno-Sakhalinsk, Russia.

Weller D.W., R.L. Brownell, Jr. 2000. Eschrichtius robustus (Asian or Northwest Pacific Stock), in: C. Hilton-Taylor (comp.) 2000 IUCN Red List of Threatened Species. IUCN/SSC, Gland, Switzerland and Cambridge, United Kingdom.

Weller D.W., B. Wursig, A.M. Burdin, A. L. Bradford. 2001. Gray whales off Sakhalin Island, Russia: June-September 2000. A joint U.S.-Russian scientific investigation. Interim Report by Texas A&M University, College Station, TX, and Kamchatka

Institute of Ecology and Nature Management, Russian Academy of Sciences, Petropavlosk-Kamchatkii, Russia, for Sakhalin Energy Investment Company Limited, Yuzhno-Sakhalinsk, Russia. 24 p.

Weller D. W., B. Wursig, A.L. Dradford, A.M. Burdin, S.A. Blokhin, H. Minakuchi. 1999. . Gray whales off Sakhalin Island, Russia: seasonal and annual patterns of occurrence // Marine mammal science. V. 15, N 4. P. 1208-1227.

Weller, D.W., A.M. Burdin, A.L. Bradford, G.A. Tsidulko, Y.V. Ivashchenko. 2002. Gray whales off Sakhalin Island, Russia: June-September 2001. A joint U.S.-Russian scientific investigation.

Wildish D., D. Kristmans. 1997. Benthic suspension feeders and flow. Cambridge Univ. Press. 1997. 409 pp.

Yablokov,A.V., and L.S. Bogoslovskaya. 1984. A review of Russian research on the biology and commercial whaling of the Gray Whale. // In: The Gray Whale Eschrichtius robustus.M.L. Jones, S.L. Swartz, and S. Leatherwood (eds.), Academic Press, Orlando etc., pp. 465-485.

Yakovlev, Y. and O. Tyurneva. 2004. Photo-identification of the Korea-Okhotsk gray whale (*Eschrichtius robustus*) population along the Northeast coast of Sakhalin Island, Russia, 2003. Final report to Exxon Neftegas and Sakhalin Energy Investment Company. Yuzhno-Sakhalinsk, Russia. 24pp.

Yakovlev, Y. and O. Tyurneva. 2005. Photo-identification of the Korea-Okhotsk gray whale (*Eschrichtius robustus*) population on the Northeast shelf of Sakhalin Island, Russia 2004. Final report to Exxon Neftegas and Sakhalin Energy Investment Company. Yuzhno-Sakhalinsk, Russia. 82pp.

Yakovlev, Y. and O. Tyurneva. 2006. Photo-identification of the Korea-Okhotsk gray whale (*Eschrichtius robustus*) population on the Northeast shelf of Sakhalin Island, Russia 2004. Final report to Exxon Neftegas and Sakhalin Energy Investment Company. Yuzhno-Sakhalinsk, Russia.

Yakovlev, Y. and O. Tyurneva. 2007. Photo-identification of the Korea-Okhotsk gray whale (*Eschrichtius robustus*) population on the Northeast shelf of Sakhalin Island, Russia 2004. Final report to Exxon Neftegas and Sakhalin Energy Investment Company. Yuzhno-Sakhalinsk, Russia.

Yazvenko S., T. MacDonald, S.K. Meier, S. Blokhin, S.R. Johnson, V. Vladimirov, S. Lagerev, M. Maminov, E. Razlivalov, and M. Newcomer. 2002. Aerial marine mammal monitoring during the 2001 3-d seismic survey of Odoptu block, northeast Sakhalin Island, Okhotsk Sea, Russia. Final Report by LGL Limited, Sidney, for Exxon Neftegas Limited, Yuzhno-Sakhalinsk, Russia. 163 p.

Zenkovich, V. A. 1937. Feeding of Far East Whales// DAN USSR, Vol. 16 No. 4. Pages 231-234.

Zimushko, V. V., and S. A. Lenskaya. 1970. On Feeding of Gray Whales (Es*chrichtins gibbosus Erxl*.) in Summer Feeding Grounds //

APPENDICES 1 – 4

TO REPORT

CURRENT STATUS OF THE BENTHOS AND FOOD SUPPLY IN FEEDING GROUNDS OF THE OKHOTSK-KOREAN GRAY WHALE POPULATION IN 2006

APPENDIX 1. ADDITIONAL FIGURES

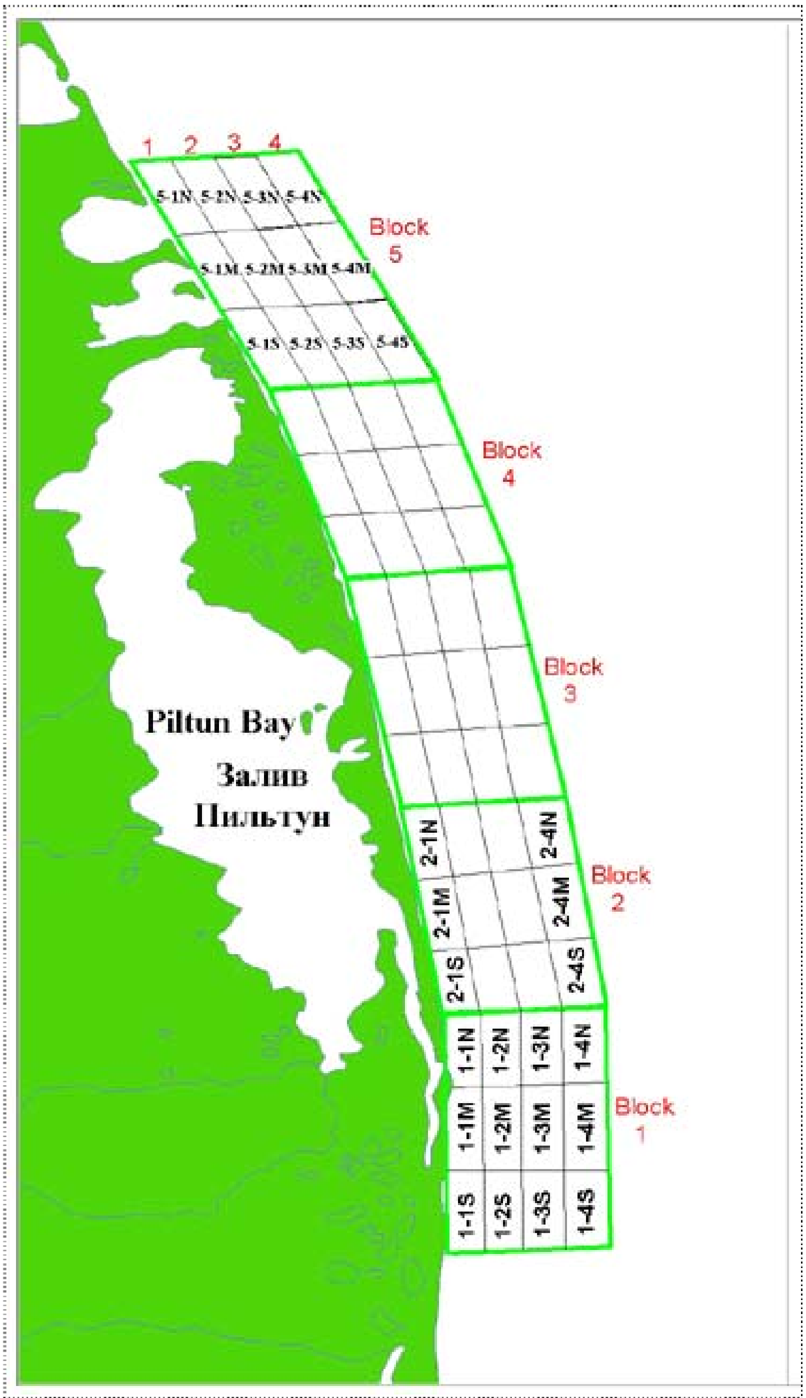


Figure P1.1. Chart of blocks in the Piltun Area.

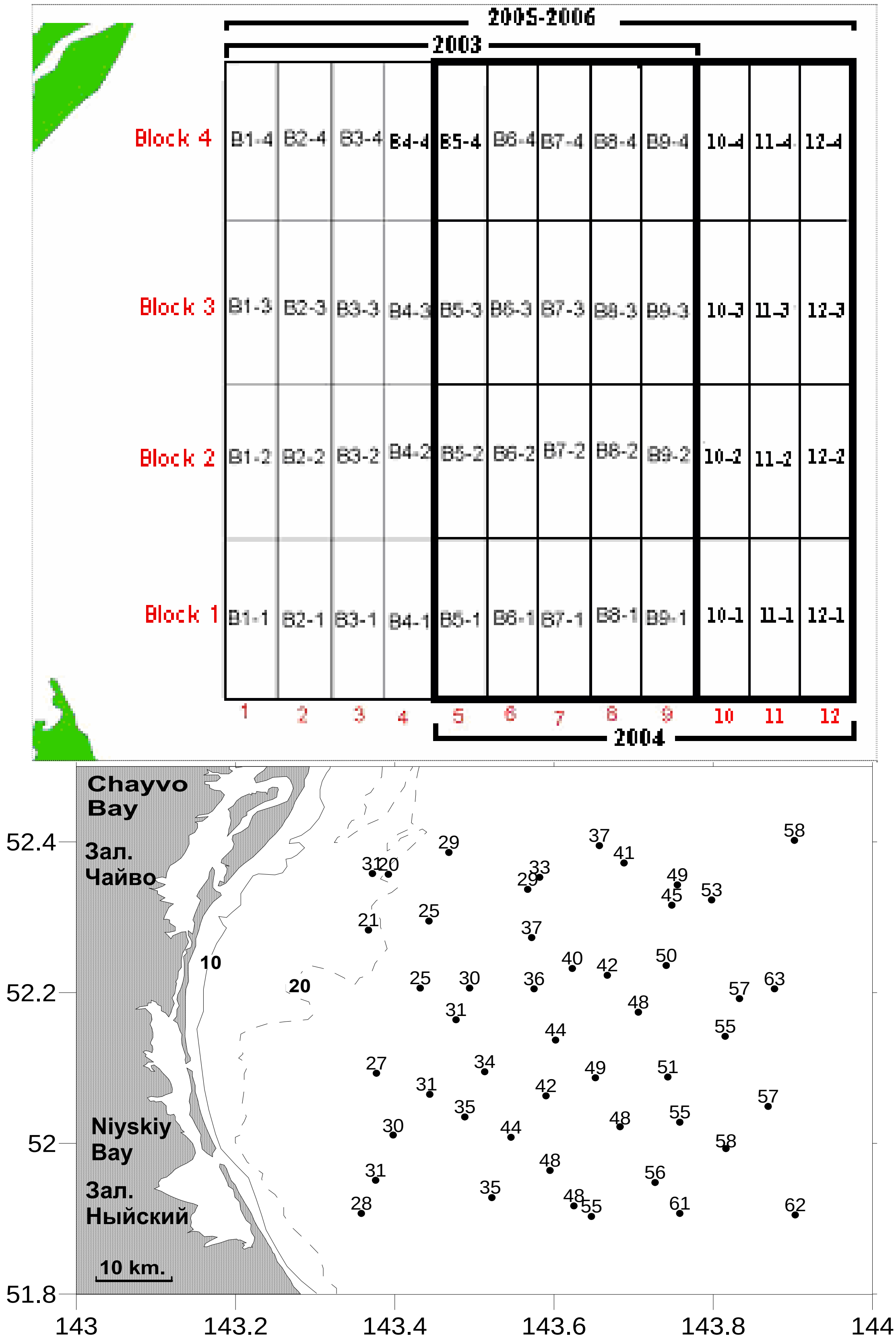


Figure P1.2. Chart of blocks in the Offshore area and stations in 2006.

