

BELUGA WHALE (*Delphinapterus leucas*): Cook Inlet Stock

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).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach, which considers four types of data: 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 (Fig. 1), 2) Bristol Bay, 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea.

Data from satellite transmitters attached to beluga whales from the Beaufort Sea, Eastern Chukchi Sea, and Eastern Bering Sea 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 in the Bering Sea (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

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 eastern 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. 2012a; Sheldon et al. 2015, 2018; Lowry et al. 2019) remained in those areas throughout the year, showing only small seasonal shifts in distribution.



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.

During summer months, Cook Inlet beluga whales are often concentrated near river mouths (Shelden et al. 2015) and are found seasonally in distinct areas (Susitna River delta, Chickaloon Bay, Turnagain Arm, and Knik Arm), where they aggregate in large groups of both sexes and all age classes as they rear calves and feed (McGuire et al. 2020a). The fall-winter-spring distribution of this stock is not fully understood; however, there is evidence that most whales in this population inhabit upper Cook Inlet year-round but small groups also enter bays and rivers in the lower inlet such as Tuxedni Bay and Kenai River (Lammers et al. 2013, Castellote et al. 2015, Shelden et al. 2015). From 1999 to 2002, satellite tags were attached to a total of 18 Cook Inlet beluga whales to determine their movement patterns (Goetz et al. 2012a; Shelden et al. 2015, 2018). All tag locations occurred within Cook Inlet, primarily in the upper inlet north of East and West Foreland, with some whales briefly entering the lower inlet in the fall and then returning to the upper inlet (Shelden et al. 2015, 2018).

A review of all marine mammal surveys and anecdotal sightings in the northern Gulf of Alaska between 1936 and 2000 found only 28 beluga whale sightings, indicating that very few beluga whale sightings occurred in the Gulf of Alaska outside Cook Inlet (Laidre et al. 2000). Yakutat Bay is the only area in the Gulf of Alaska outside of Cook Inlet where multiple beluga whale sightings have occurred (Laidre et al. 2000, Lucey et al. 2015, O’Corry-Crowe et al. 2015). Based on genetic analyses, traditional ecological knowledge, and observations by fishermen and others, the Yakutat Bay beluga whales likely represent a small, resident group (fewer than 20 whales) that has been observed year round and is reproductively separated from Cook Inlet (Lucey et al. 2015, O’Corry-Crowe et al. 2015). Furthermore, this group in Yakutat Bay appears to be showing signs of inbreeding and low diversity due to their isolation and small numbers (O’Corry-Crowe et al. 2015). Although the beluga whales in Yakutat Bay are not included in the Cook Inlet Distinct Population Segment (DPS) of beluga whales under the Endangered Species Act (ESA), they are considered part of the depleted Cook Inlet stock under the Marine Mammal Protection Act (MMPA) (50 CFR 216.15; 75 FR 12498, 16 March 2010) because insufficient information was available to identify Yakutat Bay beluga whales as a separate population when Cook Inlet beluga whales were designated as depleted under the MMPA. Thus, Yakutat Bay beluga whales remain part of the Cook Inlet stock, are designated as depleted, and are provided the same protections as the Cook Inlet stock, including hunting regulations/restrictions.

This stock assessment report assesses the abundance and human-caused mortality and serious injury of Cook Inlet beluga whales throughout the stock’s entire geographic range.

POPULATION SIZE

Aerial surveys during June documented the distribution and abundance of Cook Inlet beluga whales and were conducted by NMFS each year from 1994 to 2012 (Rugh et al. 2000, 2005; Shelden et al. 2013), after which NMFS began biennial surveys in 2014 (Shelden et al. 2019) (Fig. 2). NMFS changed to a biennial survey schedule after analysis showed there would be little reduction in the ability to detect a trend given the current growth rate of the population (Hobbs 2013).

