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

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980) and are closely associated with open leads and polynyas in ice-covered regions (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, the eastern Bering Sea (i.e., Yukon Delta and Norton Sound), eastern Chukchi Sea, and Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. 1997) (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 a few whales from the Beaufort Sea, Eastern Chukchi Sea, and Eastern Bering Sea stocks show ranges that are relatively distinct month to month for these populations' summering areas and autumn migratory routes (e.g., Hauser et al. 2014, Citta et al. 2017). The few transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; the stocks may use separate wintering locations and probably remain separated through the winter (Suydam 2009, Citta et al. 2017).

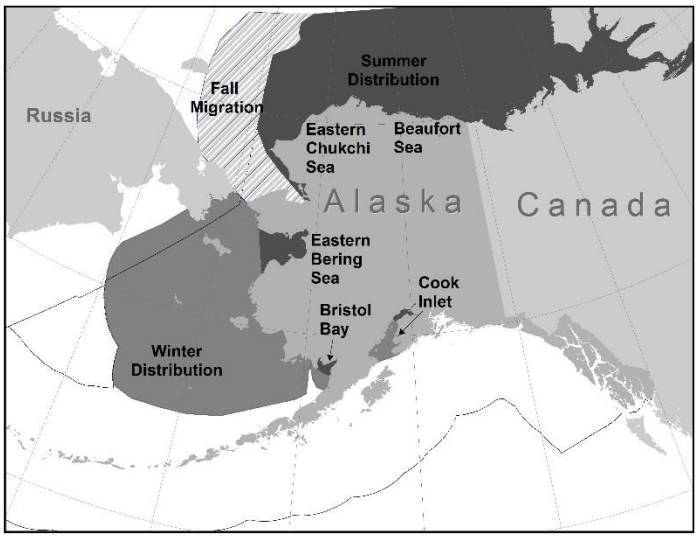

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration.

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart from the Bering Sea in early spring, 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 migrate out of the Bering Sea in late spring and early summer, into the Chukchi Sea and western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea stock remains in the Bering Sea but moves 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). Beluga whales found in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (Hobbs et al. 2005, Goetz et al. 2012, Shelden et al. 2015) 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 during 2002 and 2003 and 22 whales in the Nushagak River in 2006-2011 (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 lasted 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 have confirmed these movement observations (NMFS and Alaska SeaLife Center, unpubl. data; https://alaskafisheries.noaa.gov/sites/default/files/andrews_limpettagging041514.pdf).

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 summer; 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. 1997). Based on this information, five beluga whale stocks

are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea (Fig. 1).

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 between 1978 and 1987 that were specifically designed to estimate the number of beluga whales. Surveys did not cover the entire habitat of beluga whales but were directed to specific areas at the times of year when beluga whales are known to concentrate during 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, and 2005, with average counts of 444, 421, 609, and 637 whales, respectively (Lowry et al. 2008). The results from the 2004 and 2005 surveys give an average count of 623 (CV = 0.25) and, using the correction values above, a population estimate of 1,926 beluga whales (623 × 2.62 × 1.18).

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 this beluga whale stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the estimate from the 2004 and 2005 surveys of 1,926 and the coefficient of variation (CV) of 0.25, N_{MIN} for the Bristol Bay stock is 1,565 beluga whales. However, because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a PBR, and N_{MIN} is considered unknown.

Current Population Trend

A survey program involving replicate aerial counts using standardized methods was conducted during 1993-2005. Data from 28 complete counts of Kvichak and Nushagak bays made in good or excellent survey conditions were analyzed, and results showed that the population increased by 65% over the 12-year period (Lowry et al. 2008).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The estimated rate of increase in abundance of beluga whales in Bristol Bay during 1993-2005 was 4.8% per year (95% CI = 2.1%-7.5%: Lowry et al. 2008). This estimate exceeds the default cetacean maximum net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997). It is not clear why this stock should be increasing at such a high rate, 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).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. As this stock is known to be increasing (Lowry et al. 2008), the recovery factor (F_R) is 1.0 (Wade and Angliss 1997, DeMaster 1997; see discussion under PBR for the Eastern Bering Sea stock). However, the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for this stock is considered undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Detailed information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals in 2011-2015 is listed, by marine mammal stock, in Helker et al. (2017);

however, only the mortality and serious injury data are included in the Stock Assessment Reports. The total estimated annual level of human-caused mortality and serious injury for Bristol Bay beluga whales in 2011-2015 is 25 beluga whales: 0.2 in U.S. commercial fisheries, 0.2 in subsistence fisheries, and 25 in subsistence takes by Alaska Natives. 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. Assignment of mortality and serious injury to the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks when stock is unknown, and the event occurred at a time and in an area where the three stocks could occur, may result in overestimating stock specific mortality and serious injury in federal commercial fisheries. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

During 2011-2015, one beluga whale mortality occurred in the Bering Sea/Aleutian Islands pollock trawl fishery (Table 1; Breiwick 2013; MML, unpubl. data). A genetics sample was collected but has not been analyzed. Since the stock of the beluga whale is unknown, and the event occurred at a time and in an area where the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks could occur, this mortality has been assigned to all three stocks (NMFS 2016).