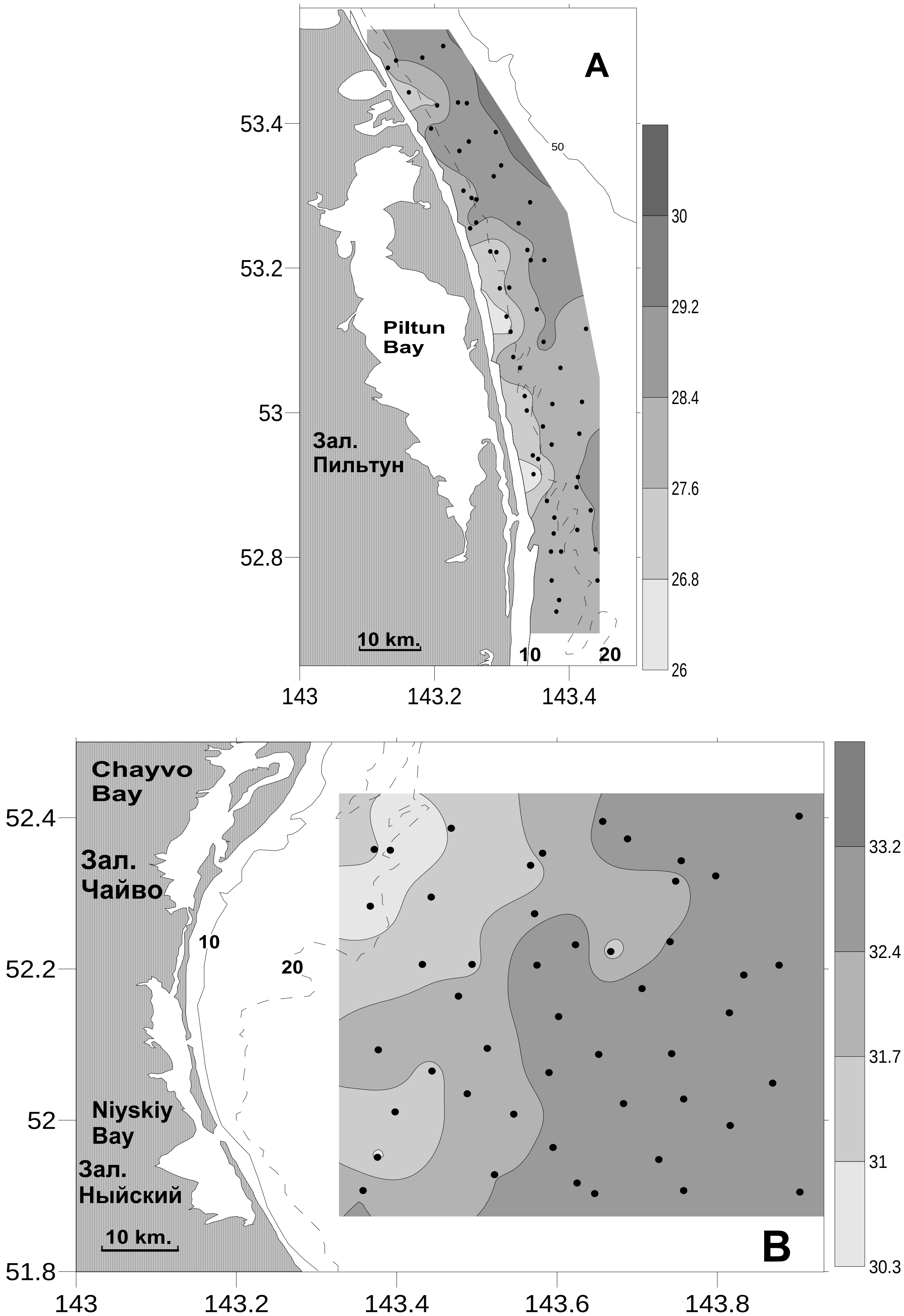


Figure P1.3. Distribution of salinity (S, ,‰) of the bottom water layer in the Piltun (A) and Offshore (B) areas during the study period.

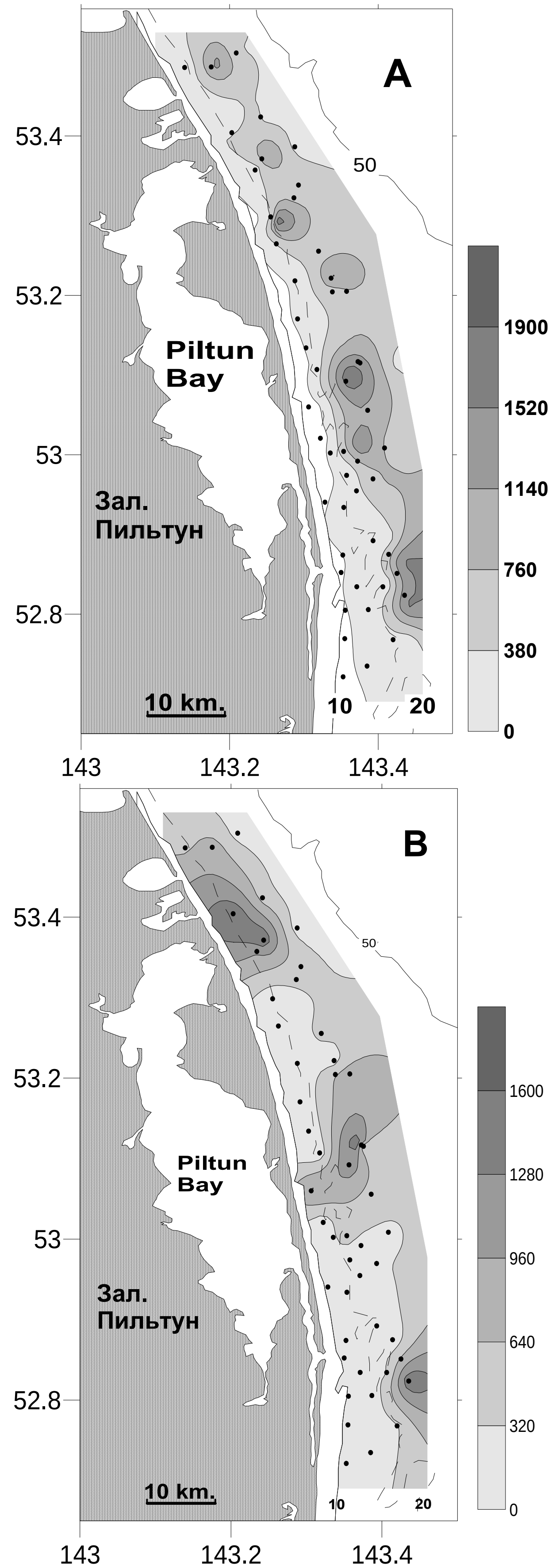


Figure P1.4. Distribution of total biomass (g/m^2) of macrobenthos in the Piltun area in 2006(A) and 2005 (B).

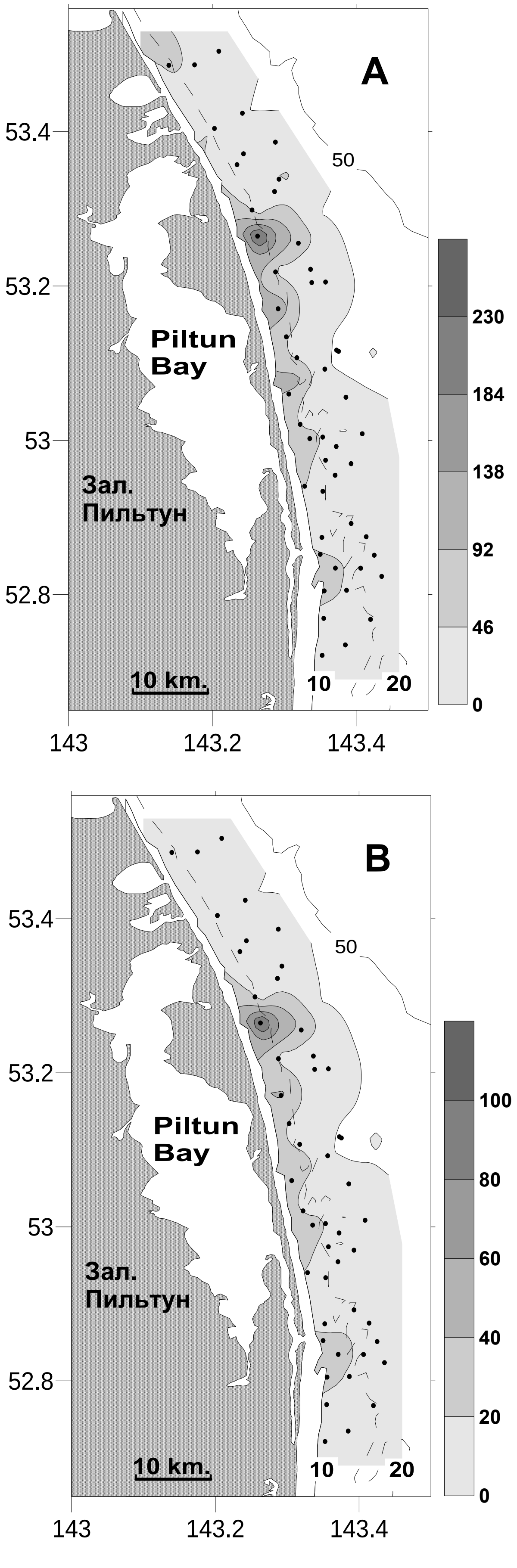


Figure P1.5. Distribution of total biomass (g/m^2) of amphipods and isopods (A) and proportion (%) of amphipods (B) in benthos biomass in the Piltun area in 2006.

