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Bigg's Killer Whales (*Orcinus orca*) in the Kuril Islands

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Abstract

This article summarizes our observations from land and vessels of transient (Bigg's) ecotype killer whales (*Orcinus orca*) in the Kuril Islands during the period 2002 to 2015. We also conducted a review of published information on the occurrence of these killer whales in the Kuril Islands. During 12 years of vessel observations, no cases of killer whales hunting marine mammals were observed. During land-based observations, Bigg's killer whales were observed from land near two Kuril Islands: Brat Chirpoev Island and Dolgaya Rock. In total, eight instances of Bigg's killer whale attacks on pinnipeds were observed: seven were directed toward Steller sea lions (*Eumetopias jubatus*) and one toward northern fur seals (*Callorhinus ursinus*). The behavior of killer whales during hunting corresponded to published descriptions of the tactics used by killer whales in other regions. According to the photo-identification analysis in July 2009 and July 2011, the same group of four Bigg's killer whales was observed near Brat Chirpoev Island. These individuals were not found in any of the published catalogues of killer whales inhabiting the North Pacific. According to both the information collected by us and that in published literature, the predominant ecotype of killer whales summering in the Kuril Islands is the fish-eating (resident) ecotype.

Key Words: killer whale, *Orcinus orca*, Steller sea lion, *Eumetopias jubatus*, northern fur seal, *Callorhinus ursinus*, ecotype, foraging specialization, photo-identification, Kuril Islands

Introduction

The eastern (USA, Canada) and western (Russia) North Pacific Ocean is inhabited by two main ecological types of killer whales (*Orcinus orca*; Linnaeus, 1758) that specialize on different foraging resources: fish and squid (resident ecotype) and marine mammals (transient or Bigg's ecotype) (Bigg, 1982; Ford & Ellis, 1999; Ford et al., 2000; Burdin et al., 2004a, 2004b; Shulezhko, 2008; Ivkovich et al., 2010; Filatova et al., 2014b). In addition to these two ecotypes, "offshore" killer whales occur in the eastern North Pacific Ocean. Offshore killer whales are still poorly studied and probably specialize in feeding on sharks (Ford et al., 2011).

A number of ecological, genetic, and morphological differences exist between fish- and mammal-eating killer whales. According to different studies, examination of morphological features and vocalizations were sufficient for reliable identification of killer whale ecotypes (Baird & Stacey, 1988a; Ford et al., 2000; Matkin et al., 2007; Zerbini et al., 2007; Shulezhko, 2008; Shulezhko & Burkanov, 2008; Durban et al., 2010; Parsons et al., 2013). The Committee on Taxonomy (2012) recommended that these two ecotypes of North Pacific killer whales be recognized as two subspecies of *O. orca*. Subsequently, genetic research of mitochondrial and nuclear DNA provided strong evidence that resident and transient ecotype killer whales differed at the species level (Morin et al., 2010; Parsons et al., 2013; Filatova et al., 2014b). Although two different species have not yet been recognized, the scientific community suggested that the mammal-eating killer whales be referred to as "Bigg's" killer whales.

As predators with high energetic requirements occupying the upper trophic level (Williams et al., 2004), Bigg's killer whales are of great interest to scientists. Some research suggested that sharp decreases in the number of marine mammal species (Steller sea lions [*Eumetopias jubatus*], northern fur seals [*Callorhinus ursinus*], harbor seals [*Phoca vitulina stejnegeri*], and sea otters [*Enhydra lutris*]) in the North Pacific were caused by killer whale predation (Estes et al., 1998;

Springer et al., 2003; Williams et al., 2004). Bigg's killer whales were infrequently encountered throughout their range and in significantly fewer numbers than resident ecotype killer whales, and their repeated encounters were uncommon (Zerbini et al., 2007; Shulezhko, 2008; Shulezhko & Burkanov, 2012). At present, the population size and structure of Bigg's killer whales in the northwest Pacific Ocean remain unknown.