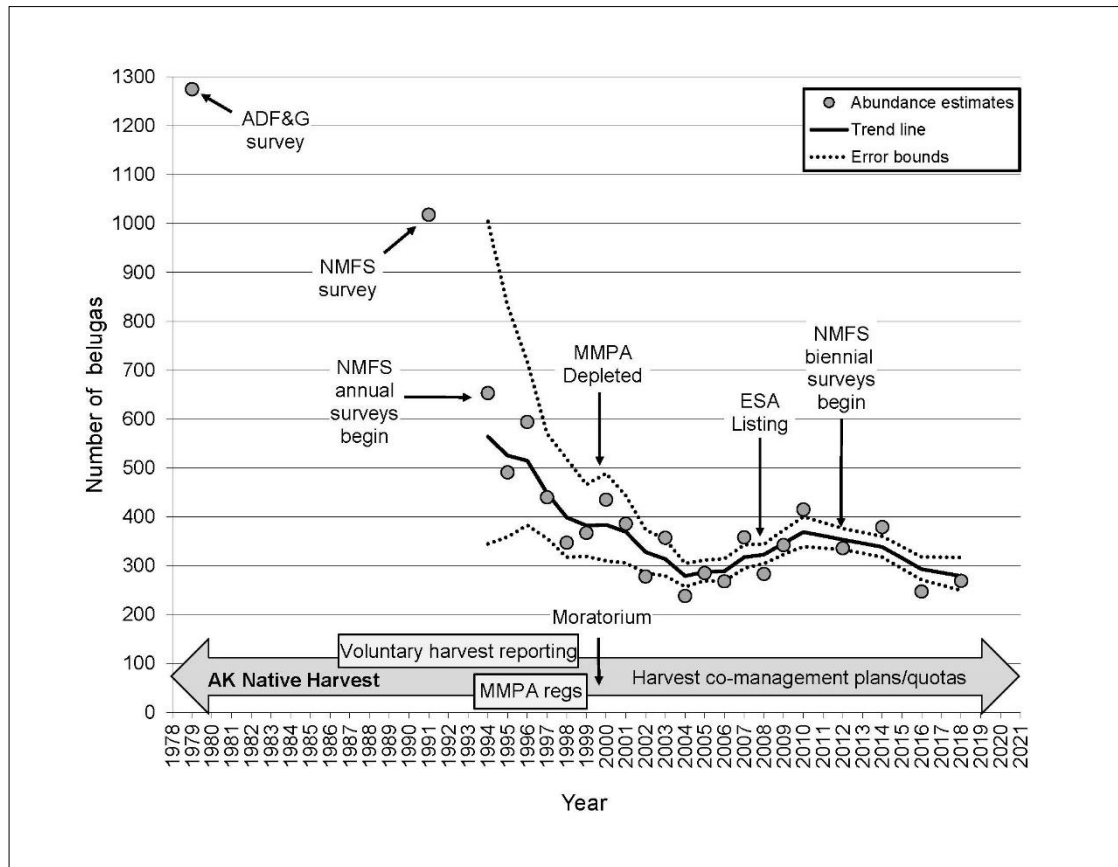


Figure 2. Annual abundance estimates (circles) of beluga whales in Cook Inlet, Alaska, 1979-2018 (Calkins 1989, Hobbs et al. 2015a, Shelden et al. 2015, Shelden and Mahoney 2016, Wade et al. 2019). The solid line from 1994 to 2018 is a weighted moving average of the abundance estimates that represents the smoothed trend of the population through time. Dashed lines above and below the solid line are 95% probability intervals around the smoothed trend line. Changes to harvest reporting are shown along the x-axis and indicate periods when Alaska Native hunting households provided data to the Alaska Department of Fish and Game, Alaska Beluga Whale Committee, Cook Inlet Marine Mammal Council, and NMFS and when MMPA harvest reporting regulations and co-management plans were adopted.

The survey covers all coastal areas and all river mouths and deltas in Cook Inlet in early June. The surveys are designed with the intention of detecting all substantially-sized beluga whale groups in the upper inlet. When beluga whale groups are detected, the group sizes are estimated by visual counts by observers or from video data recorded of the groups. The group-size estimates are summed across all detected groups to calculate an abundance estimate from each day's survey. Daily estimates from all survey days considered acceptable are combined to form an annual estimate of abundance for the population.

The method used for estimating group size from video data requires estimating multiple correction factors for visibility bias (Hobbs et al. 2000, 2015a). Following the June 2016 abundance survey, a major revision was made to the methods used to estimate group sizes from the survey data (Boyd et al. 2019). The new method was developed using a Bayesian statistical approach to group-size estimation; this new method was then applied to the 2004-2016 time series (Boyd et al. 2019). Wade et al. (2019) applied the same methodology to the 2018 survey data to estimate abundance for the 2018 survey. The new approach was designed to address the same four types of bias in the group-size estimation process as previous methods: 1) availability bias due to diving behavior; 2) proximity bias due to individuals concealed by another individual in the video data; 3) perception bias due to individuals not detected because of small image size in the video data; and 4) individual observer bias in visual estimates of group size (see Boyd et al. 2019 for a complete description of methods). The main advantages to the change in group-size

estimation methods are as follows: (a) the Bayesian methods allow the variance in the parameter estimates to be fully propagated through the analysis (unlike the previous methods) and also allow for specification of distributions for some parameters, rather than just single values, to more completely consider uncertainty in the analyses; (b) for estimating the visibility bias correction factors (availability, proximity bias, and perception), the important assumption was added that the true group size was the same for all video passes of the same group (this assumption was not previously used in the analysis); (c) for availability bias, a prior distribution is specified for mean dive time for a beluga whale group; previously this was fixed at the single value of 24.1 seconds; and (d) for perception bias, the analysis now simultaneously estimates two distributions as part of the integrated analysis: 1) detection probability as a function of image size, and 2) the distribution of image sizes for all individuals; previously, this was done as a separate ad hoc analysis (Wade et al. 2019).