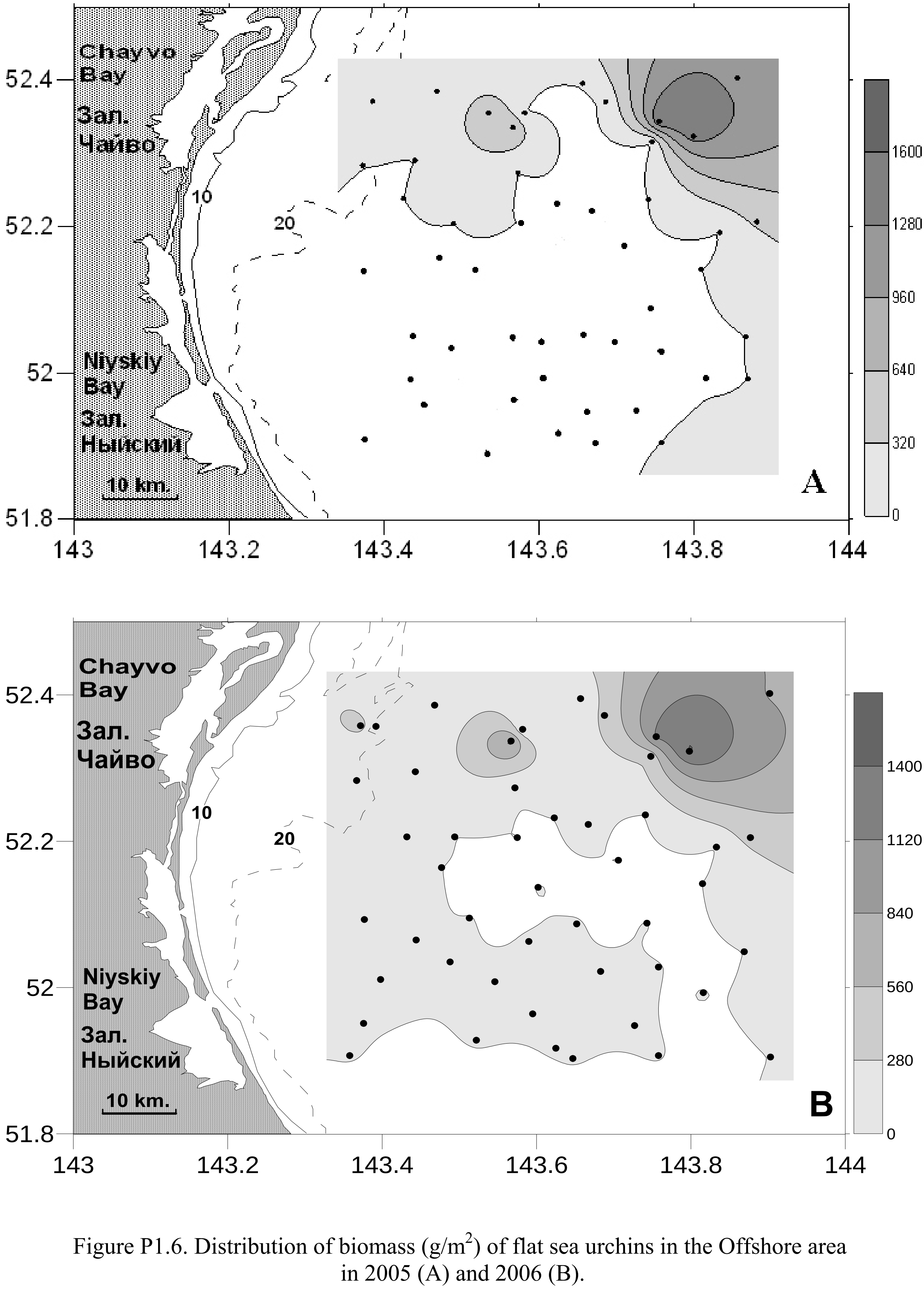


Figure P1.6. Distribution of biomass (g/m^2) of flat sea urchins in the Offshore area in 2005 (A) and 2006 (B).

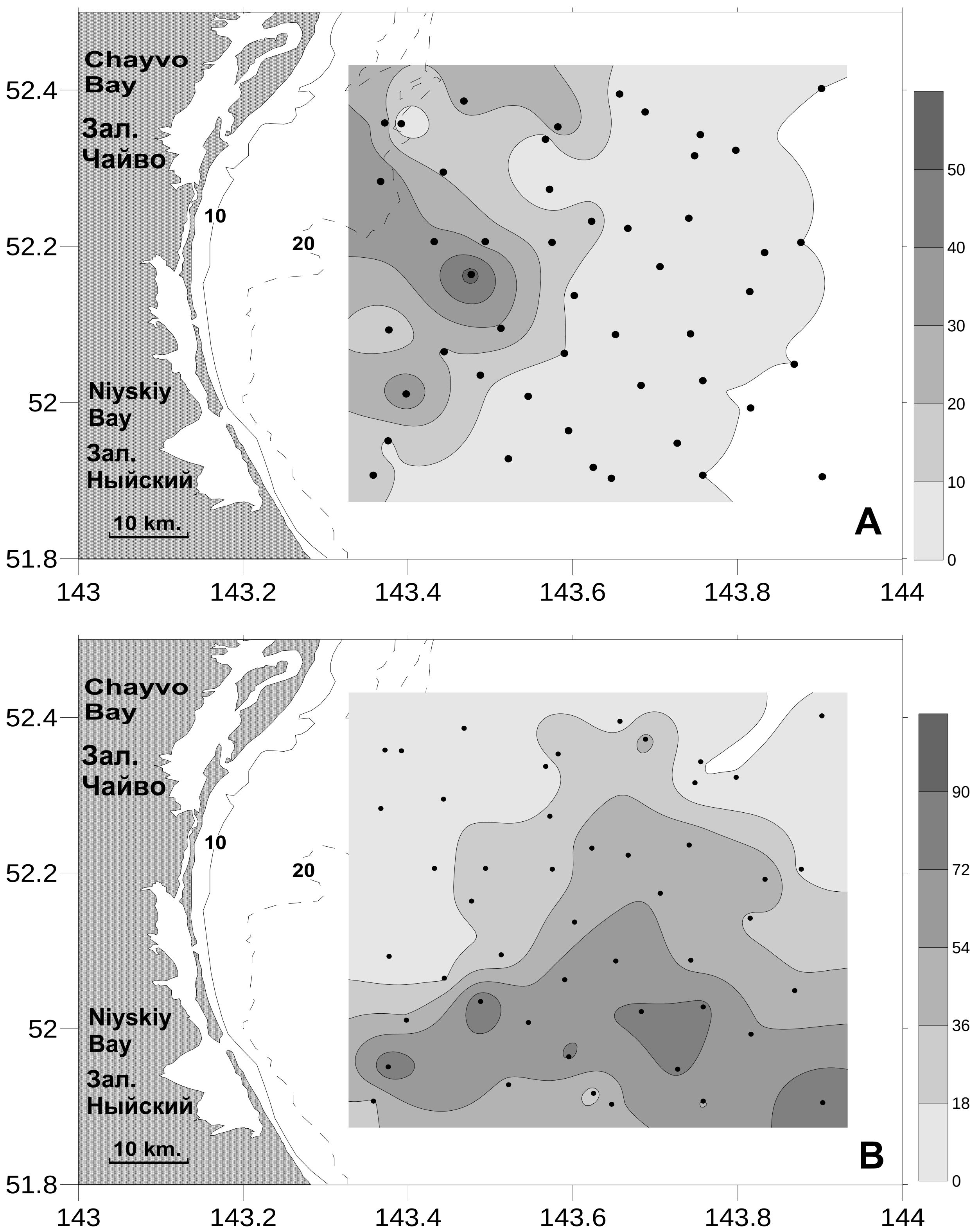


Figure P1.7. Proportion (%) of cumaceans (A) and amphipods (B) in the average benthos biomass (g/m^2) in the Offshore area in 2006.

