

# The Distribution of Zooplankton and Bowhead Whales, *Balaena mysticetus* Linnaeus, 1758, in Akademiya Bay, Sea of Okhotsk

V. V. Melnikov and Yu. V. Fedorets

*Il'ichev Pacific Oceanological Institute, Far East Branch, Russian Academy of Sciences,  
ul. Baltiiskaya 43, Vladivostok, 690031 Russia*

*e-mail: vmelnikov@poi.dvo.ru*

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**Abstract**—The modern pattern of distribution and feeding habits of the bowhead whale, *Balaena mysticetus*, in the Sea of Okhotsk are studied. The existence of a feeding aggregation of this whale species in the south-westernmost portion (apex) of Ulban Bay has been confirmed. There, the animals feed in shallow waters with depths of 3–5 m, which are only slightly larger than their body height. The quantitative composition and species structure of zooplankton at the stations that were set near feeding whales have been analyzed. In the samples taken in the immediate proximity to the feeding whales, the abundance of zooplankton reached 31409 ind./m<sup>3</sup>, with the average value of 17565 ind./m<sup>3</sup>. The lowest abundance, from 56 to 1879 ind./m<sup>3</sup> (mean 927 ind./m<sup>3</sup>), was in the samples from western Konstantin Bay, where bowhead whales were not observed. In 16 samples collected in the immediate proximity to the feeding whales in the shallow waters of Ulban Bay, the average zooplankton biomass was 547.9 mg/m<sup>3</sup>, which is 3.9 times higher than that in the samples from waters where the whales were absent. Copepods dominated quantitatively at all the stations in Akademiya Bay. The proportion of euphausiids in the zooplankton biomass was lower than 1%, both near the feeding whales and in the absence of whales.

**Keywords:** Sea of Okhotsk, Akademiya Bay, bowhead whale, zooplankton

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## INTRODUCTION

The Okhotsk population of the bowhead whale *Balaena mysticetus* Linnaeus, 1758 is a separate historically isolated group that inhabit the Sea of Okhotsk. The summer range of these animals is associated with the western portion of the sea (waters off the Shantar Islands), where whales of this species occur mainly in Akademiya Bay (the Ulban, Konstantin, and Nikolay bays) and Tugur Bay [1, 3–5, 8, 11, 14, 18].

The goals of the present work were to study the modern distribution of bowhead whales, *B. mysticetus*, in Akademiya Bay, Sea of Okhotsk, to analyze the quantitative composition and species structure of zooplankton in the water column at the stations that were set where the whales feed, and to compare the plankton biomass and distribution of the whales in their feeding areas.

## MATERIALS AND METHODS

The distribution of bowhead whales was studied and dedicated surveys were conducted from August 21 to September 8, 2013 (Fig. 1). The surveys were done mainly from a boat, as well as aboard R/V *Lugovoye* on its way to the operation area or while lying at anchorage. Observations were performed, as a rule, in calm

weather, at a sea state no higher than 2 by the Beaufort scale and a visibility of at least 5 km. Observations from the boat covered the sea surface within a distance of 3 km or, from the vessel bridge, within 6 km.

Zooplankton samples were collected from September 1 to 7, 2013, during daylight hours, in immediate proximity to the feeding whales and at the points of their dives. For comparison, samples were collected from waters where the whales were absent or single individuals occurred episodically. Zooplankton was caught using a standard Juday net, mesh size 0.4 mm, which was hauled up vertically from the bottom to the surface. The samples were collected at a depth from 1 to 15 m. The depth was measured with a lead line. The zooplankton samples were fixed in 4% formalin-sea-water solution. A total of 41 plankton samples were collected and processed.

The number of plankton organisms was counted according to the recommendations [7] and expressed in term of density (ind./m<sup>3</sup>). The biomass was estimated using the standard weight tables and nomograms [12, 15].

