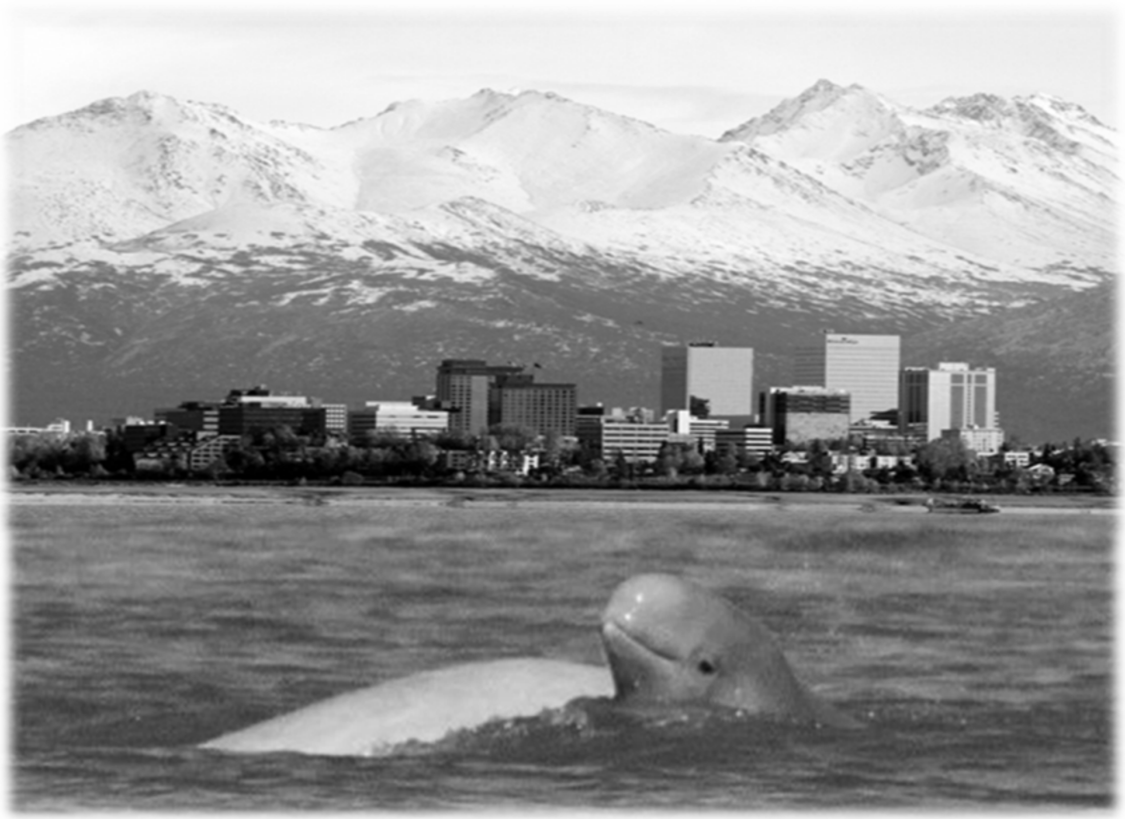
Recovery Plan
for the
Cook Inlet Beluga Whale
(Delphinapterus leucas)



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Recovery Plan

for the

Cook Inlet Beluga Whale

(*Delphinapterus leucas*)

Prepared by:
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Alaska Region
Protected Resources Division

Approved: ______________________
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Date: 12/27/16

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CIBRT Science Panel: Dr. Pierre Béland (St. Lawrence National Institute of Ecotoxicology); Dr. William Bechtol (Bechtol Research); Dr. Manuel Castellote (NMFS Alaska Fisheries Science Center, Marine Mammal Laboratory); Dr. Carrie Goertz (Alaska SeaLife Center); Dr. Daniel Goodman (Montana State University); Dr. Rod Hobbs (NMFS Alaska Fisheries Science Center, Marine Mammal Laboratory); Craig Matkin (North Gulf Oceanic Society); Dr. Tamara McGuire (LGL Alaska Research Associates); Dr. Robert Michaud (Group for Research and Education of Marine Mammals); Dr. Greg O'Corry-Crowe (Harbor Branch Oceanographic Institute); Randy Standifer, Sr. (preceded by the late Peter Merryman) (Cook Inlet Marine Mammal Council); Dr. Robert Suydam (North Slope Borough).

CIBRT Stakeholder Panel: Bruce Anders (Cook Inlet Region, Inc.); Joel Blatchford (Alaska Native Marine Mammal Hunters Committee); Jason Brune (Resource Development Council of Alaska, Inc.); Mayor David Carey (Kenai Peninsula Borough); Karla Dutton (Defenders of Wildlife); Chris Garner (Joint Base Elmendorf Richardson); Willie Goodwin (Alaska Beluga Whale Committee); Page Herring (Northern District Set Netters Association of Cook Inlet); Brett Jokela (Anchorage Water and Wastewater Utility); Nancy Lord (Cook Inletkeeper); Nikki Martin (Alaska Oil and Gas Association); Roland Maw (United Cook Inlet Drift Association); Andrew Niemiec (Knik Arm Bridge and Toll Authority); Eileen Probasco (Matanuska-Susitna Borough); Steve Ribuffo (Port of Anchorage); John Schoen (National Audubon Society); Paul Shadura (Kenai Peninsula Fishermen's Association); George Vakalis (Anchorage Municipality); Doug Vincent-Lang (Alaska Department of Fish and Game).

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Individuals: Marc Bourdon, Kathy Burek-Huntington, Joe Canesi, Dale Funk, Ken Goldman, Richard Gustafson, Glenn Hollowell, Sam Ivey, Jon Kurland, Michael Link, Barb Mahoney, Barry McPherson, Scott Meyer, Mandy Migura, Lucy Moore, Mark Nelson, Steve Okkonen, Ted Otis, Lori Quakenbush, Scott Raborn, Tim Ragen, Randall Reeves, Susan Saupe, Kate Savage, Kim Shelden, Patrick Shields, Bob Small, Brad Smith, Mark Willette, Sheyna Wisdom

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ACMP	Alaska Coastal Management Program
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
AFSC MML	Alaska Fisheries Science Center, Marine Mammal Laboratory (formerly National Marine Mammal Laboratory [NMML])
AKR	Alaska Region
ASM	age at sexual maturity
°C	degrees Celsius
CFR	Code of Federal Regulations
CI beluga	Cook Inlet beluga whale
CIBRT	Cook Inlet Beluga Whale Recovery Team
CIMMC	Cook Inlet Marine Mammal Council
CIRI	Cook Inlet Region, Inc.
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	centimeter
Corps	United States Army Corps of Engineers
CV	coefficient of variation
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
dB	decibel
DPS	distinct population segment
DDT	dichlorodiphenyltrichloroethane, a chlorinated pesticide
DFO	Department of Fisheries and Oceans
EPA	Environmental Protection Agency
ESA	Endangered Species Act
°F	degrees Fahrenheit
FR	Federal Register
ft	feet
FWCA	Fish and Wildlife Coordination Act
GLG	growth layer group
HABs	harmful algal blooms
HCB	hexachlorobenzene
HCH	hexachlorocyclohexane
Hz	hertz
IHA	incidental harassment authorization
IUCN	International Union for the Conservation of Nature and Natural Resources
KABATA	Knik Arm Bridge and Toll Authority

kg	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
km/hr	kilometer per hour
lb	pound
LGL	LGL Alaska Research Associates, Inc.
m	meter
mg	milligram
MHW	mean high water
MMC	Marine Mammal Commission
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
mi	mile
mi^2	square mile
mi/hr	miles per hour
mtDNA	mitochondrial DNA
NGO	non-governmental organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OSP	optimum sustainable population
PAH	polycyclic aromatic hydrocarbon
PFC	perfluorinated compound
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyls
ppt	parts per thousand
PTS	permanent threshold shift
PVA	population viability analysis
SD	standard deviation
SE	standard error
SEDAR	SouthEast Data, Assessment, and Review
SLE	St. Lawrence Estuary
TEK	Traditional Ecological Knowledge
TTS	temporary threshold shift
URS	URS Corporation
µPa	microPascal
USFWS	United States Fish and Wildlife Service

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EXECUTIVE SUMMARY

Current Status

The best available historical abundance estimate of 1,293 Cook Inlet beluga whales (CI belugas, *Delphinapterus leucas*) was obtained from an aerial survey conducted in 1979 (Calkins 1989). The National Marine Fisheries Service (NMFS) has adopted 1,300 as the value for the carrying capacity to be used for management purposes.

NMFS began conducting comprehensive and systematic aerial surveys of CI belugas in 1993. These surveys documented a decline in CI beluga abundance from 653 whales in 1994 to 347 whales in 1998, a decline of nearly 50%. This rapid decline was associated with a substantial, unregulated subsistence hunt.

In 1999, in response to this dramatic decline NMFS received one petition to designate CI belugas as depleted under the Marine Mammal Protection Act (MMPA) and two petitions to list them as endangered under the Endangered Species Act (ESA). In 2000, NMFS designated the CI beluga stock as depleted under the MMPA, but determined that listing CI belugas as threatened or endangered under the ESA was not warranted at that time.

Subsequent cooperative efforts between NMFS and Alaska Native subsistence users dramatically reduced subsistence hunts beginning in 1999. This reduction in hunting should have allowed the CI beluga population to begin increasing at an expected growth rate of between 2% and 6% per year if subsistence harvest was the only factor limiting population growth; however, abundance data collected since 1999 indicated that the population did not increase as expected. This lack of population growth led NMFS to reevaluate the status of CI belugas. In October 2008, NMFS finalized the *Conservation Plan for the Cook Inlet Beluga Whale* (Conservation Plan; NMFS 2008a), as required by the MMPA for any species or stock designated as depleted. The Conservation Plan reviewed and assessed the known and possible threats influencing CI belugas. During that same month NMFS listed the CI beluga whale distinct population segment (DPS[1]) as endangered under the ESA (73 FR 62919, October 22, 2008).

The most recent comprehensive survey for CI belugas from 2014 indicates a point estimate of 340 belugas, with the population continuing to show a negative trend since 1999 (a decline of 1.3% per year; Shelden et al. 2015a).

Threats to Recovery

CI belugas are the most reproductively and demographically isolated of all the Alaskan belugas, and are unique in Alaska given that their habitat, a semi-enclosed tidal estuary in southcentral Alaska, is in close proximity to the greatest concentration of Alaska's human population. Belugas are predominately found in nearshore waters. The distribution of CI belugas

[1] DPS is a vertebrate population or group of populations that is discrete from other populations and significant in relation to the entire taxon (61 FR 4722; February 7, 1996). The ESA defines "species" to include any subspecies and any DPS of vertebrate fish or wildlife that interbreeds when mature (16 U.S.C. § 1532(16)). Throughout this recovery plan, the terms "CI beluga population," "CI beluga whales," and "CI belugas" refer to the CI beluga whale DPS (CI belugas).

has changed significantly since the 1970s, and the summer range has contracted to the upper Inlet in recent years, coincident with the decline in population size.

Ten potential threat types are identified and assessed in this recovery plan, based on current knowledge of threat factors. Assessments were made based on the information and data gaps presented in the plan's Background section. Climate change, while considered a potential threat to CI beluga recovery, is not addressed as a separate threat, but rather is discussed with respect to how it may affect each of the listed threats. The ten identified potential threats and their overall relative concern to the CI beluga population discussed in this plan include:

- Threats of High Relative Concern
  - Catastrophic events (e.g., natural disasters; spills; mass strandings);
  - Cumulative effects of multiple stressors; and
  - Noise.
- Threats of Medium Relative Concern
  - Disease agents (e.g., pathogens, parasites, and harmful algal blooms);
  - Habitat loss or degradation;
  - Reduction in prey; and
  - Unauthorized take.
- Threats of Low Relative Concern
  - Pollution;
  - Predation; and
  - Subsistence hunting.

Recovery Plan

The ESA requires the preparation and implementation of recovery plans for all listed species, unless the Secretary of Commerce determines that doing so does not promote the recovery of the species. In 2010, NMFS began the process of developing a recovery plan for CI belugas by announcing its intent to prepare a recovery plan and soliciting public comments (75 FR 4528, January 28, 2010). In February 2010, NMFS prepared a recovery outline, which, in concert with the Conservation Plan, served as an interim guidance document to direct recovery efforts until a full recovery plan was finalized. In March 2010 NMFS convened a Recovery Team to aid in the development of a draft recovery plan for CI belugas. The Recovery Team was composed of two advisory groups: a Science Panel and a Stakeholder Panel. In March 2013, the Recovery Team provided NMFS with the first draft of the recovery plan. This marked the completion of the team's work; therefore it disbanded and NMFS took responsibility for finalizing the recovery plan. NMFS released a final draft version of the recovery plan for public comment in May 2015 (80 FR 27925, May 15, 2015). During this public comment period, NMFS also obtained peer review of the draft recovery plan from five reviewers. NMFS considered all of the peer review and public comments and information received on the draft recovery plan in developing this final plan.

Recovery Strategy

We know the CI beluga population is not recovering as expected after the regulation of subsistence hunting in 1999, but we do not know why. In light of the CI belugas' recent population decline, small overall population size, life history characteristics, and increasing number of potential threats, it is challenging to identify the most immediate needs for the recovery of CI belugas. Until we know which threats are limiting this species' recovery, the strategy of this recovery plan is to focus recovery efforts on threats identified as of medium or high relative concern. This will focus efforts and resources on actions that are more likely to benefit CI beluga recovery. Therefore, the recovery criteria and recovery actions outlined in the following sections address the threats of medium (disease agents, habitat loss or degradation, reduction in prey, and unauthorized take) or high (catastrophic events, cumulative effects of multiple stressors, and noise) relative concern, and do not discuss in detail the threats of low relative concern. To ensure the recovery plan remains strategic, the status of threats ranked as low relative concern will be reassessed periodically to determine whether the significance of one or more of these threats has elevated to the point that recovery actions need to be defined.

The recovery actions in this recovery plan include research, management, monitoring, and education/outreach efforts, since a comprehensive approach to CI beluga recovery is likely to have greater success than focusing on any one type of action. There are also actions targeted at incorporating new information and conducting regular reassessments, making this recovery plan an adaptive management plan. Threats-based recovery actions attempt to improve our understanding of whether a particular threat is limiting recovery. The plan also includes recommended actions to eliminate or mitigate threats of medium or high relative concern, and to improve our understanding of, and ability to manage those threats. As such, the strategy of this recovery plan is to:

- Continue to monitor the status of the CI beluga population and improve the understanding of CI beluga biology;
- Improve the understanding of the effects of threats of medium or high relative concern on CI belugas;
- Improve the management of threats of medium or high relative concern to reduce or eliminate the effects of those threats on CI belugas;
- Periodically reassess whether the relative concern of each potential threat identified in this plan has changed over time;
- Integrate research findings into current and future management actions; and
- Keep the public informed and educated about the status of CI belugas, the threats limiting their recovery, and how the public can help achieve recovery of these whales.

Recovery Goals

The goal of this recovery plan is to guide efforts that achieve the recovery of CI belugas to a level sufficient to warrant their removal from the federal List of Endangered and Threatened Wildlife and Plants under the ESA (i.e., delist) by meeting the recovery criteria and addressing threats. The intermediate goal is to guide efforts that result in reclassification of CI belugas from endangered to threatened (i.e., downlist). The determinations regarding whether these goals are met include consideration of the population's risk of extinction and threats as identified under the ESA section 4(a)(1) factors. If a species is determined to be *recovered*, then the protections afforded by the ESA no longer apply, although other pertinent federal (e.g., MMPA) and state protections will still apply.

Recovery Objectives

Five factors identified in ESA section 4(a)(1) inform NMFS's decision as to whether a species merits listing as threatened or endangered under the ESA (see Section I.B. History of the Listing Status of CI Belugas). These factors must be considered in listing decisions as well as downlisting and delisting, with objectives related to each factor included as part of the recovery criteria. The following recovery objectives were identified for CI belugas and linked to the five ESA section 4(a)(1) factors:

- Ensure adequate habitat exists to support a recovered population of CI belugas. Habitat needs include sufficient quantity, quality, and accessibility of prey species (*Factor A: the present or threatened destruction, modification, or curtailment of its habitat or range)*;
- Ensure that commercial, recreational, scientific, or educational activities are not inhibiting the recovery of CI belugas (*Factor B: overutilization for commercial, recreational, scientific, or educational purposes*);
- Ensure that the effects of diseases and disease agents on CI beluga reproduction and survival are not limiting the recovery of the CI beluga population (*Factor C: disease or predation*);
- Ensure that regulatory mechanisms other than the ESA are adequate to prevent the recurrence of threats to the sustainability of CI belugas (*Factor D: the inadequacy of existing regulatory mechanisms*); and
- Continue monitoring the population to identify and mitigate any new natural or manmade factors affecting the recovery of CI belugas *(Factor E: other natural or manmade factors affecting its continued existence*).

Recovery Criteria

Under section 4(f)(1) of the ESA, recovery plans must contain objective, measurable criteria which, when met, would result in a determination that the species be delisted. This recovery plan contains both demographic criteria (e.g., population size and trend) and threats-based criteria (i.e., addressing the five ESA section 4(a)(1) factors) which would indicate that downlisting or delisting the species should be considered.

The threats-based recovery criteria are designed to evaluate the five factors described in the ESA listing determination for CI belugas, with objectives related to each factor included as part of the recovery criteria. The downlisting and delisting criteria specified in the recovery plan are organized according to the five factors, then by the threat types ranked as medium or high relative concern.

We note that recovery under the ESA is an iterative process with periodic analyses to provide feedback into the species' listing status and progress toward recovery. The ESA requires a review of the status of each listed species at least once every five years after it is listed. Periodic review of the species may lead to updates or revisions to the recovery plan, changes in the listing status of the species, or delisting. While meeting all of the recovery criteria would indicate that the species should be delisted, it is possible that delisting could occur without meeting all of the recovery criteria if the best available information indicated that the species no longer met the definition of endangered or threatened. Changes to the species' status and delisting would be made through additional rulemaking after considering the same five ESA factors considered in listing decisions, taking new information into account.

Summary of Recovery Criteria for CI Belugas

Status	Demographic Criteria		Threats-Based Criteria
Reclassified from Endangered to Threatened (i.e., downlisted)	The abundance estimate for CI belugas is greater than or equal to 520 individuals, and there is 95% or greater probability that the most recent 25-year population abundance trend (where 25 years represents one full generation) is positive.	**AND**	The 10 downlisting threats-based criteria are satisfied (see Section V.C.1.b. Downlisting Threats-Based Criteria).
Reclassified to Recovered (i.e., delisted)	The abundance estimate for CI belugas is greater than or equal to 780 individuals, and there is 95% or greater probability that the most recent 25-year population abundance trend (where 25 years represents one full generation) is positive.	**AND**	The 10 downlisting and 9 delisting threats-based criteria are satisfied (see Section V.C.1.b. Downlisting Threats-Based Criteria; and Section V.C.2.b. Delisting Threats-Based Criteria).

Recovery Actions

This recovery plan provides a listing of recommended research, management, and education/outreach actions targeted at recovering CI belugas. Overall, these actions are organized in two categories: 1) population monitoring, recovery plan implementation, and education/outreach actions; and 2) threats management actions. The population monitoring, recovery plan implementation, and education/outreach actions are designed to allow for the effective implementation of this recovery plan. Continued monitoring of the CI beluga population is essential to improve our understanding of the whales and as a means to determine if recovery of the CI beluga population is occurring. A multi-faceted education/outreach action is important to keep the public apprised of the status and outcome of the recovery actions. The threats management actions encompass actions aimed at assessing and managing the threats ranked as medium or high relative concern. Each of these threats has three subsets of actions: 1) actions to assess whether that threat is limiting CI beluga recovery; 2) actions that will improve the understanding of, and ability to manage that threat; and 3) actions that eliminate or mitigate that threat.

This recovery plan is a dynamic document that will change over time based on the progress of recovery and the availability of new information. As new information is obtained, additional actions may be identified and incorporated into the plan or some actions which are no longer relevant may be modified or omitted. As is the case for all recovery plans under the ESA, NMFS will review this plan regularly and will assess the relative success of these actions in protecting CI belugas. Recovery actions and criteria may be changed or added accordingly.

Implementation Schedule

The Implementation Schedule includes recovery action numbers, action descriptions, recovery priorities, parties responsible[2] for funding and/or carrying out actions, duration of actions, and estimated costs. Costs are estimated for the fiscal year in thousands of 2016 dollars and are not corrected for inflation. The cost estimates do not imply that appropriate levels of funding will necessarily be available for all CI beluga recovery tasks. The Implementation Schedule (see Section VII) includes annual cost estimates for the first five years of plan implementation, in accordance with the standard five-year cycle of review and update or revision for all recovery plans. Any projections of total costs over the full recovery period are likely to be imprecise. The total cost of achieving recovery will be largely dependent upon how many of the threats management actions need to be implemented. Since that cannot be determined at this time, the total cost presented here assumes that every threat of medium or high relative concern will be found to be limiting recovery and that every action addressing those threats will be implemented. Thus, we expect the total cost estimate presented here is high, and the actual costs will be lower if actions addressing some threats are not implemented because those threats have been determined to not be limiting the recovery of CI belugas. It is expected that recovery may take at least two generations (50 years); therefore, for ongoing actions costs have only been estimated for the next 50 years. If every identified recovery action must be implemented, and if it takes 50 years to recover CI belugas, then the estimated cost of implementing this entire recovery program is approximately $76.8 million (in 2016 dollars).

[2] Responsible parties have no legal or regulatory obligation to carry out any action. Rather, this is an indication of the entity that would most appropriately implement a particular action.

I. INTRODUCTION

A. The Importance of Belugas to Cook Inlet

Cook Inlet belugas (CI belugas; *Delphinapterus leucas)*, which have co-existed with people since the first indigenous hunters and fishermen came to the shores of Cook Inlet, hold an important place in both the regional ecosystem and the lives of those who have depended upon and interacted with them throughout that long, shared history. Alaska's Native people have relied upon CI belugas for food, other materials, cultural continuity, and community cohesion; indeed, there is a significant desire to rebuild a beluga population capable of again supporting subsistence use. For the last fifty years the white whales have held a primary position as remarkable animals people enjoy living near and observing in Cook Inlet. Apart from the belugas found in Canada's St. Lawrence Estuary (SLE), CI belugas are the only other beluga population in the world to live in close proximity to urban centers and to be easily accessed via a road system.

Oral histories collected by Dutton et al. (2012) document both the values that today's Alaskans place on living beside these belugas and the opportunities that were lost as the CI beluga population declined. Visitors to Alaska also enjoy being able to watch belugas in the wild. Stories, artwork, the names of streets and businesses all emphasize these belugas' role within our lives and cultures. In addition to their subsistence, cultural, economic (tourism), and spiritual values, CI belugas play a role as an indicator of environmental health and resilience in a region undergoing considerable natural and human-related change.

This recovery plan represents a significant step in increasing our understanding of the CI beluga population and assisting it to rebuild—not just for its own sake or the sake of the ecosystem, but also for the sake of future human generations.

B. History of the Listing Status of Belugas in Cook Inlet

In response to the dramatic decline in the population size of the CI beluga stock between 1994 and 1998, NMFS initiated a status review of CI belugas on November 19, 1998. In early 1999, NMFS received three petitions: one from Alaska Department of Fish and Game (ADF&G) to designate CI belugas as depleted under the MMPA and two from tribal and non-governmental organizations to list the population as endangered under the ESA. On May 31, 2000, NMFS designated the CI beluga stock as below its optimum sustainable population level (OSP)[3] and, hence, depleted[4] as defined in the MMPA (65 FR 34590). Based on the best scientific data available at the time, NMFS determined that the CI beluga stock qualified as a DPS under the ESA based on genetic distinction from other Alaskan beluga stocks, but NMFS further determined that listing the DPS as endangered or threatened under the ESA was not warranted (65 FR 38778, June 22, 2000).

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[3] Section 3 of the MMPA defines OSP as "the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element" (16 U.S.C 1362(9); see also 50 CFR 216.3).

[4] A species or population is said to be depleted under the MMPA when one of three conditions are met; one of which is when the Secretary of Commerce determines that a species or population stock is below its OSP.

Concerned that the stock had not recovered as expected, on March 24, 2006, NMFS announced its intention to reevaluate the status of the CI beluga under the ESA (71 FR 14836). The 2006 status review (Hobbs et al. 2006) drew several significant conclusions about the status of the CI beluga. First, the review concluded that the reduced summer range into the upper Inlet makes CI belugas far more vulnerable to catastrophic events that have the potential to kill or injure a significant portion of the population. Second, the population did not grow as anticipated after imposition of subsistence harvest reductions and regulations beginning in 1999 (which precluded any harvest in most years), but had continued to decline 4.1% per year from 1999 through 2006. Third, should this discrete population not survive, it was deemed highly unlikely that other belugas would repopulate Cook Inlet. Based on models that incorporated the latest data available at the time, the 2006 status review predicted a 68% probability that belugas in Cook Inlet would continue to decline and become extinct within the next 300 years (with a 26% probability of extinction within the next 100 years), unless factors that determine beluga whale growth and survival were altered to improve the stock's chances to recover (Hobbs et al. 2006).

Based on the findings of the 2006 status review and based on consideration of factors that may affect this species, on April 20, 2007, NMFS published a proposed rule to list the CI beluga whale DPS as an endangered species under the ESA (72 FR 19854). Subsequently, in April 2008 NMFS completed an updated status review (Hobbs et al. 2008) that supported the conclusions set forth in the 2006 report. The April 2008 status review report documented higher probabilities of extinction than those presented in 2006; the 2008 modeling showed a 79% probability of extinction within 300 years and a 39% probability of extinction within 100 years. On April 22, 2008, NMFS announced a 6-month extension of the deadline for issuing the final ESA listing determination until October 20, 2008, (73 FR 21578) to allow for consideration of the 2008 abundance estimate. In October 2008, NMFS published a supplemental status review (Hobbs and Shelden 2008) which updated the April 2008 review by considering the 2008 CI beluga population abundance estimate. The general conclusions of the October 2008 supplemental status review were similar to the 2006 and 2008 status reviews; but the inclusion of the 2008 abundance estimate resulted in a 26% probability of extinction in 100 years and a 70% probability of extinction within 300 years.

On October 22, 2008 NMFS issued the final determination to list the CI beluga whale DPS as endangered under the ESA (73 FR 62919). This final listing rule included the following statements regarding the ESA section 4(a)(1) factors:

A. ***The present or threatened destruction, modification, or curtailment of its habitat or range:***

"Concern is warranted about the continued development within and along upper Cook Inlet and the cumulative effects on important beluga whale habitat. Ongoing activities that may impact this habitat include: (1) continued oil and gas exploration, development, and production; and (2) industrial activities that discharge or accidentally spill pollutants (e.g., petroleum, seafood processing waste, ship ballast discharge, effluent from municipal wastewater treatment systems, and runoff from urban, mining, and agricultural areas). Destruction and modification of habitat may result in 'effective mortalities' by reducing carrying capacity or fitness of individual whales, with the same consequence to the population survival as direct mortalities. Therefore, threatened destruction and modification of CI beluga whale DPS habitat contributes to its endangered status." (73 FR 62927)

B. Overutilization for commercial, recreational, scientific, or educational purposes:

"A brief commercial whaling operation existed along the west side of upper Cook Inlet during the 1920s, where 151 belugas were harvested in five years (Mahoney and Sheldon, 2000). There was also a sport (recreational) harvest for beluga whales in Cook Inlet prior to enactment of the Marine Mammal Protection Act (MMPA) in 1972. It is possible that some residual effects for this harvest may remain and may be a factor in the present status of this stock.

Alaska Natives have legally harvested CI beluga whales prior to and after passage of the MMPA in 1972. The effect of past harvest practices on the CI beluga whale is significant. While subsistence harvest occurred at unknown levels for decades, the observed decline from 1994 through 1998 and the reported harvest (including estimates of whales which were struck but lost, and assumed to have perished) indicated these harvest levels were unsustainable. Annual subsistence take by Alaska Natives during 1995 to 1998 averaged 77 whales (Angliss and Lodge 2002). The harvest was as high as 20% of the population in 1996. Subsistence removals reported during the 1990s are sufficient to account for the declines observed in this population and must be considered as a factor in the proposed classification of the CI beluga whale DPS as endangered." (73 FR 62927)

C. Disease or predation:

"Killer whales are thought to take at least one CI beluga per year (Shelden et al., 2003). The loss of more than one beluga whale annually could impede recovery, particularly if total mortality due to predation were close to the recruitment level in the DPS." (73 FR 62927)

D. The inadequacy of existing regulatory mechanisms:

"Cook Inlet beluga whales are hunted by Alaskan Natives for subsistence needs. The absence of legal authority to control subsistence harvest prior to 1999 is considered a contributing factor to the CI beluga whale DPS's decline. NMFS promulgated regulations on the long-term subsistence harvest of CI beluga whales on October 15, 2008 (73 FR 60976). These regulations constitute an effective conservation plan regarding Alaska Native subsistence harvest, but they are not comprehensive in addressing the many other issues now confronting CI beluga whales. At present, regulations cover the short-term subsistence harvest." (73 FR 62928)

E. Other natural or manmade factors affecting its continued existence:

"Cook Inlet beluga whales are known to strand along mudflats in upper Cook Inlet, both individually and in number. The cause for this is uncertain, but may have to do with the extreme tidal fluctuations, predator avoidance, or pursuit of prey, among other possible causes. We have recorded stranding events of more than 200 CI beluga whales. Mortality during stranding is not uncommon. We consider stranding to be a major factor establishing this DPS as endangered." (73 FR 62928)

The MMPA requires the Secretary of Commerce to prepare a Conservation Plan for any species or stock designated as depleted under the MMPA and for which NMFS has management responsibility. In October 2008, NMFS finalized the *Conservation Plan for the Cook Inlet Beluga Whale* (NMFS 2008a), which reviewed and assessed the known and possible threats to CI belugas. The Conservation Plan listed natural threats (including stranding events, predation, parasitism, disease, and environmental change) and potential human-caused threats (including subsistence harvest, poaching, fishing, pollution, vessel traffic, tourism and whale watching, coastal development, noise, oil and gas activities, and scientific research). In addition to identifying and assessing threats, the Conservation Plan also defined strategies for restoring the CI belugas to OSP and identified specific conservation actions to aid in that effort. The goal of the Conservation Plan is to conserve and restore the CI beluga whale population to its minimum OSP of 780 whales. NMFS has been working with its partners to implement conservation actions identified in the Conservation Plan, and has continued to use that document as a guide for conserving CI belugas. The Conservation Plan remains in effect, insofar as it covers efforts to rebuild the CI beluga stock to the point that it is no longer considered depleted under the MMPA (which in some cases may not be synonymous with no longer being listed under the ESA).

Appendices IX.A and IX.B provide more information regarding federal actions, regulations, and existing protective measures and conservation efforts pertaining to CI belugas. Existing conservation efforts have not been sufficient for CI belugas since the population has continued to decline.

C. Designation of Critical Habitat for CI Belugas

On April 11, 2011, NMFS published a final rule designating two areas (minus an exclusion zone) of Cook Inlet as critical habitat for the CI beluga (76 FR 20180; 50 CFR part 226.220). These two areas encompass 7,800 square kilometers (km^2) (3,013 square miles [mi^2]) of marine habitat (Figure 1).

In designating critical habitat, NMFS evaluated physical and biological features essential to the conservation of the species and which may require special management considerations or protection. Under NMFS regulations, these features may include: 1) space for individual and population growth, and for normal behavior; 2) food, water, air, light, minerals, or other nutritional or physiological requirements; 3) cover or shelter; 4) sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally 5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of the species. Based on the best scientific data available of the ecology and natural history of CI belugas and their conservation needs, NMFS determined the following physical or biological features are essential to the conservation of this species:

1. Intertidal and subtidal waters of Cook Inlet with depths less than 30 feet mean lower low water (9.1 m) and within 5 mi (8 km) of high and medium flow anadromous fish streams.
2. Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.
3. Waters free of toxins or other agents of a type and amount harmful to CI beluga whales.
4. Unrestricted passage within or between the critical habitat areas.
5. Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by CI beluga whales.

The critical habitat areas are bounded on the upland by the Mean High Water (MHW) line, except for the lower reaches of specific tributary rivers. Critical habitat does not extend into the tidally influenced channels of tributary waters of Cook Inlet, with the exceptions noted in the descriptions of each critical habitat area.

D. Recovery and Recovery Plans

Section 4(f) of the ESA requires the preparation and implementation of recovery plans for all listed species with certain exceptions. Under the ESA, each recovery plan must contain at a minimum:

- A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
- Objective, measurable criteria that, when met, would result in a determination that the species be removed from the list; and
- Estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and achieve intermediate steps toward that goal.

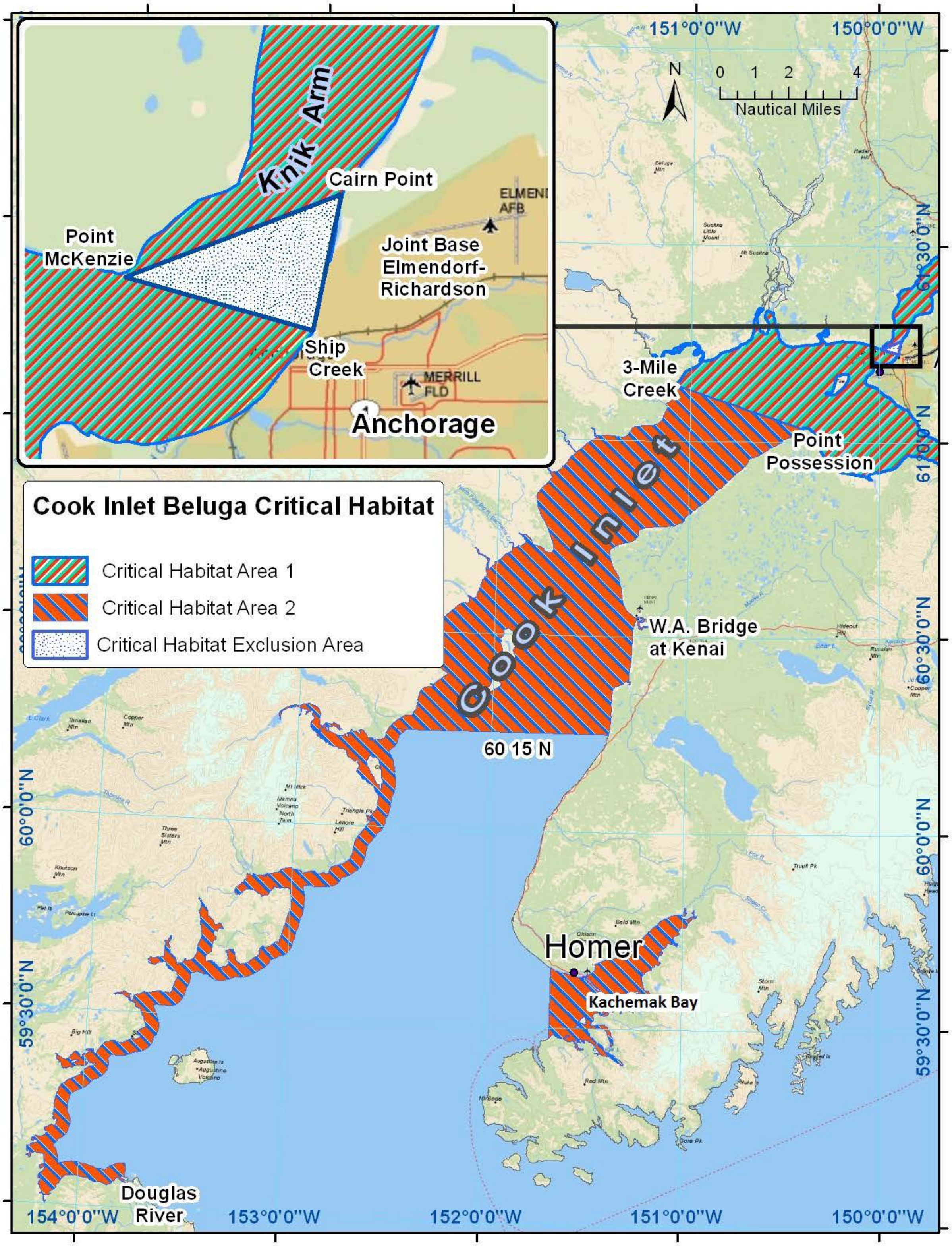
In addition, the *Interim Endangered and Threatened Species Recovery Planning Guidance* developed by NMFS (NMFS 2010) stipulates that recovery plans must include a concise summary of the current status of the species and its life history, and an assessment of the factors that led to the population decline and/or which are impeding recovery. It is also important that the plan includes a comprehensive monitoring and evaluation program for NMFS to gauge effectiveness of recovery measures and overall progress toward recovery. The overall goal of a recovery plan is to guide efforts that achieve recovery of the species such that it may be removed from the List of Endangered and Threatened Wildlife (50 CFR 17.11).

While similar in content, recovery plans under the ESA and conservation plans under the MMPA do not necessarily have the same end goal. As discussed later, the goal of recovery plans is to aid in species' recovery such that ESA protection is no longer needed. The goal of MMPA conservation plans is to aid in the status of depleted population being upgraded so they are no longer considered "depleted."

E. The Recovery Plan for CI Belugas

It is challenging to identify the most immediate needs for recovery of CI belugas because little is known about the effects of potential threats to recovery of this population. The documented decline of the CI beluga population during the mid-1990s has been attributed to subsistence harvest removals at a level that this small population could not sustain (65 FR 34590, May 31, 2000; NMFS 2008a, 2008b). NMFS and subsistence users dramatically reduced subsistence takes; such a reduction should have allowed the CI beluga population to rebound if subsistence harvest was the only factor preventing population growth. However, abundance data collected since 1999 indicate that the population is not increasing as expected. It is unknown what specific factor(s) continue to limit growth and recovery of this population. It may be that the cumulative impacts of several threats are impeding recovery to a greater extent than the sum of the individual impacts of those threats.

This plan addresses each of the potential threats based on our current knowledge. In addition to examining threats, this plan provides background information on CI beluga life history, status, and existing protective measures. Furthermore, this plan identifies a strategy, goals, criteria, and actions targeted at recovering the species. Priorities and estimated costs for the recovery actions are provided in an implementation schedule.



Source: NMFS Alaska Region Cook Inlet Beluga Whale Critical Habitat webpage at: http://www.alaskafisheries.noaa.gov/pr/cib-critical-habitat.

Figure 1. CI beluga critical habitat (76 FR 20180, April 11, 2011).

The recovery actions recommended in this plan are based on the best available science at the time the plan was written. Research and monitoring are key components of the plan and will make an adaptive management approach possible. Recovery of CI belugas will require a long-term cooperative effort that will evolve as more is learned from research and monitoring. Continued monitoring of the status of the population will assist in evaluating the effectiveness of management actions. Research will help refine recovery actions and identify new actions to fill data gaps about the threats. An adaptive management approach will also provide information to adjust priorities as recovery progresses, and will allow the plan to be periodically modified and updated.

The process NMFS used to develop a recovery plan for CI belugas is discussed in Appendix IX.C.

F. Section Summary: Introduction

ESA Listing Status

In response to a decline in the CI beluga population between 1994 and 1998, NMFS was petitioned to designate CI belugas as depleted under the MMPA and/or as endangered under the ESA. In 2000, NMFS designated CI belugas as depleted under the MMPA, but determined that listing CI belugas as endangered or threatened under the ESA was not warranted at that time. NMFS later reevaluated the status of CI belugas and, in 2008, listed the CI beluga whale distinct population segment (DPS) as endangered under the ESA. Throughout the recovery plan, the term “CI beluga population,” “CI belugas,” and “CI beluga whales” refer to the CI beluga whale DPS.

In listing the CI beluga whale DPS as endangered, NMFS referenced the five factors set forth in section 4(a)(1) of the ESA: 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting its continued existence.

The ESA listing of CI belugas as endangered led to the 2011 designation of their critical habitat. The ESA requires all federal agencies to consult with NMFS regarding any action they authorize, fund, or carry out to ensure that the action does not jeopardize the continued existence of the species or result in the destruction or adverse modification of designated critical habitat.

Recovery Plan for CI Belugas

This *Recovery Plan for the Cook Inlet Beluga Whale* begins with background information on CI beluga life history, population size and trends, and known sources of mortality or injury. It then discusses the current threats to the population’s recovery, and presents the recovery strategy, goals, and criteria. It concludes with the recovery program, which includes recovery actions and an implementation schedule containing priorities and estimated costs for the actions.