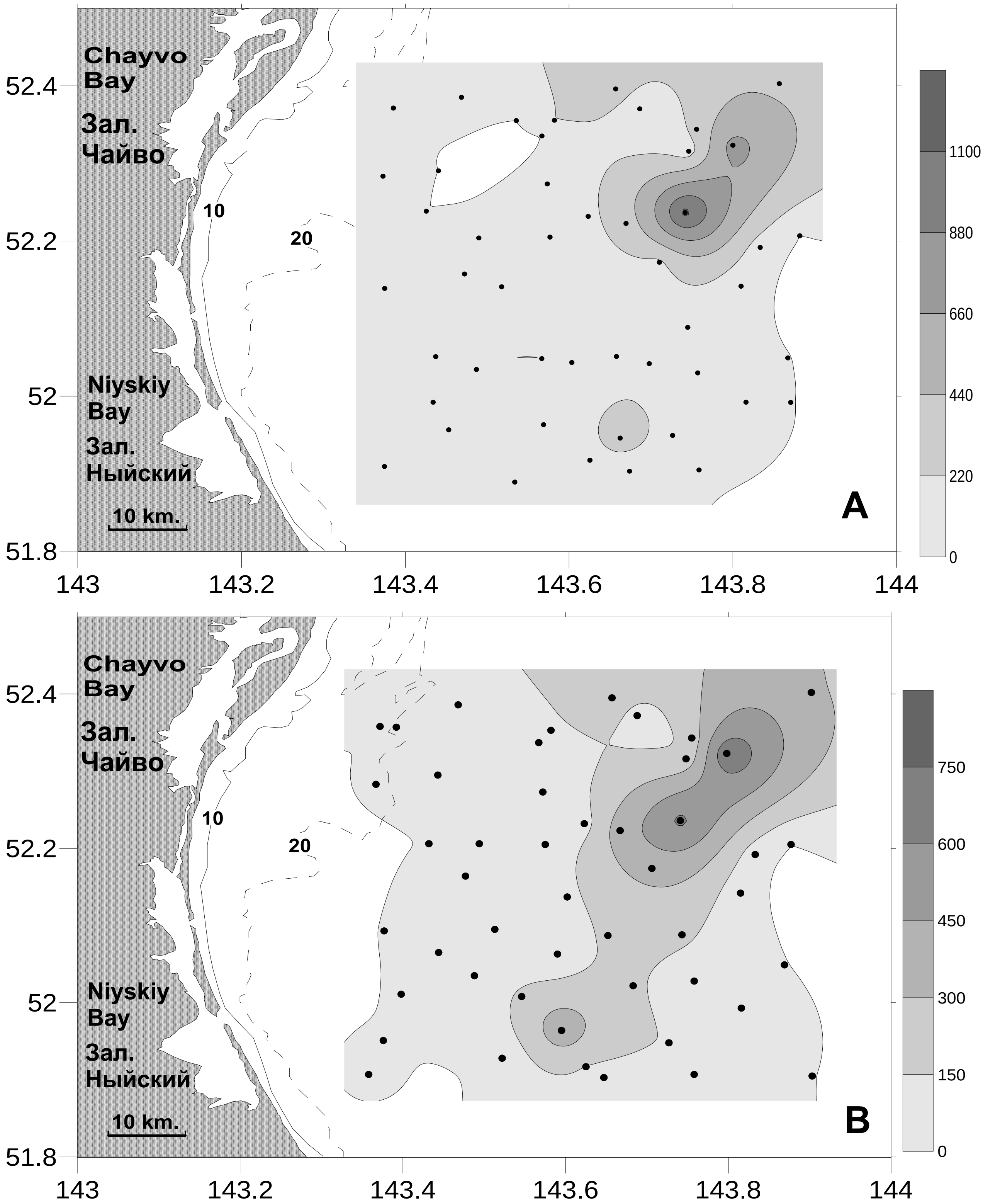


Figure P1.8. Biomass (g/m^2) of sea anemones in the Offshore area in 2005 (A) and 2006 (B).

APPENDICES 2 – 4

APPENDIX 2. Sampling log for August-October 2006 for the expedition of the Institute of Marine Biology of the Far East Branch of the Russian Academy of Sciences aboard the research *Academic Oparin.*

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (ºC)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
1	1	1-1M	Piltun Area	52,808'N	143,373'E	2006.09.14	13:40	17	19,0	10,72	5,85	27,93	31,09	-	+
2	2	1-1N	Piltun Area	52,878'N	143,367'E	2006.09.14	10:30	17	14,8	10,66	6,65	27,78	30,75	-	+
3	3	1-1S	Piltun Area	52,725'N	143,380'E	2006.09.14	16:47	15	19,4	9,65	6,74	28,73	30,53	-	+
4	4	1-2M	Piltun Area	52,915'N	143,347'E	2006.09.07	8:05	18	20,0	13,23	12,87	26,31	26,95	-	-
5	5	1-2N	Piltun Area	53,023'N	143,334E	2006.09.27	15:10	20	18,1	10,84	9,02	28,95	29,78	-	-
6	6	1-2S	Piltun Area	52,940'N	143,346'E	2006.09.27	19:00	13	17,0	11,16	9,79	28,74	29,55	-	-
7	7	1-3M	Piltun Area	53,110'N	143,310'E	2006.09.24	13:15	12	10,7	11,27	11,18	27,78	28,24	-	-
8	8	1-3N	Piltun Area	53,172'N	143,297'E	2006.09.27	10:20	15	10,7	11,05	9,91	28,19	29,08	-	-
9	9	1-3S	Piltun Area	53,062'N	143,327'E	2006.09.27	14:15	18	16,0	10,8	7,9	28,94	30,43	-	-
10	10	1-4M	Piltun Area	53,255'N	143,253'E	2006.08.30	17:30	13	14,0	11,44	4,19	28,6	31,44	-	-
11	11	1-4N	Piltun Area	53,307'N	143,240'E	2006.09.02	9:30	15	14,0	11,49	4,8	26,93	31,17	-	-
12	12	1-4S	Piltun Area	53,223'N	143,283'E	2006.09.24	9:10	13	11,8	11,1	10,92	27,92	28,88	-	-
13	13	1-5M	Piltun Area	53,443'N	143,160'E	2006.09.07	19:00	17	17,5	10,5	8,64	28,37	29,57	-	-
14	14	1-5N	Piltun Area	53,477'N	143,130'E	2006.09.07	19:55	16	15,4	13,21	7,84	26,92	29,96	-	-
15	15	1-5S	Piltun Area	53,393'N	143,195'E	2006.08.31	10:40	19	13,0	6,78	2,94	30,07	31,92	-	-
16	16	2-1M	Piltun Area	52,833'N	143,377'E	2006.09.14	13:05	17	17,0	10,7	6,29	27,89	30,92	-	+
17	17	2-1N	Piltun Area	52,855'N	143,378'E	2006.09.14	12:34	17	15,1	10,74	6,61	27,82	30,71	-	+
18	18	2-1S	Piltun Area	52,768'N	143,374'E	2006.09.14	15:10	16	17,0	10,89	6,46	27,7	30,75	-	-

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (°C)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
19	19	2-2M	Piltun Area	52,980'N	143,361'E	2006.09.27	17:00	22	17,3	11,01	8,98	28,96	30,07	-	-
20	20	2-2N	Piltun Area	53,003'N	143,337'E	2006.09.27	16:15	14	17,0	10,67	9,19	29,08	29,95	-	-
21	21	2-2S	Piltun Area	52,936'N	143,354'E	2006.09.27	19:25	18	14,0	10,76	9,43	29,05	29,85	-	-
22	22	2-3M	Piltun Area	53,133'N	143,307'E	2006.09.24	11:15	17	10,8	11,25	11,2	27,76	28,18	-	-
23	23	2-3N	Piltun Area	53,173'N	143,300'E	2006.09.09	15:15	15	12,0	8,84	5,73	29,7	31,02	-	-
24	24	2-3S	Piltun Area	53,077'N	143,317'E	2006.09.01	8:00	22	14,0	12,28	3,5	27,64	31,7	-	-
25	25	2-4M	Piltun Area	53,263'N	143,262'E	2006.08.30	18:00	15	14,0	10,3	3,54	29,19	31,66	-	-
26	26	2-4N	Piltun Area	53,297'N	143,255'E	2006.08.30	18:35	15	13,5	10,52	3,96	28,65	31,52	-	-
27	27	2-4S	Piltun Area	53,222'N	143,290'E	2006.09.24	9:43	21	11,0	11,1	10,62	27,86	28,62	-	-
28	28	2-5M	Piltun Area	53,425'N	143,204'E	2006.09.04	7:00	22	17,0	10,84	9,02	28,95	29,78	-	-
29	29	2-5N	Piltun Area	53,487'N	143,143'E	2006.09.03	18:55	18	16,0	10,41	4,1	28,73	31,53	-	-
30	30	2-5S	Piltun Area	53,362'N	143,237'E	2006.08.31	13:20	26	14,0	9,25	2,94	29,39	31,97	-	-
31	31	3-1M	Piltun Area	52,808'N	143,388'E	2006.09.13	10:20	17	13,0	9,55	7,66	28,22	29,91	-	-
32	32	3-1N	Piltun Area	52,838'N	143,412'E	2006.09.13	9:35	24	10,0	9,82	5,15	28,25	31,32	-	-
33	33	3-1S	Piltun Area	52,741'N	143,385'E	2006.09.14	16:20	15	18,6	9,55	6,12	28,74	30,82	-	-
34	34	3-2M	Piltun Area	52,956'N	143,374'E	2006.09.27	18:25	23	18,0	10,38	8,65	29,27	30,29	-	-
35	35	3-2N	Piltun Area	53,012'N	143,375'E	2006.09.08	16:00	23	14,0	12,37	7,05	27,51	30,36	-	-
36	36	3-2S	Piltun Area	52,897'N	143,400'E	2006.09.14	10:00	23	12,0	10,88	5,22	27,72	31,39	-	-
37	37	3-3M	Piltun Area	53,140'N	143,352'E	2006.09.03	8:00	26	17,0	11,85	6,66	29,47	31,42	-	-
38	38	3-3N	Piltun Area	53,210'N	143,343'E	2006.09.09	13:20	27	13,0	9,07	4,1	29,45	31,7	-	-
39	39	3-3S	Piltun Area	53,098'N	143,362'E	2006.09.01	9:45	25	14,8	12,26	2,68	27,89	31,95	-	-

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (ºC)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
40	40	3-4M	Piltun Area	53,260'N	143,325'E	2006.08.30	16:50	25	14,3	12,32	2,15	28,08	32,24	-	-
41	41	3-4N	Piltun Area	53,327'N	143,288'E	2006.09.02	8:00	29	14,0	12,02	3,21	26,85	31,92	-	-
42	42	3-4S	Piltun Area	53,295'N	143,262'E	2006.09.02	11:05	23	14,0	11,06	4,28	27,74	31,41	-	-
43	43	3-5M	Piltun Area	53,429'N	143,235'E	2006.08.31	7:40	31	14,0	12,67	1,63	27,84	32,47	-	-
44	44	3-5N	Piltun Area	53,490'N	143,182'E	2006.09.03	18:20	30	18,0	11,49	5,8	29,39	31,92	-	-
45	45	3-5S	Piltun Area	53,375'N	143,251'E	2006.08.31	12:55	28	14,0	11	2,22	28,69	32,27	-	-
46	46	4-1M	Piltun Area	52,811'N	143,439'E	2006.09.14	8:00	24	12,6	10,33	4,94	28,13	31,54	-	-
47	47	4-1N	Piltun Area	52,865'N	143,432'E	2006.09.13	9:00	23	10,9	8,23	4,88	29,47	31,42	-	-
48	48	4-1S	Piltun Area	52,768'N	143,442'E	2006.09.14	14:20	17	18,1	10,63	5,66	27,92	31,1	-	-
49	49	4-2M	Piltun Area	52,971'N	143,415'E	2006.09.27	17:40	29	18,0	11,1	6,25	28,36	31,34	-	-
50	50	4-2N	Piltun Area	53,015'N	143,419'E	2006.09.08	15:10	22	14,0	12,4	5,96	27,52	30,88	-	-
51	51	4-2S	Piltun Area	52,900'N	143,413'E	2006.09.14	9:35	24	14,4	10,91	4,95	27,74	31,58	-	-
52	52	4-3M	Piltun Area	53,116'N	143,425'E	2006.09.27	13:10	32	16,5	10,75	8,11	28,89	30,49	-	-
53	53	4-3N	Piltun Area	53,210'N	143,363'E	2006.09.09	14:05	28	13,0	10,41	3,61	27,59	31,88	-	-
54	54	4-3S	Piltun Area	53,062'N	143,387'E	2006.09.08	14:00	28	15,0	11,85	6,66	27,84	30,5	-	-
55	55	4-4M	Piltun Area	53,291'N	143,340'E	2006.08.30	15:30	33	16,5	11,81	1,21	28,09	32,67	-	-
56	56	4-4N	Piltun Area	53,342'N	143,299'E	2006.08.30	14:25	33	16,9	12,36	0,88	27,84	32,75	-	-
57	57	4-4S	Piltun Area	53,225'N	143,338'E	2006.09.04	14:15	29	14,1	14,39	6,52	26,01	30,98	-	-
58	58	4-5M	Piltun Area	53,428'N	143,248'E	2006.08.30	12:30	35	13,7	12,1	0,98	28,14	32,75	-	-
59	59	4-5N	Piltun Area	53,507'N	143,213'E	2006.08.30	11:00	36	13,2	12,46	0,75	27,87	32,83	-	-
60	60	4-5S	Piltun Area	53,388'N	143,291'E	2006.08.30	13:30	36	15,8	12,56	0,63	27,9	32,9	-	-

