A multi-species synthesis of satellite telemetry data in the Pacific Arctic (1987–2015): overlap of marine mammal distributions and core use areas

John J. Citta[a,*], Lloyd F. Lowry[b], Lori T. Quakenbush[a], Brendan P. Kelly[c], Anthony S. Fischbach[d], Josh M. London[e], Chadwick V. Jay[d], Kathryn J. Frost[f], Gregory O'Corry Crowe[g], Justin A. Crawford[a], Peter L. Boveng[h], Michael Cameron[h], Andrew L. Von Duyke[i], Mark Nelson[a], Lois A. Harwood[j], Pierre Richard[k], Robert Suydam[i], Mads Peter Heide-Jørgensen[l], Roderick C. Hobbs[h], Dennis I. Litovka[m], Marianne Marcoux[n], Alex Whiting[o], Amy S. Kennedy[p], John C. George[i], Jack Orr[n], Tom Gray[q]

[a]*Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701, USA*

[b]*University of Alaska, School of Fisheries and Ocean Science, 73-4388 Paiaha Street, Kailua Kona, Hawaii 96740, USA*

[c]*International Arctic Research Center, University of Alaska, Fairbanks, Alaska 99775, USA*

[d]*U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, Alaska 99508, USA*

[e]*Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way N.E., Seattle, Washington 98115, USA*

[f]*73-4388 Paiaha Street, Kailua Kona, Hawaii 96740, USA*

[g]*Harbor Branch Oceanographic Institute, Florida Atlantic University, 5600 U.S. 1 North, Fort Pierce, Florida 34946, USA*

[h]*Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way N.E., Seattle, Washington 98115, USA*

[i]*North Slope Borough Department of Wildlife Management, PO Box 69, Utqiaġvik, Alaska, 99723, USA*

[j]*Department of Fisheries and Oceans, Yellowknife, Northwest Territories X1A 1E2, Canada*

[k]*Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, MB R3T 2N6, Canada (retired)*

[l]*Greenland Institute of Natural Resources, Strandgade 91, 2, DK-1401 Copenhagen K, Denmark*

[m]*Marine Mammal Laboratory, ChukotTINRO, Str. Otke 56, Anadyr, Chukotka, 689000, Chukotka, Russia*

[n]*Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada*

[o]*Native Village of Kotzebue, PO Box 296, Kotzebue, Alaska, 99752, USA*

[p]*Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, Washington, 98105, USA*

[q]*Alaska Beluga Whale Committee, PO Box 306, Nome, Alaska 99762, USA*

Abstract

We collated available satellite telemetry data for six species of ice-associated marine mammals in the Pacific Arctic: ringed seals (*Pusa hispida*; *n*=118), bearded seals (*Erignathus barbatus, n*=51), spotted seals (*Phoca largha, n*=72), Pacific walruses (*Odobenus rosmarus divergens, n*=389); bowhead whales (*Balaena mysticetus, n*=46), and five Arctic and sub-arctic stocks of beluga whales (*Delphinapterus leucas, n*=103). We also included one seasonal resident, eastern North Pacific gray whales (*Eschrichtius robustus, n*=12). This review summarized the distribution of daily locations from satellite-linked transmitters during two analysis periods, summer (May–November) and winter (December–April), and then examined the overlap among species. Six multi-species core use areas were identified during the summer period: 1) Chukotka/Bering Strait; 2) Norton Sound; 3) Kotzebue Sound; 4) the northeastern Chukchi Sea; 5) Mackenzie River Delta/Amundsen Gulf; and 6) Viscount Melville Sound. During the winter period, we identified four multi-species core use areas: 1) Anadyr Gulf/Strait; 2) central Bering Sea; 3) Nunivak Island; and 4) Bristol Bay. During the summer period, four of the six areas were centered on the greater Bering Strait region and the northwestern coast of Alaska and included most of the species we examined. The two remaining summer areas were in the western Canadian Arctic and were largely defined by the seasonal presence of Bering-Chukchi-Beaufort stock bowhead whales and Eastern Beaufort Sea stock beluga whales, whose distribution overlapped during both summer and winter periods. During the winter period, the main multi-species core use area was located near the Gulf of Anadyr and extended northwards through Anadyr and Bering Straits. This area is contained within the Bering Sea "green belt", an area of enhanced primary and secondary productivity in the Bering Sea. We also described available telemetry data and where they can be found as of 2017. These data are important for understanding ice-associated marine mammal movements and habitat use in the Pacific Arctic

and should be archived, with appropriate metadata, to ensure they are available for future retrospective analyses.

Key words: ringed seal, *Pusa hispida*, bearded seal, *Erignathus barbatus*, bowhead whale, *Balaena mysticetus*, Pacific walrus, *Odobenus rosmarus divergens*, beluga whale, *Delphinapterus leucas,* gray whale, *Eschrichtius robustus,* Bering Sea, Chukchi Sea, Beaufort Sea, distribution, core area

* Corresponding author

E-mail address: john.citta@alaska.gov (J.J. Citta)

1. Introduction

Knowledge of where animals are located throughout the year is fundamental to managing their populations. Satellite telemetry is arguably one of the most effective tools for determining the distribution of marine species (Hart and Hyrenbach, 2009), especially in remote Arctic waters that are at times difficult to access from land, ship, or aircraft, such as in winter or when international jurisdictions preclude complete surveys. Although satellite telemetry data have been collected from most species of marine mammals in the Pacific Arctic, the data have not been considered in a multi-species manner that illustrates the potential for overlap in areas of importance.

A summary of marine mammal species distributions in the Pacific Arctic is timely, because their populations are at risk from factors related to declining sea ice and increasing anthropogenic disturbances. Arctic sea ice is forming later in the fall and melting earlier in the spring (Markus et al., 2009; Stroeve et al., 2014) and summer ice is rapidly declining in extent (e.g. Comiso et al., 2008; Stroeve et al., 2014) and thickness (e.g. Nghiem et al., 2007; Kwok et al., 2009; Comiso 2012). These trends are expected to continue; the Arctic is expected to be largely ice-free in summer sometime this century, perhaps by the 2030s or 2040s (e.g. Wang and Overland, 2012; Koenigk et al., 2013). The decline in sea-ice extent and changes in the timing of melt and freeze-up are expected to be problematic for some populations of Arctic marine mammals. Declining sea-ice habitat may directly threaten marine mammal populations that rely on sea ice as a platform for resting, molting, pupping, or from which to feed (e.g. Kelly 2001; Laidre et al., 2008, 2015; Jay et al., 2011; Kovacs et al., 2011; Udevitz et al., 2013; Luque et al., 2014), or as a refuge from predators (e.g. Higdon and Ferguson, 2009; Reinhart et al., 2013).

Arctic warming is also predicted to have profound impacts upon the ecology of the region. These impacts include, but are not limited to, changes in ocean circulation (e.g. Koenigk et al., 2013; Wassmann et al., 2015), declining salinity due to increasing freshwater input (e.g. Bluhm and Gradinger, 2008; Koenigk et al., 2013), changes in primary and secondary productivity (e.g. Bluhm and Gradinger, 2008; Tremblay et al., 2008; Søreide at al., 2010; Arrigo and van Dijken, 2015), less on-ice snow fall (e.g. Hezel et al., 2012; Iacozza and Ferguson, 2014), a de-coupling of resting and nursing habitat from foraging habitat (Kelly 2001), the northward advance of species (e.g. Mueter and Litzow, 2008; Ware et al., 2016), the influx of pathogens novel to the Arctic (e.g. Kutz et al., 2005), a potential increase in the virulence of existing pathogens (Hueffer et al., 2011), and an increase in algal toxins from harmful algal blooms (Lefebvre et al., 2016).

At the same time, declining sea ice has generated interest in the economic development of the Arctic, including the development of offshore petroleum fields and renewed interest in Arctic shipping lanes. Low crude oil prices combined with the high costs of Arctic petroleum development have put most current plans for petroleum exploration and drilling on hold. However, in the Pacific Arctic, petroleum wells are still active in the U.S. portion of the Beaufort Sea (Houseknecht and Bird, 2006) and petroleum exploration lease areas remain in the Canadian Beaufort Sea (see review in BREA, 2013; see also: https://www.aadnc-aandc.gc.ca/eng/1100100036298/1100100036301) and in U.S. and Russian waters in the Chukchi Sea (BOEM, 2012, 2015; Rosneft, 2014). Two shipping lanes pass through the Pacific Arctic and Bering Strait: the Northern Sea Route (NSR), which passes through northeastern Russia, and the Northwest Passage (NWP), which passes through the Canadian Archipelago. Although these shipping lanes have yet to become profitable (see review in Lasserre, 2015), shipping within the Pacific Arctic is increasing, particularly for tourism, and this trend is expected to continue (Arctic Council, 2009; Huntington et al., 2015). By midcentury, both the NSR and NWP are expected to be navigable by open-water vessels in September, while routes passing over the North Pole are expected to be navigable by ice-strengthened ships (Smith and Stephenson, 2013; Aksenov et al., 2017).

Our goal was to summarize available satellite telemetry data for a broad suite of marine mammals in the Pacific Arctic, particularly as a means of understanding the potential for impacts from the changes that are underway. We limited our consideration to species that occur at least seasonally within the Chukchi and/or Beaufort seas. We included data for ringed seals (*Pusa hispida)*, bearded seals (*Erignathus barbatus*), spotted seals (*Phoca largha*), Pacific walruses (*Odobenus rosmarus divergens*), Bering-Chukchi-Beaufort stock of bowhead whales (*Balaena mysticetus*), Eastern North Pacific gray whales (*Eschrichtius robustus*), and five different Arctic and sub-Arctic stocks of beluga whales (*Delphinapterus leucas*): the Eastern Beaufort Sea, Eastern Chukchi Sea, Eastern Bering Sea, Bristol Bay, and Anadyr stocks. We present the distribution of locations, derived from satellite telemetry data, for each species during two analysis periods, a "summer" period (May–November) and "winter" period (December–April), and then examine the overlap in species distributions and delineate multi-species core use areas in the Bering, Chukchi, and Beaufort seas. This information will provide a more holistic understanding of the distribution of marine mammals in the Pacific Arctic and should be useful for planning industrial activities, marine protected areas, and shipping lanes. It should help researchers and managers visualize where past marine mammal tagging efforts have been concentrated, and where additional telemetry studies may be needed.

2. Methods

2.1. Conceptual approach

The philosophy of our analysis was to present a simple, robust description of how the satellite location data were spatially distributed for each species. It is outside the scope of this study to examine the effects of sex, age, or sea ice. Many relationships have yet to be examined by the principal investigators that collected these data. Furthermore, this is not a study of animal movements, but a description of how satellite telemetry data are spatially distributed. Neither do we use animal movements or habitat associations to predict where animals may be located. We decided to include species for which there were small sample sizes, knowing that the resulting distributions are incomplete, so the reader can assess what data exist. The ability of the satellite telemetry data to accurately reflect the distributions of marine mammals is limited; these limitations are specific to each species and are discussed in Sections 4.1 and 4.3. In spite of these limitations, there is value in presenting what data exist, where those data are stored, where telemetry locations are positioned for each species, and how they overlap in space and time.

2.2. Animal tagging

Data used in this paper come from marine mammals tagged with satellite transmitters in northwestern Canada, northern and western Alaska, and eastern Russia by multiple organizations and investigators during 1987-2015 (Table 1; Appendices A-G). Tags that we used were of two basic types: "standard" transmitting tags and Fastloc GPS tags. With standard tags the Argos system (http://www.argos-system.org) uses polar orbiting satellites to estimate the location of a transmitter using Doppler shift whenever sufficient transmissions are received during a satellite pass. Data from the satellite are sent to a ground station where a location and its quality are calculated. Location quality is based mostly on the number of transmissions received during a satellite pass. A few tags included Fastloc™ GPS (Wildtrack Telemetry Systems Ltd., Leeds, UK) which acquires Global Positioning System data that are passed to Argos satellites and the ground station where position is calculated. GPS locations have an estimated standard deviation of 100 m, while Argos location classes 3, 2, and 1 have estimated standard deviations of 250 m, 500 m, and 1500 m, respectively (see http://www.argos-system.org/manual/). The standard deviations for locations with quality scores 0, A, and B are not provided by CLS, the company that administers the Argos system.

In general, seals and belugas were captured using nets. Seals had tags glued to their pelage or anchored through the web of a hind flipper. Typically, seals receiving flipper tags also had a tag glued to their pelage. Beluga tags were attached by two or three pins that pass through the dorsal surface of a whale. Walrus tags deployed prior to 2004 were attached to the tusk of a captured animal, and thereafter, most walrus tags were fit with a sub-dermal barbed anchor that embedded under the skin of the walrus's upper back by use of a crossbow, jab stick, or air gun. Bowhead and gray whale tags also had single anchors that were barbed and were deployed using air guns or were fitted to poles that were thrown by hand. We refer readers to the primary literature for each species for detailed capture and tag attachment methods (Table 1).

2.3. Location processing

We estimated a daily location for each animal using a continuous-time Correlated Random Walk (CRW) model developed by Johnson et al. (2008) and implemented in package *crawl*, version 2.0 (Johnson et al., 2016), in R (R Core Team, 2017). The CRW algorithm performs poorly when Argos error greatly exceeds measured values and CRW model priors. Because of this, Johnson et al. (2008) recommended pre-filtering Argos locations to remove locations with extreme error. To remove extreme outliers, we passed the raw location data through the sdafilter in R package *argosfilter* (Freitas et al., 2008a; Freitas, 2012). We set the velocity threshold to 4 m/s, which is greater than twice the maximum published velocities for any of the marine mammals we considered. The filter can also remove locations that form the vertex of acute angles in the path of movement. Such “spikes” in the path of movement are typically outliers and are not useful data. We removed locations that formed angles $< 45^o$ when they were farther than 15 km from the previous location. We used a distance threshold of 15 km, as Vincent et al. (2002) found that the 95% of low quality locations (location class = B) were within 15 km of the true location.

The CRW model treats movement as a velocity process with two parameters, β, the autocorrelation in velocity and σ, the variation in velocity. Location error was assumed to be normally distributed with a mean of 0 and a standard deviation equal to that declared by CLS for GPS locations, and location classes 3, 2, and 1. We treated error for the remaining three location classes as parameters to be estimated and fitted them to half normal distributions with semi-informative priors. Locations with classes 0, A, and B should have more error than those with a class of 1 (SD=1500 m). Hence, our half normal distributions had a lower bound of 1500 m. Using data from Vincent et al. (2002), our priors had a mean error 1500 m and a standard deviation of 5000 m for location classes 0 and A, and 7500 m for location quality score B. We also set a Laplace prior (double exponential) for β and σ, following the form recommended in the R vignette for package *crawl* (available online at: https://cran.r-project.org/web/packages/crawl/index.html). The Laplace prior had a mean of 3 and a variance of 0.5 on a natural log scale, which is approximately the value of β and σ we observe for most species. Note that this is only significant for tracks with few location data. The algorithm will estimate an animal's location during time periods in which we have no Argos locations, but we only use estimated daily locations from the CRW model when Argos locations were collected within 24 hours of the estimated location.

Daily locations were estimated at 0 UTC, which is approximately solar noon in Bering Strait. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). This restriction ensured we had enough data to fit the CRW model and also reduced the bias induced by tagging location, because animals that transmit for >30 days are less likely to have locations clustered near the deployment site.

2.4. Definition of seasons

We investigated two time periods based upon when marine mammals in the Pacific Arctic entered and exited the Bering Sea. The "summer" period was defined as May–November and the "winter" period as December–April. To distinguish the periods of analysis with meteorological or astronomical definitions of summer and winter, we refer to the period of analysis as either the "summer period" or the "winter period". Most ice-associated marine mammals that summer in the Pacific Arctic follow advancing sea ice southward and enter the Bering Sea in November and December, and then move northward with retreating sea ice in

April and May. This is generally true for the ice-associated seals (e.g. Burns, 1970, 2002; Lowry et al., 1998; Cameron et al., 2010; Crawford et al., 2011), walruses (e.g. Fay, 1982), bowhead whales (Citta et al., 2012), and the arctic stocks of beluga whales (Citta et al., 2016a). We acknowledge that this definition does not perfectly reflect the migratory timing for each species. Furthermore, while inclusion of more seasons would be interesting, many species lacked enough data to examine smaller time periods. Specifically, most species had small sample sizes during March – June. (see Appendix).

2.5. Utilization Distributions

For the analysis of seasonal distributions, we employed a raster grid of square cells, with 50 km sides on an Alaska Albers equal-area conic projection, with standard parallels at 55° and 65° north latitude, across our study area. We then used the command ‘raster.vol’ from the *spatialEco* package (Evans, 2016) in R (R Core Team, 2017) to calculate the percent volume for cells in a raster (i.e. a grid of cells). This approach is directly analogous to calculating a percent density contour using kernel methods (e.g. Worton et al., 1989); as such, the volume rasters we calculate are utilization distributions (UDs). Estimating UDs in this fashion differs from using a kernel method to estimate UDs in that there is no need to estimate the kernel bandwidth, also known as the kernel smoothing factor or the kernel variance. In kernel-based methods, the bandwidth smooths the location data, resulting in location density where no locations occurred. While this is theoretically valid because animals occur in-between the locations where position data are collected, the choice of bandwidth may result in over or under smoothing, which leads the resulting UDs to be too large or too small. Unfortunately, any bandwidth estimator may result in biased UDs depending upon how data are distributed in space (e.g. Kernohan et al., 2001; Gitzen and Millspaugh, 2003; Hemson et al., 2005). Furthermore, each species, perhaps each individual, may warrant different bandwidth values or even different bandwidth estimators. Rather than grapple with these issues, we based our UDs directly on the density of locations per grid cell which results in a clear and straightforward representation of the location data. Like kernel-based UDs, the density sums to 1 across the grid; unlike kernel-based UDs, only raster cells with location data have values in our UDs. A similar method (i.e. counting locations in raster cells) was used recently by Maxwell et al. (2013).

All daily locations received equal weight when calculating species-specific UDs. As such, tags that last longer contribute more days of data to a UD and inherently receive more weight. More complex weighting systems could be used; for example, Block et al. (2011) used a system that weighted animal locations by the number of tags that were transmitting on each day. With such an approach, locations received when fewer tags are transmitting are weighted more. The main conceptual issue with such a weighting system is that we do not know how representative of the population our sample is when few tags are transmitting. Because we do not know how to optimally weight locations, we decided to give the locations equal weight, which provides a very straightforward and reproducible representation of the data. To make the raster layers easier for the human eye to assess, we smoothed the grid by resampling the 50 km cells into 5 km cells. This was only done for visual presentation; all statistics were calculated from the 50 km cells.

We examined overlap of species distribution by calculating the proportion of overlap between the 99% and 50% UDs for each species within a season. Overlap in the 99% UDs represents the overlap in species' distributions and overlap in the 50% UDs represents the overlap in their core use areas. We identified core use areas that account for the density of all species by overlaying the species specific UDs, adding the grid cells across all species, and then re-scaling them to sum to 1 across the grid. We then re-calculated the 50% density contour to identify core use areas on our multi-species grid. We refer to these as "multi-species core use areas". Within multi-species core use areas, we calculated how many locations and animals from each species occurred in each core use area.

3. Results

3.1. Species distributions

3.1.1. Ringed seals

We used data from 118 ringed seals tagged in Alaska (77) and Canada (41) during 1999-2015 (Table 1, Appendix A). The distribution of tagged ringed seals during the summer period included the northern Bering, Chukchi, Beaufort, and East Siberian seas (Fig. 2a). Density of locations was generally higher close to where seals were tagged, with the notable exception of the Russian coast near Cape Serdtse-Kamen where density was high, but no seals were tagged. During the winter period, ringed seal locations largely shifted into the southern Chukchi Sea and northern Bering Sea, in shelf waters < 200 m deep (Fig. 2b).

3.1.2. Bearded seals

We used data from 51 bearded seals tagged in Alaska during 2004-2015 (Table 1, Appendix B). The majority of seals (75%) were tagged in Kotzebue Sound. Due to their elusive behavior and large size (~ 2.4 m long and weighing > 230 kg) only two adult bearded seals have been tagged in Alaska, the remaining bearded seals were immatures or pups (Appendix B).

The distribution of tagged bearded seals during the summer period was concentrated along the Alaskan coast from St. Michael north to Utqiaġvik (formerly Barrow; Fig. 3a). During the winter period, the distribution of tagged bearded seals extended from the southern Chukchi Sea south into the northern Bering Sea (Fig. 3b) and extended from Bristol Bay in the east to Karaginsky Bay in the west. Virtually all use was in shelf waters < 200 m deep.

3.1.3. Spotted seals

We used data from 72 spotted seals tagged in Alaska (67) and Russia (5) during 1991-2015 (Table 1, Appendix C). The distribution of tagged spotted seals during the summer period extended from the western Beaufort Sea to the eastern Siberian Sea in the north and from Bristol Bay to Karaginsky Bay in the south, and was almost completely limited to shelf waters < 200 m deep. Unlike ringed seals, the distribution of spotted seals was less dependent on where they were tagged and seals used the Russian coast extensively, near Cape Serdtse-Kamen and also areas in the southern Gulf of Anadyr (Fig. 4a). The distribution during the winter period was limited to shelf waters (< 200 m) mostly in the northern Bering Sea (Fig. 4b). Spotted seals were seldom located in Norton Sound and use was generally higher west of Nunivak Island, with the exception of Bristol Bay which had a high density of spotted seal locations. Spotted seals also used shelf waters south of the Gulf of Anadyr and Karaginsky Bay, along the eastern coast of Kamchatka.

3.1.4. Pacific walruses

We used data from 389 adult walruses from tags deployed during 1987-2015 (Table 1, Appendix D). Most tags (89%) were deployed after 2004 and 74% were deployed in the Chukchi Sea. Of the total, 79% were female, 19% were male, and 3% were of unknown sex. The distribution of tagged walruses during the summer period was heavily weighted towards the Chukchi Sea, and even more so in the eastern Chukchi Sea (Fig. 5a). We found areas of high walrus use near Hanna Shoal and Cape Serdtse-Kamen. The distribution of tagged walruses during the winter period was largely constrained to the areas that were targeted for tagging (Speckman et al., 2011; Jay et al., 2014), south of St. Lawrence and Nunivak islands (Fig. 5b) and areas of high use corresponded to these areas. During both periods, areas used by walruses were mainly limited to shelf waters (< 200 m).

3.1.5. Bering-Chukchi-Beaufort (BCB) bowhead whales

We used data from 46 bowhead whales from tags deployed during 2006 and 2015 (Table 1, Appendix E). The distribution of BCB bowhead whales during the summer period was centered on three areas: (1) shelf waters in the Canadian Beaufort Sea, extending from Tuktoyaktuk east into the deeper waters of Amundsen Gulf, (2) shelf waters adjacent to Utqiaġvik (formerly Barrow), and (3) the northern coast of Chukotka, mostly from Vankarem south to Bering Strait (Fig. 6a). The distribution during the winter period extended from Cape Serdtse-Kamen south through Bering and Anadyr straits. The main use area extended no farther south than Cape Navarin and there was also some use of the area adjacent to St. Matthew Island (Fig. 6b). In general, use was restricted to shelf waters.

3.1.6. Eastern North Pacific Gray whales

We used data from 12 gray whales, from tags deployed during 2006 and 2013 (Table 1, Appendix F). The distribution of tagged gray whales during the summer period was largely limited to the areas in which they were tagged (Fig. 7). This is mainly because so few whales have been tagged and tags attached to gray whales typically do not transmit for very long. No tags transmitted into the winter period.

3.1.7. Beluga whales

Five stocks of beluga whales summer in the Pacific Arctic: the Eastern Beaufort Sea (EBS), the Eastern Chukchi Sea (ECS), Eastern Bering Sea (NS), Bristol Bay (BB), and Anadyr (AN). To avoid confusing acronyms for the Eastern Beaufort Sea and Eastern Bering Sea stocks, we refer to the Eastern Bering Sea stock as (NS), because they frequent Norton Sound in summer. For the EBS stock we analyzed data from 32 belugas tagged in the Mackenzie Delta (Table 1 and Appendix G). During the summer period they primarily used the Canadian Beaufort Sea and Archipelago (Fig. 8a). The 21 ECS whales tagged at Point Lay primarily used the Alaskan Beaufort Sea and the eastern Arctic Basin (Fig. 9a). The two NS belugas were located in Norton Sound during the summer period and ranged into the southeastern Bering Sea during the winter period (Fig. 10), the seven AN belugas were located in the Gulf of Anadyr during the summer period and moved towards Cape Navarin and south along the Russian coast during the winter period (Fig. 11), and the 40 BB belugas remained in Bristol Bay during both winter and summer periods, but ranged farther from shore during the winter period (Fig. 12). Tagging efforts in Bristol Bay have recently included the deployment of Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) tags, which are small tags with dual anchor barbs (e.g. Andrews et al., 2008); no LIMPET data are included in this analysis, however, the inclusion those data would not alter our results.

3.2. Overlap of species distributions and core use areas

During the summer period, the distributions (99% probability distributions) of ringed, spotted, and bearded seals overlapped the most with other species, while distributions of the Bering Sea stocks of beluga whales (BB, NS, and AN) overlapped the least (Table 2). As expected, there was less overlap in the summer-period core use areas (50% probability distributions) than there was in the overall distribution for most species, indicating that the core use areas for each species was partially distinct. Because the ice-associated seals are widespread and migrate long distances, their summer-period core areas overlapped the most with other species and the core areas of the tagged Bering Sea stocks of belugas overlapped little with other species because they have limited distributions during the summer period. The largest amount of overlap in summer-period core areas was for EBS belugas which overlapped that of bowhead whales by 47%.

During the winter period, most Arctic species migrate into the southern Chukchi and northern Bering Seas and we expected overlap to increase. The average amount of overlap was higher during the winter period than during the summer period for both the overall distributions ($\bar{x}_{winter}$ =35% vs. $\bar{x}_{summer}$=25%) and core use areas ($\bar{x}_{winter}$ =11% vs. $\bar{x}_{summer}$=8%). Again, because ringed, spotted, and bearded seals are widely distributed and migrate long distances, they have more overlap than other species during the winter period, both in their overall distribution and core use areas (Table 3). The distribution of bowhead whales during the winter period had more than 50% overlap with that of EBS and ECS belugas, Pacific walruses had more than 50% overlap with bearded seals, EBS and ECS belugas. Ringed seals, spotted seals, bearded seals, bowhead whales, and EBS belugas all had 50% overlap in winter-period core areas with ECS belugas. This is because half of the core use area for ECS belugas was in Anadyr Strait, which many other species use. There was no overlap in winter-period core use areas of Pacific walruses with spotted and bearded seals (Table 3).

3.3. Multi-species core-use areas

3.3.1. Summer period

We identified six main areas where species overlapped during the summer period (May-November; Fig. 13a). We named these six areas: 1) Chukotka/Bering Strait; 2) Norton Sound; 3) Kotzebue Sound; 4) northeastern Chukchi Sea; 5) Beaufort Shelf/Amundsen Gulf; and 6) Viscount Melville Sound. The delineation of areas within the greater Bering Strait region (areas 1-4) is somewhat arbitrary in that the entire region could be considered a single area, however, there are clearly different zones within this area. For example, Norton Sound is clearly distinct from Kotzebue Sound.

The Chukotka/Bering Strait area included a large proportion of daily locations (>20%) of ringed, spotted, and bearded seals, bowhead whales, gray whales, walruses, and ECS belugas (Table 4). The Norton Sound area was largely defined by NS belugas; 52% of NS beluga daily locations were in Norton Sound. Norton Sound was also used by 20% of tagged bearded seals and 33% of tagged spotted seals. The Kotzebue Sound area was visited by many species, including some that were not tagged locally, such as ECS beluga whales. However, except for bearded seals, most species spent little time in Kotzebue Sound (Table 4). The northeastern Chukchi Sea area was the most diverse of the summering areas and contained >20% of daily locations for bearded seals, gray whales, walruses and ECS belugas. In addition, many species used the area: >20% of tags for all species were located within the northeastern Chukchi Sea area, except those for BB, NS and AN belugas, which never entered the Chukchi Sea. The Tuktoyaktuk/Amundsen Gulf area was predominantly important for ringed seals, bowhead whales, and EBS belugas. Viscount Melville Sound was predominantly important for EBS belugas, although it was also visited by a ringed seal and a bowhead whale.

3.3.2. Winter period

We identified four main areas where species overlap during the winter period (December-April): 1) Anadyr Gulf/Strait; 2) central Bering Sea; 3) Nunivak Island; and 4) Bristol Bay. The largest and most diverse area was Anadyr Gulf/Strait (Fig. 13b). This area extended from the west side of Bering Strait, south through Anadyr Strait, spanned the entrance into the Gulf of Anadyr, and branched east towards St. Matthew Island. The Anadyr Gulf/Strait core area included >20% of all locations for bowhead whales, Pacific walruses, and EBS, ECS, and AN belugas during the winter period. Additionally, more than 50% of all individuals for all species used this area during the winter period, except belugas from the BB beluga population, which never left Bristol Bay (Table 5). The central Bering Sea core use area was dominated by NS belugas; the identification of this core use area was largely an artifact of the how we weighted all species and stocks equally. Because only two NS belugas were tagged, they had a relatively large influence on the multi-species distribution; however, this area was also used by ringed, spotted, and bearded seals. The Nunivak Island core use area had a relatively large number of walrus locations (19%) and NS beluga locations (28%). This area was also used by 34% of tagged walruses and both NS belugas. The Bristol Bay core use area was largely defined by BB belugas. Because the cell resolution was 50 km, many beluga locations in the upper bays and rivers were not included on the grid. Thus, although our analysis showed 77% of all tagged BB belugas used Bristol Bay and that the area included 42% of all BB beluga daily locations, in reality, 100% of all tagged BB belugas and 100% of all daily locations were within the Bristol Bay core use area. Although Bristol Bay is clearly important for BB belugas, this area was little used by other species.