In addition to the new group-size estimation method, the revised abundance method controls for possible strong positive and negative outliers on single days (Wade et al. 2019). Strong negative outliers (days with very low abundance) can potentially happen when some groups are not seen. Strong positive outliers (days with very high abundance) can potentially happen when the whales occur in one or more very large groups, and the video group-size estimation process becomes difficult, with large sampling and model error leading to large scatter between survey days. Previously (i.e., Hobbs et al. 2015a), the annual estimate of abundance was calculated as the average of three or more days, excluding a day's estimate if it was less than approximately 60% of the highest day. However, it is not possible to objectively determine if one specific estimate was low because a group was missed (in which case the estimate should be dropped) or if it was low because of sampling and model error as part of the estimation process (in which case it should not be dropped). Therefore, the annual abundance is calculated as the median of all the daily abundance estimates, using all days with an acceptable survey day, defined objectively by weather/sighting conditions and spatial coverage. Using the median lessens the influence of strong positive and negative outliers.

The point estimate of abundance for 2018, based on the median of all acceptable daily estimates in 2018, is 269 beluga whales (coefficient of variation (CV) = 0.103; 95% probability interval (PI): 227 to 333). The best estimate of current abundance is based on a weighted average from the last three annual abundance estimates (2014, 2016, and 2018), giving more weight to the more recent estimates. From that weighted average, the best estimate of abundance for the Cook Inlet beluga whale population in 2018 is 279 (CV = 0.061; 95% PI: 250 to 317) (Wade et al. 2019).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) is calculated as the 20th percentile of the best abundance estimate, according to the potential biological removal (PBR) guidelines (NMFS 2016a). In this case, N_{MIN} is calculated as the 20th percentile of the posterior distribution of the best estimate of abundance in 2018, which is 267 (Wade et al. 2019). Therefore, N_{MIN} for the Cook Inlet beluga whale stock is 267 beluga whales.

Current Population Trend

The annual abundance estimates for 1994 to 2018 are shown in Figure 2, along with a weighted moving average to show the smoothed trend over time. The population declined substantially during the period of unregulated hunting, with the peak hunting mortality reported in 1996 (123 whales) and the last year of substantial hunting mortality in 1998 (42 whales). Although only five whales were reported killed from hunting from 1999 to 2005, the population continued to decline until about 2004. The population showed an increase from 2005 to 2010 but has apparently declined since 2010. During the most recent 10-year time period (2008-2018), the estimated exponential trend in the abundance estimates is a decline of 2.3% per year (95% PI: -4.1% to -0.6%), with a 99.7% probability of a decline and a 93.0% probability of a decline that is more than 1% per year (Wade et al. 2019).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the Cook Inlet beluga whale stock. Until additional data become available, the default cetacean maximum theoretical net productivity rate of 4% will be used for this stock (NMFS 2016a).

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: $\text{PBR} = N_{\text{MIN}} \times 0.5R_{\text{MAX}} \times F_R$. The recovery factor (F_R) for this stock is 0.1, the value for cetacean stocks that are listed as endangered (NMFS 2016a). Using the N_{MIN} of 267 beluga whales, the calculated PBR for this stock is 0.53 beluga whales ($267 \times 0.02 \times 0.1$).

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 2015 and 2019 is listed, by marine mammal stock, in Freed et al. (2021); however, only the mortality and serious injury data are included in the Stock Assessment Reports. No human-caused mortality or serious injury of Cook Inlet beluga whales was confirmed between 2015 and 2019. There are no observers in Cook Inlet fisheries, so the mean annual mortality and serious injury in commercial fisheries is unknown, although likely low, given that an observer program conducted in Cook Inlet in 1999-2000 did not observe mortality or serious injury of beluga whales (Manly 2006). Other potential threats most likely to result in direct human-caused mortality or serious injury of this stock include ship strikes.

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 2021).

Based on historical reports, Cook Inlet beluga whale mortality and serious injury has occurred in the Cook Inlet salmon set gillnet and drift gillnet fisheries. Because these fisheries are not currently observed, the potential for fisheries-caused mortality and serious injury may be greater than is reflected in existing observer data.

Alaska Native Subsistence/Harvest Information

Subsistence harvest of Cook Inlet beluga whales is important to the Native Village of Tyonek and the Alaska Native subsistence hunter community in Anchorage. Between 1993 and 1998, the annual subsistence take ranged from 17 to more than 123 beluga whales (Fig. 2), including struck and lost whales (NMFS 2016b).