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (ºC)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
61	1	B1-1	Offshore Area	51,907'N	143,358'E	2006.09.17	9:05	27	11,7	9,88	1,93	29,57	32,38	-	-
62	2	B1-2	Offshore Area	52,093'N	143,377'E	2006.09.18	9:35	29	10,0	8,95	2,94	30,23	32,12	-	-
63	3	B1-3	Offshore Area	52,283'N	143,367'E	2006.09.18	17:00	20	10,8	10,15	6,74	29,43	30,55	-	-
64	4	B1-4	Offshore Area	52,357'N	143,392'E	2006.08.29	14:20	22	12,4	9,6	5,51	28,91	30,28	-	-
65	5	B2-1	Offshore Area	52,000'N	143,398'E	2006.09.17	8:00	28	13,9	8,55	4,27	30,1	31,56	-	-
66	6	B2-2	Offshore Area	52,065'N	143,440'E	2006.09.18	8:50	32	10,4	10,25	4,32	29,5	31,6	-	-
67	7	B2-3	Offshore Area	52,206'N	143,432'E	2006.09.18	15:00	25	11,3	10,82	4,66	29,59	31,55	-	-
68	8	B2-4	Offshore Area	52,295'N	143,443'E	2006.08.29	16:35	25	12,8	12,06	2,9	28,12	31,5	-	-
69	9	B3-1	Offshore Area	51,951'N	143,376'E	2006.08.29	15:45	30	12,4	10,75	4,37	28,87	30,88	-	-
70	10	B3-2	Offshore Area	52,035'N	143,488'E	2006.09.18	8:00	36	13,0	11,12	3,52	29,36	31,86	-	-
71	11	B3-3	Offshore Area	52,164'N	143,477'E	2006.09.18	14:15	32	11,0	8,52	3,5	29,98	31,96	-	-
72	12	B3-4	Offshore Area	52,386'N	143,468'E	2006.08.29	13:20	31	13,0	12,16	2,9	28,2	31,04	-	-
73	13	B4-1	Offshore Area	51,928'N	143,520'E	2006.09.17	10:10	38	11,8	9,91	1,93	29,54	32,38	-	-
74	14	B4-2	Offshore Area	52,095'N	143,513'E	2006.09.18	10:35	37	10,4	8,95	2,94	30,25	32,12	-	-
75	15	B4-3	Offshore Area	52,206'N	143,494'E	2006.09.18	16:00	30	11,0	9,55	3,66	30,08	31,5	-	-
76	16	B4-4	Offshore Area	52,358'N	143,372'E	2006.08.29	10:50	31	12,7	11,44	3,24	28,69	31,24	-	-
77	17	B5-1	Offshore Area	52,008'N	143,546'E	2006.09.17	16:25	42	14,6	9,23	2,1	29,82	31,97	-	-
78	18	B5-2	Offshore Area	52,063'N	143,590'E	2006.09.16	9:22	43	13,4	8,91	0,82	29,84	32,7	-	-
79	19	B5-3	Offshore Area	52,205'N	143,575'E	2006.08.28	8:00	37	15,0	9,83	-0,44	31,02	33,09	-	-
80	20	B5-4	Offshore Area	52,337'N	143,567'E	2006.08.29	10:10	29	12,6	11,6	3,35	28,47	31,17	-	-
81	21	B6-1	Offshore Area	51,964'N	143,595'E	2006.09.17	15:20	48	14,8	9,82	0,96	29,34	32,59	-	-

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (ºC)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
82	22	B6-2	Offshore Area	52,137'N	143,602'E	2006.09.18	13:00	43	10,4	10,22	1,52	29,81	32,57	-	-
83	23	B6-3	Offshore Area	52,273'N	143,572'E	2006.09.18	18:35	33	10,7	10,4	2,96	29,65	32,15	-	-
84	24	B6-4	Offshore Area	52,353'N	143,582'E	2006.08.29	9:35	32	12,0	12,76	4,54	29,06	32,11	-	-
85	25	B7-1	Offshore Area	51,917'N	143,625'E	2006.09.17	10:55	48	11,8	9,77	1,15	29,37	32,55	-	-
86	26	B7-2	Offshore Area	52,087'N	143,652'E	2006.09.15	19:55	48	12,8	10,78	0,58	29,01	32,65	-	-
87	27	B7-3	Offshore Area	52,232'N	143,623'E	2006.08.28	9:40	40	13,0	9,93	-0,57	31,04	33,02	-	-
88	28	B7-4	Offshore Area	52,395'N	143,657'E	2006.08.29	8:00	38	15,0	12,77	4,65	27,06	32,46	-	-
89	29	B8-1	Offshore Area	51,903'N	143,647'E	2006.09.17	12:10	54	12,3	9,87	0,76	29,3	32,62	-	-
90	30	B8-2	Offshore Area	52,020'N	143,683'E	2006.09.17	18:35	48	14,4	9,4	0,38	29,7	32,81	-	-
91	31	B8-3	Offshore Area	52,223'N	143,667'E	2006.08.28	10:40	42	12,7	11,48	-0,13	28,67	31,39	-	-
92	32	B8-4	Offshore Area	52,372'N	143,688'E	2006.08.28	19:50	41	14,7	11,59	0,04	26,75	32,73	-	-
93	33	B9-1	Offshore Area	51,948'N	143,727'E	2006.08.27	11:10	56	12,8	9,56	-0,67	31,55	33,11	-	-
94	34	B9-2	Offshore Area	52,088'N	143,743'E	2006.08.27	17:57	50	13,5	10,4	-0,75	30,68	33,05	-	-
95	35	B9-3	Offshore Area	52,174'N	143,706'E	2006.08.28	12:45	49	13,0	9,89	-0,48	30,77	32,95	-	-
96	36	B9-4	Offshore Area	52,316'N	143,748'E	2006.08.28	15:55	48	14,2	11,78	-0,1	29,06	32,1	-	-
97	37	B10-1	Offshore Area	51,907'N	143,758'E	2006.08.27	12:30	61	14,0	8,61	-0,71	31,77	33,12	-	-
98	38	B10-2	Offshore Area	52,028'N	143,758'E	2006.08.27	16:55	54	13,5	9,25	-0,71	31,46	33,04	-	-
99	39	B10-3	Offshore Area	52,236'N	143,741'E	2006.08.28	14:25	49	15,5	12,31	-0,13	28,85	32,45	-	-
100	40	B10-4	Offshore Area	52,343'N	143,755'E	2006.08.28	17:20	47	15,0	13,04	-0,28	28,45	32,89	-	-
101	41	B11-1	Offshore Area	51,990'N	143,816'E	2006.08.27	14:00	55	15,7	8,57	-0,65	31,78	33,11	-	-
102	42	B11-2	Offshore Area	52,142'N	143,815'E	2006.08.27	18:50	54	13,8	11,21	-0,36	29,68	32,73	-	-

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (°C)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
103	43	B11-3	Offshore Area	52,192'N	143,833'E	2006.08.27	19:50	57	13,3	10,47	-0,52	30,42	32,88	-	-
104	44	B11-4	Offshore Area	52,323'N	143,798'E	2006.08.28	16:35	50	14,8	11,01	-0,47	29,46	32,93	-	-
105	45	B12-1	Offshore Area	51,905'N	143,903'E	2006.09.17	13:30	65	14,4	12,05	-0,44	29,06	33,13	-	-
106	46	B12-2	Offshore Area	52,049'N	143,869'E	2006.08.27	15:45	48	16,0	9,99	-0,87	31,57	33,13	-	-
107	47	B12-3	Offshore Area	52,205'N	143,877'E	2006.08.27	20:50	63	14,0	11,04	-0,57	30,45	32,92	-	-
108	48	B12-4	Offshore Area	52,402'N	143,902'E	2006.08.28	18:20	58	15,0	12,64	0,53	29,36	32,51	-	-
109	1	FP-07	Chayvo Area	52,518'N	143,333'E	2006.09.13	14:30	13	10,8	7,8	6,42	30,56	30,74	+	+
110	2	FP-08	Chayvo Area	52,508'N	143,338'E	2006.09.13	15:08	13	12,0	6,43	6,22	30,8	30,67	+	+
111	3	FP-09	Chayvo Area	52,490'N	143,342'E	2006.09.13	16:00	15	13,0	7,18	6,34	30,64	30,75	+	+
112	4	FP-10	Chayvo Area	52,475'N	143,362'E	2006.09.13	16:40	18	13,0	10,66	9,37	28,94	29,54	+	+
113	5	FP-23	Chayvo Area	52,503'N	143,335'E	2006.09.25	8:30	12	11,7	10,73	10,75	28,36	28,56	+	+
114	6	FP-24	Chayvo Area	52,483'N	143,333'E	2006.09.25	9:00	13	10,9	10,78	10,8	28,6	28,63	+	+
115	7	FP-07R	Chayvo Area	52,485'N	143,321'E	2006.09.25	9:40	10	11,0	10,71	10,71	29,12	29,18	+	+
116	8	FP-08R	Chayvo Area	52,474'N	143,335'E	2006.09.25	10:05	11	11,5	10,73	10,74	28,32	28,51	+	+
117	9	FP-09R	Chayvo Area	52,465'N	143,324'E	2006.09.25	10:55	12	11,4	10,71	10,75	28,36	29,75	+	+
118	10	FP-10R	Chayvo Area	52,461'N	143,323'E	2006.09.25	12:50	12	11,7	10,81	10,79	28,36	28,67	+	+
119	11	FP-23R	Chayvo Area	52,460'N	143,330'E	2006.09.25	13:40	13	13,0	10,77	9,97	29,83	30,18	+	+
120	12	FP-24R	Chayvo Area	52,460'N	143,330'E	2006.09.25	14:00	15	13,1	9,25	9,03	30,84	31,79	+	+
121	13	FP-20	North Area	54,360'N	142,607'E	2006.09.23	8:00	26	12,7	7,57	5,9	31,6	31,88	+	+
122	14	FP-21	North Area	54,402'N	142,542'E	2006.09.23	9:00	31	10,8	10,24	5,22	29,98	31,82	+	+
123	15	FP-22	North Area	54,375'N	142,540'E	2006.09.23	9:40	39	10,9	11,18	3,3	29,23	31,98	+	+

