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# Beluga whales in the western Beaufort Sea: Current state of knowledge on timing, distribution, habitat use and environmental drivers

Kathleen M. Stafford[a,*], Megan C. Ferguson[b], Donna D.W. Hauser[a,c], Stephen R. Okkonen[d], Catherine L. Berchok[b], John J. Citta[e], Janet T. Clarke[f], Ellen C. Garland[g], Joshua Jones[h], Robert S. Suydam[i]

[a] Applied Physics Laboratory, University of Washington, 1013 NE 40th St, Seattle, WA 98105, USA
[b] Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115, USA
[c] School of Aquatic & Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195, USA
[d] Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK 99775, USA
[e] Alaska Department of Fish and Game, 1300 College Rd, Fairbanks, AK 99701, USA
[f] Leidos, 4001 N. Fairfax Drive, Arlington, VA 22203, USA
[g] School of Biology, University of St. Andrews, St. Andrews, Fife KY16 9TH, UK
[h] Scripps Institution of Oceanography, University of California San Diego, 9500 Gilman Dr, La Jolla, CA 92093, USA
[i] North Slope Borough, Department of Wildlife Management, PO Box 69, Utqiaġvik AK 99723, USA

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ABSTRACT

The seasonal and geographic patterns in the distribution, residency, and density of two populations (Chukchi and Beaufort) of beluga whales (*Delphinapterus leucas*) were examined using data from aerial surveys, passive acoustic recordings, and satellite telemetry to better understand this arctic species in the oceanographically complex and changing western Beaufort Sea. An aerial survey data-based model of beluga density highlights the Beaufort Sea slope as important habitat for belugas, with westerly regions becoming more important as summer progresses into fall. The Barrow Canyon region always had the highest relative densities of belugas from July-October. Passive acoustic data showed that beluga whales occupied the Beaufort slope and Beaufort Sea from early April until early November and passed each hydrophone location in three broad pulses during this time. These pulses likely represent the migrations of the two beluga populations: the first pulse in spring being from Beaufort animals, the second spring pulse Chukchi belugas, with the third, fall pulse a combination of both populations. Core-use and home range analyses of satellite-tagged belugas showed similar use of habitats as the aerial survey data, but also showed that it is predominantly the Chukchi population of belugas that uses the western Beaufort, with the exception of September when both populations overlap. Finally, an examination of these beluga datasets in the context of wind-driven changes in the local currents and water masses suggests that belugas are highly capable of adapting to oceanographic changes that may drive the distribution of their prey.

## 1. Introduction

That the Arctic is changing rapidly is indisputable. The most visible environmental changes are the reductions in summer sea ice extent and thickness (Frey et al., 2015; Kwok and Rothrock, 2009; Stroeve et al., 2012), but there are many other changes, including increasing wind strength and storms (Pickart et al., 2013; Spall et al., 2014), and changes in primary and possibly secondary productivity (Ardyna et al., 2014; Arrigo and van Dijken, 2015; Arrigo et al., 2008). In concert with this changing environment, human use of the Arctic is also changing. There are increased interests in exploring for oil, gas and other mineral resources and in shipping through arctic waters (Reeves et al., 2014). Interest in commercial fishing, tourism and scientific research is also on the rise. Predictions about future impacts to marine mammals and other species are uncertain because of our limited understanding of future environmental and anthropogenic changes, how animals use the Arctic, and the linkages between habitat changes and population dynamics, among other factors (Laidre et al., 2015). How beluga whales (*Delphinapterus leucas*) will respond to rapid environmental changes is currently unknown but informed predictions could be made

* Corresponding author.
*E-mail addresses:* kate2@uw.edu (K.M. Stafford), megan.ferguson@noaa.gov (M.C. Ferguson), dhauser@uw.edu (D.D.W. Hauser), srokkonen@alaska.edu (S.R. Okkonen), catherine.berchok@noaa.gov (C.L. Berchok), john.citta@alaska.gov (J.J. Citta), janet.clarke@leidos.com (J.T. Clarke), ecg5@st-andrews.ac.uk (E.C. Garland), j8jones@ucsd.edu (J. Jones), robert.suydam@north-slope.org (R.S. Suydam).

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based on a better understanding of how belugas currently interact with their environment.