In the Sea of Okhotsk, Bigg's killer whales have been seen in the northeastern part of Sakhalin Island (Burdin et al., 2004b, 2016; Parsons et al., 2013; Bobkov et al., 2014; Filatova et al., 2016a), in the northern part of the Okhotsk Sea (Shulezhko, 2008; Parsons et al., 2013; Filatova et al., 2016b), near the southwestern coast of Kamchatka Peninsula (Burdin et al., 2016; Filatova et al., 2016a), and in Shantar region and Sakhalinsky Bay, the western part of the Okhotsk Sea (Shpak & Shulezhko, 2013; Filatova et al., 2014a, 2014b, 2016a; Shpak, 2015; Shpak & Paramonov, 2015; Shpak et al., 2016). Over many years of study in the Kuril Islands, only a few cases of killer whale predation on marine mammals have been described (Sleptzov, 1955; Kornev, 2008; Permyakov & Burkanov, 2009). According to the majority of reported observations, only resident killer whales were encountered in these waters (Betesheva, 1961; Ivanova, 1961; Burdin et al., 2004b; Parsons et al., 2013).

The Kuril Islands are one of the richest commercial regions of the world's oceans, abundant with diverse fish resources and marine mammals. Pinnipeds that typically occur here include Steller sea lions, northern fur seals, spotted seals (*Phoca largha*), and harbor seals; sea otters are also common (Kostenko et al., 2004). Numerous cetacean species occur around these islands during summer months and, besides killer whales, include Dall's porpoises (*Phocoenoides dalli*), sperm whales (*Physeter macrocephalus*), and minke whales (*Balaenoptera acutorostrata*) (Shulezhko, unpub. data, 2002-2015; Shulezhko, 2008).

The objective of this article is to summarize our observations of Bigg's killer whales around the Kuril Islands from 2002 to 2015 and to include a review of all publications detailing documented sightings of mammal-eating killer whales in these waters.

Methods

Research was conducted from 2002 to 2015 using shipboard and land-based observations of the water around the Kuril Islands from Shumshu Island in the north to Iturup Island in the south (Figure 1).

Land-Based Observations

Land-based observations were conducted near Steller sea lion rookeries located on four islands of the Kuril archipelago: (1) Antsiferov Island, (2) Dolgaya Rock (Kamennye Lovushki Islands), (3) Raykoke Island, and (4) Brat Chirpoev Island (Chernye Brat'ya Islands) (Figure 1). The pinniped rookery located on Dolgaya Rock consisted of both Steller sea lions and northern fur seals. Another mixed species rookery located on Srednego Islands (Figure 1) was visited occasionally—up to one or two times during summer months, usually in July.

Observations were conducted during the entire breeding period of Steller sea lions, beginning annually in May and running through mid-July from 2002 to 2011. No observations were conducted in 2008 on Brat Chirpoev Island. In 2012 to 2015, the rookeries were monitored not by observers but with time-lapse cameras, and they were visited twice during each breeding season: at the end of May/beginning of June and in mid-July. In total, 80% of Steller sea lion rookeries and 50% of northern fur seal rookeries, including adjacent waters, were studied with regular, long-term observations during the pinniped breeding season.

At each rookery, a single observer scanned the water surface every hour beginning at daylight. Observers replaced one another every 4 to 6 h. Binoculars (Nikon, Commander 8 × 40), spotting scopes (Bausch & Lomb Discoverer, 15-60 × 60 mm), and cameras for photo and video recording (Canon Rebel XTi/EOS-400D with EF 75-300 mm f/4-5.6 III Lens) were used during observations. When killer whales approached the rookery, group size, sex, and age structure of the group; their behavior; and the response of nearby pinnipeds to their presence were noted. The behavior of killer whales was classified into one of four categories: (I) killer whales were just passing by the rookery (transient travelling), (II) nonhunting on marine mammals activities (such as hunting for fish and surface activity) of killer whales near the rookery with no obvious reaction of nearby pinnipeds, (III) nonhunting on marine mammals activities (such as high surface activity including breaching, spy hopping, fluke slapping, etc.) with obvious behavior change of nearby pinnipeds, and (IV) hunting pinnipeds.

During statistical analyses, each category of killer whale behavior was considered as an independent scenario with binomial distribution, where N was taken as the total number of killer whale encounters, X was the number of "successes" in each of the categories, and $\hat{p}$ was sample estimate for proportion of "successes" (binomial mean). Confidence intervals (CIs) for binomial mean values in each category were computed using the Adjusted Wald method (Agresti & Caffo, 2000; Zar, 2010). Statistical analysis was done using *R* statistical computing software, Version 2.15.0.