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (ºC)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
124	16	FP-20R	North Area	54,377'N	142,579'E	2006.09.23	10:05	37	11,3	10,44	4,67	29,88	31,75	+	+
125	17	FP-21R	North Area	54,367'N	142,591'E	2006.09.23	10:55	31	11,8	10,51	5,34	30,12	31,87	+	+
126	18	FP-01	Offshore Area	52,026'N	143,565'E	2006.08.26	12:50	44	15,0	7,71	-0,09	29,9	32,85	-	+
127	19	FP-02	Offshore Area	52,032'N	143,573'E	2006.08.27	13:40	44	15,0	8,11	-0,05	29,74	32,8	-	+
128	20	FP-03	Offshore Area	52,025'N	143,588'E	2006.08.27	9:16	46	12,5	6,19	-0,24	31,54	32,95	-	+
129	21	FP-04	Offshore Area	52,016'N	143,598'E	2006.08.27	9:50	46	12,8	6,38	-0,26	31,6	32,88	-	+
130	22	FP-11	Offshore Area	52,043'N	143,578'E	2006.09.16	8:40	44	12,3	8,15	-0,03	29,85	32,84	-	+
131	23	FP-12	Offshore Area	52,050'N	143,615'E	2006.09.16	10:05	45	13,1	9,68	0,56	29,51	32,77	-	+
132	24	FP-13	Offshore Area	52,050'N	143,565'E	2006.09.16	10:55	41	13,5	9,35	0,72	29,68	32,72	-	+
133	25	FP-14	Offshore Area	52,043'N	143,578'E	2006.09.16	12:40	45	14,4	9,61	0,93	29,38	32,62	-	+
134	26	FP-15	Offshore Area	52,224'N	143,752'E	2006.09.16	15:55	51	14,0	11,49	0,4	28,94	32,83	-	+
135	27	FP-16	Offshore Area	52,239'N	143,765'E	2006.09.16	16:30	50	14,7	11,5	0,42	28,87	32,87	-	+
136	28	FP-17	Offshore Area	52,264'N	143,757'E	2006.09.16	17:15	50	14,0	11,05	0,5	29,06	32,81	-	+
137	29	FP-18	Offshore Area	52,269'N	143,779'E	2006.09.16	17:55	52	14,0	10,89	0,51	29,13	32,81	-	+
138	30	FP-19	Offshore Area	52,080'N	143,573'E	2006.09.17	17:10	40	15,4	10,52	0,73	29,55	32,74	-	+
139	31	FP-31	Offshore Area	52,020'N	143,583'E	2006.10.02	9:20	43	12,7	10,6	2,48	29,1	32,37	-	+
140	32	FP-25	Piltun Area	52,700'N	143,364'E	2006.09.28	16:00	16	18,2	10,12	9,95	29,25	29,32	+	+
141	33	FP-26	Piltun Area	52,685'N	143,355'E	2006.09.28	16:25	11	18,0	10,35	10,31	28,98	29,01	+	+
142	34	FP-27	Piltun Area	52,685'N	143,032'E	2006.09.28	17:00	16	17,9	10,64	9,87	28,91	29,34	+	+
143	35	FP-28	Piltun Area	52,693'N	143,373'E	2006.09.28	17:30	16	18,1	11,12	9,64	28,02	29,47	+	+
144	36	FP-05	Piltun Area	53,382'N	143,218'E	2006.08.31	10:15	20	13,0	9,52	2,49	29,38	32,14	+	+

Item	Number	Station	Area	Coordinates (decimal form)		Date	Time	Depth (m)	Temperature (ºC)			Salinity (‰)		Epibenthic Net	Bongo Net
				longitude	latitude				Air	Water ottom	Water surface	Water bottom	Water surface		
145	37	FP-06	Piltun Area	53,368'N	143,244'E	2006.08.31	12:10	21	14,0	11,13	2,24	28,63	32,06	+	+
146	38	FP-12R	Piltun Area	53,293'N	143,287'E	2006.09.09	8:35	25	14,0	11,55	5	28,3	31,41	+	+
147	39	FP-29D	Piltun Area	53,161'N	143,273'E	2006.09.29	8:40	5	18,2	10,12	9,95	29,25	29,32	+	+
148	40	FP-30D	Piltun Area	53,161'N	143,269'E	2006.09.29	10:05	10	18,0	10,35	10,31	28,98	29,01	+	+
149	41	FP-32	Piltun Area	53,303'N	143,288'E	2006.10.09	8:40	26	11,0	8,45	7,67	30,3	31,14	+	+
150	42	FP-33	Piltun Area	53,323'N	143,282'E	2006.10.09	9:00	27	9,3	8,48	7,64	30,26	31,17	+	+
151	43	FP-34	Piltun Area	53,293'N	143,290'E	2006.10.09	9:35	25	9,0	8,5	7,97	30,24	30,96	+	+
152	44	FP-35	Piltun Area	53,296'N	143,278'E	2006.10.09	9:55	25	9,7	8,45	7,76	30,28	31,15	+	+
153	45	FP-36	Piltun Area	53,288'N	143,240'E	2006.10.09	10:30	14	10,0	8,43	8,15	30,32	30,63	+	+

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	1-1M	Piltun	52,808'N	143,373'E	17	0	0	0,1	0,2	0,1	0,6	**94,1**	4,7	0,2	0	Sf
2	2	1-1N	Piltun	52,878'N	143,367'E	17	0	0	0	0	0	1,6	**96,4**	2	0	0	Sf
3	3	1-1S	Piltun	52,725'N	143,380'E	15	0	0	0	1	11,2	29,7	**55,6**	2,1	0,4	0	Sf
4	4	1-2M	Piltun	52,915'N	143,347'E	18	0	0	0	0,2	0,2	1,2	**89,4**	8,6	0,4	0	Sf
5	5	1-2N	Piltun	53,023'N	143,334E	20	0	0	0,6	4,3	1,8	0,7	**89,7**	2,8	0,1	0	Sf
6	6	1-2S	Piltun	52,940'N	143,346'E	13	0	0	0	0	0,2	0,6	**97,4**	1,8	0	0	Sf
7	7	1-3M	Piltun	53,110'N	143,310'E	12	0	0	0	0	0,3	0,3	**92,2**	5,2	2	0	Sf
8	8	1-3N	Piltun	53,172'N	143,297'E	15	0	0	0	0,2	0,2	2,5	**94,1**	3	0	0	Sf
9	9	1-3S	Piltun	53,062'N	143,327'E	18	0	0	0	0,3	1,2	10,6	**86,2**	1,7	0	0	Sf
10	10	1-4M	Piltun	53,255'N	143,253'E	13	0	1,4	7,9	43	20,7	4,7	21,6	0,7	0	0	GrSfm
11	11	1-4N	Piltun	53,307'N	143,240'E	15	0	0,4	0,2	4,4	7,2	33,2	**53,2**	1,4	0	0	Sf
12	12	1-4S	Piltun	53,223'N	143,283'E	13	0	0	0	0,1	0,1	0,2	**95,4**	4,2	0	0	Sf
13	13	1-5M	Piltun	53,443'N	143,160'E	17	0	0	0,4	0,4	0,8	5,6	**88**	4,8	0	0	Sf
14	14	1-5N	Piltun	53,477'N	143,130'E	16	0	2,8	0	1,8	1,1	6,1	**85,5**	1,8	0,9	0	Sf
15	15	1-5S	Piltun	53,393'N	143,195'E	19	0	0	0,2	0,6	1,4	4	**91,6**	2,2	0	0	Sf
16	16	2-1M	Piltun	52,833'N	143,377'E	17	0	0	0,1	0,2	0,5	2	**92,1**	4,4	0,7	0	Sf
17	17	2-1N	Piltun	52,855'N	143,378'E	17	0	0	0	0	0,4	22,7	**76,5**	0,4	0	0	Sf
18	18	2-1S	Piltun	52,768'N	143,374'E	16	0	0	0,1	0,6	1,5	3	**89,7**	5	0,1	0	Sf
19	19	2-2M	Piltun	52,980'N	143,361'E	22	0	0,3	0,9	8,8	23,4	41	23,6	1,2	0,8	0	Smfc
20	20	2-2N	Piltun	53,003'N	143,337'E	14	0,0	0,0	0,0	0,5	1,8	39,4	**56,0**	2,0	0,4	0,0	Sf
21	21	2-2S	Piltun	52,936'N	143,354'E	18	0	0	0	0	0	0,8	**95,8**	3,4	0	0	Sf
22	22	2-3M	Piltun	53,133'N	143,307'E	17	0	0	0,2	0,1	0,2	2,1	**94,8**	2,6	0	0	Sf