4. Discussion

4.1. Limits to population-level inference

Satellite telemetry studies are generally better suited for determining the movement behavior of individuals, rather than population-level distributions. For some species, such as bowhead and beluga whales that aggregate in recurring and relatively specific areas, the distribution of tagged animals may represent the distribution of the population. For example, most bowhead whales migrate past Utqiaġvik (formerly Barrow) in the spring and fall. Through tags deployed at Utqiaġvik, we can learn how the population is distributed and identify areas that are important for the population (e.g. Citta et al., 2015). Likewise, tagging ECS belugas at Point Lay (e.g. Suydam et al., 2001) or EBS belugas in the Mackenzie Delta (e.g. Richard et al., 2001) can be used to identify important areas for these species (e.g. Hauser et al., 2014; Citta et al., 2016a). In these cases, tagging in a restricted area can illuminate much of the year-round distribution of the population.

Satellite telemetry data are much less likely to reflect the population-level distribution for other species, such as ice seals and walruses. For the ice seals, this is because the distribution of telemetry locations is sensitive to the location and season of tagging. The location of tagging is important because ice seals appear to be philopatric to breeding areas. Ringed seals are known to return to the same areas of stable ice and fast ice in successive breeding seasons (Smith and Hammill, 1981; Sipilä et al., 1996; Kunnasranta 2001; Koskela et al., 2002; Krafft et al., 2007; Freitas et al., 2008b; Kelly et al., 2010; Martinez-Bakker et al., 2013). Van Parijs and Clark (2006) analyzed the trills of adult male bearded seals and found that 63% of adult male bearded seals were present in more than one year at the same location. This problem is exacerbated because adults can have small home range sizes. During the ice-bound season, Kelly et al. (2010) found that the home ranges of adult males ranged from <1 to 13.9 km^2 (median= 0.63 km^2) while the home ranges of adult females ranged from <1 to 27.9 km^2 (median=0.65 km^2). As such, data from adult ringed or bearded seals tagged on breeding territories will generally not be useful for determining their broader regional distribution in winter.

The timing of tagging is important for ice seals because most satellite tags are glued to the pelage and fall off when seals molt in spring. Following the molt, seals are difficult to tag because they are often found far from shore and seldom haul out, thus the data for much of the summer period is quite limited. For example, most of the seals tagged at Paktoa in the Canadian Beaufort Sea (Table 1; Fig. 2) were adults tagged on the sea ice in late March and early April, prior to the spring molt in late May and early June. Most of these seals did not travel far before tags were lost during the molt (Harwood et al., 2007; Figs. 2a and 13b). Flipper-mounted tags, attached through the web of the hind flipper, transmit for a longer period of time, but they provide few locations during periods of open water. For example, nine ringed seals tracked throughout the year via flipper-mounted tags were out of the water—and, hence could be located—only 5-10% of the time between August and December (Kelly et al., 2010).

Data from individual spotted seals appear to be more representative of the population-level distributions, as understood from natural history documentation and local traditional knowledge, than what we believe to be the case for ringed or bearded seals. Spotted seals associate with the southern ice edge in the winter, pup there in spring, and then migrate north to coastal areas in summer (Fay, 1974; Shaughnessy and Fay, 1977). The ice edge is highly dynamic in the Bering Sea and likely prevents spotted seals from keeping small home ranges. Indeed, the winter distribution of spotted seals was more evenly distributed in the Bering Sea than that of bearded or ringed seals (compare Fig. 4b with Figs. 2b and 3b). The seasonal distribution of satellite telemetry data from spotted seals was also generally what we would expect: more use of the central Bering Sea in winter and more use of coastal areas in summer (Lowry et al., 1998). However, to reliably identify core use areas, spotted seals would have to be tagged from more locations. Specifically, few spotted seals have been tagged south of Bering Strait and we would expect the Bering Sea summer distribution to be poorly captured by tagged individuals.

The distribution of walrus satellite telemetry locations was also limited by where and when walruses were tagged. During both seasonal periods, most tags were deployed in Alaskan waters and this likely weighted the distribution of locations towards Alaska (Fig. 5a). Only 15 walruses were tagged west of the international dateline in the Chukchi and Bering seas; most of these tags (11 of 15) were deployed on the north coast of Chukotka (Vankarem and Serdtse-

Kamen) between late-August and November (Appendix D, Fig. 5). Walrus distribution in winter was also poorly represented by the telemetry data. Typically, tags do not last more than 4-6 weeks on walruses and few tags lasted into winter. Out of the 389 tags we included in this analysis, only four provided data in January or February. As with the ice seals, more walruses would have to be tagged throughout more of species' seasonal ranges, for the distribution of tag locations to adequately represent the entire population.

These limitations do not invalidate the analysis; we identified common use areas that are important for marine mammals in the Pacific Arctic, many of which were previously identified by shipboard and aerial surveys and/or local knowledge (e.g. Moore et al., 1995, 2000; Harwood et al., 2010; Clarke and Ferguson, 2011; Clarke et al., 2013, 2016).

4.2. Multi-species core use areas during the summer period

During the summer period, three of the multi-species core use areas were within the greater Bering Strait region (Fig. 13a). Although this region has elevated densities of marine mammals partly because it is a migratory corridor connecting the Bering Sea to more northern waters and many animals move through in spring and fall (Fay, 1982, Lowry et al., 1998; Citta et al., 2012, 2016a; Crawford et al., 2011), it is also known to have elevated benthic and pelagic biomass. In the spring, primary production from ice algae is known to fall to the seafloor in this area and supports a rich benthic environment (e.g. Grebmeier et al., 2006, 2015; Grebmeier, 2012). Benthic biomass in the Hope Basin is dominated by bivalves and, not surprisingly, is known to be important for walruses that feed on them (Fay, 1982; Sheffield and Grebmeier, 2009; Jay et al., 2012). High densities of benthic amphipods were also found in both the Hope and Chirikov Basins (Budnikova and Blokin, 2012; Grebmeier et al., 2015). Although the Chirikov Basin has been considered to be a prime area for gray whales to feed on amphipods (e.g. Braham, 1984; Moore et al., 2000), most use of the basin by tagged gray whales occurred nearshore, along the coast of Chukotka (Fig. 7), and not in the central basin where they are typically spotted during aerial surveys (e.g. see Fig. 7 in Moore et al., 2000). In contrast, much of the biomass of zooplankton in the Bering Strait region is thought to originate farther south in Bering Sea and carried north by currents (e.g. Springer et al., 1996; Hopcroft et al., 2010). Temperature and salinity measurements and zooplankton sampling in the northern Bering and southern Chukchi Seas in September show that combined Bering Shelf/Anadyr Waters (BSAW), which originate in the Gulf of Anadyr and on the Bering Sea shelf, carry a higher abundance of large calanoid copepods and euphausiids than Alaska Coastal Water, which is predominantly composed of relatively fresh river discharge, especially where BSAW occurs near the seafloor (Eisner et al., 2013; Ershova et al., 2015). Large copepods are important prey for bowhead whales and both bowheads and ringed seals feed on euphausiids (Lowry et al., 1980, 2005). Zooplankton also serve as prey for species like Arctic cod (*Boreogadus saida*; Lowry and Frost,1981) that are in turn eaten by spotted and ringed seals and belugas (Lowry et al., 1980; Bukhtiyarov et al., 1984; Quakenbush et al., 2015).

The fourth summer-period core use area was the northeastern Chukchi Sea which included Hanna Shoal and Barrow Canyon (Fig. 13a). Grebmeier et al. (2015) found high benthic biomass at Hanna Shoal, which is also known to be important for walruses (Jay et al., 2012). A well-known gray whale foraging area is located along the Alaska coast, between Icy Cape and Utqiaġvik (formerly Barrow), where benthic amphipods are abundant (e.g. Moore et al., 2000; Brower et al., 2017). The region near Utqiaġvik is also known to have elevated densities of beluga whales (e.g. Moore et al., 2000; Lowry et al., 2017), which may be feeding on Arctic cod (Hauser et al., 2015), and bowhead whales (e.g. Moore et al., 2000; Clark and Ferguson, 2011), which are known to feed on dense aggregations of zooplankton in shelf waters north and east of Point Barrow (Ashjian et al., 2010).

During the summer period, multi-species core use areas extended from Bering Strait, north as far as Point Barrow (71ºN) along the Alaskan coast, but only extended north as far as Vankarem (67 ºN) along the Russian coast (Fig. 13a). Species that we might expect to use the northwestern Chukchi Sea, such as walrus (Fig. 5a), bowhead whales (Fig. 6a), and EBS or ECS beluga whales (Figs. 8a, 9a), rarely did. Citta et al. (*in press*) recently examined the association of bowhead whales with different water masses in the Chukchi Sea and found that bowhead whales avoided Siberian Shelf Water (SSW), which is largely composed of relatively fresh river discharge. Ershova et al. (2015) found that SSW has the lowest density of zooplankton of any water mass in the Chukchi Sea. A low density of zooplankton prey may result in a lower amount of use by bowheads and may also support fewer fish, resulting in less use by belugas. However, this may not explain why there were few walruses along the northern coast of Chukotka. As noted in Section 4.1, relatively few walruses in our analysis were tagged in the western Chukchi Sea and, although the number of haulout sites in the northwestern Chukchi and East Siberian seas may have declined over time, there are still large haulout sites located here (Fischbach et al., 2016).

The other two summer-period core use areas are in and adjacent to the Beaufort Sea (Fig. 13a), and were used by ringed seals, bowhead whales, and EBS beluga whales. The importance of the Beaufort Shelf/Amundsen Gulf area for marine mammals has been documented with methods other than satellite telemetry, including harvests by subsistence hunters in this area

(Harwood et al., 2002, 2012b) and aerial surveys flown to count beluga and bowhead whales (e.g. Harwood and Stirling, 1992; Davis et al., 1982; Harwood et al., 2010). The importance of Viscount Melville Sound, however, is mainly known through satellite telemetry studies, using data that were included here (Heide-Jørgensen et al., 2011; Hauser et al., 2014; Yurkowski et al., 2016; Harwood et al., 2017). Although telemetry data suggest that this area is mainly important for EBS beluga whales, one tagged ringed seal and one tagged BCB bowhead whale also went there. Furthermore, Viscount Melville Sound was used by a bowhead whale tagged in West Greenland in 2010 (Heide-Jørgensen et al., 2011). This area is certainly used by more ringed seals and possibly by more bowhead whales.

4.3. Multi-species core use areas during the winter period

During the winter period, core use areas are probably more representative of the true winter distributions of marine mammals than the summer-period core use areas are of true summer distributions. Winter ranges tend to be farther from tagging locations, thus, the effects of the tagging location should be diminished. With that said, walrus wintering areas may be an exception, because the winter distribution identified in this study is known to be incomplete. The two areas that walruses used during the winter period, south of St. Lawrence and Nunivak Islands (Fig. 5b), are known breeding areas (Fay et al., 1984). However, there is another suspected breeding area in the northern Gulf of Anadyr (Fay et al., 1984; Sonsthagen et al., 2012) that was not identified in the telemetry data. Walruses are known to breed in January and February (Fay et al., 1984) and no tags were deployed prior to March in any year. Out of 389 tags used in this analysis, only four provided data in January or February. Therefore, although the two areas identified for walruses in early spring are important and walruses may be breeding there, the telemetry data apparently were not sufficient for delineating all breeding areas.

The Anadyr Gulf/Strait winter core use area (Fig. 13b) loosely follows what is referred to as the Bering Sea “green belt” (Springer et al., 1996). The Bering Slope Current (Schumacher and Reed, 1992) flows westward along the shelf break and, upon reaching Cape Navarin, most flows south as the Kamchatka Current. A northern branch, named the Anadyr Current, flows northward into the Gulf of Anadyr and passes through Anadyr and Bering Straits (Overland et al., 1996). Shelf break waters are characterized by periodic eddies and upwelling (e.g. Stabeno and Van Meurs, 1999), which moves nutrient rich waters from the Aleutian Basin into the euphotic zone near the shelf break. These nutrient rich waters result in a green belt of high primary and secondary productivity that extends along the Bering Sea shelf break toward Russia and northwards through Anadyr and Bering Straits (See Fig. 2 in Springer et al., 1996).

During the winter period, the distribution of bowhead whales, Pacific walruses, and ECS, EBS, and AN beluga whales, in addition to all three seal species, fall within portions of the green belt. The winter distribution of bowhead whales closely corresponds to the portion of the green belt that lies between Cape Navarin and St. Matthew Island, and extends north through Anadyr and Bering Straits (Fig. 6b). However, it appears that the other species use different parts of this area. AN beluga whales predominantly use the southwestern portion of the area (Fig. 11b), while EBS belugas use the middle and southeastern portion (Fig. 8b), and ECS belugas predominantly use the area north of St Lawrence Island (Fig. 9b; see Citta et al., 2016a). Walruses predominantly used the area south of St. Lawrence Island and Anadyr Strait (Fig. 5b); an area that overlaps the St. Lawrence Island polynya. As stated in Section 4.2, Grebmeier et al.

(2015) found high bivalve biomass within the polynya and this area is known to be important for walruses (Fay, 1982; Sheffield and Grebmeier, 2009; Jay et al., 2012).

The other multi-species core use areas occurred north of both the green belt and the seasonal ice edge. As stated above, the Central Bering Sea core use area (#2 in Fig. 13b) may be spurious, as it is the result of only two NS beluga whales. The Nunivak and Bristol Bay core use areas are more reliably defined; the Nunivak area includes a recurrent polynya (Niebauer and Schell, 1993) and a known breeding area for walruses (Fay et al., 1984) and the Bristol Bay core use area contains the entire population of Bristol Bay beluga whales (Citta et al., 2016b).

4.4. Overlap of species distributions and core use areas.

Although our study was not designed to examine inter-species interactions and niche partitioning at the individual-level, there are some interesting patterns. Notable is the overlap in the distribution of BCB bowhead whales and EBS beluga whales. The winter distribution of bowhead whales overlaps with 96% of the winter distribution of EBS belugas (Table 3) and these two populations begin to migrate north at approximately the same time in April (Citta et al., 2016a, 2012). Hydrophone recordings show that BCB bowhead whales and EBS belugas also pass by Point Barrow at approximately the same time each spring; in 2015 and 2016, bowhead whales and EBS belugas were detected from the first week of April to the first week of June (K. Stafford, pers. comm.). There was also a large amount of overlap in the general distribution (Table 2, top) and core use areas (50% distribution, Table 2, bottom) of BCB bowheads and EBS belugas in summer. Indeed, multi-species core use areas in Canada were largely defined by BCB bowhead whales and EBS beluga whales (Table 4).

The general association between BCB bowhead whales and EBS beluga whales may be due to the need for concentrated prey. Bowhead whales are known to target areas with dense aggregations of zooplankton (e.g. Moore et al., 1995; Ashjian et al., 2010; Walkuz et al., 2012), which may also attract large numbers of Arctic cod that are thought to be the primary prey of belugas in the Pacific Arctic (Loseto et al., 2009).

4.5. Information needs

An important contribution of this manuscript is to identify gaps in the satellite telemetry record. Although our understanding of the movements, distribution, and ecology of all species could be improved by deploying more tags from more tagging sites, these are the five most important areas where more data are necessary:

1. Tagging locations need to be better distributed for ice-associated seals. As noted in section 4.1., the distribution of ice seal telemetry data is probably not representative of the true distribution of ice seals.
2. Related to #1, very few adult bearded seals have been tagged. Methods for capturing and tagging adult bearded seals need to be developed.
3. More large adult bowhead whales need to be tagged. There is speculation that adult bowhead whales may exhibit more exploratory movements than sub-adults, as such tagging a large sample of adult whales is necessary to better understand the entire distribution of bowhead whales.
4. More belugas in the Eastern Bering Sea stock need to be tagged.

5. Tagging of Eastern North Pacific gray whales needs to be more widespread and tags need to transmit for longer durations. Tags typically do not last long on gray whales and their distribution is largely limited to areas near where they are tagged.

With that said, we acknowledge that telemetry studies are often designed to answer specific questions that are unrelated to describing population-level distribution. As such, we are not suggesting that these gaps be used to formally evaluate the validity of proposed telemetry studies. Furthermore, the identification of missing information is problematic because ice conditions are changing. We may find that existing telemetry data are no longer representative of population-level distributions as sea ice declines; in effect, a changing climate widens the information gap.

4.6. Archiving telemetry data

A major contribution of this manuscript is that it identifies what tag data are available and where they can be found (Appendices A-G). These data are important for understanding the movements of ice-associated marine mammal and their habitat use in the Pacific Arctic and need to be preserved. There are currently several efforts to create repositories for animal telemetry data so that researchers can easily access data in near real-time (e.g. Cooke et al., 2011; Kranstauber et al., 2011; Block et al., 2016). A relatively recent system for archiving animal telemetry data is the Animal Telemetry Network (ATN; Block et al., 2016). In 2016, the Interagency Ocean Observations Committee (IOOC) of the National Science and Technology Council (which is comprised of 12 U.S. federal agencies, including NOAA, BOEM, and the U.S. Navy) adopted a plan for coordinating the management of animal telemetry data across the U.S.

(available online at: https://ioos.noaa.gov/wp-content/uploads/2016/04/ATN-Implementation-Plan-12-22-16.pdf), which recommended that data from federally funded biotelemetry projects in the U.S. be uploaded into the ATN. The Ocean Telemetry Network, an international repository housed in Canada (Cooke et al., 2011; Apostle and Gazit, 2016) is a similar effort.

While such data repositories provide long-term storage for telemetry data, they are focused on bringing current telemetry data to bear upon current conservation issues and there is little incentive for researchers to upload data from projects that are no longer active. A surprising amount of the telemetry data that we included in this manuscript required researchers to search old file cabinets and computers. Some of the data had to be decoded from the original Argos files, as data summaries were lost, misplaced, or unavailable. We stress that these data should be properly archived, with appropriate metadata, to ensure they are available for future retrospective analyses.

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References

Aksenov, Y., Popova, E.E.,Yool, A., Nurser, A.J.G., Williams, T.D., Bertino, L., Bergh, J., 2017. On the future navigability of Arctic sea routes: High-resolution projections of the Arctic Ocean and sea ice. Marine Policy 75, 300-317. doi:10.1016/j.marpol.2015.12.027.

Allen, B.M., Angliss, R.P., 2011. Gray whale (*Eschrichtius robustus*): eastern north Pacific stock. NOAA-TM-AFSC-234.

Andrews, R.D., Pitman, R.L., Balance, L.T., 2008. Satellite tracking reveals distinct movement patterns for Type B and Type C killer whales in the southern Ross Sea, Antarctica. Polar Biology 31, 1461-1468.

Apostle, R., Gazit, T., 2016. Ocean tracking technologies: observing species at risk. Maritime Studies 15:13. Doi:10.1186/s40152-016-0052-2.

Arctic Council, Arctic Marine Shipping Assessment 2009 Report, edited by: Ellis, B., and Brigham, L., Arctic Council, Tromsø, Norway, 194 pp., 2009b

Arrigo, K.R., van Dijken, G.L., 2015. Continued increases in Arctic Ocean primary production. Progress in Oceanography 13, 60–70.

Ashjian, C.J., Braund, S.R., Campbell, R.G., George, J.C., Kruse, J., Maslowski, W., Moore, S.E., Nicolson, C.R., Okkonen, S.R., Sherr, B.F., Sherr, E.B., Spitz, Y.H., 2010. Climate variability, oceanography, bowhead whale distribution, and Inupiat subsistence whaling near Barrow, Alaska. Arctic 63, 179–194.

Barber, D.G., Saczuk, E., Richard, P., 2001. Examination of beluga habitat relationships through the use of telemetry and a geographic information system. Arctic 54, 305–316.

Block, B.A., Jonsen I.D., Jorgensen S.J., Winship A.J., Shaffer S.A., Bograd S.J., Hazen E.L., Foley, D.G., Breed, G.A., Harrison, A.-L., Ganong, J.E., Swithenbank, A., Castleton, M., Dewar, H., Mate, B.R., Shillinger, G.L., Schaefer, K.M., Benson, S.R., Weise, M.J., Henry, R.W., Costa, D.P., 2011. Tracking apex marine predator movements in a dynamic ocean. Nature 475, 86–90. doi:10.1038/nature10082

Block, B.A., Holbrook, C.M., Simmons, S.E., et al., 2016. Toward a national animal telemetry network for aquatic observations in the United States. Animal Biotelemerty 4, 6 doi: 10.1186/s40317-015-0092-1.

Bluhm, B.A., Gradinger, R., 2008. Regional variability in food availability for Arctic marine mammals. Ecological Applications, 18(2) Supplement, pp. S77–S96.

BOEM (Bureau of Ocean Energy Management), 2012. Proposed final outer continental shelf oil & gas leasing program 2012-2017. U.S. Department of the Interior, Bureau of Ocean Energy Management. 212 pp.

BOEM (Bureau of Ocean Energy Management), 2015. Shell Gulf of Mexico, Inc. Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska. OCS EIS/EA BOEM 2015-020.

Braham, H.W., 1984. Distribution and migration of gray whales in Alaska. Pages 249–265 *in*: M. Jones, S.L. Swartz, and S. Leatherwood. The Gray Whale. Academic Press.

BREA (Beaufort Regional Environmental Assessment), 2013. Oil and gas exploration and development activity forecast: Canadian Beaufort Sea 2013-2028. Prepared for the Aboriginal Affairs and Northern Development Canada. Available online: http://www.beaufortrea.ca/wp-content/uploads/2012/03/NCR-5358624-v4-BREA_-

_FINAL_UPDATE_-_EXPLORATION_AND_ACTIVITY_FORECAST-__MAY_2013.pdf

Brower, A.A., Ferguson, M.C., Schonberg, S.V., Jewett, S.C., Clarke, J.T., 2017. Gray whale distribution relative to benthic invertebrate biomass and abundance: Northeastern Chukchi Sea 2009-2012. Deep-Sea Research II. DOI: 10.1016/j.dsr2.2016.12.007.

Budnikova, L.L., Blokhin, S.A., 2012. Food contents of eastern gray whale *Eschrichtius robustus* Lilljeborg, 1861 in the Mechigmensky Bay of the Bering Sea. Russian Journal of Marine Biology 38, 149-155.

Bukhtiyarov, Y.A., Frost, K.J., Lowry, L.F., 1984. New information on foods of the spotted seal (*Phoca largha*) in the Bering Sea in spring. Pages 55-59 in F. H. Fay and G. A. Fedoseev, eds. Soviet-American Cooperative Research on Marine Mammals. Vol. 1. Pinnipeds. NOAA Technical Report NMFS 12.

Burns, J.J., 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. Journal of Mammalogy 51, 445-454.

Burns, J.J., 2002. Harbor seal and spotted seal, *Phoca vitulina* and *P. largha*. Pages 552-560 in W. F. Perrin, B. Würsig, and J. G. M. Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA.

Cameron, M.F., Bengtson, J.L., Boveng, P.L., et al., 2010. Status review of the bearded seal (*Erignathus barbatus*). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-211, 246 p.

Citta, J.J., Quakenbush, L.T., George, J.C., Small, R.J., Heide-Jørgensen, M.P., Brower, H., Adams, B., Brower, L., 2012. Winter movements of bowhead whales (*Balaena mysticetus*) in the Bering Sea. Arctic 65, 13-34.

Citta, J.J., Quakenbush, L.T., Okkonen, S.R., Druckenmiller, M.L., Maslowski, W., Clement-Kinney, J., George, J.C., Brower, H., Small, R.J., Ashjian, C.J., Harwood, L.A., Heide-Jørgensen, M.P., 2015. Ecological characteristics of core areas used by western Arctic bowhead whales, 2006-2012. Progress in Oceanography 136, 201-222. http://dx.doi.org/10.1016/j.pocean.2014.08.012

Citta, J.J., Richard, P., Lowry, L.F., O'Corry Crowe, G., Marcoux, M., Suydam, R., Quakenbush, L.T., Hobbs, R.C., Litovka, D.I., Frost, K.J., Gray, T., Orr, J., Tinker, B., Aderman, H., Drukenmiller, M.L., 2016a. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Marine Mammal Science DOI: 10.1111/mms.12357.

Citta, J.J., Quakenbush, L.T., Frost, K.J., Lowry, L., Hobbs, R.C., Aderman, H., 2016b. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Marine Mammal Science 32, 1272-1298. DOI: 10.1111/mms.12337

Citta, J.J., Okkonen, S.R., Quakenbush, L.T., Maslowski, W., Osinski, R., George, J.C., Small, R.J., Brower, H. Heide-Jørgensen, M.P., Harwood, L.A., *In press.* Oceanographic characteristics associated with bowhead whale movements in the Chukchi Sea in autumn. Deep Sea Research II.

Clarke, J.T., Ferguson, M.C., 2011. Aerial surveys for bowhead whales in the Alaskan Beaufort Sea: BWASP Update 2000-2009 with comparisons to historical data. Report to the International Whaling Commission Scientific Committee, SC/62/BRG14.

Clarke, J., Stafford, K., Moore, S.E., Rone, B., Aerts, L, Crance, J., 2013. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. Oceanography 26, 136–149.

Clarke, J.T., Kennedy, A.S., Ferguson, M.C., 2016. Bowhead and gray whale distributions, sighting rates, and habitat associations in the eastern Chukchi Sea, summer and fall 2009–15, with a retrospective comparison to 1982–91. Arctic 69, 359–377.

Comiso, J.C., 2012. Large decadal decline of the Arctic Multiyear Ice Cover. Journal of Climate 25, 1176-1193.

Comiso, J.C., Parkinson, C.L., Gersten, R., Stock, L., 2008. Accelerated decline in Arctic sea ice cover. Geophysical Research Letters 35, L01703, doi:10.1029/2007GL031972.

Cooke, S.J., Iverson, S.J., Stokesbury, M.J., Hinch, S.G., Fisk, A.T., VanderZwaag, D.L., Apostle, R., Whoriskey, F., 2011. Ocean Tracking Network Canada: a network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries 36:583-592.

Cordes, L.S., O'Corry-Crowe, G., Small, R.J., 2017. Surreptitious sympatry: exploring the ecological and genetic separation of two sibling species. Ecology and Evolution 7, 1725-1736.

Crawford, J.A., Frost, K.J., Quakenbush, L.T., Whiting A., 2012. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biology. 35, 241-255.

Davis, R.A., Koski, W.R., Richardson, W.J., Evans, C.R., and Alliston, G.W., 1982. Distribution, numbers and productivity of the western Arctic stock of bowhead whales in the eastern Beaufort Sea and Amundsen Gulf, 1981. Unpubl. rep. for Sohio Petroleum Ltd., Dome Petroleum Ltd., and others by LGL Ltd, Box 457, King City, Ontario, Canada, L0G 1K0.

Eisner, L., Hillgruber, N., Martinson, E., Maselko, J., 2013. Pelagic fish and zooplankton species assemblages in relation to water mass characteristics in the northern Bering and southeast Chukchi seas. Polar Biology 36, 87–113.

Ershova, E.A., Hopcroft, R.R., Kosobokova, K.N., Matsuno, K., Nelson, R.J., Yamaguchi, A., Eisner, L.B., 2015. Long-term changes in summer zooplankton communities of the western Chukchi Sea, 1945–2012. Oceanography 28, 100–115. DOI: 10.5670/oceanog.2015.60.

Evans, J.S., 2016. *spatialEco*. R package version 0.0.1-4, http://CRAN.R-project.org/package=spatialEco

Fay, F.H., 1974. The role of ice in the ecology of marine mammals of the Bering Sea. Pages 383–389 *in*: D.W. Hood and E.J. Kelley, eds. Oceanography of Bering Sea. University of Alaska Fairbanks, Institute of Marine Science, Occasional Publication 2.

Fay, F.H., 1982. Ecology and biology of the Pacific walrus, *Odobenus rosmarus divergens* Illiger. North American Fauna No. 74. 279 pp.

Fay, F.H., Ray, G.C., Kibal'chich, A.A., 1984. Time and location of mating and associated behavior of the Pacific walrus, *Odobenus rosmarus divergens* Illiger. Pages 89–99 *in:* F.H. Fay and G.A. Fedoseev, eds. Soviet-American Cooperative Research on Marine Mammals. Vol. 1 Pinnipeds. U.S. Department of Commerce, NOAA Technical Report NMFS 12.

Fischbach, A.S., Kochnev, A.A., Garlich-Miller, J.L., Jay, C.V., 2016. Pacific walrus coastal haulout database, 1852–2016—Background report: U.S. Geological Survey Open-File Report 2016–1108, 27 p., http://dx.doi.org/10.3133/ofr20161108.

Freitas, C., 2012. argosfilter: Argos locations filter. R package version 0.63. https://CRAN.R-project.org/package=argosfilter

Freitas, C., Lydersen, C., Fedak, M.A., Kovacs, K.M., 2008a. A simple new algorithm to filter marine mammal Argos locations. Marine Mammal Science 24, 315–325.

Freitas, C., Kovacs, K.M., Ims, R.A., Fedak, M.A., Lydersen, C., 2008b. Ringed seal post-moulting movement tactics and habitat selection. Oecologia 155, 193-204.

Gitzen, R.A., and Millspaugh, J.J., 2003. Comparison of least-squares cross-validation bandwidth options for kernel home-range estimation. Wildlife Society Bulletin 31, 823-831.

Grebmeier, J.M., 2012. Shifting patterns of life in the Pacific Arctic and sub-Arctic seas. Annual Review of Marine Science 4, 63-78.

Grebmeier, J.M., Overland, J.E., Moore, S.E., Farley, E.V., Carmack, E.C., Cooper, L.W., Frey, K.E., Helle, J.H., McLaughlin, F.A., McNutt, S.L., 2006. A major ecosystem shift in the northern Bering Sea. Science 311 (5766), 1461–1464. http://dx.doi.org/10.1126/science.1121365.

Grebmeier, J.M., Bluhm, B.A., Cooper, L.W., et al., 2015. Ecosystem characteristics and processes facilitation persistent microbenthic biomass hotspots and associated benthivory in the Pacific Arctic. Progress in Oceanography 136, 92-114.

Hart, K.M., Hyrenbach, K.D., 2009. Satellite telemetry of marine megavertebrates: the coming of age of an experimental science. Endangered Species Research 10, 9–20.

Harwood, L.A., and Stirling, I., 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Canadian Journal of Zoology 70, 891-900.