## RESULTS

*The Distribution of Bowhead Whales*

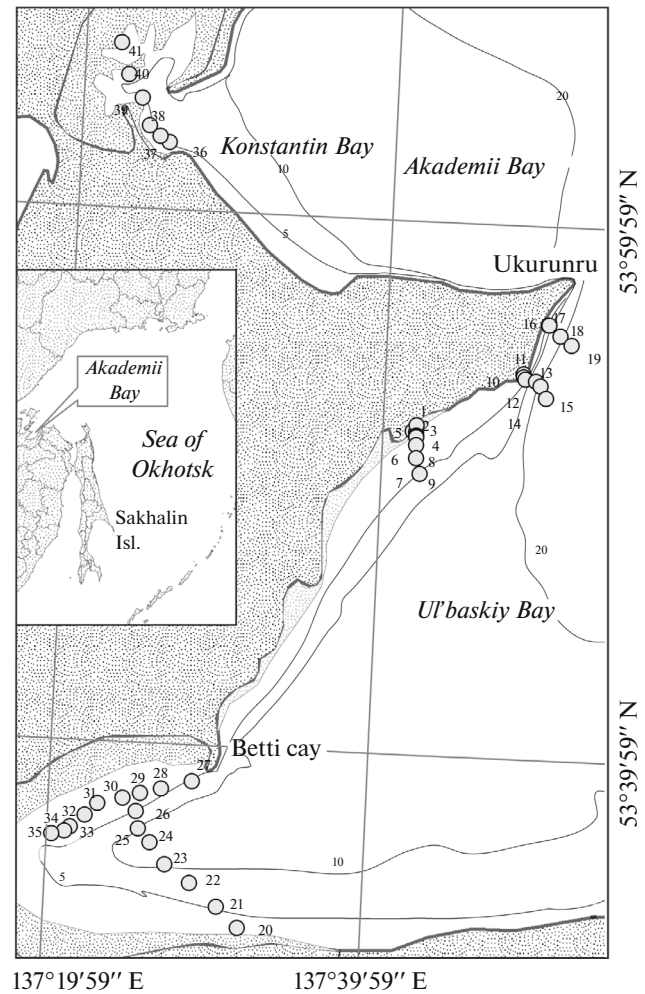
In the initial period of the works, from August 21 to 29, whales were not observed. The first animal was sighted on August 30 (Table 1). Subsequently, single whales and pairs occurred quite frequently off the eastern tip of Cape Ukurunru (Fig. 2). These were young animals that were feeding near rocks that protrude into the sea and solitary stones, around which the tidal currents form eddies, where the zooplankton concentration is thought to increase. All the sighted whales kept near the rocks within 500 m off the shore. A mother/calf pair was observed in these waters as well. The calf was swimming close to its mother and did not leave her. This was probably related to the presence of killer whales, as earlier we had seen a group of seven individuals not far from this pair.

As many as 50–60 whales were feeding in the southwestern portion (apex) of Ulban Bay, in shallow waters with depths from 3 to 5 m, which is unusual for these large animals. Despite the fact that the configuration of the western Konstantin Bay is very similar to that of Ulban Bay, only one whale was found in its apex. One more whale was observed in the estuarine portion on Nikolay Bay.

*Characteristics of the Zooplankton*

A total of six taxonomical groups of holoplankton were recorded from the samples collected in the western portion of Akademiya Bay in the Sea of Okhotsk: Copepoda, Cladocera, Chaetognatha, Mysidacea, Euphausiidae, and Ctenophora; Cumacea and juvenile Arctic rainbow smelt *Osmerus mordax dentex* were also found. Copepods in the samples were represented mostly by small forms, which can make up the core of the community due to their dense aggregations. The small fraction consisted of *Oithona similis*, a widely distributed species in the Far Eastern seas, whose density varied from 24 to 18442 ind./m<sup>3</sup>. Cladocera was represented by three species (*Podan leuckarii*, *P. polyphemoides*, and *Evande nordmanni*); euphausiids, also by three species (*Euphausia pacifica*, *Euphausia* sp., *Thysanoessa longipes*). Among obligatory predators, Chaetognatha (*Sagitta elegans* s.l.), Ctenophora (*Beroe* sp.), and Amphipoda (*Hyperia* spp.) were found. Meroplankton was comprised of larval Gastropoda and Polychaeta.

The abundance of zooplankton averaged 17565 ind./m<sup>3</sup>, reaching 31409 ind./m<sup>3</sup> (Table 2). These values were characteristic for the samples collected from the shallow waters of western Ulban Bay in immediate proximity to the feeding whales. In the samples from western Konstantin Bay, where whales had not been observed (stations 36–41), the zooplankton abundance was the lowest, on average 927 ind./m<sup>3</sup>; it ranged from 56 to 1879 ind./m<sup>3</sup>. At all



**Fig. 1.** The study area in Akademiya Bay, Sea of Okhotsk, in 2013. The numerals are the numbers of the stations and isobaths.

the stations, copepods dominated quantitatively with their average proportion of 88% and the maximum one of 100% in some of the samples.