23	23	2-3N	Piltun	53,173'N	143,300'E	15	0	0	0	0,1	0,4	1,8	**88,6**	8,5	0,6	0	Sf
24	24	2-3S	Piltun	53,077'N	143,317'E	22	0	0	0,4	0,6	0,6	1,6	**92,8**	4	0	0	Sf
25	25	2-4M	Piltun	53,263'N	143,262'E	15	0	0	0	0	0,2	0,4	**96,2**	3,2	0	0	Sf
26	26	2-4N	Piltun	53,297'N	143,255'E	15	0	1,2	2,8	12,9	16,7	3,8	**60,8**	1,8	0	0	Sf
27	27	2-4S	Piltun	53,222'N	143,290'E	21	0	0	0,4	3,4	4,4	37,4	**54**	0,4	0	0	Sf
28	28	2-5M	Piltun	53,425'N	143,204'E	22	0	0	0	0,8	1,2	3	**93,4**	1,6	0	0	Sf
29	29	2-5N	Piltun	53,487'N	143,143'E	18	0	0	0	0,4	0,4	1,4	**94**	3,8	0	0	Sf
30	30	2-5S	Piltun	53,362'N	143,237'E	26	0	0	1,7	4,6	11,1	31,1	**50,7**	0,8	0	0	Sf
31	31	3-1M	Piltun	52,808'N	143,388'E	17	0	0	0,1	0,9	11,5	47,4	39,1	1	0	0	Smf
32	32	3-1N	Piltun	52,838'N	143,412'E	24	0	0	0	0,1	0,1	1	**95,2**	2,2	1,4	0	Sf
33	33	3-1S	Piltun	52,741'N	143,385'E	15	0	0,7	13	26,1	1,5	0,1	**52,7**	5,5	0,4	0	Sf
34	34	3-2M	Piltun	52,956'N	143,374'E	23	0,4	3,2	10,1	34	21,2	18,2	11,7	0,5	0,7	0	GrSc
35	35	3-2N	Piltun	53,012'N	143,375'E	23	0	0	0	0,6	2,2	4,6	**88,2**	4	0,4	0	Sf
36	36	3-2S	Piltun	52,897'N	143,400'E	23	7,9	21,9	13,3	1,9	5,1	9,8	38,9	1,2	0	0	SfGr
37	37	3-3M	Piltun	53,140'N	143,352'E	26	0	0	0	2,6	5	29,6	**62**	0,8	0	0	Sf
38	38	3-3N	Piltun	53,210'N	143,343'E	27	0	0,2	4,6	33,4	20	10,4	30,2	0,7	0,5	0	GrSf
39	39	3-3S	Piltun	53,098'N	143,362'E	25	0	0	0	0,2	0,6	8	**88,6**	2,2	0,4	0	Sf
40	40	3-4M	Piltun	53,260'N	143,325'E	25	0	0	0,6	4,2	10,4	35,6	49,2	0	0	0	Sfm
41	41	3-4N	Piltun	53,327'N	143,288'E	29	10,9	1,4	8,4	29	19,2	15	15,1	0,9	0,1	0	GrScm
42	42	3-4S	Piltun	53,295'N	143,262'E	23	0	0	0	0,6	0,3	1,7	**80,3**	10,7	4,7	1,7	Sf
43	43	3-5M	Piltun	53,429'N	143,235'E	31	0	0	0,3	4,4	11,2	28,2	**55,6**	0,3	0	0	Sf
44	44	3-5N	Piltun	53,490'N	143,182'E	30	4,8	14,3	10	6,4	3,4	22,5	37,8	0,8	0	0	Smf
45	45	3-5S	Piltun	53,375'N	143,251'E	28	7,9	21,9	13,3	1,9	5,1	9,8	38,9	1,2	0	0	SfGr
46	46	4-1M	Piltun	52,811'N	143,439'E	24	0	0,2	0,9	3,8	10,2	31,1	**53**	0,8	0	0	Sf
47	47	4-1N	Piltun	52,865'N	143,432'E	23	0	0	7,9	19	31,9	32,8	8,4	0	0	0	Smc
48	48	4-1S	Piltun	52,768'N	143,442'E	17	0	0	0	2,2	12,8	**60**	25	0	0	0	Sm
49	49	4-2M	Piltun	52,971'N	143,415'E	29	0	0	0	0,2	0,1	0,3	**96,6**	2,6	0,2	0	Sf

50	50	4-2N	Piltun	53,015'N	143,419'E	22	0	0	0	0,4	4,7	**55,6**	39,2	0,1	0	0	Sm
51	51	4-2S	Piltun	52,900'N	143,413'E	24	15,3	12,2	10,4	1,1	6,2	8,6	40,7	9,7	0	0	SfGr
52	52	4-3M	Piltun	53,116'N	143,425'E	32	0	0	0,8	6,2	7,4	**60,3**	24,8	0,5	0	0	Sm
53	53	4-3N	Piltun	53,210'N	143,363'E	28	0	0,7	6,4	22,4	36,9	27,6	6	0	0	0	Sm
54	54	4-3S	Piltun	53,062'N	143,387'E	28	0	0	0	0,7	1,4	3,2	**83,7**	9,6	1,4	0	Sf
55	55	4-4M	Piltun	53,291'N	143,340'E	33	1,4	0	0,7	1,8	5,5	**55,9**	29,3	4,8	0,1	0,5	Sm
56	56	4-4N	Piltun	53,342'N	143,299'E	33	15,8	7,5	3,5	11,2	31,6	24,3	12,5	2,6	0	0	Scm
57	57	4-4S	Piltun	53,225'N	143,338'E	29	0	0,0	0,0	3,5	5,5	31,0	**58,7**	1,1	0,2	0,0	Sf
58	58	4-5M	Piltun	53,428'N	143,248'E	35	0	0	0,2	2	2,9	19,8	**73,9**	1,2	0	0	Sf
59	59	4-5N	Piltun	53,507'N	143,213'E	36	0	0	1,2	7,2	7,3	15	**65,6**	3,7	0	0	Sf
60	60	4-5S	Piltun	53,388'N	143,291'E	36	0	2,1	12,2	22,9	14,3	15,1	29,2	4,2	0	0	SfGr
61	1	B1-1	Offshore	51,907'N	143,358'E	27	0	0	0	0,1	1,8	5,2	**82,4**	9,3	1,2	0	Sf
62	2	B1-2	Offshore	52,093'N	143,377'E	29	0	0	0	0,2	0,1	0,2	**78,9**	19,6	1	0	Sf
63	3	B1-3	Offshore	52,283'N	143,367'E	20	0	0	0	0	0,2	1,4	**96**	2,2	0,2	0	Sf
64	4	B1-4	Offshore	52,357'N	143,392'E	22	0	0	0,1	1,3	2,4	3	**92,4**	0,8	0	0	Sf
65	5	B2-1	Offshore	52,000'N	143,398'E	28	0	0	0	0	0	0,2	**92,4**	7	0,4	0	Sf
66	6	B2-2	Offshore	52,065'N	143,440'E	32	0	0	0	0	0,1	0,1	**88,4**	10,4	1	0	Sf
67	7	B2-3	Offshore	52,206'N	143,432'E	25	0	0	0	0	0	0,1	**96,5**	3,2	0,2	0	Sf
68	8	B2-4	Offshore	52,295'N	143,443'E	25	0	0	0	0	0,2	1,8	**97**	1	0	0	Sf
69	9	B3-1	Offshore	51,951'N	143,376'E	30	0	0	0	0,1	0,4	1,8	**96,9**	0,8	0	0	Sf
70	10	B3-2	Offshore	52,035'N	143,488'E	36	0	0	0		0	0	**92,6**	6,5	0,9	0	Sf
71	11	B3-3	Offshore	52,164'N	143,477'E	32	0	0	0	0	0	0	**94,5**	4,9	0,6	0	Sf
72	12	B3-4	Offshore	52,386'N	143,468'E	31	0	0	0	0,1	0,4	4,1	**92,8**	2,2	0,4	0	Sf
73	13	B4-1	Offshore	51,928'N	143,520'E	38	0	0	0	0,2	0,2	1	**92,8**	5,2	0,6	0	Sf
74	14	B4-2	Offshore	52,095'N	143,513'E	37	0	0	0	0,1	0,1	0,3	**94,1**	4,7	0,7	0	Sf
75	15	B4-3	Offshore	52,206'N	143,494'E	30	0	0	0	0		0,1	**96,7**	3	0,2	0	Sf
76	16	B4-4	Offshore	52,358'N	143,372'E	31	0	0	0	0,2	0,6	5,6	**92,6**	1	0	0	Sf

77	17	B5-1	Offshore	52,008'N	143,546'E	42	0	0	0	0,3	0,3	2	**81**	9,3	4,4	2,7	Sf
78	18	B5-2	Offshore	52,063'N	143,590'E	43	0	0	0	0	0	0,2	**96,1**	3,5	0,2	0	Sf
79	19	B5-3	Offshore	52,205'N	143,575'E	37	0	0	0	0	0,1	0,6	**97,7**	1,6	0	0	Sf
80	20	B5-4	Offshore	52,337'N	143,567'E	29	0	2,5	30,3	9,5	26,6	8,9	20,7	1,4	0,1	0	GrmSc
81	21	B6-1	Offshore	51,964'N	143,595'E	48	0	0	0	0,3	0,2	0,8	**93**	5	0,7	0	Sf
82	22	B6-2	Offshore	52,137'N	143,602'E	43	0	0	0	0	0,1	0,1	**95,8**	3,8	0,2	0	Sf
83	23	B6-3	Offshore	52,273'N	143,572'E	33	0	0	0	0,2	0,2	1,4	**97**	1,2	0	0	Sf
84	24	B6-4	Offshore	52,353'N	143,582'E	32	0	0	1	6,6	25,1	**49,1**	17,5	0,6	0,1	0	Smc
85	25	B7-1	Offshore	51,917'N	143,625'E	48	16,4	10,8	21,8	28	9,6	3,4	8,8	1	0,2	0	Grfm
86	26	B7-2	Offshore	52,087'N	143,652'E	48	0	0	0	2	4	8,3	**66,7**	8,3	6,3	4,4	Sf
87	27	B7-3	Offshore	52,232'N	143,623'E	40	0	0	0	0	0,1	0,6	**98,5**	0,8	0	0	Sf
88	28	B7-4	Offshore	52,395'N	143,657'E	38	0	0	0	0,1	3,4	**52,8**	43,4	0,3	0	0	Sm
89	29	B8-1	Offshore	51,903'N	143,647'E	54	0	0	0	2	1,3	2,7	**70,3**	10,7	7,3	5,7	Sf
90	30	B8-2	Offshore	52,020'N	143,683'E	48	0	0	0	0	0,5	8,6	**87,7**	2,8	0,4	0	Sf
91	31	B8-3	Offshore	52,223'N	143,667'E	42	0	0	0	0,2	0,2	0,6	**97,6**	1,4	0	0	Sf
92	32	B8-4	Offshore	52,372'N	143,688'E	41	0	0	0,2	1,2	3,2	4,9	**90,1**	0,4	0	0	Sf
93	33	B9-1	Offshore	51,948'N	143,727'E	56	0	0	0	1	0,3	1,4	**74,3**	8,7	8,6	5,7	Sf
94	34	B9-2	Offshore	52,088'N	143,743'E	50	0	0	0	1,4	4,6	8,3	**73,3**	6,4	3,7	2,3	Sf
95	35	B9-3	Offshore	52,174'N	143,706'E	49	0	0	0	0,2	0,2	0,9	**93,4**	5	0,3	0	Sf
96	36	B9-4	Offshore	52,316'N	143,748'E	48	0	0	0	0	0,2	0,8	**97,6**	1,2	0,2	0	Sf
97	37	B10-1	Offshore	51,907'N	143,758'E	61	0	0	0	0,3	0,7	4	**76**	7	6,7	5,3	Sf
98	38	B10-2	Offshore	52,028'N	143,758'E	54	0	0	0	1	1	3,7	**75,7**	6,3	7,3	5	Sf
99	39	B10-3	Offshore	52,236'N	143,741'E	49	0	0	0	0	0,1	0,2	**98,9**	0,8	0	0	Sf
100	40	B10-4	Offshore	52,343'N	143,755'E	47	0	0	0,2	0,2	0,4	2,4	**96**	0,6	0,2	0	Sf
101	41	B11-1	Offshore	51,990'N	143,816'E	55	0	0	0	0,3	0,3	1,4	**72,7**	12,3	7	6	Sf
102	42	B11-2	Offshore	52,142'N	143,815'E	54	0	0	0	0,3	1	1,4	**71**	14	7,3	5	Sf
103	43	B11-3	Offshore	52,192'N	143,833'E	57	0	0	0	0,7	0,3	0,3	**78,4**	9,7	5,8	4,8	Sf