Harwood, L.A., Norton, P., Day, B., and Hall, P.A., 2002. The harvest of beluga whales in Canada's western Arctic: hunter-based monitoring of the size and composition of the catch. Arctic 55, 10-20.

Harwood, L., Smith, T.G, Melling, H., 2007. Assessing the potential effects of near shore hydrocarbon exploration on ringed seals in the Beaufort Sea region 2003-2006. Environmental Studies Research Funds Report No. 162. 103 p.

Harwood, L.A., Auld, J.C., Joynt, A.A., Moore, S.E., 2010. Distribution of bowhead whales in the SE Beaufort Sea during late summer, 2007–2009. DFO Canadian Science Advisory Research Document 2009/111, v + 22 p

Harwood, L.A., Smith, T.G., and Auld, J.C., 2012a. Fall migration of ringed seals (*Phoca hispida*) through the Beaufort and Chukchi Seas, 2001-02. Arctic 65, 35-44.

Harwood, L.A., Smith, T.G., Melling, H., Alikamik, J., Kingsley, M.C.S., 2012b. Ringed seals and sea ice in Canada's Western Arctic: harvest-based monitoring 1992–2011. Arctic 65 (4), 377–390.

Harwood, L.A., Smith, T.G., Auld, J.C., Yurkowski, D., 2015. Seasonal movements and diving of ringed seals, *Pusa hispida*, in the Western Canadian Arctic, 1999-2001 and 2010-11. Arctic 68, 193-209.

Harwood, L.A., Quakenbush, L.T., Small, R.J., George, J.C., Pokiak, J., Pokiak, C., Heide-Jørgensen, P.P., Lea E.V., Brower H., 2017. Movements and inferred foraging by bowhead whales in the Canadian Beaufort Sea during August and September, 2006-12. Arctic 70:161-176.

Hauser, D.W.W., Laidre, K.L., Suydam, R.S., Richard, P.R., 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biology 37, 1171–1183.

Hauser, D.D.W., Laidre, K.L., Parker-Stetter, S.L., Horne, J.K., Suydam, R.S., and Richard, P.R. 2015. Regional diving behavior of Pacific Arctic beluga whales *Delphinapterus leucas* and possible associations with prey. Marine Ecology Progress Series 541:245 – 264.

Hemson, G., Johnson, P., South, A., Kenward, R., Ripley, R., MacDonald, D., 2005. Are kernels the mustard? Data from global positioning system (GPS) collars suggests problems for kernel home-range analyses with least-squares cross-validation. Journal of Animal Ecology 74, 455–463.

Heide-Jørgensen, M.P., Laidre, K.L., Quakenbush, L.T., Citta, J.J., 2011. The northwest passage opens for bowhead whales. Biology Letters 8, 270–273.

Heide-Jørgensen, M.P., Laidre, K.L., Litovka, D., Villum Jensen, M., Grebmeier, J.M., Sirenko, B.I., 2012. Identifying gray whale (*Eschrichtius robustus*) foraging grouns along the Chukotka Peninsula, Russia, using satellite telemetry. Polar Biology 35, 1035-1045. DOI: 10.1007/s00300-011-1151-6.

Hezel, P.J., Zhang, X., Bitz, C.M., Kelly, B.P., Massonnet, F., 2012. Projected decline in snow depth on Arctic sea ice caused by progressively later autumn open ocean freeze-up this century. Geophysical Research Letters, VOL. 39, L17505, doi:10.1029/2012GL052794.

Higdon, J., Fersuson, S.H., 2009. Loss of Arctic sea ice causing punctuated change in sightings of killer whales (*Orcinus orca*) over the past century. Ecological Applications 19, 1365-1375.

Hopcroft, R.R., Kosobokova, K.N., Pinchuk, A.I., 2010. Zooplankton community patterns in the Chukchi Sea during summer 2004. Deep-Sea Research Part II 57, 27–39.

Houseknecht, D.W., Bird, K.J., 2006. Oil and gas resources of the Arctic Alaska petroleum province: U.S. Geological Survey Professional Paper 1732-A, 11 p., available online at: http: //pubs.usgs.gov/pp/pp1732a/

Hueffer, K., O'Hara, T., Follmann, E.H., 2011. Adaptation of mammalian host-pathogen interactions in a changing Arctic environment. Acta Veterinaria Scandinavica 53, 17.

Huntington, H.P., Daniel, R., Hartsig, A., Harun, K., Heiman, M., Meehan, R., Noongwook, G., Pearson, L., Prior-Parks, M., Robards, M., Stetson, G., 2015. Vessels, risks, and rules: planning for safe shipping in Bering Strait. Marine Policy 51, 119-127.

Iacozza, J., Ferguson, S.H., 2014. Spatio-temporal variability of snow over sea ice in western Hudson Bay, with reference to ringed seal pup survival. Polar Biology 37, 817-832.

Jay, C.V., Hills, S., 2005. Movements of walruses radio-tagged in Bristol Bay, Alaska. Arctic 58, 192-202.

Jay, C.V., Marcot, B.G., Douglas, D.C., 2011. Projected status of the Pacific walrus (*Odobenus rosmarus divergens*) in the twenty-first century. Polar Biology 34, 1065-1084.

Jay, C.V., Fischbach, A.S., Kochnev, A.A., 2012. Walrus areas of use in the Chukchi Sea during sparse sea ice cover. Marine Ecology Progress Series 468, 1-13.

Jay, C.V., Grebmeier, J.M., Fischbach, A.S, McDonald, T.L., Cooper, L.W., Hornsby, F., 2014. Pacific walrus (*Odobenus rosmarus divergens*) resource selection in the northern Bering Sea. PLos ONE 9(4), e93035. doi:10.1371/journal.pone.0093035.

Johnson, D.S., London, J.M., Lea, M.-A., Durban, J.W., 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89, 1208–1215.

Johnson, D., London, J.M., Wilson, K., 2016. crawl: v2.0.1 [Data set]. Zenodo. http://doi.org/10.5281/zenodo.59122

Koenigk, T., Brodeau, L., Graversen, R.G., Karlsson, J., Svensson, G., Tjernström, M., Willén, U., Wyser, K., 2013. Arctic climate change in the 21st century CMIP5 simulations with EC-Earth. Climate Dynamics 40, 2719-2743.

Kelly, B.P., 2001. Climate change and ice breeding pinnipeds. Pages 43-55 in G.-R. Walther, C. A. Burga and P. J. Edwards, eds. "Fingerprints" of climate change: adapted behaviour and shifting species' ranges. Kluwer Academic/Plenum Publishers, New York and London.

Kelly, B.P., Badajos, O.H., Kunnasranta, M., Moran, J.R., Martinez-Bakker, M., Wartzok, D., Boveng, P., 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology 33, 1095-1109.

Kernohan, B.J., Gitzen, R.A., Millspaugh, J.J., 2001. Analysis of animal space use and movements. Pages 125-166 *in:* Radio Tracking and Animal Populations J.J. Millspaugh and J.M. Marzluff, eds.. Academic Press, San Diego.

Kovacs, K.M., Moore, S., Overland, J.E., Lydersen, C., 2011. Impacts of changing sea ice conditions on Arctic marine mammals. Marine Biodiversity 41:181–194.

Krafft, B.A., Kovacs, K.M., Lydersen, C., 2007. Distribution of sex and age groups of ringed seals Pusa hispida in the fast-ice breeding habitat of Kongsfjorden, Svalbard. Marine Ecology Progress Series 335, 199-206.

Kranstauber, B., Cameron, A., Weinzerl, R., Fountain, T., Tilak, S., Wikelski, M., Kays, R., 2011. The Movebank data model for animal tracking. Environmental modelling and software 26, 834-835.

Kunnasranta, M., 2001. Behavioural biology of two ringed seal (Phoca hispida) subspecies in the large European lakes Saimaa and Ladoga. University of Joensuu, Joensuu, Finland. 86 p.

Kutz, S.J., Hoberg, E.P., Polley, L., Jenkins, E.J., 2005. Global warming is changing the dynamics of Arctic host–parasite systems. Proc R Soc Lond B 272, 2571–2576.

Kwok, R., Cunningham, G.F., Wensnahan, M., Rigor, I., Zwally, H.J., Yi, D., 2009. Thinning and volumn loss of the Arctic Ocean sea ice cover: 2003-2008. Journal of Geophysical Research 114, C07005, doi: 10.1029/2009JC005312.

Laidre, K.L., Stirling, I., Lowry, L.F., Wiig, Ø., Heide-Jørgensen, M.P., Ferguson, S.H., 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecological Applications 18, S97–S125.

Laidre, K. L., Stern, H., Kovacs, K. M., Lowry, L., Moore, S. E., Regehr, E. V., Ferguson, S.H., Wiig, Ø., Boveng, P, Angliss, R.P., Born, E.W., Litovka, D., Quakenbush, L., Lydersen, C., Vongravel, D., Ugarte, F., 2015. Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. Conservation Biology, 29, 724–737. http://doi.org/10.1111/cobi.12474

Lasserre, F., 2015. Simulations of shipping along Arctic routes: comparison, analysis and economic perspectives. Polar Record 51, 239-259. doi: 10.1017/S0032247413000958.

Lefebvre, K.A., Quakenbush, L., Frame, E., Burek Huntington, K., Sheffield, G., Stimmelmayr, R., Bryan, A., Kendrick, P., Ziel, H., Goldstein, T., Snyder, J.A., Gelatt, T., Gulland, F., Dickerson, B., Gill, V., 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae 55, 13–24. Doi: dx.doi.org/10.1016/j.hal.2016.01.007

Litovka D.I., Andronov, P.Yu., Batanov R.L., 2013. Analysis of seasonal distribution of beluga whales *Delphinapterus leucas* and its prey objects in coastal waters of north-western Bering Sea. Bulletin of KanchatNIRO: Investigations of biological resources of Kamchatka and north-western Pacific 27:50-71. (In Russian)

Lowry, L.F., Frost, K.J., Burns, J.J., 1980. Variability in the diet of ringed seals, *Phoca hispida* Schreber, in Alaska. Canadian Journal of Fisheries and Aquatic Sciences 37, 2254-2261.

Lowry, L.F., Frost, K.J., 1981. Distribution, growth, and foods of Arctic cod (*Boreogadus saida*) in the Bering, Chukchi, and Beaufort seas. Canadian Field-Naturalist 95, 186-191.

Lowry, L.F., Frost, K.J., Davis, R., DeMaster, D.P., Suydam, R.S., 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. Polar Biology 19, 221-230.

Lowry, L.F., Frost, K.J., Burkanov, V.N., Simpkins, M.A., et al., 2000. Habitat use and habitat selection by spotted seals (*Phoca largha*) in the Bering Sea. Canadian Journal of Zoology 78, 1959-1971.

Lowry, L.F., Sheffield, G., George, J.C., 2005. Bowhead whale feeding in the Alaskan Beaufort Sea based on stomach contents analyses. Journal of Cetacean Research and Management 6, 215-223.Loseto, L.L., Stern, G.A., Connelly, T.L., Deibel, D., Gemmill, B., Prokopowicz, A., Fortier, L., Ferguson, S.H., 2009. Summer diet of beluga whales inferred by fatty acid analysis of the eastern Beaufort Sea food web. Journal of Experimental Marine Biology and Ecology 374, 12-18.

Lowry, L.F., Kingsley, M.C.S., Hauser, D.D.W., Clarke, J., Suydam, R., 2017. Aerial survey estimates of abundance of the Eastern Chukchi Sea stock of beluga whales (Delphinapterus leucas) in 2012. Arctic 70, 273-286.

Luque, S.P., Ferguson, S.H., Breed, G.A., 2014. Spatial behavior of a keystone Arctic marine predator and implications of climate warming in Hudson Bay. Journal of Experimental Marine Biology and Ecology 461, 504-515.

Markus, T., Stroeve, J. C., Miller, J., 2009. Recent changes in Arctic sea ice melt onset, freezeup, and melt season length. Journal of Geophysical Research 114, C12024, doi: 10.1029/2009JC005436.

Martinez-Bakker, M.E., Sell, S.K., Swanson, B.J., Kelly, B.P., Tallmon, D.A., 2013. Combined genetic and telemetry data reveal high rates of gene flow, migration, and long-distance dispersal potential in Arctic ringed seals (*Pusa hispida*). PLoS ONE 8(10): e77125. doi:10.1371/journal.pone.0077125

Matsuno, K., Yamaguchi, A., Hirawake, T., Imai, I., 2011. Year-to-year changes of the mesozooplankton community in the Chukchi Sea during summers of 1991, 1992 and 2007, 2008. Polar Biology 34, 1349–60.

Maxwell, S.M., Hazen, E.L., Bograd, S.J., Halpern, B.S., Breed, G.A., Nickel, B. et al., 2013. Cumulative human impacts on marine predators. Nature Communications, 4, 2688, *doi:* 10.1038/ncomms3688.McClintock, B.T., London, J.M., Cameron, M.F., Boveng, P.L., 2017. Bridging the gaps in movement: hidden behaviors and ecological relationships revealed by integrated data streams. Ecosphere 8(3):e01751. 10.1002/ecs2.1751

Moore, S.E., George, J.C., Coyle, K.O., Weingartner, T.J., 1995. Bowhead whales along the Chukotka coast in Autumn. Arctic 48, 155–160.

Moore, S.E., DeMaster, D.P., Dayton, P.K., 2000. Cetacean habitat selection in the Alaskan Arctic during summer and autumn. Arctic 53(4), 432–447.

Mueter, F.J., Litzow, M.A., 2008. Sea ice retreat alters the biogeography of the Bering Sea continental shelf. Ecological Applications 18, 309-320.

Niebauer, H.J., Schell, D.M., 1993. Physical environment of the Bering Sea population. Pages 23–43 *in* J. J. Burns, J. H. Montague, and C. J. Cowles, eds. The bowhead whale, Special Publication Number 2. The Society for Marine Mammalogy.

Nghiem, S.V., Rigor, I.G., Perovich, D.K., Clemente-Colón, P., Weatherly, J.W., 2007. Rapid reduction of Arctic perennial sea ice. Geophysical Research Letters, 34, L19504, doi:10.1029/2007GL031138.

Overland, J.E., Stabeno, P.J., Salo, S., 1996. Direct evidence for northward flow on the northwestern Bering Sea shelf. Journal of Geophysical Research 101, 8971–8976.

Quakenbush, L.T., Citta, J.J., George, J.C., Small, R.J., Heide-Jorgensen, M.P., 2010. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. Arctic 63, 289-307.

Quakenbush, L.T., Suydam, R.S., Bryan, A.L., Lowry, L.F., Frost, K.J., Mahoney, B.A., 2015. Diet of beluga whales, (*Delphinapterus leucas*), in Alaska from stomach contents, March-November. Marine Fisheries Review 77, 70-84.

R Core Team, 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Reinhart, N.R., Ferguson, S.H., Koski, W.R., Higdon, J.W., LeBlanc, B., Tervo, O., Jepson, P.D., 2013. Occurrence of killer whale *Orcinus orca* rake marks on Eastern Candad-West Greenland bowhead whales *Balaena mysticetus*. Polar Biology 36, 1133-1146.

Richard, P. R., Martin, A.R., Orr, J.R., 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic 54, 223–236.

Rosneft, 2014. Rosneft and ExxonMobil extended agreement on implementation of the Far East LNG Project. Rosneft news release, 23 May 2014, available online at: https://www.rosneft.com/press/releases/item/153268/.

Schumacher, J.D., Reed, R.K., 1992. Characteristics of currents over the continental slope of the eastern Bering Sea. Journal of Geophysical Research 97, 9423–9433.

Shaughnessy, P.D., Fay, F.H., 1977. A review of taxonomy and nomenclature of North Pacific harbor seals. Journal of Zoology 182, 385-419.

Sheffield, G., Grebmeier, J.M., 2009. Pacific walrus (*Odobenus rosmarus divergens*): Differential prey digestion and diet. Marine Mammal Science 25, 761-777.

Sipilä, T., Medvedev, N.V., Hyvärinen, H., 1996. The Ladoga seal (*Phoca hispida ladogensis Nordq*). Hydrobiologia 322, 193-198.

Smith, T.G., Hammill, M.O., 1981. Ecology of the ringed seal, Phoca hispida, in its fast ice breeding habitat. Canadian Journal of Zoology 59, 966-981.

Smith, L.C., Stephenson, S.R., 2013. New Trans-Arctic shipping routes navigable by midcentury. Proceedings of the National Academy of Sciences, E1191-E1195, doi: 10.1073/pnas.12142110.

Sonsthagen, S.A., Jay, C.V.,Fischbach, A.S., Sage, G.K., Talbot, S.L., 2012. Spatial genetic structure and asymmetrical gene flow within the Pacific walrus. Journal of Mammalogy 93, 1512-1524. doi:10.1644/11-MAMM-A-344.1

Søreide, J.E., Leu, E., Berge, J., Graeve, M., Falk-Petersen, S., 2010. Timing of blooms, algal food quality and *Calanus glacialis* reproduction and growth in a changing Arctic. Global Change Biology, 16, 3154-3163.

Springer, A.M., McRoy, P.C., Flint, M.V., 1996. The Bering Sea green belt: shelf-edge processes and ecosystem production. Fisheries Oceanography 5, 205–223.

Stabeno, P.J., Van Meurs, P., 1999. Evidence of episodic on-shelf flow in the southeastern Bering Sea. Journal of Geophysical Research 104, 715–720.

Stroeve, J. C., Markus, T., Boisvert, L., Miller, J., Barrett, A., 2014. Changes in Arctic melt season and implications for sea ice loss, Geophysical Research Letters, 41, 1216-1225, doi:10.1002/2013GL058951.

Suydam, R.S., 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. dissertation, University of Washington, Seattle, WA. 152 pp.

Suydam, R.S., Lowry, L.F., Frost, K.J., O'Corry-Crowe, G.M., Pikok, Jr., D., 2001. Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic Ocean. Arctic 54, 237–243.

Suydam, R.S., Lowry, L.F., Frost, K.J., 2005. Distribution and movements of beluga whales from the eastern Chukchi Sea stock during summer and early autumn. Final Report to Coastal Marine Institute, University of Alaska, Fairbanks, AK. 39 pp.

Tremblay, J.-E., Simpson, K., Martin, J., Miller, L., Gratton, Y., Barber, D., Price, N.M., 2008. Vertical stability and the annual dynamics of nutrients and chlorophyll fluorescence in the coastal, southeast Beaufort Sea. Journal of Geophysical Research, 113, C07S90, doi:10.1029/2007JC004547.

Udevitz, M.S., Taylor, R.L., Garlich-Miller, J.L., Quakenbush, L.T., Snyder, J.A., 2013. Potential population-level effects of increased haulout-related mortality of Pacific walrus calves. Polar Biology 36, 291-298.

Van Parijs, S.M., Clark, C.W., 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, *Erignathus barbatus*. Animal Behavior 72, 1269-77.

Vincent, C., McConnell, B.J., Ridoux, V., Fedak, M.A., 2002. Assessment of Argos location accuracy from satellite tags deployed on captive gray seals. Marine Mammal Science 18, 156–166.

Walkusz, W., Williams, W.J., Harwood, L.A., Moore, S.E., Stewart, B.E., Kwasniewski, S., 2012. Composition, biomass and energetic content of biota in the vicinity of feeding bowhead whales (*Balaena mysticetus*) in the Cape Bathurst upwelling region (south eastern Beaufort Sea). Deep-Sea Research Part I 69, 25–35.

Wang, M., Overland, J.E., 2012. A sea ice free summer Arctic within 30 years: An update from the CMIP5 models. Geophysical Research Letters 39, L18501, doi:10.1029/2012GL052868.

Ware, C., J. Berge, A. Jelmert, S.M. Olsen, L. Pellissier, M. Wisz, D. Kriticos, G. Semenov, S Kwaśniewski, I.G. Alsos., 2016. Biological introduction risks from shipping in a warming Arctic. Journal of Applied Ecology 53, 340-349.

Wassmann, P., Kosobokova, K.N., Slagstad, D., Drinkwater, K.F., Hopcroft, R.R., Moore, S.E., Ellingsen, I., Nelson, R.J., Popova, E., Carmack, E., Berge, J., 2015. The contiguous domains of Arctic Ocean advection: Trails of life and death. Progress in Oceanography, 139, 42-65. DOI: 10.1016/j.pocean.2015.06.011.

Worton, B.J., 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70, 164–168.

Yurkowski, D.J., Semeniuk, C.A.D., Harwood L.A., Rosing-Asvid, A., Dietz, R., Brown, T.M., Clackett, S., Grgicak-Mannion, A., Fisk, A.T., Ferguson, S.H., 2016. Influence of sea ice phenology on the movement ecology of ringed seals across their latitudinal range. Marine Ecology Progress Series 562, 237-250.

Table 1. Summary of satellite-linked tags that were attached to marine mammals in Canada, Alaska, and Russia that provided data used in this analysis (see Appendices A-G for details). Agency abbreviations are as follows: DFO is the Department of Fisheries and Oceans Canada; NSB is the Department of Wildlife Management of Alaska's North Slope Borough; UAF is the University of Alaska Fairbanks; ADFG is the Alaska Department of Fish and Game, NVK is the Native Village of Kotzebue, Alaska; MML is the National Marine Fisheries Service's Marine Mammal Laboratory; TINRO is the Pacific Research Fisheries Center , Russia; USGS is the United States Geological Survey; GINR is the Greenland Institute of Natural Resources.

Species	Location	Tagging Years	# Tags	Tag Agency	Publications
Ringed seal	Ulukhaktok	1999-2010	16	DFO	Harwood et al., 2015; Yurkowski et al., 2016
	Cape Parry	2001-2002	8	DFO	Harwood et al., 2012a; Yurkowski et al., 2016
	Paktoa	2004-2006	17	DFO	Harwood et al., 2007;
	Barrow	2011-2015	14	NSB	
	Peard Bay	2005-2008	15	UAF	Kelly et al., 2010; Martinez-Bakker et al., 2013
	Kotzebue	2007	1	UAF	Kelly et al., 2010; Martinez-Bakker et al., 2013
	Kotzebue	2007-2009	43	ADFG/NVK	Crawford et al., 2011
	Saint Michael	2015	1	ADFG	
	Hooper Bay	2012-2015	3	ADFG	
Total ringed seal		*1999-2015*	*118*		
Bearded seal	Dease Inlet	2015	2	ADFG/NSB	
	Barrrow	2012	1	NSB	
	Kotzebue	2004-2012	27	MML	McClintock et al., 2017
	Kotzebue	2009-2014	11	ADFG/NVK	
	Koyuk	2014-2015	7	ADFG	
	Saint Michael	2015	3	ADFG	
Total bearded seal		*2004-2015*	*51*		
Spotted seal	Barrow	2012-2015	22	NSB	
	Point Lay	1991-1993	11	ADFG/NSB	Lowry et al., 1998
	Bristol Bay	2000	6	ADFG	Cordes et al., 2017
	Bering Sea	2005-2010	28	MML	
	Kamchatka	1993	5	ADFG/TINRO	Lowry et al., 2000
Total spotted seal		*1993-2015*	*72*		
Pacific walrus	Chukchi Sea	2007-2015	190	USGS	Jay et al., 2012

	Chukchi Sea	2007-2015	64	ADFG	
	Point Lay	2010-2015	20	USGS	Jay et al. 2012
	Cape Vankarem	2010-2013	7	USGS	Jay et al., 2012
	Cape Serdtse-Kamen	2011-2013	4	USGS	Jay et al., 2012
	Bering Sea	1988-2009	81	USGS	Jay et al., 2014
	Cape Newenham	1997	1	USGS	Jay and Hills 2005
	Cape Pierce	1995-2002	13	USGS	Jay et al., 2001; Jay and Hills 2005
	Round Island	1987-1989	9	USGS	Jay and Hills 2005
Total Pacific walrus		*1987-2015*	*389*		
Bowhead whale	Atkinson Point	2008-2014	13	ADFG/DFO	Quakenbush et al., 2010; Citta et al., 2012, 2015; Harwood et al. 2017
	Herschel Island	2010	1	ADFG	Same as above
	Barrow	2006-2015	29	ADFG	Same as above
	Gambell	2012	1	ADFG	Same as above
	Pugughileq	2012-2013	2	ADFG	Same as above
Total bowhead whale		*2006-2015*	*46*		
Gray whale	Atkinson Point	2009	1	ADFG/DFO	
	Barrow	2011	1	ADFG	
	Chukchi Sea	2012-2013	4	MML	
	Lavrentiya Bay	2006	5	GINR	Heide-Jørgensen et al. 2012
	Gambell	2012	1	ADFG	
Total gray whale		*2006-2013*	*12*		
Beluga whale	Mackenzie Delta	1993-2005	32	DFO	Barber et al. 2001; Richard et al. 2001; Hauser et al., 2014; Citta et al. 2016a
	Point Lay	1998-2012	22	NSB	Suydam et al. 2001, 2005; Suydam 2009; Hauser et al., 2014; Citta et al. 2016a
	Nome	2012	2	ABWC	Citta et al. 2016a
	Anadyr	2001-2008	7	MML/TINRO	Litovka et al., 2013; Citta et al. 2016a
	Bristol Bay	2002-2012	40	ABWC/ADFG/MML	Citta et al. 2016a, 2016b
Total beluga whale		*1993-2012*	*103*		

Table 2. Proportion of overlap between the summer-period (May–November) 99% probability distributions (overall distributions) of species (top) and the 50% probability distributions (core use areas) of species (bottom). Columns are the proportion of overlap with rows. For example, the 99% probability distribution for ringed seals (column #1) overlaps 0.47 or 47% of the 99% probability distribution for ECS belugas. Proportions $\geq$ 0.5 are in bold font to help the reader discern patterns in the information.

Proportion overlap in 99% distribution	**ringed seal**	**spotted seal**	**bearded seal**	**Pacific walrus**	**bowhead whale**	**gray whale**	**EBS beluga**	**ECS beluga**	**BB beluga**	**NS beluga**	**AN beluga**
ringed seal	1	**0.52**	0.35	0.45	**0.54**	0.10	0.36	0.32	0	0.06	0
spotted seal	**0.64**	1	0.40	**0.50**	0.32	0.11	0.14	0.21	0	0.10	0.04
bearded seal	**0.84**	**0.78**	1	**0.65**	**0.53**	0.17	0.28	0.43	0	0.11	0
Pacific walrus	**0.66**	**0.60**	0.40	1	**0.56**	0.10	0	0.33	0	0	0
bowhead whale	**0.74**	0.36	0.30	**0.51**	1	0.10	**0.53**	0.42	0	0	0
gray whale	**0.94**	**0.88**	**0.67**	**0.64**	**0.70**	1	0.45	0.33	0	0	0
EBS beluga	**0.50**	0.16	0.16	0	**0.54**	0.07	1	0.45	0	0	0
ECS beluga	0.47	0.25	0.26	0.33	0.45	0.05	0.48	1	0	0	0
BB beluga	0	**0.67**	0	0	0	0	0	0	1	0	0
NS beluga	**0.80**	**0.98**	**0.60**	0	0	0	0	0	0	1	0
AN beluga	0	1	0	0	0	0	0	0	0	0	1

Proportion overlap in 50% distribution	**ringed seal**	**spotted seal**	**bearded seal**	**Pacific walrus**	**bowhead whale**	**gray whale**	**EBS beluga**	**ECS beluga**	**BB beluga**	**NS beluga**	**AN beluga**
ringed seal	1	0.39	0.20	0.05	0.20	0	0.16	0.14	0	0.02	0
spotted seal	0.23	1	0.16	0.07	0.14	0.03	0.03	0.08	0.01	0	0
bearded seal	0.35	0.46	1	0.12	0	0	0.04	0.23	0	0.04	0
Pacific walrus	0.13	0.33	0.20	1	0.07	0	0	0.33	0	0	0
bowhead whale	0.18	0.20	0	0.02	1	0.02	0.47	0.06	0	0	0
gray whale	0	0.33	0	0	0.17	1	0	0.17	0	0	0
EBS beluga	0.09	0.03	0.01	0	0.30	0	1	0.01	0	0	0
ECS beluga	0.17	0.17	0.17	0.14	0.08	0.03	0.03	1	0	0	0
BB beluga	0	1	0	0	0	0	0	0	1	0	0
NS beluga	0.13	0	0.13	0	0	0	0	0	0	1	0
AN beluga	0	0	0	0	0	0	0	0	0	0	1

Table 3. Proportion of overlap between the winter-period (December – April) 99% probability distributions (overall distribution) of species (top) and the 50% probability distributions (core use areas) of species (bottom). Columns are the proportion of overlap with rows. For example, the 99% probability distribution for ringed seals (column #1) overlaps 0.74 or 74% of the 99% probability distribution for bowhead whales. Proportions $\geq$ 0.5 are in bold font to help the reader discern patterns in the information.

