BELUGA WHALE (*Delphinapterus leucas*): Bristol Bay Stock

NOTE – April 2022: NMFS is evaluating whether scientific issues raised by co-management partners in November 2021 concerning the Eastern Bering Sea beluga whale Stock Assessment Report may also be applicable to the Bristol Bay beluga whale Stock Assessment Report. Any resulting changes will be reflected in a future Stock Assessment Report.

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980). In ice-covered regions, they are closely associated with open leads and polynyas (Hazard 1988). In Alaska, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, eastern Bering Sea (i.e., Yukon River Delta, Norton Sound), eastern Chukchi Sea, and Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. 2018) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Data from satellite transmitters attached to beluga whales from the Beaufort Sea, Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks identify ranges that are relatively distinct month to month for these stocks' summering areas and autumn migratory routes (e.g., Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; these stocks are not known to overlap in space and time (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

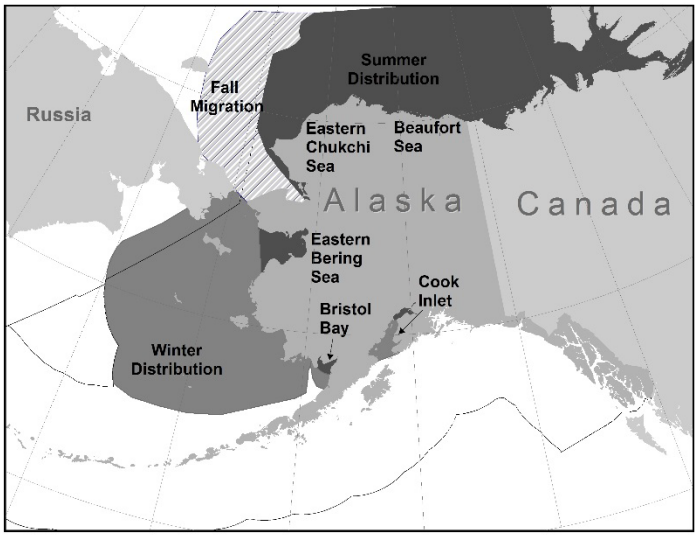

Figure 1. Approximate distribution for all five beluga whale stocks. The Beaufort Sea, Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay beluga whale stocks summer in the Beaufort Sea (Beaufort Sea and Eastern Chukchi Sea stocks) and Bering Sea (Eastern Bering Sea and Bristol Bay stocks); they overwinter in the Bering Sea. The Bristol Bay and Cook Inlet beluga whale stocks show only small seasonal shifts in distribution, remaining in Bristol Bay and Cook Inlet, respectively, throughout the year. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black line.

New genetic analyses have further defined five of the summering aggregations in the Bering, Chukchi, and Beaufort seas as follows: Bristol Bay, eastern Bering Sea (Norton Sound), eastern Chukchi Sea (Kasegaluk Lagoon), eastern Beaufort Sea (Mackenzie-Amundsen), and Gulf of Anadyr (Anadyr Bay) (O'Corry-Crowe et al. 2018). These genetic analyses, combined with new telemetry data, demonstrate that the demographically distinct summering aggregations return to discrete wintering areas and disperse and interbreed over limited distances but do not appear to interbreed extensively (O'Corry-Crowe et al. 2018).

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart the Bering Sea in early spring, migrate through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales depart the Bering Sea in late spring and early summer, migrate through the Chukchi Sea and into the western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea beluga whale stock remains in the Bering Sea but migrates south

near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Beluga whales tagged in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (Goetz et al. 2012; Shelden et al. 2015, 2018; Lowry et al. 2019) remain in those areas throughout the year, showing only small seasonal shifts in distribution.