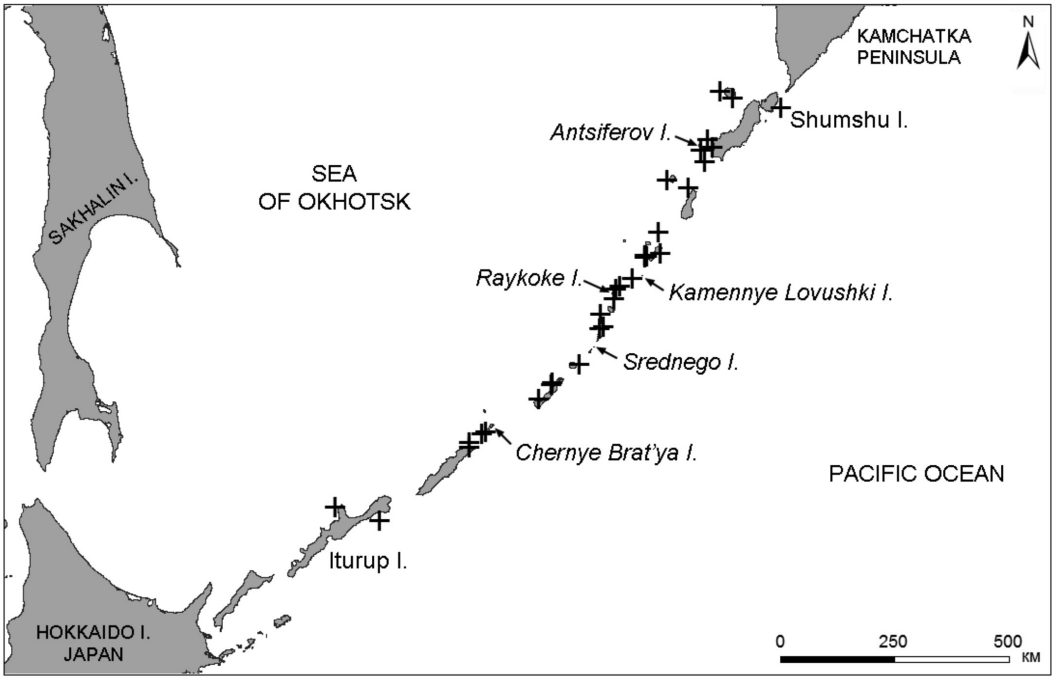

Figure 1. The geographic area of killer whale (*Orcinus orca*) observations in 2002 to 2015. The islands with pinniped rookeries are annotated with arrows; the locations where photo-identification and acoustic data were collected during shipboard observations are marked by crosses.

Shipboard Observations and Data Collecting from Skiffs

Shipboard observations were held opportunistically while conducting pinniped research during 41 vessel cruises in the spring-summer period(s) for 2002 to 2015. Near the Kuril Islands, research ships travelled on both the Okhotsk Sea and Pacific Ocean sides of the islands. Standard cetacean data collection methods were used, including photo-identification (Bigg, 1982; Bigg et al., 1983), acoustic recording, and biopsy sampling. To minimize animal disturbance, first the acoustic record of an encountered killer whale group was made from a distance of 50 to 200 m; and then the skiff approached the group and photographed the left sides of each individual, if possible. Next, a biopsy sample of one photo-identified animal from the group was taken. The sound recording system consisted of a Marantz professional tape recorder or Sony DAT TCD D100 digital recorder and an omnidirectional Offshore Acoustics hydrophone with a frequency range from 10 Hz to 40 KHz. Depending on weather conditions, the hydrophone was deployed to a depth of 5 to 10 m. Records were made at a sampling frequency of 44.1 or 48 kHz. A Canon EOS 1D camera with a 100 to 400 mm lens was used for photographs.

Ecotype Identification

A number of characters that differ between resident and Bigg's killer whales were used for ecotype identification, including morphological features (Baird & Stacey, 1988b; Shulezhko et al., 2006; Shulezhko, 2008; Shulezhko & Burkanov, 2008), acoustic behavior (Ford, 1989; Ford & Ellis, 1999; Deecke et al., 2005; Shulezhko et al., 2006; Shulezhko, 2008; Shulezhko & Burkanov, 2008), killer whale behavior and group size (Ford & Ellis, 1999; Ford et al., 2000; Shulezhko et al., 2006), and behavior of other marine mammals present nearby (Baird & Stacey, 1988a; Deecke, 2005; Ghai & Insley, 2011). Morphological features were analyzed from photos that were obtained during shipboard and land-based observations. Dorsal fin shape and the shape and pigmentation pattern of the saddle patch were analyzed and classified as either resident or transient ecotype (Baird & Stacey, 1988b; Shulezhko et al., 2006; Shulezhko, 2008; Shulezhko & Burkanov, 2008). During land-based observations, photos of a quality sufficient for ecotype identification were obtained only for animals that were detected at a distance not more than 200 m from shore. Photos were analyzed in *ACDSee*, Version 3.0.