Proportion overlap in 99% distribution	**ringed seal**	**spotted seal**	**bearded seal**	**Pacific walrus**	**bowhead whale**	**EBS beluga**	**ECS beluga**	**BB beluga**	**EB beluga**	**AN beluga**
ringed seal	1	**0.74**	**0.53**	0.31	0.41	0.17	0.06	0.02	0.16	0.08
spotted seal	**0.78**	1	**0.55**	0.36	0.39	0.17	0.07	0.03	0.21	0.08
bearded seal	**0.90**	**0.89**	1	**0.51**	0.45	0.24	0.11	0.01	0.25	0.03
Pacific walrus	**0.84**	**0.95**	0.83	**1**	0.49	0.28	0.11	0.03	0.27	0.01
bowhead whale	**0.74**	**0.67**	0.48	0.32	1	0.31	0.08	0	0.08	0.06
EBS beluga	**0.93**	**0.91**	**0.81**	**0.58**	**0.96**	1	0.14	0	0.01	0.03
ECS beluga	1	**0.96**	**0.96**	**0.63**	**0.70**	0.37	1	0	0	0
BB beluga	**0.73**	1	0.18	0.36	0	0	0	1	0.36	0
NS beluga	**0.82**	**0.99**	**0.73**	0.49	0.23	0.01	0	0.05	1	0
AN beluga	**0.77**	**0.75**	0.18	0.05	0.30	0.05	0	0	0	1

Proportion overlap in 50% distribution	**ringed seal**	**spotted seal**	**bearded seal**	**Pacific walrus**	**bowhead whale**	**EBS beluga**	**ECS beluga**	**BB beluga**	**EB beluga**	**AN beluga**
ringed seal	1	0.15	0.07	0	0.11	0.07	0.02	0.02	0	0.04
spotted seal	0.08	1	0.07	0.05	0.16	0.21	0.01	0.01	0.04	0.07
bearded seal	0.09	0.18	1	0	0.09	0.03	0.03	0	0	0.09
Pacific walrus	0	0.25	0	1	0.13	0.38	0	0	0.06	0
bowhead whale	0.18	**0.50**	0.11	0.07	1	0.43	0.04	0	0	0
EBS beluga	0.08	0.47	0.03	0.16	0.32	1	0.03	0	0	0
ECS beluga	**0.50**	**0.50**	**0.50**	0	**0.50**	**0.50**	1	0	0	0
BB beluga	1	1	0	0	0	0	0	1	0	0
NS beluga	0	0.17	0	0.06	0	0	0	0	1	0
AN beluga	0.05	0.14	0.07	0	0	0	0	0	0	1

Table 4. Proportion of locations (top) and proportion of tags (bottom) occurring within each multi-species core use area during the summer period (May-November). Proportions > 0.2 are in bold font to help the reader discern patterns. The multi-species core use areas are shown in Fig. 13a.

Proportion of locations	**Species**	**Chukotka/ Bering Strait**	**Norton Sound**	**Kotzebue Sound**	**Northeastern Chukchi Sea**	**Tuktoyaktuk/ Amundsen Gulf**	**Viscount Melville Sound**	**# locations**
	ringed seal	0.05	0.02	0.08	0.13	0.14	0	7802
	spotted seal	0.10	0.02	0.05	0.11	0	0	12490
	bearded seal	0.12	0.07	0.19	**0.20**	0	0	4129
	Pacific walrus	0.06	0	0	**0.46**	0	0	16914
	gray whale	**0.42**	0	0	**0.32**	0.04	0	583
	bowhead whale	0.10	0	0	0.10	**0.26**	0	5214
	EBS beluga	0.01	0	0	0.05	**0.22**	0.05	1740
	ECS beluga	0.02	0	0.02	**0.36**	0	0	2242
	BB beluga	0	0	0	0	0	0	3598
	NS beluga	0	**0.52**	0	0	0	0	316
	AN beluga	0	0	0	0	0	0	667

Proportion of tags	**Species**	**Chukotka/ Bering Strait**	**Norton Sound**	**Kotzebue Sound**	**Northeastern Chukchi Sea**	**Tuktoyaktuk/ Amundsen Gulf**	**Viscount Melville Sound**	**# tags**
	ringed seal	**0.34**	0.11	**0.39**	**0.44**	**0.36**	0.01	117
	spotted seal	**0.69**	**0.33**	**0.84**	**0.39**	0	0	51
	bearded seal	**0.48**	**0.20**	**0.36**	**0.51**	0	0	61
	Pacific walrus	**0.30**	0.02	0.06	**0.74**	0	0	376
	bowhead whale	**0.77**	0	0.02	**0.91**	**0.57**	0.02	47
	gray whale	**0.75**	0	0	**0.50**	0.08	0	12
	EBS beluga	0.12	0	0.03	**0.27**	**0.85**	**0.30**	33
	ECS beluga	**0.27**	0	**0.23**	**1**	0	0	22
	BB beluga	0	0	0	0	0	0	40
	NS beluga	0	**1**	0	0	0	0	2
	AN beluga	0	0	0	0	0	0	7

Table 5. Proportion of locations (top) and proportion of tags (bottom) occurring within each multi-species core use area duirng the winter period. Proportions > 0.2 are in bold font to help the reader discern patterns in the information. The multi-species core use areas are shown in Fig. 13b.

Proportion of locations	**Species**	**Anadyr**	**Central Bering Sea**	**Nunivak**	**Bristol Bay**	**# locations**
	ringed seals	0.12	0.01	0.01	0.01	10234
	spotted seals	0.19	0.01	0.02	0.05	7045
	bearded seals	0.18	0	0.04	0	3686
	Pacific walrus	**0.46**	0	0.19	0	2167
	bowhead whales	**0.64**	0	0	0	2844
	EBS beluga	**0.72**	0	0	0	152
	ECS beluga	**0.69**	0	0	0	312
	BB beluga	0	0	0	**0.42**	1425
	NS beluga	0.01	0.16	**0.28**	0	302
	AN beluga	**0.33**	0	0	0	456

Proportion of tags	**Species**	**Anadyr**	**Central Bering Sea**	**Nunivak**	**Bristol Bay**	**# tags**
	ringed seals	**0.27**	0.05	0.03	0.02	91
	spotted seals	**0.66**	0.14	0.16	0.14	44
	bearded seals	**0.41**	0.07	0.11	0	46
	Pacific walrus	**0.57**	0	**0.34**	0	82
	bowhead whales	**1**	0.03	0.03	0	30
	EBS beluga	**0.71**	0	0	0	7
	ECS beluga	**0.50**	0	0	0	4
	BB beluga	0	0	0	**0.77**	22
	NS beluga	**0.50**	**1**	**1**	0	2
	AN beluga	**1**	0	0	0	5

Appendix A: Details for satellite transmitter deployments on ringed seals (*Pusa hispida*) used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. PTT (Platform Transmitter Terminal) is the transmission code used by the Argos when identifying transmitters (some are reused). Some animals were double tagged; if so, the secondary tag is denoted as PTT2. Ages include 'pup' for young of the year, 'Imm' for immature, and 'Adu' for breeding age adults. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. Agency is the entity providing data access: DFO is the Division of Fisheries and Oceans, Canada; UAF is the University of Alaska, Fairbanks; and ADFG is the Alaska Department of Fish and Game.

ID	**PTT**	**PTT2**	**Sex**	**Age**	**Deployment date**	**Date of last location (UTC)**	**# Summer days w/locations**	**# Winter days w/locations**	**Deployment location**	**Agency**
DFO_13	5092	-	M	Adu	8-Jun-99	10-Nov-99	127	-	Ulukhaktok	DFO
DFO_12	5056	-	M	Adu	20-Jun-99	3-Mar-00	145	80	Ulukhaktok	DFO
DFO_14	11747	-	F	Imm	1-Jul-99	1-Feb-00	144	72	Ulukhaktok	DFO
DFO_18	23528	-	M	Imm	16-Jul-00	21-Feb-01	104	142	Ulukhaktok	DFO
DFO_19	23529	-	F	Adu	16-Jul-00	26-Oct-00	92	-	Ulukhaktok	DFO
DFO_17	23527	-	M	Adu	17-Jul-00	15-Jun-01	155	168	Ulukhaktok	DFO
DFO_16	23526	-	F	Adu	19-Jul-00	2-Jun-01	142	130	Ulukhaktok	DFO
RS-5092a	5092	-	M	Imm	17-Sep-01	23-Oct-01	46	-	Cape Parry	DFO
RS-11747	11747	-	M	Imm	19-Sep-01	13-Nov-01	61	-	Cape Parry	DFO
RS-21212	21212	-	F	Adu	19-Sep-01	15-Apr-02	75	176	Cape Parry	DFO
RS-5056	5056	-	F	Imm	19-Sep-01	7-Oct-01	34	-	Cape Parry	DFO
RS-23527	23527	-	M	Adu	7-Sep-02	25-Feb-03	55	98	Cape Parry	DFO
RS-23528	23528	-	F	Imm	7-Sep-02	30-Dec-02	52	56	Cape Parry	DFO
RS-5092b	5092	-	M	Imm	7-Sep-02	29-Oct-02	53	-	Cape Parry	DFO
RS-23529	23529	-	F	Imm	8-Sep-02	7-Nov-02	32	-	Cape Parry	DFO
PK-04-01	23526	-	M	Adu	27-Apr-04	5-Jun-04	25	-	Paktoa	DFO
PK-05-1	57085	-	F	Adu	23-Mar-05	26-May-05	17	58	Paktoa	DFO
PK-05-2	23527	-	M	Imm	30-Mar-05	24-May-05	23	44	Paktoa	DFO
PK-05-4	5092	-	M	Adu	30-Mar-05	25-May-05	17	38	Paktoa	DFO

PK-05-5	5056	-	M	Adu	31-Mar-05	31-May-05	26	40	Paktoa	DFO
PK-05-6	11747	23529	M	Adu	31-Mar-05	14-May-05	8	36	Paktoa	DFO
PK-05-7	23528	-	F	Imm	1-Apr-05	20-May-05	19	54	Paktoa	DFO
PK-05-8	57084	-	F	Adu	3-Apr-05	8-May-05	4	22	Paktoa	DFO
VK05	57979	-	F	Adu	1-May-05	21-Jul-05	18	-	Peard Bay	UAF
LY05	57994	-	F	Adu	4-May-05	22-Jan-06	35	10	Peard Bay	UAF
AS05	57989	-	F	Adu	6-May-05	15-Mar-06	29	42	Peard Bay	UAF
IO05	57987	-	F	Adu	9-May-05	13-Jul-05	20	-	Peard Bay	UAF
SI05	57990	-	F	Adu	11-May-05	25-Aug-05	22	-	Peard Bay	UAF
IB05	57991	-	M	Adu	16-May-05	9-Jul-06	44	52	Peard Bay	UAF
TT05	57992	-	M	Adu	18-May-05	27-Feb-06	29	38	Peard Bay	UAF
JJ05	57995	-	M	Adu	25-May-05	21-Jun-06	28	-	Peard Bay	UAF
PK-06-01	23527	57997	M	Adu	20-Mar-06	9-Jun-06	26	6	Paktoa	DFO
PK-06-03	23526	57983	M	Adu	20-Mar-06	29-Apr-06	-	70	Paktoa	DFO
PK-06-02	23529	57982	M	Adu	20-Mar-06	29-May-06	22	38	Paktoa	DFO
PK-06-04	5092	57984	M	Adu	21-Mar-06	28-May-06	36	62	Paktoa	DFO
PK-06-05	57085	57988	F	Adu	22-Mar-06	21-May-06	18	54	Paktoa	DFO
PK-06-06	23528	57993	F	Adu	23-Mar-06	4-Jun-06	32	2	Paktoa	DFO
PK-06-07	57084	57980	F	Adu	24-Mar-06	23-May-06	17	64	Paktoa	DFO
PK-06-08	21212	-	M	Adu	26-Mar-06	17-May-06	10	30	Paktoa	DFO
PK-06-10	5056	-	M	Adu	29-Mar-06	7-Jun-06	26	42	Paktoa	DFO
AM06	64736	-	M	Adu	28-Apr-06	2-Nov-06	32	4	Peard Bay	UAF
BM06	64737	-	M	Adu	2-May-06	7-Jun-07	28	22	Peard Bay	UAF
AF06	64747	-	F	Adu	6-May-06	12-Feb-07	34	4	Peard Bay	UAF
BF06	64740	-	F	Adu	14-May-06	5-Jan-07	26	6	Peard Bay	UAF
CM06	64733	-	M	Adu	14-May-06	17-Jan-07	26	2	Peard Bay	UAF
RS06-02-U	21182	-	Unk	Adu	12-Oct-06	17-Mar-07	4	186	Kotzebue	ADFG
RS06-01-U	19414	-	Unk	Adu	19-Oct-06	13-Feb-07	37	120	Kotzebue	ADFG
JS07	64739	-	M	Imm	23-May-07	2-Dec-07	35	2	Kotzebue	UAF
RS07-09-M	76982	-	M	Adu	11-Oct-07	27-Jan-08	48	88	Kotzebue	ADFG
RS07-03-F	76986	-	F	Imm	12-Oct-07	13-Jan-08	48	70	Kotzebue	ADFG

RS07-04-F	76984	-	F	Adu	14-Oct-07	15-May-08	59	234	Kotzebue	ADFG
RS07-15-M	76983	-	M	Imm	14-Oct-07	18-Nov-07	35	-	Kotzebue	ADFG
RS07-01-M	76981	-	M	Adu	18-Oct-07	27-Nov-07	38	-	Kotzebue	ADFG
RS07-02-F	40791	-	F	Adu	18-Oct-07	9-Jan-08	42	78	Kotzebue	ADFG
RS07-10-F	40797	-	F	Adu	21-Oct-07	28-Jun-08	16	20	Kotzebue	ADFG
RS07-14-M	40792	-	M	Imm	21-Oct-07	30-Jun-08	101	278	Kotzebue	ADFG
RS07-05-M	40795	-	M	Adu	24-Oct-07	4-Dec-07	37	8	Kotzebue	ADFG
RS07-06-M	40794	-	M	Adu	25-Oct-07	18-Feb-08	34	138	Kotzebue	ADFG
RS07-08-F	40796	-	F	Adu	25-Oct-07	20-Dec-07	35	36	Kotzebue	ADFG
RS07-12-F	40928	-	F	Adu	25-Oct-07	24-Jun-08	21	18	Kotzebue	ADFG
RS07-16-M	40793	-	M	Adu	25-Oct-07	18-Feb-08	36	148	Kotzebue	ADFG
RS07-11-M	40800	-	M	Adu	26-Oct-07	7-Dec-07	11	2	Kotzebue	ADFG
ME08	64734	-	F	Adu	25-May-08	3-Aug-08	21	-	Peard Bay	UAF
BU08	64744	-	M	Adu	26-May-08	13-Oct-08	26	-	Peard Bay	UAF
RS08-01-F	40800	-	F	Imm	10-Oct-08	17-Dec-08	51	28	Kotzebue	ADFG
RS08-02-F	76984	-	F	Adu	12-Oct-08	16-Jul-09	122	252	Kotzebue	ADFG
RS08-11-M	76981	-	M	Imm	14-Oct-08	18-Jun-09	95	294	Kotzebue	ADFG
RS08-07-F	76982	-	F	Imm	17-Oct-08	10-Mar-09	43	144	Kotzebue	ADFG
RS08-03-M	76986	-	M	Adu	19-Oct-08	19-Feb-09	35	150	Kotzebue	ADFG
RS08-05-M	40799	-	M	Imm	19-Oct-08	16-May-09	57	298	Kotzebue	ADFG
RS08-08-M	76983	-	M	Imm	19-Oct-08	6-Aug-09	137	300	Kotzebue	ADFG
RS08-09-F	76985	-	F	Imm	19-Oct-08	24-Nov-08	20	-	Kotzebue	ADFG
RS08-06-M	40795	-	M	Imm	20-Oct-08	31-May-09	63	274	Kotzebue	ADFG
RS08-10-M	40794	-	M	Imm	20-Oct-08	13-Aug-09	143	260	Kotzebue	ADFG
RS08-12-M	40796	-	M	Adu	20-Oct-08	24-Feb-09	39	132	Kotzebue	ADFG
RS08-13-F	40792	-	F	Imm	21-Oct-08	29-Jun-09	99	294	Kotzebue	ADFG
RS09-01-M	88473	-	M	Imm	26-Sep-09	14-Jun-10	110	302	Kotzebue	ADFG
RS09-02-M	88471	-	M	Imm	29-Sep-09	2-Feb-10	62	76	Kotzebue	ADFG
RS09-10-M	88470	-	M	Imm	29-Sep-09	27-Nov-09	34	-	Kotzebue	ADFG
RS09-04-F	95954	-	F	Imm	30-Sep-09	29-Jun-10	120	296	Kotzebue	ADFG
RS09-07-M	95955	-	M	Adu	30-Sep-09	10-Jan-10	58	74	Kotzebue	ADFG

RS09-08-F	88468	-	F	Adu	30-Sep-09	7-Mar-10	58	152	Kotzebue	ADFG
RS09-05-M	40800	-	M	Imm	1-Oct-09	30-Dec-09	58	50	Kotzebue	ADFG
RS09-06-F	95956	-	F	Adu	1-Oct-09	9-Jan-10	58	80	Kotzebue	ADFG
RS09-03-F	95953	-	F	Imm	2-Oct-09	16-Nov-09	45	-	Kotzebue	ADFG
RS09-09-M	76981	-	M	Imm	13-Oct-09	29-Dec-09	48	46	Kotzebue	ADFG
RS09-11-M	76984	-	M	Imm	13-Oct-09	21-Nov-09	38	-	Kotzebue	ADFG
DFO_43	44393	-	M	Imm	4-Jul-10	26-Apr-11	144	126	Ulukhaktok	DFO
DFO_49	44402	-	M	Adu	5-Jul-10	23-Mar-11	136	90	Ulukhaktok	DFO
DFO_42	44392	-	F	Adu	6-Jul-10	6-Apr-11	144	166	Ulukhaktok	DFO
DFO_45	44396	-	M	Adu	6-Jul-10	17-Jun-11	172	198	Ulukhaktok	DFO
DFO_46	44397	-	F	Adu	6-Jul-10	15-Feb-11	142	50	Ulukhaktok	DFO
DFO_47	44399	-	M	Adu	6-Jul-10	11-Mar-11	130	116	Ulukhaktok	DFO
DFO_41	44391	-	M	Adu	9-Jul-10	1-Mar-11	139	102	Ulukhaktok	DFO
DFO_44	44395	-	F	Imm	10-Jul-10	26-Jun-11	189	148	Ulukhaktok	DFO
DFO_48	44400	-	F	Adu	10-Jul-10	27-Mar-11	143	110	Ulukhaktok	DFO
PH2011BW02	106427	106409	M	Adu	14-Jul-11	13-Nov-13	34	24	Barrow	NSB
PH2011BW03	106429	106408	M	Imm	15-Jul-11	10-Jun-12	174	292	Barrow	NSB
PH2011BW04	106434	106413	M	Imm	15-Jul-11	18-Sep-11	16	-	Barrow	NSB
PH2011BW05	106424	-	M	Pup	15-Jul-11	7-Sep-11	53	-	Barrow	NSB
PH2011BW10	106420	106416	F	Adu	19-Jul-11	2-May-12	135	254	Barrow	NSB
PH2011BW11	106425	106414	F	Adu	20-Jul-11	5-Jun-12	166	252	Barrow	NSB
PH2011BW12	106428	106407	M	Adu	20-Jul-11	5-May-12	137	296	Barrow	NSB
PH2011BW13	106422	106410	M	Adu	20-Jul-11	13-Feb-12	132	88	Barrow	NSB
PH2011BW20	-	106418	F	Adu	25-Aug-11	30-Sep-11	12	-	Barrow	NSB
PH2011BW21	118090	118108	F	Pup	29-Sep-11	14-Jul-14	59	142	Barrow	NSB
RS12-01-M	110584	-	M	Imm	2-Jun-12	24-Aug-12	55	-	Hooper Bay	ADFG
RS12-03-M	110593	-	M	Adu	5-Jun-12	31-Oct-12	74	-	Hooper Bay	ADFG
PH2013BW03	118088	118121	F	Imm	8-Apr-13	23-Oct-13	48	-	Barrow	NSB
PH2013BW01	118087	118115	F	Adu	16-Jul-13	20-Jan-14	39	34	Barrow	NSB
RS14-01-M	136704	137522	M	Adu	18-Jun-14	24-Feb-16	233	192	Kotzebue	ADFG
RS14-02-F	136712	137523	F	Adu	18-Jun-14	11-Jun-15	202	154	Kotzebue	ADFG

RS14-03-M	136708	137525	M	Adu	19-Jun-14	16-Jun-15	191	156	Kotzebue	ADFG
RS14-04-F	137520	-	F	Adu	19-Jun-14	7-Jul-15	80	128	Kotzebue	ADFG
PH2014BW01	118094	118124	M	Adu	18-Jul-14	20-May-15	151	292	Barrow	NSB
PH2014BW02	118098	118116	M	Imm	22-Jul-14	3-Feb-15	131	114	Barrow	NSB
RS15-01-M	95957	149033	M	Imm	14-May-15	5-Aug-15	30	-	Hooper Bay	ADFG
RS15-02-F	149036	-	F	Imm	23-Aug-15	16-Dec-15	20	20	St. Michael	ADFG

Appendix B: Details for satellite transmitter deployments on bearded seals (*Erignathus barbatus*) used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. PTT (Platform Transmitter Terminal) is the transmission code used by the Argos when identifying transmitters (some are reused). Some animals were double tagged; if so, the secondary tag is denoted as PTT2. Ages include 'pup' for young of the year, 'Imm' for immature, and 'Adu' for breeding age adults. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. Agency is the entity providing data access: MML is the National Marine Fisheries Service's Marine Mammal Lab; UAF is the University of Alaska, Fairbanks; ADFG is the Alaska Department of Fish and Game; and NSB is the North Slope Borough.

ID	PTT	PTT2	Sex	Age	Deployment date	Date last location	# Summer days w/locations	# Winter days w/locations	Deployment location	Agency
EB2004_5972_04L0016	53604	-	F	Pup	5-Oct-04	31-Dec-04	55	30	Kotzebue	MML
EB2004_5973_04L0035	53605	-	F	Pup	12-Oct-04	1-Dec-04	48	1	Kotzebue	MML
EB2005_6020_04L0044	53609	-	M	Pup	26-Sep-05	4-Jun-06	78	119	Kotzebue	MML
EB2005_5954_04L0043	53608	-	M	Pup	30-Sep-05	26-Nov-05	59	-	Kotzebue	MML
EB2005_6021_04L0046	53610	-	M	Pup	1-Oct-05	30-Apr-06	62	134	Kotzebue	MML
EB2005_5956_04L0165	59971	-	F	Pup	2-Oct-05	27-Dec-05	58	27	Kotzebue	MML
EB2005_5957_04L0047	53611	-	M	Pup	2-Oct-05	15-Jan-06	59	38	Kotzebue	MML
EB2005_5958_04L0164	59970	-	M	Pup	3-Oct-05	20-Apr-06	57	135	Kotzebue	MML
EB2005_5959_04L0166	59972	-	F	Pup	4-Oct-05	29-Mar-06	56	119	Kotzebue	MML
EB2005_5964_04L0170	59976	-	M	Pup	7-Oct-05	24-Jan-06	53	39	Kotzebue	MML
EB2005_5962_04L0162	59968	-	F	Pup	7-Oct-05	4-May-06	57	132	Kotzebue	MML
EB2005_5950_04L0168	59974	-	F	Pup	7-Oct-05	22-Feb-06	53	55	Kotzebue	MML
EB2005_5960_04L0167	59973	-	F	Pup	8-Oct-05	7-Jan-06	53	30	Kotzebue	MML
EB2005_5963_04L0163	59969	-	M	Pup	8-Oct-05	18-Nov-05	41	-	Kotzebue	MML
EB2005_5952_04L0041	53607	-	F	Pup	24-Oct-05	7-Feb-06	68	69	Kotzebue	MML
EB2005_5970_04L0040	53606	-	M	Pup	24-Oct-05	1-Apr-06	68	121	Kotzebue	MML
EB2006_5939_05L0107	58069	-	F	Pup	3-Oct-06	25-May-07	83	150	Kotzebue	MML
EB2006_5945_05L0097	58059	-	M	Pup	7-Oct-06	3-May-07	52	151	Kotzebue	MML

EB2006_5947_05L0258	65914	-	M	Pup	20-Oct-06	21-Dec-06	42	20	Kotzebue	MML
EB2006_5946_05L0098	58060	-	F	Pup	23-Oct-06	18-Jan-07	43	49	Kotzebue	MML
EB2009_3000_06A1346	74627	64462	M	Imm	23-Jun-09	12-Jun-12	191	144	Kotzebue	MML
EB2009_3001_06A1332	74626	83904	M	Adu	25-Jun-09	24-Apr-12	178	114	Kotzebue	MML
EB2009_3002_06A1357	74630	64459	M	Imm	26-Jun-09	18-May-12	174	110	Kotzebue	MML
BS09-08-M	88469	-	M	Imm	22-Sep-09	31-Mar-10	68	57	Kotzebue	ADFG
BS09-03-F	40791	-	F	Imm	25-Sep-09	15-Apr-10	63	108	Kotzebue	ADFG
BS09-05-F	40792	-	F	Imm	6-Oct-09	25-Feb-10	54	85	Kotzebue	ADFG
BS09-06-F	40793	-	F	Imm	6-Oct-09	27-May-10	81	139	Kotzebue	ADFG
BS09-11-F	40794	-	F	Imm	6-Oct-09	1-Dec-09	47	1	Kotzebue	ADFG
BS09-04-M	40796	-	M	Imm	9-Oct-09	21-May-10	17	6	Kotzebue	ADFG
BS09-02-M	40799	-	M	Imm	11-Oct-09	18-Feb-10	49	75	Kotzebue	ADFG
BS09-07-F	40795	-	F	Imm	12-Oct-09	26-May-10	74	113	Kotzebue	ADFG
BS09-09-M	76982	-	M	Imm	13-Oct-09	8-Feb-10	48	70	Kotzebue	ADFG
BS09-10-F	76983	-	F	Imm	13-Oct-09	26-Feb-10	48	87	Kotzebue	ADFG
EB2011_3000_10A0219	39489	67007	F	Imm	16-Jun-11	1-Aug-12	178	129	Kotzebue	MML
EB2011_3001_10A0552	66971	99310	F	Imm	17-Jun-11	30-May-12	172	73	Kotzebue	MML
EB2011_3002_10A0200	38553	66983	M	Imm	18-Jun-11	24-May-14	193	121	Kotzebue	MML
EB2012_3003_09A0888	99287	67004	F	Imm	4-Jul-12	12-Jun-13	156	110	Kotzebue	MML
EB2012BW01	118095	118105	M	Imm	21-Jul-12	19-Apr-13	131	135	Barrow	NSB
BS14-01-M	136709	137524	M	Pup	18-Jun-14	23-May-15	176	63	Kotzebue	ADFG
BS14-02-M	136707	138006	M	Pup	26-Sep-14	31-Dec-15	102	110	Koyuk	ADFG
BS14-03-M	76986	110587	M	Pup	26-Sep-14	17-Nov-14	47	-	Koyuk	ADFG
BS14-04-M	136713	138003	M	Pup	30-Sep-14	18-Jul-15	85	65	Koyuk	ADFG
BS15-01-M	136711	110591	M	Pup	18-Aug-15	10-Oct-15	52	-	Koyuk	ADFG
BS15-02-M	110596	110592	M	Pup	18-Aug-15	21-Oct-15	63	-	Koyuk	ADFG
BS15-03-F	136705	138005	F	Pup	19-Aug-15	20-Jan-16	100	48	Koyuk	ADFG
BS15-04-F	136706	149034	F	Pup	20-Aug-15	5-Jan-16	102	33	Koyuk	ADFG
BS15-06-F	149043	149035	F	Imm	22-Aug-15	29-Feb-16	11	35	St. Michael	ADFG
BS15-07-M	110598	110590	M	Imm	23-Aug-15	28-Feb-16	96	90	St. Michael	ADFG
BS15-08-F	110595	137519	F	Imm	23-Aug-15	12-Dec-15	92	4	St. Michael	ADFG
EB2015OI01	150998	149397	M	Imm	9-Sep-15	10-Feb-16	82	70	Dease Inlet	NSB

EB2015OI02	150995	149379	M	Pup	18-Sep-15	10-Feb-16	54	72	Dease Inlet	NSB

Appendix C: Details for satellite transmitters deployed on spotted seals (*Phoca largha*) used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. PTT (Platform Transmitter Terminal) is the transmission code used by the Argos when identifying transmitters (some are reused). Some animals were double tagged; if so, the secondary tag is denoted as PTT2. Ages include 'pup' for young of the year, 'Imm' for immature, and 'Adu' for breeding age adults. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. Seals tagged in Bristol Bay in 2000 have the abbreviation 'PV' within their ID because they were initially thought to be harbor seals (*Phoca vitulina*); genetic testing proved otherwise. We preserve the original ID to aid in locating records. Agency is the entity providing data access: ADFG is the Alaska Department of Fish and Game; TINRO is the Pacific Research Fisheries Center, Russia; MML is the National Marine Fisheries Service's Marine Mammal Lab; and NSB is the North Slope Borough.