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II. BACKGROUND

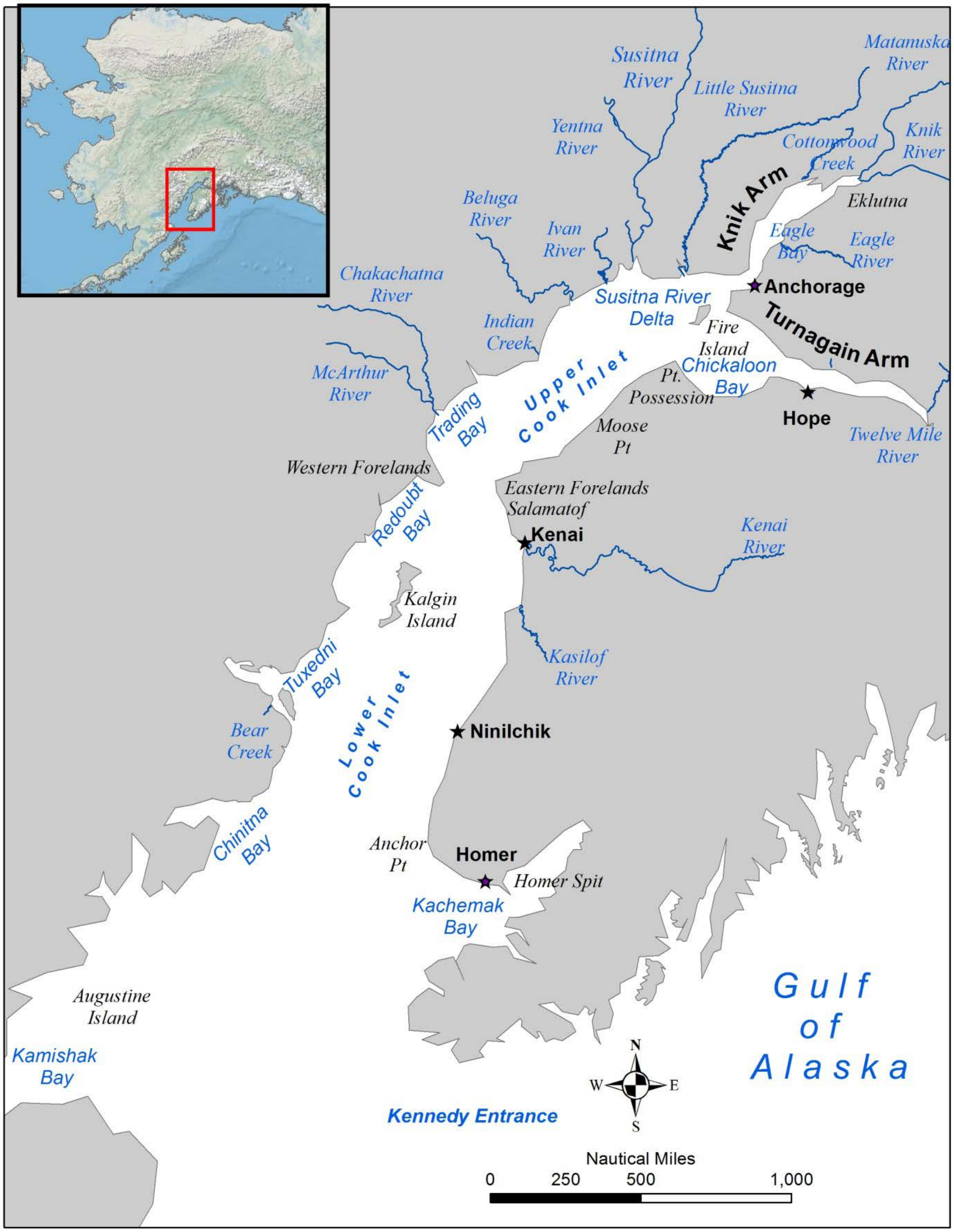
A. Physical Habitat of Cook Inlet

Cook Inlet is a semi-enclosed tidal estuary located in southcentral Alaska (Figure 2). The Inlet is approximately 370 kilometers (km) (230 miles [mi]) in length and extends in a northeast/southwest orientation from Knik and Turnagain Arms in the north to the southernmost reaches of Kamishak Bay in the south (Figure 2). Cook Inlet covers 20,000 km^2 (12,427 mi^2) and has 1,350 km (839 mi) of coastline (Rugh et al. 2000). The Cook Inlet watershed includes approximately 98,000 km^2 (60,894 mi^2). The Susitna River occupies the largest drainage basin (50,800 km^2, 31,566 mi^2), followed by the Matanuska (5,670 km^2, 3,523mi^2), Knik, Chakachatna, and Kenai rivers (each exceeding 2,500 km^2, 1,553 mi^2).

The bathymetry of Cook Inlet is varied and consists of shoals, canyons, and mudflats (Figure 3). Cook Inlet is generally shallow, with most waters less than 73 meters (m) (240 feet [ft]) deep. However deeper waters exist along the channels and at the entrance to the Inlet near the Barren Islands, where depths range from 183–366 m (600–1200 ft; Mulherin et al. 2001). During low tides, large areas along the shoreline are exposed as mudflats in Knik Arm, Turnagain Arm, Chickaloon Bay, Redoubt Bay, Trading Bay, Kachemak Bay, and the Susitna River Delta. In other areas of Cook Inlet, bottom sediments consist of cobbles, pebbles, sand, and clay, with occasional patches of boulders or coal seams. Areas with stronger currents associated with constrictions in Cook Inlet’s width tend to have coarser bottom sediments.

The physical oceanography of Cook Inlet is characterized by a net inflow along the eastern boundary and a net outflow along the western boundary (Burbank 1977). A major inflow is the Alaska Coastal Current, a current driven by wind and water densities that flows along the southern coast of Alaska and passes through Kennedy Entrance (Figure 4). Upon entering lower Cook Inlet, the Alaska Coastal Current turns west just north of Anchor Point, mixing with western boundary outflow (Burbank 1977, Muench et al. 1978). A significant component of the water along the western boundary originates from Turnagain and Knik Arms, the Susitna River, and numerous other glacial streams. In the lower Inlet, this outflow is typically more turbid than the water further east due to the heavy glacial runoff from these drainages (Figure 3). These sources deposit considerable sediment into Cook Inlet, creating a highly turbid, low visibility environment, particularly in the northern portion of the Inlet. Seasonal stream discharges and sediment transports typically peak in July to August. In the upper Inlet, summer surface temperatures are about 10 degrees Celsius (^{o}C) (50 degrees Fahrenheit [^{o}F]) with salinities less than 20 parts per thousand (ppt). During summer in the lower Inlet, a relatively warm (10^{o}C, 50^{o}F), low salinity (less than 29 ppt), surface layer forms along the west side and a cooler (9^{o}C, 48^{o}F), higher salinity (greater than 30 ppt) layer forms along the east side.

Cook Inlet experiences some of the greatest tidal fluctuations in the world (Mulherin et al. 2001). The difference between high and low tide levels may reach 12 m (39 ft). These large tidal ranges, combined with broad tidal flats, can result in currents reaching 6.2 meters per second (20.3 feet per second), sometimes causing significant changes to shorelines (Moore et al. 2000). Three distinct convergence zones, known as tide rips, have been identified in the Inlet (Figure 4). The east rip is typically located 2–3 km (1.2–1.9 mi.) offshore of the eastern shore. The west and mid-channel rips are located just east of Kalgin Island, and are associated with a 50–80 m (164–262 ft) deep channel running north to south (Figure 4).

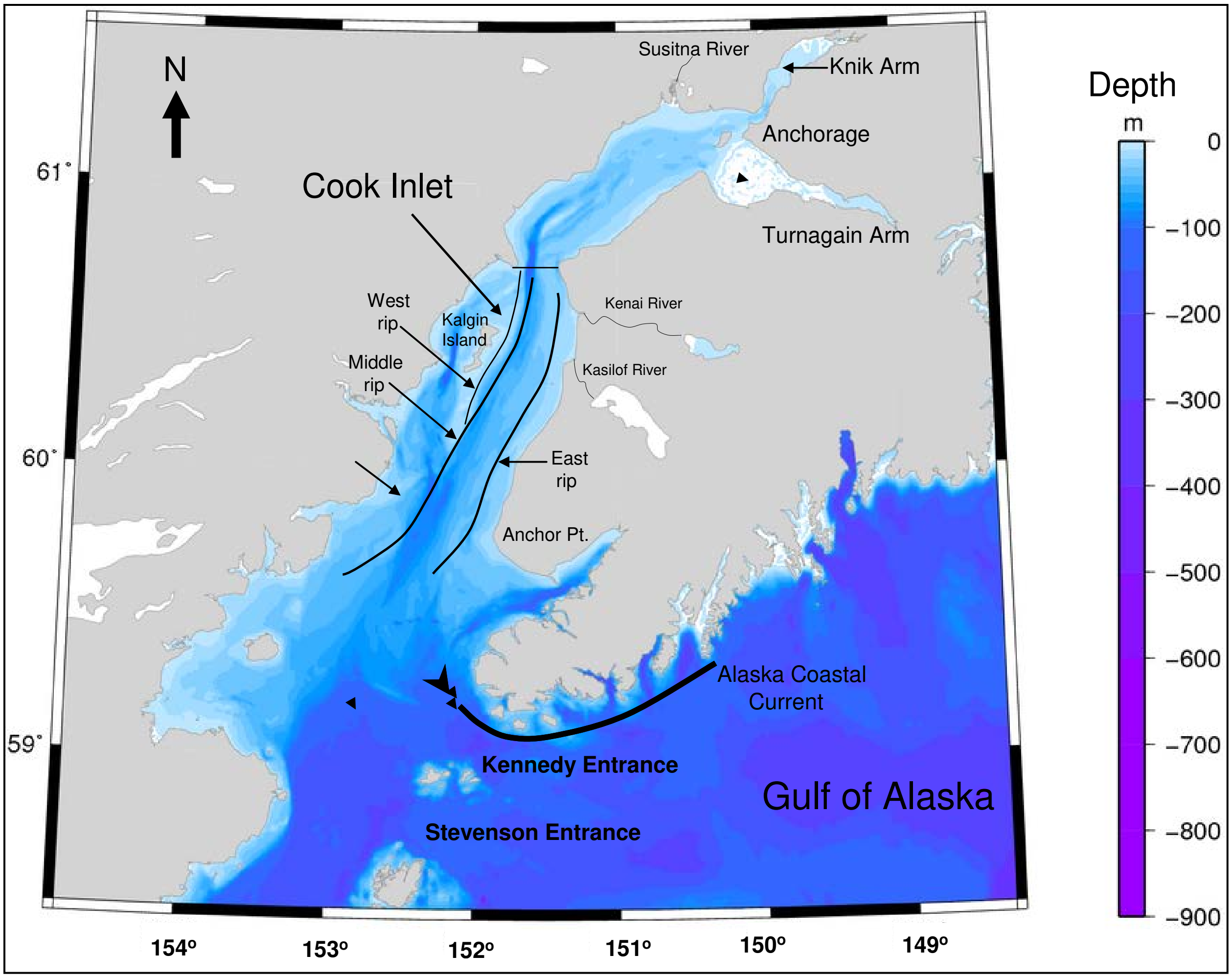


Source: Map created by NMFS 2013.

Figure 2. Major streams and rivers flowing into Cook Inlet.

Source: MODIS true color image, acquired 2 September 2002; Okkonen 2005.

Figure 3. Glacial input into Cook Inlet.



Source: Burbank 1977.

Figure 4. Cook Inlet bathymetry and locations of major tide rips.

In winter, ice covers much of upper Cook Inlet. Rivers begin to freeze in October and November and waters of upper Cook Inlet contain persistent ice by December. Large amounts of freshwater entering Knik and Turnagain Arms contribute to relatively high ice concentrations in the upper Inlet. South of the Forelands, small floes of open pack ice are typical. Maximum ice extent is typically reached in late January. Inlet circulation and winter winds tend to move the ice south down the west side of the Inlet. Ice breakup in the Inlet typically begins between March and May.

The physical environment of Cook Inlet is shifting towards increasingly long ice-free seasons as Alaska undergoes climate change. Alaska has experienced the greatest warming of any region in the United States (U.S.) (Karl et al. 2009) and Cook Inlet's reduction in duration of seasonal sea ice is consistent with other portions of the state. Alaska's regional warming is part of a larger Arctic-wide warming trend (ACIA 2004; IPCC 2013) that is projected to increase over time.

B. Natural History of CI Belugas

1. Physical Description of Belugas

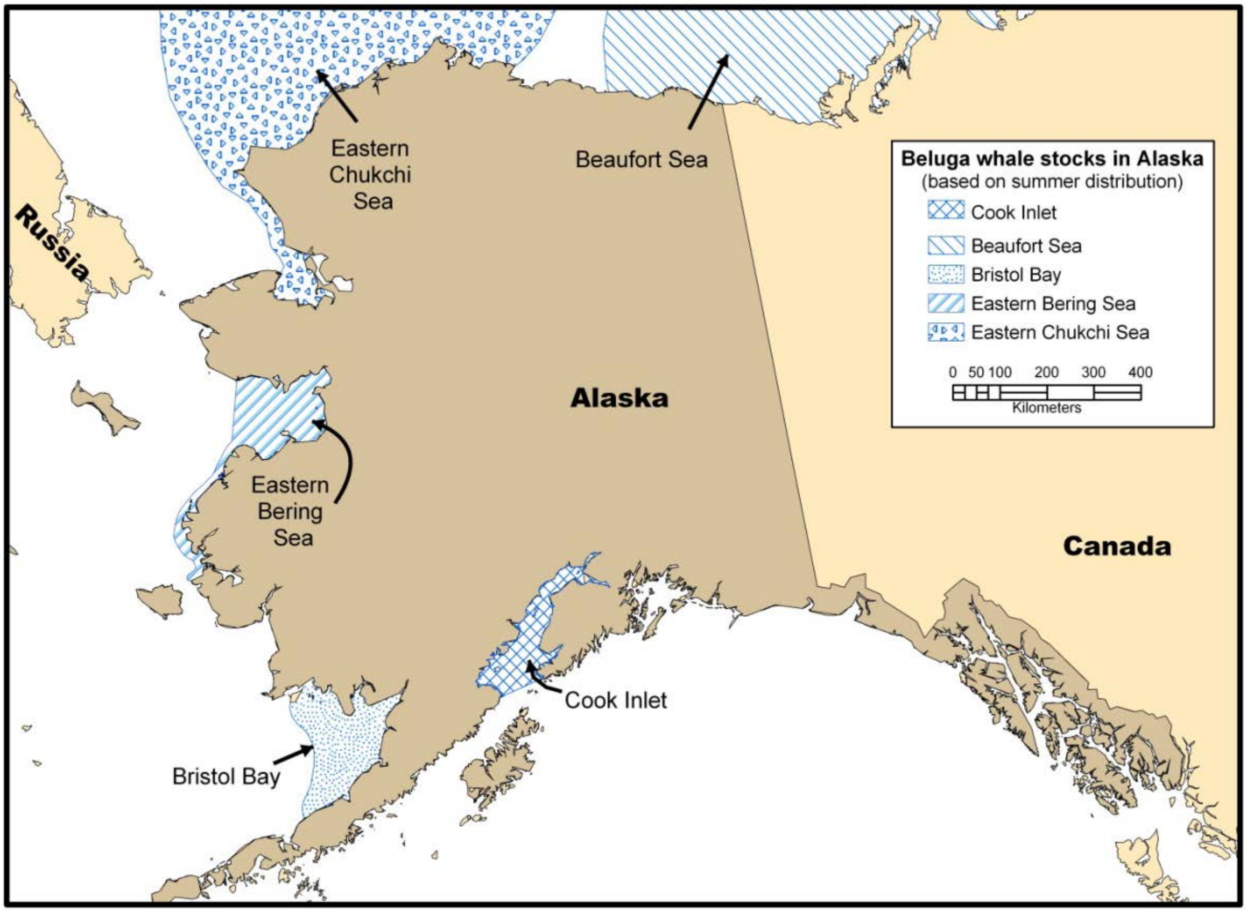
The beluga (*Delphinapterus leucas*), or “white whale,” is a small odontocete (toothed-whale). Known for the striking white coloration of the adults, the word “beluga” is derived from the Russian word for white, and the specific name *leucas* is the Latin word for white. The Latin “*apterus*” refers to the lack of a dorsal fin, another prominent characteristic. Belugas have a stocky body, flexible neck, small rounded head, short beak, and conical teeth. The flippers are relatively small but broad and spatulate with edges that tend to curl with age. Their flukes are broad and notched with convex trailing edges. Physical characteristics that distinguish belugas from most other cetaceans include unfused cervical vertebrae accompanied by increased head mobility, a very bulbous flexible melon in the forehead region, the lack of a dorsal fin, and presence of a tough dorsal ridge. Belugas are relatively slow swimmers that often roll slowly at the surface, and their blow is often inconspicuous.

Calves are born dark gray to brownish gray and become lighter colored with age. Adults may become white to yellow-white at sexual maturity, although Burns and Seaman (1986) report females may retain some gray coloration for as long as 42 years (assuming one dentinal layer per year). McGuire et al. (2008) reported several photo-identified mothers that were still gray when they had calves, suggesting that coloration is not a definitive indicator of maturity. Beluga researchers commented that the gray belugas they observed in Cook Inlet (during August 2016) appeared larger than the gray belugas found in the St. Lawrence Estuary (R. Michaud, GREMM, pers. comm. to Mandy Migura, NMFS).

Belugas are sexually dimorphic, with length averaging 355 centimeters (cm) (11.6 ft) in adult females and 415 cm (13.6 ft) in adult males (Burns and Seaman 1986). Males weigh up to 1,500 kg (3,307 pounds [lb]) and females 1,360 kg (2,998 lb) (Nowak 1991). Beluga calves in Alaska have been reported to average 150 cm (4.9 ft) in length and 72 kg (159 lb) at birth (Burns and Seaman 1986

2. Taxonomy, Geographic and Genetic Variation

The beluga is a member of the Monodontidae, the taxonomic family it shares with the narwhal. The earliest fossil record of the Monodontids is an extinct beluga (*Denebola brachycephala*) from late Miocene deposits in Baja California, Mexico, indicating that this family once occupied temperate ecozones (Barnes 1984). Fossils of belugas found in Pleistocene clays in northeastern North America reflect successive range expansions and contractions of this species associated with glacial maxima and minima. The beluga is a northern hemisphere species, ranging primarily over the Arctic Ocean and some adjoining seas and inhabiting fjords, estuaries, and shallow waters in Arctic and subarctic oceans, except for a small population in the Gulf of St. Lawrence, Canada. Some belugas seek out shallow coastal waters in summer and remain near the ice edge in winter. In Alaska, there are five recognized beluga stocks (Figure 5) delineated based on summer range: the Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet stocks (Allen and Angliss 2012). Murray and Fay (1979) suggested the CI beluga stock has been isolated from the other stocks for several thousand years. The lack of CI beluga observations along the southern side of the Alaska Peninsula (Laidre et al. 2000) and genetic data (O’Corry-Crowe et al. 1997, 2002, 2010) have corroborated Murray and Fay’s (1979) suggestion of distinction from the other stocks.



Source: NMFS 2008a.

Figure 5. Map of summer distributions of the beluga stocks in Alaska.

Sightings of belugas in the Gulf of Alaska are rare outside of Cook Inlet (Laidre et al. 2000). The degree of genetic differentiation between the Cook Inlet stock and the other four Alaska beluga stocks indicates the Cook Inlet stock is the most isolated (O'Corry-Crowe et al. 1997, 2002, 2010). This suggests that the Alaska Peninsula has long been an effective physical barrier to genetic exchange and that migration of whales into Cook Inlet from other stocks is unlikely.

The exception to the rarity of belugas in the Gulf of Alaska outside of Cook Inlet may be a very small group of belugas that appear to reside year-round in Yakutat Bay (Fiscus et al. 1976; Consiglieri and Braham 1982; Hansen and Hubbard 1999; O'Corry-Crowe et al. 2006). Genetic samples collected from whales in Yakutat Bay are more closely related to each other than they are to whales sampled in other areas of Alaska (O'Corry-Crowe et al. 2006), and are unlikely to represent whales traveling from the Cook Inlet population. Since there is no evidence of interaction between CI belugas and belugas found in other areas of the Gulf of Alaska, including the Yakutat Bay area, this recovery plan focuses only on the belugas inhabiting Cook Inlet.

3. Beluga Distribution in Cook Inlet

Data on distribution and habitat use comes primarily from two main sources: aerial surveys (Hansen and Hubbard 1999; Speckman and Piatt 2000; Rugh et al. 2010; Shelden et al. 2015b) and satellite transmitter tagging studies during August through March (Hobbs et al. 2005).

Additional information is provided by traditional ecological knowledge (TEK) of Alaska Natives (e.g., Huntington 2000; Braun and Huntington 2011; Carter and Neilsen 2011), boat and land-based observations (e.g., McGuire and Bourdon 2012; Brueggeman et al. 2013), passive acoustic monitoring studies (e.g., Small 2011), opportunistic reports (e.g., Rugh et al. 2000; Vate-Bratstrom et al. 2010; Shelden et al. 2015b; NMFS, unpub. data), NMFS stranding records (e.g., Vos and Shelden 2005; NMFS, unpub. data), and data from a citizen science CI beluga sighting project (Švarný Carlson et al. 2015).

Localized information on distribution and habitat use of specific areas of Cook Inlet is available from studies conducted in conjunction with the development activities, universities, or other entities. Some of the available data sources are associated with: the Port of Anchorage Expansion Project; Ocean Renewable Power Company's Fire Island Tidal Project; Pac-Rim Coal's Chuitna Coal Project; Cook Inlet Region Inc.'s Fire Island Wind Project; the Alaska Department of Transportation's Seward Highway Expansion Project; the Port MacKenzie Expansion Project; the Knik Arm Bridge and Toll Authority's (KABATA) Knik Arm Crossing; the Alaska Communication System's Fiber Optic Cable Project; seismic programs for Apache Alaska, ConocoPhillips Alaska, and Furie/Escopeta Oil; Joint Base Elmendorf Richardson's CI beluga studies program; and LGL's CI beluga Photo-Identification Project. Many of these projects' reports may be found on the NMFS AKR website at: http://www.alaskafisheries.noaa.gov/pr/ci-belugas.

a. Distribution Patterns: 1970s, 1990s, and 2000s

The distribution of CI belugas has changed significantly since the 1970s, when aerial surveys for belugas in Cook Inlet were first conducted. ADF&G conducted aerial surveys of Cook Inlet in June and July in the late 1970s. These surveys were limited in scope and involved a single sample of a portion of Cook Inlet. While many of the early reports lacked sufficient descriptions of how and where the surveys occurred, good documentation is available for aerial surveys conducted on 18 June 1978 and 18–22 June 1979 (ADF&G, unpub. data). Beginning in 1993 NMFS started conducting comprehensive surveys annually (with the exception of 2013 when surveys were switched to a biennial schedule) during a 1- to 2-week period each year, with 3–7 repetitions of coastal flights around the upper Inlet plus 1–2 days dedicated to a survey of the lower Inlet (Rugh et al. 2000, 2005a,b; Hobbs et al. 2015a; Alaska Fisheries Science Center, Marine Mammal Laboratory [AFSC MML], unpub. data).[5]

Rugh et al. (2010) used three time periods to examine changes in historical distribution patterns of CI belugas: late 1978 to 1979 (when well-documented data are available; Figure 6); 1993 to 1997 (during a decline in abundance; Figure 7); and 1998 to 2008 (when hunting was regulated and recovery was anticipated; Figure 8). This analysis of aerial survey data showed that the extent of the late spring/early summer distribution (June/July) of CI belugas has changed considerably since the late 1970s. The whales were distributed over a relatively large area in 1978 and 1979, with the central location of the summer range occurring between the McArthur and Beluga rivers (Figure 6). The area of highest concentration included the region from Drift River to the Susitna Delta. The TEK also indicated that CI belugas had long been observed in the

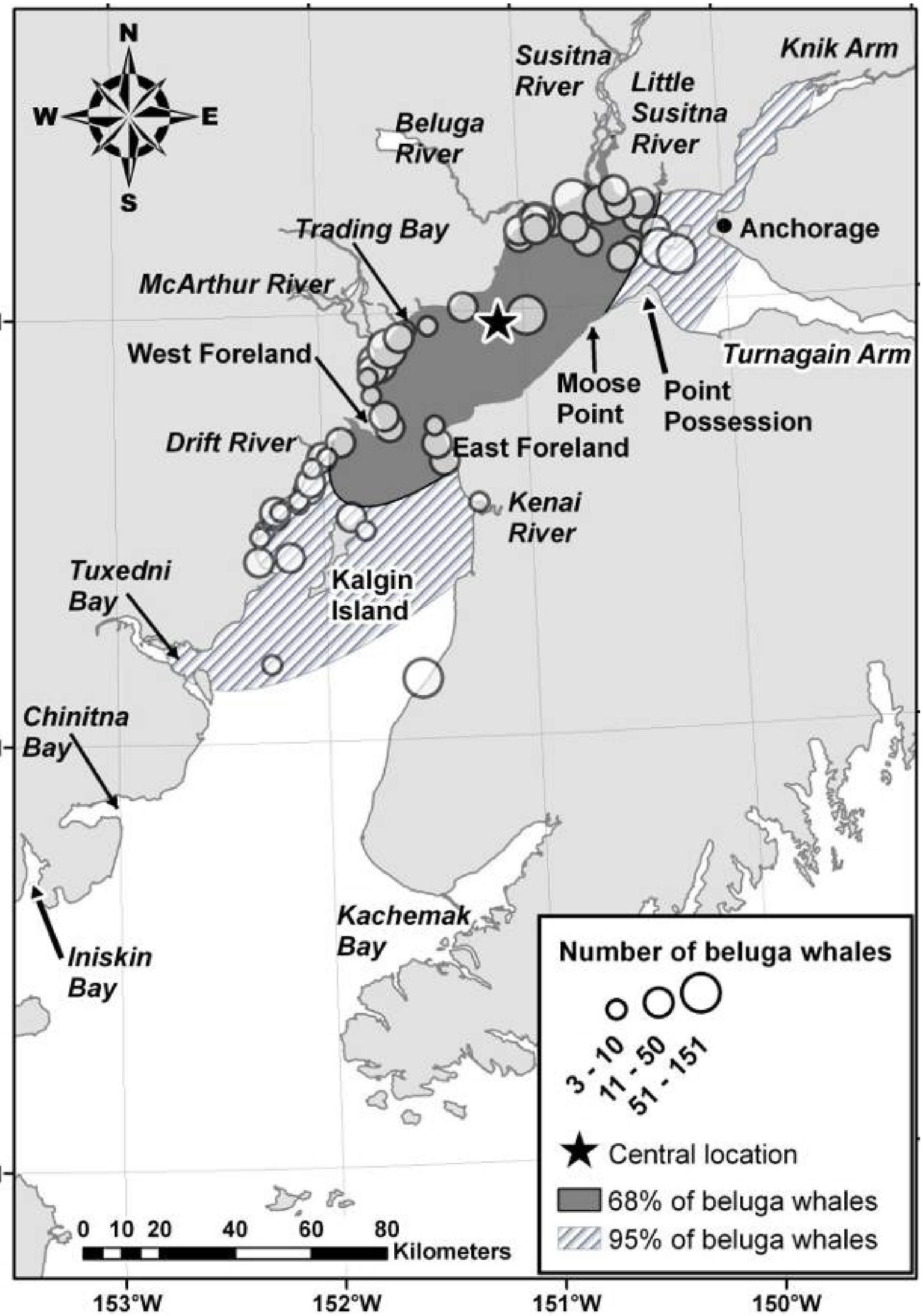
[5] For more information, contact the NMFS AFSC MML, Cetacean Assessment and Ecology Program.

lower Inlet, including Kachemak Bay on the eastern side and Tuxedni and Trading Bays on the western side, although rarely in large numbers (Huntington 2000; Braund and Huntington 2011). From 1993 to 1997, the central location of the summer range shifted northeast to the mouth of the Susitna River and the area of highest concentration contracted to a region north of Moose Point (Figure 7). From 1998 to 2008, the central location of the summer range shifted east, then occurring between the Little Susitna River and Fire Island (Figure 8); the area of highest concentration included Knik Arm and Chickaloon Bay (between Point Possession and Turnagain Arm). Changes in distribution over the three time periods were significant. These include the northeast contraction of the summer range of belugas into upper Cook Inlet from the 1970s to the 1990s and into the 2000s, as well as a longitudinal shift east toward Anchorage between 1993 and 2008. Core summer distribution was estimated to have contracted from over 7,000 km^2 (2,703 mi^2) in 1978 to 1979, to 2,800 km^2 (1,081 mi^2) in 1998 to 2008 (Rugh et al. 2010). Subsequent to this analysis, Shelden et al. (2015b) compared the core summer distributions reported for the three time periods examined by Rugh et al. (2010) (Figures 6, 7, 8) with the core summer distribution of CI belugas observed in 2009 to 2014 (Figure 9). In this more recent time period, the core summer distribution (estimated area = 1,787 km^2) continued to contract northward, while remaining centered on the Susitna Delta (Figure 9). Fewer sightings of CI belugas in lower Cook Inlet in recent decades (Hansen and Hubbard 1999; Speckman and Piatt 2000; Rugh et al. 2000, 2004, 2010) also indicate that the summer range of CI belugas has contracted to the mid and upper Inlet, coincident with their decline in population size.

The reason for this change of distribution is not known, but several hypotheses have been proposed, including: 1) an effect of changing habitat, such as through diminished prey availability (Moore et al. 2000); 2) avoidance of killer whales (Shelden et al. 2003); and 3) preference and ability of this remnant population to remain in preferred habitat areas due to reduced intra-specific competition as a result of a reduction in population size (Goetz et al. 2007). Regardless of the reason, the result of the CI beluga range contraction brings animals in a small range proximal to Anchorage during summer months, where there is increased potential for disturbance from human activities.

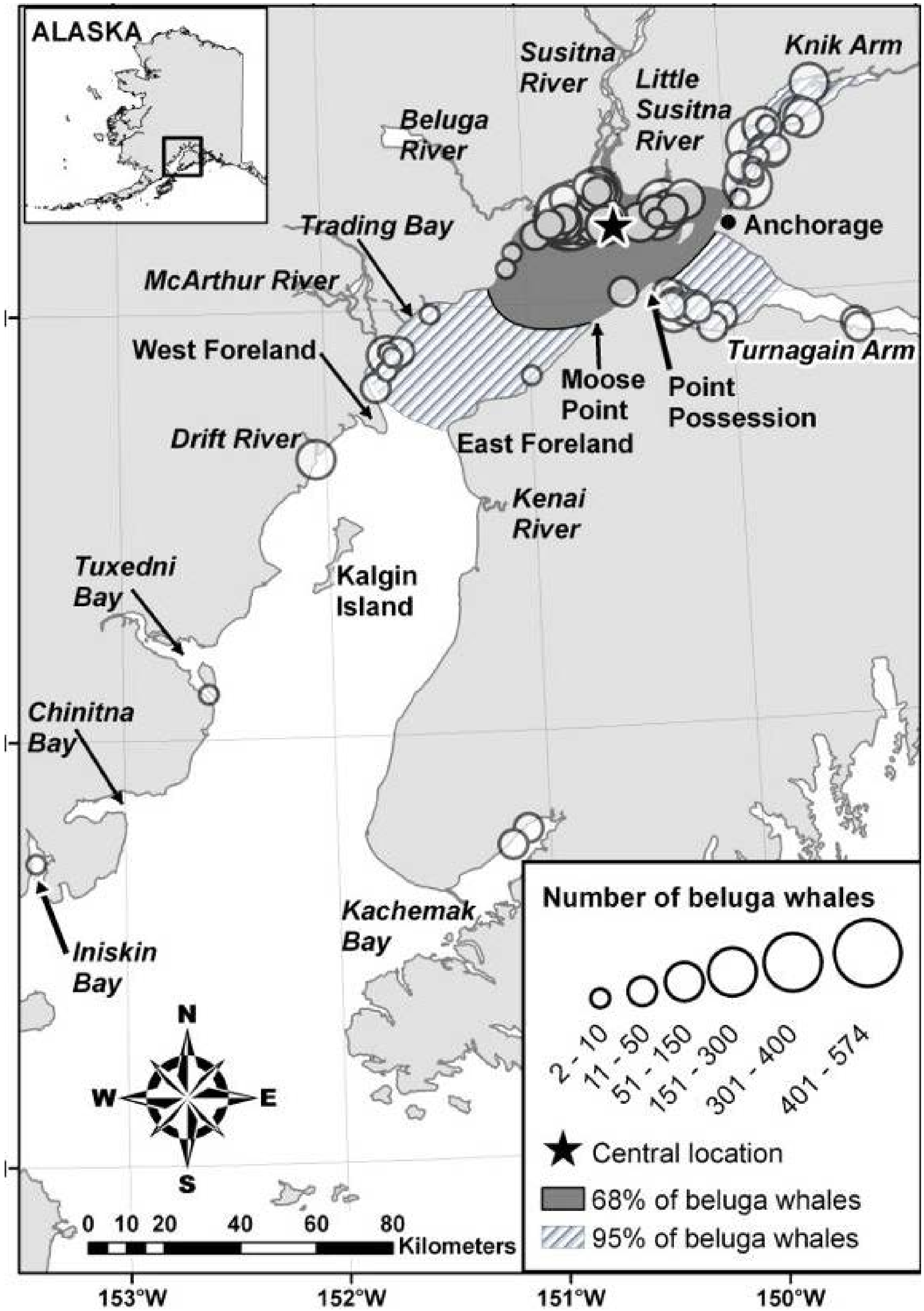
b. Seasonal Distribution Patterns

Multiple data sources indicate that belugas exhibit seasonal shifts in distribution and habitat use within Cook Inlet, however, belugas in Cook Inlet do not migrate out of Cook Inlet. The known seasonal shifts in distribution of CI belugas appear to be related to seasonal changes in the physical environment (e.g., ice and currents) and to shifts in food sources, specifically the timing of fish runs. Generally, CI belugas spend the ice-free months in the upper Inlet (often at discrete high-use areas), then expand their distribution south and into more offshore waters of the middle Inlet in winter (Hobbs et al. 2005), although they may be found throughout the Inlet at any time of year. These seasonal patterns have been long observed and utilized by subsistence hunters (Huntington 2000), and as reviewed by Shelden et al. (2015b), have more recently been documented by aerial surveys (Rugh et al. 2000, 2004), satellite telemetry (Ferraro et al. 2000; Hobbs et al. 2005), and during shore and boat-based observations (e.g., Funk et al. 2005; McGuire and Bourdon 2012; McGuire et al. 2014a). Most recently, passive acoustic monitoring is being used to assess seasonal movements throughout the Inlet (Lammers et al. 2013; Castellote et al. 2016a).



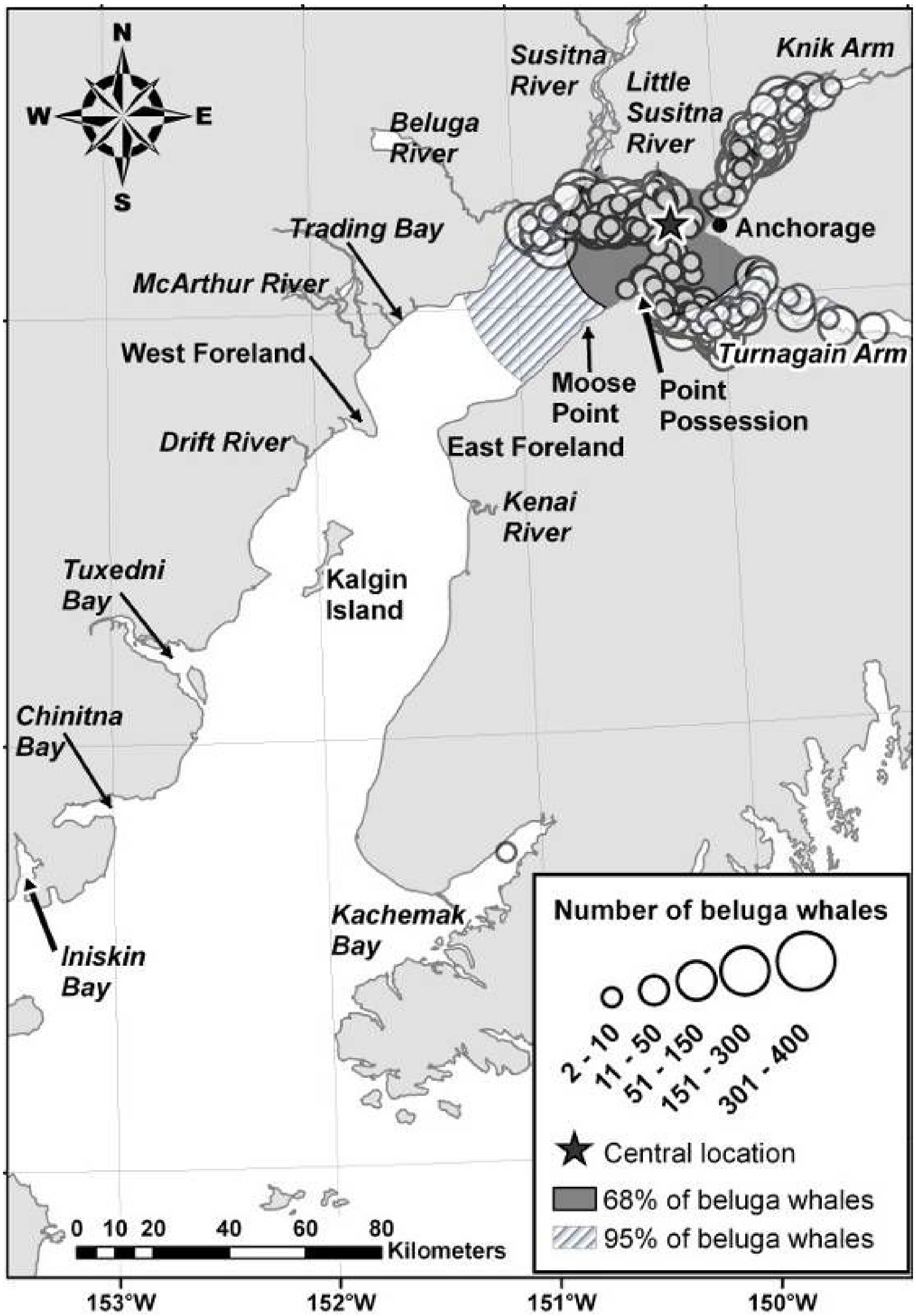
Source: Rugh et al. 2010.

Figure 6. Areas occupied by belugas in Cook Inlet, Alaska, in June/July 1978 to 1979.



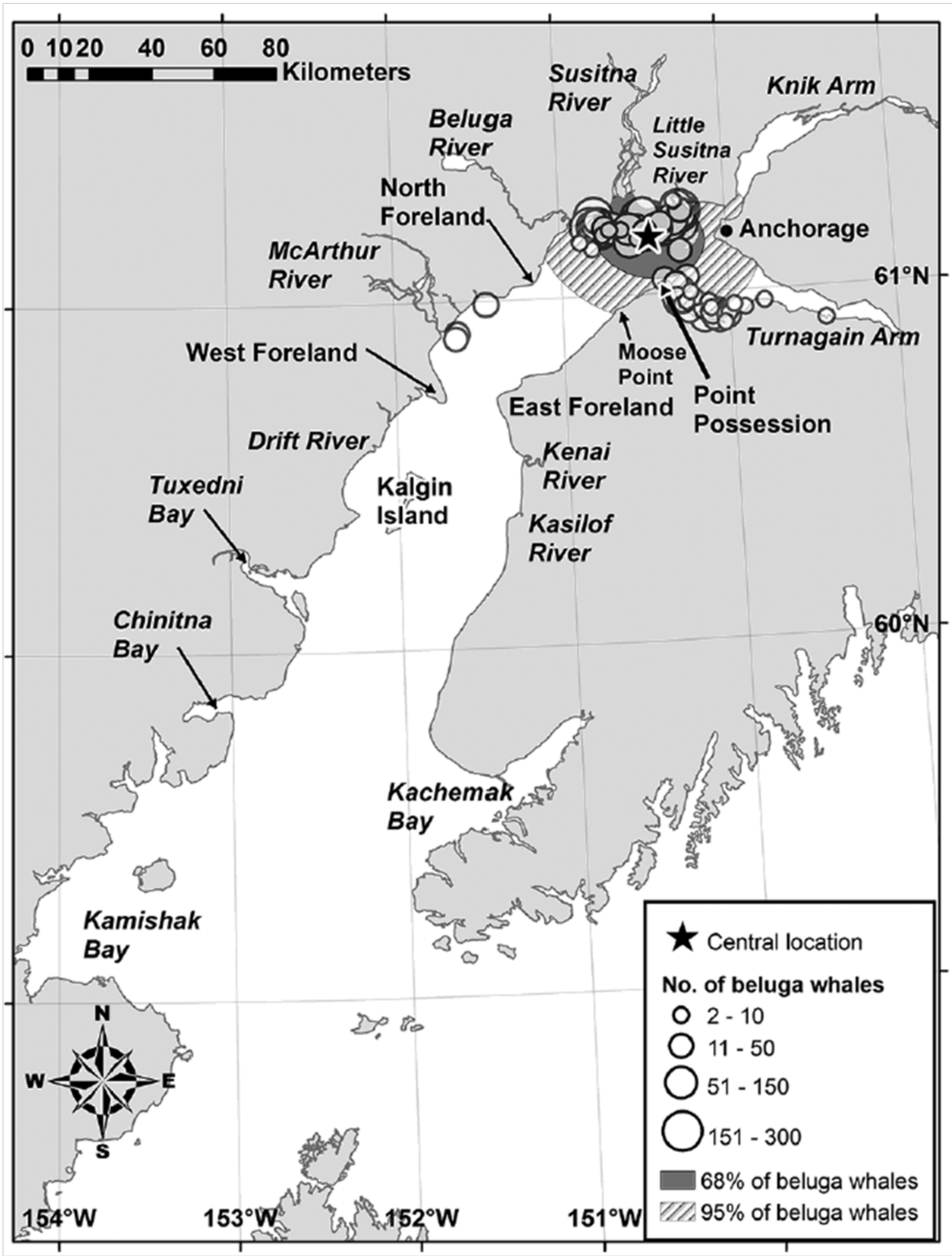
Source: Rugh et al. 2010.

Figure 7. Areas occupied by belugas in Cook Inlet, Alaska, in June/July 1993 to 1997.



Source: Rugh et al. 2010.

Figure 8. Areas occupied by belugas in Cook Inlet, Alaska, in June 1998 to 2008.



Source: Shelden et al. 2015b.