Records for acoustic analysis were obtained only from skiffs in the course of shipboard observations; no records were made during land-based observations. Vocal activity of resident and Bigg's killer whales differs significantly and, therefore, can be used as one of the additional tools for ecotype identification (Deecke et al., 2005; Shulezhko et al., 2006; Shulezhko, 2008; Shulezhko & Burkanov, 2008). The acoustic activity of each killer whale pod (total number of sounds per unit of time) was calculated. The repertoires of discrete (stereotype) calls used by resident and Bigg's killer whales are completely different (Ford, 1989; Ford & Ellis, 1999), so comparison of repertoires can also serve as a tool for ecotype identification. The discrete call repertoire of each group was compared with discrete calls produced by killer whales of each known ecological type such as the resident killer whales of Avacha Gulf, eastern Kamchatka Peninsula (Burdin et al., 2006). When similarity among repertoires was revealed, the encountered group of killer whales was classified as resident. Otherwise, the other above-mentioned features that differ between resident and Bigg's killer whales were used for ecotype identification. Acoustic analyses were made with *Avisoft SASLab Pro*, Version 4.3.

Analysis of the Repeated Encounters

Photographs of Bigg's killer whales that we examined and in which we confirmed individual whale identity were added to the *Catalogue of Killer Whales of the Kuril Islands*. Following the standard method, only an animal's left side was used in the catalogue (Bigg et al., 1990). To reveal repeated encounters, the best photographs of identified individuals were compared with each other and with photographs of killer whales from published resources (catalogues and articles). These sources included killer whales of Ul'bansky Bay, the western part of the Okhotsk Sea (36 animals) (Shpak & Shulezhko, 2013); killer whales of eastern Kamchatka (350 animals) (Burdin et al., 2006); and killer whales of eastern Hokkaido (25 animals) (Sato, 2004). Additional comparisons were made to photographs of killer whales from the northeastern Pacific Ocean (three catalogues, 726 individuals) (Ford & Ellis, 1999; Matkin et al., 1999; Ford et al., 2000). We also compared our photographs to unpublished photographs of Bigg's killer whales from the northwestern Pacific; these included three animals encountered near Utashud Island, southeastern Kamchatka (2014; data provided by V. V. Vertyankin), and 32 animals from the Commander Islands (2005 to 2015; data provided by O. A. Belonovich, S. V. Fomin, and A. D. Kirillova). When a repeated encounter was detected, time interval and distance between the encounters were defined.

Results

Results of Shipboard Observations Along the Kuril Island Chain

During opportunistic marine mammal observations from vessels, 31 killer whale groups were approached either by ship or from an inflatable motor boat launched from the ship. During the research, 7,943 photos and 293 min of acoustic records of killer whales were obtained. In total, 139 killer whales were identified. Based on analyses of morphological and acoustic features of these individuals, they were all categorized as resident ecotypes and were repeatedly observed hunting for salmon. During 10 years of photo-identification and acoustic data sampling from large vessels or small inflatable boats, no killer whales with features typical of Bigg's ecotype were detected, and no cases of killer whale attacks on other marine mammals were observed.

Bigg's Killer Whales at Brat Chirpoev Island

We recorded 144 observations of killer whale groups of both ecotypes in close proximity (< 200 m) to the rookery at Brat Chirpoev Island (Table 1). Killer whales were sighted from six to 40 times in a single season; group sizes varied from two to 23 animals. The behavior of the majority of the encountered killer whale groups was travelling in passing by mode (Behavior Type I; see "Methods") by the island at distances of 50 to 200 m from shore ($\hat{p}$ = 0.73, CI = 0.49 to 0.88). During this travelling behavior, the killer whales showed no obvious reaction to the rookery or pinnipeds swimming in the water adjacent to the rookery. Nonhunting on marine mammals activities by killer whales with no obvious reaction of pinnipeds (Behavior Type II) included hunting for fish and surface activity and was observed less often than travelling in passing by mode ($\hat{p}$ = 0.15; CI = 0.05 to 0.40). During these activities, no reactions of pinnipeds directed towards the killer whales were observed. Nonhunting on marine mammals activities of killer whales with obvious disturbance of pinnipeds (Behavior Type III) was uncommon ($\hat{p}$ = 0.07; CI = 0.00 to 0.32) at this island and near these rookeries. Any killer whale disturbance to sea lions seemed more to be a result of fast movements by killer whales at distances less than 100 m from the rookery and were accompanied by surface activities such as spy hopping, breaching, and tail slapping. It is important to note here that the observed reactions of sea lions (increased vocal activity and escapes into the water) are typical for this species when encountering any unexpected sound or movement close to the rookery. Together with photo-identification results and the group size analysis, Behavior Types I, II, and III allowed us to suggest that these encountered killer whales were the resident ecotype.