Belugas are a top predator in the Arctic. They help meet cultural and nutritional needs of Inuit residents in the Arctic and subarctic. Belugas feed on a wide variety of prey, including fishes, cephalopods and invertebrates (Huntington et al., 1999; Quakenbush et al., 2015; Seaman et al., 1982), but in the Beaufort and Chukchi seas, Arctic cod (*Boreogadus saida*) is thought to be their primary prey (Loseto et al., 2009). Belugas occupy a wide range of habitats, including inlets, glacier fronts, continental slopes, underwater canyons, and deep-water basins; each habitat having ice concentrations that vary spatially (within and across habitats) and temporally (e.g., on seasonal, annual, and longer time scales) (Lydersen et al., 2001; Moore et al., 2000; Suydam et al., 2001). Belugas are generally considered ice-associated, primarily because sea ice plays a critical role in structuring arctic ecosystems (Kovacs et al., 2010; Moore and Huntington, 2008).

Off northern Alaska, there are at least two populations of belugas: the Beaufort Sea stock (hereafter referred to as Beaufort belugas) and the eastern Chukchi Sea stock (hereafter referred to as Chukchi belugas)[1]. These populations are genetically distinct and segregate in different summering areas in the Beaufort Sea, although they may overlap in time and space during the winter in the Bering Sea (Hauser et al., 2014; O'Corry-Crowe et al., 1997; Seaman et al., 1988). In the western Beaufort Sea (west of 140°W), their home ranges overlap during fall migration, although their migratory timing and core use areas differ somewhat by stock. Beaufort belugas migrate north from the Bering Sea in April and May through leads in the sea ice. This stock spends the summer in the Mackenzie Estuary, the eastern Beaufort Sea, Viscount Melville Sound, Amundsen Gulf and beyond, before migrating back to the Bering Sea (Harwood et al., 1996; Richard et al., 2001). Chukchi belugas appear to migrate from the Bering Sea to the Chukchi Sea in June and July before moving into the western Beaufort Sea for the summer and early autumn months (Suydam et al., 2001). The overall trends in abundance for these two populations are considered "unknown" based on a recent review of the status of Arctic marine mammals (Laidre et al., 2015) because there are no recent stock estimates. There is some evidence that the Beaufort stock is stable or possibly increasing (Harwood and Kingsley, 2013). There is a need to better understand how belugas use the western Beaufort Sea to predict impacts and prepare for and mitigate continuing changes in the Arctic. Such knowledge will be essential for adapting management strategies to conserve beluga populations and to ensure food security for many northern communities.

We synthesize what is known about the residency and distribution of beluga whales in this area by reviewing available aerial survey, passive acoustic, and satellite tracking data. The purpose of synthesizing these temporally and spatially diverse data sets (Table 1) is to gain a more holistic understanding of beluga distribution in the western Beaufort Sea and to develop testable hypotheses for future integrated studies of how and why belugas use this area. Previous analyses of telemetry data show that the migratory range of both beluga populations extends from the northern Bering Sea as far north as the Arctic Basin (Richard et al., 2001; Suydam et al., 2001; Hauser et al., 2014). However, our study focuses on belugas in the western Beaufort Sea from roughly 140°W to 159°W because this area has the most extensive overlap of data types, allowing constructive comparison of results from the different studies (Fig. 1). Interest in anthropogenic activities is also expanding within this region where baseline information is particularly needed (Reeves et al., 2014). In addition, the oceanography of the area around Barrow Canyon has been relatively well studied, allowing inference into ecological mechanisms that shape beluga distribution patterns in the western Beaufort Sea.

[1] These two populations are sometimes referred to as the EBS or BS (eastern Beaufort Sea or Beaufort Sea) and ECS (eastern Chukchi Sea) belugas. To avoid confusion with the eastern Bering Sea (also EBS) population of belugas, we prefer the nomenclature above.

**Table 1**
Temporal and spatial extent of the three data sources used in this synthesis with strengths and limitations of each.

| Data Source | Geographic Extent | Sampling Period | Stock ID | Sex and Age Estimation | Calf Presence | Enable Population Density Estimation | Multi-species Sampling | Dive Data | Daylight or Weather Limitations |
|---|---|---|---|---|---|---|---|---|---|
| Tagging | Global, limited only by the whale's range | Tagging occurred in late June/early July, 1993–2012, deployments ranged 7 d[a] – 18 m | X | X | X[b] | | | X | |
| Acoustics | 6 moorings, each with an effective radius of 20 km | Year-round, data from 2007–2014 | | | | | X | | |
| Aerial Surveys | 67–72°N, 140–169°W | Daytime surveys, July - October 2000–2015 | | | X | X | X | | X |

[a] Tag deployments occurred in specific years, 1993-2012: 1993, 1995, 1997, 2004, 2005 (Beaufort belugas); 1998, 1999, 2001, 2002, 2007, 2010, 2012 (Chukchi belugas). Tag analyses were restricted to deployments ≥ 1 wk (see Hauser et al., 2014).
[b] Calf presence and length was noted for the Beaufort population (see Richard et al., 2001).