Figure 9. Areas occupied by belugas in Cook Inlet, Alaska, in June 2009 to 2014.

Movement data are available from 14 CI belugas tracked for variable periods of time (2–240 days) with satellite transmitters between May 1999 and March 2003. Tags attached to nine whales logged movements from August or September into December, with four continuing to transmit movement data into the following March (Hobbs et al. 2005; Goetz et al. 2012a; Shelden et al. 2015b). All tagged CI belugas remained within Cook Inlet for the period they were tracked. Whales spent the summer and early fall months in the upper Inlet, concentrating at river mouths. Within this time period, whales often made weekly movements between the mouth of the Little Susitna River, Knik Arm, Turnagain Arm, and Chickaloon Bay. During the late summer the belugas remained in the upper Inlet, centered in Knik Arm (Figures 10a, 10b). During the fall, the belugas concentrated in Chickaloon Bay and areas of the west side near Tyonek (Figures 10c, 10d). In late fall, tagged whales began to make more extensive movements south into the middle Inlet and into deeper offshore waters (Figure 10e), and were not found in the large dense groups commonly seen in the summer months (Rugh et al. 2004). This pattern continued through winter (Figures 10f–10h), when whales exhibited the most wide-ranging movements, spanning both nearshore and offshore waters from the upper reaches of Knik Arm to the middle Inlet.

Several other observational studies have been conducted which contribute to our understanding of CI belugas' seasonal movements. A year-round shore and boat-based observational study in Knik Arm (July 2004 to July 2005) revealed seasonal patterns in habitat use and abundance of this area, with peak abundances in fall (September) declining to lowest numbers in winter, and highest use of river mouths and mud flats (Funk et al. 2005). Shore-based studies during the ice-free months along Turnagain Arm found peak beluga abundances mid-August through October, with whales occasionally present mid-April to early May (Markowitz and McGuire 2007; McGuire and Bourdon 2012). An ongoing (2005–present) photo-identification study within the upper Inlet with sighting histories of 376 individual belugas (2005–2015; T. McGuire, LGL Alaska Research Associates [LGL], pers. obs.) has documented movements by individual whales among several high-use areas within a summer season, including Susitna Flats, Knik Arm, Chickaloon Bay, Turnagain Arm (McGuire et al. 2009), and the Kenai River (McGuire et al. 2014a). Results from passive acoustic monitoring across the entire Inlet (summarized in Section II.B.4. Use of Critical Habitat by Belugas) support seasonal patterns observed with other methods (M. Castellote et al., AFSC MML, pers. comm.).

Large aggregations of belugas in specific areas of upper Cook Inlet during May to October are presumed to indicate a critical time period for foraging, based on the need to assimilate resources for overwinter survival (Calkins 1983; Huntington 2000). It is during the ice-free months when calves are born and nursed and when the whales acquire the thick blubber layer they will need to survive through the winter months, when anadromous fish runs end and prey move to deeper, offshore regions (Hobbs et al. 2005; Hobbs et al. 2008).

4. CI Beluga Habitat Characteristics and Use

a. CI Beluga Feeding Habitat

CI belugas are frequently seen aggregating near the mouths of rivers and streams, when anadromous fish species are present and often at their peak availability (Moore et al. 2000). These concentrations of belugas within discrete areas of the upper Inlet and offshore of several

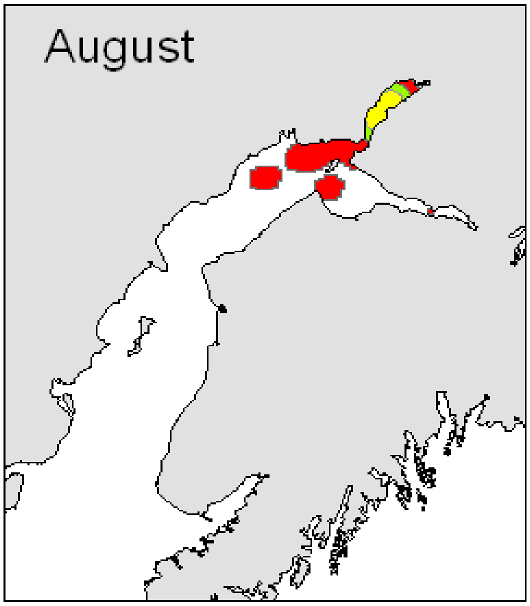


Figure 10a.

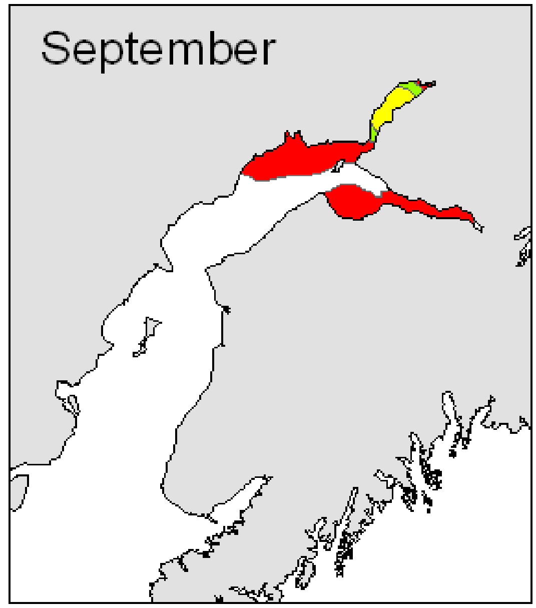


Figure 10b.

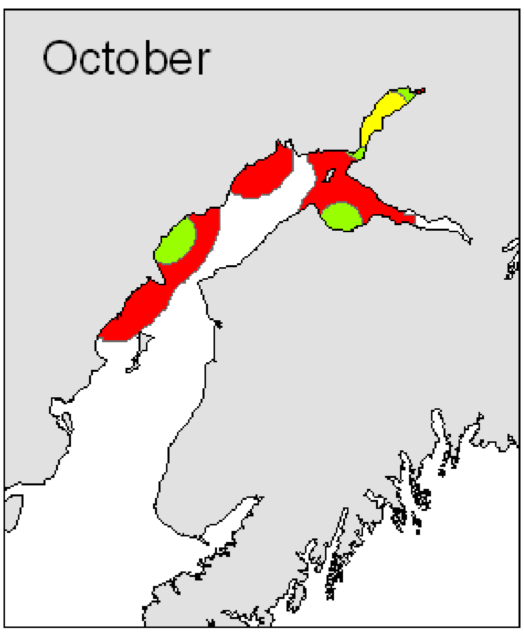


Figure 10c.

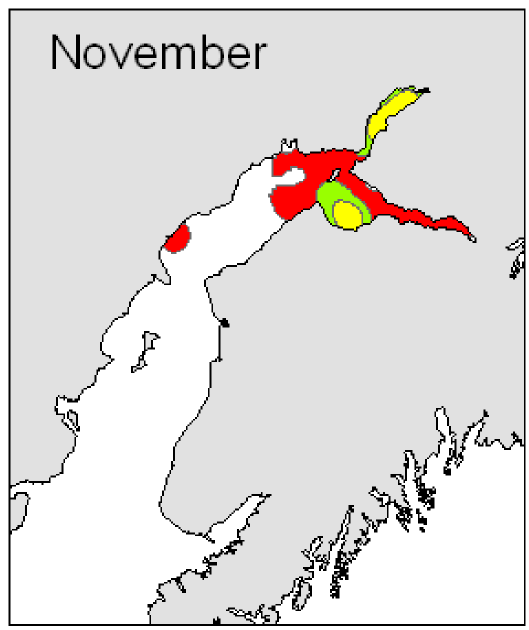


Figure 10d.

Notes: A single best location was chosen for each day. Predictions derived via kernel probability estimates. Note the large increase in total area use and offshore locations beginning in December and continuing through March. The red area (95% probability) encompasses the green (75%) and yellow (50%) regions; the yellow area represents the highest density.

Source: Hobbs et al. 2005.

Figure 10 (a–h). Predicted CI beluga distribution by month based on known locations of 14 satellite-tagged belugas.

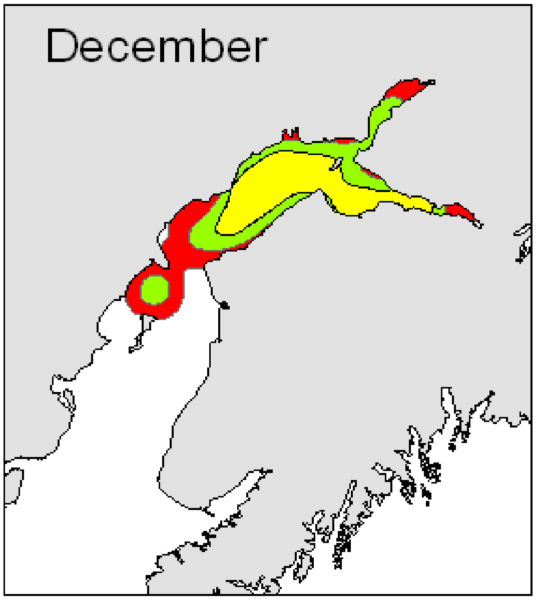


Figure 10e.

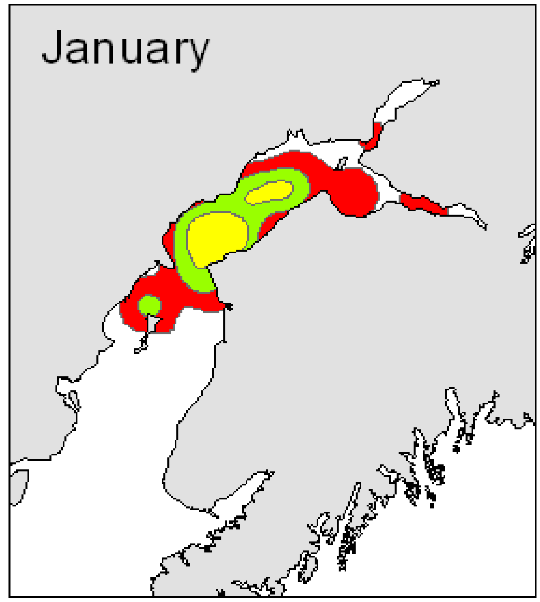


Figure 10f.

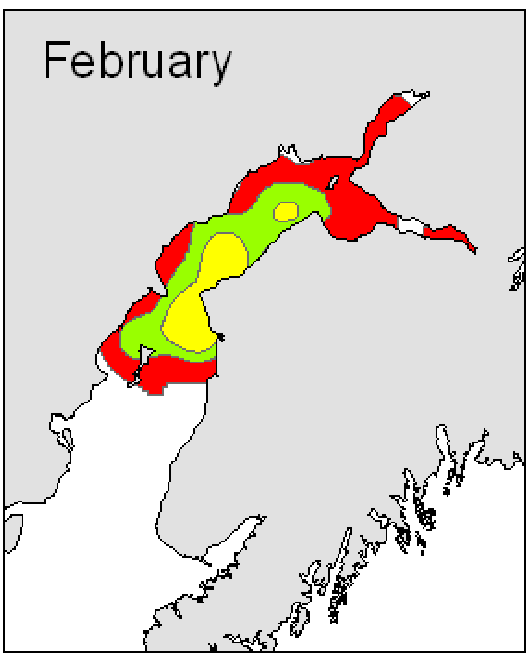


Figure 10g.

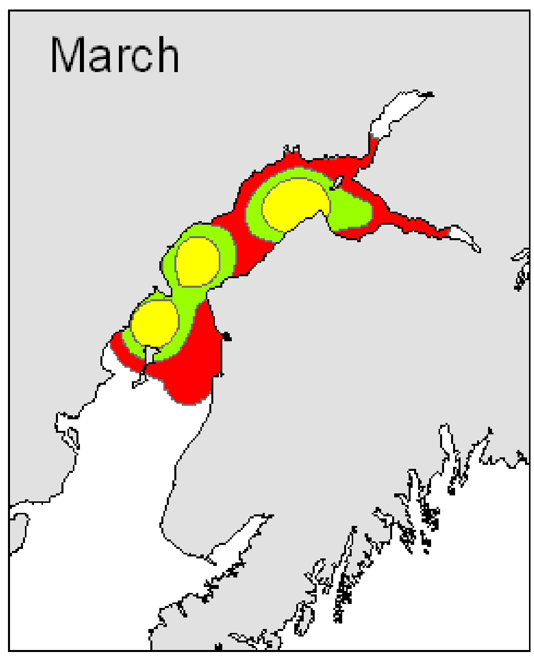


Figure 10h.

Figure 10 (a–h). Continued.

important salmon streams are assumed to be the result of a feeding strategy that takes advantage of the bathymetry of the area: the fish are funneled into the channels formed by the river mouths, and the shallow waters act as a gauntlet for fish as they move past waiting belugas. Hazard (1988) hypothesized that belugas were more successful feeding in rivers where prey were concentrated than in bays where prey were dispersed, implying that CI belugas seek areas where anadromous prey escapement (return to freshwater spawning habitat) numbers are high, but also areas that have certain habitat features. Research by Frost et al. (1983) on belugas in Bristol Bay suggested those whales preferred certain streams for feeding based on the configuration of the stream channel. Their study theorized beluga feeding efficiency improved in relatively shallow channels where fish were confined or concentrated. Because belugas do not always feed at the streams with the largest runs of fish, bathymetry, fish density, and lack of disturbance may be more important than sheer numbers of fish in determining their feeding success. For example, CI belugas today are seen less frequently at the mouth of the Kenai River than they were historically, despite large salmon returns to the river. Whether this is due to changes in prey species composition or density, bathymetric changes, increased levels of disturbance, or other unknown factors remains a matter of speculation.

Habitat use in the summer months consists of semi-predictable movements of groups of belugas between river mouths and shallow tidal flats in the upper Inlet. These movements are largely cued to physical conditions, especially tide, but may also be influenced by anthropogenic activities. TEK indicates that daily movements are determined by the ebb and flow of the tide and the related movements and size of fish runs, and also by the presence of killer whales (Huntington 2000). For example, whales often concentrate on the shallow mudflats of the Susitna River Delta and Chickaloon Bay at low tide, and may enter upper Inlet rivers on the flooding tide, although the reverse tidal pattern has been observed in Eagle River in Knik Arm (T. McGuire, LGL, pers. obs.). Observational studies (Funk et al. 2005; Markowitz and McGuire 2007) and ocean circulation and inundation models, combined with tracks from tagged individual whales (Ezer et al. 2008), confirm long-held local knowledge that daily feeding movements are influenced greatly by tidal cycle.

In the fall, as anadromous fish runs begin to decline, belugas consume the fish species found in nearshore bays and estuaries; however, some belugas may feed on salmon kelts (spawned fish) during this time. Habitat associations of nonanadromous beluga prey species in Cook Inlet include preferences for sand and mud substrates (Eschmeyer et al. 1983; Cohen et al. 1990; ADF&G 2004), and a number of these species move seasonally from shallow to deep water. Movements of belugas within the Inlet during the months when anadromous fish runs are not present may reflect the seasonal movements of these other prey species. Unlike salmon and eulachon, the prey available in winter do not tend to form large concentrations, and it may be that belugas tend to disperse throughout the Inlet during November through April, to utilize the more-dispersed prey (Hobbs et al. 2005). In the winter, CI belugas use deeper waters in the mid Inlet past Kalgin Island and make deep feeding dives. The presence of Kalgin Island south of the Forelands may create upwelling and eddies which concentrate nutrients and provides a still-water refuge area for migrating anadromous fishes (Calkins 1983, 1989). This area may also be a late-winter staging area for eulachon before they return to streams in the upper Inlet. Given the unique oceanographic conditions and the diversity of fish and crustaceans found near Kalgin Island, this area may be rich in biological productivity, and thus an important winter feeding habitat for belugas.

Castellote et al. (2016a) obtained information on the seasonal distribution and foraging behavior of belugas in Cook Inlet through passive acoustic monitoring of beluga social calls and echolocation activity at 13 locations in lower Cook Inlet (Homer, Tuxedni Bay, and Kenai River), upper Cook Inlet (Trading Bay, Beluga River, Little Susitna River, and Fire Island), and Knik Arm (Point Mackenzie, Cairn Point, Six Mile, South Eagle Bay, Eagle River Mouth, and North Eagle Bay) during 2008–2013. Analysis of the echolocation data indicated that foraging behavior, as inferred from presumed foraging buzzes, was more prevalent during summer than during winter, particularly at upper Inlet rivers. Passive acoustic monitoring was restricted to nearshore areas, so offshore foraging was not assessed, and due to a limitation of the study methods, foraging on benthic prey may not have been readily detectable.

Goetz et al. (2007, 2012b) used geographic information systems (GIS) to develop quantitative models of the summer habitat preferences of CI belugas. Habitat models were used to examine ecological relationships among belugas and several environmental variables. Parameters used in the models were based on June/July beluga sightings (1993 to 2004) relative to available environmental data: 1) bathymetry; 2) mudflats; and 3) flow rates among freshwater tributaries entering Cook Inlet. The two quantitative models predicted similar size and location of beluga habitat and identified mudflats and river size as important environmental features. Belugas are found near mudflats and prefer medium and high flow accumulation areas (i.e., medium to large river basins). Although sighting data in this study were collected primarily in June, other aerial surveys (Rugh et al. 2000, 2004), shore-based systematic and opportunistic observations (Funk et al. 2005; NMFS, AFSC MML, unpub. data), boat-based photo-identification surveys (McGuire and Bourdon 2012), and whales tagged with satellite transmitters (Hobbs et al. 2005) show that the distribution documented in June is largely representative of the distribution throughout the ice-free months; Knik Arm, Turnagain Arm, Chickaloon River, and the Susitna River Delta are used extensively. In fact, belugas occasionally access these preferred habitats in winter despite thick ice cover (Hobbs et al. 2005). Tidal movement corridors are also important to CI belugas, as beluga movements with the tides may occur up to twice daily and allow or limit access to feeding areas (Hobbs et al. 2005; Funk et al. 2005; Markowitz and McGuire 2007). Access to these areas and to corridors between these areas is important to the feeding strategy of CI belugas.

Additional analyses by Goetz et al. (2012b) concluded that belugas were found in areas of high fish availability and access to tidal flats and sandy substrates and that belugas were negatively associated with anthropogenic disturbance. These habitat models predicted that beluga distribution would include coastal areas extending nearly the entire length of Cook Inlet (Goetz et al. 2007), and, historically belugas inhabited large parts of the Inlet, including its central and southern reaches (Rugh et al. 2000). However, since 1993, beluga sightings have been rare (0–4% of all reported sightings per year) in areas south of the Forelands, and almost all sightings have been in the upper Inlet, from the Susitna Delta to Knik Arm and Chickaloon Bay (Rugh et al. 2000, 2005a, b). A significantly reduced CI beluga population (Hobbs et al. 2000), in combination with beluga preference for estuarine waters with the largest concentration of prey species, may explain the current distribution of whales, but data on relative densities of fish by species and season are not available to test this hypothesis.

b. CI Beluga Calving Habitat

In addition to being important feeding habitats, the shallow waters of the upper Inlet may also play important roles in reproduction. Since newborn belugas do not have the thick blubber layer of adults, they may benefit from the warmer water temperatures in the shallow tidal flats areas where fresh water empties into the Inlet, and it is likely these regions are used as nursery areas (Katona et al. 1983; Calkins 1989). These shallow areas may also provide refuge from killer whale predation on calves. The TEK of Alaska Natives has described historical beluga calving and nursery habitats as the northern side of Kachemak Bay, the mouths of the Beluga and Susitna Rivers, as well as Chickaloon Bay and Turnagain Arm (Huntington 2000). Knik Arm is also used extensively in the late summer and fall by cow/calf pairs: Funk et al. (2005) noted a relatively high representation of calves in the uppermost part of Knik Arm; the mouth of Knik Arm has been reported to be transited in the summer and fall by cow/calf pairs (Cornick and Kendall 2008); and groups seen in Eagle Bay usually contain calves (McGuire and Bourdon 2012).

Because calving events have not been documented in Cook Inlet, specific calving grounds have not been identified, although it seems likely that the areas identified as nursery areas might also serve as calving grounds. Based on the presence of calves sighted in summer aerial surveys, Calkins (1983) speculated that calving might occur in the larger estuaries of upper western Cook Inlet. During boat-based surveys for calves conducted in 2007 to 2011, the first neonates (i.e., newborns) of the season were seen at the Susitna River Delta (McGuire and Bourdon 2012). Later in the season, groups seen in Knik Arm were more likely to contain neonates than groups in other areas. Distinct areas for neonate and calf rearing were not identified, as calves and neonates were seen in all locations surveyed in upper Cook Inlet (the Susitna River Delta, Knik Arm, Chickaloon Bay/Southeast Fire Island, and Turnagain Arm). McGuire et al. (2016) reported that during photo-identification surveys conducted in upper Cook Inlet (2005 to 2015) and the Kenai River Delta (2011 to 2013), the first neonates seen each survey year were located in the waters of the Susitna River Delta. Neonates were seen later in the season in all other survey areas where belugas were encountered (i.e., the Susitna River Delta, Knik Arm, Chickaloon Bay, Turnagain Arm, and the Kenai River). McGuire et al. (2016) also documented the birth of a CI beluga in the Susitna River Delta. Based on these data, they suggested the Susitna River Delta should be considered a calving ground for CI belugas, and the nearshore waters of upper Cook Inlet should be considered CI beluga nursery grounds.

c. Other Uses of Habitat

Other important uses of habitat by CI belugas may include avoidance/escape from predators, transiting among feeding and/or nursery habitats, refuge from human activities (e.g., in-water noise, ship traffic, and hunting), and molting. In the 2008 Conservation Plan (NMFS 2008a), NMFS stated that warmer, fresher coastal waters may be important areas for belugas' seasonal summer molt (Finley 1982) and that shallow waters may provide conditions necessary to help facilitate the shedding of dead skin and regeneration of epidermal layers. However, eight years of photographic records of over 303 individual CI belugas photographed from April to November do not display signs of obvious molting; it may be that molting in CI belugas is a more diffuse, gradual process than it is for those beluga stocks found in more northern latitudes and that habitat specifically for seasonal molting is not required for CI belugas. Molting has also not been observed in SLE belugas, despite over 25 years of studies on this population (P. Béland, St. Lawrence National Institute of Ecotoxicology, pers. obs.).

d. Human Environment of Cook Inlet

Belugas in Cook Inlet are unique in Alaska given that their habitat is in close proximity to the largest urban area in the state with over 60% of the state-wide population. In 2010 (the most recent census year available), the population of the State of Alaska was 710,231 people, with 291,826 in the Municipality of Anchorage, 88,995 in the Matanuska-Susitna Borough, and 55,400 in Kenai Peninsula Borough.[6] The population in this region has been increasing; between 1980 and 2010 the population grew by 67%.[7]

Belugas are not uniformly distributed throughout Cook Inlet, but are predominately found in nearshore waters, adjacent to areas of high human activity. Humans use the waters and shores of Cook Inlet for fishing, hunting, recreating, timber harvesting, mining, shipping, dredging, renewable energy production, discharge of wastewater, military activities, oil and gas development, transportation, and residential and industrial development (Figure 11).

The majority of land in the Cook Inlet Basin is publicly managed by state or federal agencies. Native groups and individuals are among the most significant private landowners.

5. Age, Growth, Reproduction, and Survival

Belugas are long-lived and have a relatively slow reproductive cycle, giving birth to a single calf every two, three, or more years, and devoting considerable time to caring for their young. Although some life history data are available for CI belugas, considerably more data exist for other beluga populations (see Table 1). Most general beluga life history data have been obtained through measurements and samples of animals taken in subsistence harvests, although some information has come from live stranded, dead beach-cast or floating whales, and some from captive belugas. Relatively little life history data are available specifically for CI belugas.

To understand growth, reproduction, and survival rates, investigators must determine the age structure of the population. Age is primarily assessed by counting the number of growth layer groups (GLGs) of teeth in thin longitudinal sections (see Appendix IX.D – CI Beluga Natural History Supplement). Historically, it was believed that belugas might live more than 30 years (Burns and Seaman 1986); however, it is now thought that belugas may live 60 to 70 years or more (Suydam 2009). It is difficult to know the exact age of older belugas because their teeth wear down and some GLGs are lost as animals age; therefore it is likely that ages determined by counting GLGs are underestimates. For teeth of the 102 CI belugas that have been aged using the single GLG method, the oldest CI beluga was estimated to be at least 49 years (Vos 2003; NMFS, unpub. data).[8]

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[6] Census information obtained from State of Alaska Department of Labor and Workforce Development Census and Geographic Information website at: http://live.laborstats.alaska.gov/cen/index.cfm.

[7] Census information obtained from U.S. Census Bureau Quickfacts at: http://quickfacts.census.gov/qfd/states/02/0203000.html.

[8] For more information, contact NMFS AKR, Protected Resources Division.

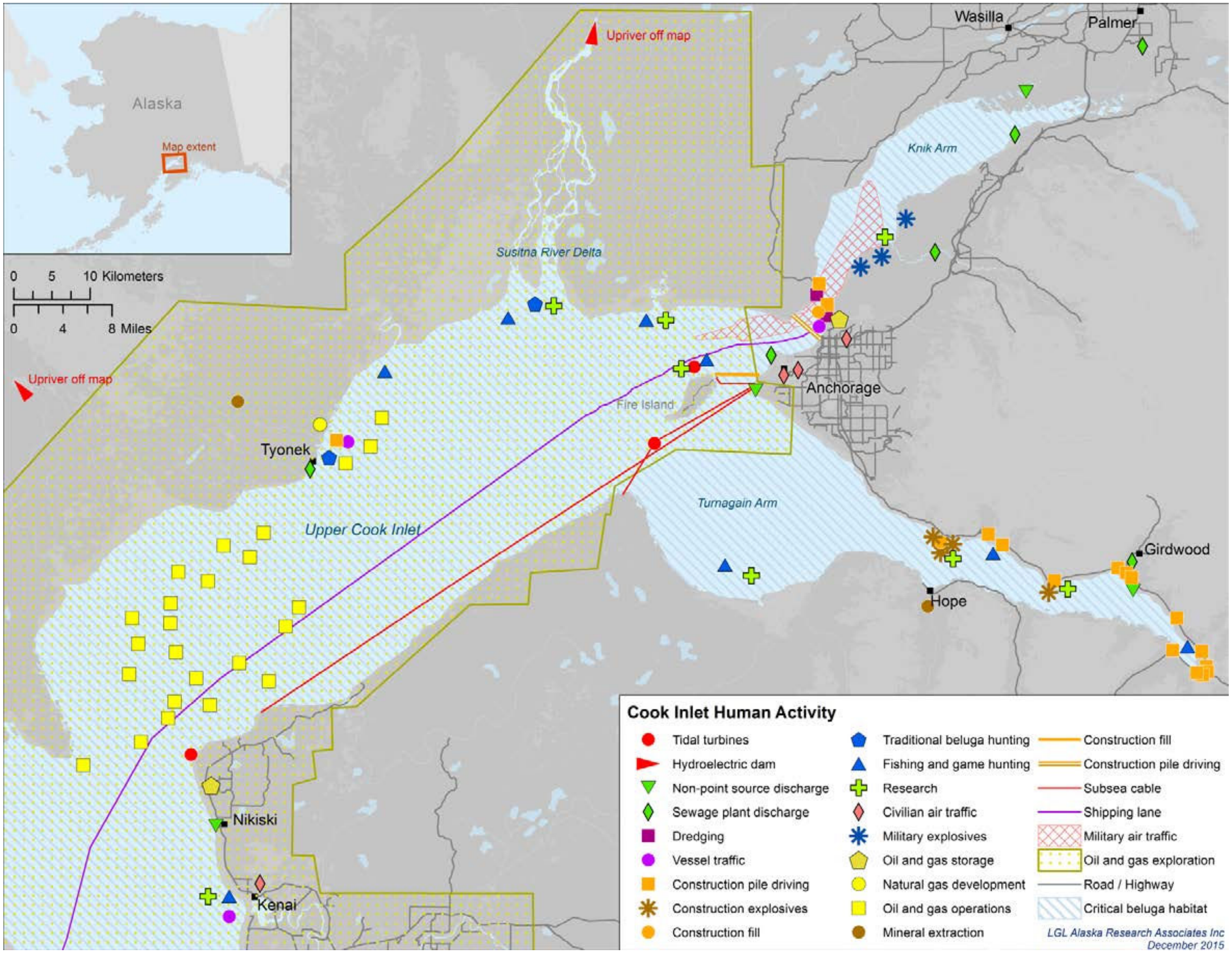

Figure 11. General geographic distribution of current and proposed human activities in Cook Inlet, Alaska.

Obtaining information on the age at sexual maturity (ASM) sheds light on reproduction, and increasing or decreasing trends in ASM may help determine ecosystem dynamics. For instance, if ASM decreases over time in females, this might suggest that resources are not limiting population growth. In published literature, estimates of ASM in belugas ranged from 4–14 years for females and 8–15 years for males (Braham 1984; Nowak 1991; Heide-Jørgensen and Teilmann 1994; Suydam 2009; Table 1). While the cause of the wide range of ASM is currently unknown, possible reasons include: 1) animals may mature at different ages among stocks; 2) different methods may have been used to estimate ages; or 3) the definition of ASM may have differed (e.g., age at first ovulation vs. age at first conception vs. age at first birth). Burns and Seaman (1986) estimated the age at first conception for 22 female belugas in northeast Alaska to be between 8 and 13 years (based on 1 GLG per year).

Estimates of the length of gestation for belugas have also varied from 11 to 16 months (Table 1), although data from captive belugas where conception and birth are precisely known indicate a gestation of 15.6 months (Robeck et al. 2005). Calkins (1983) suggested that most calving in Cook Inlet occurs from mid-May to mid-July. Alaska Native hunters have reported calving from April through August (Huntington 2000). More recently, observations of neonates during annual photo-identification surveys of CI belugas conducted from spring to fall in upper Cook Inlet (2005 to 2015) and the Kenai River Delta (2011 to 2013) led McGuire et al. (2016) to conclude the peak calving period for CI belugas is mid-July through mid-October. The lactation period for belugas is known to last at least a year, and likely longer in some cases. This estimate is based on observations of lactating females that are pregnant with a new fetus and with some estimates of weaning not occurring for about two years; thus, the entire reproductive process on average takes three years (Sergeant 1973; Burns and Seaman 1986). Depending on the age and experience of the mother, however, the calving interval may be as short as two years or over three years (Suydam 2009). Many studies suggest a calving interval for belugas of approximately three years, which equates to a pregnancy rate of about 0.33 per year (Kleinenberg et al. 1969; Sergeant 1973; Ognetov 1985; Burns and Seaman 1986; Doidge 1990b; Heide-Jørgensen et al.1994). This would indicate that approximately one-third of mature females would be newly pregnant in any given year. However, belugas in Hudson Bay, Canada, and Point Lay, Alaska, had greater pregnancy rates of 0.47 (Hudson Bay; Sergeant 1973; Doidge 1990a) and 0.41 (Point Lay; Suydam 2009) indicating calving intervals shorter than three years. Several studies have also suggested a decrease in the pregnancy rate (based on studies of the ovaries) as a female beluga ages, particularly after 40 years (GLGs) (Brodie 1982; Heide-Jørgensen and Teilmann 1994; Suydam 2009). Kleinberg et al. (1969; as presented in Brodie 1971) arbitrarily estimated age at senescence to be around 42–43 years (GLGs). However, this does not mean that older female belugas are not capable of reproducing past this age; a 68 year old female beluga in the St. Lawrence Estuary population in Canada showed signs of recent reproductive activity (McAlpine et al. 1999 *as cited in* DFO 2012).

In 2005 NMFS began August calf surveys of Cook Inlet. Calving indices were estimated for the period from 2006 to 2012, and indicated that more calves were born by the time the August surveys were conducted in 2006 (12%) than in subsequent years 2007 to 2012, when the average rate was 1.9% (Hobbs et al. 2015a). These calving indices have several potential biases; accordingly, they should be used for trend analysis only, and not for absolute estimates of calf production. They indicate considerable variability from year to year so that a much longer time series is required to determine an average. A similar observation has been made in the SLE

Table 1. Review of female beluga life history parameters found in the published literature.

Parameters	Data	Sources
Age at sexual maturity	9–11 growth layer groups in teeth (GLGs) (mean=10, excluded one immature animal age 15 GLGs, sample sizes not provided).	1
	7–13 GLGs (mean=10 GLGs), 5–6 to 11–12 GLGs (mean=9 GLGs, *n* = 33, calculated from data collected by Khuzin [1961] in the Kara and Barents seas, Russia).	2
	0% at 8–9 GLGs, 33% at 10–11 GLGs, 94% at 12–13 GLGs, 100% at 16–17 GLGs (*n* = 207).	3[a]
	9.1 ± 2.8 GLGs (captive beluga studies, *n* = 23).	4
	50% at 8.25 GLGs (*n* = 87)	15
Age at color change (gray to white)	12 GLGs (minimum age)	1
	14 GLGs (minimum from Mackenzie Delta), 17 GLGs (minimums from western Hudson Bay)	2
	9–10 GLGs for males, 10–12 GLGs for females	15
Age at 1st conception	54% at 8–9 GLGs (*n* = 12 of 22) 41% at 10–11 GLGs (*n* = 9 of 22) 5% at 12–13 GLGs (*n* = 1 of 22)	3
	8.27 GLGs (SE = 2.88, *n* = 87)	15
Age at senescence	42–43 GLGs (arbitrarily assumed by Kleinenberg et al. 1969)	1
	40 GLGs (corpora level off and decline)	15
Pregnancy and birth rates	With small fetuses: 0.055 at 0–11 GLGs 0.414 at 12–21 GLGs 0.363 at 22–45 GLGs 0.267 at 46–57 GLGs 0.190 at 58–77 GLGs	3
	With full–term fetuses or neonates: 0.000 at 0–11 GLGs 0.326 at 12–21 GLGs 0.333 at 22–45 GLGs 0.278 at 46–51 GLGs 0.182 at 52–57 GLGs 0.125 at 58–77 GLGs	3
	0.41 (with small fetuses); 0.56 (with full term fetuses or neonates)	15
Lifespan	60–61 GLGs	1
	50–53 GLGs	2[b]
	>60 GLGs (oldest female estimated at 70+ GLGs)	3
	46 GLGs (male, tooth worn with no visible neonatal line)	15
	57 GLGs (female)	15
Adult annual survival	0.9064 (average based on mean annual mortality rate = 0.0936)	3
	0.91–0.92	5, 6
	0.842 and 0.905 (assuming 2GLGs/yr vs. 1 GLG/yr)	7
	0.96–0.97	8

Parameters	Data	Sources
	0.935	9
Immature annual survival	0.905 (for neonates in first half year of life, mortality rate=0.095)	2
	0.955 (based on pilot whale net recruitment)	10
Reproductive rate	0.13 (ratio of calves to adult females, modeled)	2
	0.143 (ratio of calves to adult females)	2
	0.114–0.117 (ratio of calves to whales)	2
	0.104 (a model population of 1,000 that included 94 calves)	3
	0.097 (ratio of calves to whales)	6
	0.08–0.10 (ratio of calves to whales)	10
	0.12 (ratio of calves to whales)	11
	0.056–0.10 (ratio of calves to whales)	12
	0.08–0.14 (ratio of calves to whales)	13
	0.08 (unknown)	14
Lactation period	At least 2 years	1
	21 months on average (based on length of gestation (14 months) x 33 lactating/22 pregnant whales)	2
	23 months (range:18–32 months, analysis of data collected by Seaman and Burns [1981])	6
Calving interval	3 years	1, 2[c], 3[d]
	>2 years (based on the assumption that females produce 10 calves within a 14–15 year active breeding period)	6[e]
	2–3 years	15

[a] Sampling occurred in June, a time when most Alaskan belugas are born. It is possible non–pregnant 8–9 GLGs belugas would have conceived before their 10–11 GLGs birth date.

[b] Found differences in maximum age based on sampling technique. Life span of netted whales tended to be lower (40 GLGs at Whale Cove) than those selected and harpooned (50 GLGs at Churchill, 53 GLGs at Mackenzie Delta). Similar results were reported by Brodie (1971) for whales netted in Cumberland Sound (40 GLGs).

[c] In 7 of the 29 pregnant females examined from Whale Cove, lactation was still occurring and for some analyses a 2 year calving cycle was assumed for 25% of the adult female population (p. 1084). Sergeant (1973) concluded "overlap of pregnancy and previous lactation is infrequent so that calving occurs about once in 3 years."

[d] For some female belugas. This was a tentative conclusion based on high conception rates noted in some females between the ages of 12–13 GLGs and 44–45 GLGs.

[e] Braham (1984) based this assumption on data from Brodie (1971) and Sergeant (1973) that age at first pregnancy is 6 years (12 GLGs) and last pregnancy is about 21 years (42 GLGs) resulting in a 14–15 year breeding period, which would allow only 6 calves rather than the 10 calves predicted by the authors if a female's reproductive cycle is 3 years. However, this calculation was based on 2 GLGs = 1 year, using 42–12 = a 30-year breeding period and a 3-year reproductive cycle would produce 10 calves.

Sources: 1. Brodie (1971) [Canada] Cumberland Sound, Baffin Island, population, n = 124 animals (86% captured in nets which biased the sample toward females with newborns), Fig.3 appears to show 51 females in the sample. 2. Sergeant (1973) [Canada] Churchill and Whale Cove in western Hudson Bay, additional information from the Mackenzie Delta, Beaufort Sea and Kara/Barents seas, Russia. 3. Burns and Seaman (1986) [Northwest Alaska]; 4. Robeck et al. (2005) [captive belugas]; 5. Allen and Smith (1978) reviewed in 6. Braham (1984); 7. Ohsumi (1979); 8. Béland et al. (1992) [Canada] St. Lawrence population; 9. Lesage and Kingsley (1998) [Canada] St. Lawrence population; 10. Brodie et al. (1981) [Canada] Cumberland Sound, Baffin Island; 11. Ray et al. (1984); 12. Davis and Finley (1979) [eastern Arctic]; 13. Davis and Evans (1982) [eastern Beaufort Sea and Amundsen Gulf]; 14. Breton-Provencher (1981) [Poste-de-la-Baleine region]; 15. Suydam (2009) [eastern Chukchi Sea].

beluga population where annual calf production appears to be cyclical (R. Michaud, Group for Research and Education of Marine Mammals, unpub. data). Also, it was assumed, based on mid-July beluga calf sightings in Cook Inlet during aerial surveys in the 1970s, and May calving reported by Alaska Native hunters for the Susitna area, that most calves were born by August. However, during annual photo-identification studies (2005 to 2015), McGuire et al. (2016) reported observations of neonate belugas in upper Cook Inlet extending from July through mid-October.

Based on gestation and timing of birthing, mating is believed to occur sometime between late winter and early spring; however, there is little documentation on the mating behavior of belugas. A reproductive study of belugas in captivity reported that all conception ($n = 13$) occurred from February to June, with 80.6% of the conceptions occurring from March to May (Robeck et al. 2005). Suydam (2009) stated it was unlikely the eastern Chukchi Sea belugas became pregnant after late June since they did not observe fetuses of a length indicative of an August or September birth date.

Survival data for CI belugas consist of annual summaries of beach-cast and floating carcasses reported to the NMFS AKR, and consequently represent a minimum estimate of mortality for the CI beluga. From 1999 to 2005, when the population size averaged approximately 350 animals and a limited harvest of CI belugas occurred, an average of 12 mortalities were reported each year (Vos and Shelden 2005). This provided an estimated annual survival probability for CI belugas of 0.97 per year. From the literature, survival probabilities for belugas have been estimated as low as 0.84 per year but most were above 0.90 per year. The lactation period is known to last longer than one year, so calf survival closely relates to survival of the mother during the first year following birth. While survival rates and age at maturity have been estimated for males, these estimates did not significantly differ from those for females.

Data are not available for the CI beluga population to precisely determine the generation time, however, when we consider available information regarding the age at first reproduction and age at senescence for belugas, we estimate a generation time for belugas of approximately 25 years.[9] The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species[10] estimated the generation time for belugas in Cook Inlet to be 16 years based on the information provided by Burns and Seaman (1986), which considered a year to be represented by two GLGs, rather than the currently recognized one GLG/year. Thus, 16 years may underrepresent the actual generation time for belugas. The generation time of between 26 to 30 years has been proposed for belugas in the St. Lawrence Estuary (David Lee, Committee on the Status of Wildlife in Canada [COSEWIC] Member, pers. comm. to R. Hobbs, AFSC MML, October 2014). Therefore, we determine our estimate of generation time of 25 years to be reasonable.

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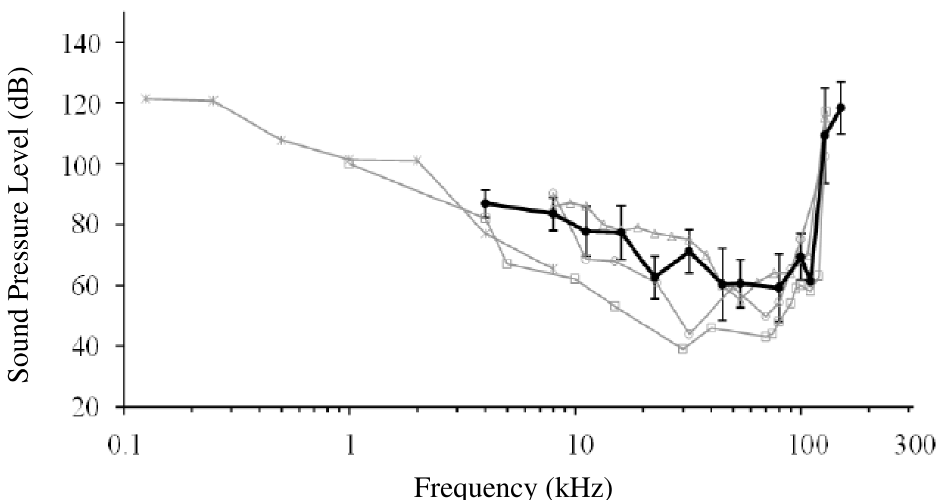
[9] Generation time was estimated by subtracting the age at first reproduction (~8–12 years) from the age at senescence (~40–43 years), multiplying by ½, and then adding the age at first reproduction. Given the imprecision of the data available, we determined 25 years is a reasonable estimate of generation time.