Table 1. Behavior of killer whales (*Orcinus orca*) near Brat Chirpoev Island in 2002 to 2011

Behavior category	Year									Total number of registrations
	2002	2003	2004	2005	2006	2007	2009	2010	2011	
Travelling in passing by mode (*X*)	5	7	15	30	8	12	14	7	7	105
Activities with no obvious reaction of pinnipeds (*X*)	0	4	0	7	2	5	1	1	2	22
Nonhunting on marine mammals activities of killer whales with obvious disturbance of pinnipeds (*X*)	0	1	0	1	2	0	3	2	1	10
Attacks on pinnipeds (*X*)	1	2	0	2	0	0	1	0	1	7
Total number of killer whale encounters (*N*)	6	14	15	40	12	17	19	10	11	144

Near Brat Chirpoev Island, hunting Steller sea lions (Behavior Type IV) was observed on seven occasions ($\hat{p}$ = 0.05; CI = 0.00 to 0.29) (Table 1). In three cases, killer whales suddenly appeared near the rookery (the observer did not notice from which direction they came), moved rapidly along the shoreline, and immediately attacked sea lions resting in the water. The active phase of hunting during each of these three observations—attacking the pinnipeds—consisted of only one attack lasting less than 10 min, and the killer whales made no repeated attempts. Each single observed hunting attempt was not successful, and the killer whales left the area after each attempted hunt.

For four other cases, killer whales approached the island directly from the sea and started patrolling the rookery along the kelp line; this patrolling lasted up to 1 h. Attacks of pinnipeds were observed only in two (50%) of these four cases. During one of these two cases (2002), an adult female killer whale swam up and over the kelp (*Laminaria* sp.) at high speed and tried to catch a sea lion in the water nearshore. The attempt failed, and the killer whale went back beyond the kelp line. During the other case (2011), a killer whale group of four animals (one female had a calf; Figure 2) approached the rookery and started hunting sea lions. During the next hour, this group attacked sea lions in the water at least ten times in different places along the shore. All attacks were made at great speed, and it looked like the killer whales were attempting to ram and stun the sea lions rather than catch them with their teeth, although it was difficult to see whether the whale mouths were closed or open. The sea lions easily avoided all attacks, climbing ashore or onto nearby reefs. After each unsuccessful attempt, the killer whales left that target before immediately going for another.

Steller sea lion reactions to killer whale attacks were displayed via different defensive tactics. When killer whales showed little interest in the rookery or moved in different directions near the rookery without attacking sea lions, the sea lions escaped onto shore or hid in the kelp and vocalized loudly each time they noticed the predators. When killer whales attacked the sea lions or exhibited surface activities indicative of attack, the sea lions went into the water where they gathered in two dense groups of variable numbers and

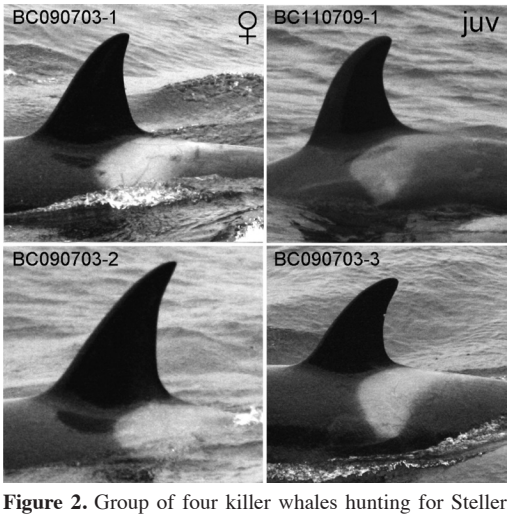

Figure 2. Group of four killer whales hunting for Steller sea lions (*Eumetopias jubatus*) near Brat Chirpoev Island in 2009 and 2011

sex/age composition. The smaller group consisted of adult males, and they stayed in the kelp opposite the predators. The other group, which was about twice the size of the male group, consisted of females and young animals that stayed closer to shore. Both pinniped groups moved actively in the water, joining and disjoining with each other and loudly vocalizing in response to every emergence of the killer whales. While in the water, the sea lions stayed within the limits of the kelp, which apparently was considered a safe area. After the killer whales left the area, the sea lions did not resume normal activity nor return to land for about an hour.