Following a significant decline in Cook Inlet beluga whale abundance estimates between 1994 and 1998, the Cook Inlet hunters voluntarily stopped hunting in 1999 and the Federal government took actions to conserve, protect, and prevent further declines in the abundance of these whales. Public Laws 106-31 (1999) and 106-553 (2000) established a moratorium on Cook Inlet beluga whale harvests unless such taking occurs pursuant to a cooperative agreement between NMFS and affected Alaska Native organizations. A cooperative agreement, also referred to as a co-management agreement, was not signed in 1999 and 2004. In December 2000, an administrative hearing was held to create interim harvest regulations for 2001 through 2004 (69 FR 17973, 6 April 2004). Three Cook Inlet beluga whales were killed under this interim harvest plan (2001-2003). In August 2004, an administrative hearing was held to create a long-term harvest plan, which allowed up to eight whales to be harvested between 2005 and 2009 (NMFS 2008). Two whales were harvested in 2005 and no whales were harvested in 2006. The long-term harvest plan was signed in 2008 and established a harvest level for a 5-year period, based on the average abundance in the previous 5-year period and the growth rate during the previous 10-year period (NMFS 2008). A harvest is not allowed if the previous 5-year average abundance was less than 350 beluga whales. Under the long-term harvest plan, the 5-year average abundance during the first review period (2003-2007) was 336 whales and, therefore, a harvest was not allowed during the subsequent 5-year period (2008-2012) (73 FR 60976, 15 October 2008). The average abundance of Cook Inlet beluga whales remained below 350 whales during the second review period (2008-2012); therefore, a harvest was not allowed for the subsequent 5-year period (2013-2017). NMFS changed to a biennial survey schedule after 2012, therefore, the 5-year average abundance is now based on either two or three surveys in a 5-year period. Hobbs (2013) showed that biennial rather than annual surveys may lead to higher variation in allowable harvest levels, but it is not expected to change the probability of recovery while using the algorithm that determines the allowable harvest level. The average abundance for a third review period (2013-2017), using the 2014 and 2016 estimates, is still below 350 whales (Wade et al. 2019), so a harvest is not allowed for the subsequent 5-year period (2018-2022).

Other Mortality

Reports from the NMFS Alaska Region marine mammal stranding network provide information on beluga whale mortality. Mortality related to live stranding events, where a beluga whale group strands as the tide recedes, has been regularly observed in upper Cook Inlet (Table 1). Reports include the number of live stranded beluga whales, as well as floating and beachcast carcasses (NMFS 2016b; McGuire et al. 2020b; <https://www.fisheries.noaa.gov/resource/document/alaska-region-marine-mammal-annual-stranding-reports>, accessed December 2021). Most beluga whales involved in live stranding events survive, although some associated deaths may not be observed if whales die later from related injuries (Vos and Shelden 2005, Burek-Huntington et al.

2015). Between 2015 and 2019, there were reports of approximately three beluga whales involved in two known live stranding events (Table 1; NMFS 2016b; McGuire et al. 2020b; NMFS, unpubl. data). The beluga whale calf that stranded alive in 2017 was sent to the Alaska SeaLife Center for rehabilitation; after rehabilitation, NMFS determined the animal could not survive on its own if returned to the wild, so it was transferred to SeaWorld in San Antonio, Texas, in 2018.

Long-term photo-identification data from approximately 420 individual beluga whales identified between 2005 and 2017 were compared with stranding data from 95 dead beluga whales to identify patterns of mortality with respect to age, sex, geographic range, and cause of death and to estimate minimum mortality rates (McGuire et al. 2020b). Reported mortality was greatest for adults of reproductive age, followed by calves, with fewer subadults and no adults older than 49 years in the stranding data set. Live stranding was the predominant assigned cause of death but represented only approximately 33% of deaths with known cause. Annual mortality from all causes estimated from reported carcasses relative to total population size averaged 2.2% (SE = 0.36%) (McGuire et al. 2020b).

Table 1. Cook Inlet beluga whale strandings investigated by NMFS between 2015 and 2019 (NMFS 2016b; McGuire et al. 2020b; NMFS, unpubl. data). These numbers include non human-caused strandings.

Year	Floating and beachcast carcasses	Number of beluga whales per live stranding event (number of associated known or suspected resulting deaths)
2015	3	2 (0)
2016	8	0
2017	12	1*
2018	7	0
2019	13	0
Total	43	3 (0)

*The beluga whale calf that stranded alive in 2017 was sent to the Alaska SeaLife Center for rehabilitation and then transferred to SeaWorld in San Antonio, Texas, in 2018. It is considered a permanent removal from the wild population.

Another source of beluga whale mortality in Cook Inlet is predation by transient-type (mammal-eating) killer whales. Killer whale sightings were not well documented and were likely rare in the upper inlet prior to the mid-1980s. From 1982 through 2018, NMFS received 31 reports of killer whale sightings in upper Cook Inlet (north of East and West Foreland). Up to 12 beluga whale deaths, inlet-wide, were suspected to be a direct result of killer whale predation (NMFS 2016b). The last confirmed killer whale predation of a Cook Inlet beluga whale occurred in 2008 in Turnagain Arm. From 2015 through 2019, NMFS received two separate killer whale sighting reports (both in 2015) in upper Cook Inlet, but there were no reports of predation attempts. Transient killer whale vocalizations have been detected on acoustic moorings in upper Cook Inlet (Castellote et al. 2016a) but only once in a 5-year period (Castellote et al. 2016b).