[10] The IUCN Red List of Threatened Species information webpage for Cook Inlet beluga whales was accessed October 17, 2014, and is available at: http://www.iucnredlist.org/details/full/61442/0.

6. Hearing and Vocalizations

a. Beluga Hearing

Several published studies (e.g., Awbrey et al. 1988; Klishin et al. 2000; Mooney et al. 2008) and one unpublished study (White et al. 1978) have assessed the hearing sensitivity of captive belugas using behavioral or electrophysiological (i.e., auditory evoked potential [AEP]) methods. In addition, one published study investigated hearing sensitivity (from 4 to 150 kilohertz[11] [kHz]) in seven wild Bristol Bay belugas using AEPs (Castellote et al. 2014). Hearing abilities in these belugas were generally similar to those measured in captive belugas. All seven belugas heard well, up to at least 128 kHz, and two heard up to 150 kHz. Lowest auditory thresholds (35–45 dB[12]) were identified in the range 45 to 80 kHz (Figure 12). Greatest differences in hearing abilities among individuals occurred at both the high end of the auditory range and at frequencies of maximum sensitivity. Collectively, these studies indicate belugas have an overall auditory bandwidth of approximately 40 Hz to 150 kHz, roughly eight times that of humans (Au 1993).



Notes: Data are means ± SD for wild belugas (black circles). Audiograms from captive belugas are indicated by gray symbols. Lower thresholds (intensity of a signal heard by the beluga) indicate better hearing. Best hearing for the wild belugas was typically in the 22.5–80 kHz range, with the absolute lowest thresholds between 45 and 80 kHz.

Sources: Figure from Mooney and Castellote 2012; audiograms from White et al. 1978, Awbrey et al. 1988, Mooney et al. 2008, Klishin et al. 2000, and Mooney and Castellote 2012.

Figure 12. Audiograms from wild belugas and captive belugas.

b. Beluga Echolocation

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[11] The hertz (symbol Hz) is the unit of frequency defined as the number of cycles per second of a periodic phenomenon. One of its most common uses is the description of sound sine waves as the frequency of musical tones.

[12] The decibel (dB) is a logarithmic unit that indicates the ratio of a physical quantity (in this case sound intensity) relative to a specified or implied reference level. A ratio in decibels is ten times the logarithm to base 10 of the ratio of two power quantities. For sound in water, the reference quantity is 1 microPascal.

Beluga echolocation (sonar) has been well studied and described (Au et al. 1985, 1987). Studies show that belugas have highly developed and sophisticated echolocation capabilities, with the capacity to adapt their click energy distribution as a function of the ambient noise in order to maximize the echo reception (Au et al. 1985). The echolocation capabilities of belugas, when compared to bottlenose dolphins, appear to be superior in the ability to detect targets (e.g., short steel cylinders) in the presence of masking noise (Turl et al. 1987) and in the ability to detect targets in clutter (reverberation composed of echoes scattered back to a sonar from objects and heterogeneity in the water and on its boundaries) (Turl et al. 1991). In an effort to detect a target in the midst of masking noise, belugas were shown to gain signal-to-noise ratio by projecting and receiving signals off the surface of the water, a technique not observed in the bottlenose dolphin (Penner et al. 1986). Hypothetically, this may be a similar strategy to using the underside of ice cover to reflect signals, possibly an adaptation to living in an Arctic environment. Turl and Penner (1989) suggest: “[T]he beluga lives in a high-noise and reverberant environment. It might be expected that the beluga’s sonar system has developed optimal adaptations to minimize the effects of interference found in the Arctic.”

c. Beluga Acoustic Social Signals

Belugas are among the most vocal cetaceans, making a wide variety of sounds that fall into two acoustic categories: whistles or narrow band frequency modulated vocalizations, and pulsed sounds or trains of broad band pulses. The latter can be divided into two functional categories: click trains, used largely for echolocation, and burst pulse sounds (bursts of pulses with rapid pulse repetition rates), believed to be social signals, which may sound to the human ear like grunts, squawks, screams, whines, and whistles.

These varied sounds earned belugas the nickname “Sea Canaries” by early Arctic whalers. There have been a number of attempts to classify the vocal repertoire of belugas (Fish and Mowbray 1962; Morgan 1979; Sjare and Smith 1986a, 1986b; Faucher 1988; Bel'kovich and Sh'ekotov 1993; Recchia 1994; Angiel 1997; Belikov and Bel'kovich 2001, 2003, 2006, 2007, 2008; Karlsen et al. 2002). This body of data provides some indication that sounds vary with behavioral and group context, and suggests geographic variation in signal use among populations. It is thought that these calls, both in captivity and in the wild, function to maintain group cohesion, and the variants shared by related animals are used for mother-calf recognition (Vergara et al. 2010). For example, belugas show an increase in the rate of vocalizations during social gatherings in the Canadian high Arctic, in Svalbard, Norway, and in the White Sea, Russia (Sjare and Smith 1986b’ Karlsen et al. 2002; Belikov and Bel’kovich 2003). They become much quieter when disturbed by humans or frightened (Finley 1990, Karlsen et al. 2002; Sjare and Smith 1986b; Belikov and Bel’kovich 2003). There is evidence of a decrease or even a cessation in acoustic activity of belugas in the presence of natural predators (e.g., killer whales) or engine noise.

Belikov and Bel’kovich (2003) attempted to correlate specific beluga call types with four behavioral states: quiet swimming, social interactions, sexual behavior, and disturbance caused by humans. While all call types were heard during all four behavioral states, there was a significant increase in “chirps” heard during sexual behavior and social interactions, and a decrease in whistles during sexual behavior. The conclusion was that “chirping” was the best acoustic indicator of beluga behaviors, marking both social and sexual interactions (Belikov and Bel’kovich 2003).

d. Acoustics of CI Belugas

Limited work has been done regarding acoustics of CI belugas. Castellote et al. (2011) recorded the acoustic behavior of CI belugas concurrently with visual observations using both boat-based and land-based methods in open waters as well as inside river mouths (Eagle and Little Susitna Rivers). The authors described how the acoustic behavior of CI belugas is modified when feeding. During presumed feeding or prey search, social calls were absent and echolocation clicks often occurred in train packets. Burst pulses were also found more often, although the authors indicated that few of these were conclusively assigned as “terminal buzzes” related to prey capture since most of the events were partially incomplete, probably due to the highly directional nature of these sounds. The authors concluded that echolocation train packets ending with a terminal buzz were produced by feeding belugas, that this behavior was commonly recorded in river mouths, and that it could be acoustically monitored with the potential to be used as an indirect indicator of foraging behavior. Garner et al. (2014) also used echolocation data to assess the seasonal use of Eagle River by CI belugas.

As noted above (see Section II.B.4. Use of Critical Habitat by Belugas), Castellote et al. (2016a) obtained information on the seasonal distribution and foraging behavior of belugas in Cook Inlet through passive acoustic monitoring of beluga social calls and echolocation activity at 13 locations in lower Cook Inlet and upper Cook Inlet. Belugas were detected at 12 of the 13 locations, with no detections in lower Cook Inlet at Homer Spit (the most southern site monitored). In general, the seasonal distribution of acoustic detections was consistent with descriptions based on aerial surveys and satellite telemetry. Echolocation data were also used to explore when and where presumed foraging buzzes occurred.

Passive acoustic recordings of CI belugas have also been collected in conjunction with a construction project at the Port of Anchorage. Širović and Kendall (2009) deployed a passive acoustic array of sonobuoys during 20 days in summer 2009 to acoustically detect the presence of belugas in the vicinity of in-water pile driving at the Port of Anchorage. Belugas were detected 55% of the monitoring time, with virtually all detection based on echolocation clicks (one whistle and over 65,000 clicks). Kendall et al. (2013) suggested that during the monitoring period, other lower frequency beluga whale vocalizations (e.g., whistles) were potentially masked, there may be have been an overall reduction in beluga vocalizations, or it is possible belugas were avoiding the area during construction activity.

A review of available information reveals four main gaps regarding our acoustic knowledge on CI belugas:

1. Hearing sensitivity data collected for seven wild belugas indicated that hearing abilities in these belugas were generally similar to those reported for captive belugas (Castellote et al. 2014). Thus based on this one study, it appears that hearing measurements in a laboratory setting may be reasonable substitutes for data from wild belugas. However, larger sample sizes are needed to fully assess maximum hearing sensitivity and variability within the species (especially age and sex based differences).
2. Very specific noise types (e.g., simulated underwater explosions, pure tones, seismic water gun, white noise, icebreaker noises) have been used in hearing experiments with belugas. Even if these studies set the baseline information on the effect of noise in the beluga auditory system, their results might not be applicable to CI belugas because most of the noise sources tested are foreign to Cook Inlet. Castellote et al. (2016b) evaluated the

sources, acoustic characteristics, and frequency of occurrence of anthropogenic noise in Cook Inlet and concluded that the temporal prevalence and levels of anthropogenic noise measured "indicate that beluga communication and hearing is largely masked by anthropogenic noise in most of the locations and periods sampled." Future research should broaden the geographic extent and months sampled, and improve the classification of unknown noise sources.

3. Little is currently known regarding chronic effects of noise exposure on belugas. CI belugas are exposed to anthropogenic noise sources of notable prevalence (e.g., tug boats, pile driving, dredging), but most of the studies to date have been focused on short-term and acute exposure to noise. Similarly, most of the current studies on the effects of anthropogenic noise on belugas have been focused at the physiological level (e.g., masked temporary threshold shifts, TTS, PTS), but the effects of anthropogenic noise at the behavioral level (e.g., geographical displacements, changes in acoustic communication) have barely been considered.
4. The current understanding of social communication in different populations of belugas highlights an important lack of standardized methods. Considering that the repertoire of beluga vocalizations has been suggested to vary geographically, the standardization of acoustic analysis methods is needed to better understand the population structure and seasonal distribution of this species. Research efforts in this direction will probably be beneficial in a broader scale, not just towards the Cook Inlet population.

7. Other Senses

Belugas have acute vision both in and out of the water. A beluga's eye is particularly well adapted for seeing in water. In air, certain features of the lens and cornea correct for the nearsightedness that result from the refraction (bending) of light rays as they go from water to air. A beluga's retinas contain both rod and cone cells, indicating that they may have the ability to see in both dim and bright light (rod cells respond to lower light levels than do cone cells). As with other whales, belugas lack short wavelength sensitive visual pigments in their cone cells indicating a more limited capacity for color vision than most land mammals (Peichl et al. 2001; Levenson and Dizon 2003).

Among marine mammals, adaptation to a strictly marine environment has favored a primary sensory modality based on sound production and reception (Wood 1973). Other senses, such as smell, are diminished or even absent (Caldwell and Caldwell 1972). The available sensory channels that are utilized by marine mammals are acoustic, tactual, visual, and chemical (gustatory; Caldwell and Caldwell 1977; Winn and Schneider 1977). Except for the bottlenose dolphin (Herman 1980) and California sea lion (Thomas et al. 1992), few studies have examined in any detail the sensory capabilities of marine mammals. Olfactory lobes of the brain are absent in all odontocetes, suggesting that they have no sense of smell, although these lobes are found in the embryos (Kellogg, 1958).

Some studies have noted sensory areas in beluga mouths that may function in taste (Haley 1986). There is further evidence of chemoreception in the mouth in some species including the beluga. Reports have suggested that belugas react to blood in the water by quickly retreating and showing unusual alarm. Furthermore, it has been proposed that belugas release a pheromone when alarmed (Dudzinski et al. 2002).

8. Social Organization

Throughout their distribution, belugas are extremely social animals that typically migrate, hunt, and interact together, often in dense groups. In areas of the Arctic, belugas aggregate in the hundreds and sometimes thousands (O'Corry-Crowe 2002). High group cohesion and large group sizes may provide benefits to group members in terms of information gathering and transfer with regard to resource availability (e.g., prey, calving sites, oceanographic conditions) and cooperation in predator avoidance and reduced predation risk (Hamilton 1971; Reluga and Viscido 2005). It is not known whether social structure plays a role in determining which adults are available for breeding. It is thought that the basic social units of these groups are maternal lineages of adult females and their offspring and that males migrate separately (Smith et al. 1994). Genetic evidence for Canadian stocks of belugas indicates that migration routes and summer distribution are maintained by maternal lineages (Turgeon et al. 2012); however, this information is unavailable for Cook Inlet. It is possible the strong site fidelity belugas exhibit may be learned during the period of dependence when the mother teaches the weaning calf to forage.

In Cook Inlet, groups of four to 250 belugas have been observed during the ice-free months, and single whales are only occasionally seen (McGuire and Bourdon 2012; T. McGuire, LGL, pers. comm.). It is not known if groups represent distinct social divisions. Preliminary results from photo-identification research indicate beluga groups in upper Cook Inlet during the ice-free months of the field season are mixed and homogenous, without evident long-term sub groupings (McGuire et al. 2011). That is, there do not appear to be distinct groups consisting of CI belugas of the same gender or ages, and the available information suggest individual belugas spend time with different groups of belugas, many of which are found in all or several of the regions surveyed by the photo-identification project. Information on beluga social structure during months with ice and for groups found in the lower Inlet does not currently exist. Studies of beluga groups in the Kenai River and its vicinity were conducted 2011–2013 and indicate these are the same individuals that use the upper Inlet, with the same fluid social structure (McGuire et al. 2014a).

9. Swimming and Diving Behavior

Belugas typically swim between 1 and 10 kilometer per hour (km/hr) (0.6–6.2 miles per hour [mi/hr]), but have been estimated to sustain speeds over 20 km/hr (12.4 mi/hr) for periods of a half hour (Richard et al. 1998). Suydam (2009) estimated typical speeds at 2.5–3.3 km/hr (1.5–2.0 mi/hr), and Smith and Martin (1994) estimated swimming speeds of 1.6–6.0 km/hr (1.0–3.7 mi/hr) during the fall migration.

According to Goetz et al. (2012a), CI belugas tagged from 1999–2000 displayed a mean transit rate of 2.8 (SD ±2.4) km/hr (1.7 mi/hr), with individuals' travel rates ranging from 1.6 (SD ± 2.0) km/hr to 4.3 (SD± 3.1) km /hr (1.0–2.7 mi/hr). Tagged CI belugas travelled faster during December to May than June to November, and travelled slower in coastal areas than they did in offshore waters of the Inlet (Goetz et al. 2012a). Based on an acoustic study conducted in Eagle River, swimming speeds of CI belugas were estimated to be from 1.8–7.56 km/hr (1.1–4.7 mi/hr) (Castellote et al. 2013).

Belugas from stocks found in regions with access to deep water are capable of dives deeper than 1,000 m (3,281 ft) (Citta et al. 2013) and at vertical speeds of 2–7 km/hr (1.2–4.3 mi/hr; Heide-Jørgensen et al. 1998). In the areas of Cook Inlet occupied by belugas, the depth does not exceed 100 m and much of the time the belugas are in waters less than 20 m (65.6 ft) depth. Consequently, CI belugas are able to access the entire water column. Typical dive sequences consist of three to five short intervals of 7–10 seconds followed by a longer dive of a minute or more. Mean dive depth ranged from 1.6 (SD ± 2.1) to 6.7 (SD ±10.4) m (5.2 to 22 ft) and mean dive duration ranged from 1.1 (SD ±1.3) to 6.9 (SD ±9.5) minutes (Goetz et al. 2012a), with shorter dives occurring in nearshore areas. The average dive interval (the time from the beginning of one surfacing to the beginning of the next) is 24.1 seconds for CI beluga (Lerczak et al. 2000).

10. Foraging Behavior, Diet, and Fisheries Management

a. Foraging Behavior

Belugas are known to feed on prey that concentrate, including shrimp and schooling or spawning fish (Seaman et al. 1982), and beluga presence has been used by fish harvesters as indicators of fish abundance. Feeding both independently and cooperatively, belugas capture and swallow their prey whole, using blunt teeth to grab prey. Quakenbush et al. (2015) noted that because belugas swallow their prey whole, the diet of smaller (young) belugas is limited by the size of the esophagus to smaller prey. The suitability of some adult salmon as prey for young belugas may thus be limited, even when salmon are available. While belugas are known to eat large amounts of fish in spring and summer, little is known about winter distribution and less about winter feeding. An extensive review of potential CI beluga prey species, including their distribution and known abundances, is presented in Appendix IX.F – CI Beluga Prey Supplement.

Current data on the foraging ecology of CI belugas are quite limited and based primarily on visual observations of whales in areas of seasonal prey concentrations. However, dive behavior data was obtained through satellite tags deployed on 11 belugas during 1999 to 2002 (Goetz et al. 2012a). Dives were significantly shorter and shallower June to November versus December to May. Over 50% of the dive effort occurred in shallow, nearshore areas of Chickaloon Bay, Susitna Delta, Knik Arm, Turnagain Arm, and Trading Bay, a behavior suggesting feeding in these areas. These locations are also recognized as areas where anadromous prey concentrate when entering river mouths. Belugas in northern Cook Inlet likely benefit from the tendency of anadromous prey species to be concentrated by shallow water and the time required to transition from salt water to fresh as these prey enter the stream mouths, which presumably makes them easier to capture.

Belugas in Cook Inlet appear to feed extensively on concentrations of spawning eulachon in the spring; CI belugas then shift to foraging on salmon species as eulachon runs diminish and salmon return to spawning streams. While winter foraging is not well known, some components of beluga whale populations in other areas forage more on benthic species (DFO 2011). It is presumed that CI belugas in winter forage more on benthic species or opportunistically on infrequently encountered pelagic species. Analysis of CI beluga stomach contents indicated gadid and flounder species were relatively important prey items in spring and fall (and likely winter), seasons when fewer salmon are available (Quakenbush et al. 2015). The degree of prey switching, either seasonally or on longer time scales, is not well understood, although belugas must be somewhat opportunistic with respect to foraging selectivity relative to prey availability.

b. Diet

The diet of belugas throughout their circumpolar range is dominated by fish and invertebrate prey. While published reports on beluga diets are available from Canada (Vladykov 1946, cited by Seaman et al. 1982; Doan and Douglas 1953, cited by Seaman et al. 1982; Sergeant 1973), Russia (Kleinenberg et al. 1969, cited by Seaman et al. 1982; Tomlin 1967, cited by Seaman et al. 1982), and Europe (Lono and Oynes 1961, cited by Seaman et al. 1982), published data for Alaska are limited to one published report (Seaman et al. 1982; n = 119 belugas from three stocks) and several unpublished reports from Bristol Bay (Brooks 1954, 1955, 1956, 1957; Lensink 1961, cited by Seaman et al. 1982; Klinkhart 1966, cited by Seaman et al. 1982). Diet data for CI belugas are currently limited to a relatively small sample of stomach contents (Quakenbush et al. 2015), stable isotope analyses (Nelson and Quakenbush 2014), as well as observations from Alaska Native subsistence hunters (Fall et al. 1984; Huntington 2000).

A total of 53 stomachs from CI belugas were collected from 1992 to 2010 (Quakenbush et al. 2015). Stomachs collected from 1992 to 2001 (April to October; n = 24) were analyzed separately from stomachs collected during 2002 to 2010 (March to November; n = 27). Thirty five non-empty stomachs were sampled; 17 from the earlier and 18 from the later time periods. For 1992 to 2001, the only prey items identified were eulachon and Chinook (king) salmon, with additional items identified only as "salmon." However, because only a portion of the contents from each stomach collected was analyzed, additional prey items were likely present. For non-empty stomachs from 2002 to 2010, fish were identified in 18 stomachs and invertebrates in nine (Table 2). Fish prey included seven families and at least 12 species. Fish frequencies of occurrence were greatest for salmon (67%), gadids (39%), smelts (11%), and flounders (11%); salmon frequencies included coho (28%), Chinook (11%), and chum (17%). Gadid frequencies included saffron cod (22%), walleye pollock (17%), and Pacific cod (6%). Eulachon was the only smelt identified, whereas two flounder species, yellowfin sole (11%) and starry flounder (6%), were identified. A longnose sucker was the only freshwater fish found. Seven types of invertebrates were found in the beluga stomachs, with the frequency of occurrence among non-empty stomachs being highest for shrimp (33%), followed by polychaetes (11%) and amphipods (11%). Other invertebrates included Tanner crab (6%) and sponges (6%). Because fish appearing in beluga stomachs have also consumed a variety of prey, including polychaetes, shrimps, amphipods, and other fishes (Clausen 1981, 1983; Seaman et al. 1982), some prey items in the beluga stomachs could have resulted from secondary ingestion.

Alaska Natives have reported CI belugas feeding on freshwater/brackish fish, including trout, whitefish, northern pike, grayling, and Pacific tomcod (Fall et al. 1984; Huntington 2000).

Stomach samples from CI belugas are lacking for the winter months of December to February. Dive data from belugas tagged with satellite transmitters suggest whales feed in deeper waters south of the Forelands during winter (Hobbs et al. 2005), possibly on prey such as flatfishes, sculpins, and gadids. Diet data for early spring are limited to one dead whale found in March 2003, which had thinner blubber than beach-cast belugas found in summer. This early spring beluga stomach contained saffron cod, walleye pollock, Pacific cod, eulachon, Tanner crab, shrimp, and polychaetes (NMFS unpub. data; Table 2).

Table 2. Prey items from CI beluga stomachs, 2002 to 2010.

	No. stomachs								
	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Total among months	Percent frequency[a]
Total no. stomachs	1	3	4	7	3	8	1	27	
Total no. stomachs with prey	1	2	4	5	1	5	0	18	67
Stomachs that contained fish	1	2	3	5	1	5	0	17	94
Salmon	0	2	3	4	1	2	0	12	67
Gadid	1	0	0	1	1	4	0	7	39
Eulachon	1	0	1	0	0	0	0	2	11
Flounder	0	0	0	1	0	1	0	2	11
Other identified fish	0	0	0	2	0	1	0	3	17
Unidentified fish	1	0	0	1	0	0	0	2	11
Stomachs that contained invertebrates	1	0	3	1	0	4	0	9	50
Shrimp	1	0	1	1	0	4	0	7	39
Amphipod	0	0	1	0	0	1	0	2	11
Polychaete	1	0	0	0	0	1	0	2	11
Other identified invertebrates	1	0	2	1	0	0	0	4	22
Unidentified invertebrates	0	0	0	0	0	1	0	1	6

[a] Percent frequency is the number of stomachs containing a prey item relative to the total number of non-empty stomachs.
Source: L. Quakenbush, ADF&G, unpub. data.

Analysis of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes in 23 archived skull bones revealed a depletion of both $\delta^{13}C$ and $\delta^{15}N$ values between 1964 and 2007 (Nelson and Quakenbush 2014). Annual growth layers from teeth (1961–2007) also showed a decline in isotope values (Nelson and Quakenbush 2014). However, the decline in $\delta^{13}C$ appeared steady over time, while the decline in $\delta^{15}N$ was steep from 1970 to 1978 and more gradual after 1978. The authors noted that the decline in $\delta^{13}C$ is consistent with the reduction of the CI belugas' range into the upper more freshwater reaches of Cook Inlet, where their prey may have a greater freshwater influence and thus be more depleted in $\delta^{13}C$ than the same prey from marine waters. The overall decline in $\delta^{15}N$ indicates a decline in trophic level. Prey isotope signatures were not identified to species. However, possible examples of such a change to lower trophic level prey include a switch from pollock or Pacific herring to capelin or sandlance, or a switch from older piscivorous pollock to younger planktivorous pollock.

Caution is warranted regarding interpretation of diet information. For example, more-recently ingested prey items are likely to be more identifiable owing to less digestion, although hard parts of prey may accumulate in the digestive tract. However, recently eaten prey are also more likely to be regurgitated from stimuli such as stress. The cause of mortality may create additional bias, as stranded belugas may have fed differently, due to poor health, compared to harvested belugas. Thus, depending on beluga health, prey type, and time since consumption, some prey items may be over or under-represented in diet analysis from stomach samples. The relatively small sample size for CI beluga stomachs remains a concern as aspects such as feeding preferences by individual whales may be underrepresented in the current analysis. While salmon is obviously important as a prey item throughout the spring to fall season, some whales may be more proficient at foraging on salmon, while other whales supplement salmon with other prey items. Thus, a better understanding of foraging selectivity by individual whales is compromised by the low sample size.

c. Fisheries Management

Management of salmon fisheries in Alaska attempts to constrain harvests to be no greater than the level of surplus production, defined as returning adult salmon in excess of the spawning production that is needed to maintain productive salmon populations (Quinn and Deriso 1999). In addition to reproductive needs, harvest considerations must include commercial fisheries and upstream consumptive uses such as recreational, personal use, and subsistence fisheries (Shields 2010), as well as allowances for natural mortality, which includes predation by belugas, bears, and other species. However, it is unlikely that escapement goals will be met in all tributaries across all years. Thus, while fishery management, on average, should maintain sufficient total numbers of prey for belugas, the timing of prey concentration or densities in the river mouths can vary and may not always be adequate for efficient feeding by belugas.

An important concern is that salmon are an essential feature of CI beluga critical habitat (76 FR 20180; 50 CFR part 226.220), and some species of salmon, most notably Chinook salmon, have had reductions in run strength in Cook Inlet and throughout Alaska. In 2012, the U.S. Secretary of Commerce determined in response to a request from the Alaska governor that commercial fishery failures due to fishery resource disasters had occurred for Chinook salmon stocks in the Yukon, Kuskokwim, and Cook Inlet regions.[13] The declaration acknowledged hardships for commercial, sport, and subsistence users as a result of the Chinook fishery failures. To identify key knowledge gaps and discuss how best to address those gaps, ADF&G sponsored a Chinook salmon symposium, "Understanding the Abundance and Productivity Trends of Chinook Salmon in Alaska," in Anchorage during October 22–23, 2012.[14] Subsequently, ADF&G worked collaboratively with federal agencies and academic partners to develop a stock assessment and research plan with recommended studies to address critical knowledge gaps (ADF&G Salmon Research Team 2013). Implementation of strict fishery management actions has been necessary to meet escapement objectives, and many fisheries have been curtailed to protect Chinook salmon. In 2016, runs improved for the westward stocks (i.e., Yukon, Kuskokwim, and Nushagak), as well as in Kodiak and Cook Inlet, but overall these runs were still below long-term averages. Runs in these regions are expected to continue to improve.[15]

More information on this topic is presented in Appendix IX.F – CI Beluga Prey Supplement.

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[13] See news release at: http://www.nmfs.noaa.gov/stories/2012/09/09_13_12disaster_determinations.html; A copy of the letter from Acting Secretary Blank to Governor Parnell can be viewed at: http://www.nmfs.noaa.gov/stories/2012/09/docs/blank_parnell_9_13_12.pdf.

[14] For more information about the Chinook salmon symposium, visit ADF&G's website at: http://www.adfg.alaska.gov/index.cfm?adfg=chinook_efforts_symposium.information.

[15] Information on Chinook salmon runs in 2016 is from ADF&G's website (accessed December 2016) at: http://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main.

C. CI Beluga Population Size and Trends

1. Historic Abundance Estimate and Carrying Capacity

Aerial surveys in the 1960s, 1970s, and early 1980s counted belugas in Cook Inlet but only a few of these had sufficient coverage to estimate the population size (Calkins 1984, 1989). A survey in 1979 resulted in an estimate of 1,293 whales using a correction factor of 2.7 developed to account for submerged whales under similar conditions in Bristol Bay (Calkins 1989). This is the best available estimate of historical beluga abundance in Cook Inlet, and represents the maximum observed size of this population. Therefore, based on the best information available, NMFS has adopted this maximum historical abundance estimate, rounded to 1,300 belugas, as the estimated carrying capacity to be used for management purposes (65 FR 34590, May 31, 2000). We have no data at this time to indicate whether this carrying capacity may have changed.

Between 1979 and 1994, the CI beluga population declined from 1,300 to 650 belugas, which represents an average annual decline of around 5% (i.e., $650 = 1300*0.955^{(1994-1979)}$). While the decline between 1994 and 1998 is well documented and attributed to unsustainable subsistence harvest, empirical data are lacking for the period between 1979 and 1994 to identify a mechanism of decline. Native subsistence harvest (enumerated through hunter interviews) was significant during the 1970s and 1980s and may have been at levels similar to the hunts reported in the mid-1990s, but there was no comprehensive count of subsistence harvest until the 1990s (Mahoney and Shelden 2000). Commercial and sport hunts also occurred during the 1960s and 1970s, but no information is available to assess whether the 1979 abundance estimate of 1,293 (based on the 1979 ADF&G survey; Calkins 1989) may represent a partially depleted population, and thus a conservative estimate of Cook Inlet carrying capacity for belugas.

2. Recent Abundance Estimates and Population Trends

NMFS began conducting comprehensive, systematic annual aerial surveys of the beluga population in Cook Inlet in 1993 (Hobbs et al. 2015b). Beginning with the 2012 annual survey, the survey schedule was switched from annually to biennially, to occur in even numbered years (see Hobbs 2013). These surveys occur in early June (except in 1995 when the survey was in late July), include the upper, middle, and lower sections of the Inlet, and are stratified to focus survey effort in the areas of the upper Inlet where belugas are typically at their highest concentrations during June. At the time of publication of this document, aerial surveys had been flown in 2016; however, the data analysis to determine the 2016 abundance estimate had not been completed.

Annual estimates of the numbers of CI belugas resulting from these surveys documented a decline in abundance of nearly 50% between 1994 and 1998, from an estimate of 653 whales to 347 whales (Table 3). This period of rapid decline was associated with a substantial, unregulated subsistence hunt; although the hunt was regulated starting in 1998, CI beluga numbers did not increase. An analysis indicated the decline in beluga abundance from 1994 to 1998 was adequately explained by the estimated take from the subsistence hunt. With the very limited hunt beginning in 1999 (a total of five whales hunted from 1999–2014, 16 years) NMFS anticipated that the population would begin to increase at a growth rate of between 2% and 6% per year. The 2014 abundance estimate was 340 belugas, with a declining trend for both the most recent 10-year time period (–0.4% per year; standard error [SE] = 1.3%) and since the hunt was managed

Table 3. CI beluga abundance estimates and coefficients of variance (CVs), June/July 1994 to 2014.

Year[a]	Survey dates	Abundance estimate	CV[b]
1994	June 1–5	653	0.24
1995	July 18–24	491	0.21
1996	June 11–17	594	0.20
1997	June 8–10	440	0.13
1998	June 9–15	347	0.17
1999	June 8–14	367	0.09
2000	June 6–13	435	0.14
2001	June 5–12	386	0.10
2002	June 4–11	313	0.10
2003	June 3–12	357	0.08
2004	June 2–9	366	0.13
2005	May 31–June 9	278	0.10
2006	June 5–15	305	0.10
2007	June 7–15	375	0.08
2008	June 3–12	375	0.11
2009	June 2–9	321	0.11
2010	June 1–9	340	0.08
2011	May 31–June 9	284	0.09
2012	May 29–June 7	312	0.13
2014	June 3–12	340	0.08

[a] Surveys in 1993 were not suitable for analysis using the abundance estimation methods of 1994 and later. No surveys were conducted in 2013 or 2015.

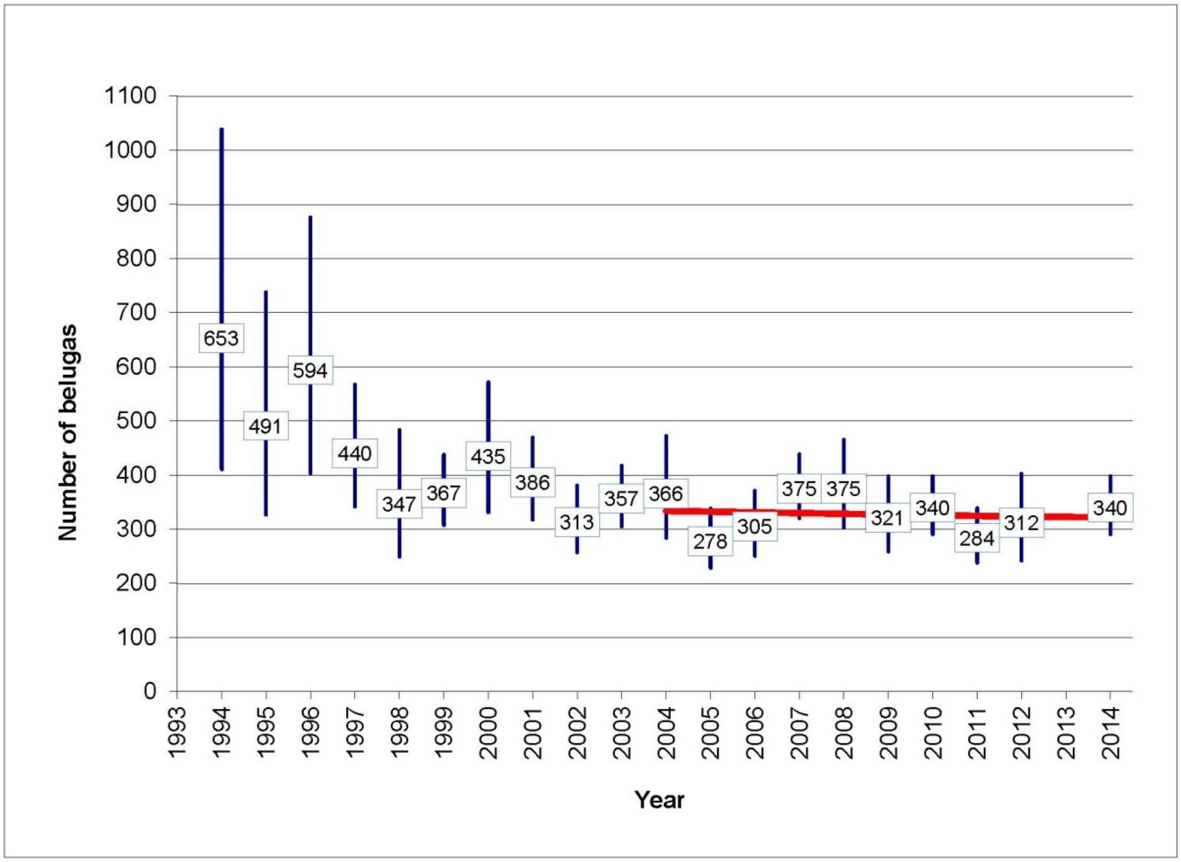
[b] CV estimates prior to 2011 used the method of Hobbs et al. (2000) in previous publications. These have been recalculated using a revised CV formula based on the standard error of the daily abundance estimates and an estimate of the variance in behavior of the whales which better reflects the sources of variability in the estimate. The method for calculating the CVs was revised in 2011; CV's for older estimates have been recalculated using the new formula.

Source: Shelden et al. 2015a; Hobbs et al. 2015b.

in 1999 (–1.3% per year, SE = 0.7%) (Shelden et al. 2015a; Figure 13). Thus, the population is not growing as expected despite the regulation of the subsistence harvest.

3. Small Population Dynamics

Small populations, such as the CI beluga population, may face inherent risks that large populations do not, simply as a result of their small population size. Small population dynamics may be at play when the impact to individual survival and fecundity increases as the population abundance decreases, or when there are persistent effects that result from a population having been small at an earlier time. These small population dynamics may manifest in various ways, including inbreeding, loss of genetic or behavioral diversity, or Allee effects. The Allee effect refers to a positive relationship between individual fitness and either abundance or densities of individuals (Stephens et al. 1999). For example, a very small population may experience Allee effects such as reduced reproductive success due to difficulties finding mates or reduced foraging success due to difficulties in locating prey. Reduced population sizes could mean reduced breeding opportunities and an increased potential for breeding with relatives. If a population



Notes: Abundance estimates for belugas in Cook Inlet with 95% confidence intervals for revised coefficients of variation (CVs) (vertical bars). From 1994 to 1998, when the harvest was unrestricted, the annual rate of decline was –13.7% (SE = 0.045) per year. In the years since a hunting quota was in place (1999–2014), the rate of decline was –1.3% (SE = 0.7%) per year. The 10-year trend (2004–2014) was –0.4% (SE = 1.3%) per year.

Source: Shelden et al. 2015a.

Figure 13. Estimated abundance of CI belugas, 1994–2014, with 95% confidence intervals for each estimate (vertical bars).

remains small, genetic diversity will decrease with each generation, resulting in a greater risk of extinction. Even if the population later increases in size, there may still be lingering consequences of the low genetic diversity. Reduced genetic diversity could result in:

- Increased susceptibility to disease due to reduced variety of immune responses within inbred individuals, such that each beluga is more susceptible to a disease organism and also more likely to suffer severe symptoms.
- Increased risk of epidemic disease due to loss of variability among individuals. With more similarity among individuals, the disease organism also requires less adaptation among individuals, resulting in greater virulence and more rapid spread.
- Decreased resilience to environmental change at both individual and population levels. Individual belugas will have a more limited phenotypic (i.e., the observable properties of an organism that are produced by the interaction of the genotype and the environment) response to changes in the environment; this limited response will narrow the adaptive range for the population.

- Decreased fecundity due to failed pregnancies and birth defects. With loss of diversity in the population, the likelihood increases for a fetus to develop a phenotype with decreased survival, resulting in a lost reproductive opportunity and reducing the net number of offspring that a female produces over her lifetime.

While these are potential consequences of small population size, NMFS concluded that the Allee effect is not a relevant concern for CI belugas unless the population size is smaller than 50 animals (Hobbs et al. 2006). Similarly, inbreeding depression and loss of genetic diversity do not pose a significant risk to CI belugas unless the population is reduced to fewer than 200 whales (Hobbs et al. 2006).

Little is known about the social structure of CI belugas and how it relates to effective population size. Social structure may limit who and how many belugas breed, resulting in a lower effective population size and reproductive capacity than the population size and age-sex composition would indicate. In addition, some behaviors are transmitted from parents to offspring in other better-studied matriarchal odontocetes. In these other matriarchal odontocete groups, behavioral variation of females is passed to their offspring, much like genetic variation (e.g., Würsig and Pearson 2015). As a result, social units or groups within the same population might display significant behavioral differences. Seasonal foraging strategies and site fidelity are examples of learned behaviors. Belugas show strong site fidelity, which may be learned during the period of dependence when the mothers teach the weaning calves to forage. Loss of behavioral diversity could result in:

- Reduced spatial distribution, increased risk of stranding, reduced prey choices, and reduced predatory efficiency due to fewer learning opportunities and greater similarity of experiences among remaining females.
- Decreased juvenile survival due to a reduction of learned recognition of habitat and resources, such as alternative prey, refuge from predators or disturbance, or other use-specific areas (Wade et al. 2012).
- Reduced socialization with fewer opportunities to learn foraging techniques, mating, group cohesion, and hierarchical definition or strengthening, as well as a reduction in mutual defense against, or avoidance of, predators. A decline in the population will be paralleled by a reduction in behavioral diversity.
- Overall fitness and resilience to perturbations such as catastrophic events.

CI belugas have exhibited a marked contraction of their summer habitat range. If CI belugas are matriarchal and pass knowledge from female to offspring, it is possible that some knowledge regarding preferred summer habitats in mid- and lower-Inlet might not have been passed on to the current generation. If this is the case, it is unknown how long it would take for these habitats to be recognized again by individuals in the current or a recovered CI beluga population. Our knowledge regarding CI beluga social structure and differences in behavior among groups is quite limited, but the available information indicate that large groups of CI belugas observed in the Susitna River Delta do not appear to be segregated by color or age-class, with most groups consisting of both white and gray animals (McGuire et al. 2014b). Photo-identification studies of the upper CI also suggest that most, and perhaps all, of the CI beluga population uses Eagle Bay seasonally, with 90% of CI belugas also having been seen elsewhere in upper CI (McGuire et al. 2014c). Thus there seems to be significant intermixing of age groups/color classes and a high resight rate of individuals in multiple locations, and at this time we have no information to suggest there has been a loss of behavioral diversity in the CI beluga population.

Although reduction of range likely increases the risk of extinction, the implications of this shift are not entirely clear and are in need of investigation. Range contractions generally increase vulnerability to catastrophic loss from stochastic events and point sources of disturbance, disease, and mortality. These risks may have become exacerbated in the CI beluga population by a range contraction to the area of greatest human impact. It is not known how the range contraction may have altered behavior and habitat use within the consistently occupied areas in the upper Inlet. With fewer whales, prey may be relatively more abundant, thus reducing competition and the need for more wide ranging movements. Concentrating in large numbers in discrete areas appears to be a basic trait of belugas and a strategy by the Cook Inlet population. While likely increasing vulnerability to catastrophic events, such behavior may reduce risk from other factors such as predation. It is essential to focus research on understanding both the cause and implications of the range contraction in CI belugas.