According to analysis of video records from 2002 and 2005 and photographs from 2009 and 2011, the killer whales hunting for sea lions near Brat Chirpoev Island had saddle patches and dorsal fins typical of Bigg's killer whales.

Bigg's Killer Whales at the Kamennye Lovushki Islands

Bigg's killer whales were encountered near the Kamennye Lovushki Islands on 8 July 2015. This group of six killer whales included one adult male, one female with a calf, and three others (Figure 3), and they attacked a northern fur seal 200 m north of Dolgaya Rock. The killer whales circled the fur seal and then exhibited individual abrupt rushes into the center of the circle towards the fur seal. The attack lasted about 2 min. Once the attack ended, the killer whales hovered close to each other near the surface for about 10 s and then slowly left the area. Based on body size, the fur seal was likely a female or an immature male. The observer was unable to determine if the hunt was successful: the distance between him and whales was about 350 m. However, he did not see the fur seal after the attacks. The other northern fur seals and Steller sea lions stayed on the rookery and showed no reaction to the presence of the killer whales or to the attack on the fur seal. All killer whales in the group were photographed, and their dorsal fins and saddle patches were typical for Bigg's ecotype. The adult male was easily distinguishable even at a distance due to a large, roundish notch on the trailing edge of the dorsal fin (Figure 3).

Repeated Encounters

We compared photographs of the Bigg's ecotype killer whales that were observed near Brat Chirpoev Island in July of 2009 and 2011, and found that they were the same whales. The killer whales consisted of a single pod of four individuals (Figure 2). We also compared all our photographs to published and unpublished sources and found that none of these whales had been encountered or photo-identified earlier in any other part of the North Pacific.

Figure 3. Group of killer whales hunting for northern fur seals (*Callorhinus ursinus*) near Dolgaya Rock in 2015

Discussion

During commercial whaling in the middle of the 20th century, 43 stomachs of killer whales caught off the Kuril Islands were examined. Of those, 26 were empty and 17 contained fish or squid remains (Betesheva, 1961; Ivanova, 1961). Soviet scientists wrote that "in Kuril waters killer whales . . . are at times content with feeding only on fish and squid" (Ivanova, 1961, p. 210). They assumed a piscine diet because of the lack of available marine mammals, not because killer whales had become specialized on fish consumption (Betesheva, 1961; Ivanova, 1961). According to current genetic studies, the killer whales encountered near the Kuril Islands should be classified as resident ecotype (Burdin et al., 2004b; Parsons et al., 2013). There are only a few published records of killer whale predation on marine mammals in the Kuril Islands. In the 19th century, Captain Henry G. Snow, who had been hunting marine mammals in the Kuril Islands for 16 years, described a group of killer whales attacking a female humpback whale (*Megaptera novaeangliae*) with a calf (Snow, 1897). In the

20th century, "killer whales chasing fin whales were repeatedly observed by whalers of the Kuril fleet" (Sleptzov, 1955, p. 37). In the 21st century, Kornev (2008) reported a case of predation by a small killer whale group on a single sea otter near Paramushir Island, which is the northern part of the Kuril Islands. Killer whale attacks on pinnipeds have been reported only within the time period of the present study (Permyakov, 2006; Permyakov & Burkanov, 2009). According to both information collected by us and that in the published literature, the predominant killer whale ecotype summering near the Kuril Islands is the fish-eating (resident) ecotype.