Summer movement patterns of Bristol Bay beluga whales were determined from satellite-linked tags deployed on 10 animals in the Kvichak River in 2002 and 2003 and 22 whales in the Nushagak River from 2006 to 2011 (Citta et al. 2016). Those whales used the shallow upper portions of Kvichak and Nushagak bays between May and August (Quakenbush 2003) and remained in the nearshore waters of Bristol Bay throughout September and October (Quakenbush and Citta 2006). Data from two beluga whales whose tags transmitted into December and January showed they were in Nushagak and Kvichak bays, suggesting that some beluga whales do not leave the nearshore waters of Bristol Bay during the winter (Citta et al. 2017). Tags attached to whales in 2012, 2013, 2014, and 2016 confirmed these movement observations (NMFS and Alaska SeaLife Center, unpubl. data; https://www.fisheries.noaa.gov/resource/document/2014-cook-inlet-beluga-whale-science-conference-presentations, accessed December 2020).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends among regions occupied in summering areas (O'Corry-Crowe et al. 2018); 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. 2018). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay (Fig. 1), 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea.

POPULATION SIZE

The sources of information to estimate abundance for beluga whales in the waters of western and northern Alaska have included both opportunistic and systematic observations. Frost and Lowry (1990) compiled data collected from aerial surveys conducted in Bristol Bay between 1978 and 1987 that were specifically designed to estimate the beluga whale population. Surveys focused on areas where beluga whales had been found to aggregate during the summer. Frost and Lowry (1990) reported an estimate of 1,000-1,500 whales for Bristol Bay, similar to that reported by Seaman et al. (1985). In 1994, the abundance was estimated at 1,555 beluga whales (Lowry and Frost 1998). That estimate was based on a maximum count of 503 whales, which was corrected using radio-telemetry data for the proportion of whales that were diving and thus not visible at the surface (2.62: Frost and Lowry 1995) and for the proportion of newborns and yearlings not observed due to their small size and dark coloration (1.18: Brodie 1971). The Alaska Department of Fish and Game and the Alaska Beluga Whale Committee (ABWC) conducted aerial beluga whale surveys in Bristol Bay in 1999, 2000, 2004, 2005, and 2016, with average counts of 444, 421, 609, 637, and 660 whales, respectively (Lowry et al. 2008, Lowry et al. 2019). The data from the 2004 and 2005 surveys result in an average count of 623 (coefficient of variation (CV) = 0.25) and, using the correction values above, a population estimate of 1,926 beluga whales (623 × 2.62 × 1.18). Using the count from the 2016 surveys and the correction values that have been applied in the past yields an estimated abundance of 2,040 beluga whales (CV = 0.26) in 2016 (660 × 2.62 × 1.18).

The Bristol Bay stock of beluga whales is genetically distinct. Citta et al. (2018) used a POPAN Jolly-Seber model to estimate abundance using genetic mark-recapture methods. Of the 516 individual whales identified from skin biopsies collected between 2002 and 2011, 75 beluga whales were identified (recaptured) in separate years, resulting in an estimate of 1,928 beluga whales (95% CI: 1,611-2,337), not including calves, which were not sampled (Citta et al. 2018).

Minimum Population Estimate

The survey technique used for estimating the abundance of beluga whales in this stock is a direct count which incorporates correction factors for submerged whales and calves. The abundance estimate is thought to be conservative because no correction was made for whales that were at the surface but were missed by the observers (Lowry and Frost 1998). The minimum population estimate (N_{MIN}) for the Bristol Bay beluga whale stock is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) from the 2016 surveys of 2,040 and the CV of 0.26, N_{MIN} for the Bristol Bay stock is 1,645 beluga whales.