104	44	B11-4	Offshore	52,323'N	143,798'E	50	0	0	0	0,8	0,6	1,6	**96,8**	0,2	0	0	Sf
105	45	B12-1	Offshore	51,905'N	143,903'E	65	0	0	0	3	7	29,8	**59,4**	0,6	0,2	0	Sf
106	46	B12-2	Offshore	52,049'N	143,869'E	48	0	0	2,2	1,8	2,6	10	**81**	2,4	0	0	Sf
107	47	B12-3	Offshore	52,205'N	143,877'E	63	0	0	0	0,3	0,3	0,7	**82,7**	8,3	5,3	2,4	Sf
108	48	B12-4	Offshore	52,402'N	143,902'E	58	0	0	1	0,6	1,4	3,8	**92,8**	0,4	0	0	Sf
109	1	FP-07	Chayvo	52,518'N	143,333'E	13	0	0	0	0,1	0,1	0,6	**95**	4,2	0	0	Sf
110	2	FP-08	Chayvo	52,508'N	143,338'E	13	0	0	0	0	1,6	**64,4**	34	0	0	0	Sm
111	3	FP-09	Chayvo	52,490'N	143,342'E	15	0	0	0	0,8	2	8,2	**86,4**	2,6	0	0	Sf
112	4	FP-10	Chayvo	52,475'N	143,362'E	18	0	0	0,1	1,4	2,2	7	**87,2**	2,1	0	0	Sf
113	5	FP-23	Chayvo	52,503'N	143,335'E	12	0	0	0	0	0,4	30,9	**67,1**	1	0,6	0	Sfm
114	6	FP-24	Chayvo	52,483'N	143,333'E	13	0	0	0	1,2	1,8	4,8	**84,6**	5,6	2	0	Sf
115	7	FP-07R	Chayvo	52,485'N	143,321'E	10	0	0	0,4	2,9	6	38,3	**50,9**	1,5	0	0	Sf
116	8	FP-08R	Chayvo	52,474'N	143,335'E	11	0	0	0,6	7,6	2,3	3,2	**75,3**	11	0	0	Sf
117	9	FP-09R	Chayvo	52,465'N	143,324'E	12	0,6	0	0,2	1	0,6	10	**77,7**	1,3	2,1	6,6	Sf
118	10	FP-10R	Chayvo	52,461'N	143,323'E	12	0	0	1,1	1,4	5,3	43,7	43	5,5	0	0	Smf
119	11	FP-23R	Chayvo	52,460'N	143,330'E	13	0	0,7	6,8	10,2	12,4	14,5	**53,4**	2	0	0	Sf
120	12	FP-24R	Chayvo	52,460'N	143,330'E	15	0	0	0	2,9	7,3	23,7	**64**	2,1	0	0	Sf
121	13	FP-01	Offshore	52,026'N	143,565'E	44	0	0	0	0	0	0,6	**88**	10	1,4	0	Sf
122	14	FP-02	Offshore	52,032'N	143,573'E	44	0	0	0	0	0,2	0,8	**90**	8	1	0	Sf
123	15	FP-03	Offshore	52,025'N	143,588'E	46	0	0	0	0	0,2	1,4	**91,2**	5,6	1,6	0	Sf
124	16	FP-04	Offshore	52,016'N	143,598'E	46	0	0	0	0	0,2	1,4	**95,2**	3,2	0	0	Sf
125	17	FP-05	Piltun	53,382'N	143,218'E	20	0	0	0	0,4	1	20,8	**76,8**	1	0	0	Sf
126	18	FP-06	Piltun	53,368'N	143,244'E	21	0	0,6	6,4	15,9	16,6	31,7	**28,6**	0,2	0	0	Smf
127	19	FP-11	Offshore	52,043'N	143,578'E	44	0	0	0	0,4	0,6	1,6	**92,8**	3,8	0,8	0	Sf
128	20	FP-12	Offshore	52,050'N	143,615'E	45	0	0	0	0,1	0,1	0,6	**95**	4,1	0,1	0	Sf
129	21	FP-12R	Piltun	53,293'N	143,287'E	25	0	0	0	0,3	2	22,6	**60,7**	0,3	0	14,1	Sf
130	22	FP-13	Offshore	52,050'N	143,565'E	41	0	0	0	0	0	0,2	**89,4**	8,1	2,3	0	Sf

131	23	FP-14	Offshore	52,043'N	143,578'E	45	0	0	0	0,3	0,3	0,7	**82,7**	11	3,7	1,3	Sf
132	24	FP-15	Offshore	52,224'N	143,752'E	51	0	0	0,1	0,2	0,2	0,8	**94,6**	3,1	1	0	Sf
133	25	FP-16	Offshore	52,239'N	143,765'E	50	0	0	0	0	0	0,8	**96,4**	2,8	0	0	Sf
134	26	FP-17	Offshore	52,264'N	143,757'E	50	0	0	0	0,3	0,4	1,8	**96,8**	0,7	0	0	Sf
135	27	FP-18	Offshore	52,269'N	143,779'E	52	0	0	0	0	0,1	1,6	**97,4**	0,9	0	0	Sf
136	28	FP-19	Offshore	52,080'N	143,573'E	40	0	0	0	0,3	0,2	0,6	**89**	8,4	1,5	0	Sf
137	29	FP-20	North	54,360'N	142,607'E	26	4,6	0	0	1,2	1,8	30,3	**60,6**	0,5	0,4	0,6	Sf
138	30	FP-20R	North	54,377'N	142,579'E	37	0	0	0	0	0	0,2	**99,3**	0,3	0	0,2	Sf
139	31	FP-21	North	54,402'N	142,542'E	31	0,6	0,5	1,3	1,9	2,1	5,6	**80,7**	1,7	5,6	0	Sf
140	32	FP-21R	North	54,367'N	142,591'E	31	0	0	0	0,5	2,7	9	**80,6**	7	0,2	0	Sf
141	33	FP-22	North	54,375'N	142,540'E	39	0	0	0,3	0,3	0,7	1,3	**78**	9,2	5,5	4,7	Sf
142	34	FP-25	Piltun	52,700'N	143,364'E	16	0	0	0,1	0,9	1	1,9	**93,1**	3	0	0	Sf
143	35	FP-26	Piltun	52,685'N	143,355'E	11	0	0	0	0	0	0,6	**96,4**	3	0	0	Sf
144	36	FP-27	Piltun	52,685'N	143,032'E	16	0	0	0,4	0,1	0,2	0,8	**95,7**	2,6	0,2	0	Sf
145	37	FP-28	Piltun	52,693'N	143,373'E	16	0	0	0	0,2	0,2	0,7	**94,3**	4,4	0,2	0	Sf
146	38	FP-29D	Piltun	53,161'N	143,273'E	5	0	0	0	0	0,4	9,3	**88,8**	0,3	0,5	0,7	Sf
147	39	FP-30D	Piltun	53,161'N	143,269'E	10	0	0	0	0	4,3	33,9	**47,4**	4,9	0,4	9,1	Smf
148	40	FP-31	Offshore	52,020'N	143,583'E	43	0	0	0	0	1,3	5,7	**81,1**	0,7	0	11,2	Sf
149	41	FP-32	Piltun	53,303'N	143,288'E	26	0	0	0	0,3	0,2	1,4	**95,8**	2,3	0	0	Sf
150	42	FP-33	Piltun	53,323'N	143,282'E	27	0	0	0	0	20,9	**69,6**	5,9	0,3	1,3	2	Sm
151	43	FP-34	Piltun	53,293'N	143,290'E	25	0	0,1	0,9	10,8	1,9	29,1	**52,6**	1,8	0,9	1,8	Sf
152	44	FP-35	Piltun	53,296'N	143,278'E	25	0	0	0	0	3,4	36,4	**51,3**	7,2	1,7	0	Sf
153	45	FP-36	Piltun	53,288'N	143,240'E	14	0	0	0	0,6	0	1,1	**91,9**	5	1,4	0	Sf

APPENDIX 4. Taxonomic List of Benthic and Nektobenthic Species Observed in the Piltun and Offshore areas in 2001-2006.

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	*Anisogamcarus pugettensis*	Am
174	7	*Anisogamcarus 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	*Eogamcarus 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
200	36	*Ischyrocerus anguipes*	Am

Item	Species Count	Taxon/Species Name	*Code*
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
48	79	*Protomedeia fasciata.*	Am

Item	Species Count	Taxon/Species Name	*Code*
45	80	*Protomedeia macrocarpa*	Am
46	81	*Protomedeia microdactila*	Am
47	82	*Protomedeia popovi*	Am
211	83	*Protomedeia sp.*	Am
49	84	*Psamconyx 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
75	28	*Serripes groenlandicus*	Bi

Item	Species Count	Taxon/Species Name	*Code*
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
106	15	*Solariella obscura intermedia*	Ga

Item	Species Count	Taxon/Species Name	*Code*
		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
137	12	*Cistenides soldatovi*	Po
138	13	*Demonax fullo*	*Po*

Item	Species Count	Taxon/Species Name	*Code*
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 gemcifera*	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
248	55	*Potamilla reniformis*	Po
162	56	*Potamilla torelli*	Po

Item	Species Count	Taxon/Species Name	*Code*
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	*Amcodytes hexapterus*	*Pi*