Table 1. Summary of incidental mortality and serious injury of Bristol Bay beluga whales due to U.S. commercial fisheries in 2011-2015 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl	2011	obs data	98	0	0	0.2 (CV = 0.09)
	2012		98	0	0	
	2013		97	1	1.0	
	2014		98	0	0	
	2015		99	0	0	
Minimum total estimated annual mortality						0.2 (CV = 0.16)

The Bristol Bay commercial salmon set gillnet and drift gillnet fisheries combined had 2,752 active permits in 2016 (Appendix 3 of the Alaska Stock Assessment Reports). These fisheries are known to have caused mortality of beluga whales from this stock in the past (Frost et al. 1984). However, they have never been monitored by an observer program so there is no reliable information on the number of animals that have been or are being taken.

There is substantial effort in a subsistence gillnet fishery for salmon in Bristol Bay. Beluga whales are occasionally entangled and killed in this fishery, but there is no established protocol to report incidental takes in non-commercial fisheries to NMFS. In 2013, one mortality of a beluga whale in a Bristol Bay subsistence salmon gillnet was reported to the NMFS Alaska Region stranding network and the ABWC (Table 2; Helker et al. 2017). Based on this stranding report, the minimum mean annual mortality and serious injury rate due to subsistence fishery interactions in 2011-2015 is 0.2 beluga whales. However, this figure is likely an underestimate because subsistence fishermen are not required to report marine mammal takes. Also, 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 and may be included in the subsistence harvest data reported below. An additional three beluga whales that entangled in Bristol Bay subsistence salmon set gillnets (2 whales in 2013 and 1 in 2014) were

used for subsistence purposes and are included in the subsistence harvest data for 2011-2015 (Table 3; ABWC, unpubl. data; Helker et al. 2017).

A minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2011-2015 is 0.2 beluga whales from this stock; however, a reliable estimate of the mortality rate incidental to U.S. commercial fisheries is not available.

Table 2. Summary of Bristol Bay beluga whale mortality and serious injury, by year and type, reported to the Alaska Region marine mammal stranding network in 2011-2015 (Helker et al. 2017). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of Injury	2011	2012	2013	2014	2015	Mean annual mortality
Entangled in Bristol Bay subsistence salmon gillnet	0	0	1	0	0	0.2
Minimum total annual mortality						0.2

Alaska Native Subsistence/Harvest Information

Data on the subsistence take of beluga whales from the Bristol Bay stock are provided by the ABWC. The most recent subsistence harvest estimates for this stock are provided in Table 3 (ABWC, unpubl. data, 2016). These data show the annual subsistence take by Alaska Native villages averaged 25 beluga whales landed from the Bristol Bay stock in 2011-2015.

Table 3. Summary of Bristol Bay beluga whales landed by Alaska Native subsistence hunters in 2011-2015 (ABWC, unpubl. data, 2016). These are minimum estimates for the total number of beluga whales taken, since struck and lost data are not consistently provided.

Year	Reported total number landed
2011	22
2012	29
2013	29
2014	26
2015	18
Mean annual number landed	25

STATUS OF STOCK

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries is 0.2 beluga whales. However, it is unknown whether this level is insignificant and approaching zero mortality and serious injury rate (i.e., less than 10% of PBR) because PBR is undetermined and a reliable estimate of the mortality and serious injury rate incidental to U.S. commercial fisheries is not available. Bristol Bay beluga whales are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. Because the population size increased at a rate above R_{MAX} from 1993 to 2005, the sum of human impacts on the population was not a concern (Lowry et al. 2008). Therefore, 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 to be 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 fish 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 and included in the subsistence harvest estimates for this stock.

HABITAT CONCERNS

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 the 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).

CITATIONS

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

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

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 .

DeMaster, D. P. 1997. Minutes from the fifth meeting of the Alaska Scientific Review Group, 7-9 May 1997, Seattle, Washington. 21 p. + appendices. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

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 .

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354, 112 p.

Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subarctic Alaskan estuary. Arctic 58(4):331-340.

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.

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 June 2018.

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. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.

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 .

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 .

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.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.