ID	**PTT**	**PTT2**	**Sex**	**Age**	**Deployment date**	**Date last location**	**# Summer days w/locations**	**# Winter days w/locations**	**Deployment location**	**Agency**
PL-10919	*Phoca largha*	10919	-	M	Imm	4-Aug-91	4-Mar-92	43	35	Point Lay
PL-10920	*Phoca largha*	10920	-	M	Imm	4-Aug-91	20-Apr-92	41	37	Point Lay
PL-11044	*Phoca largha*	11044	-	F	Imm	4-Aug-91	19-May-94	112	75	Point Lay
PL-11041	*Phoca largha*	11041	-	M	Imm	6-Aug-91	17-Feb-94	103	58	Point Lay
PL-14098	*Phoca largha*	14098	-	F	Adu	6-Aug-91	3-Jan-92	43	26	Point Lay
PL-15991	*Phoca largha*	15991	-	M	Imm	6-Aug-91	3-Oct-93	49		Point Lay
PL-15992	*Phoca largha*	15992	-	F	Imm	6-Aug-91	30-Dec-93	44	25	Point Lay
PL-15993	*Phoca largha*	15993	-	F	Imm	6-Aug-91	26-Apr-94	86	72	Point Lay
PL-14099	*Phoca largha*	14099	-	M	Adu	7-Aug-91	10-Oct-91	15		Point Lay
PL-2281	*Phoca largha*	2281	-	M	Adu	8-Aug-91	2-Jun-94	53	68	Point Lay
PL-2284	*Phoca largha*	2284	-	M	Adu	27-Aug-91	19-Apr-93	79	105	Point Lay
PL-Kam-2245	*Phoca largha*	2245	-	M	Adu	5-Aug-93	19-Sep-93	18		Kamchatka
PL-Kam-2241	*Phoca largha*	2241	-	F	Adu	11-Aug-93	19-Feb-94	64	38	Kamchatka
PL-Kam-11038	*Phoca largha*	11038	-	M	Adu	13-Aug-93	8-May-94	77	109	Kamchatka
PL-Kam-11039	*Phoca largha*	11039	-	M	Adu	13-Aug-93	11-May-94	93	79	Kamchatka
PL-Kam-11043	*Phoca largha*	11043	-	F	Adu	13-Aug-93	26-Apr-94	68	83	Kamchatka

PV01BB35	*Phoca largha*	19840	-	F	Imm	8-Sep-00	3-May-02	82	138	Bristol Bay
PV00BB02	*Phoca largha*	2088	-	F	Imm	12-Sep-00	30-Dec-00	60	30	Bristol Bay
PV00BB03	*Phoca largha*	2091	-	M	Imm	12-Sep-00	24-Oct-00	38		Bristol Bay
PV00BB04	*Phoca largha*	2086	-	M	Imm	12-Sep-00	16-May-01	66	97	Bristol Bay
PV00BB06	*Phoca largha*	2087	-	F	Imm	12-Sep-00	30-Jan-01	47	43	Bristol Bay
PV00BB11	*Phoca largha*	2084	-	F	Imm	13-Sep-00	21-May-01	31		Bristol Bay
PL2005_5966_05L0002	*Phoca largha*	57999	-	F	Pup	25-Sep-05	21-May-06	89	151	at-sea
PL2005_5967_05L0026	*Phoca largha*	58001	-	F	Pup	26-Sep-05	16-Dec-05	65	16	at-sea
PL2005_5969_04L0021	*Phoca largha*	58003	-	M	Adu	28-Sep-05	28-Apr-06	8	28	at-sea
PL2005_5971_05L0017	*Phoca largha*	58014	-	M	Adu	29-Sep-05	30-Mar-06	43	119	at-sea
PL2005_5968_05L0005	*Phoca largha*	58002	-	F	Pup	25-Oct-05	23-Dec-05	36	17	at-sea
PL2006_5990_05L0244	*Phoca largha*	65932	-	F	Pup	6-May-06	20-Jun-06	45		at-sea
PL2007_6040_07L0019	*Phoca largha*	74644	-	M	Imm	7-May-07	5-Mar-08	151	90	at-sea
PL2007_6042_07L0016	*Phoca largha*	74642	-	M	Imm	8-May-07	18-Nov-07	108		at-sea
PL2009_2002_06L0124	*Phoca largha*	74633	-	F	Pup	18-May-09	1-Aug-09	73		at-sea
PL2009_2003_08L0035	*Phoca largha*	85864	-	M	Pup	19-May-09	16-Dec-09	194	8	at-sea
PL2009_2004_08L0033	*Phoca largha*	85862	-	F	Pup	19-May-09	10-Aug-09	82		at-sea
PL2009_2005_06L0126	*Phoca largha*	74635	-	F	Pup	23-May-09	28-Oct-09	157		at-sea
PL2009_2006_08L0046	*Phoca largha*	85871	-	F	Pup	23-May-09	27-Feb-10	188	87	at-sea
PL2009_2016_08L0039	*Phoca largha*	85866	-	M	Imm	29-May-09	4-Jul-09	35		at-sea
PL2009_2019_08L0050	*Phoca largha*	85875	-	M	Imm	31-May-09	21-Sep-09	100		at-sea
PL2009_2020_08L0030	*Phoca largha*	85859	-	M	Imm	31-May-09	1-Feb-10	182	57	at-sea
PL2009_1020_09L0043	*Phoca largha*	64485	-	M	Imm	3-Jun-09	23-Oct-09	142		at-sea
PL2009_1025_09L0045	*Phoca largha*	64488	-	M	Imm	6-Jun-09	10-Mar-10	176	100	at-sea
PL2009_2033_07L0013	*Phoca largha*	74631	-	F	Pup	6-Jun-09	3-May-10	145	140	at-sea
PL2009_2034_08L0028	*Phoca largha*	85857	-	F	Imm	7-Jun-09	30-Jan-10	176	53	at-sea
PL2009_2038_08L0053	*Phoca largha*	85878	-	F	Imm	8-Jun-09	20-Mar-10	174	110	at-sea
PL2009_2039_08L0040	*Phoca largha*	85867	-	M	Pup	9-Jun-09	28-Sep-09	98		at-sea
PL2010_1002_08L0028	*Phoca largha*	85858	-	F	Pup	5-May-10	14-Feb-11	192	61	at-sea
PL2010_2002_08L0052	*Phoca largha*	85877	-	M	Pup	6-May-10	26-Jul-10	81		at-sea
PL2010_1003_08L0128	*Phoca largha*	74637	-	F	Pup	6-May-10	10-Apr-11	199	105	at-sea
PL2010_2004_08L0044	*Phoca largha*	85869	-	F	Pup	6-May-10	8-Jan-11	193	39	at-sea

PL2010_2005_08L0026	*Phoca largha*	85855	-	F	Pup	8-May-10	31-Oct-10	170		at-sea
PL2010_2021_10A0192	*Phoca largha*	37515	-	M	Imm	22-May-10	23-Apr-11	191	144	at-sea
PL2012TI01	*Phoca largha*	118090	118108	F	Adu	8-Aug-12	31-May-13	141	143	Barrow
PL2014OI01	*Phoca largha*	118102	118109	M	Imm	29-Jul-14	1-Sep-14	33		Barrow
PL2014OI02	*Phoca largha*	118096	118120	M	Adu	31-Jul-14	26-May-15	147	146	Barrow
PL2014OI03	*Phoca largha*	118093	118110	M	Imm	18-Aug-14	7-May-15	111	151	Barrow
PL2014OI04	*Phoca largha*	118104	118123	M	Imm	18-Aug-14	16-Apr-15	103	136	Barrow
PL2014OI05	*Phoca largha*	118086	118106	M	Imm	18-Aug-14	25-Oct-14	32		Barrow
PL2014OI06	*Phoca largha*	118101	118117	M	Adu	19-Aug-14	28-May-15	128	151	Barrow
PL2014OI07	*Phoca largha*	118092	118113	F	Imm	19-Aug-14	16-Apr-15	103	137	Barrow
PL2014OI08	*Phoca largha*	118103	118119	M	Imm	19-Aug-14	15-Jan-15	101	45	Barrow
PL2014OI09	*Phoca largha*	118097	118111	F	Imm	19-Aug-14	5-Mar-15	102	95	Barrow
PL2014OI10	*Phoca largha*	118099	118122	M	Adu	22-Aug-14	23-Apr-15	100	144	Barrow
PL2015OI04	*Phoca largha*	149367	149399	F	Adu	8-May-15	10-Feb-16	112	72	Barrow
PL2015OI02	*Phoca largha*	149354	149396	M	Imm	14-Jul-15	23-Jan-16	138	53	Barrow
PL2015OI03	*Phoca largha*	149368	149376	F	Imm	15-Jul-15	10-Feb-16	137	72	Barrow
PL2015OI07	*Phoca largha*	150999	149392	M	Adu	13-Aug-15	11-Jan-16	104	34	Barrow
PL2015OI08	*Phoca largha*	149359	149377	M	Imm	13-Aug-15	9-Feb-16	108	71	Barrow
PL2015OI09	*Phoca largha*	149358	149378	M	Imm	15-Aug-15	10-Feb-16	106	72	Barrow
PL2015KB10	*Phoca largha*	149369	149391	M	Imm	19-Aug-15	10-Feb-16	100	72	Barrow
PL2015KB11	*Phoca largha*	149353	149375	F	Imm	19-Aug-15	5-Oct-15	44		Barrow
PL2015KB12	*Phoca largha*	150997	149387	M	Imm	20-Aug-15	9-Feb-16	101	44	Barrow
PL2015OI05	*Phoca largha*	149364	149380	M	Imm	8-Oct-15	10-Feb-16	111	72	Barrow
PL2015OI06	*Phoca largha*	150994	149401	F	Adu	8-Nov-15	8-Feb-16	106	25	Barrow

Appendix D: Details for satellite transmitters attached to Pacific walruses (*Odobenus rosmarus divergens*) used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. PTT (Platform Transmitter Terminal) is the transmission code used by the Argos when identifying transmitters (some are reused). Ages include 'Imm' for immature, and 'Adu' for breeding age adults. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. Agency is the entity providing data access: USGS is the United State Geological Survey and ADFG is the Alaska Department of Fish and Game.

ID	PTT	Sex	Age	Deployment date	Date last location	# Summer days w/locations	# Winter days w/locations	Location	Agency
W001	?	M	Adu	14-Aug-87	27-Oct-87	27	-	Round Island	USGS
W002	?	M	Adu	11-May-88	3-Sep-88	12	-	Bering Sea	USGS
W005	?	F	Adu	5-Aug-88	20-Sep-88	29	-	Bering Sea	USGS
W014	?	M	Adu	7-May-90	16-Aug-90	32	-	Bering Sea	USGS
W015	?	M	Adu	7-May-90	12-Oct-90	152	-	Bering Sea	USGS
W016	?	M	Adu	8-May-90	1-Sep-90	54	-	Bering Sea	USGS
W018	?	M	Adu	9-May-90	7-Jul-90	52	-	Bering Sea	USGS
W019	?	M	Adu	9-May-90	22-Sep-90	88	-	Bering Sea	USGS
W020	?	M	Adu	21-May-90	24-Jan-91	119	24	Round Island	USGS
W021	?	M	Adu	21-May-90	15-Nov-90	174	-	Round Island	USGS
W022	?	M	Adu	22-May-90	14-Sep-90	105	-	Round Island	USGS
W023	?	F	Adu	8-Apr-91	16-Aug-91	82	16	Bering Sea	USGS
W024	?	F	Adu	8-Apr-91	2-Aug-91	85	21	Bering Sea	USGS
W026	?	F	Adu	11-May-91	1-Sep-91	100	-	Bering Sea	USGS
W028	?	F	Adu	13-May-91	24-Jun-91	42	-	Bering Sea	USGS
W031	?	M	Adu	2-Aug-95	12-Dec-95	36	3	Cape Pierce	USGS
W034	?	M	Adu	3-Aug-95	18-Sep-95	31	-	Cape Pierce	USGS
W036	?	M	Adu	4-Aug-95	18-Nov-95	72	-	Cape Pierce	USGS
W038	?	M	Adu	1-Aug-96	5-Feb-97	48	17	Cape Pierce	USGS
W042	?	M	Adu	18-Aug-96	24-Sep-96	35	-	Cape Pierce	USGS

W045	?	M	Adu	22-Aug-96	25-Jan-97	25	22	Cape Pierce	USGS
W046	?	M	Adu	30-May-97	7-Nov-97	17	-	Round Island	USGS
W048	?	M	Adu	30-May-97	17-Dec-97	36	3	Round Island	USGS
W053	?	M	Adu	2-Jul-97	9-Sep-97	19	-	Cape Newenham	USGS
W057	?	M	Adu	6-Aug-97	10-Oct-97	21	-	Cape Pierce	USGS
W064	?	M	Adu	9-Jun-98	3-Dec-98	30	1	Round Island	USGS
W068	?	M	Adu	12-Jun-98	31-Oct-99	42	12	Round Island	USGS
W070	?	M	Adu	12-Jun-98	3-Nov-99	106	17	Round Island	USGS
W074	?	M	Adu	14-Aug-98	2-Dec-98	26	1	Cape Pierce	USGS
W078	?	M	Adu	22-Aug-99	2-Feb-00	17	11	Cape Pierce	USGS
W088	?	M	Adu	30-Sep-02	18-Jul-03	79	82	Cape Pierce	USGS
W092	?	M	Adu	30-Sep-02	8-Sep-03	51	12	Cape Pierce	USGS
W095	?	M	Adu	30-Sep-02	2-Jun-03	34	22	Cape Pierce	USGS
W096	?	M	Adu	30-Sep-02	29-Aug-03	83	26	Cape Pierce	USGS
W116	?	F	Adu	10-Apr-04	20-May-04	20	20	Bering Sea	USGS
W119	?	M	Adu	11-Apr-04	30-May-04	26	13	Bering Sea	USGS
W120	?	F	Adu	11-Apr-04	21-May-04	20	17	Bering Sea	USGS
W128	?	F	Adu	14-Apr-04	5-Jun-04	32	16	Bering Sea	USGS
W131	?	F	Adu	17-Apr-04	29-Jun-04	35	8	Bering Sea	USGS
W132	?	M	Adu	17-Apr-04	29-Jun-04	21	4	Bering Sea	USGS
W136	?	M	Adu	19-Apr-04	24-Jul-04	57	8	Bering Sea	USGS
W142	?	M	Adu	20-Apr-04	21-May-04	20	7	Bering Sea	USGS
W145	?	M	Adu	20-Apr-04	26-May-04	25	9	Bering Sea	USGS
W148	?	M	Adu	17-Mar-05	2-May-05	2	42	Bering Sea	USGS
W154	?	M	Adu	18-Mar-05	22-May-05	20	40	Bering Sea	USGS
W155	?	U	Adu	18-Mar-05	29-Apr-05	-	41	Bering Sea	USGS
W159	?	F	Adu	18-Mar-05	12-May-05	12	42	Bering Sea	USGS
W160	?	M	Adu	19-Mar-05	23-Apr-05	-	34	Bering Sea	USGS
W161	?	M	Adu	19-Mar-05	20-Apr-05	-	32	Bering Sea	USGS
W163	?	F	Adu	19-Mar-05	26-Apr-05	-	38	Bering Sea	USGS
W164	?	F	Adu	19-Mar-05	6-May-05	6	36	Bering Sea	USGS
W165	?	F	Adu	19-Mar-05	30-Apr-05	-	40	Bering Sea	USGS

W167	?	F	Adu	19-Mar-05	19-Apr-05	-	28	Bering Sea	USGS
W170	?	U	Adu	19-Mar-05	2-May-05	2	41	Bering Sea	USGS
W171	?	M	Adu	19-Mar-05	23-May-05	14	25	Bering Sea	USGS
W177	?	F	Adu	24-Mar-06	18-May-06	18	28	Bering Sea	USGS
W178	?	F	Adu	25-Mar-06	2-May-06	2	35	Bering Sea	USGS
W180	?	U	Adu	25-Mar-06	2-May-06	2	15	Bering Sea	USGS
W182	?	F	Adu	25-Mar-06	8-May-06	8	16	Bering Sea	USGS
W183	?	F	Adu	25-Mar-06	21-May-06	19	11	Bering Sea	USGS
W184	?	F	Adu	25-Mar-06	7-May-06	6	35	Bering Sea	USGS
W186	?	F	Adu	26-Mar-06	16-May-06	16	35	Bering Sea	USGS
W187	?	F	Adu	26-Mar-06	30-Apr-06	-	35	Bering Sea	USGS
W188	?	U	Adu	26-Mar-06	10-May-06	10	35	Bering Sea	USGS
W190	?	F	Adu	26-Mar-06	23-May-06	20	18	Bering Sea	USGS
W191	?	M	Adu	26-Mar-06	6-May-06	6	35	Bering Sea	USGS
W193	?	F	Adu	26-Mar-06	27-Apr-06	-	27	Bering Sea	USGS
W194	?	F	Adu	26-Mar-06	15-May-06	14	31	Bering Sea	USGS
W195	?	F	Adu	27-Mar-06	23-May-06	19	23	Bering Sea	USGS
W196	?	F	Adu	27-Mar-06	26-May-06	16	22	Bering Sea	USGS
W197	?	F	Adu	29-Mar-06	9-May-06	7	30	Bering Sea	USGS
W198	?	F	Adu	29-Mar-06	9-May-06	9	32	Bering Sea	USGS
W199	?	F	Adu	29-Mar-06	5-May-06	5	32	Bering Sea	USGS
W200	?	M	Adu	29-Mar-06	30-Apr-06	-	32	Bering Sea	USGS
W201	?	F	Adu	29-Mar-06	18-May-06	8	32	Bering Sea	USGS
W202	?	F	Adu	29-Mar-06	3-May-06	3	20	Bering Sea	USGS
W206	?	F	Adu	29-Mar-06	22-May-06	10	28	Bering Sea	USGS
W209	?	F	Adu	29-Mar-06	28-May-06	24	11	Bering Sea	USGS
W210	?	F	Adu	29-Mar-06	11-May-06	11	31	Bering Sea	USGS
W211	?	F	Adu	29-Mar-06	1-May-06	1	31	Bering Sea	USGS
W212	?	M	Adu	30-Mar-06	1-May-06	1	17	Bering Sea	USGS
W214	?	F	Adu	30-Mar-06	29-May-06	26	18	Bering Sea	USGS
W215	?	F	Adu	30-Mar-06	30-Apr-06	-	31	Bering Sea	USGS
W216	?	F	Adu	30-Mar-06	10-May-06	10	29	Bering Sea	USGS

W217	?	F	Adu	30-Mar-06	19-May-06	16	18	Bering Sea	USGS
W220	?	M	Adu	30-Mar-06	13-May-06	13	30	Bering Sea	USGS
W224	?	F	Adu	24-Jun-07	30-Jul-07	30	-	Chukchi Sea	USGS
W227	?	F	Adu	24-Jun-07	21-Aug-07	34	-	Chukchi Sea	USGS
W228	?	F	Adu	24-Jun-07	29-Jul-07	31	-	Chukchi Sea	USGS
W229	?	F	Adu	24-Jun-07	29-Jul-07	32	-	Chukchi Sea	USGS
W241	?	M	Adu	23-Sep-07	24-Oct-07	25	-	Bering Sea	USGS
W257	?	M	Adu	19-Mar-08	15-May-08	15	42	Bering Sea	USGS
W258	?	M	Adu	19-Mar-08	8-May-08	8	42	Bering Sea	USGS
W259	?	F	Adu	19-Mar-08	4-May-08	4	42	Bering Sea	USGS
W262	?	U	Adu	21-Mar-08	29-Apr-08	-	25	Bering Sea	USGS
W265	?	M	Adu	22-Mar-08	3-May-08	3	39	Bering Sea	USGS
W267	?	F	Adu	31-May-08	9-Aug-08	67	-	Bering Sea	USGS
W269	?	F	Adu	31-May-08	1-Jul-08	30	-	Bering Sea	USGS
W271	?	F	Adu	31-May-08	12-Sep-08	98	-	Bering Sea	USGS
W274	?	F	Adu	31-May-08	1-Jul-08	31	-	Bering Sea	USGS
W275	?	F	Adu	31-May-08	7-Jul-08	29	-	Bering Sea	USGS
W276	?	M	Adu	2-Jun-08	29-Aug-08	88	-	Chukchi Sea	USGS
W277	?	F	Adu	2-Jun-08	12-Jul-08	40	-	Chukchi Sea	USGS
W278	?	M	Adu	2-Jun-08	3-Jul-08	30	-	Chukchi Sea	USGS
W279	?	M	Adu	2-Jun-08	12-Jul-08	37	-	Chukchi Sea	USGS
W283	?	F	Adu	2-Jun-08	15-Jul-08	42	-	Chukchi Sea	USGS
W285	?	M	Adu	2-Jun-08	14-Jul-08	42	-	Chukchi Sea	USGS
W286	?	F	Adu	3-Jun-08	20-Sep-08	105	-	Chukchi Sea	USGS
W287	?	F	Adu	3-Jun-08	27-Sep-08	114	-	Chukchi Sea	USGS
W303	?	F	Adu	18-Mar-09	26-Apr-09	-	39	Bering Sea	USGS
W305	?	M	Adu	18-Mar-09	5-May-09	5	42	Bering Sea	USGS
W306	?	F	Adu	18-Mar-09	6-May-09	6	42	Bering Sea	USGS
W307	?	F	Adu	18-Mar-09	21-Apr-09	-	32	Bering Sea	USGS
W308	?	M	Adu	21-Mar-09	24-May-09	24	40	Bering Sea	USGS
W310	?	M	Adu	23-Mar-09	24-May-09	24	37	Bering Sea	USGS
W311	?	M	Adu	23-Mar-09	3-May-09	3	37	Bering Sea	USGS

W313	?	U	Adu	6-Jun-09	16-Aug-09	70	-	Chukchi Sea	USGS
W314	?	F	Adu	6-Jun-09	7-Jul-09	31	-	Chukchi Sea	USGS
W317	?	F	Adu	8-Jun-09	31-Jul-09	51	-	Chukchi Sea	USGS
W320	?	F	Adu	8-Jun-09	15-Jul-09	30	-	Chukchi Sea	USGS
W325	?	F	Adu	8-Jun-09	20-Jul-09	40	-	Chukchi Sea	USGS
W326	?	F	Adu	8-Jun-09	5-Sep-09	67	-	Chukchi Sea	USGS
W327	?	F	Adu	8-Jun-09	20-Jul-09	42	-	Chukchi Sea	USGS
W328	?	F	Adu	8-Jun-09	28-Jul-09	50	-	Chukchi Sea	USGS
W331	?	F	Adu	8-Jun-09	20-Jul-09	42	-	Chukchi Sea	USGS
W333	?	F	Adu	8-Jun-09	2-Aug-09	45	-	Chukchi Sea	USGS
W335	?	F	Adu	8-Jun-09	8-Aug-09	58	-	Chukchi Sea	USGS
W336	?	F	Adu	8-Jun-09	16-Jul-09	37	-	Chukchi Sea	USGS
W337	?	F	Adu	8-Jun-09	3-Sep-09	86	-	Chukchi Sea	USGS
W338	?	F	Adu	9-Jun-09	11-Aug-09	61	-	Chukchi Sea	USGS
W339	?	F	Adu	9-Jun-09	17-Jul-09	38	-	Chukchi Sea	USGS
W340	?	F	Adu	9-Jun-09	22-Jul-09	43	-	Chukchi Sea	USGS
W342	?	F	Adu	9-Jun-09	13-Aug-09	60	-	Chukchi Sea	USGS
W343	?	F	Adu	9-Jun-09	18-Jul-09	39	-	Chukchi Sea	USGS
W344	?	F	Adu	9-Jun-09	3-Aug-09	55	-	Chukchi Sea	USGS
W345	?	F	Adu	9-Jun-09	16-Jul-09	37	-	Chukchi Sea	USGS
W346	?	F	Adu	2-Jul-09	10-Nov-09	52	-	Chukchi Sea	USGS
W347	?	F	Adu	2-Jul-09	18-Aug-09	36	-	Chukchi Sea	USGS
W350	?	M	Adu	2-Jul-09	30-Aug-09	59	-	Chukchi Sea	USGS
W351	?	M	Adu	2-Jul-09	18-Aug-09	46	-	Chukchi Sea	USGS
W352	?	M	Adu	2-Jul-09	4-Sep-09	63	-	Chukchi Sea	USGS
W355	?	F	Adu	16-Sep-09	1-Nov-09	39	-	Chukchi Sea	USGS
W356	?	F	Adu	16-Sep-09	15-Nov-09	60	-	Chukchi Sea	USGS
W357	?	F	Adu	16-Sep-09	9-Nov-09	54	-	Chukchi Sea	USGS
W358	?	F	Adu	16-Sep-09	18-Oct-09	30	-	Chukchi Sea	USGS
W359	?	F	Adu	16-Sep-09	30-Oct-09	44	-	Chukchi Sea	USGS
W364	?	F	Adu	16-Sep-09	29-Oct-09	35	-	Chukchi Sea	USGS
W370	?	M	Adu	9-Jun-10	20-Jul-10	40	-	Chukchi Sea	USGS

W371	?	F	Adu	9-Jun-10	31-Aug-10	83	-	Chukchi Sea	USGS
W372	?	M	Adu	9-Jun-10	27-Jul-10	48	-	Chukchi Sea	USGS
W375	?	F	Adu	11-Jun-10	26-Jul-10	45	-	Chukchi Sea	USGS
W377	?	F	Adu	11-Jun-10	25-Jul-10	44	-	Chukchi Sea	USGS
W378	?	F	Adu	11-Jun-10	28-Jul-10	47	-	Chukchi Sea	USGS
W379	?	F	Adu	11-Jun-10	5-Aug-10	55	-	Chukchi Sea	USGS
W380	?	F	Adu	11-Jun-10	27-Jul-10	46	-	Chukchi Sea	USGS
W381	?	F	Adu	11-Jun-10	28-Jul-10	47	-	Chukchi Sea	USGS
W383	?	F	Adu	11-Jun-10	30-Jul-10	49	-	Chukchi Sea	USGS
W384	?	F	Adu	11-Jun-10	26-Jul-10	45	-	Chukchi Sea	USGS
W386	?	F	Adu	11-Jun-10	25-Jul-10	44	-	Chukchi Sea	USGS
W388	?	F	Adu	11-Jun-10	26-Jul-10	38	-	Chukchi Sea	USGS
W389	?	F	Adu	11-Jun-10	2-Aug-10	52	-	Chukchi Sea	USGS
W390	?	F	Adu	11-Jun-10	25-Jul-10	44	-	Chukchi Sea	USGS
W391	?	F	Adu	11-Jun-10	26-Jul-10	41	-	Chukchi Sea	USGS
W393	?	F	Adu	11-Jun-10	31-Jul-10	50	-	Chukchi Sea	USGS
W394	?	M	Adu	12-Jun-10	15-Aug-10	64	-	Chukchi Sea	USGS
W397	?	F	Adu	12-Jun-10	9-Sep-10	89	-	Chukchi Sea	USGS
W398	?	F	Adu	12-Jun-10	24-Jul-10	42	-	Chukchi Sea	USGS
W399	?	F	Adu	12-Jun-10	15-Jul-10	25	-	Chukchi Sea	USGS
W400	?	F	Adu	12-Jun-10	21-Jul-10	39	-	Chukchi Sea	USGS
W401	?	F	Adu	12-Jun-10	15-Jul-10	33	-	Chukchi Sea	USGS
W402	?	F	Adu	12-Jun-10	14-Jul-10	27	-	Chukchi Sea	USGS
W403	?	M	Adu	12-Jun-10	14-Aug-10	58	-	Chukchi Sea	USGS
W406	?	F	Adu	12-Jun-10	2-Aug-10	51	-	Chukchi Sea	USGS
W407	?	F	Adu	12-Jun-10	12-Aug-10	48	-	Chukchi Sea	USGS
W408	?	F	Adu	12-Jun-10	21-Jul-10	38	-	Chukchi Sea	USGS
W409	?	F	Adu	12-Jun-10	1-Sep-10	80	-	Chukchi Sea	USGS
W411	?	F	Adu	8-Jul-10	9-Sep-10	60	-	Chukchi Sea	USGS
W413	?	F	Adu	9-Jul-10	5-Sep-10	58	-	Chukchi Sea	USGS
W415	?	F	Adu	9-Jul-10	28-Aug-10	50	-	Chukchi Sea	USGS
W416	?	F	Adu	9-Jul-10	16-Sep-10	66	-	Chukchi Sea	USGS

W417	?	U	Adu	9-Jul-10	15-Aug-10	37	-	Chukchi Sea	USGS
W418	?	F	Adu	9-Jul-10	24-Aug-10	46	-	Chukchi Sea	USGS
W420	?	F	Adu	9-Jul-10	3-Sep-10	56	-	Chukchi Sea	USGS
W421	?	F	Adu	9-Jul-10	25-Aug-10	47	-	Chukchi Sea	USGS
W422	?	M	Adu	9-Jul-10	1-Sep-10	54	-	Chukchi Sea	USGS
W423	?	F	Adu	9-Jul-10	31-Aug-10	53	-	Chukchi Sea	USGS
W424	?	F	Adu	9-Jul-10	14-Sep-10	67	-	Chukchi Sea	USGS
W425	?	F	Adu	9-Jul-10	17-Sep-10	70	-	Chukchi Sea	USGS
W426	?	F	Adu	9-Jul-10	19-Sep-10	72	-	Chukchi Sea	USGS
W427	?	F	Adu	9-Jul-10	2-Sep-10	55	-	Chukchi Sea	USGS
W428	?	F	Adu	9-Jul-10	4-Sep-10	57	-	Chukchi Sea	USGS
W429	?	F	Adu	9-Jul-10	28-Aug-10	50	-	Chukchi Sea	USGS
W430	?	F	Adu	9-Jul-10	8-Oct-10	72	-	Chukchi Sea	USGS
W431	?	F	Adu	9-Jul-10	19-Aug-10	40	-	Chukchi Sea	USGS
W432	?	F	Adu	9-Jul-10	1-Sep-10	54	-	Chukchi Sea	USGS
W435	?	F	Adu	9-Jul-10	1-Sep-10	54	-	Chukchi Sea	USGS
W436	?	F	Adu	9-Jul-10	2-Sep-10	55	-	Chukchi Sea	USGS
W439	?	F	Adu	9-Jul-10	4-Oct-10	87	-	Chukchi Sea	USGS
W440	?	F	Adu	9-Jul-10	26-Aug-10	48	-	Chukchi Sea	USGS
W442	?	F	Adu	9-Jul-10	22-Aug-10	44	-	Chukchi Sea	USGS
W443	?	F	Adu	7-Sep-10	20-Oct-10	43	-	Point Lay	USGS
W446	?	F	Adu	7-Sep-10	6-Nov-10	59	-	Point Lay	USGS
W447	?	F	Adu	7-Sep-10	17-Oct-10	40	-	Point Lay	USGS
W449	?	U	Adu	7-Sep-10	9-Nov-10	63	-	Point Lay	USGS
W450	?	U	Adu	7-Sep-10	17-Oct-10	40	-	Point Lay	USGS
W457	?	F	Adu	9-Sep-10	23-Oct-10	44	-	Point Lay	USGS
W458	?	F	Adu	9-Sep-10	30-Oct-10	51	-	Point Lay	USGS
W459	?	F	Adu	9-Sep-10	28-Dec-10	82	28	Point Lay	USGS
W462	?	F	Adu	9-Sep-10	15-Oct-10	36	-	Point Lay	USGS
W463	?	F	Adu	9-Sep-10	24-Oct-10	45	-	Point Lay	USGS
W465	?	F	Adu	2-Oct-10	8-Nov-10	37	-	Vankarem	USGS
W480	?	F	Adu	17-Oct-10	20-Nov-10	34	-	Vankarem	USGS