No hunting for fish has been observed for the Bigg's killer whales we identified. Hunting tactics used by these killer whales while pursuing Steller sea lions near Brat Chirpoev Island (i.e., patrolling the kelp line from open sea with subsequent attacks) is similar to killer whale "corralling" during predation on southern elephant seals (*Mirounga leonina*) and South American sea lions (*Otaria flavescens*) near Valdez Peninsula, Argentina (Lopez & Lopez, 1985). Attacks along the shoreline were similar to the nearshore foraging of killer whales hunting on spotted seals in the northeastern Pacific (Baird & Dill, 1995). Hunting tactics of killer whales during attack on the northern fur seal near the Dolgaya Rock (i.e., swimming around the prey and then darting in to attack) was repeatedly observed in the Commander Islands (Ryazanov, unpub. data, 2008-2012). This attack behavior was also observed when killer whales preyed on walruses (*Odobenus rosmarus*) in the Eastern Bering Sea off the Chukotka coast (Kryukova et al., 2012) and on Steller sea lions in Alaska (Barrett-Lennard et al., 1995). Thus, the behavior of killer whales attacking Steller sea lions and northern fur seals in the Kuril Islands corresponded to published descriptions of killer whale pinniped hunting tactics in other parts of their range.

According to studies conducted in the northeastern Pacific, Steller sea lions reacted differently to resident and Bigg's killer whales that approached the rookery, suggesting they seemed to recognize the predator's ecotype (Baird & Stacey, 1988a; Deecke, 2005; Ghai & Insley, 2011). In most instances at Brat Chirpoev Island, Steller sea lions showed no reaction to killer whales, which were indifferent to the rookery. We assume that the killer whales that showed no interest towards sea lions and did not disturb them were resident ecotype. This assumption is consistent with observations on killer whale behavior and group size, as well as photo-analyses data. Nevertheless, the group of killer whales that caused a slight disturbance when they passed within 100 m of the Steller sea lion rookery in 2009 was likely resident. We think that this disturbance was caused by the sounds of the killer whales' blow, which were easily audible during calm weather. Such response is a common reaction of Steller sea lions to any sudden or unusual sounds or objects appearing near the rookery.

In response to the presence of Bigg's killer whales, Steller sea lions either stayed on shore or rushed into the water where they gathered in groups. Both types of reaction were accompanied by increasing vocal activity. Grouping as a counteraction to predators is a typical defensive tactic (Begon et al., 1989); this behavior was also observed in Steller sea lions in open water (Branson, 1971). Mass movement into the water as a reaction to killer whales was also described for Steller sea lions in the northeastern Pacific (Ghai & Insley, 2011). So far as this behavior makes them more susceptible to predation, it was not a directed defensive tactic but likely a result of panic provoked by certain sea lions who suddenly noticed the killer whales near the shore. Interestingly, killer whales hunting northern fur seals near Dolgaya Rock did not cause any reaction among the fur seals on the rookery. These killer whales were 200 m or more offshore, and the fur seals may not have seen them—visual acuity of pinnipeds in air is not high (Andreev, 1978). When Bigg's killer whales approached to within 100 m or less to the rookery, they caused noticeable changes in pinniped behavior, including an increase of vocal activity and demonstration of different defensive tactics.

We found no records of killer whale attacks on pinnipeds in the waters of the Kuril Islands except for those occurring during this study. In summer, about 50 Steller sea lion haul-out sites and rookeries are found within the Kuril Islands. The total number of sea lions can approximate nearly 10,000 individuals (Burkanov & Loughlin, 2005; Burkanov et al., 2008). There are two northern fur seal rookeries in the Kuril Islands. During the 2000s, the number of northern fur seal pups born each year on these rookeries was estimated to be 30,000 individuals (Burkanov, unpub. data, 2002-2017), which represents about 30% of the population (Kuzin, 1999). Spotted seals also occur at numerous haul-out sites in the northern and southern parts of the Kuril Islands with an estimated 4,000 individuals (Kornev et al., 2001; Trukhin, 2005). Harbor seals occur in all parts of the Kuril Islands with an estimate of 3,000 to 3,500 individuals in 2000 (Trukhin, 2000; Kornev et al., 2001). Undoubtedly, the Kuril Islands provide abundant available pinnipeds for killer whales to hunt and consume.

None of the documented cases of killer whale attacks on Steller sea lions near Brat Chirpoev Island were successful. Near Dolgaya Rock, killer whales hunted for northern fur seals but not for Steller sea lions. Over 10 years of research, our observations covered the entire period from arrival of the first animals at the rookeries to when pups