The zooplankton biomass was also formed mostly by copepods. Its mean values varied from 22.3 mg/m<sup>3</sup> (max, 40.9 mg/m<sup>3</sup>; min, 3.7 mg/m<sup>3</sup>) in the apex of Konstantin Bay (stations 36–41), where whales were absent, to 773 mg/m<sup>3</sup> in the apex of Ulban Bay (stations 27–35), where about 60 individuals were feeding (Tables 3, 4; Fig. 3). In 16 samples that were collected from the shallow waters of Ulban Bay, in the immediate proximity to the feeding whales, the average zooplankton biomass constituted 547.9 mg/m<sup>3</sup> (min, 100.4; max, 1949.5; median, 372.6 mg/m<sup>3</sup>) (Table 4). In 19 zooplankton samples from western Konstantin Bay and the waters off Cape Ukurunru, where whales were absent, the biomass averaged at 140 mg/m<sup>3</sup> (min, 3.7; max, 549; median, 66.6 mg/m<sup>3</sup>). Thus, in the

**Table 1.** The dates and locations of bowhead whale, *Balaena mysticetus*, sightings in Akademiya Bay in 2013

Date	Place of observations	Coordinates		Numb. of individuals	Comments
		N	E		
Aug. 30, 2013	Vessel	53°52'	137°46'	1	Whale entered Ulban Bay near the shore
Aug. 31, 2013	"	53°52'	137°46'	1	Whale entered Ulban Bay
Aug. 31, 2013	"	53°52'	137°46'	1	Whale entered Ulban Bay
Sept. 1, 2013	"	53°52'	137°46'	1	Young whale was feeding
Sept. 1, 2013	"	53°52'	137°41'	2	Whales were feeding near the pebbly spit
Sept. 1, 2013	"	53°54'	137°48'	3	Whales were feeding 500 m off the shore
Sept. 5, 2013	Shore, 5 km	53°58'	137°50'	1	Young whale was feeding 10 m off stones near the shore
Sept. 5, 2013	Shore, 3 km	53°58'	137°44'	3	A female with calf and a young whale moved along the northern shore
Sept. 5, 2013	Shore, 3 km	53°58'	137°43'	1	Young whale moved along the shore
Sept. 5, 2013	Shore	53°54'	137°48'	2	Whales were 50 m off the pebbly spit
Sept. 5, 2013	Shore	53°54'	137°48'	3	500 m off the shore
Sept. 6, 2013	Boat	53°37' to 53°36'	137°23' to 37°20'	60	Aggregation of feeding whales in the apex of Ulban Bay
Sept. 7, 2013	"	54°04'	137°23'	1	Young whale near the spit in Konstantin Bay
Sept. 7, 2013	"	53°58'	137°51'	1	Young whale near the rocks off the eastern tip of Cape Ukurunru
Sept. 8, 2013	Anchorage	53°55'	138°36'	2	Whales near the sandy spit in Nikolay Bay

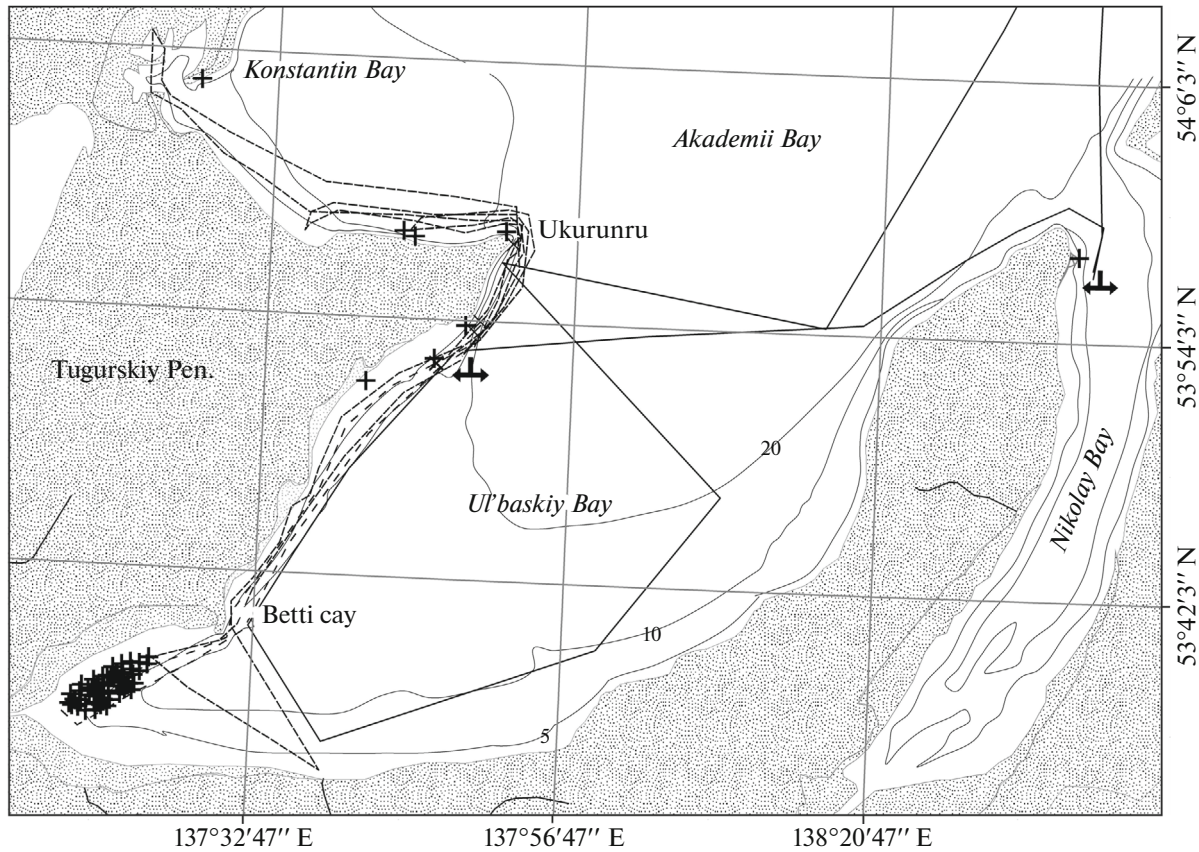
**Table 2.** The abundance of zooplankton (ind./m<sup>3</sup>) at transects in Akademiya Bay, Sea of Okhotsk