W481	?	F	Adu	17-Oct-10	21-Nov-10	33	-	Vankarem	USGS
W490	?	M	Adu	20-Jul-11	1-Sep-11	43	-	Chukchi Sea	USGS
W494	?	F	Adu	20-Jul-11	24-Aug-11	35	-	Chukchi Sea	USGS
W495	?	F	Adu	20-Jul-11	26-Aug-11	37	-	Chukchi Sea	USGS
W498	?	M	Adu	20-Jul-11	21-Aug-11	32	-	Chukchi Sea	USGS
W502	?	F	Adu	20-Jul-11	29-Aug-11	40	-	Chukchi Sea	USGS
W511	?	F	Adu	21-Jul-11	29-Aug-11	39	-	Chukchi Sea	USGS
W520	?	F	Adu	21-Jul-11	30-Aug-11	40	-	Chukchi Sea	USGS
W523	?	M	Adu	21-Jul-11	29-Aug-11	39	-	Chukchi Sea	USGS
W524	?	F	Adu	21-Jul-11	21-Aug-11	31	-	Chukchi Sea	USGS
W525	?	F	Adu	21-Jul-11	25-Aug-11	35	-	Chukchi Sea	USGS
W526	?	F	Adu	21-Jul-11	2-Sep-11	43	-	Chukchi Sea	USGS
W537	?	F	Adu	25-Aug-11	27-Sep-11	33	-	Point Lay	USGS
W541	?	F	Adu	25-Aug-11	9-Oct-11	45	-	Point Lay	USGS
W542	?	F	Adu	25-Aug-11	7-Oct-11	43	-	Point Lay	USGS
W543	?	F	Adu	25-Aug-11	30-Sep-11	20	-	Point Lay	USGS
W549	?	F	Adu	26-Aug-11	1-Oct-11	36	-	Point Lay	USGS
W551	?	F	Adu	26-Aug-11	4-Oct-11	39	-	Point Lay	USGS
W561	?	F	Adu	26-Aug-11	28-Sep-11	33	-	Vankarem	USGS
W568	?	F	Adu	7-Oct-11	29-Nov-11	53	-	Vankarem	USGS
W569	?	F	Adu	7-Oct-11	30-Nov-11	31	-	Serdtse-Kamen	USGS
W576	?	F	Adu	17-Oct-11	20-Nov-11	34	-	Serdtse-Kamen	USGS
W579	?	F	Adu	17-Oct-11	30-Nov-11	44	-	Chukchi Sea	USGS
W600	?	F	Adu	14-Jul-12	13-Sep-12	61	-	Chukchi Sea	USGS
W612	?	F	Adu	14-Jul-12	3-Oct-12	81	-	Chukchi Sea	USGS
W613	?	F	Adu	14-Jul-12	26-Aug-12	43	-	Chukchi Sea	USGS
W616	?	F	Adu	14-Jul-12	11-Oct-12	89	-	Chukchi Sea	USGS
W619	?	F	Adu	14-Jul-12	17-Aug-12	34	-	Chukchi Sea	USGS
W621	?	F	Adu	14-Jul-12	14-Oct-12	92	-	Chukchi Sea	USGS
W623	?	F	Adu	14-Jul-12	7-Sep-12	55	-	Chukchi Sea	USGS
W626	?	F	Adu	14-Jul-12	19-Aug-12	33	-	Chukchi Sea	USGS
W628	?	F	Adu	14-Jul-12	8-Sep-12	56	-	Chukchi Sea	USGS

W592	?	F	Adu	15-Jul-12	29-Sep-12	75	-	Chukchi Sea	USGS
W595	?	F	Adu	15-Jul-12	21-Aug-12	37	-	Chukchi Sea	USGS
W603	?	F	Adu	15-Jul-12	10-Oct-12	87	-	Chukchi Sea	USGS
W617	?	F	Adu	15-Jul-12	28-Aug-12	44	-	Chukchi Sea	USGS
W618	?	F	Adu	15-Jul-12	11-Sep-12	55	-	Chukchi Sea	USGS
W622	?	F	Adu	15-Jul-12	15-Sep-12	62	-	Chukchi Sea	USGS
W625	?	F	Adu	15-Jul-12	2-Oct-12	79	-	Chukchi Sea	USGS
W627	?	F	Adu	15-Jul-12	1-Oct-12	78	-	Chukchi Sea	USGS
W629	?	F	Adu	15-Jul-12	15-Aug-12	31	-	Chukchi Sea	USGS
W591	?	F	Adu	17-Jul-12	2-Sep-12	47	-	Chukchi Sea	USGS
W593	?	F	Adu	17-Jul-12	29-Aug-12	43	-	Chukchi Sea	USGS
W594	?	F	Adu	17-Jul-12	8-Sep-12	52	-	Chukchi Sea	USGS
W602	?	F	Adu	17-Jul-12	13-Sep-12	57	-	Chukchi Sea	USGS
W608	?	F	Adu	17-Jul-12	20-Aug-12	33	-	Chukchi Sea	USGS
W609	?	F	Adu	17-Jul-12	4-Sep-12	48	-	Chukchi Sea	USGS
W611	?	F	Adu	17-Jul-12	22-Sep-12	66	-	Chukchi Sea	USGS
W624	?	F	Adu	17-Jul-12	21-Aug-12	35	-	Chukchi Sea	USGS
W13-01-F	93092	F	Adu	7-Jun-13	29-Jul-13	40	-	Cape Lisburne	ADFG
W13-02-F	93109	F	Adu	7-Jun-13	10-Jul-13	25	-	Cape Lisburne	ADFG
W13-09-F	50679	F	Adu	13-Jun-13	3-Aug-13	51	-	Chukchi Sea	ADFG
W13-12-F	60015	F	Adu	13-Jun-13	26-Jul-13	34	-	Chukchi Sea	ADFG
W13-05-F	96427	F	Adu	14-Jun-13	15-Oct-13	121	-	Chukchi Sea	ADFG
W13-13-F	93111	F	Adu	14-Jun-13	1-Aug-13	47	-	Chukchi Sea	ADFG
W13-06-F	96422	F	Adu	14-Jun-13	16-Sep-13	73	-	Chukchi Sea	ADFG
W13-15-F	93090	F	Adu	14-Jun-13	4-Aug-13	46	-	Chukchi Sea	ADFG
W13-07-F	96418	F	Adu	14-Jun-13	9-Sep-13	60	-	Chukchi Sea	ADFG
W13-16-F	93110	F	Adu	14-Jun-13	3-Aug-13	48	-	Chukchi Sea	ADFG
W13-17-F	50687	F	Adu	14-Jun-13	8-Aug-13	55	-	Chukchi Sea	ADFG
W13-08-F	96421	F	Adu	15-Jun-13	8-Sep-13	71	-	Chukchi Sea	ADFG
W13-20-F	60011	F	Adu	17-Jun-13	5-Aug-13	47	-	Chukchi Sea	ADFG
W13-22-F	50685	F	Adu	17-Jun-13	3-Aug-13	39	-	Chukchi Sea	ADFG
W13-25-M	96417	M	Adu	18-Jun-13	19-Aug-13	59	-	Chukchi Sea	ADFG

W13-26-M	96423	M	Adu	18-Jun-13	12-Aug-13	53	-	Chukchi Sea	ADFG
W13-27-F	60013	F	Adu	20-Jun-13	8-Aug-13	48	-	Chukchi Sea	ADFG
W13-19-M	96430	M	Adu	20-Jun-13	10-Sep-13	58	-	Chukchi Sea	ADFG
W13-29-F	37286	F	Adu	21-Jun-13	16-Aug-13	40	-	Chukchi Sea	ADFG
W13-30-F	96424	F	Adu	24-Jun-13	14-Oct-13	106	-	Chukchi Sea	ADFG
W13-32-F	37280	F	Adu	26-Jun-13	14-Aug-13	43	-	Chukchi Sea	ADFG
W13-34-F	37283	F	Adu	28-Jun-13	30-Jul-13	25	-	Chukchi Sea	ADFG
W630	?	F	Adu	15-Jul-13	26-Oct-13	103	-	Chukchi Sea	USGS
W634	?	F	Adu	15-Jul-13	18-Aug-13	33	-	Chukchi Sea	USGS
W636	?	F	Adu	16-Jul-13	6-Sep-13	51	-	Chukchi Sea	USGS
W638	?	F	Adu	16-Jul-13	24-Aug-13	39	-	Chukchi Sea	USGS
W640	?	F	Adu	16-Jul-13	23-Sep-13	69	-	Chukchi Sea	USGS
W641	?	U	Adu	16-Jul-13	12-Sep-13	57	-	Chukchi Sea	USGS
W642	?	F	Adu	16-Jul-13	17-Aug-13	32	-	Chukchi Sea	USGS
W644	?	F	Adu	18-Jul-13	28-Aug-13	41	-	Chukchi Sea	USGS
W645	?	F	Adu	18-Jul-13	18-Sep-13	62	-	Chukchi Sea	USGS
W647	?	F	Adu	20-Jul-13	3-Oct-13	73	-	Chukchi Sea	USGS
W658	?	F	Adu	18-Sep-13	18-Oct-13	30	-	Point Lay	USGS
W685	?	F	Adu	19-Sep-13	29-Oct-13	40	-	Vankarem	USGS
W695	?	F	Adu	19-Sep-13	27-Oct-13	29	-	Point Lay	USGS
W700	?	F	Adu	24-Sep-13	27-Oct-13	33	-	Vankarem	USGS
W704	?	F	Adu	3-Oct-13	14-Nov-13	42	-	Serdtse-Kamen	USGS
W717	?	F	Adu	8-Oct-13	26-Dec-13	52	26	Serdtse-Kamen	USGS
W14-01-F	96422	F	Adu	2-Jun-14	18-Jul-14	45	-	Chukchi Sea	ADFG
W14-04-F	96419	F	Adu	2-Jun-14	23-Jul-14	51	-	Chukchi Sea	ADFG
W14-05-F	60015	F	Adu	5-Jun-14	20-Jul-14	42	-	Chukchi Sea	ADFG
W14-06-F	96424	F	Adu	5-Jun-14	16-Jul-14	41	-	Chukchi Sea	ADFG
W14-10-F	96430	F	Adu	6-Jun-14	22-Jul-14	36	-	Chukchi Sea	ADFG
W14-09-F	96420	F	Adu	8-Jun-14	13-Jul-14	19	-	Chukchi Sea	ADFG
W14-08-F	96429	F	Adu	10-Jun-14	19-Jul-14	33	-	Chukchi Sea	ADFG
W14-13-F	93092	F	Adu	13-Jun-14	3-Aug-14	50	-	Chukchi Sea	ADFG
W14-14-F	96427	F	Adu	13-Jun-14	31-Jul-14	36	-	Chukchi Sea	ADFG

W14-15-F	96421	F	Adu	13-Jun-14	30-Jul-14	45	-	Chukchi Sea	ADFG
W14-16-F	93109	F	Adu	14-Jun-14	22-Jul-14	38	-	Chukchi Sea	ADFG
W14-17-F	96431	F	Adu	15-Jun-14	10-Aug-14	56	-	Chukchi Sea	ADFG
W14-19-F	96417	F	Adu	15-Jun-14	9-Aug-14	55	-	Chukchi Sea	ADFG
W14-20-F	93111	F	Adu	16-Jun-14	18-Aug-14	59	-	Chukchi Sea	ADFG
W14-23-F	93080	F	Adu	16-Jun-14	31-Jul-14	43	-	Chukchi Sea	ADFG
W14-24-F	50679	F	Adu	16-Jun-14	15-Aug-14	54	-	Chukchi Sea	ADFG
W14-25-F	50687	F	Adu	16-Jun-14	3-Aug-14	48	-	Chukchi Sea	ADFG
W14-21-F	96425	F	Adu	16-Jun-14	6-Aug-14	46	-	Chukchi Sea	ADFG
W14-30-F	60011	F	Adu	22-Jun-14	10-Aug-14	48	-	Chukchi Sea	ADFG
W14-31-F	60014	F	Adu	22-Jun-14	6-Sep-14	75	-	Chukchi Sea	ADFG
W14-28-M	50685	M	Adu	22-Jun-14	30-Aug-14	51	-	Chukchi Sea	ADFG
W14-27-F	37232	F	Adu	22-Jun-14	10-Aug-14	40	-	Chukchi Sea	ADFG
W14-32-F	37288	F	Adu	23-Jun-14	27-Jul-14	27	-	Chukchi Sea	ADFG
W14-33-F	60013	F	Adu	23-Jun-14	18-Sep-14	63	-	Chukchi Sea	ADFG
W14-29-F	60009	F	Adu	24-Jun-14	5-Oct-14	94	-	Chukchi Sea	ADFG
W14-26-M	42521	M	Adu	24-Jun-14	14-Aug-14	44	-	Chukchi Sea	ADFG
W722	?	F	Adu	15-Jul-14	11-Sep-14	57	-	Chukchi Sea	USGS
W731	?	F	Adu	15-Jul-14	1-Sep-14	47	-	Chukchi Sea	USGS
W737	?	F	Adu	15-Jul-14	20-Aug-14	36	-	Chukchi Sea	USGS
W742	?	F	Adu	15-Jul-14	15-Aug-14	30	-	Chukchi Sea	USGS
W743	?	F	Adu	15-Jul-14	22-Aug-14	35	-	Chukchi Sea	USGS
W745	?	F	Adu	15-Jul-14	8-Sep-14	54	-	Chukchi Sea	USGS
W747	?	F	Adu	15-Jul-14	23-Aug-14	39	-	Chukchi Sea	USGS
W754	?	F	Adu	15-Jul-14	22-Aug-14	37	-	Chukchi Sea	USGS
W719	?	F	Adu	16-Jul-14	24-Aug-14	39	-	Chukchi Sea	USGS
W720	?	F	Adu	16-Jul-14	18-Aug-14	33	-	Chukchi Sea	USGS
W721	?	F	Adu	16-Jul-14	31-Aug-14	42	-	Chukchi Sea	USGS
W726	?	F	Adu	16-Jul-14	8-Sep-14	49	-	Chukchi Sea	USGS
W727	?	F	Adu	16-Jul-14	19-Aug-14	34	-	Chukchi Sea	USGS
W734	?	F	Adu	16-Jul-14	31-Aug-14	46	-	Chukchi Sea	USGS
W735	?	F	Adu	16-Jul-14	25-Aug-14	40	-	Chukchi Sea	USGS

W739	?	F	Adu	16-Jul-14	21-Aug-14	31	-	Chukchi Sea	USGS
W748	?	F	Adu	16-Jul-14	8-Sep-14	54	-	Chukchi Sea	USGS
W749	?	F	Adu	16-Jul-14	6-Sep-14	52	-	Chukchi Sea	USGS
W755	?	F	Adu	16-Jul-14	15-Sep-14	61	-	Chukchi Sea	USGS
W764	?	F	Adu	17-Sep-14	30-Nov-14	74	-	Chukchi Sea	USGS
W775	?	F	Adu	17-Sep-14	23-Oct-14	36	-	Chukchi Sea	USGS
W760	?	F	Adu	19-Sep-14	23-Oct-14	31	-	Point Lay	USGS
W15-07-F	96417	F	Adu	5-Jun-15	11-Jul-15	36	-	Chukchi Sea	ADFG
W15-08-F	96419	F	Adu	5-Jun-15	27-Jul-15	52	-	Chukchi Sea	ADFG
W15-09-F	60017	F	Adu	5-Jun-15	7-Jul-15	32	-	Chukchi Sea	ADFG
W15-10-F	93111	F	Adu	5-Jun-15	27-Jul-15	48	-	Chukchi Sea	ADFG
W15-11-F	96425	F	Adu	7-Jun-15	7-Jul-15	30	-	Chukchi Sea	ADFG
W15-06-F	96423	F	Adu	7-Jun-15	8-Aug-15	45	-	Chukchi Sea	ADFG
W15-14-F	96424	F	Adu	8-Jun-15	6-Aug-15	52	-	Chukchi Sea	ADFG
W15-12-F	96421	F	Adu	10-Jun-15	12-Aug-15	31	-	Chukchi Sea	ADFG
W15-15-M	37286	M	Adu	17-Jun-15	25-Jul-15	36	-	Chukchi Sea	ADFG
W15-21-F	60014	F	Adu	18-Jun-15	22-Sep-15	87	-	Chukchi Sea	ADFG
W15-18-F	50687	F	Adu	18-Jun-15	24-Aug-15	66	-	Chukchi Sea	ADFG
W15-22-F	93090	F	Adu	19-Jun-15	29-Jul-15	40	-	Chukchi Sea	ADFG
W15-24-F	60015	F	Adu	19-Jun-15	23-Jul-15	33	-	Chukchi Sea	ADFG
W15-23-F	60018	F	Adu	19-Jun-15	9-Sep-15	81	-	Chukchi Sea	ADFG
W15-25-F	93092	F	Adu	19-Jun-15	10-Sep-15	75	-	Chukchi Sea	ADFG
W15-26-F	93080	F	Adu	19-Jun-15	30-Oct-15	92	-	Chukchi Sea	ADFG
W849	?	F	Adu	14-Jul-15	22-Aug-15	38	-	Chukchi Sea	USGS
W795	?	F	Adu	15-Jul-15	3-Sep-15	50	-	Chukchi Sea	USGS
W797	?	F	Adu	15-Jul-15	1-Sep-15	48	-	Chukchi Sea	USGS
W798	?	F	Adu	15-Jul-15	21-Aug-15	37	-	Chukchi Sea	USGS
W799	?	F	Adu	15-Jul-15	22-Aug-15	38	-	Chukchi Sea	USGS
W800	?	F	Adu	15-Jul-15	9-Sep-15	53	-	Chukchi Sea	USGS
W801	?	F	Adu	15-Jul-15	3-Sep-15	50	-	Chukchi Sea	USGS
W802	?	F	Adu	15-Jul-15	10-Sep-15	57	-	Chukchi Sea	USGS
W803	?	F	Adu	15-Jul-15	25-Aug-15	41	-	Chukchi Sea	USGS

W804	?	F	Adu	15-Jul-15	18-Aug-15	34	-	Chukchi Sea	USGS
W805	?	F	Adu	15-Jul-15	2-Sep-15	49	-	Chukchi Sea	USGS
W806	?	F	Adu	15-Jul-15	22-Aug-15	38	-	Chukchi Sea	USGS
W808	?	F	Adu	15-Jul-15	28-Aug-15	44	-	Chukchi Sea	USGS
W809	?	F	Adu	15-Jul-15	29-Aug-15	37	-	Chukchi Sea	USGS
W811	?	M	Adu	15-Jul-15	20-Aug-15	36	-	Chukchi Sea	USGS
W812	?	F	Adu	15-Jul-15	31-Aug-15	47	-	Chukchi Sea	USGS
W813	?	F	Adu	15-Jul-15	18-Sep-15	65	-	Chukchi Sea	USGS
W815	?	F	Adu	15-Jul-15	11-Sep-15	58	-	Chukchi Sea	USGS
W816	?	F	Adu	15-Jul-15	3-Sep-15	43	-	Chukchi Sea	USGS
W817	?	F	Adu	15-Jul-15	14-Sep-15	60	-	Chukchi Sea	USGS
W819	?	F	Adu	15-Jul-15	2-Sep-15	49	-	Chukchi Sea	USGS
W820	?	F	Adu	15-Jul-15	2-Sep-15	49	-	Chukchi Sea	USGS
W821	?	F	Adu	15-Jul-15	18-Aug-15	34	-	Chukchi Sea	USGS
W823	?	F	Adu	15-Jul-15	31-Aug-15	47	-	Chukchi Sea	USGS
W852	?	F	Adu	15-Jul-15	17-Aug-15	33	-	Chukchi Sea	USGS
W848	?	F	Adu	11-Sep-15	14-Oct-15	33	-	Point Lay	USGS

Appendix E: Details for satellite transmitters attached to bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort (BCB) stock used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. The Platform Transmitter Terminal (PTT) is the transmission code used by the Argos when identifying transmitters (some are reused). Ages include 'Imm' for immature and 'Adu' for breeding age adults. Based upon the work of Koski et al. (1993), we defined adult whales as those at least 13 m in length and "immature" whales as those less than 13 m in length. However, age class is based upon visual estimation of length and is therefore approximate. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. Agency is the entity providing data access: ADFG is the Alaska Department of Fish and Game.

ID	PTT	Sex	Age	Deployment date	Date last location	# Summer days w/locations	# Winter days w/locations	Tagging location	Agency
B06-01	60010	M	Adu	12-May-06	10-Nov-06	180	-	Barrow	ADFG
B08-01	37233	F	Imm	12-Aug-08	18-Aug-09	193	96	Atkinson Point	ADFG
B08-02	37235	M	Imm	10-Sep-08	16-Oct-08	36	-	Barrow	ADFG
B08-03	37236	Unk	Adu	10-Sep-08	22-Nov-08	72	-	Barrow	ADFG
B08-06	37230	Unk	Imm	20-Sep-08	12-Mar-09	70	102	Barrow	ADFG
B08-07	37234	M	Imm	21-Sep-08	19-Oct-09	227	151	Barrow	ADFG
B08-08	37277	Unk	Imm	23-Sep-08	3-Jul-09	128	149	Barrow	ADFG
B08-09	37280	M	Imm	23-Sep-08	6-Jul-09	115	119	Barrow	ADFG
B08-10	50679	M	Imm	23-Sep-08	16-Apr-09	67	136	Barrow	ADFG
B08-11	50685	M	Imm	24-Sep-08	16-Apr-09	67	136	Barrow	ADFG
B08-12	60009	M	Imm	23-Sep-08	31-Aug-09	159	130	Barrow	ADFG
B08-13	60017	Unk	Imm	23-Sep-08	12-Mar-09	58	102	Barrow	ADFG
B08-14	60018	M	Adu	23-Sep-08	24-Jul-09	113	148	Barrow	ADFG
B09-01	37231	F	Adu	22-Aug-09	21-Dec-09	100	21	Barrow	ADFG
B09-02	37232	Unk	Adu	22-Aug-09	30-Jan-10	100	52	Barrow	ADFG
B09-03	93091	Unk	Imm	22-Aug-09	4-Dec-09	100	4	Barrow	ADFG
B09-04	93086	M	Imm	23-Aug-09	31-Jul-10	189	140	Atkinson Point	ADFG
B09-05	93078	M	Imm	23-Aug-09	3-Sep-10	205	150	Atkinson Point	ADFG

B09-08	42522	M	Adu	29-Aug-09	4-Mar-10	18	23	Barrow	ADFG
B09-09	93089	Unk	Adu	29-Aug-09	23-Aug-10	189	142	Barrow	ADFG
B09-12	42521	Unk	Imm	2-Sep-09	4-Nov-09	61		Atkinson Point	ADFG
B09-13	93079	F	Imm	14-Oct-09	15-Nov-10	233	148	Barrow	ADFG
B09-15	93085	F	Imm	14-Oct-09	2-Sep-10	168	115	Barrow	ADFG
B09-16	33001	M	Adu	14-Oct-09	28-May-10	63	127	Barrow	ADFG
B10-01	93080	M	Adu	24-May-10	17-Nov-10	177	-	Barrow	ADFG
B10-03	93083	F	Adu	24-May-10	6-Aug-10	74	-	Barrow	ADFG
B10-04	93084	F	Adu	25-May-10	11-Sep-10	27	-	Barrow	ADFG
B10-05	93082	Unk	Imm	24-Aug-10	25-Sep-10	31	-	Atkinson Point	ADFG
B10-06	93081	Unk	Imm	25-Aug-10	6-Oct-10	30	-	Atkinson Point	ADFG
B10-08	50685	Unk	Imm	26-Aug-10	16-Sep-11	215	86	Atkinson Point	ADFG
B10-09	93088	F	Imm	25-Aug-10	8-Mar-11	33	54	Hershel Island	ADFG
B10-11	42521	M	Imm	27-Aug-10	25-Jun-11	110	61	Atkinson Point	ADFG
B10-12	60009	F	Imm	27-Aug-10	21-Feb-11	92	39	Atkinson Point	ADFG
B10-13	60017	F	Imm	28-Aug-10	14-Nov-10	78	-	Atkinson Point	ADFG
B10-14	37277	M	Imm	30-Aug-10	13-Jul-11	152	126	Atkinson Point	ADFG
B10-15	37234	F	Imm	30-Aug-10	13-Sep-11	228	134	Atkinson Point	ADFG
B12-01	37280	Unk	Imm	24-Apr-12	12-Dec-12	214	12	Pugughileq	ADFG
B12-02	93090	Unk	Adu	30-Apr-12	13-Oct-12	116	-	Gambell	ADFG
B12-03	20687	M	Adu	10-Sep-12	31-Jan-13	81	45	Barrow	ADFG
B12-04	37232	M	Adu	10-Sep-12	27-Nov-12	38	-	Barrow	ADFG
B12-05	93087	M	Adu	21-Sep-12	24-Oct-12	32	-	Barrow	ADFG
B13-01	37277	M	Imm	22-Apr-13	30-Nov-15	220	11	Pugughileq	ADFG
B14-01	37280	Unk	Imm	20-Aug-14	4-Mar-15	102	86	Atkinson Point	ADFG
B15-01	20693	Unk	Adu	23-Aug-15	26-Nov-15	95	-	Barrow	ADFG
B15-02	20686	Unk	Imm	2-Sep-15	20-Nov-15	79	-	Barrow	ADFG
B15-03	33001	Unk	Imm	3-Sep-15	13-Nov-15	70	-	Barrow	ADFG

Appendix F: Details for satellite transmitters attached to Eastern North Pacific gray whales (*Eschrichtius robustus*) used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. PTT (Platform Transmitter Terminal) is the transmission code used by the Argos when identifying transmitters (some are used). Ages include 'Imm' for immature and 'Adu' for breeding age adults; age is estimated using a visual estimate of whale length, mature whales are approximately 12 m (Rice and Wolfman 1971; Blokhin 1984). Therefore ages are approximate. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. Agency is the entity providing data access: GINR is the Greenland Institute of Natural Resources, ADFG is the Alaska Department of Fish and Game, and MML is the National Marine Fisheries Service's Marine Mammal Lab.

ID	PTT	Sex	Age	Deployment date	Date last location	# Summer days w/locations	# Winter days w/locations	Tagging location	Agency
Gray21793	21793	Unk	Imm	2-Sep-06	18-Nov-06	70	-	Laurentia Bay	GINR
Gray37277	37277	Unk	Imm	2-Sep-06	22-Nov-06	68	-	Laurentia Bay	GINR
Gray20692	20692	Unk	Adu	12-Sep-06	17-Oct-06	36	-	Laurentia Bay	GINR
Gray20693	20693	Unk	Adu	12-Sep-06	4-Nov-06	22	-	Laurentia Bay	GINR
Gray37233	37233	Unk	Imm	12-Sep-06	15-Oct-06	33	-	Laurentia Bay	GINR
Gray09-01	93082	Unk	Unk	3-Sep-09	12-Dec-09	74	-	Atkinson Point	ADFG
Gray11-03	93111	Unk	Adu	1-Sep-11	2-Oct-11	29	-	Barrow	ADFG
Gray12-01	93080	F	Adu	12-Aug-12	16-Oct-12	55	-	Gambell	ADFG
Gray112713	112713	Unk	Unk	25-Aug-12	11-Oct-12	45	-	Chukchi Sea	MML
Gray84484	84484	Unk	Unk	7-Sep-13	27-Oct-13	49	-	Chukchi Sea	MML
Gray87636	87636	Unk	Unk	7-Sep-13	12-Nov-13	62	-	Chukchi Sea	MML
Gray84482	84482	Unk	Unk	8-Sep-13	18-Oct-13	40	-	Chukchi Sea	MML

Appendix G: Details for satellite transmitters attached to beluga whales (*Delphinapterus leucas*) used in this analysis. We limited the analysis to animals with at least 30 locations over a 30-day period (after filtering). Identification codes are those used by the agencies that deployed the transmitters. PTT (Platform Transmitter Terminal) is the transmission code used by the Argos when identifying transmitters (some are reused). Ages include 'Imm' for immature and 'Adu' for breeding age adults; for belugas, animals <350 cm are generally gray in color and sexually immature. The number of 'summer locations' are the number of daily locations estimated from the CRW model during the summer period (May-November) and the 'number of winter locations' are those during the winter period (December-April). Tagging locations are approximate and are also shown on the species distribution maps in the text. The stock (population) abbreviations are: EBS: Eastern Beaufort Sea stock; ECS: Eastern Chukchi Sea stock; BB: Bristol Bay stock; EB: Eastern Bering Sea stock; and AN: Anadyr stock. Agency is the entity providing data access: MML is the National Marine Fisheries Service's Marine Mammal Lab; ABWC is the Alaska Beluga Whale Committee; ADFG is the Alaska Department of Fish and Game; and DFO is the Division of Fisheries and Oceans, Canada; and TINRO is the Pacific Research Fisheries Center, Russia.