4. CI Beluga Population Viability Analysis (PVA)

A population viability analysis (PVA) for CI belugas that was completed at the time of listing under the ESA indicated a risk of extinction in 100 years between 1% and 27% (Hobbs and Shelden 2008). The model that NMFS considered to best represent the risk to the CI beluga population indicated a 26% probability of extinction in 100 years. The detailed PVA population model used the abundance estimates for 1994 to 2008 and accounted for immature and mature stages of both sexes (Hobbs and Shelden 2008). The PVA was based on a Bayesian analysis[16] using a population model that accounts for the removals from the population by the subsistence hunt, births and deaths in the population, and time lags in the response of the population to changes. More recently, Hobbs et al. (2015c) developed another PVA analysis that incorporated five additional abundance estimates (for the years 2010, 2011, 2012, and 2014). This recent PVA included some model scenarios that were not included in the 2008 analysis, and the values for some model parameters differed from those used in corresponding models in Hobbs and Shelden (2008). There was considerable variation in risk of extinction at 100 years among the models, with the probability of extinction (among the five models that best fit the existing CI beluga data, along with the model accounting for risk of catastrophic events) ranging between 0% and 14%. Based on the modelling results, the authors concluded it is likely the CI beluga population will continue to decline or go extinct unless factors determining its growth and survival are ameliorated.

[16] Statistical modeling technique that factors in uncertainty.

D. Sources of CI Beluga Mortality or Injury

1. Natural Sources

a. Predation

The only known current predator of CI belugas is the "transient" or mammal-eating killer whale; there has not been a subsistence hunt by Alaska Natives in Cook Inlet after 2005. However, it is possible that sharks may also occasionally prey upon belugas.

Killer whales are infrequently reported (Table 4) in upper Cook Inlet (Shelden et al. 2003; NMFS, unpub. data), which is now the primary summer range of CI belugas (Rugh et al. 2010). The contraction in CI beluga summer range to the shallow waters of the upper Inlet may reduce the opportunity for killer whales to pursue belugas in this area.

Interviews with people that have fished the upper Inlet for 20 to 50 years reported few sightings of killer whales (Shelden et al. 2003). In his study of TEK, Huntington (2000) interviewed Alaska Native beluga hunters who reported that killer whales were rarely seen in the upper Inlet or near belugas. Currently, beluga sighting networks are scattered along those portions of Cook Inlet shorelines that are road-accessible, and interest among the public is high, so there is an increased opportunity for any killer whale occurrences near Cook Inlet road access points to be reported, especially when these include encounters with belugas.

Additional evidence that killer whale presence in upper Cook Inlet is rare comes from beluga observational and photo-identification work. Between 2004 and 2014, over 30,800 observational hours were logged between May and October in areas that included Turnagain Arm, western upper Cook Inlet, the area west of Fire Island to the Little Susitna, Knik Arm, and around the Kenai River, and no killer whales were observed (McGuire, LGL, unpub. data).

Killer whales have been seen in the upper Cook Inlet in Turnagain Arm and Knik Arm, between Fire Island and Tyonek, and near rivers along the Susitna Delta (Shelden et al. 2003; NMFS, unpub. data). Killer whales have also been reported in areas of the mid and lower Inlet, including near the Chuitna and Kenai Rivers (Table 4) and Kamishak Bay. In addition, Lammers et al. (2013) reported a single detection of a killer at both the Beluga River and Tuxedni Bay. From morphology, behavior, and the small group sizes described in sighting reports, it would appear the killer whales observed in upper Cook Inlet are a transient (marine mammal eating) group. The frequency of sightings in upper Cook Inlet is very low; therefore, killer whales observed in the upper Inlet apparently center their range elsewhere. Killer whales have stranded at least four times in Turnagain Arm since 1990: in May 1991, August 1993, September 2000, and August 2002. During the 1993 stranding event, a large male killer whale regurgitated pieces of beluga and harbor seal (Shelden et al. 2003) and subsequently died.

The number of different killer whales that use the upper Inlet is not known but appears to be small. Photographs taken of killer whales that stranded in Turnagain Arm in 1991, 1993, and 2000 provide evidence that the same adult male was sighted in both 1991 and 1993 (Shelden et al. 2003). Poor quality of additional photographs precluded the identification of other individuals, but they do suggest that the composition of the killer whale pod during these three encounters was similar and the same individuals may be involved in each event. No matches were found between the images of killer whales in Turnagain Arm and those in all available catalogs for Alaska south to Mexico (Shelden et al. 2003).

Table 4. Reported killer whale observations in upper Cook Inlet, and reports of killer whale predation on CI belugas Inlet-wide, 1982–2016.

Year	Reported location of killer whale sighting / predation event[a]	No. reported killer whale sighting / predation events in upper Cook Inlet *(including events in mid and lower Cook Inlet if associated with a potential predation event)*	No. reported killer whales observed per sighting event[b]	No. beluga mortalities suspected to be a direct result of killer whale predation[b]
1982	Knik Arm	1	5	0
1983	*No Reports*	0	0	0
1984	*No Reports*	0	0	0
1985	Turnagain Arm	1	1	UNK
1986	*No Reports*	0	0	0
1987	*No Reports*	0	0	0
1988	*No Reports*	0	0	0
1989	*No Reports*	0	0	0
1990	Chickaloon Bay	1	>3	1
	Fire Island[c]	1	4	0
1991	Turnagain Arm	1	6	0
1992	Kenai River	(1)	6	0
1993	Turnagain Arm	1	5	1
1994	Susitna River	1[d]	UNK	0
1995	Ivan River	1	3	0
1996	Ivan River	1	UNK	0
1997	Ivan River	1	UNK	0
1998	Ivan River	1	UNK	0
	Port MacKenzie to Fire Island	1	3	0
1999	Turnagain Arm	1	3	0
	Ivan River	1	UNK	0
	Chinitna Bay	(1)	1	1 (2)[e]
2000	Turnagain Arm	1	3–5	2 (4)[e]
	Kenai River	(1)	3	1
	Kachemak Bay	(1)	1	UNK
2001	Turnagain Arm	1	1	0
2002	Turnagain Arm	3	1	0
	Knik Arm	1	1	0
	Chuitna River	1	2	0
2003	Knik Arm	1	2	1
2004	*No Reports*	0	0	0
2005	*No Reports*	0	0	0
2006	*No Reports*	0	0	0
2007	Turnagain Arm	1	3	0

Year	**Reported location of killer whale sighting / predation event**[a]	**No. reported killer whale sighting / predation events in upper Cook Inlet** *(including events in mid and lower Cook Inlet if associated with a potential predation event)*	**No. reported killer whales observed per sighting event**[b]	**No. beluga mortalities suspected to be a direct result of killer whale predation**[b]
2008	Tyonek	1	2	0
	Turnagain Arm	1	2[f]	1
2009	Turnagain Arm	1	6	0
2010	Point Possession	2	4–5 and 3	1[g]
2011	Turnagain Arm	1	1	0
2012	*No Reports*	0	0	0
2013	*No Reports*	0	0	0
2014	*No Reports*	0	0	0
2015	Knik Arm	2	1 and 1	0
2016	*No Reports*	0	0	0
Totals: 1982–2016		**35** *(31 upper CI + 4 mid-lower CI)*	**Total: 77+ Average: 2–3**	**9** (*12 if potentially dependent calves included*)

[a] A predation event is defined as an event during which killer whales were observed chasing belugas, catching belugas, or when a beluga carcass was found with evidence of killer whale tooth marks on it.

[b] UNK = the information is unknown, undetermined, or unreported

[c] Year of sighting estimated; this report was from Shelden et al. (2003) and was based upon an anecdotal report of a killer whale sighting in the "early 1990s."

[d] This was an unconfirmed sighting of killer whales in the area of the Susitna River; see Shelden et al. (2003) for more details.

[e] These reports suggest that a dependent calf may have been present. Although there is no evidence the calf was killed, we assume the calf may also have died, either as a direct predation event or due to the death of its mother; thus, we have reported the number of mortalities as a range (1–2) indicating the possibility that a mom/calf pair died.

[f] This sighting of killer whales may have been the same two killer whales previously reported near Tyonek.

[g] The necropsy report for this beluga mortality indicated that killer whale predation may have been a possible cause of death, but poor body condition of the beluga carcass prevented a positive determination.

Sources: Moore et al. 2000, Shelden et al. 2003, Vos and Shelden 2005, NMFS, unpub. data. (Level A stranding and necropsy reports)

Between 1982 and 2016, NMFS received 31 reports of killer whales in upper Cook Inlet, 4 reports of killer whales possibly preying on CI belugas in mid- and lower Cook Inlet, and 9–12 CI beluga mortalities Inlet-wide suspected to be a direct result of killer whale predation (Table 4). The 9–12 CI beluga mortalities suspected to be a direct result of killer whale predation were identified based upon evidence of predation observed on beluga carcasses or eye witness reports. We present this number as a range to indicate our uncertainty regarding the fate of three calves still dependent upon their mothers, which were killed by killer whales. However, there is no evidence available to document the deaths of these three calves.

A review of the original sightings reports has resulted in a change of opinion about some mortalities originally attributed to killer whale predation. Shelden et al. (2003) reported that two CI belugas died on October 6, 1992 with "killer whale teeth marks on their flukes." Although there were reports of killer whales in the Kenai River in September 1992, a review of the original

Level A stranding reports[17] for the two belugas reveal that there were "no gross injuries" observed and no mention of killer whale teeth marks on either beluga. A comparison of the photographs taken of the October 1992 beluga carcasses against photographs of CI beluga carcasses with confirmed killer whale teeth marks from 2000 led NMFS AKR to determine that the whales stranded in the Kenai River in October 1992 were "not attacked by killer whales" (NMFS, unpub. data; Level A stranding report). Additionally, Moore et al. (2000) reported that in early September 2000 a CI beluga carcass was documented near Nikiski with "possible orca teeth marks" (reproduced in Shelden et al. 2003). However, after review of the original Level A stranding report, NMFS AKR confirmed the report never mentioned possible orca (a.k.a., killer whale) teeth marks, and given that the report states the whale was "very decomposed", "skeletal remains were visible", and it was "too deteriorated to collect skin for genetics" testing, there would be too little skin available to see teeth marks from a killer whale. Despite the person reporting the dead whale speculating that a "killer whale took bites from its belly", without evidence supporting killer whale predation, the stranding event in Nikiski in 2000 cannot be deemed to be the result of killer whale predation. Finally, Shelden et al. (2003) indicated "killer whale teeth marks [were] evident" on a dead beluga found June 20, 1991, based on a report by Moore et al. (2000) that the beluga was found with teeth marks and a piece of its tail missing. However, after review of the original Level A stranding report, NMFS AKR found that the "bitemark" noted in the report was qualified as "may have been." Without additional corroborating information, there is insufficient evidence to deem this stranding to be the result of killer whale predation. Thus, although previously considered evidence of killer whale predation on CI belugas (see Moore et al. 2000 and Shelden et al. 2003), the mortalities from June 1991, October 1992, and September 2000 are not included in Table 4 as mortalities suspected to be the direct result of killer whale predation.

Since 2001, only three CI beluga deaths have been suspected to be a result of killer whale predation: one in Knik Arm in August 2003; one in Turnagain Arm in September 2008; and one near Point Possession in June 2010. However, the 2010 mortality necropsy report stated although predation was a possible cause of death, it could not be positively determined due to the poor condition of the beluga carcass.

Killer whales in the vicinity or actively chasing belugas could also cause CI belugas to strand alive. Such events may have contributed to several more CI beluga mortalities beyond those listed in Table 4 (strandings are discussed in the next section). For instance, in August of 1999, approximately 60 belugas live stranded in Turnagain with reports of killer whales in the vicinity prior to the stranding. Five mortalities were associated with that stranding event. However, in the absence of trained observers documenting killer whales' pursuit of belugas directly to the location of a stranding, it is not possible to definitively attribute a mortality after a live stranding event to killer whale predation without physical evidence of predation on the carcass. Therefore, any mortalities associated with a live stranding event, despite reported killer whale presence in the area, are not included in Table 4.

There have been anecdotal reports and other observations of killer whales attacking or chasing CI belugas in lower Cook Inlet when belugas were more frequently observed in lower

[17] Level A stranding report forms are the forms used by NMFS to document stranding-related events.

Cook Inlet. For instance, one person reported in 2002 that in 1999 they saw a killer whale dragging an adult beluga by its flipper from Chinitna Bay into deeper water, with the beluga's calf following; and another person recalled seeing a killer whale chasing a beluga in Kachemak Bay in 2000 (Shelden et al. 2003; included in Table 4). Hobbs and Shelden (2008) and NMFS (2008a) also reported that killer whales chased and fed on a beluga near Anchor Point on June 14, 2007. However, after follow-up interviews and a review of additional photos and video, it was determined that it was a minke whale that was killed by killer whales near Anchor Point, and not a CI beluga.

In directed killer whale surveys in lower Cook Inlet in July 2008 and July 2009, there were eleven encounters with resident type killer whales (fish-eaters) and five encounters with transient type killer whales (mammal-eaters; Matkin et al. 2009). During these directed, and other opportunistic, observations of killer whales in lower Cook Inlet, transient killer whales were recorded killing minke whales, harbor porpoises, and harbor seals, and attacking sea otters and humpback whales (Matkin et al. 2009; C. Matkin, North Gulf Oceanic Society, unpub. data). No beluga predation was observed during directed or opportunistic observations by researchers or the public in the lower Inlet during this time period (Matkin et al. 2009).

CI belugas may also be susceptible to shark predation, although attacks have not been witnessed, nor has clear evidence of shark predation been documented. Wounds from possible shark attacks have been observed in photographs of CI belugas (T. McGuire, LGL, unpub. data). Salmon sharks and Pacific sleeper sharks are found in Cook Inlet, although neither has been determined to attack free-swimming cetaceans. Salmon shark jaw and tooth structure is indicative of a fish predator and it is highly unlikely they would attack a marine mammal (K. Goldman, Alaska Department of Fish and Game [ADF&G], pers. comm.to C. Goertz). Pacific sleeper sharks are known to feed on whale carcasses (Barrett-Lennard et al. 2011), and although cetacean remains have been found in their stomachs, this was apparently the result of scavenging and conclusive evidence of predation on live cetaceans is lacking (Sigler et al. 2006). A counterpart in the Atlantic Ocean, the Greenland shark, apparently consumes live pinnipeds (Sigler et al. 2006), but is not known to be a predator of free swimming cetaceans. It is possible that great white sharks make rare visits to the area (Martin 2005), but they are very unlikely to pose a threat to belugas due to their rarity.

b. Strandings

CI beluga strandings include beached or floating carcasses as well as live animals found in waters too shallow to permit them to swim. An extensive review of the NMFS AKR Level A stranding reports resulted in some updates to the CI beluga stranding data presented in Moore et al. (2000), Vos and Shelden (2005), and NMFS (2008a and 2008b). The total number of CI beluga carcasses reported in Table 5 reflects the most current information available regarding the number of reported, non-subsistence related mortalities since 1988.

Beluga whale live strandings in upper Cook Inlet are not uncommon, with a majority occurring in Turnagain Arm and Knik Arm (Table 5). Live stranded whales are often opportunistically spotted from the Seward Highway off of Turnagain Arm, or from small aircraft traveling over Cook Inlet. Between 1988 and 2016, 214 dead CI belugas were reported, and at least 876 belugas were involved in live strandings in Cook Inlet (some individual belugas were likely involved in multiple live stranding events over the years; Table 5). Mass strandings (involving two or more whales) primarily occurred in Turnagain Arm and often coincided with

Table 5. CI beluga stranding records (for beach-cast or floating carcasses, and live strandings), 1988–2016.

Year	Total no. carcasses (beached or floating) reported each year[a]	Date of live stranding event[b]	Location of live stranding event[b]	No. belugas per live stranding event (suspected associated mortalities)[b]
1988	0	Oct 23	Turnagain Arm	27 (0)
1989	5	NA	NA	NA
1990	2	NA	NA	NA
1991	1	Aug 31	Turnagain Arm	70–80 (0)
1992	5	Oct 3	Kenai River	2 (2)
1993	2	Jul 6	Turnagain Arm	10+ (0)
1994	8	Jun 14	Susitna River	186 (0)
1995	3	NA	NA	NA
1996	12	Jun 12 Aug 28 Sep 2 Sep 8 Oct 2	Susitna River Turnagain Arm Turnagain Arm Knik Arm Turnagain Arm	63 (0) 60 (4) 20–30 (1) 1 (0) 10–20 (0)
1997	3	NA	NA	NA
1998	14	May 14 Sep 17	Turnagain Arm Turnagain Arm	30 (0) 5 (0)
1999	12	Aug 29 Sep 9	Turnagain Arm Turnagain Arm	58–70 (5) 12–13 (0)
2000	13	Aug 27 Sep 24 Oct 24	Turnagain Arm Turnagain Arm Turnagain Arm	8 (0) 15–20 (0) 2 (0)
2001	10	NA	NA	NA
2002	10	NA	NA	NA
2003	20	Apr 18 Aug 28 Sep 6 Sep 14 Oct 6 Oct 17	Turnagain Arm Turnagain Arm Turnagain Arm Turnagain Arm Turnagain Arm Ship Creek	1–2 (0) 46+ (5) 26 (0) 32 (0) 4–9 (0) 1 (0)
2004	13	NA	NA	NA
2005	6	Aug 24	Knik Arm	7 (1)
2006	8	Sep 12	Knik Arm	12 (0)
2007	15	NA	NA	NA
2008	11	Aug 7 Sep 28	Knik Arm Turnagain Arm	28–30 (2) 20–40 (0)

Year	Total no. carcasses (beached or floating) reported each year[a]	Date of live stranding event[b]	Location of live stranding event[b]	No. belugas per live stranding event (suspected associated mortalities)[b]
2009	4	Aug 22	Knik Arm	16–21 (0)
2010	5	Aug 21 Aug 29	Knik Arm Knik Arm	11 (0) 2 (0)
2011	3	Aug 10	Knik Arm	2 (0)
2012	3	May 8 Aug 21 Aug 29	Turnagain Arm Turnagain Arm Turnagain Arm	12(0) 23 (0) 3 (0)
2013	5	NA	NA	NA
2014	10	UNK (late May?) Aug 23	UNK Eagle Bay	UNK (2)[c] 76+ (0)
2015	3	Aug 27	Turnagain Arm	2 (0)
2016	8	NA	NA	NA
Total	214			876–953 (22)

[a] Known subsistence harvested belugas are not included.

[b] NA indicates there were no live strandings reported to NMFS that particular year.

[c] On May 26, 2014 NMFS received a report of two dead belugas on the shore of Kincaid Park along Turnagain Arm; although there was no live stranding event reported, the necropsy of these two whales suggests they were recently live stranded and that the live stranding may have contributed to their death.

Source: Moore et al. 2000; NMFS 2008a, 2008b; NMFS AKR, unpub. data (CI beluga stranding database).

extreme tides or killer whale sighting reports (Shelden et al. 2003). In 2003, an unusually high number of beluga live strandings (five separate events in Turnagain Arm involving between 2 and 46+ whales) and mortalities (n = 20) occurred in Cook Inlet (Vos and Shelden 2005).

Marine mammals strand alive for a variety of reasons. Belugas may intentionally ground themselves in shallow waters to more easily rub off molting skin, to avoid predation or other perceived threats (e.g., acoustic disturbances, vessel traffic, or other anthropogenic activity), when chasing prey, or as a result of an inability to properly navigate or maneuver when debilitated by injury or disease (Smith et al. 1992, Moore et al. 2000, Shelden et al. 2003, Vos and Shelden 2005, Burek-Huntington et al. 2015). A prolonged period out of the water may ensue if animals strand during outgoing tides, especially with the extreme/rapid tidal changes and gently sloping mudflats of Cook Inlet. The perception is that belugas tolerate such events better than other cetaceans due to their relatively small size and flat abdomens which spread out their weight and allow them to remain upright, their light color which minimizes the absorption of heat from sunlight, and their ability to create wallows in the mud to retain at least some water to help them stay cool and moist. While belugas often appear calm and seem to float off without incident with the incoming tide, these animals have not been assessed or tracked other than during the stranding itself and from a great distance.

However, carcasses found following documented mass strandings, as well as carcasses found in the absence of such events, have shown evidence of death as a result of a live stranding. Findings from 38 CI belugas necropsied between 1998 and 2013 indicated nine died following a live stranding (Burek-Huntington et al. 2015; note Table 5 documents a total of 13 belugas may have died after a live stranding event; not all of these belugas were accessible and necropsied, but were included in the table due to the close timing of a dead beluga with a reported live stranding event). Five of these nine belugas were found dead shortly after documented mass strandings. Some of these dead belugas appeared to have been robust and otherwise healthy, with no other definitive causes of death. However, they did have debris deep in their airways suggesting forceful inspiration of mud while alive, such as might occur during a live stranding (Burek-Huntington et al. 2015; NMFS AKR, unpub. data). In May 2014, two belugas found dead near Anchorage also had sand deposited within their airways suggesting a recent live stranding event (NMFS AKR, unpub. data), although no live stranding event was reported.

Four additional individual carcasses had extensive post-mortem sampling and analyses which did not reveal a pre-existing health problem or other cause of death; however, sand and silt was found in the airways, again suggesting forceful inspiration of mud as might occur during a live stranding. In addition to the obstructive inhalation of debris leading to asphyxia (lack of oxygen), live strandings could also lead to death due to stress, hyperthermia (abnormally elevated temperature), pressure necrosis (cellular death due to excessive pressure) of internal organs, aspiration pneumonia (pneumonia due to inhaled material), and kidney damage secondary to myopathy (muscular damage) or muscle compartment syndrome (muscular swelling constricted by surrounding tissue resulting in reduction of blood supply). Some of these conditions may take weeks to months to fully develop and cause death. They may also exacerbate pre-existing conditions, making it difficult to determine whether death was caused by a previous live stranding. Understanding the true impact of live stranding on animals that survive the ordeal requires a more directed assessment and tracking of those animals. Live belugas have not been observed to strand in SLE and deaths attributed to such events have not been identified there (S. Lair, pers. comm. to C. Goertz).

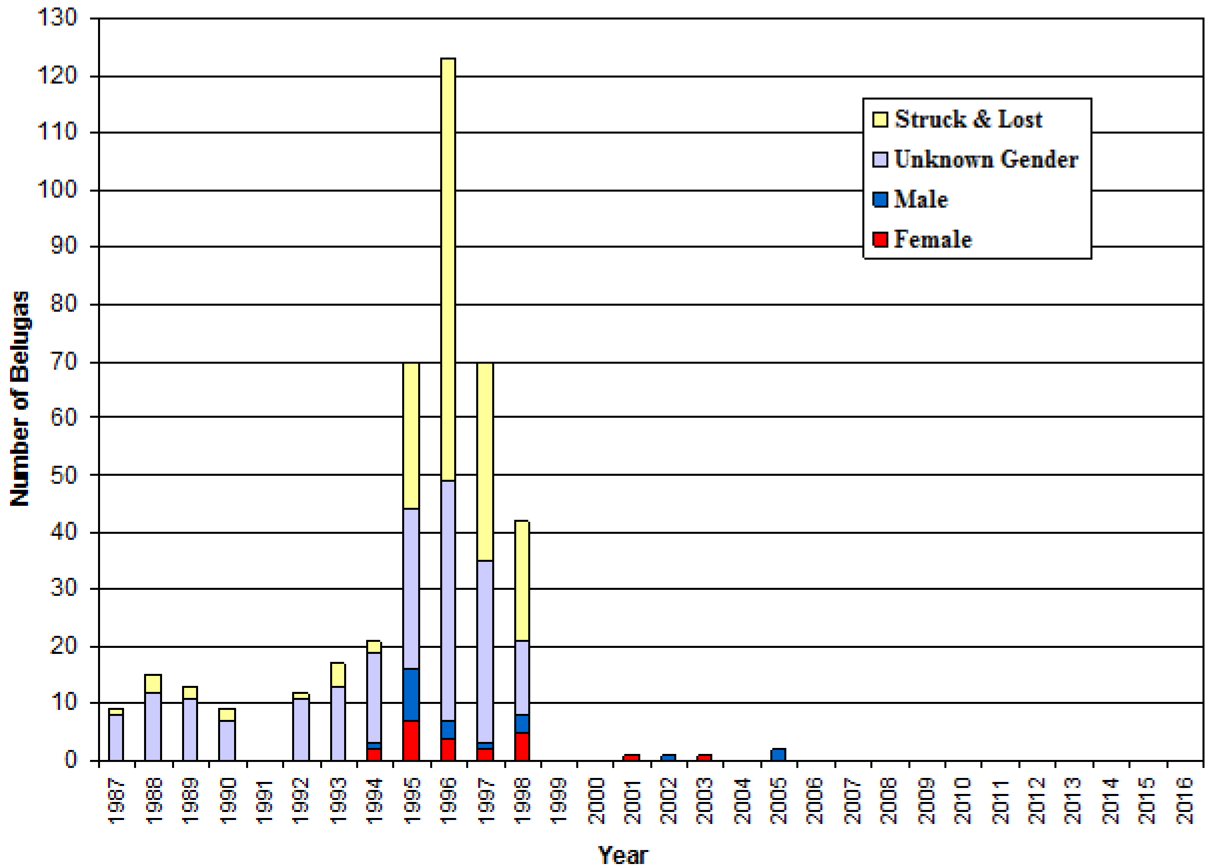
2. Anthropogenic Sources

a. Subsistence Harvest

Alaska Natives harvested CI belugas for cultural, subsistence, and handicraft purposes prior to and after passage of the MMPA in 1972. The effect of past harvest practices on the CI beluga population is significant, particularly the harvests of the mid-to late-1990s. While harvests occurred at traditional (but undocumented) levels for decades, the subsistence harvest removals apparently increased substantially beginning in the 1980s, with unsustainable removals in the 1990s (Figure 14) (CIMMC [Cook Inlet Marine Mammal Council] 1996, 1997; Mahoney and Shelden 2000; Angliss et al. 2001; Angliss and Lodge 2002; National Oceanic and Atmospheric Administration [NOAA] 2007; NMFS AKR, unpub. data[18]). This increase in harvest numbers may have been the result of an increased Alaska Native population in the Cook Inlet region, with new participation by hunters who previously lived in areas without a traditional history of hunting in the Inlet.

A study conducted by ADF&G, in cooperation with the Alaska Beluga Whale Committee and the Indigenous People's Council for Marine Mammals, estimated the subsistence take of

[18] For more information, contact NMFS AKR, Protected Resources Division.



Source: Angliss and Lodge 2002; CIMMC 2007; NMFS 2008b; NMFS AKR, unpub. data.

Figure 14. Summary of reported CI beluga subsistence harvests and estimated numbers struck and lost, 1987 to 2016.

belugas in Cook Inlet in 1993 at 17 whales. In consultation with Native Elders from the Cook Inlet region, the CIMMC estimated the annual number of belugas taken by subsistence hunters during this time to be over 30 per year. However, without a complete survey of hunters, this most likely is a minimum estimate (Hill and DeMaster 1998; DeMaster 1995). There was no systematic CI beluga harvest survey in 1994; instead, harvest data were compiled at the November 1994 Alaska Beluga Whale Committee meeting. The most thorough CI beluga subsistence harvest surveys, including struck and lost estimates, were completed by CIMMC during 1995 and 1996 (CIMMC 1996, 1997; Angliss and Lodge 2002). While there was no survey during 1997 or 1998, NMFS estimated the subsistence harvest from hunter reports. The known annual subsistence harvest by Alaska Natives during 1995 to 1998 averaged 77 belugas per year which, in combination with struck and lost estimates, can account for the estimated population decline during this interval (Figure 14). The harvest was sufficiently high to account for the nearly 50% total decline in the population during the period from 1994 through 1998 (Hobbs et al. 2000). Hunters have described harvest numbers and effort in the late 1980s as similar to the 1990s (B. Mahoney, NMFS AKR, pers. comm.). If subsistence takes prior to 1994 were at levels approaching those recorded in the mid-1990s that potentially unsustainable level of take could account for the CI beluga decline from 1,300 whales to 653 whales from 1979 to 1994.

In 1999 and 2000, Public Laws 106–31 and 106–553, established a requirement that hunting of CI belugas for subsistence uses by Alaska Natives must be conducted pursuant to cooperative agreements between NMFS and the affected Alaska Native organizations. A voluntary moratorium by hunters in 1999 resulted in no CI beluga harvest that year. During 2000 to 2003 and 2005 to 2006, NMFS entered into co-management agreements for the CI beluga subsistence harvest, limiting harvest to one or two belugas per year starting in 2000. From 2000 to 2006, subsistence harvests were 0, 1, 1, 1, 0, 2, and 0 belugas, respectively. There has been no subsistence harvest of CI belugas after 2005.

b. Commercial Whaling

A brief commercial whaling operation existed along the west side of upper Cook Inlet during the 1920s, where 151 belugas were killed in five years (Mahoney and Sheldon 2000). There was also a recreational hunt for belugas in Cook Inlet prior to enactment of the MMPA (Mahoney and Shelden 2000). The potential impacts of these pre-MMPA hunts on the present status of this stock cannot be determined.

c. Poaching or Intentional Harassment

Due to their approachable nature, the potential for poaching belugas in Cook Inlet exists. NOAA Law Enforcement has investigated several incidents of reported harassment of CI belugas, and as of September 2016, there has been one civil conviction of harassment (L. Cockreham, NOAA, Office of Law Enforcement, pers. comm.). There are reports and photographs of CI belugas with wounds consistent with harpoon or gunshot trauma (McGuire et al. 2011), but these animals have not been examined further, and no poaching incidents have been confirmed.

d. Incidental Mortalities or Injuries

The following section discusses mortalities or injuries to CI belugas incidental to the associated human activity. In this context, “incidental” refers to the death or injury (to include entanglement) of animals where death or injury was not intended. Activities with the potential to cause incidental injury or death include fisheries activities, vessel activities, or research projects. There is also documented evidence of CI belugas being entangled in marine debris. This section does not consider injuries that may occur as a result of noises associated with human activities. Those are discussed separately.

Fisheries activities: NMFS has only documented one CI beluga whale mortality associated with personal use, subsistence, or recreational fisheries (see Burek-Huntington et al. 2015). In May 2012, a yearling CI beluga carcass was recovered from a 60 ft subsistence set net with 8 inch mesh located approximately 1–2 miles south of the Kenai River. Histopathological analysis of tissues indicated cause of death was most likely drowning. However, this animal also suffered from severe bronchopneumonia, and it appeared unusually small for its age. The whale may have been unable to extract itself from the net when an otherwise healthy individual may have escaped. While there have been other sporadic reports over the years of single belugas becoming entangled in fishing nets, mortalities were not confirmed.

The only other reports of fatalities of CI belugas incidental to fishing in Cook Inlet are from the literature. Murray and Fay (1979) stated that commercial salmon gillnet fisheries in Cook

Inlet caught five belugas in 1979. Burns and Seaman (1986) estimated incidental take rates by commercial salmon gillnet fisheries in the Inlet at 3–6 belugas per year during 1981 to 1983. Neither report, however, differentiated between set gillnet and drift gillnet fisheries.

NMFS placed observers in the Cook Inlet salmon drift net and upper and lower Inlet set gillnet fisheries in 1999 and 2000 (Angliss and Lodge 2002, Manly 2006). During the two years of observations, an estimated total of 384 net-days were observed for the drift gillnet fishery, and an estimated 614 net days were observed for the set gillnet fishery. Only three sightings of belugas were made at set gillnet locations in upper Cook Inlet (Moore et al. 2000). Although one harbor porpoise was reported dead in the Upper Cook Inlet driftnet fishery, belugas were never observed within 10 m (32.8 ft) of a net (i.e., within a distance categorized as an interaction) in the drift or set gill net fisheries; therefore, no beluga injuries or mortalities were reported from drift or set gillnets in either 1999 or 2000 (Manly 2006). The most likely impacts from personal use, subsistence, recreational, and commercial fisheries include disturbance from the operation of watercraft in stream mouths and shallow waters, ship strikes, displacement from important feeding areas, harassment, and prey competition.

Vessel activities*:* Ship strikes have not been confirmed, but could not be ruled out in CI beluga deaths caused by trauma. For example, in September 2007, a dead beluga was found to have a wide, blunt trauma along the right side of its chest (NMFS AKR unpub. data). While a cause of the trauma was not determined, it may have been caused by the animal being hit by a boat or other watercraft (e.g., jet ski). Additionally, there are reports and photographs of CI belugas with scarring patterns consistent with propeller injuries (McGuire et al. 2011).

Research activities: Passive research with a low potential to affect CI belugas may include aerial surveys, shore-based observations, passive acoustic studies (non-tagging), prey studies, habitat studies, pathology and disease studies on dead animals, and contaminant studies. Other research may change the behavior of, harass, injure, or kill belugas. Such activities include capturing belugas, applying satellite tags, applying suction cup dive tags, taking blood and biopsies from live animals, and any boat or in-water work that changes whale behavior or movements. Between 1999 and 2002, NMFS researchers captured and affixed satellite tags to a total of 18 CI belugas. In 2002, data from one satellite-tagged CI beluga indicated a weak swim pattern for 32 hours post-tagging; the whale was found floating dead a short time later and was positively identified by a fin tag. The beluga's belly-up position while floating prevented detection of satellite tag transmissions. Two other satellite-tagged whales captured during the same season exhibited similarly weak swim patterns prior to the loss of the satellite tags' signals less than 48 hours post-tagging. These whales were not found, but were presumed to have died less than 54 hours after tagging. While the available data do not conclusively point to the cause of death of these three belugas, NMFS concluded the most apparent explanation is that they died as a result of the capture and tagging activities (NMFS, unpub. data).

Photo-identification studies by McGuire et al. (2013) reported identification of seven individual belugas with scarring due to satellite tags, providing evidence that at least seven of the previously tagged CI belugas survived at least four years after the tagging event, with five of the seven whales re-photographed in 2011 (McGuire et al. 2013). Five of these seven whales are presumed to be females based on close associations with calves (McGuire et al. 2013).

Marine debris: There have been reports of CI belugas alive, but entangled in marine debris. In 2005, a CI beluga was photographed in Eagle Bay, entangled in an unknown object, perhaps a tire rim or a culvert liner (McGuire et al. 2013). In 2010, 2011, 2012, and 2013, another CI beluga was repeatedly photographed with what appeared to be a rope entangled around the upper portion of its body near the pectoral flippers (McGuire et al. 2014a, 2014b). NMFS determined that attempts to disentangle the whale were not warranted because there was no apparent physical injury due to its entanglement, and the benefit of disentanglement did not outweigh the harassment-induced risks that such an operation would posed to that and other whales.

3. Cause of Death Analysis of Necropsied CI Belugas

Causes of death for most stranded CI belugas remain largely unknown. Post-mortem exams are hampered by the lack of road access and extensive hazardous tidal flats in Cook Inlet. In addition, the remote nature of much of Cook Inlet's coastline preclude the timely reporting of carcasses suitable for necropsy and make responding with a necropsy team logistically difficult. Additional carcasses may go unexamined because animals may sink after dying or be surrounded by winter ice and swept out of the Inlet prior to detection. From 1998 to 2013, only 38 carcasses out of 164 observed dead stranded belugas were subjected to some degree of post-mortem examination or necropsy (Burek-Huntington et al. 2015). Necropsied belugas were concentrated close to Anchorage and along the road system. Burek-Huntington et al. (2015) reviewed the causes of morbidity and mortality determined from these examinations. A more detailed discussion of the necropsy analyses from 1989–2009 is provided in Appendix IX.H – Cause of Death Analysis.

Of the 38 CI beluga carcasses examined from 1998 to 2013, a primary cause of death was not identified in 29% of the cases, primarily because most carcasses were in an advanced state of decomposition (Burek-Huntington et al. 2015). Identification and reporting of strandings, both live and dead, as well as the subsequent responses, need to be accelerated and enhanced in order to obtain the quality information necessary to understand the causes of morbidity and mortality in CI belugas. Nevertheless, it is often difficult to determine a cause of death even when carcasses are examined promptly under laboratory conditions. Conditions identified as a primary cause of death in CI belugas included previous mass or single live stranding (24%), trauma (18%), perinatal mortality (13%), malnutrition (8%), and disease (8%). Factors considered contributory to mortality (i.e., findings not assigned as a primary cause of death) included disease, aspiration of glacial silt and/or stomach content, malnutrition, and trauma. It has been noted that the number of documented mortalities of CI belugas seems to be equivalent to that of belugas in the St. Lawrence Estuary in Canada (P. Béland, St. Lawrence National Institute of Ecotoxicology, unpub. data), which has a much larger estimated population size of about 889 individuals (COSEWIC 2014).

E. Section Summary: Background

Cook Inlet

Cook Inlet is a semi-enclosed tidal estuary located in southcentral Alaska and is approximately 370 km (230 mi) in length and extends in a northeast/southwest orientation from Knik and Turnagain Arms in the north to the southernmost reaches of Kamishak Bay in the south. Considerable amounts of sediment are naturally deposited into Cook Inlet, creating a highly turbid, low visibility environment, particularly in the northern portion of the Inlet. Cook Inlet experiences some of the greatest tidal fluctuations in the world, with the difference between high and low tide levels reaching 12 m (39 ft). These large tidal ranges, combined with broad tidal flats, can result in currents reaching 6.2 m/sec (20.3 ft/sec). In winter, ice covers much of upper Cook Inlet as rivers begin to freeze in October and November.

Relevant CI Beluga Life History

In Alaska, there are five recognized beluga stocks delineated based on summer range: the Beaufort Sea, the eastern Chukchi Sea, the eastern Bering Sea, Bristol Bay, and Cook Inlet. The degree of genetic differentiation among the Cook Inlet stock and the other four Alaska beluga stocks indicates CI belugas are the most isolated reproductively and demographically. This isolation is long established, resulting in localized adaptation and indicating that the possibility of rescue from neighboring populations is remote.

CI belugas are unique in Alaska given that their habitat is in close proximity to the greatest concentration of Alaska's human population. Belugas are not uniformly distributed throughout Cook Inlet, but are predominately found in nearshore waters of the upper Inlet. Humans use the waters and shores of Cook Inlet for fishing, hunting, timber harvest, mining, shipping, dredging, renewable energy production, wastewater discharge, military activities, oil and gas development, transportation, and residential and industrial development.

The distribution of CI belugas has changed significantly since the 1970s; as their population declined, their summer range has contracted to the upper Inlet. Belugas spend the summer and early fall months in the upper Inlet, concentrating at river mouths. In late fall, belugas disperse south into the middle Inlet and into deeper offshore waters. This pattern continues through winter, when whales exhibit the most wide-ranging movements, spanning both nearshore and offshore waters from the upper reaches of Knik Arm to the middle Inlet. Large aggregations of belugas in specific areas of upper Cook Inlet during May to October likely indicate a critical time period for foraging; it is during the ice-free months that calves are born and nursed and that the whales acquire the thick blubber layer they will need to survive through the winter months. In addition to comprising important feeding habitats, the shallow waters of the upper Inlet may also play important roles in reproduction. Other critical uses of habitat by CI belugas may include avoidance/escape from predators, transiting among feeding and/or nursery habitats, and refuge from human activities (e.g., in-water noise, ship traffic and hunting).

Belugas have low reproductive potential; that is, females have a single calf only every two or more years, and devote considerable time to caring for their young. Age at sexual maturity, length of gestation, and calving interval are unknown for CI belugas. Data are not available for CI belugas to precisely determine the generation time; however, when we consider available information regarding the age at first reproduction and age at senescence for belugas, we estimate a generation time of approximately 25 years.

Belugas make a wide variety of sounds and have highly developed echolocation capabilities. Their high auditory sensitivity, wide frequency bandwidth, and dependence upon sound to navigate, communicate, and find prey and breathing holes in the ice make belugas vulnerable to noise pollution, which may mask beluga signals or lead to temporary or permanent hearing impairment.

Belugas are extremely social animals that typically travel and hunt together. High group cohesion and large group sizes may provide benefits to group members in terms of information gathering and transfer with regard to resource availability (e.g., prey, calving sites, oceanographic conditions, etc.) and cooperation in predator avoidance and reduced predation risk. The evidence available for CI belugas suggests that individual belugas intermix and interact with various beluga groups across the Inlet.

The diet of CI belugas is dominated by fish and invertebrates. Recent analysis suggests CI beluga diets changed in the last few decades and whales have been feeding at lower trophic levels. Pacific salmon, including Chinook (king) salmon, are an essential feature of CI beluga critical habitat. There is therefore concern that recent reductions in run strength of Chinook salmon stocks across Alaska, particularly in Cook Inlet, may be affecting CI belugas.

CI Beluga Whale Population Size and Trends

Aerial surveys in the 1960s, 1970s, and early 1980s counted belugas in Cook Inlet but only a few of these had sufficient coverage to estimate the population size. A 1979 survey resulted in an estimate of 1,293 belugas in Cook Inlet; NMFS has adopted 1,300 belugas as the value for the carrying capacity to be used for management purposes. Between 1979 and 1994 the CI beluga population declined roughly 5% annually from about 1,300 whales to 650 whales. Between 1994 and 1998 the population declined nearly 50% from 650 whales to 347 whales, likely a result of unsustainable levels of subsistence harvest. Since 1999, when subsistence hunting was restricted, the population has continued to decline by 1.3% per year. The 2014 abundance estimate was 340 CI belugas.

Sources of Mortality or Injury

In the past, there have been both natural and anthropogenic sources of mortality or injury of CI belugas. Natural sources include predation by “transient” killer whales, live strandings, and potentially disease; anthropogenic sources include subsistence harvest, poaching or intentional harassment, and mortalities or injuries incidental to other human activities. Although the cause of death for most CI belugas remains unknown, 38 CI belugas were necropsied between 1998 and 2013; identified causes of death included association with previous mass or single live strandings, trauma, perinatal mortality, malnutrition, and disease.