Between 1998 and 2013, 38 necropsies were performed on beluga whale carcasses (23% of the 164 known stranded carcasses) (Burek-Huntington et al. 2015). The sample included adults (n = 25), juveniles (n = 6), calves (n = 3), and aborted fetuses (n = 4). When possible, a primary cause of death was noted along with contributing factors. Cause of death was unknown for 29% of the necropsied carcasses. Other causes of death were attributed to various types of trauma (18%), caused by confirmed and suspected killer whale predation, blunt force, choking on a starry flounder, and entanglement in a setnet (although this individual was in poor health and it could not be determined if it died before or after entanglement); perinatal mortality (13%); live mass stranding (13%); live single stranding (11%); malnutrition (8%); or disease (8%). Several animals had mild to moderate pneumonia, kidney disease, and/or stomach ulcers that likely contributed to their deaths.

Individual beluga whales photographed from 2005 to 2017, along with stranding records, were examined to determine prevalence of scars indicative of anthropogenic trauma (McGuire et al. 2020c). Scars were classified by likely source (e.g., entanglements, vessel strikes, puncture wounds, and research). Of 78 whales examined, 7 had signs of trauma confirmed or possibly from entanglement in rope or lines; 6 had signs of trauma that were possibly from entanglement or from a vessel collision; 3 had signs of trauma possibly from a vessel collision or a predation attack; 4 had signs of possible puncture scars consistent with bullets, arrows, or harpoons; and 2 had signs of trauma consistent with a vessel collision. The authors concluded the sample did not allow them to reliably infer the rate of anthropogenic trauma at the population level, but the study does provide evidence of the types and level of trauma experienced by a subset of the population.

STATUS OF STOCK

The Cook Inlet beluga whale stock was designated as depleted under the MMPA in 2000 (65 FR 34590, 21 May 2000) and listed as endangered under the ESA in 2008 (73 FR 62919, 22 October 2008); therefore, it is considered a strategic stock.

There are key uncertainties in the assessment of the Cook Inlet stock of beluga whales. The stock decline is well documented. While the early decline was likely due to unrestricted subsistence harvesting, it is unknown what has prevented recovery of this stock, because subsistence harvest has not been allowed since 2007 and the mortality and serious injury in commercial fisheries is likely low. PBR is designed to allow stocks to recover to, or remain above, the maximum net productivity level (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward Optimum Sustainable Population and that some surplus growth could be removed while still allowing recovery. However, the Cook Inlet beluga whale population is far below historical levels and yet, for unknown reasons, is not increasing. If the Cook Inlet beluga whale population was increasing at an expected rate of approximately 2 to 4%, it would currently be adding, on average, about 7 to 13 whales per year to the population. Currently, there is not a subsistence harvest and direct human-caused mortality due to fisheries bycatch, vessel strikes, or other sources has not been definitively determined, although McGuire et al. (2020c) documented beluga whales with scars due to vessel strikes and entanglements in ropes and lines, indicating these sources are a potential cause of injury or mortality. However, even if the PBR level (~one whale every 2 years) was taken, it is clear this would have little consequence on the overall population trend given the unexplained lack of increase by 7 to 13 whales per year. Stranding data from Cook Inlet have shown that an average of approximately 10 beluga whales died per year between 1998 and 2013 (Burek-Huntington et al. 2015) due to non-human-related or unknown causes, but total mortality in the population is unknown without information on the carcass recovery rate. Individuals die from natural causes even in a growing population; for example, if the average survival rate was a relatively high 0.95, there would still be approximately 14 (0.05×279) deaths expected each year; therefore, it is hard to conclude anything definitive from an average of 10 observed deaths per year.