ID	Stock	PTT	Sex	Age	Deployment date	Date last location	# Summer days w/locations	# Winter days w/locations	Tagging location	Agency
EBS_017005	EBS	17005	M	Adu	10-Jul-93	19-Sep-93	68	-	Mackenzie Delta	DFO
EBS_017002	EBS	17002	M	Adu	19-Jul-93	22-Aug-93	33	-	Mackenzie Delta	DFO
EBS_017001_01	EBS	17001	M	Adu	3-Jul-95	26-Sep-95	67	-	Mackenzie Delta	DFO
EBS_017002_02	EBS	17002	M	Adu	4-Jul-95	22-Aug-95	37	-	Mackenzie Delta	DFO
EBS_017005_02	EBS	17005	M	Adu	5-Jul-95	16-Aug-95	32	-	Mackenzie Delta	DFO
EBS_017004_01	EBS	17004	M	Adu	5-Jul-95	8-Aug-95	32	-	Mackenzie Delta	DFO
EBS_017010_01	EBS	17010	M	Adu	9-Jul-95	7-Aug-95	30	-	Mackenzie Delta	DFO
EBS_017011_01	EBS	17011	M	Adu	10-Jul-95	8-Aug-95	30	-	Mackenzie Delta	DFO
EBS_017012_01	EBS	17012	M	Adu	10-Jul-95	10-Aug-95	30	-	Mackenzie Delta	DFO
EBS_005801_01	EBS	5801	M	Adu	11-Jul-95	10-Aug-95	30	-	Mackenzie Delta	DFO
EBS_017014_01	EBS	17014	F	Imm	12-Jul-95	11-Aug-95	30	-	Mackenzie Delta	DFO
EBS_008754_01	EBS	8754	F	Adu	13-Jul-95	11-Aug-95	27	-	Mackenzie Delta	DFO
EBS_005800_01	EBS	5800	M	Adu	16-Jul-95	14-Aug-95	30	-	Mackenzie Delta	DFO
EBS_017007_01	EBS	17007	F	Adu	16-Jul-95	22-Sep-95	35	-	Mackenzie Delta	DFO
EBS_002118_01	EBS	2118	F	Adu	26-Jul-97	30-Sep-97	65	-	Mackenzie Delta	DFO
EBS_025846_01	EBS	25846	M	Adu	29-Jul-97	17-Sep-97	49	-	Mackenzie Delta	DFO

EBS_008755_01	EBS	8755	M	Adu	29-Jul-97	30-Sep-97	62	-	Mackenzie Delta	DFO
EBS_008757_01	EBS	8757	M	Adu	29-Jul-97	30-Sep-97	52	-	Mackenzie Delta	DFO
EBS_008754_02	EBS	8754	F	Adu	31-Jul-97	29-Sep-97	59	-	Mackenzie Delta	DFO
EBS_008758_01	EBS	8758	M	Adu	31-Jul-97	30-Sep-97	60	-	Mackenzie Delta	DFO
EBS_010693_01	EBS	10693	M	Adu	31-Jul-97	30-Sep-97	61	-	Mackenzie Delta	DFO
EBS_010692_01	EBS	10692	F	Imm	1-Aug-97	27-Sep-97	38	-	Mackenzie Delta	DFO
EBS_008756_01	EBS	8756	M	Adu	1-Aug-97	26-Sep-97	51	-	Mackenzie Delta	DFO
EBS_2004_10972	EBS	10972	M	Adu	4-Jul-04	14-Oct-04	92	-	Mackenzie Delta	DFO
EBS_2004_10899	EBS	10899	M	Adu	4-Jul-04	4-Jun-05	138	32	Mackenzie Delta	DFO
EBS_ 2004_40152	EBS	40152	M	Adu	5-Jul-04	15-Aug-04	16	-	Mackenzie Delta	DFO
EBS_ 2004_36641	EBS	36641	F	Adu	8-Jul-04	12-Jan-05	38	4	Mackenzie Delta	DFO
EBS_ 2004_37023	EBS	37023	M	Adu	8-Jul-04	28-Jun-05	54	32	Mackenzie Delta	DFO
EBS_ 2004_37024	EBS	37024	M	Adu	8-Jul-04	6-May-05	101	36	Mackenzie Delta	DFO
EBS_2005-57590	EBS	57590	M	Adu	4-Jul-05	5-Sep-05	11	-	Mackenzie Delta	DFO
EBS_2005-57591	EBS	57591	F	Imm	5-Jul-05	21-Apr-06	129	67	Mackenzie Delta	DFO
EBS_2005-57593	EBS	57593	F	Adu	10-Jul-05	21-Dec-05	128	9	Mackenzie Delta	DFO
EC01-1	ECS	2093	M	Adu	3-Jul-01	10-Aug-01	30	-	Point Lay	NSB
EC01-3	ECS	11038	F	Imm	5-Jul-01	29-Nov-01	142	-	Point Lay	NSB
EC01-4	ECS	11041	M	Imm	5-Jul-01	6-Dec-01	146	6	Point Lay	NSB
EC01-5	ECS	2280	F	Imm	5-Jul-01	23-Oct-01	106	-	Point Lay	NSB
EC01-6	ECS	11037	M	Adu	7-Jul-01	17-Nov-01	131	-	Point Lay	NSB
EC01-8	ECS	2282	M	Adu	7-Jul-01	13-Aug-01	36	-	Point Lay	NSB
EC02-1	ECS	11036	F	Imm	7-Jul-02	14-Sep-02	68	-	Point Lay	NSB
EC02-2	ECS	11044	M	Imm	7-Jul-02	30-Sep-02	74	-	Point Lay	NSB
EC02-4	ECS	2088	M	Imm	8-Jul-02	13-Sep-02	62	-	Point Lay	NSB
EC07-01	ECS	22149	M	Adu	1-Jul-07	4-Dec-08	366	156	Point Lay	NSB
EC07-02	ECS	77015	F	Adu	1-Jul-07	13-Nov-07	126	-	Point Lay	NSB
EC07-03	ECS	36516	F	Adu	1-Jul-07	9-Nov-07	123	-	Point Lay	NSB
EC10-01	ECS	22117	M	Imm	30-Jun-10	6-Dec-10	109	3	Point Lay	NSB
EC10-02	ECS	36517	M	Adu	30-Jun-10	9-Oct-10	71	-	Point Lay	NSB
EC12-1	ECS	108772	F	Adu	9-Jul-12	11-May-13	162	147	Point Lay	NSB

EC98-3	ECS	11036	M	Adu	29-Jun-98	11-Oct-98	100	-	Point Lay	NSB
EC98-4	ECS	2285	M	Adu	29-Jun-98	29-Sep-98	70	-	Point Lay	NSB
EC98-5	ECS	2282	M	Adu	1-Jul-98	30-Aug-98	59	-	Point Lay	NSB
EC99-1	ECS	11035	M	Adu	30-Jun-99	25-Sep-99	81	-	Point Lay	NSB
EC99-2	ECS	11036	F	Imm	30-Jun-99	12-Sep-99	64	-	Point Lay	NSB
EC99-3	ECS	11037	M	Adu	30-Jun-99	26-Aug-99	56	-	Point Lay	NSB
EC99-4	ECS	11041	M	Adu	30-Jun-99	23-Sep-99	60	-	Point Lay	NSB
BB12-4	BB	111857	M	Adu	8-Sep-12	30-Nov-12	76	-	Bristol Bay	ABWC/ADFG
BB12-1	BB	111858	M	Adu	1-Sep-12	6-May-13	85	151	Bristol Bay	ABWC/ADFG
BB12-2	BB	111859	F	Imm	1-Sep-12	26-Dec-12	58	24	Bristol Bay	ABWC/ADFG
BB12-5	BB	111860	F	Imm	9-Sep-12	29-Dec-12	79	29	Bristol Bay	ABWC/ADFG
BB12-3	BB	111861	F	Imm	8-Sep-12	29-Apr-13	64	144	Bristol Bay	ABWC/ADFG
BB12-6	BB	111862	F	Adu	10-Sep-12	15-Dec-12	62	15	Bristol Bay	ABWC/ADFG
BB12-9	BB	111863	F	Adu	12-Sep-12	23-Nov-12	71	-	Bristol Bay	ABWC/ADFG
BB12-8	BB	111864	M	Imm	12-Sep-12	14-Dec-12	62	5	Bristol Bay	ABWC/ADFG
BB12-7	BB	111865	M	Adu	12-Sep-12	6-Sep-12	3	-	Bristol Bay	ABWC/ADFG
BB12-10	BB	87626	F	Adu	12-Sep-12	15-Apr-13	50	113	Bristol Bay	ABWC/ADFG
BB02-1	BB	14180	F	Imm	18-May-02	30-Sep-02	133	-	Bristol Bay	ABWC/ADFG
BB02-2	BB	30721	M	Imm	19-May-02	30-Sep-02	129	-	Bristol Bay	ABWC/ADFG
BB02-3	BB	11043	M	Imm	19-May-02	25-Sep-02	56	-	Bristol Bay	ABWC/ADFG
BB02-4	BB	2283	F	Imm	20-May-02	11-Sep-02	66	-	Bristol Bay	ABWC/ADFG
BB02-5	BB	11040	M	Imm	20-May-02	20-Aug-02	55	-	Bristol Bay	ABWC/ADFG
BB03-2	BB	22117	F	Imm	10-May-03	27-Aug-03	67	-	Bristol Bay	ABWC/ADFG
BB03-5	BB	11039	M	Adu	13-May-03	20-Nov-03	107	-	Bristol Bay	ABWC/ADFG
BB06-1	BB	22132	F	Imm	8-Sep-06	23-Nov-06	25	-	Bristol Bay	ABWC/ADFG
BB06-3	BB	11035	F	Imm	10-Sep-06	3-Jan-07	27	30	Bristol Bay	ABWC/ADFG
BB06-4	BB	36519	M	Adu	10-Sep-06	26-Feb-07	44	34	Bristol Bay	ABWC/ADFG
BB06-5	BB	36518	M	Adu	10-Sep-06	1-Feb-07	75	60	Bristol Bay	ABWC/ADFG
BB08-1	BB	84482	F	Imm	17-May-08	31-Oct-08	126	-	Bristol Bay	MML/ADFG
BB08-10	BB	84484	F	Imm	21-May-08	25-Sep-08	86	-	Bristol Bay	MML/ADFG
BB08-11	BB	87625	M	Imm	17-Sep-08	12-Mar-09	71	86	Bristol Bay	MML/ADFG

BB08-12	BB	84494	M	Imm	19-Sep-08	10-Feb-09	40	42	Bristol Bay	MML/ADFG
BB08-13	BB	84498	F	Imm	21-Sep-08	21-Apr-09	60	126	Bristol Bay	MML/ADFG
BB08-14	BB	87627	M	Adu	20-Sep-08	24-May-09	55	136	Bristol Bay	MML/ADFG
BB08-15	BB	84497	F	Imm	20-Sep-08	19-Jun-09	85	147	Bristol Bay	MML/ADFG
BB08-16	BB	84496	M	Adu	21-Sep-08	26-Aug-09	120	145	Bristol Bay	MML/ADFG
BB08-17	BB	87628	F	Imm	21-Sep-08	29-Jan-09	57	54	Bristol Bay	MML/ADFG
BB08-18	BB	87624	M	Imm	24-Sep-08	14-Feb-09	53	21	Bristol Bay	MML/ADFG
BB08-2	BB	84485	F	Imm	17-May-08	5-Dec-08	167	-	Bristol Bay	MML/ADFG
BB08-3	BB	84488	F	Imm	18-May-08	5-Dec-08	183	5	Bristol Bay	MML/ADFG
BB08-5	BB	84480	F	Imm	19-May-08	22-Dec-08	184	20	Bristol Bay	MML/ADFG
BB08-6	BB	84487	M	Adu	19-May-08	11-Jan-09	181	37	Bristol Bay	MML/ADFG
BB08-7	BB	84481	F	Imm	20-May-08	30-Nov-08	162	-	Bristol Bay	MML/ADFG
BB08-8	BB	84479	M	Imm	20-May-08	2-Dec-08	167	1	Bristol Bay	MML/ADFG
BB08-9	BB	84486	F	Imm	21-May-08	26-Nov-08	158	-	Bristol Bay	MML/ADFG
BB11-1	BB	84495	F	Imm	18-May-11	26-Nov-11	164	-	Bristol Bay	MML/ADFG
BB11-2	BB	77016	F	Imm	20-May-11	27-Sep-11	85	-	Bristol Bay	MML/ADFG
NS12-1	EB	108770	Unk	Imm	29-Sep-12	30-Sep-13	204	151	Nome	ABWC
NS12-2	EB	108767	Unk	Imm	14-Oct-12	12-Jul-13	116	151	Nome	ABWC
AN01-1	AN	2285	F	Adu	18-Jul-01	22-Feb-02	78	84	Anadyr	MML/TINRO
AN01-2	AN	10970	Unk	Unk	18-Jul-01	22-Aug-01	35	-	Anadyr	MML/TINRO
AN01-3	AN	25850	Unk	Unk	16-Jul-01	27-Oct-01	72	-	Anadyr	MML/TINRO
AN01-4	AN	30719	M	Unk	20-Jul-01	22-Jan-02	127	53	Anadyr	MML/TINRO
AN06-1	AN	30721	F	Unk	16-Aug-06	23-Jan-07	84	54	Anadyr	MML/TINRO
AN08-1	AN	25848	M	Adu	22-Aug-08	21-Apr-09	97	132	Anadyr	MML/TINRO
AN08-2	AN	84492	M	Imm	22-Aug-08	31-Jul-09	174	133	Anadyr	MML/TINRO

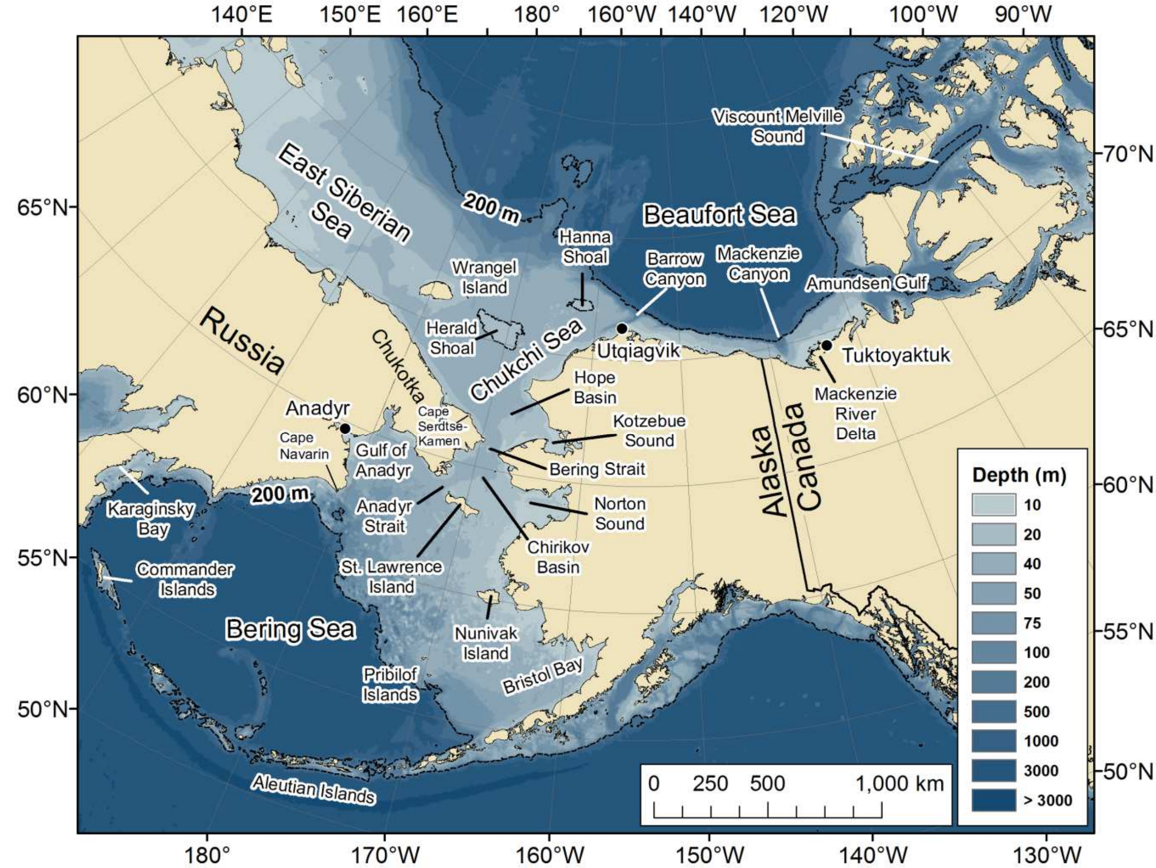


Figure 1. The Pacific Arctic.

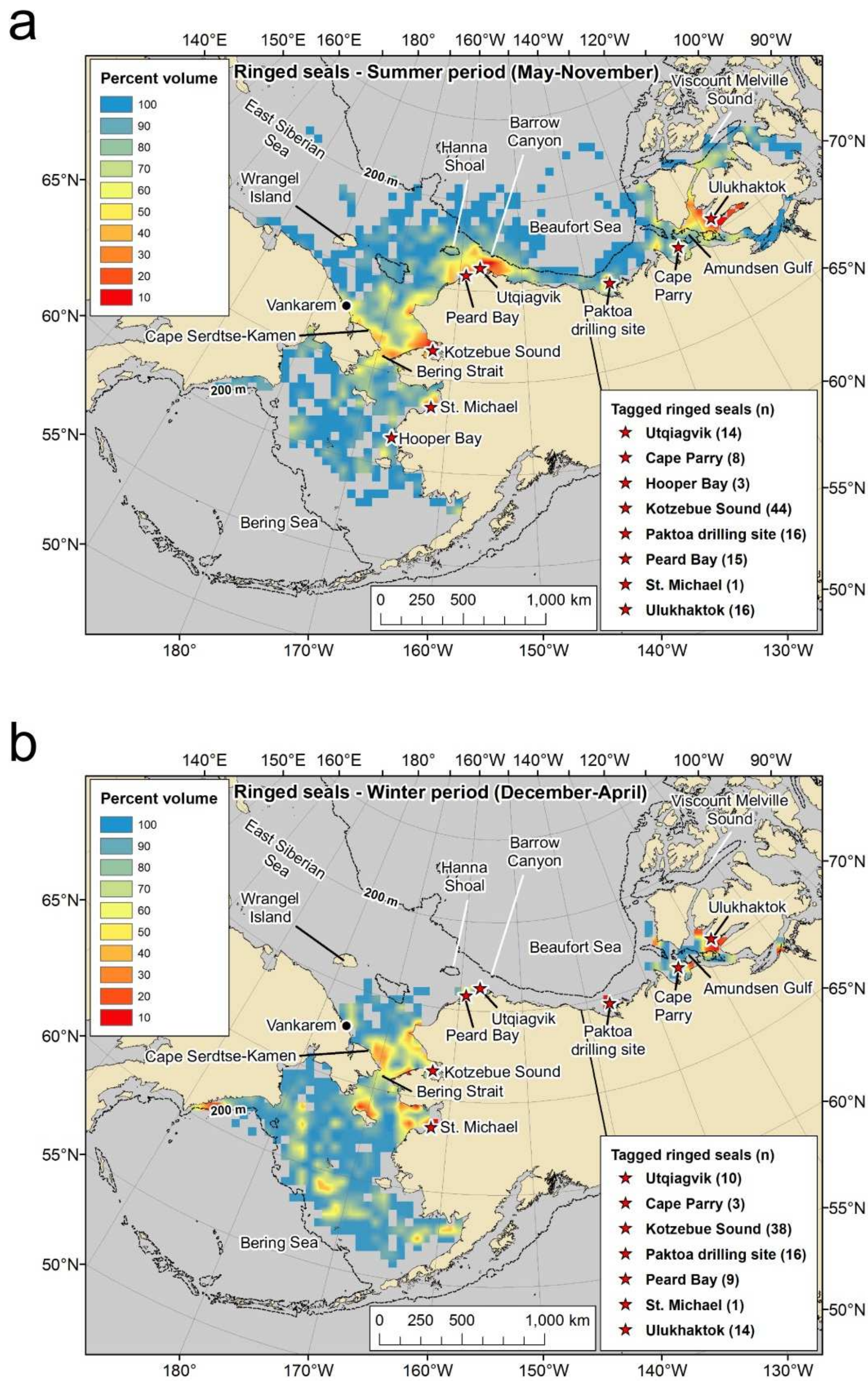


Figure 2. Distribution of satellite tagged ringed seals during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates where ringed seals were tagged and how many (*n*) provided data in each season.

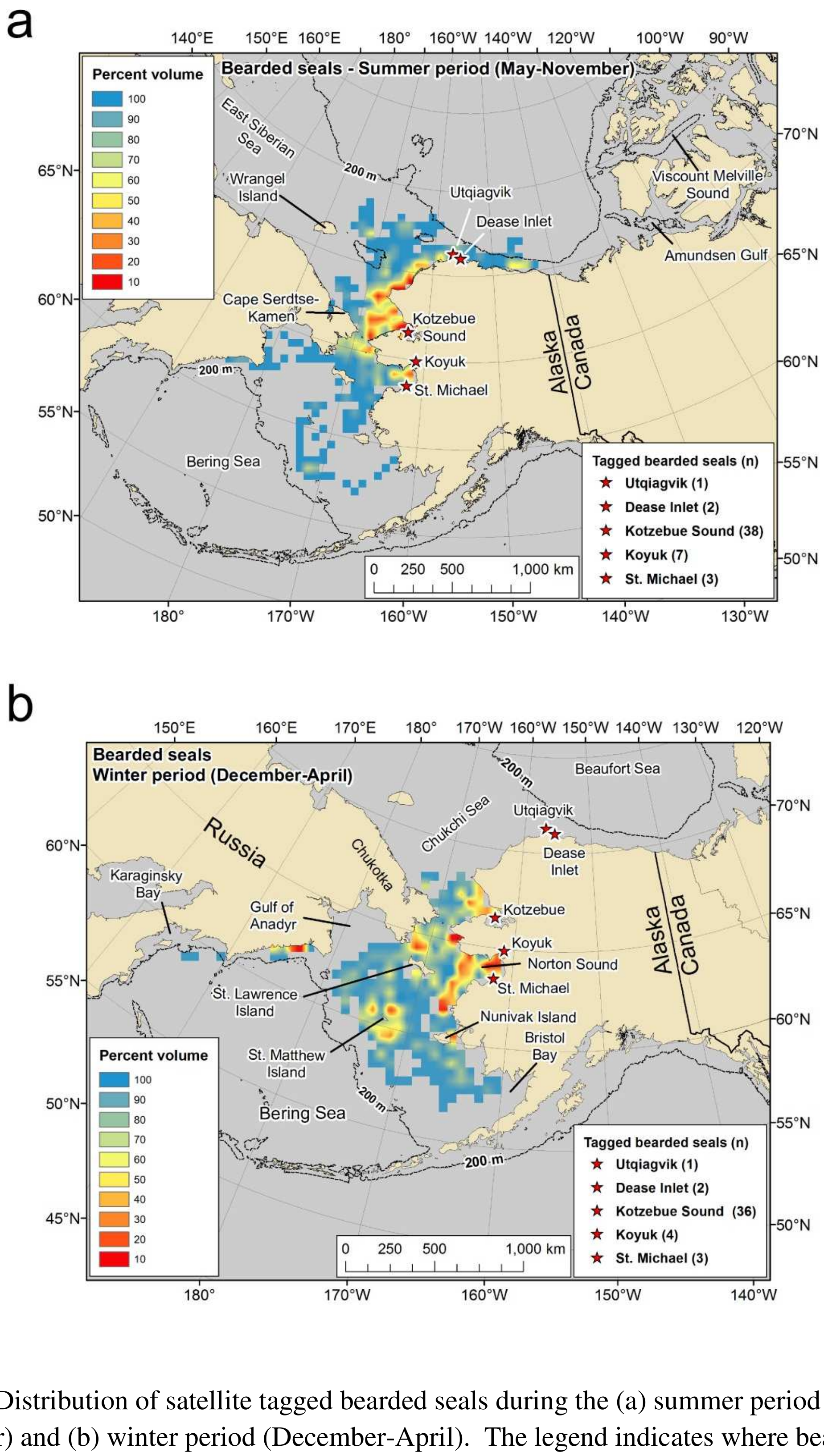


Figure 3. Distribution of satellite tagged bearded seals during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates where bearded seals were tagged and how many (*n*) provided data in each season.

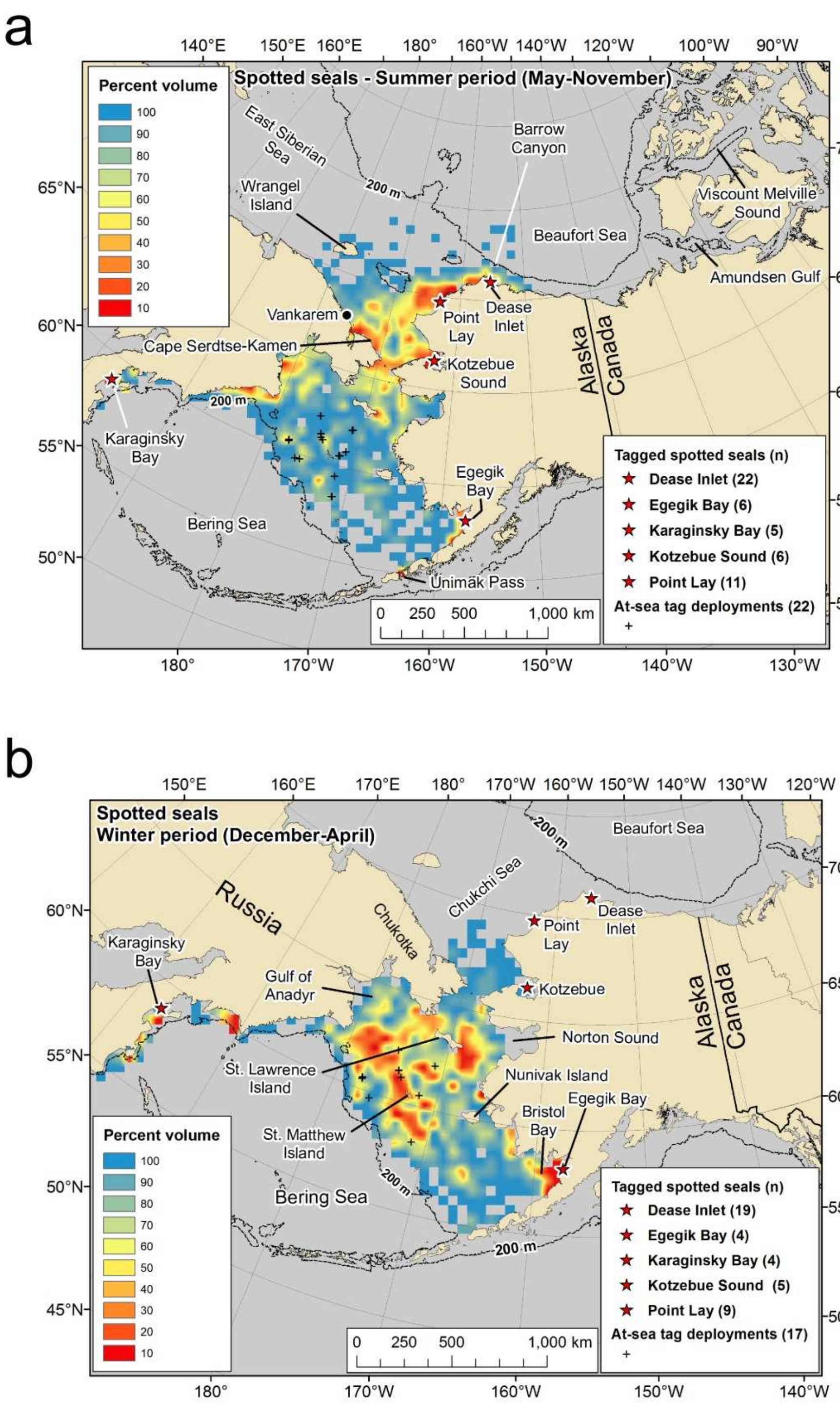


Figure 4. Distribution of satellite tagged spotted seals during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates where spotted seals were tagged and how many (*n*) provided data in each season.

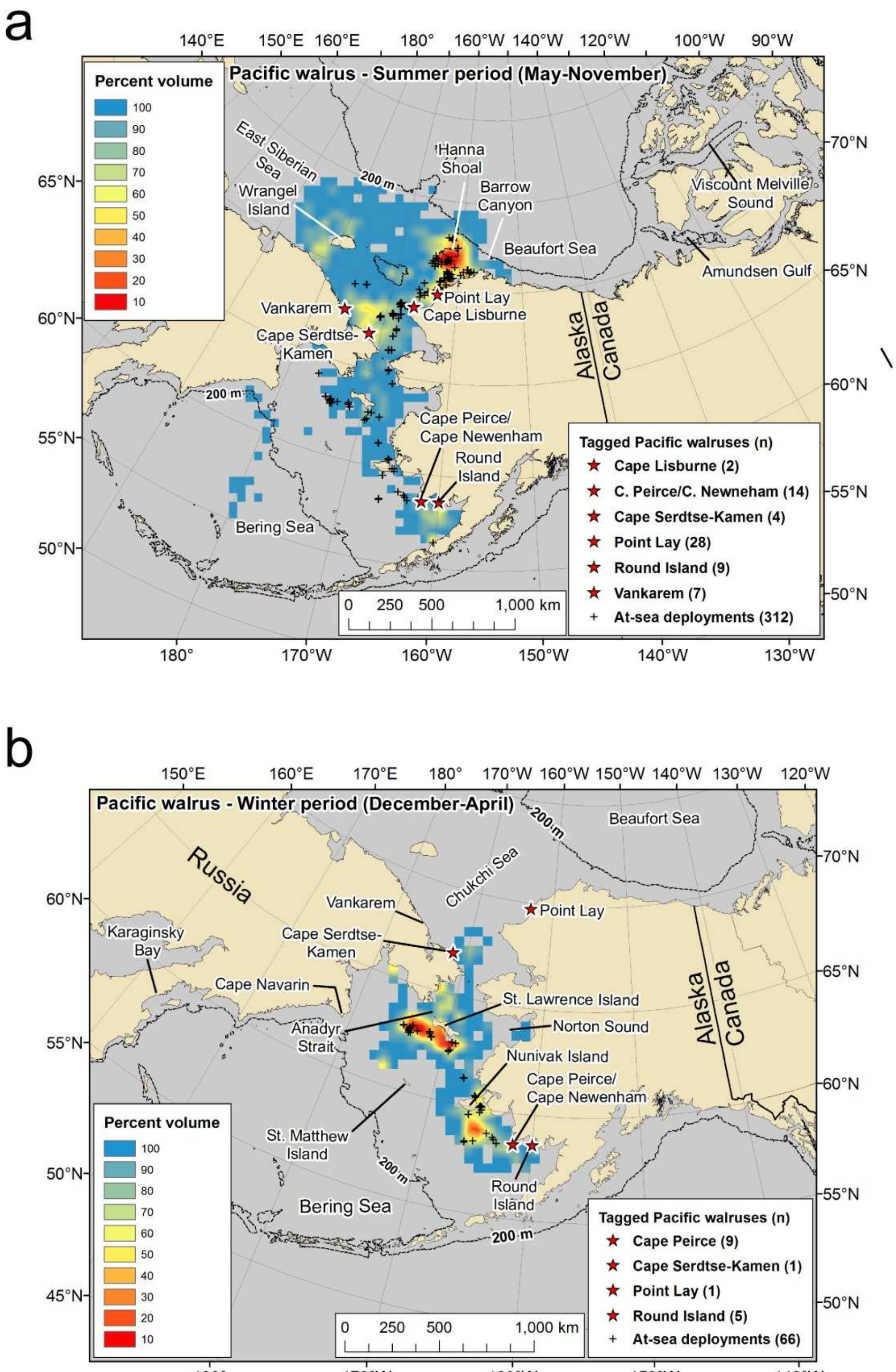


Figure 5. Distribution of satellite tagged Pacific walruses during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates the location where Pacific walruses were tagged and how many (*n*) provided data in each season.