III. THREATS TO RECOVERY

While the recent downward trends in CI beluga abundance and range are well documented, little is known about the mechanisms impeding recovery. Previous hypotheses for the delay in recovery include: 1) reduced fecundity because the mature female segment of the population is depleted; 2) reduced fecundity or survival due to potential population-wide stressors such as reduced prey, contaminants, disease, or inbreeding effects; 3) loss of whales as a result of predation by killer whales or stranding events; and 4) risks associated with contracting range and grouping behavior of the whales (NMFS 2008a). A population model that implicitly considered the time lags inherent in long-lived populations where sexual maturity does not occur for many years (Litzky 2001; Hobbs and Shelden 2008) indicated that the depletion of females is an unlikely cause for the current continued decline. While concluding that other effects besides the subsistence hunt have contributed to the decline and failure to rebuild, the population model was unable to narrow down the causal effects using the available data (Hobbs and Shelden 2008). The model also projected population abundance into the future and demonstrated that extinction risk varied considerably under different scenarios of risk factors for CI belugas. A more recent PVA reached similar conclusions (Hobbs et al. 2015c)

The following section examines potential obstacles to the recovery of CI belugas. It is unlikely that all threats listed in this recovery plan impact CI beluga recovery equally, so ideally each threat would be investigated and either dismissed as insignificant or prioritized for action according to defined criteria. Table 6 lists each threat and summarizes our assessment of the major effect of the threat, its extent, frequency, trend, probability, magnitude, and rating of relative concern (among the threats identified) for CI beluga recovery (definitions of these terms are provided in Table 6). Assessments were made based on the information and data gaps presented in the Background section of this recovery plan.

Climate change, while considered a potential threat to CI beluga recovery, is not addressed as a separate threat in this recovery plan, but rather is discussed with respect to how it may affect each of the listed threats. Although climate change occurs naturally, the effects of greenhouse gas emissions are fundamentally changing global processes. This recovery plan does not attempt to identify the sources of such emissions or to assess the relative contribution of each potential source. Instead it focuses on the effects of a changing climate to CI belugas. For example, climate change may result in increased frequency and intensity of storms and droughts, and these events can have effects on belugas. Thus, since we are assessing effects of climatic changes to the species and not the causes of climatic changes, in many instances in this recovery plan climate change is referenced as a factor that affects natural events, even though we acknowledge that certain natural events may be exacerbated by human-induced climate change.

As previously discussed (see Section II.C.3. Small Population Dynamics), there are inherent risks associated with small populations, such as loss of genetic or behavioral diversity. The effects of threats on small populations may be greater than on large populations due to these inherent risks. Small populations may be more susceptible to disease, inbreeding, predator pits, or catastrophic events than large populations. In this section, we address ten principal threats to the CI beluga population and consider how they may be exacerbated by these types of inherent risks due to small population size.

Section 4(a)(1) of the ESA and the associated regulations (50 CFR Part 424) set forth the following considerations for the listing status of a species: 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) inadequacy of existing regulatory mechanisms; or 5) other natural or human-made factors affecting its continued existence. In the 2008 decision to list CI belugas as endangered, NMFS cited all five ESA section 4(a)(1) factors (73 FR 62919). In Table 6, the ten threats identified below are associated with the relevant ESA section 4(a)(1) factors (identified as Factors A–E).

Table 6. Summary of threats assessment for CI belugas.

Threat Type	ESA § 4(a)(1) factor	Major effect	Extent	Frequency	Trend	Probability	Magnitude	Relative concern
Catastrophic events (e.g., natural disasters; spills; mass strandings)	A, D, E	Mortality, compromised health, reduced fitness, reduced carrying capacity	Localized	Intermittent & Seasonal	Stable	Medium to High	Variable Potentially High	High
Cumulative effects	C ,D, E	Chronic stress; reduced resilience	Range wide	Continuous	Increasing	High	Unknown Potentially High	High
Noise	A, D, E	Compromised communication & echolocation, physiological damage, habitat degradation	Localized & Range wide	Continuous, Intermittent, & Seasonal	Increasing	High	Unknown Potentially High	High
Disease agents (e.g., pathogens; parasites; harmful algal blooms)	C	Compromised health, reduced reproduction	Range wide	Intermittent	Unknown	Medium to High	Variable	Medium
Habitat loss or degradation	A	Reduced carrying capacity, reduced reproduction	Localized & Range wide	Continuous & Seasonal	Increasing	High	Medium	Medium
Reduction in prey	A, D, E	Reduced fitness (reproduction and/or survival); reduced carrying capacity	Localized & Range wide	Continuous, Intermittent, & Seasonal	Unknown	Unknown	Unknown	Medium
Unauthorized take	A, E	Behavior modification, displacement, injury or mortality	Range wide, localized hotspots	Seasonal	Unknown	Medium	Variable	Medium
Pollution	A	Compromised health	Localized & Range wide	Continuous, Intermittent, & Seasonal	Increasing	High	Low	Low
Predation	C	Injury or mortality	Range wide	Intermittent	Stable	Medium	Low	Low
Subsistence hunting	B, D	Injury or mortality	Localized	Intermittent	Stable or Decreasing	Low	Low	Low

<u>Definitions used in Table 6 - Summary of threats assessment for CI belugas:</u>

ESA §4(a)(1) factor: The ESA factors NMFS relied upon for listing CI belugas (73 FR 62919, October 22, 2008)

A: The present or threatened destruction, modification, or curtailment of its habitat or range

B: Overutilization for commercial, recreational, scientific, or educational purposes

C: Disease or predation

D: The inadequacy of existing regulatory mechanisms

E: Other natural or manmade factors affecting its continued existence

Major effect: A brief description of immediate/proximate/primary effect of the threat on a biological process or the mechanism by which it impacts belugas. Ultimately all threats have an impact on fitness, reproduction, and/or mortality, but often there is an immediate effect on a specific aspect of life history, which is listed here.

Extent: The portion of the CI beluga range over which the threat is found.

Range wide: The threat occurs throughout the CI beluga distribution.

Localized: The threat is primarily found in only a portion of the range, or is present at low levels throughout the range but is greatest in discrete areas.

Frequency: The occurrence/regularity of the threat over time.

Continuous: The threat is relatively constant through the year.

Seasonal: The threat is greatest during specific seasons, but may occur at other times of the year.

Intermittent: The threat may occur at any time of the year or at irregular/sporadic intervals not associated with specific seasons or time frequencies.

Trend: The change in frequency or intensity of a threat over time; described as increasing, decreasing, stable, or unknown.

Probability: Qualitative description of the chance of a threat occurring in the future.

Magnitude: Describes the perceived qualitative impact of the threat (if it were to occur) on the CI beluga whale population.

Relative concern: The overall perception of how a threat affects CI beluga recovery, after accounting for other parameters listed in the table.

A. Discussion of Threat Types

The ten potential threat types discussed below were identified as having a low, medium, or high level of relative concern for affecting the CI beluga population (see Table 6). Information presented in this section is summarized in Table 6, and is used to determine the relative concern of each threat type to the CI beluga population. The identified threat types and their level of relative concern are:

- Catastrophic events (relative concern: high);
- Cumulative effects of multiple stressors (relative concern: high);
- Noise (relative concern: high);
- Disease agents (relative concern: medium);
- Habitat loss or degradation (relative concern: medium);
- Reduction in prey (relative concern: medium);
- Unauthorized take (relative concern: medium);
- Pollution (relative concern: low);
- Predation (relative concern: low); and
- Subsistence hunting (relative concern: low).

1. Threat Type: Catastrophic Events

A catastrophic event in Cook Inlet may be the result of a natural or anthropogenic event. Regardless of source, the potential for injury or mortality of CI belugas exists. A catastrophic event could directly affect CI belugas (e.g., harm due to spilled contaminants), or could indirectly affect them through effects upon their habitat or prey. A catastrophic event may also be a contributing factor to a mass stranding event. A mass stranding resulting in numerous mortalities would be catastrophic to the recovery of CI belugas; as such, we consider mass strandings as a potential catastrophic event.

a. Potential Sources of a Catastrophic Event

Several natural factors may result in a catastrophic event with potential to adversely affect CI belugas, including effects from environmental or climatic changes, earthquakes, volcanos, disease outbreaks, lethal mass strandings, and failures of key salmon runs. Anthropogenic events, such as oil spills and natural gas blowouts, may also have detrimental effects on CI belugas. Catastrophic events may also affect CI beluga prey, whether through changes to spawning or migration patterns, direct mortality, or potential long-term sub-lethal impacts (Moles et al. 1994; Marty et al. 1997; Murphy et al. 1999).

The State of Alaska maintains a record of all spills of harmful substances. From 1994 to 2011, there were 255 events in or near Cook Inlet releasing more than 100 gallons or 100 lb (378.5 liters or 45.4 kg) of reportable substances (Alaska Department of Natural Resources, Division of Oil & Gas, 2011, unpub. data). These spills included 90 events releasing a total of 84,195 gallons (318,713 liters) of various types of oils (diesel, hydraulic, gasoline, engine lube, aviation fuel, and natural gas); 48 events releasing a total of 25,404 gallons (96,165 liters) and

11,364,847 kg (25,055,199 lb) of hazardous materials (bases or alkaline substances, drilling muds, glycols, and urea); and 73 events releasing 110,332 kg (243,241 lb) and 1,574 gallons (5,958 liters) of extremely hazardous substances (anhydrous ammonia, hydrochloric acid, and sulfur dioxide). The most significant events releasing more than 10,000 lb or 10,000 gallons (4,536 kg or 37,854 liters) are listed in Table 7 (Alaska Department of Natural Resources, Division of Oil & Gas, 2011, unpub. data). There are no reports of CI belugas being directly impacted by any of these events.

Belugas may live-strand in response to a variety of natural and anthropogenic stimuli that may occur singly or in combination, including predator avoidance, chasing prey, changes in water flow, disease, illness, injury, acoustic events, or catastrophic events. Belugas are usually able to survive through a live stranding event and escape to deeper water on the rising tide. However, some deaths have occurred from these events (see Table 5). If a large number of mortalities were associated with a live stranding, the effects on the population could be catastrophic. Fortunately, mortalities associated with a live stranding event do not appear to be common. The last mortalities suspected to be associated with a live stranding event were in May 2014 when two CI belugas were found dead with evidence of glacial silt in their lungs (NMFS AKR, unpub. data). Although NMFS received no reports of a live stranding, the presence of silt in the airway is indicative of a likely live stranding event. Prior to 2014, the last suspected mortalities from a live stranding event were in 2008 (Table 5). For the purposes of this section, we would consider mass mortalities associated with a live stranding as a catastrophic event.

b. Relative Concern

Effects from catastrophic events are variable, ranging from mortality to compromised health or injury to individual whales, reduced overall fitness or resilience of the population, or reduced carrying capacity of the environment. A catastrophic event resulting in CI beluga mortality will increase the likelihood of extinction, currently projected at 0–14% probability in the next 100 years (Hobbs et al. 2015c). A catastrophic event in which only carrying capacity was affected will likely have minimal impact to CI belugas because the population (300–400) is small compared to carrying capacity (K = at least 1,300). Compared to other effects of catastrophes, decreased survival and fecundity have a much greater impact on recovery than does a decrease in carrying capacity. For example, an anthropogenic spill of some chemical in a marginal area of habitat would result in limited exposure of CI belugas to that chemical. However, a spill in a more centrally located area will increase the exposure of CI belugas and increase the severity of the impact, to the point recovery of the population could be delayed (Hobbs et al. 2009).

Small populations, such as CI belugas, may be more susceptible than large populations to adverse effects resulting from catastrophic events. The reduced summer range of CI belugas into the upper Inlet makes them vulnerable to catastrophic events that have the potential to kill or injure a significant portion of the population. It is expected that most catastrophic events would be localized events, affecting only a portion of the CI belugas' range. However, depending on the location of the event, the exposure or effect to the whales will vary. With the exception of live strandings, a catastrophic event in lower Cook Inlet which occurs in the summer when most CI belugas are in the upper Inlet will have less effect than if the same event were to occur during summer in the upper Inlet. Fortunately, the frequency of catastrophic events in Cook Inlet has been low, and such events occur only intermittently. Although past experience indicates the frequency of catastrophic events is low, anthropogenic activity in Cook Inlet is increasing,

Table 7. Events releasing more than 10,000 pounds or gallons of reportable substances into Cook Inlet, 1994–2011.

Year	Spill name/description	Region	Quantity	Unit	Substance
Refineries, pipelines, and production					
2003 to 2008	Agrium Ammonia	Nikiski	78,123	Pounds	Ammonia, anhydrous 37 Events
2008	Aurora Gas Moquawkie	West Kenai	11,000	Gallons	Drilling mud
2004	Marathon Beaver Creek Fire	Beaver Creek Field	21,000	Gallons	Natural gas liquid
1995 to 1996	UNOCAL	Central Kenai	57,940	Pounds	Ammonia, anhydrous 16 events
2008 to 2009	Tesoro Refinery SO2	Nikiski	104,595	Pounds	Sulfur dioxide 13 Events
1999	UNOCAL SRF	Swanson River Field	10,500	Gallons	Produced water[a]
Vessels					
1997	Crowley Oregon Barge	South Cook Inlet	25,000,000	Pounds	Urea (solid)

[a] The water produced when oil and gas are extracted from the ground.

Source: Alaska Department of Natural Resources, Division of Oil & Gas, 2011, unpub. data.

and environmental and climatic conditions are changing; accordingly, we infer that the probability of a catastrophic event occurring in the future will be higher than it has been, and thus we categorize this probability as medium to high. The magnitude of effect of a catastrophic event on CI belugas is assumed to be variable and dependent upon several factors including type of event, location of event, timing of event, and exposure of whales to the event. However, we ranked the magnitude as variable, but potentially high given the fact that mortalities from live strandings or other catastrophic events would have a greater and more immediate adverse effect on the recovery potential of the population than other types of effects (e.g., behavior modification; reduced carrying capacity). When we consider all these factors, we conclude the overall relative concern of the impact of catastrophic events on CI belugas to be of high concern.

2. Threat Type: Cumulative Effects of Multiple Stressors

a. Potential Cumulative Effects of Multiple Stressors

While it is difficult to quantify or characterize individual stressors, it is even more difficult to quantify the potential impacts that a combination of stressors, either concurrently or sequentially, would have on CI beluga recovery. Exposure to any given stressor at a sub-lethal level may predispose individual belugas to greater susceptibility to mortality or long-term effects (e.g., reproductive failure) from other stressors.

Anything that affects the probability of reproduction or survival of an individual affects that individual’s fitness. Death can also result from different combinations and intensities of multiple stressors. Because body condition (one measure of health) varies among individual whales, deaths observed from the cumulative effects of multiple stressors are likely to occur over a period of time rather than as a single instantaneous event as progressively less robust individuals succumb. However, peaks in mortalities are likely to be associated with periods of greatest stress, such as over winter or during the birthing/nursing season. Environmental factors can also interact with other factors to impact beluga whale health. For example, a reduction in availability of preferred, high-lipid prey, such as salmon, will reduce individual body condition, increasing susceptibility to parasites, disease, and predation, and possibly reduce reproductive potential. Also, a period of restricted food access can cause belugas to use their fat reserves, resulting in the short-time release into the blood stream of contaminants that may have bioaccumulated in that tissue (Couillard et al. 2008a; Couillard et al. 2008b).

Cumulative impacts have been a long-standing issue in the debate over noise effects on marine mammals (Clark et al. 2009). The additive effects of multiple noise sources, as well as the combination of noise and other stressors, are of particular concern, but this field remains poorly understood (NRC 2005, Kuczaj 2007).

Cumulative effects include synergistic effects in which two stressors interact to cause greater harm than the sum of the effects of the individual component stressors. This is particularly relevant for marine mammals, including CI belugas, because potential cumulative effects are not well-understood in marine mammals generally and in CI belugas specifically. However, available scientific data, discussed below, highlights the concerns surrounding these potential cumulative effects, some of which are tied to stressors that are present in CI beluga habitat (e.g., chemicals, noise, presence of predators).

For example, there is the potential for synergistic effects occurring as a result of co-exposure to certain chemical pollutants and noise. Ototoxins are substances that temporarily or permanently damage hearing. These chemicals can be absorbed through the respiratory tract, the skin, or the gastrointestinal tract. Understanding the effects of these compounds on the hearing of marine mammals is limited; however, hearing deficits have been established in cetaceans, including belugas, which were treated with aminoglycosides, a class of antibiotics known to be ototoxic (Finneran et al. 2005). When exposure to ototoxic chemicals is combined with exposure to noise, hearing loss is exacerbated by increasing both the breadth and severity of permanent threshold shifts; hearing loss can even occur at subtoxic chemical and sub-traumatic noise levels when neither exposure to the chemical nor noise would cause hearing loss in isolation (Steyger 2009). The synergistic effect of noise and organic solvents is more serious after repeated exposure at lower levels (Steyger 2009).

The synergistic effect between certain chemical pollutants and noise is of increasing concern in the marine environment, especially in coastal areas where chemical pollutants are concentrated. Well-known chemicals that, when combined with excessive noise exposure, can have synergistic effects on hearing in humans include organic solvents (e.g., paint, adhesive solvents, or fuel fumes), some insecticides, heavy metals like lead and mercury, and some clinical drugs known to impact hearing (e.g., aminoglycoside antibiotics). It has been shown that the physiological impact can exponentially increase if the individual is concurrently or sequentially exposed to these chemicals and noise. For example, loud noise and solvent inhalation by dockyard workers has proven to generate a hearing deficit five times stronger than the one generated just by the loud noise exposure (Sliwinska-Kowalska et al. 2004). Jet fuel vapor inhalation and jet noise exposure led to permanent hearing loss in laboratory rats; however, when rats were exposed to the same concentration of jet fuel but not exposed to noise, no effects on hearing were detected (Fechter et al. 2007). To our knowledge, these synergistic effects have not yet been described in marine mammals. However, the fact that CI beluga habitat is surrounded by many human activities that generate chemicals known to impact hearing (e.g., jet fuel from the airplane activity around the Inlet) and the fact that CI beluga habitat is noisy, raises the concern of potential synergistic effects on CI belugas from chemicals in the water and noise.

Another example of synergistic effects of multiple stressors is the toxicity among various contaminants that augment each other, whereas individual exposure to the same concentrations of those contaminants may yield little to no detectable effect (De Guise et al. 1998). There are well-documented examples of multiple stressors in terrestrial species that individually have little impact, but, when combined, can have major, negative, synergistic impacts that may cause death. For example, two studies (Relyea and Mills 2001; Relyea 2003) reviewed in Sih et al. (2004) found that several species of North American tadpoles exposed to the common pesticide carbaryl at a concentration only one-third of the recommended level suffered 10% mortality. However, when only the smell of a predatory newt was added, tadpole mortality increased to 80%, meaning that the introduction of the predator's smell somehow increased the lethality of carbaryl eightfold. This synergistic effect was even more pronounced with bullfrog tadpoles: carbaryl alone caused only 2% mortality (indistinguishable from carbaryl-free controls), but when combined with the smell of predatory newts caused 92% mortality, a 46-fold amplification. This work showed that adding the stressor (the perceived risk of predation) to sublethal concentrations of carbaryl unexpectedly increased tadpole mortality, and the drastic increase in mortality did not require that actual predation take place.

In Chester Creek, a stream draining urban areas in Anchorage and directly discharging into Cook Inlet, the pesticide carbaryl was detected in high concentrations. This broad-spectrum insecticide, widely used throughout the Cook Inlet Basin to control spruce bark beetles, was detected in 79% of the samples from this creek (Glass et al. 2004) with concentrations as great as 0.33 µg/L. Fifteen percent of the samples had carbaryl levels that exceeded drinking water standards and Canadian guidelines (Canadian Council of Ministers of the Environment, 2009) for the protection of freshwater aquatic life (0.2 µg/L). Therefore, CI belugas in upper Cook Inlet near Chester Creek, and potentially in other streams with urban and residential watersheds, could be exposed to high levels of carbaryl. Since contaminants (e.g., the pesticide carbaryl) and predators (e.g., transient killer whales) may co-occur in the preferred beluga habitat, a potential for synergistic effects may exist, if, like in the case of the tadpoles, the contaminants make the exposed belugas more susceptible to predation. We note, however, that a direct comparison cannot be made between tadpoles and belugas, and we do not have information about the level of exposure to, or absorption of, carbaryl by CI belugas. Nevertheless, these studies underscore the possibility that CI belugas might be at risk from the negative synergistic effects as a result of co-exposure to anthropogenic noise, widespread pollutants, and the presence of transient killer whales (e.g., detecting their presence acoustically without the need of actual physical encounters).

Climate change can also amplify the effects of some contaminants as climate-driven changes in temperature, pH, and salinity can alter contaminant toxicity and bioavailability (Schiedek et al. 2007). For example, the half-life of the pesticide malathion increases substantially under a lower pH, suggesting increased persistence of this contaminant under expected conditions of climate-driven ocean acidification (Relyea 2004). Malathion serves here as an example of how contaminant toxicity may change as the climate changes. There is no evidence to suggest that this pesticide, with low toxicity for mammals, short half-life in water (2–18 days), and low level of use in Alaska, is a threat to CI belugas.

b. Relative Concern

Predicting cumulative effects is extraordinarily difficult, as it requires knowledge of a myriad of contextual factors for each exposure (e.g., acoustic exposure; contaminant exposure; predatory exposure), and synergistic effects can be very unpredictable (Wright et al. 2007). Because susceptibility varies among individuals in a population and because mortalities may be dispersed over time, factors contributing to cumulative effects are difficult to detect, making mitigation of these effects challenging. Stressors related to the current small population size of CI belugas, when combined with anticipated trends of increased anthropogenic impacts, can increase the likelihood of co-occurring and interacting multiple stressors that may combine effects to the detriment of the CI belugas' recovery.

Moreover, stress resulting from anthropogenic noise, a threat of high relative concern, needs to be evaluated in combination with other stressors because noise has been demonstrated as a component of harmful synergistic effects in several animals and humans (Steyger 2009).

Given the increase of human activities in Cook Inlet and the presence of contaminants in Cook Inlet and CI belugas, the trend for and likelihood of cumulative effects is increasing over time. Cumulative effects are categorized as a threat of high relative concern for CI belugas due to the following: 1) multiple stressors occur year-round and throughout range of CI belugas; 2) uncertainty regarding the magnitude of future cumulative effects; 3) uncertainty over the mechanisms of existing and future cumulative effects (including synergistic effects, if any); 4) difficulty in detecting impacts attributable to cumulative mechanisms; and 5) difficulty in effectively mitigating cumulative effects due to the occurrence of multiple stressors.

3. Threat Type: Noise

Anthropogenic noise effects to CI beluga prey are discussed in the "Threat Type: Reduction in Prey" section (III.A.6); and cumulative effects involving noise are considered in the "Threat Type: Cumulative Effects of Multiple Stressors" section (III.A.2).

a. Sources of Noise in Cook Inlet

The acoustic environment of Cook Inlet is naturally noisy, complex, and dynamic. Natural sources of noise are particularly abundant in the CI beluga hearing range and include: bottom substrate being transported by high currents; sand and mud bars generating breaking waves during low tide/high current periods; river mouths becoming rapids at low tide periods; and fast and pancake ice being formed during winter months and under continuous mechanical stress by high tide oscillations and currents. Furthermore, the inflow of cold freshwater of glacial origin can vary considerably near major river mouths and arms in the upper Inlet, creating a complex sound propagation environment due to changes in both salinity and temperature as a result of sharp water mass fronts. These differences in water density and temperature act as sound barriers, reflecting and refracting sound energy. In addition, the large volume of fresh water from glacial areas surrounding Cook Inlet introduces suspended glacial silt and sediments into beluga habitat. Silt and other fine sediments suspended in the water column create acoustic clutter (a volume of scattered sound reflection) that can further impede echolocation performance. The presence of all of these natural sources of noise varies over time and space, as does their contribution to the overall ambient noise of Cook Inlet. Their contribution is important as a wide range of frequencies overlap with beluga signals, including both lower frequency ranges used for social communication and higher frequency ranges used for echolocation. The effects of these natural conditions, while difficult to quantify, may compromise CI beluga acoustic communication and echolocation, particularly as the sound transmission distance increases. Consequently, the natural acoustic space for CI belugas may be more limited than for belugas found elsewhere. This particular condition enhances the potential for negative effects when anthropogenic sources of noise are introduced into CI beluga habitat.

Due to the co-occurrence of Alaska's urban center and the current range of CI belugas, a wide variety of anthropogenic noises that could affect recovery exists, especially in the upper Inlet. Most sources of anthropogenic noise in Cook Inlet are seasonal and occur during the ice-free months, although some sources are present year-round. Sources of anthropogenic noise in Cook Inlet include: propeller cavitation, engines, and depth sounders associated with vessels; dredging activities; pile driving activities; military detonations; aircraft; airguns used for seismic surveys; drilling associated with oil and gas exploration; hydraulic/mechanical noise; and sounds associated with other noise-producing activities. Although there are several technical reports documenting specific Cook Inlet noise sources and their signal characteristics,[19] a comprehensive survey of anthropogenic noise sources in Cook Inlet and beluga exposure to these sources has not been conducted. Most of the identified sources in the Inlet are not well documented, and many are not controlled, monitored, or regulated.

Due to industrial activity and development in the current range of CI beluga, a wide variety of anthropogenic noise sources that could potentially interfere with recovery are present in CI beluga habitat. Sources are listed below by order of importance, based on signal characteristics and the spatio-temporal (space and time) acoustic footprint. The order was determined by considering the following factors: intensity (loudness), frequency (range of tones), and duration of acoustic signal; area affected by the sound source; and duration of sounds in both seasonal terms (e.g., happening all summer) and frequency of occurrence (e.g., happening once per week throughout the summer; M. Castellote, NMFS, unpub. data).

- Tug boat noise: propeller cavitation (the formation of bubbles in a liquid) and engine noise including azimuth/bow thruster noise;
- Cargo/tanker noise: propeller cavitation and engine noise including bow thruster noise;
- Small vessel noise: outboard and inboard engine noise and propeller cavitation;
- Dredging: suction and/or grabbing operations;
- Pile driving noise: hammering or vibratory noise (rotatory or oscillatory to a lesser extent);

[19] See a sample listing of acoustic reports pertaining to Cook Inlet and Cook Inlet belugas available on the NMFS AKR Research on Cook Inlet Belugas webpage: http://alaskafisheries.noaa.gov/pr/beluga-research-cook-inlet.

- Military detonations of high explosives:[20] demolition and projectile explosions in military firing ranges;
- Oil/gas exploration: airgun sources for seismic survey and high power active transducers (multibeam echosounders, sub-bottom profilers, etc.);
- Shore construction noise: other than pile driving;
- Oil/gas exploitation: platform noise (in-air noise radiated into the water), drilling noise (in water and/or bottom substrate), air/water vessels during operations;
- Commercial jet aircraft: overflights, take offs, and landing approaches;
- Military jet aircraft: overflights, take offs, and landing approaches;
- Propeller aircraft: overflights, take offs, and landing approaches;
- Depth sounders: from vessels;
- Fishing related noise (other than engine noise): hydraulic/mechanical operations;
- Research related noise: sonars such as acoustic Doppler current profilers and dual-frequency imaging sonars; scientific echo sounders and other active transducers, boat transit for photo-identification surveys, and instrument deployment/retrievals, etc.; and
- Pipe and cable laying operations.

Climate change is having an indirect effect on ocean noise pollution (Reeder and Chiu 2010). As levels of carbon dioxide rise in the atmosphere, ocean waters are becoming more acidic. Ocean acidification reduces concentrations of seawater salts that absorb sound, particularly low-frequency sound. This ocean pH change is predicted to be greatest in higher latitudes, allowing lower frequency sound to carry farther and to be stronger at a given distance. Shallow sound channeling exists in Cook Inlet, which allows potential noise impacts to be concentrated in shallow waters and become more spatially extensive (i.e., sound channels can trap noise and allow it to travel farther). At the same time, climate change may directly result in either an increase or decrease of in-water noise. For example, warming temperatures may reduce the prevalence of ice cover, and thus reduce ice-associated noise, but warmer temperatures may also result in higher wind speeds resulting in higher noise levels at the waters' surface.

b. Potential Effects of Noise on CI Belugas

There is an extensive body of literature regarding the effect of anthropogenic noise on marine mammal behavior. Most of the studies addressing this problem have used behavioral attributes such as changes in site fidelity, dive patterns, swimming speed, orientation of travel, herd cohesiveness, and dive synchrony to indicate possible disturbance or stress caused by noise (Richardson et al. 1995). A review and summary of available information regarding effects from anthropogenic noise to beluga hearing and behavior is presented in Appendix IX.E – CI Beluga Hearing, Vocalization, and Noise Supplement.

[20] Demolition activities and mortar/artillery firing on military ranges.

Studies on belugas have revealed that anthropogenic noises have the possibility to cause threshold shifts in beluga hearing capabilities (e.g., Finneran et al. 2000, 2002a; Schlundt et al. 2000); to mask the ability of animals to hear and decipher specific sounds (e.g., Erbe et al. 1999; Erbe 2000); to result in belugas altering their vocal behaviors (e.g., Lesage et al. 1999; Sheifele et al. 2005); or to result in displacement of animals from habitats (e.g., Finley et al. 1990; Richardson et al. 1997; Harris et al. 2007).

c. Relative Concern

Anthropogenic noise, particularly the combined effect of different sound sources occurring simultaneously or consecutively, has the potential to affect beluga acoustic perception, communication, echolocation, and behavior (such as foraging and movement patterns). Behavioral effects include processes of sensitization (increased response following repeated exposure) or habituation (decreased response following repeated exposure) and physiological processes related to hearing and stress. In the long term, anthropogenic noise may induce chronic effects altering the health of individual CI belugas, which in turn have consequences at the population level (i.e., decreased survival and reproduction). Although the effects on CI belugas of the diverse types of anthropogenic noises occurring in their habitat have not been analyzed and are currently unknown, there is enough evidence from other odontocete species (and for some effects in other beluga populations) to conclude that the potential for a negative impact to CI beluga recovery is of high relative concern.

4. Threat Type: Disease Agents

a. Sources and Types of Disease Agents in Cook Inlet

A number of potential sources of disease-causing agents exist in and around Cook Inlet. Disease agents may include pathogens (such as bacteria, viruses, and fungi), parasites, and harmful algal blooms (HABs). Belugas may be exposed to disease agents through: interactions with, or proximity to, other infected belugas or other species; ingestion of contaminated material or organism; open wounds; or inhalation. Natural sources of disease include other belugas, other wild animals, and environmental and water-borne pathogens of natural origin. Anthropogenic sources of disease include untreated sewage outfalls; malfunctioning septic systems; pet waste; runoff from agricultural operations; and discharge from vessels (URS Corp. 2011). No comprehensive survey of disease sources or their characteristics are available. Transfer of disease and parasites between belugas and other wild or domestic species are poorly understood, and endemic disease and parasite loads of CI belugas in comparison to other populations are unknown. For an in-depth review of available information on this topic, see Appendix IX.H – Cause of Death Analysis.

b. Relative Concern

Diseases have the potential to compromise health, reduce reproductive potential, and increase the chance of mortality. Diseases can have population-level effects throughout a species range. Although disease outbreaks among CI belugas are currently expected to be intermittent, climate change and increased pollution could cause an increase in disease frequency. In 2011, 62% of CI belugas photographically identified in Eagle Bay had signs of some level of current or previous infection (McGuire et al. 2014c).

The necropsy record of stranded CI beluga carcasses shows only low levels of parasitism, and parasites that were present did not appear to have a significant negative impact (i.e., were not attributed to be the cause of death). Additionally, parasites most likely would only have a detrimental effect to the individual whale, and not result in population-wide effects. Thus, based on the available data, the threat of parasites to CI belugas currently appears to be of low relative concern.

Although HABs have the potential to detrimentally impact a large portion of the population, the reported incidence of HABs in Cook Inlet, and Alaska in general, has been very low (RaLonde 2001; Alaska Sea Grant 2012). However, LeFefebvre et al (2016) reported evidence that HAB toxins (e.g., domoic acid and saxitoxin) are present throughout Alaska waters at levels high enough to be detected in marine mammals. The authors concluded that current climate trends may result in conditions favorable to the growth of HABs, increasing the health risks to northern marine mammals. Burek-Huntington et al. (2015) found that domoic acid was present in very low levels in two of 17 CI belugas tested, and saxitoxin was present at just above detection level in one out of 15 CI belugas tested. In the one case where HABs were detected in a fetus, they were not detected in the mother, (Burek-Huntington 2015), suggesting that there may be a greater threat to CI beluga calves than adults. In addition to potential increases in the prevalence of HABs in Alaska, climate change is rapidly altering the global movement of pathogens, bringing diseases to new areas. Guimarães et al. (2007) modeled the dynamics of an infectious disease spreading through a reproductively isolated group of killer whales in the Pacific Northwest. That study's results indicated that small populations, such as the CI beluga population, are susceptible to population-wide disease outbreaks.

Currently, the incidence of disease as a factor in the deaths of CI belugas appears to be low, and there is little evidence to suggest diseases of concern are present in other mammals in the area. We assume some unknown level of disease is present in CI belugas, with a medium to high probability that disease will occur in the future. Moreover, a population-wide outbreak of a novel (new) disease could be catastrophic to the CI beluga population. As such, despite a low relative concern from parasites and a low incidence of disease currently, the threat to CI beluga recovery due to increases in HABs or a disease outbreak associated with novel pathogens in the future is of medium relative concern, and the overall relative concern for the impact of disease agents is medium.

5. Threat Type: Habitat Loss or Degradation

This section does not include habitat loss or degradation from reduction of prey, pollution, or noise, which are discussed individually in other sections.

a. Sources of Habitat Loss or Degradation in Cook Inlet

In contrast to most beluga populations, which are observed seasonally in estuarine habitats, belugas in Cook Inlet are year-round residents (NMFS 2008a). With the CI beluga population decline in the mid-1990s, the spatial distribution of CI belugas in the summer contracted such that whales are primarily found in the upper portion of Cook Inlet (Rugh et al. 2010). Range contraction proportionate to population decline is consistent with the theory that populations tend to concentrate in areas of optimal habitat during periods of low abundance and expand outside those areas during increased abundance (MacCall 1990). Upper Cook Inlet would thus represent preferred habitat, with the suitability of that habitat depending on both biotic and abiotic characteristics.

Ecological changes such as increased water temperature, siltation, and salinity changes due to changing volumes of freshwater runoff may occur over the long-term in response to climate change. Such changes may also occur due to episodic events such as earthquakes or volcanic eruptions. Anthropogenic activities can result in substantial changes in habitat, or temporary or permanent loss of habitat. Such activities include in-water construction, port expansion, highway and bridge construction, culvert placement, changes in freshwater inflow from dams, dredging, and channeling (NMFS 2008a). Seasonal anthropogenic activities that disturb the substrate can re-suspend sediments and chemicals and also degrade the acoustic propagation characteristics of the habitat, whereas continuous activities, such as sewage outfalls, can alter the chemical composition, prevalence of pathogens, or temperature of the habitat, particularly in the immediate environment of the outfall. Permanent structures, such as docks, platforms, bridges, or trestles, alter localized water flow and characteristics as long as the structure exists. While losses of area from in-water fill may be quite visible, changes in benthic substrate and currents resulting from other types of human infrastructure are less obvious and may have significant impacts on available prey.

b. Relative Concern

While some habitat loss or degradation within the core range of CI belugas is evident, the population level effects of this degradation are unknown. Habitat impacts of past activities are poorly documented, and impacts of current and planned projects are not fully understood. Anthropogenic causes of habitat loss or degradation tend to be localized, seasonal, and increasing in frequency, whereas natural causes (e.g., warmer water temperatures under climate change scenarios) may operate range-wide.

All of these factors may limit suitable habitat either directly through whale disturbance (e.g., chemical impacts to skin tissue) and reduction of fitness, or indirectly through impacts to prey populations and reduced carrying capacity of the environment. Many of the anthropogenic activities affecting CI beluga critical habitat are concentrated in the coastal areas and are often seasonal. Anthropogenic activities in Cook Inlet are increasing, and there is a high probability there will be more habitat loss or degradation in the future. Moreover, the contraction of the range of CI belugas into the upper Inlet has resulted in increased proximity to the developed areas around Anchorage. However, most of the beluga habitat in Cook Inlet is not degraded to the point that adverse effects to CI belugas are apparent. The extreme tidal ranges, land use patterns, and bathymetry of much of Cook Inlet may make it unsuitable for many types of development activities. Even though the majority of Cook Inlet is undeveloped, the loss or degradation of habitat is of medium relative concern for CI belugas due to a limited understanding of how this habitat might be altered by various factors and the resilience of this habitat.

6. Threat Type: Reduction in Prey

Several factors may result in the reduction of the abundance, quality, availability, or seasonality of CI beluga prey. The impact of reduction of available prey on CI belugas is poorly understood, but may be the result of competition with humans or other animals. It may also result from habitat disturbances or modifications as a result of anthropogenic or natural factors.

Factors, whether anthropogenic or natural, that affect the available prey species may have a greater impact on one prey species or species subcomponent (e.g., age or size-related). Resultant changes in relative abundance of prey will affect the prey composition available (Pyke et al. 1977).

a. Competition for Prey Resources

CI belugas compete with humans and other animals for prey resources, particularly salmon and eulachon. Quantitative data on the spatial and temporal distribution of beluga prey in upper Cook Inlet are limited (see Appendix IX.F – CI Beluga Prey Supplement). Although management of fisheries targeting anadromous species in Alaska attempts to constrain harvests to be no greater than the level of surplus production, it is unlikely that escapement goals will be met in all tributaries across all years. Effects of fishing by humans on beluga foraging success are not well known, yet may include spatial and temporal components for any specific prey resource. Effects on belugas will depend on the extent to which a reduction occurs to the abundance, quality, or availability of prey (localized or Inlet-wide), and if the belugas can compensate for losses of preferred prey by shifting to other feeding sites or less-preferred prey. If a non-preferred prey species is reduced, the relative or absolute abundance of preferred prey may increase over time, depending on the ecological linkages and response times. The temporal distribution of these prey resources may be as important as their magnitude, particularly for growing juveniles and pregnant and/or lactating female belugas. Changes in seasonality of prey may occur due to seasonality and species preference of fisheries, changes in seasonal fish habitat, or seasonal environmental changes affecting Cook Inlet. The extent to which shifts in the seasonality of prey species or temporal gaps in prey availability impact reproductive success and survival of belugas, particularly during critical life stages, is unknown. However, these impacts are likely to be most important if affecting temporal availability of energy-rich high-lipid prey. Alternatively, events that result in decreases of specific runs or changes in the availability of prey (e.g., by changing schooling patterns or altering nearshore terrain) may leave temporal gaps in the availability of prey at sufficient densities resulting in the reduction in total days when beluga blubber fat storage can occur. For more information see Appendix IX.F – CI Beluga Prey Supplement.

CI belugas may also compete against other predators (harbor porpoise, harbor seals, killer whales, sea lions, large whales, sea otters, sea birds, etc.) for available prey resources, particularly in upper Cook Inlet where the available prey resources may be more limited in abundance or diversity. Although there may be some foraging specialization upon available prey species, there is also likely to be a high degree of dietary overlap due to the limited prey diversity available. In upper Cook Inlet, belugas are most likely to compete for prey resources with harbor seals and harbor porpoises, which have been documented also to be present in Cook Inlet year round and co-occur in the same general locations as CI belugas (Small et al. 2011; AEA 2013; T. McGuire, LGL, unpub. data).

b. Disturbance or Modification of Prey Habitat

The amount or types of prey available to CI belugas may also be reduced as a result of disturbances or modifications to prey habitat. Anthropogenic activities that may detrimentally affect prey habitat and possibly reduce the availability of prey to belugas are present both seasonally and continuously in Cook Inlet. Anthropogenic activities in Cook Inlet that may disturb or modify the habitat of beluga prey include dredging; oil or gas activities; hard rock quarrying; laying of electrical, communication, or fluid lines; construction of docks, bridges, breakwaters or other structures; and other activities. These activities may cause avoidance or destruction of an area used by beluga prey as a result of anthropogenic disturbance. Permanent structures, such as docks, platforms, or bridges, alter the Cook Inlet habitat by altering local tidal flow, among other potential effects. However, the net effect of anthropogenic structures on beluga prey remains unknown.

In addition to loss of habitat available to beluga prey species by displacement or avoidance, anthropogenic activities may reduce the quality of the prey as a result of contamination of the habitat. For example, mechanical disturbance of the seafloor (e.g., dredging) re-suspends silt, and potentially buried chemicals, into the water column. A sewer outfall plume alters both the abiotic and biotic environment, releasing various hormones, pharmaceuticals, and other chemicals into Cook Inlet. Catastrophic events such as oil or chemical spills are infrequent, but may have significant effects on beluga prey, whether through changes to spawning or migration patterns, direct mortality, or potential long-term sub-lethal impacts (Moles et al. 1994; Marty et al. 1997; Murphy et al. 1999). While some of these contaminants are known to bioaccumulate and be passed up the food chain, they also may impact the survival, quality, and reproduction of the prey species itself. For example, elevated copper concentrations can harm salmon and other CI beluga prey.

The habitat upon which beluga prey depend may also be affected by natural events, including: Pacific decadal oscillation, an El Niño-like pattern of Pacific climate variability (potentially affecting rainfall, freshwater runoff, water temperature, and water column stability); climate change (potentially affecting glacial output and siltation and salinity in downstream estuarine environments); volcanic ash outfall (affecting siltation and water chemistry); and earthquakes and associated landslides, elevation changes, and tsunami waves. Some of these natural threats are infrequent, but may have instantaneous and substantial impacts upon abundance, quality, or seasonality of CI beluga prey. However, other threats, such as Pacific decadal oscillations, may occur more regularly, may or may not be readily detectable, may develop over an extended time period, and may have long-lasting ecological effects.