HABITAT CONCERNS

Based on available information, beluga whales remain within Cook Inlet year-round. Review of beluga whale presence data from aerial surveys, satellite tagging, protected species observers, citizen scientists, and opportunistic sightings collected in Cook Inlet from the late 1970s to 2018 shows their range has contracted remarkably since the 1970s (Shelden et al. 2019). Almost the entire population is found in northern Cook Inlet from late spring through the summer and into the fall. This differs markedly from surveys in the 1970s when beluga whales were found in, or would disperse to, lower Cook Inlet by midsummer. Since 2008, on average, 83% of the total population occupied the Susitna Delta (Beluga to Little Susitna rivers) in early June during the aerial survey period, compared to roughly 50% in the past (1978-1979, 1993-1997, 1998-2008). The 2009 to 2014 distribution was estimated to be only 25% of the range observed in 1978 and 1979 (Shelden et al. 2015). Rugh et al. (2000) first noted that whales had not dispersed to the lower inlet in July during surveys in the mid-1990s. This was also evident during aerial surveys conducted in July 2001 (Rugh et al. 2004). Whales transmitting locations from satellite tags during July in 1999 and 2002 also remained in the northern reaches of the upper inlet (Shelden et al. 2015). During surveys in the 1970s, large numbers of whales were scattered throughout the lower inlet in August (Shelden et al. 2015). This was not the case in 2001, when counts in the upper inlet in August were similar to those reported in June and July (Rugh et al. 2004). In August, only 2 of 10 tagged whales spent time in offshore waters and the lower inlet (Shelden et al. 2015). The number of whales observed in the upper inlet during the August calf index surveys, conducted from 2005 to 2012, was similar to the June surveys (Hobbs et al. 2015a), suggesting the contraction in range continued through the summer. While surveys were not conducted in September during the 1970s and 1980s, aerial surveys in 1993 showed some dispersal into lower inlet waters by late September (Shelden et al. 2015). However, surveys in September and October of 2001 resulted in counts that were similar to June (Rugh et al. 2004). With the exception of three whales that spent brief periods of time in the lower inlet during September and/or October, most whales transmitting locations in 1999, 2000, 2001, and 2002 remained in the upper inlet north of East and West Foreland (Shelden et al. 2015, 2018). Counts during aerial surveys in September 2008 were also similar to June (Shelden et al. 2015).

Goetz et al. (2012b) modeled habitat preferences using NMFS' 1994-2008 June abundance survey data. In large areas, such as the Susitna Delta and Knik Arm, there was a high probability that beluga whales were in larger group sizes. Beluga whale presence also increased closer to rivers with Chinook salmon (*Oncorhynchus tshawytscha*) runs, such as the Susitna River. Chinook salmon runs have been decreasing in many Alaska Rivers since 2007, including the Susitna River (<https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main>),

accessed December 2021). The Susitna Delta also supports two major spawning migrations of a small, schooling eulachon (*Thaleichthys pacificus*) in May and June (Goetz et al. 2012b).

The population appears to be consolidated into habitat in the upper-most reaches of Cook Inlet for much longer periods of time, in habitat that is most likely to be noisy (e.g., Moore et al. 2000, Lowry et al. 2006, Hobbs et al. 2015b, Kendall and Cornick 2015, Norman et al. 2015). An assessment of noise sources in Cook Inlet (Castellote et al. 2019) indicates that anthropogenic noise occurring in some of the most important habitat has the potential to mask beluga whale communication and hearing, and the potential reduction of communication and echolocation range is considerable. It is unknown whether this contracted distribution is a result of changing habitat (Moore et al. 2000), prey concentration, or predator avoidance (Shelden et al. 2003) or can simply be explained as the contraction of a reduced population into small areas of preferred habitat (Goetz et al. 2007, 2012b).

The Cook Inlet Beluga Whale Recovery Plan (NMFS 2016b) identifies potential threats: 1) high concern: catastrophic events (e.g., natural disasters, spills, mass strandings), cumulative effects of multiple stressors, and noise; 2) medium concern: disease agents (e.g., pathogens, parasites, and harmful algal blooms), habitat loss or degradation, reduction in prey, and unauthorized take; and 3) low concern: pollution, predation, and subsistence harvest. The recovery plan did not treat climate change as a distinct threat but rather as a consideration in the threats of high and medium concern.

CITATIONS

- Boyd, C., R. C. Hobbs, A. E. Punt, K. E. W. Shelden, C. L. Sims, and P. R. Wade. 2019. Bayesian estimation of group sizes for a coastal cetacean using aerial survey data. *Mar. Mammal Sci.* 35(4):1322-1346. DOI: [dx.doi.org/10.1111/mms.12592](https://doi.org/10.1111/mms.12592).
- Burek-Huntington, K. A., J. Dushane, C. E. C. Goertz, L. Measures, C. Romero, and S. Raverty. 2015. Morbidity and mortality in stranded Cook Inlet beluga whales (*Delphinapterus leucas*). *Dis. Aquat. Organ.* 114(1):45-60. DOI: [dx.doi.org/10.3354/dao02839](https://doi.org/10.3354/dao02839).
- Calkins, D. G. 1989. Status of belukha whales in Cook Inlet, p. 109-112. In L. E. Jarvela and L. K. Thorsteinson, (eds.), *Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting, February 7-8, 1989, Anchorage, Alaska*. U.S. Dep. Commer. and U.S. Dep. Interior, Outer Continental Shelf Environmental Assessment Program, OCS Study, MMS 89-0041, Anchorage. Available online: http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/research_pdfs/status_belukha_whales_cook_inlet_ch_15_donald_calkins.pdf. Accessed December 2021.
- Castellote, M., R. J. Small, J. Mondragon, J. Jenniges, and J. Skinner. 2015. Seasonal distribution and foraging behavior of Cook Inlet belugas based on acoustic monitoring. ADF&G Final Report to Department of Defense.
- Castellote, M., R. J. Small, M. O. Lammers, J. J. Jenniges, J. Mondragon, and S. Atkinson. 2016a. Dual instrument passive acoustic monitoring of belugas in Cook Inlet, Alaska. *J. Acoust. Soc. Am.* 139:2697. DOI: [dx.doi.org/10.1121/1.4947427](https://doi.org/10.1121/1.4947427).
- Castellote, M., R. J. Small, J. Mondragon, J. Jenniges, and J. Skinner. 2016b. Seasonal distribution and foraging behavior of Cook Inlet belugas based on acoustic monitoring. Alaska Department of Fish and Game, Final Wildlife Research Report, ADF&G/DWS/WRR-2016-3, Juneau, AK.
- Castellote, M., B. Thayre, M. Mahoney, J. Mondragon, M. O. Lammers, and R. J. Small. 2019. Anthropogenic noise and the endangered Cook Inlet beluga whale, *Delphinapterus leucas*: acoustic considerations for management. *Mar. Fish. Rev.* 80(3):63-88. DOI: [dx.doi.org/10.7755/MFR.80.3.3](https://doi.org/10.7755/MFR.80.3.3).
- 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](https://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](https://doi.org/10.1111/mms.12357).
- 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.
- Freed, J. C., N. C. Young, B. J. Delean, V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2021. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2015-2019. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-424, 112 p..