Current Population Trend

After a period of growth observed during surveys conducted from 1993 to 2005 where the population increased by 65% (Lowry et al. 2008), the estimate obtained from a survey conducted in 2016 was similar to those in 2004 and 2005 (Citta et al. 2019). Citta et al. (2019) concluded that population growth has now slowed or ceased entirely.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The estimated rate of increase in beluga whale abundance in Bristol Bay from 1993 to 2005 was 4.8% per year (95% CI: 2.1%-7.5%: Lowry et al. 2008); however, because this estimate has a large CV, the default cetacean maximum net productivity rate (R_{MAX}) of 4% (NMFS 2016) will be used for this stock. It is not clear why the stock increased at this rate between 1993 and 2005, but possibilities include recovery from research kills in the 1960s, a reduction in subsistence harvests, and a delayed response to increases in salmon stocks (Lowry et al. 2008). Genetic mark-recapture estimates that include whales sampled between 2002 and 2011 and the most recent aerial estimate from 2016 suggest the population growth previously observed has slowed or ceased (Citta et al. 2019, Lowry et al. 2019).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum estimated net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, a value that may be used for stocks that are not known to be decreasing and are taken primarily by aboriginal subsistence hunters, provided there have not been recent increases in the levels of takes (NMFS 2016, Lowry et al. 2019). Using the N_{MIN} of 1,645, calculated from the 2016 aerial survey estimate of 2,040 (CV = 0.26), PBR for this stock is 33 beluga whales ($1,645 \times 0.02 \times 1.0$).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 2014 and 2018 is listed, by marine mammal stock, in Young et al. (2020); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Bristol Bay beluga whales between 2014 and 2018 is 19 beluga whales: 19 in subsistence takes by Alaska Natives (including one take in a subsistence salmon set gillnet fishery), and 0.2 incidental to Marine Mammal Protection Act (MMPA)-authorized research. Estimates of mortality and serious injury incidental to Bristol Bay fisheries are likely to be underestimated because observers have never monitored the Bristol Bay commercial salmon set gillnet and drift gillnet fisheries, there is substantial participation in the subsistence salmon gillnet fishery in Bristol Bay but no established protocol for reporting incidental takes in non-commercial fisheries to NMFS, and beluga whales taken incidental to personal-use or commercial salmon fisheries may be used by Alaska Natives for subsistence purposes and may be reported as subsistence takes. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

Information for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is available in Appendix 3 of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed December 2020).

No beluga whale mortality or serious injury was observed incidental to U.S. commercial fisheries in Alaska between 2014 and 2018.

The Bristol Bay commercial salmon set gillnet and drift gillnet fisheries combined had 2,841 active permits listed in the NMFS 2019 LOF (https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed December 2020). These fisheries are known to have caused mortality of Bristol Bay beluga whales (Frost et al. 1984). However, complete data on incidental takes of this stock are not available because there have never been observer programs in these commercial fisheries, and there is no reporting requirement for takes in personal-use fisheries.

It should be noted that in western Alaska, beluga whales taken incidental to personal-use or commercial salmon fisheries may be used by Alaska Natives for subsistence purposes and may be included in the subsistence harvest data reported below. For example, one beluga whale that entangled in a Bristol Bay subsistence salmon set

gillnet in 2014 was known to be used for subsistence purposes and is included in the subsistence harvest data for 2014-2018 (Table 1; ABWC, unpubl. data; Young et al. 2020).

The minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between 2014 and 2018 is zero beluga whales from this stock; however, a reliable estimate of the mortality rate incidental to U.S. commercial fisheries is not available because most coastal commercial fisheries that overlap with this stock have never been observed.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the ABWC (2000) to co-manage western Alaska beluga whale populations in the Bering Sea (including Bristol Bay), Chukchi Sea, and Beaufort Sea. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of beluga whales (to the maximum extent allowed by law) as a tool for conserving beluga whale populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed December 2020).

The subsistence take of Bristol Bay beluga whales is reported by the ABWC. The most recent subsistence harvest estimates for the Bristol Bay stock are provided in Table 1 (ABWC, unpubl. data, 2020). The annual subsistence take by Alaska Native hunters averaged 19 Bristol Bay beluga whales landed between 2014 and 2018.

Table 1. Summary of Bristol Bay beluga whales landed by Alaska Native subsistence hunters between 2014 and 2018 (ABWC, unpubl. data, 2020). These are minimum estimates of the total number of beluga whales taken, because not all landed whales and struck and lost whales are consistently reported.