Ecological regime shifts, in which species composition is restructured in association with abrupt changes in climate, have been identified in the North Pacific (Hollowed and Wooster 1992; Anderson and Piatt 1999; Hare and Mantua 2000; Spies 2007) and are believed to have affected prey species availability in Cook Inlet. For example, in the 1970s, dominance in the Gulf of Alaska ecosystem transitioned from crustaceans to groundfish, particularly gadid (e.g., cods) species. In another analysis, Hare and Mantua (2000) reaffirmed the 1976 to 1977 ecosystem change in the Gulf of Alaska and identified a less dramatic shift in 1989. Analyses of multi-decadal data from small-mesh trawl surveys conducted by NMFS and ADF&G showed ecosystem reorganization in the 1970s at Kachemak Bay in southern Cook Inlet and around Kodiak Island and in Shelikof Strait located in the northern Gulf of Alaska south and west of Cook Inlet Gulf waters (Bechtol 1997; Anderson and Piatt 1999). Of particular note was a decline in forage species, particularly pandalid shrimp and capelin, and increases in cod, pollock, and flatfish.

Changes to the marine, coastal, and freshwater ecosystems are known to be occurring as a result of global climate change and the associated occurrence of shifts in temperature, oxygen content, ocean acidification, and other physical and chemical changes (Doney et al. 2012), and are expected to continue and even increase with continued changes in the earth's climate system (IPCC 2013). Climate-driven change in the environment could strongly influence CI beluga prey distribution and population size through changes in growth, survival, reproduction, and spawning distribution, but the possibilities are complex (e.g., Tillman and Siemann 2011; Hollowed et al. 2013; Link et al. 2015; Sydeman et al. 2015).

c. Anthropogenic Noise Effects on CI Beluga Prey

Recent literature reviews on the effects of sound on fish (Popper and Hastings 2009) conclude that little is known about these effects and that it is not yet possible to extrapolate from one experiment to other signal parameters of the same noise, to other types of noise, to other effects, or to other species. Limited available scientific literature indicates that noise can evoke a variety of responses from fish. Pile driving can induce a startle response, an avoidance response, and can cause injury or death to fish close to the noise source (Caltrans 2001, Abbott and Bing-Sawyer 2002, NMFS 2011, Halvorsen et al. 2011).

Some noises may evoke flight and avoidance response in juvenile salmon. Other studies have shown that the avoidance response is temporary. Salmon have been found to respond to low frequency sounds, but only at very short ranges (Chamberlin 1991). Carlson (1994), in a review of 40 years of studies concerning the use of underwater sound to deter salmonids from hazardous areas at hydroelectric dams and other facilities, concluded that salmonids were able to respond to low-frequency sound and to react to sound sources within a few feet of the source. He speculated that the reason that underwater sound had no effect on salmonids at distances greater than a few feet is because they react to water particle motion/acceleration, not sound pressures. Detectable particle motion is produced within very short distances of a sound source, although sound pressure waves travel farther (USDOT 2005). It is likely that fish will avoid sound sources within ranges that may be harmful (McCauley et al. 2003).

Of all known CI beluga prey species, only coho salmon have been studied for effects of exposure to pile driving noise (Casper et al. 2012, Halvorsen et al. 2012). These studies defined very high noise level exposures (210 dB re $1\mu Pa^2.s$) as threshold for onset of injury, and supported the hypothesis that one or two mild injuries resulting from pile driving exposure at these or higher levels are unlikely to affect the survival of the exposed animals, at least in a laboratory environment. Hart Crowser Inc. et al. (2009) studied the effects on juvenile coho salmon from pile driving of sheet piles at the Port of Anchorage in Knik Arm of Cook Inlet. The fish were exposed in-situ (in that location) to noise from vibratory or impact pile driving at distances ranging from less than 1 meter to over 30 meters. The results of this studied showed no mortality of any of the test fish within 48 hours of exposure to the pile driving activities, and for the necropsied fish, no effects or injuries were observed as a result of the noise exposure.

The effects of noise on other CI beluga prey species, such as eulachon, gadids, and flounder species is unknown.

d. Relative Concern

While the potential exists for human fishing pressure to change the abundance, seasonality, or composition of beluga prey, for targeted species, fisheries are managed with in-season reductions or closures if those fish stocks appear to be weak. However, not all fish stocks are assessed, and it is unknown whether management of fisheries for optimal returns provides sufficient densities in beluga feeding areas for efficient foraging by belugas. In addition, a fishery would not be reduced or closed if escapement goals are met. But if the escapement goal arrived in a shorter time period (e.g., 30 days instead of 90 days), the benefit of optimal returns to CI beluga energetics may be very different.

It is likely there is interspecific competition for limited prey resources between CI belugas and other predators in Cook Inlet (e.g., harbor seal, harbor porpoise). However, the impact of this competition on the availability of prey to CI belugas has not been determined.

Habitat modification may result in changes in prey species availability and/or species composition throughout the range of CI belugas. While potentially having substantial effects on local ecosystems, natural threats are difficult to predict and mitigate. Many changes are tied to infrequent, short-term, uncontrollable events such as earthquakes or volcanic eruptions. Habitat disturbances may cause beluga prey to avoid an area, reduce viability of prey species, or interfere with belugas' predation success. Anthropogenic noise may also have negative effects upon CI beluga prey. Noise impacts on fish may range from temporary displacement to barotrauma induced death (Popper and Hastings 2009). Moreover, as noted in Section III.A.3 (Threat Type: Noise), anthropogenic noise may affect beluga foraging performance.

Depending on the source, prey reduction can be a local or rangewide event, with a variable frequency of occurrence. While reduction of prey may result in reduced carrying capacity of the environment or reduce the fitness of CI belugas, the magnitude of the impact of a reduction of prey on CI belugas is unknown, as is the trend and future probability. As such, the threat to CI beluga recovery due to the reduction of prey is of medium relative concern.

7. Threat Type: Unauthorized Take

In certain instances, NMFS may authorize or permit directed or incidental "takes"[21] of CI belugas under the MMPA and ESA. "Directed take" occurs when an activity is intentionally harassing or harming the animals, such as occurs when conducting research on those animals; "incidental take" occurs when an activity results in harassment or harm to animals that were not the intended target of an activity, such as may occur when a construction activity introduces loud noises into the water. As part of ESA section 7 consultations, NMFS reviews and considers the effects of these types of requested takes on CI belugas to ensure authorization of these takes are not likely to jeopardize the continued existence of CI belugas or result in adverse modification of their critical habitat. In recent years, due to the precarious nature of the CI beluga population, no lethal takes have been authorized. NMFS has authorized a limited number of directed research projects, but the majority of the take authorizations have been for incidental take that would result in harassment only. Given that extensive reviews of the proposed activities' effects to CI belugas are conducted prior to issuing take authorizations, these authorized takes are not considered to be a threat to CI belugas.

Activities which result in harassment or harm to CI belugas but which NMFS has not authorized (i.e., unauthorized take) may result in changes in CI beluga behavior, displacement of

[21] "Take" is defined by the MMPA as "to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. § 1362(13)). The listing of a species as endangered makes it illegal to "take" ("to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct"; 16 U.S.C. § 1532(19)) that species under the ESA, with certain exceptions (16 U.S.C. § 1538). Similar prohibitions are usually extended to threatened species.

CI belugas from important areas, or injury or mortality to CI belugas. Some activities with potential to result in unauthorized take or trauma include entanglements from fisheries operations, strikes from vessel activities, unanticipated mortalities or harassment associated with research projects, mortalities or injuries from poaching and intentional harassment, and other adverse outcomes (e.g., displacement) associated with miscellaneous activities such whale watching.

a. Sources of Unauthorized Take

Entanglements: Prior to the mid-1980s, the only reports of fatal takes of belugas incidental to fishing activities in Cook Inlet are from the literature (Murray and Fay 1979; Burns and Seaman 1986). While there have been sporadic reports since the mid-1980s of single beluga becoming entangled in fishing nets, the only known mortality associated with entanglement in a fishing net was the young CI beluga carcass recovered from a subsistence set net in 2012. Overall, the current rate of direct mortality from fisheries in Cook Inlet appears to be insignificant. There have been reports of non-lethal entanglement of CI belugas. For example, in 2005, a CI beluga entangled in an unknown object, perhaps a tire rim or a culvert liner, was photographed in Eagle Bay (McGuire et al. 2013), and another CI beluga was repeatedly photographed 2010–2013 with what appeared to be a rope entangled around the upper portion of its body near the pectoral flippers (McGuire et al. 2014a, 2014b). It is not known if these animals were able to disentangle themselves or if they died as a result of the entanglements.

Strikes: Most of Cook Inlet is navigable and used by various classes of water craft that pose the threat of striking belugas. Presently, there are no restrictions on vessel speed limits, areas in which vessels may operate, or on the type or horsepower of vessels allowed in the upper Inlet. There is compelling evidence that reduced vessel speed decreases the probability of vessel collision with large whales, such as the North Atlantic right whale (e.g., Laist et al. 2014). However, smaller boats that travel at high speed and change direction frequently may present a greater strike threat for CI belugas. NMFS researchers have witnessed avoidance and overt behavioral reactions by CI belugas when approached by small vessels (e.g., Lerczak et al. 2000). While ship strikes have not been a confirmed source of CI beluga mortality, a CI beluga washed ashore dead in September 2007 with “wide, blunt trauma along the right side of the thorax” that could be the result of ship strike trauma. In October 2012, a necropsy of another CI beluga carcass indicated the most likely cause of death was “blunt trauma such as would occur with a strike with the hull of the boat” (NMFS AKR, unpub. data). Scarring consistent with propeller injuries has also been documented among CI belugas (Burek 1999; LGL 2009; McGuire et al. 2011). Further scar analysis would be required to estimate vessel size, and it would be difficult to determine whether the scars resulted from commercial, private, or research vessel interactions.

Research: Research activities conducted in Cook Inlet have the potential to take CI belugas. Research activities not targeting belugas, such as research activities studying CI beluga prey or habitat, may incidentally harass CI belugas. If these research projects are not authorized by NMFS, and harass or harm CI belugas, these are unauthorized takes. Directed CI beluga research activities also have the potential to harass or harm CI belugas. NMFS has authorized take associated with several CI beluga research projects over the years. Such activities have included captures, tagging activities, biopsy activities, and aerial and boat-based activities. While certain invasive and non-invasive research activities targeting CI belugas are authorized by NMFS, none of the authorizations since the ESA-listing have allowed for mortality. Since 2003, the only research effort involving contact with the whales was an effort to apply acoustic recorders to the whales via suction cup tags. The limited amount of invasive research efforts in recent years is due in part to the probability that three CI belugas died (an unanticipated outcome) as a result of a capture and satellite tagging research project in 2002. Photo-identification studies have identified and tracked seven individual belugas with scars attributable to the satellite tags; five of these whales were re-sighted in 2011 providing evidence that at least five whales survived a minimum of nine years after tagging (McGuire et al. 2013). With the exception of the suction cup acoustic recorders and a biopsy feasibility project in 2016, which collected six small tissue samples from CI belugas, all research activities on CI belugas since 2003 have involved non-invasive techniques (e.g., passive acoustic recordings; aerial, boat, and land-based observations; photographic studies) with a low potential to adversely affect CI belugas.

Poaching or intentional harassment: Cook Inlet is bordered by the densest human population in Alaska. This juxtaposition of people and belugas in and near coastal waters heightens the potential for illegal hunting, poaching, or intentional harassment (e.g., chasing whales with vessels). Much of the information on illegal harassment is based on data from beach-cast carcasses and anecdotal reports, which may underestimate illegal harassment due to lack of timely access to carcasses. Photographs of scars present on living CI belugas suggest that some injuries may be the result of illegal hunting (McGuire et al. 2011). However, there have been no reported fresh wounds or mortalities of CI belugas associated with firearms since the harvest was regulated in 1999; NMFS has documentation of only two potential gunshot victims (one in 1995 and one in 1998; NMFS AKR, unpub. data). Some scars have been speculated to be healed bullet wounds or possible harpoon marks (McGuire et al. 2011), however, photo-identification studies since 2005 have not documented fresh injuries suspected to be the result of illegal hunting or harassment (T. McGuire, pers. comm., LGL, unpub. data). There is little information available to suggest illegal hunting or harassment is currently occurring, perhaps in part due to increased awareness of the status of CI belugas and the prohibitions against hunting, shooting, or harassing the whales. The NOAA Office of Law Enforcement patrols Cook Inlet and investigates any reports of illegal hunting or harassment of CI belugas. As of September 2016, no poaching incidents have been confirmed, and there has been one civil conviction of harassment.

Other: Other activities also have the potential to take CI belugas. For instance, although there is currently no commercial whale watching industry for CI belugas, there are numerous small planes, boats, and other small watercraft (e.g., jet skis, kayaks, and wind and kite surfboards) in the Cook Inlet area which have been observed approaching CI belugas for closer viewing. These close approaches can result in CI belugas changing their behavior or leaving an important area in an effort to escape the harassment caused by the close approaches.

b. Relative Concern

Unauthorized takes (i.e., those without NMFS authorization) have the potential to harass, disturb, displace, injure, or kill CI belugas. The activities of greatest concern to the recovery potential of CI belugas are those with the potential to injure or kill a CI beluga. Activities with the potential to result in unauthorized takes can be found rangewide in Cook Inlet, with certain localized hotspots. These activities are primarily seasonal, but given demographic and economic trends, the number of these activities in Cook Inlet is likely increasing in frequency. However, an increase in activities that could result in unauthorized take may not be a reliable indicator of an increase in unauthorized takes. The frequency of occurrence of unauthorized takes is unknown. There is a medium probability that unauthorized take will occur in the future, but the magnitude of the impact to CI belugas is likely to be variable. If the effect is displacement or a short-term change in behavior, the magnitude of the threat on CI belugas is low, but if the effect is a mortality, then the magnitude is high. However, there is little information to definitively conclude mortalities are associated with unauthorized takes. More information is available to suggest injuries may be a notable concern, but photographic data of healed scars suggest some injuries are not life threatening. Therefore, the overall relative concern of the impact of unauthorized takes is considered to be medium.

8. Threat Type: Pollution

Pollution is the introduction of contaminants into the environment that causes adverse change. For the purpose of this review, pollution is synonymous with acute and chronic events that release notable/reportable quantities of chemicals or substances into the environment. Exposure to industrial chemicals as well as to natural substances released into the marine environment is a potential health threat for CI belugas and their prey. For an in-depth review of available information on this topic, see Appendix IX.G – CI Beluga Pollution and Contaminants Supplement.

a. Sources and Types of Pollution in Cook Inlet

A number of sources of chemical and biological pollution have been identified in and around Cook Inlet, but a comprehensive water quality survey of Cook Inlet is not available. Potential sources of pollution which could affect CI belugas include: offshore oil and gas development; municipal waste and bilge discharge; marine oil spills; runoff from roads, airport, military sites, mines, construction sites, and farms; terrestrial and marine spills of contaminants other than oil; resuspension of contaminants through dredging; ship ballast discharge; watercraft exhaust and effluent; coal transportation and burning; auto exhaust; antifouling paint; and trash.

Possible contaminants CI belugas could be exposed to include: persistent organic pollutants; aromatic hydrocarbons; chlorinated hydrocarbons; heavy metals; endocrine disruptors; pharmaceuticals; antibiotics; sanitizers; disinfectants; detergents; insecticides; fungicides; and de-icers. While NMFS has some data about levels of traditionally studied contaminants in CI belugas (e.g., Dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCBs], polycyclic aromatic hydrocarbons [PAHs], etc.), virtually nothing is known about other emerging pollutants of concern and their effects on CI belugas. The emerging pollutants of concern include endocrine disruptors (substances that interfere with the functions of hormones), pharmaceuticals, personal care products (chemicals such as soaps, fragrances, insect repellants, etc.), prions (infectious proteins that cause neurodegenerative disease), and other bacterial and viral agents that are found in wastewater and biosolids.

URS (2010) evaluated the level of potential concern (probable, possible, unlikely) to CI belugas from various classes of chemicals. Chemicals identified by URS (2010) to be of probable and possible concern and for which at least some data are available for either CI belugas or other beluga populations are described in Table 8. URS (2010) categorized the following chemicals as unlikely to be of potential concern for CI belugas: hydrocarbons (other than PAH compounds), glycols, diagnostic agents, dietary supplements, personal care products, engineered particles (<100 nanometers), or prions. Acute effects associated with oil spills and natural gas blowouts are considered in the threat type Catastrophic Events.

b. Relative Concern

Pollution occurs rangewide with localized hotspots throughout the CI belugas' habitat, at variable frequencies depending on the source of the pollution. Point source pollution enters the water from a specific source (e.g., a sewage outfall pipe; in-water construction site; etc.); these sources of pollution may result in localized effects. Non-point sources of pollution in Cook Inlet occur over broader geographic areas that can ultimately have rangewide effects (e.g., runoff from roads, airports, agricultural sites, military training areas, etc.). Individually and collectively, point and non-point source pollutants may have either local or widespread effects, depending upon the location, size and abundance of the outfall sites, time of release, tidal conditions at the point(s) of release, and characteristics of the pollutant(s).

The amount of pollution entering Cook Inlet is likely increasing as the regional human population grows, a trend that is likely to continue. However, upgrading the Asplund Wastewater Treatment Facility, currently Alaska's largest wastewater treatment facility, from a primary to a secondary treatment facility could make a notable difference in total pollutants released into Cook Inlet, particularly into Cook Inlet beluga whale critical habitat. The decision of whether to upgrade this facility is currently under review by the Environmental Protection Agency (EPA).

Exposure to contaminants found in pollution may be the result of CI belugas' direct contact with contaminants found in the water; inhalation of contaminants in the air; or ingestion of contaminants found in prey, mud, or silt. It is also possible that adult males may have higher levels of contaminants stored in the body than do adult females because females may have the ability to transfer some of their contaminant load to their calves during pregnancy and lactation. There is little information on the potentially deleterious effects of contaminants on CI belugas; but it is likely that chronic exposure to contaminants may compromise an individual whale's health, with the potential for population-level impacts.

For the contaminants that have been studied, CI belugas generally had lower contaminant loads than did belugas from other populations (Becker et al. 2000, Lebeuf et al. 2004, NMFS 2008a, Becker 2009, DFO 2012, Reiner et al. 2011, Wetzel et al. 2010, Hoguet et al. 2013). Based on these results, it is possible that the levels of pollution in Cook Inlet, the exposure to pollution by CI belugas, or the rate of uptake/retention of contaminants by CI belugas, is lower than that for other beluga populations. The more temperate habitat of CI belugas compared to belugas residing at higher latitudes may help explain why persistent organic pollutants are not as prevalent in whales living in Cook Inlet.[22] Additionally, chemical analyses of water and dredging sediments from Cook Inlet found that contaminants analyzed were below management levels, and some were below detection limits (Frenzel 2002; U.S. Army Corps of Engineers [Corps] 2003).

The available information suggests that the magnitude of the pollution threat to CI belugas appears low, although not all pollutants to which these whales are exposed have been studied in

[22] Alaska Community Action on Toxins website accessed January 2, 2015: http://www.akaction.org/tackling_toxics/world/global_transport_toxics_arctic/.

Table 8. Compounds of probable and possible concern for CI belugas, for which data are available either for CI belugas or for other beluga populations.

Chemical Class	Example Individual Constituents	Level of concern for CI Beluga	CI beluga data	Other beluga data
Chlorinated pesticides	Many banned in the U.S. in the 1970s, but are still used in other parts of the world: DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	Probable	Yes	Yes
Chlorinated dielectric fluids, transformer oils	Banned in the U.S. since the 1970s, but previously used as coolants and lubricants in transformers and other electrical equipment. 209 PCB congeners, aroclor mixtures	Probable	Yes	Yes
Chlorinated dibenzo-p-dioxins and furans	Not intentionally used; byproduct emitted from waste incinerators, chlorinated bleaching, wood preservation, chemical synthesis. 75 Dioxin congeners (PCDDs), 135 furan congeners (PCDFs)	Probable	No	Yes
Metals	Methyl mercury, selenium, butyltins, cadmium, arsenic[a], lead[a], manganese[a], mercury[a], organic tin[a]	Probable	Yes	Yes
Aryl and Polycyclic aromatic hydrocarbons (PAHs)	This is naturally occurring and also released from industrial products (asphalt, coal tar) and combustion of coal, oil, gas, wood, or organic waste. Of major concern are: Benzo(a)pyrene, anthracene, pyrene, toluene[a], benzene[a], xylene[a]	Probable	No	Yes
Polybrominated flame retardants	Commonly used as flame retardants in computers, textiles, construction, and electrical equipment. Polybrominated diphenylethers (PBDEs) (PBBs, polybrominated biphenyls are no longer produced in the U.S.)	Possible	Yes	Yes
Perfluorinated Compounds	Commonly used as a water and oil repellant, protective coatings in food packaging, textiles, and carpeting: Teflon coating, Perfluorooctane sulfonates, Perfluorooctanoic acid	Possible	Yes	No

[a] Denotes compounds with known ototoxic (i.e., damaging to hearing) effects.

Source: Modified and reproduced with permission from URS 2010, Table 5, and the factsheets.

this environment. Even though the existing studies are not comprehensive of all possible contaminants to which belugas may be exposed, the comparatively low levels of contaminants documented in CI belugas themselves as well as in the Cook Inlet water and sediment samples analyzed suggest that the relative concern of these known and tested contaminants to CI belugas is most likely low.

9. Threat Type: Predation

Predation may represent a continuing source of mortality for CI belugas. Predation rates may be a function of the size of the predator population and the availability of alternative prey, rather than the size of the prey (beluga) population. The frequency of predator induced mortality among belugas may also be influenced by anthropogenic factors, including climate change.

a. Predation by Killer Whales

Predation by killer whales has been identified as a source of mortality for CI belugas that may be independent of the size of the beluga population and may prove to be unsustainable for such a small population. While killer whales are regularly reported in lower Cook Inlet, the majority appear to be the resident (fish eating) type that would not prey on belugas (Matkin et al. 2009). There have been no documented sightings of resident killer whales in upper Cook Inlet. Transient (marine mammal-eating) killer whales are known to prey on CI belugas (Shelden et al. 2003; NMFS, unpub. data), although rates of predation are uncertain and can only be estimated. Based on the information available, 9–12 CI beluga mortalities since 1982 were suspected to be a direct result of killer whale predation (see Table 4). Over the past 25 years, predation of CI belugas by killer whales has not involved individuals in the catalog of transient killer whales identified from the Gulf of Alaska (including lower Cook Inlet) (C. Matkin, North Gulf Oceanic Society, unpub. data). It therefore appears that uncatalogued transient killer whales may prey on CI belugas.

A passive acoustic monitoring study examining the seasonal distribution of belugas throughout Cook Inlet (Lammers et al. 2013) also detected the presence of killer whales. Between June 2009 and May 2010, the acoustic recorders detected killer whales 17 times. Most detections were at the Homer Spit location, with a single detection at both the Tuxedni Bay and Beluga River locations. Of these 17 killer whale detections, only the one recorded near the Beluga River in upper Cook Inlet was likely from a transient killer whale, which has an acoustic behavior very different and distinguishable from resident killer whales (Barrett-Lennard et al. 1995). The killer whale detection off the Beluga River was concurrent with the presence of belugas at that site. Despite relatively high levels of marine mammal observer effort, killer whales have been infrequently reported in upper Cook Inlet

Based on the available data, it appears that only a small group of (uncatalogued) transient killer whales may occasionally prey on the belugas in upper Cook Inlet. It is not known whether there is a relationship between the rate of killer whale predation and the reduced size of the CI beluga population or the contraction in the range of CI belugas. The presence of killer whales in Cook Inlet may increase beluga live-stranding events, thus indirectly contributing to CI beluga mortality. However, the shallow, highly turbid, and restricted waters of the upper Inlet provide challenges to killer whales which may lead to killer whales stranding (e.g., killer whales stranded in Turnagain Arm in 1991, 1993, 2000, and 2002), and reduce the benefit of preying on belugas in that region.

b. Predation by Sharks

Sharks have been postulated as a predator of CI belugas, but there is insufficient evidence at this time to consider them a serious threat. Shark predation attempts have been suspected, based upon observations of tooth-rake marks on some CI belugas (LGL 2009), but there is no conclusive evidence that shark predation occurs. Pacific sleeper and salmon sharks are found in the region, but it is unknown whether these sharks prey on or attack living cetaceans. However, as water temperatures in Cook Inlet rise with climate change, the incidence of sharks in Cook Inlet may increase (O’Brien et al. 2013).

c. Predation Effects on a Small Population (i.e., predator pit)

Predation rates of CI belugas may or may not be density dependent. However, at low population levels of prey, predator:prey relationships can create a predator pit. That is, the prey population may decrease to a level from which it cannot recover unless the predation pressure is reduced (Liermann and Hilborn 2001). Although belugas form only a small part of the transient killer whale diet, a numerically constant annual removal of belugas by killer whales from a small and declining beluga population would represent a threat that is inversely proportionate to the beluga population level.

d. Relative Concern

As previously stated, there is no conclusive evidence that shark predation on CI belugas occurs. Killer whale predation on CI belugas appears to occur at fairly low levels, with only 10–13 suspected CI beluga mortalities attributable to killer whales since 1982. There is no information to suggest the level of predation by killer whales has increased over time. Rather, killer whale predation appears to occur intermittently at very low levels (e.g., three suspected CI beluga mortalities in the past 17 years). In 2008, killer whale predation was identified as a "moderate" threat in the *Conservation Plan for Cook Inlet Beluga Whales* (NMFS 2008) when it was assumed there was an average of one killer whale-related mortality per year. However, from January 2008 through August 2016, there have only been two suspected predation-related mortalities, and one of these two beluga carcasses was in such poor condition that a definitive determination of a predation event was not possible. Killer whale sightings in upper Cook Inlet reported to NMFS have also been infrequent.

Predation is currently of low relative concern for the recovery of CI belugas, primarily because it occurs at such low levels, and has long been a part of CI beluga population dynamics. However, any increase in predation removals in excess of one beluga per year from this small population could reduce or reverse the rate of recovery.

10. Threat Type: Subsistence Hunting

a. Legal Subsistence Hunting

Legal subsistence hunting of CI belugas by Alaska Natives is currently conservatively managed; no subsistence harvest has occurred after 2005. However, some past subsistence hunting practices have had negative population level impacts on CI belugas, and the effects of these impacts likely persist. The dramatic decline in beluga abundance during the mid-1990s, and likely during the 1980s as well, corresponds to a time of unregulated subsistence hunting. These practices were a major contributor to the observed population decline (64 FR 56298, October 19, 1999; NMFS 2008b). This spike in subsistence harvest was largely attributed to participation by hunters from locations that had not traditionally harvested CI belugas.

Because the average CI beluga population estimate for 2007–2012 was below 350 whales, no subsistence hunting is authorized through 2017, as outlined in the final subsistence harvest regulations for these whales (73 FR 60976, October 15, 2008; NMFS 2008b). Per these regulations, the average CI beluga population abundance estimate from 2013–2017 will be reviewed in 2017 to determine if a legal hunt will be authorized for the five year period 2018–2022. However, because CI belugas are an endangered species, NMFS will not authorize a hunt if it is determined that the activity is likely to jeopardize the continued existence of CI belugas.

Only Alaska Natives are eligible for subsistence hunting, and in order to qualify for subsistence hunting of CI belugas, a valid co-management agreement with NMFS must be in place. Because CIMMC disbanded in 2012, NMFS does not have a co-management agreement with any Alaska Native organization specific to CI belugas.

b. Relative Concern

In the past, subsistence hunts resulted in either injury or mortality to CI belugas. There were localized hotspots within Cook Inlet where most hunting occurred, seasonally or intermittently. However, the last CI beluga taken as a result of subsistence hunting was in 2005. The current conservative management of legal subsistence hunting means no subsistence hunts will be considered until 2018, and will only be authorized if the associated mortality would not jeopardize the continued existence of the species (i.e., the magnitude of the effect to the population would be low). Therefore, there is no immediate threat to the CI beluga population or its recovery as a result of legal subsistence harvests, and the relative concern is low.

B. State of Alaska's List of Threats to CI Belugas

The ADF&G uses *Alaska's Wildlife Action Plan* (ADF&G 2006) to assess the needs of species with conservation concerns and to prioritize conservation actions and research. The "problems, issues, or concerns" for CI belugas listed in this plan closely resemble the list of threats identified above (Table 6), and are as follows:

- Resource prey competition with people;
- Incidental mortality of belugas in fisheries (entanglements in nets, shooting);
- Potential impacts from pollution and contaminants that need monitoring:
    - Oil and gas developments,
    - Municipal waste and bilge discharge, and
    - Marine oil spills;
- Subsistence harvests;
- Vessel interactions (recreational, commercial, high speed vessel);
- Anthropogenic noise (seismic testing, vessel traffic, drilling, dredging, industrial activities like pile driving, aircraft overflights);
- Predation by killer whales;
- Strandings;
- Potential impacts from environmental change;
- Loss of genetic diversity;
- Potential for ESA listing changing ability to manage, gather information, take action;
- Unknowns (age-specific survival and reproduction, parasites, diet, life history parameters); and
- Highly concentrated, clustered distribution increasing vulnerability (e.g., oil, spills, vessel traffic, harassment, etc.).

C. Section Summary: Threats to Recovery

At this time, it is unknown what factor(s) continue to limit growth and recovery of CI belugas. It may be that the cumulative effects of multiple stressors are impeding recovery, whereas the effects of individual stressors in isolation would not impede recovery.

Ten potential threats are identified and assessed in this recovery plan, based on current knowledge of threat factors. Assessments were based on the information and data gaps presented in the plan's Background section, as well as in the supplemental information presented in the appendices. Climate change, which has both natural and anthropogenic sources, is not addressed as a separate threat, but rather is discussed with respect to how it may affect other threats. Table 6 provides: 1) a listing of each threat discussed in this section; 2) a summary of the major effect of the threat on CI belugas; 3) a qualitative description of the threat's extent, frequency, trend, probability, and magnitude; and 4) a qualitative rating of each threat's relative concern for CI beluga recovery.

The "problems, issues, or concerns" for CI belugas listed by the State of Alaska's *Wildlife Action Plan* (2006) closely resemble the list of threats identified here.

<u>Threat Type: Catastrophic Events</u>

Several natural factors may result in a catastrophic event with potential to adversely affect CI belugas, including effects from environmental or climatic changes, earthquakes, volcanos, novel disease outbreaks, mass strandings resulting in large numbers of mortalities, and failures of key salmon runs. Anthropogenic activities, such as oil spills and natural gas blowouts, among others, may also result in a catastrophic event with detrimental effects on CI belugas. Catastrophic events may also have significant effects on CI beluga prey, whether through changes to spawning or migration patterns, direct mortality, or potential long-term sub-lethal impacts. A catastrophic event on its own may not always directly adversely affect CI belugas; rather, it may lead to a mass stranding event, which could have catastrophic results if there are multiple mortalities as a result of the stranding. Mortalities associated with a live stranding event do not appear to be common. Effects from catastrophic events are variable, and in addition to mortality, may also result in compromised health or injury to individual whales, reduced overall fitness or resilience of the population, or reduced carrying capacity of the environment; however, depending on the location of the event, the exposure or effect to CI belugas will vary. Small populations, such as the CI beluga population, may be more susceptible to adverse effects resulting from catastrophic events than large populations. The reduced summer range of CI belugas into the upper Inlet makes them far more vulnerable to catastrophic events that have the potential to kill or injure a significant portion of the population. It is expected that most catastrophic events would be localized events, affecting only a portion of the CI belugas' range. Past experience indicates the frequency of catastrophic events in Cook Inlet is low. Anthropogenic activity in Cook Inlet is increasing, however, and environmental and climatic conditions are changing. Thus the probability of adverse effects resulting from a future catastrophic event is thought to be medium to high. The magnitude of effect upon CI belugas of a catastrophic event is a function of several factors, including type of event, location of event, and exposure of whales to the event. However, given the history of live stranding-related mortalities and given the fact that mortalities can have an immediate and notable impact to the recovery potential of the population, we ranked the magnitude of the effects of catastrophic events as variable, but potentially high. We conclude the overall relative concern of the impact of catastrophic events on CI belugas is of high concern.

Threat Type: Cumulative Effects of Multiple Stressors

Multiple stressors occur continuously throughout the range of CI belugas. While it is difficult to quantify or characterize effects on CI belugas from individual stressors, it is even more difficult to characterize the potential cumulative effects from a combination of stressors. Exposure to any given stressor at a sub-lethal level may predispose individual belugas to greater susceptibility to mortality or long-term effects (for example, reproductive failure) from other stressors. Death can also result from different combinations and intensities of multiple stressors. Cumulative impacts have been a long-standing issue in the debate over noise effects on marine mammals; the additive effects of multiple noise sources, as well as the combination of noise and other stressors, are of particular concern. Perhaps most important are potential synergistic effects in which two stressors interact to cause greater harm than the sum of the effects of the stressors individually. For example, a stressor may increase cortisol levels, which in turn tends to reduce immune response. There are well-documented examples of multiple stressors in terrestrial species that individually have little impact, but, when combined, can have major, negative, synergistic impacts that may cause death. In the case of CI belugas, contaminants and predators (e.g., transient killer whales) may occur in the preferred habitat, creating a potential for synergistic effects if the contaminants make the belugas more susceptible to predation. CI belugas might be at risk from the negative synergistic effects from anthropogenic noise exposures coupled with other stressors such as widespread pollutants or the presence of transient killer whales (e.g., detecting their presence acoustically without the need of actual physical encounters). Accurate prediction of all the potential cumulative effects requires a reasonable knowledge of all the various contextual factors for each exposure and is therefore difficult. Stressors related to the current small population size of CI belugas, when combined with anticipated trends of increased anthropogenic impacts, can increase the likelihood of co-occurring and interacting multiple stressors, reducing the likelihood of population recovery in the near term. Of particular concern are the cumulative effects of multiple stressors (acoustic and non-acoustic), given the noisy environment of Cook Inlet. Given the growth of activities in Cook Inlet, the trend for cumulative effects is increasing over time, with a high probability that these effects will continue in the future. Uncertainty over the complexity of potential mechanisms and difficulty in detection of their impacts and their potential mitigation make the cumulative effects of multiple stressors a threat category of high relative concern regarding potential impediments to recovery of CI belugas.

Threat Type: Noise

The acoustic environment of Cook Inlet is naturally noisy, complex, and dynamic. Natural sources of noise are particularly abundant and loud in the CI belugas' range and include: bottom substrate being transported by high currents; sand and mud bars generating breaking waves during low tide/high current periods; river mouths becoming rapids at low tide periods; and fast and pancake ice being formed during winter months and under continuous mechanical stress by high tide oscillations and currents. The effects of these natural conditions, while difficult to quantify, may compromise CI beluga acoustic communication and echolocation, particularly as the sound transmission distance increases. However, CI belugas have presumably adapted to accommodate such noise. The addition of anthropogenic noise, to which the whales have not necessarily adapted, may have negative effects. Due to the highly concentrated human population in the current range of CI belugas, a wide variety of anthropogenic noise sources that may affect fitness are present in CI beluga habitat, especially in the upper Inlet. Most sources of anthropogenic noise in Cook Inlet are seasonal and occur during the ice-free months, although some sources are present year-round. Sources of anthropogenic noise in Cook Inlet include: propeller cavitation, engines, sonar, dredging, pile driving, military detonations, aircraft, seismic air guns, drilling, geophysical and geotechnical equipment, and other mechanical noise. The effect of anthropogenic noise, particularly the combined effect of different sound sources occurring simultaneously or consecutively, has the potential to affect beluga acoustic perception, communication, echolocation, and behavior. In the long term, anthropogenic noise may induce chronic effects altering the health of individual CI belugas, which in turn have consequences at the population level (i.e., decreased survival and reproduction). Despite the fact that direct and indirect effects of these sounds on CI belugas have not been analyzed and are currently unknown, there is enough evidence from other odontocete species (including other beluga populations) to conclude that a high potential exists for negative impacts. Anthropogenic noise also has the potential to indirectly affect the survival and reproduction success of CI belugas by having negative effects on their prey. Depending on the source, a noise can be localized or occur rangewide. While noise may result in compromised communication and hearing of CI belugas and may contribute to habitat degradation, the magnitude of the impact of noise on CI belugas is unknown, but potentially high. There is a high probability that anthropogenic noise in Cook Inlet will continue and increase in the future, and given that the natural noise is already limiting, the threat to CI beluga recovery due to anthropogenic noise is of high relative concern.

Threat Type: Disease Agents (Pathogens, Parasites, Harmful Algal Blooms)

Potential sources of disease-causing agents exist in and around Cook Inlet. Disease agents may include pathogens (such as bacteria, viruses, and fungi), parasites, and harmful algal blooms (HABs). The necropsy record of stranded CI beluga carcasses shows only low levels of parasitism, and parasites that were present did not appear to have a significant negative impact (i.e., were not attributed to be the cause of death). Additionally, parasites most likely would only have detrimental effects at the scale of individual whales, with population-wide effects unlikely. Thus, the threat of parasites is currently of low relative concern for CI belugas. Although HABs have the potential to detrimentally impact a large portion of the population, the reported incidence of HABs in Cook Inlet has been very low to date. However, there is evidence that HAB toxins are present throughout Alaska waters at levels high enough to be detectable in marine mammals; moreover, current climate trends may result in conditions favorable to the growth of HABs, increasing the health risks to marine mammals. In addition to the potential prevalence of HABS, climate change is rapidly altering the global movement of pathogens, bringing diseases to new areas. Small populations, such as CI belugas, are susceptible to population-wide disease outbreaks. A population-wide outbreak of a novel (new) disease could be catastrophic to CI belugas. Based on the number of whales photographed in Eagle Bay in 2011 with indications of past infection, we assume disease of some sort is present in the population at unknown levels, and recognize there is a medium to high probability that disease will increase in the future. Currently, the incidence of disease as a factor in the deaths of CI belugas appears to be low, and there is little evidence to suggest diseases of concern are present in other mammals in the area. As such, while current incidence of disease and parasitism is a low relative concern, the threat to CI beluga recovery due to increases in HABs or a disease outbreak associated with novel pathogens in the future is of medium relative concern, and the overall threat posed by disease agents is of medium relative concern.

Threat Type: Habitat Loss or Degradation

Concurrent with the CI beluga population decline in the mid-1990s, the spatial distribution of CI belugas contracted such that whales are found primarily in the upper portion of Cook Inlet near Anchorage during the summer. Climate-driven increased water temperature, siltation, changes in volume of freshwater runoff, and reduced salinity may occur gradually. However, when they result from episodic events, such as earthquakes or volcanic eruptions, effects may be immediate. Examples of anthropogenic activities that can result in substantial changes in habitat, or temporary or permanent loss of habitat, may include in-water construction, port expansion, highway and bridge construction, dredging, changes in freshwater inflow from dams, and river dredging or channeling. These types of anthropogenic threats tend to be localized, seasonal, and increasing in frequency, whereas natural threats may operate range-wide at either unknown or increasing frequency (e.g., warmer water temperatures under climate change scenarios). Both natural and anthropogenic factors may limit suitable habitat either directly in the form of whale perturbation and reduction of fitness (e.g., chemical impacts to skin tissue), or indirectly through impacts to prey populations and reduced carrying capacity of the environment. Most of the anthropogenic activities disturbing CI beluga critical habitat are concentrated in the coastal zone and are often seasonal. Although most of the beluga habitat in Cook Inlet is not degraded to the point that adverse effects to CI belugas are apparent, anthropogenic activities in the Inlet are increasing, and there is a high probability there will be more habitat loss or degradation in the future. Concurrent with increasing anthropogenic activities in Cook Inlet, the trend of habitat loss or degradation for CI belugas is also increasing over time, and the contraction of their range into the upper Inlet has resulted in increased proximity to the developed areas around Anchorage. Due to a limited understanding of how this habitat might be altered by various factors and its resilience to perturbations, the loss or degradation of habitat is of medium relative concern for CI belugas.

Threat Type: Reduction in Prey

The impact of reduction of available prey on CI belugas is poorly understood and may have several effect pathways including: changes in the total availability, quality, species composition, and seasonality of prey. While the potential exists for human fishing pressure to dramatically change the abundance, seasonality, or composition of beluga whale prey, for targeted species, fisheries in Alaska are managed with in-season reductions or closures if those fish stocks appear to be weak. However, not all fish stocks are assessed, and it is unknown whether management of fisheries for optimal returns provides sufficient densities in beluga feeding areas for efficient foraging by belugas. It is likely there is interspecific competition for limited prey resources between CI belugas and other predators in Cook Inlet (e.g., harbor seal, harbor porpoise). Habitat modification may result in changes in species availability and/or species composition throughout the range distribution of CI belugas. Depending on the source, a reduction of prey can be a localized event or occur Inlet-wide, with a variable frequency of occurrence. While reduction of prey may result in reduced carrying capacity of CI beluga habitat or reduce CI beluga fitness, the magnitude of the impact of a reduction of prey on CI belugas is unknown, as is the trend and future probability. As such, the threat to CI beluga recovery due to the reduction of prey is of medium relative concern.

Threat Type: Unauthorized Take

In certain instances, NMFS may authorize or permit directed or incidental "takes" of CI belugas under the MMPA and ESA. These authorizations undergo extensive reviews prior to issuance. Authorized takes are not considered to be a population-level threat to CI belugas. Activities which result in harassment or harm to CI belugas but which NMFS has not authorized (i.e., unauthorized take) may result in changes in CI beluga behavior, displacement of CI belugas from important areas, or injury or mortality to CI belugas. Some activities with potential to result in unauthorized take include entanglements from fisheries operations, strikes from vessel activities, unanticipated harassment or mortalities from research activities, mortalities or injuries from poaching and intentional harassment, and other adverse outcomes (e.g., displacement) associated with miscellaneous activities such as whale watching.