- 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.
- Goetz, K. T., D. J. Rugh, A. J. Read, and R. C. Hobbs. 2007. Summer habitat preferences of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska. Mar. Ecol. Prog. Ser. 330:247-256.
- Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012a. 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.
- Goetz, K. T., R. A. Montgomery, J. M. Ver Hoef, R. C. Hobbs, and D. S. Johnson. 2012b. Identifying essential summer habitat of the endangered beluga whale *Delphinapterus leucas* in Cook Inlet, Alaska. Endang. Species Res. 16:135-147.
- 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(8):1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1.
- 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.
- Hobbs, R. C. 2013. Detecting changes in population trends for Cook Inlet beluga whales (*Delphinapterus leucas*) using alternative schedules for aerial surveys. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-252, 25 p.
- Hobbs, R. C., J. M. Waite, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, group sizes in Cook Inlet, Alaska, based on observer counts and aerial video. Mar. Fish. Rev. 62(3):46-59.
- Hobbs, R. C., K. E. W. Shelden, D. J. Rugh, C. L. Sims, and J. M. Waite. 2015a. Estimated abundance and trend in aerial counts of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, 1994-2012. Mar. Fish. Rev. 77(1):11-31. DOI: dx.doi.org/10.7755/MFR.77.1.2.
- Hobbs, R. C., P. R. Wade, and K. E. W. Shelden. 2015b. Viability of a small, geographically-isolated population of beluga whales, *Delphinapterus leucas*: effects of hunting, predation, and mortality events in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):59-88. DOI: dx.doi.org/10.7755/MFR.77.2.4.
- Kendall, L. S., and L. A. Cornick. 2015. Behavior and distribution of Cook Inlet beluga whales, *Delphinapterus leucas*, before and during pile driving activity. Mar. Fish. Rev. 77(2):106-114. DOI: dx.doi.org/10.7755/MFR.77.2.6.
- Laidre, K. L., K. E. W. Shelden, D. J. Rugh, and B. Mahoney. 2000. Beluga, *Delphinapterus leucas*, distribution and survey effort in the Gulf of Alaska. Mar. Fish. Rev. 62(3):27-36.
- Lammers, M. O., M. Castellote, R. J. Small, S. Atkinson, J. Jenniges, A. Rosinski, J. N. Oswald, and C. Garner. 2013. Passive acoustic monitoring of Cook Inlet beluga whales (*Delphinapterus leucas*). J. Acoust. Soc. Am. 134:2497-2504. DOI: dx.doi.org/10.1121/1.4816575.
- 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., 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., 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.
- Lucey, W., H. E. Abraham, G. O'Corry-Crowe, K. M. Stafford, and M. Castellote. 2015. Traditional knowledge and historical and opportunistic sightings of beluga whales, *Delphinapterus leucas*, in Yakutat Bay, Alaska. Mar. Fish. Rev. 77(1):41-46. DOI: dx.doi.org/10.7755/MFR.77.1.4.
- Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999-2000. Final Report to NMFS Alaska Region. 98 p.
- McGuire, T. L., G. K. Himes Boor, J. R. McClung, A. D. Stephens, C. Garner, K. E. W. Shelden, and B. Wright. 2020a. Distribution and habitat use by endangered Cook Inlet beluga whales: patterns observed during a photo-identification study 2005-2017. Aquatic Conservation: Marine and Freshwater Ecosystems 30(12):2402-2427. DOI: dx.doi.org/10.1002/aqc.3378.