Parameter	Stations					
	1–9	10–15	16–19	20–26	27–35	36–41
Minimum	511.0	2488	158	2931	1854	56
25% percentile	1517	2507	158	2954	9875	309.2
Median	3492	4012	342	6016	17572	665
75% percentile	4908	6872	3367	7457	26221	1678
Maximum	5443	8218	3367	7946	31409	1879
Mean	3286	4554	1289	5317	17567	927.9
Standard deviation	1841	2400	1802	2113	9761	736.5
Standard error	650.8	1074	1040	798.7	3254	329.4

waters where the whales were feeding the zooplankton biomass was 3.9 times higher. The Mann–Whitney U-test showed a highly significant difference between the zooplankton biomass in the samples taken near the feeding whales and those from the waters without whales ( $P = 0.0005$ ).

## DISCUSSION

Bays of the western Sea of Okhotsk (waters off the Shantar Islands) are the summer feeding areas for bowhead whales, *Balaena mysticetus*, of the Okhotsk population [1, 2, 4, 6, 9, 13]. The distribution of whales in August and September 2013 substantially



**Fig. 2.** The locations of bowhead whale, *Balaena mysticetus*, sightings in Akademiya Bay, August and September 2013 (indicated by crosses). The solid line is the vessel's path; dotted lines are boat's tracks.

differed from that observed in this region within the same period of the previous years. First, a relatively small number of whales were found off Cape Ukurunru, both on the side of Ulban Bay and on the side of Konstantin Bay, where significant aggregations of these animals had been recorded earlier [1, 2, 4, 9, 18]. Single whales and small groups of up to three individuals occurred mostly near the rocky cliffs at the tip of

Cape Ukurunru. In 1999, a chain of stones extended into the sea perpendicular to the shoreline from the northern tip of the cape [10]. In August and September, four or five whales arrived here every day and were feeding until the end of the low tide current. This chain and the configuration of the shore formed a small anti-cyclonic eddy [18]. However in 2013, the stones disappeared; they had probably been swept away by ice, and

**Table 3.** The estimated zooplankton biomass (mg/m<sup>3</sup>) at stations in Akademiya Bay, Sea of Okhotsk

Parameter	Stations					
	1–9	10–15	16–19	20–26	27–35	36–41
Minimum	27.36	121.4	10.53	69.12	66.65	3.7
25% percentile	52.07	152.6	*	117.7	318.6	8.7
Median	145.4	188.7	*	250.3	615.9	21.7
75% percentile	300.9	471.2	*	292.9	1227	36.2
Maximum	480.4	549.6	287.8	352.4	1949	40.9
Mean	181.7	287.2	105.9	228.1	773.2	22.3
Standard deviation	156.2	178.8	*	101.4	595.6	14.6
Standard error	55.21	79.96	*	38.33	198.5	6.525

\* Not calculated because of insufficient data



**Table 4.** Zooplankton biomass ( $\text{mg}/\text{m}^3$ ) near feeding whales and at the stations where whales were absent

Parameter	Near whales	No whales
Number of samples	16	19
Minimum	100.4	3.7
25% percentile	178.3	21.7
Median	372.6	66.7
75% percentile	746	287.8
Maximum	1949	549.6
Mean	547.9	140.3
Standard deviation	515.8	154.7
Standard error	129	35.5

the eddy was also absent. Due obviously to this circumstance we did not see whales here in 2013. In the hydrobiological samples taken from the site of former eddy, the zooplankton biomass was low, on average  $105.9 \text{ mg}/\text{m}^3$  for three samples, whereas in 2004 this parameter reached  $1200 \text{ mg}/\text{m}^3$  [18].