Year	Number landed	Number struck and lost	Total (landed + struck and lost)
2014	27	0	27
2015	22	2	24
2016	19	1	20
2017	10	no data	10
2018	11	2	13
Mean annual number (landed + struck and lost)			19

Other Mortality

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. In 2016 there was a report of one beluga whale mortality incidental to research on the Bristol Bay stock (Table 2; Young et al. 2020), resulting in a mean annual mortality and serious injury rate of 0.2 beluga whales from this stock between 2014 and 2018.

Table 2. Summary of Bristol Bay beluga whale mortality and serious injury, by year and type, reported to the NMFS Office of Protected Resources between 2014 and 2018 (Young et al. 2020). Beluga whales with non-serious injuries were excluded.

Cause of Injury	2014	2015	2016	2017	2018	Mean annual mortality
Incidental to MMPA-authorized research	0	0	1	0	0	0.2
Total incidental to MMPA-authorized research						0.2

STATUS OF STOCK

No fishery-related mortality or serious injury has been reported for the Bristol Bay beluga whale stock between 2014 to 2018; therefore, the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries can be considered insignificant and approaching a zero mortality and serious injury rate. Bristol Bay beluga whales are not designated as depleted under the MMPA or listed as threatened or endangered under the

Endangered Species Act. Because the minimum estimate of the mean annual human-caused mortality and serious injury rate (19 beluga whales) is less than the PBR (33), the Bristol Bay stock of beluga whales is not classified as a strategic stock. However, as noted previously, the estimate of fisheries-related mortality and serious injury is likely underestimated.

There are key uncertainties in the assessment of the Bristol Bay stock of beluga whales. The abundance is based on count data that are corrected for the proportion of whales that are diving and the proportion of newborns and yearlings not observed because of their size and coloration; however, the counts are not corrected for whales which are at the surface but missed by the observers. Although the apparent population rate of increase was quite high from 1993 to 2005, which may indicate that the population was depleted and reduced human-related mortality and serious injury allowed an increase, most coastal commercial fisheries that overlap with this stock have never been observed. Therefore, the mortality and serious injury of Bristol Bay beluga whales in commercial fisheries could be underestimated. Coastal subsistence fisheries for salmon will occasionally cause incidental mortality or serious injury of a beluga whale; these incidental takes used for subsistence purposes may not always be reported to the ABWC for inclusion in the subsistence harvest estimates for this stock.

HABITAT CONCERNS

Evidence indicates that climate is changing significantly in the Bristol Bay region. One result of the change is a reduction in the extent and duration of sea ice in the winter (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in Bristol Bay. Ice-associated animals, such as the beluga whale, are sensitive to changes in weather, sea-surface temperatures, and sea-ice extent, and the concomitant effect on prey availability. Decreases in seasonal sea ice may also increase the risk of killer whale predation (O'Corry-Crowe et al. 2016). There are insufficient data to make reliable predictions of the effects of climate change on beluga whales; however, Laidre et al. (2008) and Heide-Jørgensen et al. (2010) concluded that on a worldwide basis beluga whales were likely to be less sensitive to climate change in general than other arctic cetaceans because of their wide distribution and flexible behavior. However, local changes in distribution and seasonal behavior are likely to occur (Hauser et al. 2017). Increased human activity in the Bristol Bay region, including increased oil and gas exploration and development and increased nearshore development and mining activities near large tributaries, has the potential to impact habitat for beluga whales (Lowry et al. 2006, Norman et al. 2015). However, predicting the type and magnitude of these impacts is difficult.