- McGuire, T. L., K. E. W. Shelden, G. K. Himes Boor, A. D. Stephens, J. R. McClung, C. Garner, C. E. C. Goertz, K. A. Burek-Huntington, G. O’Corry-Crowe, and B. Wright. 2020b. Patterns of mortality in endangered Cook Inlet beluga whales: insights from pairing a long-term photo-identification study with stranding records. *Mar. Mammal Sci.* 37(2):492-511. DOI: [dx.doi.org/10.1111/mms.12766](https://doi.org/10.1111/mms.12766).
- McGuire, T. L., A. D. Stephens, J. R. McClung, C. Garner, K. A. Burek-Huntington, C. E. C. Goertz, K. E. W. Shelden, G. O’Corry-Crowe, G. K. Himes Boor, and B. Wright. 2020c. Anthropogenic scarring in long-term photo-identification records of Cook Inlet beluga whales, *Delphinapterus leucas*. *Mar. Fish. Rev.* 82(3-4).
- Moore, S. E., K. E. W. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. *Mar. Fish. Rev.* 62(3):60-80.
- National Marine Fisheries Service (NMFS). 2008. Cook Inlet beluga whale subsistence harvest: Final Supplemental Environmental Impact Statement. U.S. Dep. Commer., NOAA, NMFS, Alaska Region, Office of Protected Resources, Juneau, AK. Available online: <https://repository.library.noaa.gov/view/noaa/4948>. Accessed December 2021.
- National Marine Fisheries Service (NMFS). 2016a. 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 2021.
- National Marine Fisheries Service (NMFS). 2016b. Recovery plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK.
- 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](https://doi.org/10.7755/MFR.77.2.5).
- O’Corry-Crowe, G., W. Lucey, F. I. Archer, and B. Mahoney. 2015. The genetic ecology and population origins of the beluga whales, *Delphinapterus leucas*, of Yakutat Bay. *Mar. Fish. Rev.* 77(1):47-58. DOI: [dx.doi.org/10.7755/MFR.77.1.5](https://doi.org/10.7755/MFR.77.1.5).
- 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. DOI: [dx.doi.org/10.1371/journal.pone.0194201](https://doi.org/10.1371/journal.pone.0194201).
- 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.
- Rugh, D. J., K. E. W. Shelden, and B. Mahoney. 2000. Distribution of beluga whales in Cook Inlet, Alaska, during June/July, 1993 to 1999. *Mar. Fish. Rev.* 62(3):6-21.
- Rugh, D. J., B. A. Mahoney, and B. K. Smith. 2004. Aerial surveys of beluga whales in Cook Inlet, Alaska, between June 2001 and June 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-145, 26 p.
- Rugh, D. J., K. E. W. Shelden, C. L. Sims, B. A. Mahoney, B. K. Smith, L. K. Litzky, and R. C. Hobbs. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-149, 71 p.
- Shelden, K. E. W., and B. A. Mahoney. 2016. Aerial surveys of beluga whales in Cook Inlet, Alaska, June 1991. AFSC Processed Report 2016-02, 22 p. Available online: <https://repository.library.noaa.gov/view/noaa/8690>. Accessed December 2021.
- Shelden, K. E. W., D. J. Rugh, B. A. Mahoney, and M. E. Dahlheim. 2003. Killer whale predation on belugas in Cook Inlet, Alaska: implications for a depleted population. *Mar. Mammal Sci.* 19(3):529-544.
- Shelden, K. E. W., D. J. Rugh, K. T. Goetz, C. L. Sims, L. Vate Brattström, J. A. Mocklin, B. A. Mahoney, B. K. Smith, and R. C. Hobbs. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-263, 122 p.
- 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](https://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.
- Shelden, K. E. W., C. Boyd, C. L. Sims, V. A. Gill, and B. A. Mahoney. 2019. Chapter 1: Field report for the June 2018 Cook Inlet beluga aerial abundance and distribution survey. In K. E. W. Shelden and P. R. Wade (eds.), Aerial surveys, distribution, abundance, and trend of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2018. AFSC Processed Rep. 2019-09, 93 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.
- 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.
- Vos, D. J., and K. E. W. Shelden. 2005. Unusual mortality in the depleted Cook Inlet beluga population. Northwest. Nat. 86(2):59-65.
- Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mammal Sci. 14:1-37. DOI: [dx.doi.org/10.1111/j.1748-7692.1998.tb00688.x](https://doi.org/10.1111/j.1748-7692.1998.tb00688.x).
- Wade, P. R., C. Boyd, K. E. W. Shelden, and C. L. Sims. 2019. Chapter 2: Group size estimates and revised abundance estimates and trend for the Cook Inlet beluga population. In K. E. W. Shelden and P. R. Wade (eds.), Aerial surveys, distribution, abundance, and trend of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2018. AFSC Processed Rep. 2019-09, 93 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.