In the literature on bowhead whale of the Okhotsk and Bering-Chukchi populations we could not find any mention of whales in shallow waters with depths of only 3–5 m. A brief report on their presence in the apex of Ulban Bay has been published only recently [16]. Our data confirmed the existence of a bowhead whale aggregation here. In the shallow portion of

Ulban Bay, the zooplankton biomass near feeding whales averaged at  $547.9 \text{ mg}/\text{m}^3$  with the maximum reaching  $1949 \text{ mg}/\text{m}^3$  (Table 4), which is comparable to the data on feeding of whales in the western Beaufort Sea [17], as well as in Ulban Bay in 2003 and 2004 [18]. In the samples collected from the sites of whale aggregations, the zooplankton was represented mostly by copepods. In the zooplankton samples from Akademiya Bay, including those collected near the feeding whales, euphausiids were represented very poorly. This group was not registered here in 2003–2004 also [18]. The zooplankton samples collected in the apex of Ulban Bay and in Konstantin Bay differed greatly in biomass. In western Ulban Bay, the zooplankton biomass was on average  $534.7 \text{ mg}/\text{m}^3$ ; in Konstantin Bay it was only  $111.6 \text{ mg}/\text{m}^3$ . These bays have similar configurations (Fig. 1) but the apex of Ulban Bay receives five small and three larger rivers flowing through vast wetlands, whereas only one small stream flows into the apex of Konstantin Bay.

According to available data, the pelagic pteropod mollusk *Limacina helicina* dominated in Akademiya Bay, where it formed dense aggregations in 2003 and 2004 [14, 18]. In our samples this mollusk did not occur. This was apparently related to the fact that we collected the samples from the shallow waters with depths of 1 to 15 m, whereas the samples in 2003 and 2004 were collected mostly in the open portion of the bay, from a vessel that could not approach the shore closer than the 15-meter isobath.

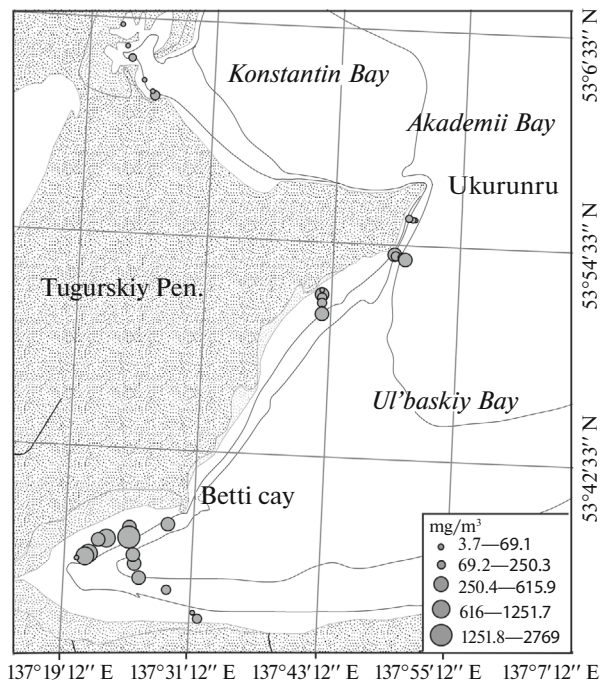
These results show that in the case of the availability of food, bowhead whales, *B. mysticetus*, may form aggregations in shallow waters with depths that slightly exceed the height of their body. Whales of the Okhotsk population can use the food patches that form in small eddies around capes and solitary stones. The biomass of zooplankton near the whales that were feeding in western Ulban Bay was  $547.9 \text{ mg}/\text{m}^3$  on average, reaching the maximum of  $1949 \text{ mg}/\text{m}^3$ . This value is thought to meet the required amount of zooplankton for feeding bowhead whales in the summer.

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**Fig. 3.** The distribution of the zooplankton biomass in the coastal zone of Ulban Bay and Konstantin Bay, Sea of Okhotsk, August and September 2013.

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