In all cases, increased human activities in or near coastal areas of Bristol Bay will increase anthropogenic noise in the water, which has been shown to have negative impacts on cetacean feeding and communication (Norman et al. 2015, Small et al. 2017). Studies of beluga whales in Bristol Bay found that some individuals have "sensitive hearing that approaches the lower levels of noise within their habitat" (Mooney et al. 2018). This may be a result of living in an acoustically quiet environment, which allows for a large dynamic range of hearing. However, if the ambient noise were to increase due to increased anthropogenic activities, masking of calls may occur. This is a particular concern for cow/calf pairs because calves have been shown to vocalize at lower amplitudes than their mothers (Vergara 2019). If ambient or anthropogenic noise levels increase, cow/calf pairs may lose the ability to communicate effectively. Additionally, masking can reduce the range of acoustic detection of prey and communication in cooperative feeding.

CITATIONS

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

Brodie, P. F. 1971. A reconsideration of aspects of growth, reproduction, and behavior of the white whale with reference to the Cumberland Sound, Baffin Island, population. J. Fish. Res. Bd. Can. 28:1309-1318.

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

Citta, J. J., P. Richard, L. F. Lowry, G. O'Corry-Crowe, M. Marcoux, R. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. Gray, J. Orr, B. Tinker, H. Aderman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33:236-250. DOI: dx.doi.org/10.1111/mms.12357 .

Citta, J. J., G. O'Corry-Crowe, L. T. Quakenbush, A. L. Bryan, T. Ferrer, M. J. Olson, R. C. Hobbs, and B. Potgieter. 2018. Assessing the abundance of Bristol Bay belugas with genetic mark-recapture methods. Mar. Mammal Sci. 34(3):666-686.

Citta, J. J., K. J. Frost, and L. Quakenbush. 2019. Aerial surveys of Bristol Bay beluga whales, *Delphinapterus leucas*, in 2016. Mar. Fish. Rev. 81(3-4):98-104.

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance, and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska, p. 39-57. *In* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.), Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Frost, K. J., and L. F. Lowry. 1995. Radio tag based correction factors for use in beluga whale population estimates. Working paper for Alaska Beluga Whale Committee Scientific Workshop, Anchorage, AK, 5-7 April 1995. 12 p.

Frost, K. J., L. F. Lowry, and R. R. Nelson. 1984. Belukha whale studies in Bristol Bay, Alaska, p. 187-200. *In* Proceedings of the workshop on biological interactions among marine mammals and commercial fisheries in the southeastern Bering Sea, October 18-21, 1983, Anchorage AK. Alaska Sea Grant Report 84-1.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37:1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1 .

Hauser, D. D. W., K. L. Laidre, K. M. Stafford, H. L. Stern, R. S. Suydam, and P. R. Richard. 2017. Decadal shifts in autumn migration timing by Pacific Arctic beluga whales are related to delayed annual sea ice formation. Glob. Change Biol. 23:2206-2217. DOI: dx.doi.org/10.1111/gcb.13564 .

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska. Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Heide-Jørgensen, M., K. Laidre, D. Borchers, T. Marques, H. Stern, and M. Simon. 2010. The effect of sea-ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland. Polar Res. 29:198-208. DOI: dx.doi.org/10.1111/j.1751-8369.2009.00142.x .

Johannessen, O. M., L. Bengtson, M. W. Miles, S. I. Kuzmina, V. A. Semenov, G. V. Alexseev, A. P. Nagurnyi, V. F. Zakharov, L. P. Bobylev, L. H. Pettersson, K. Hasselmann, and H. P. Cattle. 2004. Arctic climate change: observed and modeled temperature and sea-ice variability. Tellus 56A:328-341.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Lowry, L. F. 1985. The belukha whale (*Delphinapterus leucas*), p. 3-13. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine mammals species accounts. Alaska Department of Fish and Game, Game Tech. Bull. 7.

Lowry, L. F., and K. J. Frost. 1998. Alaska Beluga Whale Committee surveys of beluga whales in Bristol Bay, Alaska, 1993-1994. Alaska Beluga Whale Committee Report 98-3. 13 p.

Lowry, L., G. O'Corry-Crowe, and D. Goodman. 2006. *Delphinapterus leucas* (Cook Inlet population). *In* IUCN 2006. 2006 IUCN Red List of Threatened Species.