started swimming. It is unlikely that during this period some cases of successful killer whale hunting attempts were unnoticed by the observers. In the eastern Aleutian Islands, as well as near the Commander Islands, northern fur seals, but not the Steller sea lions, are the main prey of killer whales during summer (Mamaev & Burkanov, 2006; Matkin et al., 2007; Ryazanov et al., 2011; Belonovich et al., 2012). According to current estimates, Steller sea lions comprise only 4 to 14% of the killer whale diet in the Aleutian Islands and in the eastern part of the Bering Sea (Wade et al., 2010). Steller sea lions may be one of the more dangerous and difficult prey species for killer whales (Baird, 2002), which may explain why killer whale attacks on Steller sea lions are rare and usually result in failure (Ford & Ellis, 1999; Saulitis et al., 2000; Heise et al., 2003). Others have proposed that an adult Steller sea lion is a difficult prey for a single killer whale but an optimal target for a hunting group of killer whales (Baird & Dill, 1995, 1996). In support of this hypothesis, killer whales from one of the genetically isolated mammal-eating populations from the Gulf of Alaska (GOA) successfully hunt almost exclusively on Steller sea lions. GOA transients prefer this species even to harbor seals, which comprise up to 40% of the diet of Bigg's killer whales from other populations inhabiting the same area (Saulitis et al., 2000; Matkin et al., 2005; Maniscalco et al., 2007).

Specialization of predation on large pinniped species requires the development of specific hunting tactics. In killer whales, hunting skills are the likely result of cultural traditions and are passed from one generation to the next by learning (Saulitis et al., 2000; Baird, 2002; Maniscalco et al., 2007). A conclusion can be made that the Bigg's killer whales identified near Brat Chirpoev Island are not specialized for predation on adult Steller sea lions. However, we cannot exclude that these killer whales can successfully hunt young Steller sea lions and pups. For example, during 5 years of observations of GOA transients near the Chiswell Island Steller sea lion rookery, killer whales successfully attacked only young sea lions or pups (Maniscalco et al., 2007). Additionally, it is possible that predation on younger sea lions and pups might not be as noticeable by an observer as the predation on larger prey (Barrett-Lennard et al., 1995; Heise et al., 2003). We speculate that some of the repeated hunting attempts by Bigg's killer whales near Brat Chirpoev Island were successful or that these killer whales were in the process of learning how to hunt an adult Steller sea lion.

Bigg's killer whales in the northeast Pacific take prey species in proportion to their availability (Ford & Ellis, 1999; Krahn et al., 2007), and the principal diet of most populations in this region in summer consists of Dall's porpoises and harbor seals (Saulitis et al., 2000; Heise et al., 2003). Both of these species are abundant during summer in the Kuril Islands (Trukhin, 2000; Kornev et al., 2001; Shulezhko & Burkanov, unpub. data, 2002-2017). The stomachs of killer whales taken in the commercial harvest in the northwestern Pacific during 20th-century whaling contained cetacean bones four times more often than pinniped bones (Tomilin, 1980). Killer whales hunting in open water are not easy to observe simply because the action occurs mostly out of sight under water (Heise et al., 2003). It is quite possible that Bigg's killer whales in the Kuril Islands prefer hunting on phocids or cetaceans and attack eared seals only on rare occasions.

The killer whales that we identified were not in any of the published catalogues, which suggests that they were not encountered in other parts of the northwestern or northeastern Pacific. The migration pattern for Bigg's killer whales identified in the northwestern part of the Pacific to a large extent remains unknown. However, recent travel of a Bigg's killer whale female between the northeastern coast of Sakhalin Island and the western coast of Kamchatka Peninsula (the distance of about 900 km) was documented: the time interval between the two encounters amounted to 11 years (Burdin et al., 2016).

Movements of Bigg's killer whales in the North Pacific are determined by seasonal gatherings of available prey (Baird & Dill, 1995; Matkin et al., 2007; Maniscalco et al., 2007; Dahlheim et al., 2009; Barrett-Lennard et al., 2011). Bigg's killer whales are capable of travelling long distances (Goley & Straley, 1994; Matkin et al., 2007) but still display a seasonal site fidelity towards certain areas where they return to take advantage of prey aggregations (Durban et al., 2010). In the Commander Islands (Mamaev & Burkanov, 2006; Ryazanov et al., 2011; Belonovich et al., 2012) and in the western Sea of Okhotsk (Shpak, 2012; Shpak & Shulezhko, 2013), Bigg's killer whales were repeatedly encountered during one or more seasons. According to the present study, at least some of the Bigg's killer whales in the Kuril Islands periodically returned to the same area during times when the maximum numbers of pinnipeds were present.

According to our research in the Kuril Islands, Bigg's killer whales are not numerous and do not provide significant influence on the populations of the eared seals, including endangered Steller sea lions. Still, further research is needed to evaluate the impact of mammal-eating killer whales on phocids and cetacean species in this region.

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