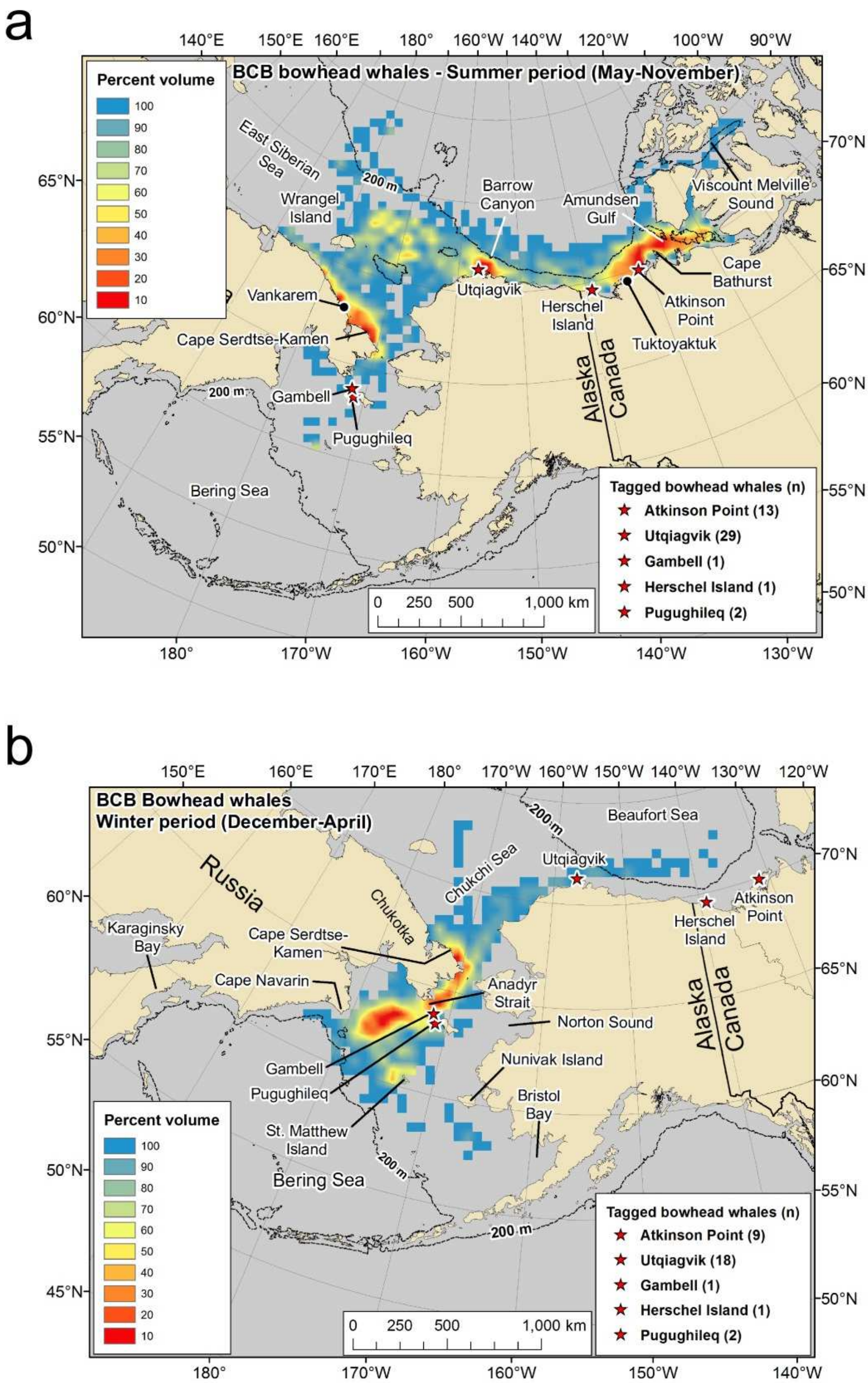


Figure 6. Distribution of satellite tagged Bering-Chukchi-Beaufort (BCB) stock bowhead whales during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates where BCB bowhead whales were tagged and how many (*n*) provided data in each season.

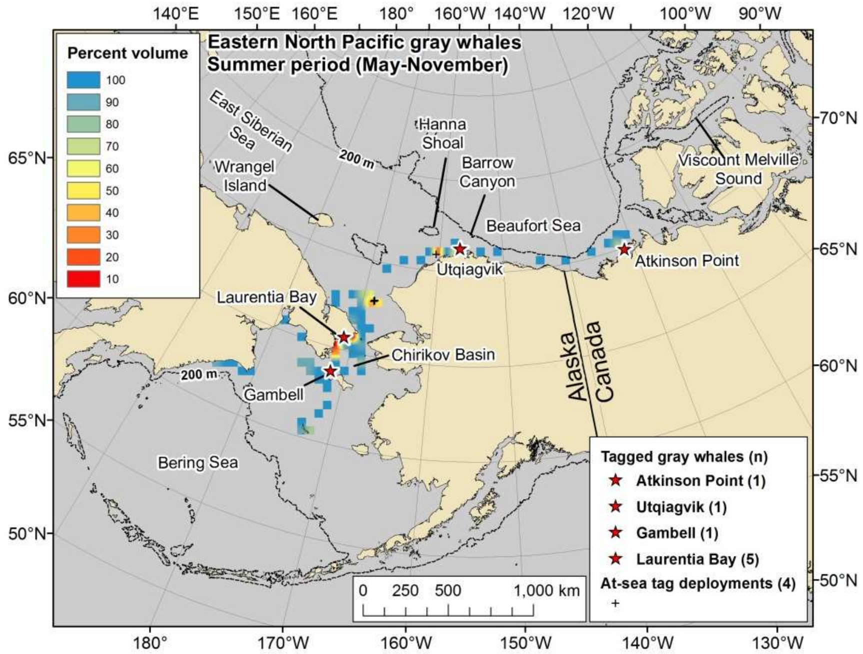
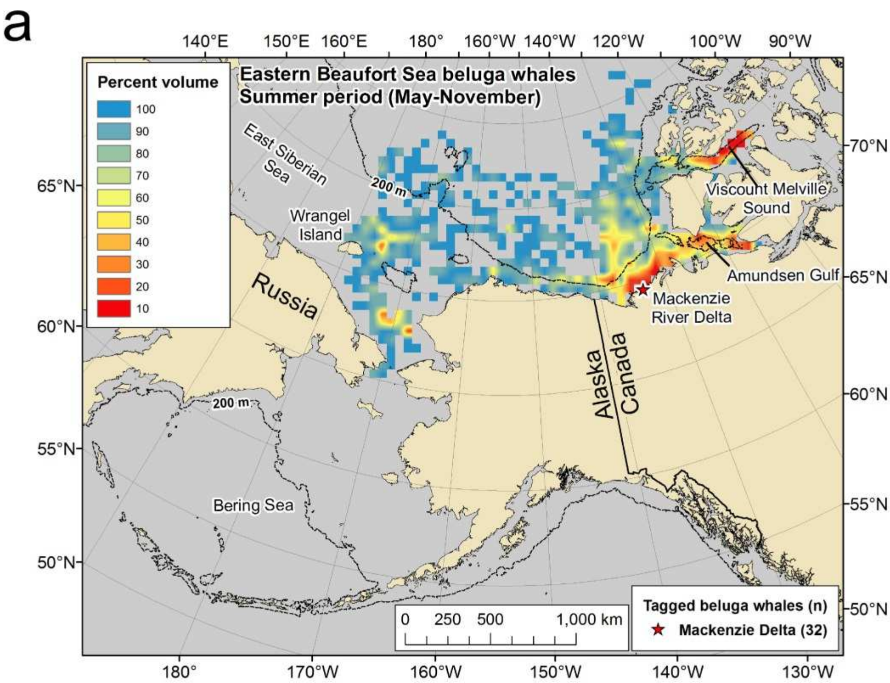


Figure 7. Distribution of satellite tagged Eastern North Pacific (ENP) gray whales during the summer period (May-November). Gray whales are seasonal residents and leave the Pacific Arctic in winter. The legend indicates the location of ENP gray whale tagging and the number of whales that provided data (*n*).



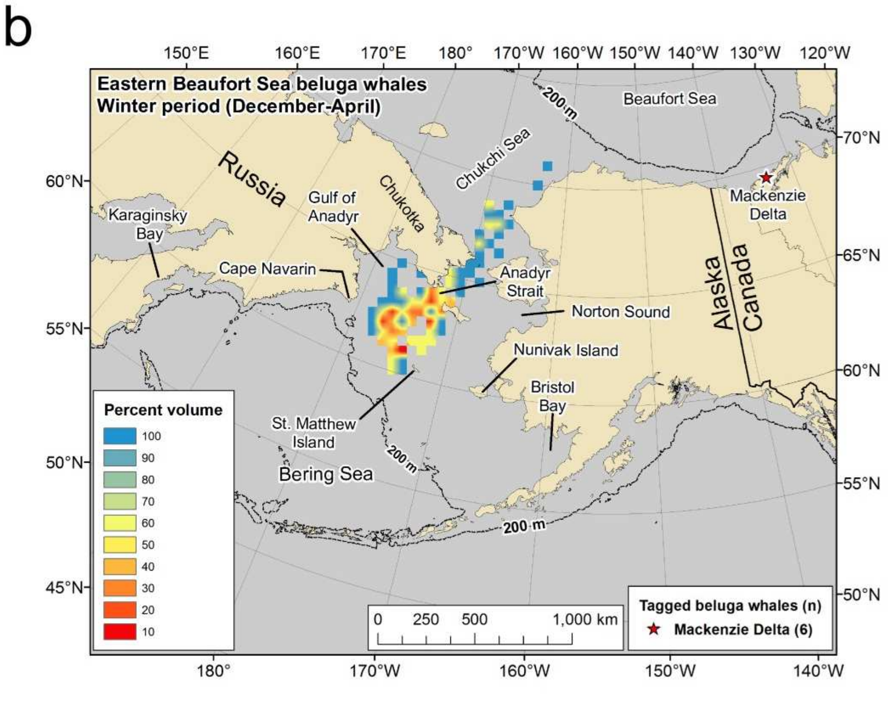
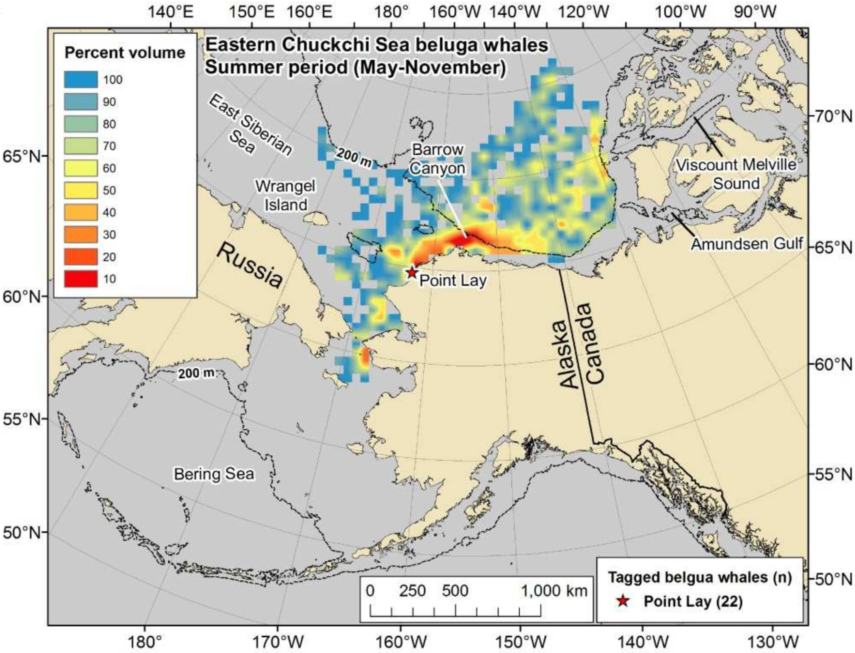


Figure 8. Distribution of satellite tagged Eastern Beaufort Sea (EBS) stock beluga whales during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates the location where EBS beluga whales were tagged and how many (*n*) provided data in each season.

a



b

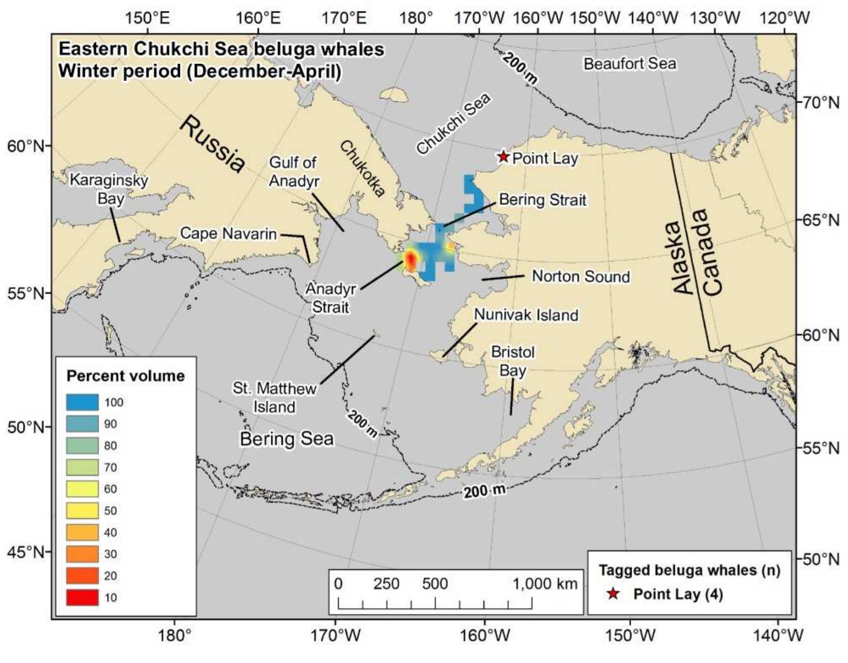
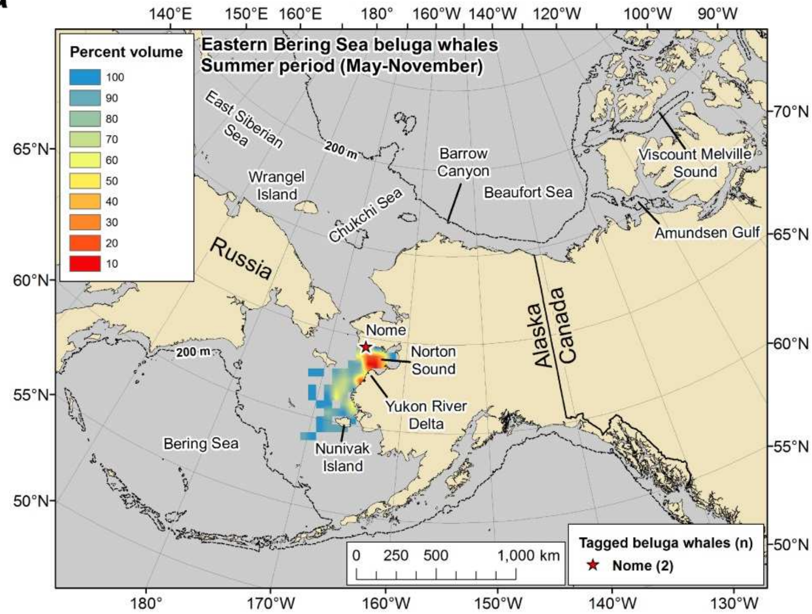


Figure 9. Distribution of satellite tagged Eastern Chukchi Sea (ECS) stock beluga whales during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates the location where ECS beluga whales were tagged and how many (*n*) provided data in each season.

a



b

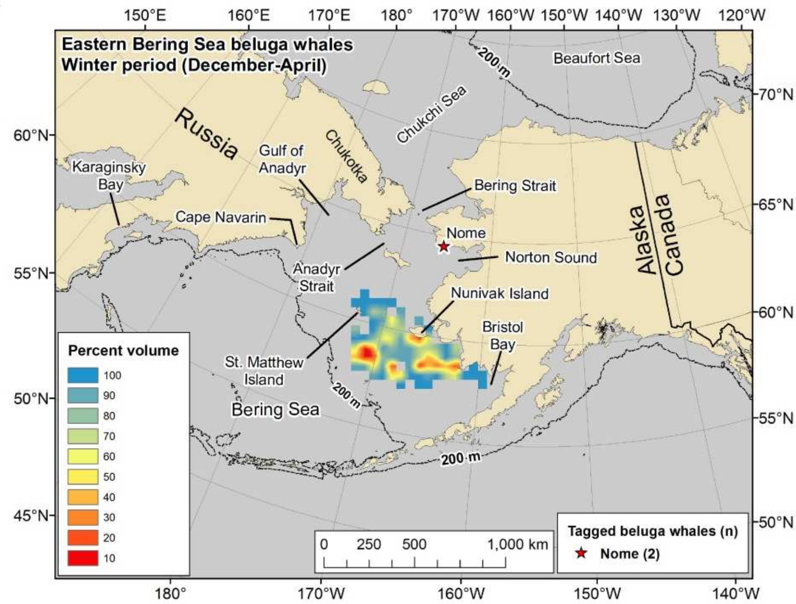


Figure 10. Distribution of satellite tagged Eastern Bering Sea (NS) stock beluga whales during the (a) summer period (May-November) and (b) winter period (December-April). We use "NS" to signify Eastern Bering Sea stock beluga whales to avoid confusion with Eastern Beaufort Stock (EBS) beluga whales. These belugas summer within Norton Sound (NS). The legend indicates the location where NS beluga whales were tagged and how many (*n*) provided data in each season.

a

b

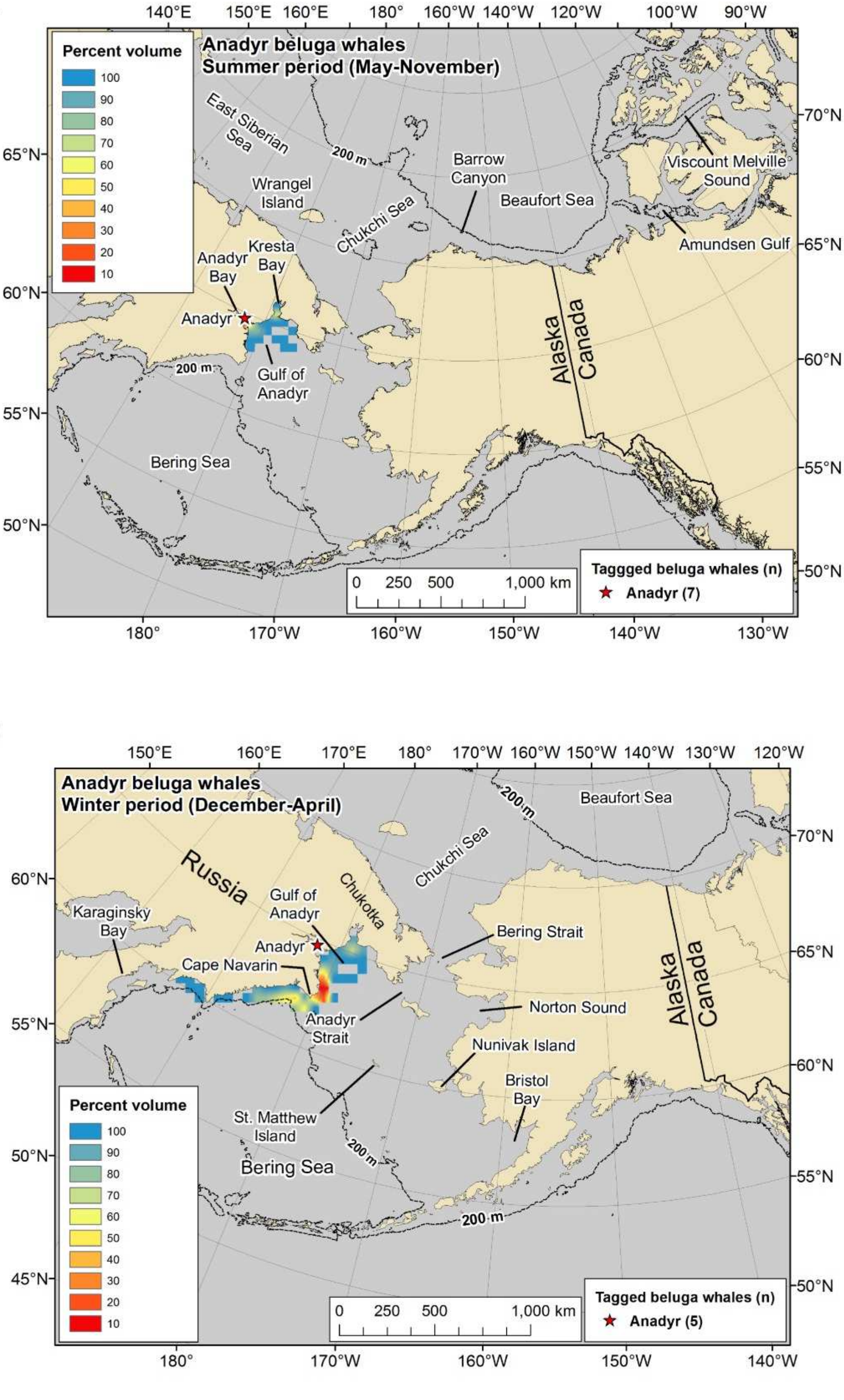


Figure 11. Distribution of satellite tagged Gulf of Anadyr (AN) stock beluga whales during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates the location where AN beluga whales were tagged and how many (*n*) provided data in each season.

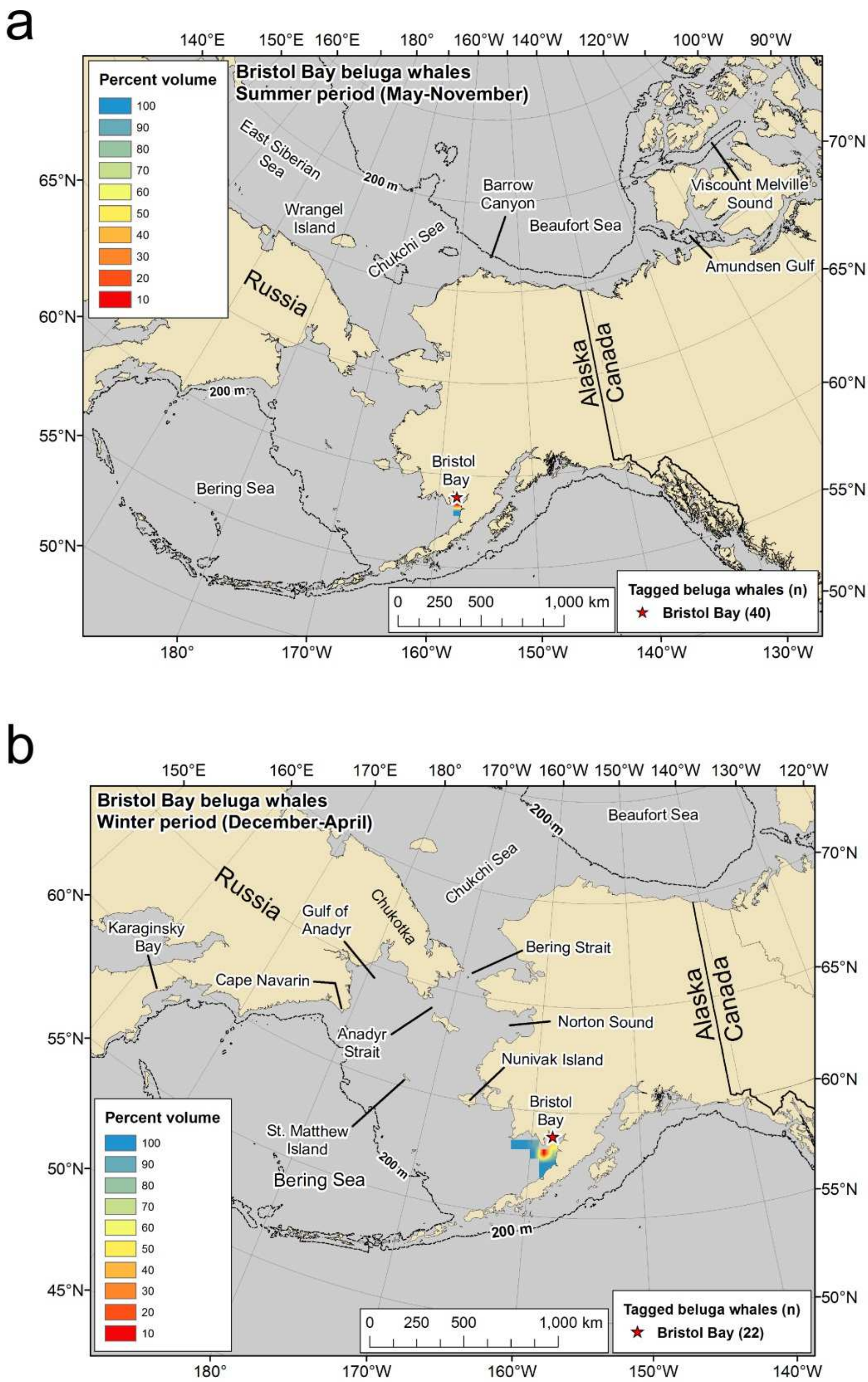


Figure 12. Distribution of satellite tagged Bristol Bay (BB) stock beluga whales during the (a) summer period (May-November) and (b) winter period (December-April). The legend indicates the location where BB stock beluga whales were tagged and how many (*n*) provided data in each season.

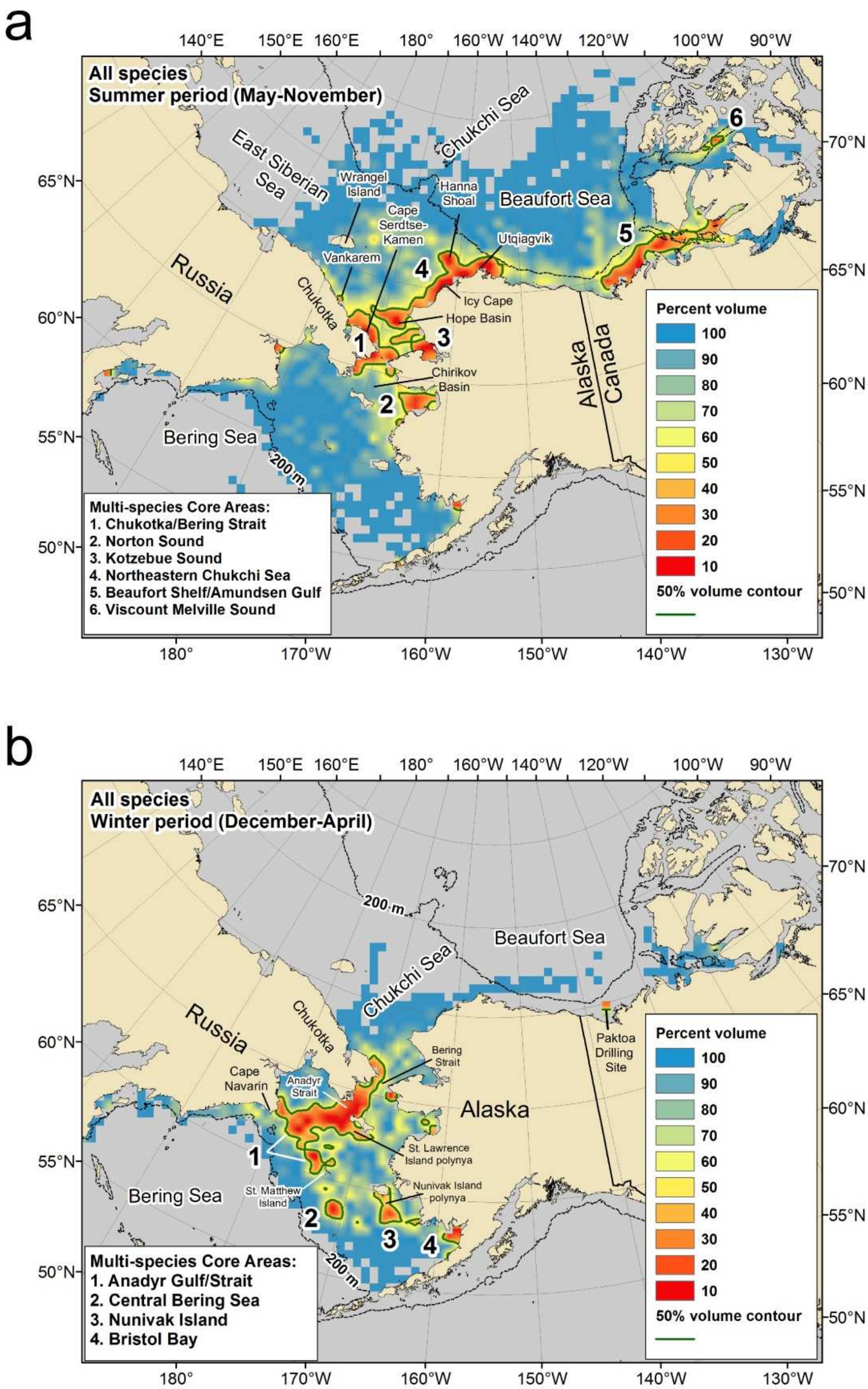


Figure 13. Multi-species core use areas during the (a) summer period (May-November) and (b) winter period (December-April). Contour lines contain 50% of the density of the multi-species distribution.