Lowry, L. F., K. J. Frost, A. Zerbini, D. DeMaster, and R. R. Reeves. 2008. Trend in aerial counts of beluga or white whales (*Delphinapterus leucas*) in Bristol Bay, Alaska, 1993-2005. J. Cetacean Res. Manage. 10(3):201-207.

Lowry, L. F., J. J. Citta, G. O'Corry-Crowe, L. T. Quakenbush, K. J. Frost, R. Suydam, R. C. Hobbs, and T. Gray. 2019. Distribution, abundance, harvest, and status of western Alaska beluga whale, *Delphinapterus leucas*, stocks. Mar. Fish. Rev. 81(3-4):54-71.

Mooney, T. A., M. Castellote, I. T. Jones, L. Quakenbush, R. Hobbs, E. Gaglione, and C. Goertz. 2018. Local acoustic habitat relative to hearing sensitivities in beluga whales (*Delphinapterus leucas*). J. Ecoacoustics 2:#QZD9Z5.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed December 2020.

Norman, S. A., R. C. Hobbs, C. E. C. Goertz, K. A. Burek-Huntington, K. E. W. Shelden, W. A. Smith, and L. A. Beckett. 2015. Potential natural and anthropogenic impediments to the conservation and recovery of Cook Inlet beluga whales, *Delphinapterus leucas*. Mar. Fish. Rev. 77(2):89-105. DOI: dx.doi.org/10.7755/MFR.77.2.5 .

O'Corry-Crowe, G., A. R. Mahoney, R. Suydam, L. Quakenbush, A. Whiting, L. Lowry, and L. Harwood. 2016. Genetic profiling links changing sea-ice to shifting beluga whale migration patterns. Biol. Lett. 12:20160404. DOI: dx.doi.org/10.1098/rsbl.2016.0404 .

O'Corry-Crowe, G., R. Suydam, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney. 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS ONE 13(3):e0194201.

Quakenbush, L. 2003. Summer movements of beluga whales captured in the Kvichak River in May 2002 and 2003. Alaska Beluga Whale Committee Report 03-03. 15 p.

Quakenbush, L., and J. Citta. 2006. Fall movements of beluga whales captured in the Nushagak River, in September 2006. Alaska Beluga Whale Committee Report. 9 p.

Seaman, G. A., K. J. Frost, and L. F. Lowry. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. Part I. Distribution, abundance and movements. U.S. Dep. Commer., NOAA, OCSEAP Final Report 56:153-220. Available from NOAA-OMA-OAD, Alaska Office, 701 C. Street, P.O. Box 56, Anchorage, AK 99513.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):1-31 + appendices. DOI: dx.doi.org/10.7755/MFR.77.2.1 .

Shelden, K. E. W., K. T. Goetz, R. C. Hobbs, L. K. Hoberecht, K. L. Laidre, B. A. Mahoney, T. L. McGuire, S. A. Norman, G. O'Corry-Crowe, D. J. Vos, G. M. Ylitalo, S. A. Mizroch, S. Atkinson, K. A. Burek-Huntington, and C. Garner. 2018. Beluga whale, *Delphinapterus leucas*, satellite-tagging and health assessments in Cook Inlet, Alaska, 1999 to 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-369, 227 p.

Small, R. J., B. Brost, M. Hooten, M. Castellote, and J. Mondragon. 2017. Potential for spatial displacement of Cook Inlet beluga whales by anthropogenic noise in critical habitat. Endang. Species Res. 32:43-57. DOI: dx.doi.org/10.3354/esr00786 .

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, School of Aquatic and Fishery Sciences, Seattle, WA.

Vergara, V., J. Wood, A. Ames, M. Mikus, V. Lesage, and R. Michaud. 2019. Mom, can you hear me? Impacts of underwater noise on mother-calf contact calls in endangered belugas (*Delphinapterus leucas*). Presented at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

Young, N. C., B. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-413, 142 p.