While there have been sporadic reports over the years of individual belugas becoming entangled in fishing nets, the only known fishery-related mortality in recent years was one yearling CI beluga carcass recovered in 2012 from a set net. Ship strikes have not been confirmed in a CI beluga death, but there are two instances where death by ship strike was highly probable given the blunt trauma sustained by the whales. Scarring consistent with non-lethal propeller injuries has also been documented in the CI beluga photo-identification catalog.

Research activities not targeting belugas, such as research activities studying CI beluga prey or habitat, may incidentally harass CI belugas, and if not authorized by NMFS, these are unauthorized takes. NMFS has authorized take associated with several directed CI beluga research projects over the years, including capture, tagging, biopsies, and aerial and boat-based surveys, but recent authorizations have not allowed for mortality. It is possible that three CI belugas died (an unanticipated outcome) as a result of a capture and satellite tagging research project in 2002. With the exception of an effort to apply acoustic recorders to the whales via suction cup tags and a biopsy feasibility project, all other directed research activities have involved non-invasive techniques (e.g., passive acoustic recordings; aerial, boat, and land-based observations; photographic studies) with a low potential to adversely affect CI belugas.

There is little information available to suggest illegal hunting or harassment is currently occurring, perhaps in part due to increased awareness of the status of CI belugas and the prohibitions against hunting, shooting, or harassing the whales. The lack of reports to NMFS regarding illegal hunting attempts; the near absence of conviction by the NOAA Office of Law Enforcement for suspected cases of illegal hunting and harassment; the lack of mortalities associated with firearms for over 15 years; and the lack of fresh injuries documented through photo-identification studies leads to a conclusion that the threat of illegal hunting or harassment has decreased in recent years, and currently occurs at levels at or near zero. There is a medium probability that unauthorized takes will occur to some degree in the future, but the magnitude of the impact to CI belugas is variable, depending upon the effect. If the effect is displacement or a short-term change in behavior, the magnitude of the threat on CI belugas population is low, but if the effect is mortality, then the magnitude is high. The overall relative concern of the impact of unauthorized takes resulting from activities such as fisheries, vessel operations, research, whale watching, and other miscellaneous activities is medium.

Threat Type: Pollution

CI belugas may be exposed to contaminants through direct contact in the water; inhalation of contaminants in the air; or ingestion of contaminants found in prey, mud, or silt. Pollution often enters the water from a specific source (e.g., a sewage outfall pipe; in-water construction site; etc.); these sources of pollution may result in localized effects. Other sources of pollution in Cook Inlet occur over broader geographic areas and can ultimately have rangewide effects (e.g., runoff from roads, airports, agricultural sites, military training areas; etc.). Thus, depending on the source of the pollution, the extent of the effect may be either localized or rangewide, with a variable frequency of occurrence. Given the increases in the human population and development of Cook Inlet, it is likely that the level of pollution entering Cook Inlet is increasing and will continue to increase in the future. However, if the Asplund Wastewater Treatment Facility, Alaska's largest wastewater treatment facility, is upgraded in the future from a primary treatment facility to a secondary treatment facility the overall pollution entering Cook Inlet could stabilize or decline in the near term. It is possible that CI belugas have been chronically exposed to low levels of contaminants in Cook Inlet for some time. For the contaminants that have been studied, CI belugas have generally had lower contaminant levels than did belugas from other populations, and thus the magnitude of the threat to CI belugas from pollution is assumed to be low. Even though the available data do not include assessment of all possible contaminants to which belugas may be exposed, the comparatively low levels of contaminants documented in CI belugas, as well as in Cook Inlet waters and sediments analyzed, suggest that known and tested contaminants are in general of low relative concern.

Threat Type: Predation

Transient (mammal eating) killer whales are known to prey on CI belugas, however, there have only been 9–12 CI beluga mortalities since 1982 suspected to be a direct result of killer whale predation. In addition to directly reducing CI beluga abundance via mortality, the presence of killer whales in Cook Inlet may increase beluga live-stranding events. It appears that only a small group of transient killer whales may occasionally prey seasonally on the belugas in upper Cook Inlet. Killer whale sightings in upper Cook Inlet reported to NMFS have been infrequent. The shallow, highly turbid, and restricted waters of the upper Inlet may lead to killer whales stranding, and may reduce the benefit of preying on belugas in that region. Although predation on CI belugas by sharks has been postulated, there is no conclusive evidence that shark predation on CI belugas occurs. There is a medium probability that a low level of predation by sharks will occur at some point in the future, but if the trend remains stable, the magnitude of the effect upon CI belugas is low. Overall, predation is currently of low relative concern for the recovery of CI belugas.

Threat Type: Subsistence Hunting

In the 1990s, legal subsistence hunting of CI belugas by Alaska Natives had a direct negative impact on belugas in Cook Inlet; however, subsistence hunting is currently conservatively managed, and no harvests are authorized through 2017. Harvests after 2017 will only be considered if specific population size parameters are met and if it is determined that allowing a mortality will not jeopardize the continued existence of CI belugas. As such, there is no immediate threat to CI belugas or their recovery as a result of legal subsistence harvests, and the relative concern from subsistence hunting is low.

IV. RECOVERY STRATEGY

We know the CI beluga population is not recovering as expected after the regulation of subsistence hunting in 1999, but we do not know why. Before that can be determined, more information must be obtained about basic CI beluga biology and effects of potential threats on CI belugas.

This complex situation requires a comprehensive, integrated, adaptive recovery strategy. This strategy consists of data acquisition (on CI beluga biology, life history, ecology, and anthropogenic activities), integration of data sets from multiple sources, and application of these results to management (e.g., development and implementation of mitigation to avoid or reduce adverse effects), with continuous feedback between research and management actions.

In light of the recent decline, small population size, life history characteristics, and increasing number and magnitude of potential threats, it is challenging to identify the most expedient way to achieve recovery of CI belugas. We recognize that recovery will not occur immediately and will require a prolonged effort that is capable of adapting as new information becomes available, threats are mitigated or new threats arise, or the status of the CI beluga population changes. Thus, we structured this plan to emphasize addressing the most critical elements as a means to first curb the population decline and stabilize the population, then incorporate adaptive management reviews and revisions in the future to work toward population growth and recovery. Given the lack of clear reasons for the failure to recover following the regulation of the subsistence harvest in 1999, a balance must be struck when allocating scarce resources in our efforts to bring about recovery of this species. In an effort to strike this balance, we assert that the most expedient way to achieve recovery is by first addressing those threats identified as of medium or high relative concern (see Table 6). Doing so is not meant to indicate threats of low relative concern are ruled out as threats, nor is it meant to preclude or discourage actions taken by NMFS or other entities to address threats initially identified as being of low relative concern. Rather, if a choice has to be made between addressing a threat of high/medium relative concern or a threat of low relative concern, we recommend the resources be allocated to addressing the higher ranked threat.

The recovery criteria and recovery actions outlined in the following sections address the threats of medium or high relative concern, and do not discuss in detail threats of low relative concern. Nevertheless, to ensure the recovery plan remains strategic, a recovery action is included that calls for periodic reassessment of the threats considered of low relative concern to determine if the status of those threats has elevated to the point specified recovery actions need to be defined. Furthermore, by adopting an adaptive recovery strategy, NMFS does not intend to require a protracted, formal process for reclassifying the severity of individual threats to CI belugas prior to taking actions to address them. Rather, we will seek guidance from experts in how to best respond to new information that has implications upon the severity of threats to CI belugas, and we will endeavor to follow that guidance.

The actions in this recovery plan include research, management, monitoring, and education/outreach efforts that take a comprehensive approach to addressing CI beluga recovery. Threats-based recovery actions attempt to improve our understanding of threats and the population-level consequences of threats; in addition, these recovery actions attempt to improve our ability to manage and eliminate or mitigate threats.

Recognizing the importance of keeping the public apprised of the status and outcome of the recovery actions, the recovery strategy also identifies a multi-faceted education and outreach action. In addition to addressing the threats, we recognize the importance of continuously monitoring the CI beluga population, and have therefore included recovery actions specific to population monitoring goals.

To summarize, the strategy of this recovery plan is to:

- Continue to monitor the status of the CI beluga population and improve the understanding of CI beluga biology;
- Improve the understanding of the effects of threats of medium or high relative concern on CI belugas;
- Improve the management of threats of medium or high relative concern to reduce or eliminate the effect of those threats on CI belugas;
- Periodically reassess whether the relative concern of each potential threat identified in this plan has changed over time;
- Integrate research findings into current and future management actions; and
- Keep the public informed and educated about the status of CI belugas, the threats limiting their recovery, and how the public can help achieve recovery of these whales.

V. RECOVERY GOALS, OBJECTIVES, AND CRITERIA

Section 4(f)(1)(B) of the ESA requires that each recovery plan contain objective, measurable criteria which, when met, would result in a determination that the species be delisted.

A. Recovery Goals

The ultimate goal of this plan is to achieve the recovery of CI belugas to a level sufficient to warrant their removal from the List of Endangered and Threatened Wildlife and Plants under the ESA (delist). The intermediate goal is to reclassify CI belugas from endangered to threatened (downlist). To downlist CI belugas from endangered to threatened, NMFS must determine that the population is no longer “in danger of extinction throughout all or a significant portion of its range” (16 U.S.C. § 1532(6)). To delist CI belugas, NMFS must further determine that the population is not “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range” (16 U.S.C. § 1532(20)). These determinations include consideration of the population’s abundance and demographic parameters, taken together with threats as identified under the ESA section 4(a)(1) factors considered for listing.

B. Recovery Objectives

When considering the listing of a species, five statutory factors (see Section I.B. History of the Listing Status of Belugas in Cook Inlet) are analyzed. These same factors must be considered in downlisting and delisting, with objectives related to each factor included as part of the recovery criteria. The following recovery objectives were identified for CI belugas and linked to the five listing factors:

- Ensure adequate habitat exists to support a recovered population of CI belugas. Habitat needs include sufficient quantity, quality, and accessibility of prey species (Listing Factor A);
- Ensure that commercial, recreational, scientific, or educational activities are not inhibiting the recovery of CI belugas (Listing Factor B);
- Ensure that the effects of diseases and disease agents on CI beluga reproduction and survival are not limiting the recovery of the CI beluga population (Listing Factor C);
- Ensure that regulatory mechanisms other than the ESA are adequate to manage threats to the sustainability of CI belugas (Listing Factor D); and
- Continue monitoring the population to identify and mitigate any new natural or manmade factors affecting the recovery of CI belugas (Listing Factor E).

C. Recovery Criteria

Section 4(f)(1) of the ESA requires recovery plans to incorporate “objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list” (16 U.S.C. § 1533(f)). For many species, these criteria have focused primarily on a population size, trend, or some other demographic factor, but neglected to address the threats that resulted in the need to list the species. This recovery plan contains both demographic criteria and threats-based criteria for downlisting and delisting. All the demographic and threats-based criteria listed below must be met in order for CI belugas to be considered “recovered”; however, only the downlisting criteria must be met for consideration for reclassification from “endangered” to “threatened” (Table 9). The threats-based downlisting and delisting criteria below are organized according to the five ESA section 4(a)(1) factors (labeled A-E, respectively).

We note that recovery under the ESA is an iterative process with periodic analyses to provide feedback into the species' status and progress towards recovery. The ESA requires a review of the status of each listed species at least once every five years. Periodic review of the species may lead to updates or revisions to the recovery plan, changes in the listing status of the species, or delisting. While meeting all of the recovery criteria would indicate that the species should be delisted, it is possible that delisting could occur without meeting all of the recovery criteria if the best available information indicated that the species no longer met the definition of endangered or threatened. Changes to the species' status and delisting would be made through rulemaking after considering the same five ESA factors considered in listing decisions, taking new information into account.

1. Downlisting Criteria for Reclassifying CI Belugas from "Endangered" to "Threatened"

CI belugas may be considered for reclassifying from endangered to threatened (i.e., downlisted) when all of the following demographic and threats-based criteria have been met. The threats-based recovery criteria are designed to evaluate the five ESA section 4(a)(1) factors and are organized accordingly (labeled A–E). There are no downlisting criteria identified for Listing Factor C (disease or predation) because we concluded that if the threats under the other listing factors are ameliorated and the population has achieved the demographic criterion for downlisting, then CI belugas will have made sufficient progress toward recovery such that reclassification from endangered to threatened may be considered (however, with respect to delisting, a recovery criterion for Listing Factor C is described below).

a. Downlisting Demographic Criterion

1. The abundance estimate for CI belugas is greater than or equal to 520 individuals, and there is a 95% or greater probability that the most recent 25-year population abundance trend (where 25 years represents one full generation) is positive.

Justification: For long-term sustainability, a recovering population must show adequate population size and positive population growth over a timeframe that is long enough to encompass expected environmental variability. In the absence of better information, NMFS considers the historical abundance estimate of 1,300 whales to be the best estimate of the carrying capacity of CI belugas. We have no data at this time to indicate whether this carrying capacity may have changed. The threshold of 520 whales (40% of carrying capacity) represents the approximate mid-point between the lowest reported abundance estimate for CI belugas (278 belugas; 21% of carrying capacity) and the abundance level at which delisting may be considered (780 belugas; 60% carrying capacity); in addition, it is a level at which the population should not be considered in danger of extinction, assuming there is also statistical confidence the population has exhibited positive growth over the previous generation (previous 25 years) and threats have been adequately addressed. A 25-year timeframe was selected for population growth because it is a biologically-based time period that is expected to reasonably encompass environmental variability affecting the population. We chose the 95% probability level for a positive population trend because this level would provide a widely accepted degree of confidence that the population trend is positive. We recognize there is variability around survey point estimates, and a single population point estimate may over- or under-estimate the true population size. Survey variance should be taken into consideration as the population size approaches 520 to help ensure that consideration of downlisting is not based on anomalous conditions and accounts for the population trend over a full generation. The longer a population sustains a positive growth rate, the more confident we can be that the population is likely to continue to grow and become stable in the future and is resilient to stochastic events.

b. Downlisting Threats-Based Criteria

Listing Factor A: The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

Objective: Measures are in place to evaluate and ensure adequate habitat exists to support a recovered population of CI belugas. Habitat needs include sufficient quantity, quality, and accessibility of prey species to support a stable or growing population at the identified demographic criterion level.

A.1 Ninety-five percent of CI belugas sampled within the most recent 25 years are determined by cetacean experts to display no signs of poor nutrition, indicating a very high degree of confidence that nutrition is not limiting CI beluga recovery.

A.2 Sufficient prey are available to, at a minimum, sustain CI belugas at the identified demographic criterion level. This determination shall take into consideration belugas' energetic requirements, accounting for variances due to age, sex, and reproductive status, and the specific prey available to CI belugas. Absent information specific to CI belugas, estimates of the energetic requirements of belugas in other wild populations or belugas in captivity may be used as proxy values in this determination.

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Objective: Ensure that commercial, recreational, scientific, or educational activities are not inhibiting the recovery of CI belugas.

B.1 All research activities in Cook Inlet that may affect CI belugas implement protocols that avoid reductions in the population's recovery rate.

Listing Factor C: Disease or Predation

Objective: Ensure that the effects of diseases and disease agents on CI beluga reproduction and survival are not limiting the recovery of the CI beluga population.

If the threats under the other listing factors are ameliorated and the population has achieved the demographic criterion, then no recovery criteria would be necessary for this listing factor to consider reclassification of CI belugas from endangered to threatened (however, with respect to delisting, a recovery criterion for this listing factor is described below).

Listing Factor D: The Inadequacy of Existing Regulatory Mechanisms

Objective: Ensure that regulatory mechanisms other than the ESA are adequate to manage threats to the sustainability of CI belugas.

D.1 Cook Inlet fisheries management programs account for the energetic needs of CI belugas and allow for adequate available prey to sustain a recovering population (i.e., accounting for beluga prey availability as opposed to focusing solely on prey escapement goals).

D.2 Oil and hazardous substance spill prevention and response plans specifically address protections for CI belugas.

D.3 Subsistence harvest is managed in accordance with the *Final Rule for the Taking of Cook Inlet Alaska Beluga Whale Stock by Alaska Natives* (73 FR 60976, October 15, 2008), and the harvest is managed to ensure that it does not cause a measurable reduction in the rate of CI beluga recovery.

D.4 Management actions address cumulative effects, as they become known, in a way that promotes recovery of CI belugas.

D.5 CI beluga foraging and reproductive habitats (e.g., calving, nursing) are protected through appropriate management measures (e.g., time and area closures) to ensure the integrity of these habitats for meeting the needs of a growing CI beluga population.

D.6 Management actions address and reduce the effects of anthropogenic noise on CI belugas and their habitat.

Listing Factor E: Other Natural or Manmade Factors Affecting its Continued Existence

Objective: Continue monitoring the population to identify and mitigate any new natural or manmade factors affecting the recovery of CI belugas.

E.1 A comprehensive stranding response program for CI belugas: 1) is implemented in partnership with the CI beluga stranding network members; 2) promotes faster notification of, and responses to, all CI beluga strandings (dead or live); 3) establishes robust protocols for responding to live strandings and/or tracking belugas after a live stranding event; 4) collects data to determine cause of death (e.g., disease, injury, predations, auditory damage, etc.); and 5) includes annual meetings or drills to review and practice stranding response protocols.

2. Delisting Criteria for Considering CI Belugas "Recovered"

CI belugas may be considered for "delisting" and hence, recovered (i.e., no longer classified as an endangered or threatened species) when, in addition to meeting the downlisting criteria above, the following demographic and threats-based delisting criteria are also met. The threats-based recovery criteria are designed to evaluate the five ESA section 4(a)(1) factors and thus are organized accordingly (labeled A–E).

a. Delisting Demographic Criteria

1. The abundance estimate for CI belugas is greater than or equal to 780 individuals, and there is a 95% or greater probability that the most recent 25-year population abundance trend (where 25 years represents one full generation) is positive.

Justification: For management purposes, NMFS considers the historical abundance estimate of 1,300 whales to be the best estimate of the carrying capacity of CI belugas. We have no data at this time to indicate whether this carrying capacity may have changed. The threshold of 780 CI belugas (60% of carrying capacity) is the approximate mid-point between the lowest reported abundance estimate for CI belugas (278 belugas; 21% of carrying capacity) and the estimated carrying capacity of 1,300 whales; in addition, it is a level at which the population would be considered unlikely to become endangered within the foreseeable future within all or a significant portion of its range, assuming the population has exhibited statistically significant positive growth over the previous generation (previous 25 years) and threats have been adequately addressed. This is also the population level at which NMFS would reconsider the depleted classification of CI belugas under the MMPA. A 25-year timeframe was selected for population growth because it is a biologically-based time period that is expected to reasonably encompass environmental variability affecting the population. We chose the 95% probability level for a positive population trend because this level would provide a widely accepted degree of confidence that the population trend is positive. We recognize there is variability around survey point estimates, and a single population point estimate may over- or under-estimate the true population size. Survey variance should be taken into consideration as the population size approaches 780 to help ensure that consideration of delisting is not based on anomalous conditions and accounts for the population trend over a full generation. The longer a population sustains a positive growth rate, the more confident we can be that the population is likely to continue to grow and become stable in the future and is resilient to stochastic events.

b. Delisting Threats-Based Criteria

Listing Factor A: The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

Objective: Ensure adequate habitat exists to support a recovered population of CI belugas. Habitat needs include sufficient availability (i.e., quantity, quality, and accessibility) of prey to sustain the population at the identified demographic criterion level.

A.1 The quantity, quality, and accessibility of prey available to CI belugas are sufficient to sustain a recovered population for the foreseeable future (as determined, for example, by beluga-specific energetics models and projections of prey availability in Cook Inlet).

A.2 The summer range of CI belugas has expanded so that 95% of CI belugas documented during comprehensive Inlet-wide summer aerial surveys are found within an area comparable to the area documented by Rugh et al. (2010) for the 95% distribution during the time period 1993–1997 (see Figure 7 in this plan). An expansion of the CI beluga summer range back to historic extent will reduce susceptibility of the entire population to most threats, and is a likely indicator of recovery. For this assessment, the CI belugas' summer range should be determined using at least the most recent six-year time period, and based on at least three different years' abundance surveys.

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Objective: Ensure that commercial, recreational, scientific, or educational activities are not inhibiting the recovery of CI belugas.

B.1 The best available scientific data (e.g., via a population model or another scientifically rigorous assessment method) indicate that commercial, recreational, educational, or scientific activities are not having negative population-level effects on CI belugas and that the effects of these activities are not expected to result in a population decline post-delisting.

Listing Factor C: Disease or Predation

Objective: Ensure that the effects of diseases and disease agents on CI beluga reproduction and survival are not reducing the rate of recovery of the CI beluga population.

C.1 Known CI beluga deaths due to disease agents (e.g., pathogens, parasites, and HABs) during the most recent 10 years are sufficiently below CI beluga recruitment levels to allow for population growth, even when deaths due to other causes are included.

Listing Factor D: The Inadequacy of Existing Regulatory Mechanisms

Objective: Ensure that regulatory mechanisms other than the ESA are adequate to manage threats to the sustainability of CI belugas.

D.1 A written agreement signed by NMFS and the State of Alaska is implemented which describes: how the State's fishery management plans for Cook Inlet salmon and eulachon are linked to goals for stock-specific spawning escapements that provide sustained yield for harvest and account for prey needed by belugas (and other ecosystem components), including quantity and temporal availability of prey; how such plans minimize the take of CI belugas pursuant to fishery activities in State waters of Cook Inlet; and how future actions taken by the State will comport with the MMPA.

D.2 A cooperative program, which includes coordination among federal, state, tribal, and local authorities, is implemented with a goal of mitigating effects from human activities in Cook Inlet and with measures in place to ensure such human activities, especially those which are noise-producing, do not result in negative population-level effects on CI belugas.

Listing Factor E: Other Natural or Manmade Factors Affecting its Continued Existence

Objective: Continue monitoring the population to identify and mitigate any new natural or manmade factors affecting the recovery of CI belugas.

E.1 A post-delisting monitoring plan for CI belugas is developed and approved prior to delisting.

E.2 Analysis of information available about the effects of stranding-associated morbidity and mortalities and other non-anthropogenic threats determines that such threats are not having negative population-level effects on CI belugas and that such threats are not expected to result in a population decline post-delisting.

E.3 Information available regarding cumulative effects of multiple stressors indicates that they are not having negative population-level effects on CI belugas and that they are not expected to result in a population decline post-delisting.

Table 9. Criteria for considering reclassification (from endangered to threatened, or from threatened to not listed) for CI belugas.

Status	Demographic criteria		Threats-Based criteria
Reclassified from Endangered to Threatened (i.e., downlisted)	The abundance estimate for CI belugas is greater than or equal to 520 individuals, and there is a 95% or greater probability that the most recent 25-year population abundance trend (where 25 years represents one full generation) is positive.	**AND**	The 10 downlisting threats-based criteria are satisfied.
Reclassified to Recovered (i.e., delisted)	The abundance estimate for CI belugas is greater than or equal to 780 individuals, and there is a 95% or greater probability that the most recent 25-year population abundance trend (where 25 years represents one full generation) is positive.	**AND**	The 10 downlisting and 9 delisting threats-based criteria are satisfied

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VI. RECOMMENDED RECOVERY ACTIONS

This section provides a listing of recommended research, management, monitoring, and education/outreach actions targeted at achieving recovery of CI belugas. These recommended actions are organized into two categories: 1) population monitoring, recovery plan implementation, and education/outreach actions; and 2) threats management actions. The population monitoring, recovery plan implementation, and education/outreach actions recognize the importance of continuing to monitor the population, not only to improve our understanding of the whales, but also as a means to determine if recovery of CI belugas is occurring. These actions are designed to allow for the implementation and oversight of recovery activities, as well as for implementation of outreach activities to ensure that the public is informed of the status of threats, and actions taken, to reduce the effects of those threats to CI belugas. The threats management actions encompass actions aimed at assessing and managing the threats ranked as medium or high relative concern, and include actions that allow us to better understand the threats and their effects on CI belugas and to improve our ability to manage or mitigate the threats.

The narrative provided for each action is intended to provide guidance to resource managers, stakeholders, industry, researchers, and the public. These actions are intended to reduce or eliminate medium- and high-ranked threats and to recover CI belugas. These recommended actions are forward looking. They do not include those actions that NMFS or others have already implemented or are in the process of implementing, nor do they include tasks that address a threat of low relative concern.

NMFS intends for the recovery plan to be a dynamic document that may change over time based on the progress of recovery and the availability of new information. As new information is obtained, additional actions will be identified and incorporated into the plan. As is the case for all recovery plans under the ESA, NMFS will regularly review this plan and will assess the relative success of these actions in protecting CI belugas. Recovery actions may be changed, subtracted, or added accordingly. We also recognize that implementing the recommended recovery actions listed in this section is not the only viable path forward and that actions not included in this plan may contribute to recovery of CI belugas. For example, there may be better methods for assessing if a particular threat is limiting recovery. In addition, we recognize that some research or monitoring actions may be dependent on continued funding, and may not be achieved if funding is unavailable. Actions intended to obtain the same information as actions contemplated in this plan should not be dismissed just because they are not included in this plan.

Any action which may harass or harm CI belugas, even if on this list, should first involve discussions with NMFS AKR staff to ensure the benefits to CI beluga recovery outweigh the potential costs to individual whales or the population. Actions which may result in any form of take to CI belugas must be authorized by NMFS in advance of the proposed implementation date.

A. Recovery Actions and Narrative

POPULATION MONITORING, RECOVERY PLAN IMPLEMENTATION, AND EDUCATION/OUTREACH ACTIONS:

1. Continue to conduct surveys to estimate abundance, and analyze population trends, calving rates, and distribution.

Non-invasive population monitoring surveys are vital to understanding the status of the species, the effects of threats, and the effectiveness of management and recovery actions. Therefore, such surveys should be continued into the future and expanded as appropriate.

Two survey methods currently being used to monitor the population are aerial surveys and a photo-identification study of individual CI belugas. Aerial surveys of belugas conducted by NMFS are used to derive population estimates, a calf index, and distribution and movement patterns. Results provide a long-term record of population trend. Results of aerial surveys were used in the ESA listing decision, to determine critical habitat, and to determine whether the population has reached the numerical threshold required before subsistence hunting can legally resume. While conducting aerial surveys less than annually will result in reduced precision in the short term trend estimates, annual survey results may not be required to reliably detect changes in trends over greater than 10 years. Of particular value for population monitoring are synoptic[23] distribution data that are not available by any other means for Cook Inlet.

A photo-identification study of CI belugas has been ongoing since 2005. The photo-identification study has the potential to provide information about individual and population characteristics of CI belugas including survivorship, calving rates, maternal investment to calves, residency and movement patterns, and life history characteristics for many individually identified belugas, including mothers with calves.

2. Create and support a CI Beluga Recovery Coordinator position.

The biggest challenges in creating this recovery plan were: 1) a lack of information; and 2) identifying and accessing information that already existed. A full time, permanent Cook Inlet Beluga Recovery Coordinator based out of Anchorage, Alaska, would be an advocate for CI beluga recovery actions and serve as a central point of contact for all information and activities relevant to CI beluga recovery. We note that NMFS has on staff Recovery Coordinators for the Hawaiian monk seal, Steller sea lion, and Pacific salmon. NMFS currently has a staff person designated to coordinate CI beluga recovery, but that person also has other substantial duties.

The duties of the Cook Inlet Beluga Recovery Coordinator should include the following:

- Coordinate and support CI beluga research activities.
- Organize an annual late-winter CI beluga research workshop to:
    - Review strandings and carcass data from the previous year;
    - Review research results from the previous field seasons; and

[23] Data obtained nearly simultaneously over a large area.

  - Plan and coordinate future research for upcoming field seasons and for longer-term projects, with the goal of increasing collaboration among projects and information acquired.

- Coordinate management, monitoring, and mitigation activities (consultations, regulations, take allocations, and permits).
- Maintains a list of CI beluga takes associated with all anthropogenic activities (all authorized takes plus any known unauthorized takes).
- Create and maintain a CI beluga geospatial database with information from research projects, strandings, sightings, environmental data, prey data, and monitoring and mitigation efforts. Make data available to researchers, stakeholders, industry, and the public. Duties include archiving, managing, and disseminating information from multiple sources.
- Coordinate the CI beluga stranding network and stranding data.
- Develop sighting networks and educational outreach.
- Coordinate a community-based beluga and habitat monitoring program.
- Keep current on global beluga research (including captive animals) and update the CI beluga research and stakeholder community.
- Maintain and expand the current library of beluga related research papers, monitoring reports, gray literature (unpublished reports), conference posters, presentations, permits, and take allocations; these items should continue to be made available to the public on the NMFS AKR website.
- Improve communications and coordination among various NMFS offices - the Anchorage field office, the regional office in Juneau, AFSC MML, the national permit office, the national stranding program office, and the national recovery program office; improved communications with the MMC, ADF&G, and NGOs would also be a goal of this position.

3. *Create and support a CI Beluga Recovery Implementation Task Force.*

A CI beluga recovery implementation task force should work with and advise the Cook Inlet Beluga Recovery Coordinator. The group, led by the Coordinator, should meet annually to review recovery progress and to advise on implementation of recovery actions recommended by this recovery plan.

4. *Increase efforts to identify and monitor individual CI belugas, coordinating photo-identification, stranding data, genetic studies, and body condition assessments via biopsy samples of skin and blubber.*

Identifying and quantifying threats to CI belugas will require obtaining a great deal of information about the individual animals that remain. To maximize our ability to detect and quantify risks, we recommend that the existing individual CI beluga photo-identification database that is primarily photo-based be expanded to include genetic identification and data gathered from any future biopsy sampling effort, as well as data obtained from stranded belugas. This would provide a multidimensional record of individual histories to include information on movements, and interactions among genetics, reproductive states, condition, stress levels, and other health indicators. In turn, these results can be analyzed to estimate abundance, determine age structure, mating patterns, and social structure, and to detect changes in fecundity, health, condition, and mortality risk with respect to variation in environmental and anthropogenic factors.

CI belugas that are necropsied or sampled alive can be identified and linked to individuals in the photo-identification catalog, which also maintains a sighting history (i.e., dates and locations individuals have been seen, as well as group associations and female reproductive history). Expanding the database to be a multidimensional record of analytical findings from individual whales, paired with each individual's life history, would allow analyses across disciplines. Meta-analysis of life history information, contaminant levels, and other findings from related analyses could better highlight critical life stages and/or effects of contaminants.

5. *Determine annual mortality and reproductive rates of CI belugas.*

Promote and coordinate research efforts to measure and monitor annual mortality rates (including juveniles) and reproductive rates of CI belugas and relate these to variation in available prey and other environmental variables. A number of research methods such as skin and blubber biopsy, photo-identification, stranding investigation, aerial survey, or scat collection can contribute data to this effort. Analyses such as mark recapture using photo-identification and genetic data, hormone levels in scat or blubber, and population distribution, abundance, and calving rates from aerial survey and individual database data will contribute to this effort. Knowing the relative significance of change in reproduction versus survival rates may also guide other research.

6. *Conduct regular biopsy surveys of CI belugas to monitor changes in condition and reproductive success in relation to environmental changes.*

Body condition, contaminant levels, reproductive status, and stress levels can potentially be monitored using a skin and blubber biopsy (this sampling approach has been effective and benign on a number of species). Regular biopsy surveys of the CI beluga could provide data necessary to relate survival and reproductive status to environmental and anthropogenic factors and could better inform population models. Any such sampling should be conducted per NMFS AKR's biopsy guidance (NMFS 2015).

Note: Because this recovery task involves invasive methods, it will require both MMPA and ESA authorizations from NMFS. Any invasive research methods involving CI belugas should be developed in conjunction with the NMFS AKR.

7. *Organize an annual review and coordination workshop to review existing data on individual CI belugas, plan expansion of future data collection and analyses, and facilitate linkage of all existing and new CI beluga-related research.*

NMFS should hold annual workshops to review and integrate existing CI beluga data, to discuss approaches for collecting more integrative individual data in the future, and to plan analyses that would improve our understanding of the CI beluga population. For instance, improving knowledge of CI beluga demography could be a topic for specific review and discussion.

The CI beluga population is sufficiently small that data on individual whales' histories are needed to identify and quantify risks to this small population. Currently only photo-identification data are collected in a systematic manner. Other types of data for individual whales, such as genetic, acoustic, contaminant load, body condition, and mortality, are collected opportunistically and held by several different research groups. Hosting an annual research workshop to connect projects working on different analyses would also encourage sharing of data, and maximize linkages among the stranding response program and other ongoing research efforts.

8. *Hold a workshop to consider the feasibility, risks, and benefits of different sampling techniques such as breath capture, remote ultrasound, and live captures to obtain samples and measures for further analyses.*

A complete health assessment requires capture of a beluga for blood sampling and other procedures, but can provide invaluable information not generally obtainable by other less invasive techniques, such as biopsies or breath capture. Such less invasive techniques can provide some information about the health of an animal and do not require capture and handling of animals. However, these techniques still require close approaches to the whales to collect samples (and therefore pose a risk of physical harm) and also carry the risk of disturbing animals. Caution in close approaches is warranted to ensure that the research itself does not adversely affect the whales or unnecessarily alter their behavior.

Before committing to or approving any large-scale invasive research sampling program of CI belugas, NMFS should convene a workshop to review research techniques and CI beluga behavior and to recommend best practices that will minimize impacts to CI belugas and ensure maximum benefits from the sampling. Workshop participants should consider the risks and benefits of all available procedures, develop recommendations for sampling and assessment, and specify which information can only be obtained through live captures. The workshop should also develop a protocol to monitor the effects of such sampling, including criteria to determine whether sampling should be discontinued if adverse effects are detected. Potential protocols should be evaluated through a pilot study with a healthy beluga population before being applied to the Cook Inlet population. The report from a NMFS-sponsored workshop specific to biopsy sampling is available on the NMFS AKR website at: http://www.alaskafisheries.noaa.gov/pr/ci-belugas.

9. *Conduct a workshop to update a model to determine the probability of extinction of CI belugas.*

The PVA model used by NMFS in the decision to list CI belugas as endangered should be reviewed, and if appropriate, updated at each 5-year review or status review. Updated population models should include spatial distribution and should incorporate explicit models of threats and those threats' interactions and impacts on CI beluga survival and reproduction by age and sex. Future PVA models should also address levels of quasi-extinction[24] and thresholds that result

[24] Quasi-extinction is defined as the population threshold where risk factors such as inbreeding depression, loss of genetic diversity, vulnerability to disease, vulnerability to predation, or dependence on limited resources intensify as the population declines to the point that there is no possibility of recovery for the population. This is likely beyond a level that is fully accounted for in the PVA model so that, while extinction may be considered certain, the timing of extinction may not be well

from small population effects. A workshop, or series of workshops, should be conducted to address these issues, possibly following the model of the SouthEast Data, Assessment, and Review (SEDAR) program.[25] Workshop topics could include: 1) defining what data are missing and discussing how to design and fund studies to obtain the missing data; 2) compiling and reviewing the latest data to be used in the PVA; 3) developing a PVA that incorporates various threats and considers cumulative effects; and 4) evaluating the results from a new PVA to estimate probability of extinction. Workshop(s) should repeat on a period basis, incorporate new information, and be compatible with the five-year update requirement for NMFS ESA status reviews.

10. Engage in education and outreach efforts targeted at informing the public of the status of CI belugas and their threats, and promoting more public involvement in reporting CI belugas.

To promote public awareness and support for the CI beluga recovery program and the management actions necessary to support recovery, effective education/outreach efforts as well as public participation are needed. Suggested actions are listed below; however, this is not an exhaustive list.

10a. Provide information regarding threats to CI belugas and ways the public can help mitigate those threats.

Throughout the CI beluga recovery process, information updates should be provided to stakeholders, interested parties, and the general public regarding the status of the population and the steps taken to: 1) improve and refine knowledge of CI beluga life history, biology, and the threats that may be limiting recovery; and 2) implement management actions to promote recovery. This information can be communicated by developing and distributing educational materials, presenting updates at public meetings or conferences, posting updates on the NMFS AKR website, and disseminating news releases to the media. One of the midwinter meetings in Anchorage, such as the Alaska Marine Science Symposium or the Forum on the Environment, could be used for an annual public review of CI beluga research findings, future research plans, and other recovery-related topics. Some of the specific topics that should be communicated to stakeholders, interested parties, and the public, include the following:

- Acoustic impacts: There is a general underestimation of the importance of the acoustic environment to CI belugas and other odontocetes in general. There may also be an underestimation of the impacts of anthropogenic noise to CI belugas. Many users of Cook Inlet are not aware of the noise their activities (e.g., outboard motors) can introduce into the water and how this noise can negatively affect CI belugas. An awareness campaign about underwater noise pollution and the importance of sound to CI belugas would make this information available to the public and would encourage good habits and responsible, considerate coexistence with CI belugas.

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determined. For example, Krahn et al (2004) defined the quasi-extinction level for Southern Resident killer whales as the level at which the population would be "doomed" to extinction, even though literal extinction might still take decades for long-lived mammals.

[25] The SEDAR website can be found at: http://sedarweb.org.

- Habitat loss: Reducing the rate of habitat loss or restoring lost habitat comes with a cost and often involves tradeoffs. The outreach and education program could acquaint/update stakeholders and the general public with the costs and benefits of ongoing mitigation and restoration measures and the results of such measures.
- Direct disturbance or injury: Annual notices/reminders should be disseminated to private boaters, subsistence users, commercial fisheries, cargo ships, and other vessels (including those engaged in recreational sport activities) describing how to avoid whales and share Cook Inlet with belugas and other marine mammals and encouraging immediate reporting of harassment or trauma. If whale-safe boating recommendations or other guidelines (e.g., responsible viewing guidelines) are developed, this information should be distributed annually to potential users.

10b. Develop and broadcast annual announcements promoting the use of citizen science and encouraging reporting of strandings and sightings by the public.

Given the remoteness of CI beluga habitat, ongoing monitoring for strandings or other catastrophic events could occur to some extent at the local level and should involve the development and implementation of a community-based, citizen science beluga monitoring, sighting, and stranding program throughout Cook Inlet. The community-based CI beluga stranding program could serve as a mechanism to increase stakeholder involvement in the stranding program while reducing overall costs. Prompt identification and proper reporting of beluga carcasses is essential to maximize the quality and quantity of samples and to determine cause of death. All posted signs that encourage such reporting should be evaluated annually for accuracy of information. Annual reminders with a single 24/7 stranding reporting phone number should be sent directly to people who are most likely to encounter carcasses such as ADF&G and commercial entities active on the Inlet. Additionally, repeated, annual public service announcements through a variety of avenues (radio, TV, the web, social media, and printed material for boaters, fisherman, and pilots via harbormasters, fishing license distributors, or flight control centers) will serve to remind the general public of the importance of promptly reporting strandings. Such announcements could be combined with messages regarding responsible viewing and boating and how to report incidental sightings. The community-based beluga program members could include pilot organization, boaters, fishing groups, hunters, school groups, senior groups, as well as existing sighting networks (e.g., Coastal Observation and Seabird Survey Team, Alaska Native Sentinel Program, Friends of the Anchorage Coastal Wildlife Refuge Beluga Surveys, Cook Inlet Keepers, the Alaska Ocean Observing System, and the CI beluga photo-identification project’s “Seen Belugas?” sighting program).

10c. Create an annual Cook Inlet Beluga Watch Day.

Using the example of the Audubon Society’s Christmas Bird Count, or the “Whale Watch Week” along the Oregon Coast, create an annual “Cook Inlet Beluga Watch Day” to promote local pride, awareness, and stewardship of Cook Inlet and CI belugas. A single day can be selected to conduct Inlet-wide beluga counts, educational talks, public service announcements, and outreach events. Ideal days would be in late August when whales are most-visible around Anchorage and along Turnagain Arm and when many summer visitors are still in the state and local schools are back in session; alternatively a day in the spring when many schools in southcentral Alaska would be available to participate during Sea Week. In addition to fostering public support for CI belugas, this type of activity will produce basic information about the location of belugas throughout the Inlet on a single day that could be used by CI beluga researchers and managers. This type of effort will likely require collaboration with several groups and organizations.

11. Improve the stranding response program for both live and dead CI belugas.

In 2009, NMFS AKR updated its stranding response plan for Cook Inlet beluga whales; however, that document is lacking in specificity in many ways, does not account for new technology, and does not emphasize the importance of the public in a timely and effective stranding response. A revised and robust stranding response plan is required in order to expand the existing program for responding to live-or dead-stranded CI belugas in a manner that is safe for both response personnel and the animals and that allows for timely access to stranded belugas. Improvements need to be made to increase the number of stranding responses (relative to reported strandings) and to decrease the stranding response time. Improvements will require increased and reliable funding for CI beluga stranding response personnel and increased effort for training, coordination, and outreach. This funding should be independent of funding for other research or management activities.

In cases where live-stranded animals are reported promptly and conditions are safe for on-site response, a vast amount of information can be obtained through bio-sampling, individual identification of animals, and tracking animals after they re-float and resume swimming freely. Results from a thorough bio-sampling program of live strandings could inform researchers about the current causes of decline or impediments to recovery. In general, greater communication and coordination is needed to increase the speed and completeness of responses, and options to achieve hands-on responses to live strandings need to be more thoroughly explored. Policies/protocols on the collection of samples, hearing testing, and attachment of tags to live animals are needed. In updating the plan, consideration should be given to responding pre-emptively to atypical situations, such as live entangled belugas, prior to animals becoming stranded.

The current primary method of obtaining samples from dead stranded CI belugas for determining cause of death or an individual's health is to collect samples from carcasses. Since information vital to determining the cause of death degrades the longer the animal is dead, prompt discovery and proper reporting of carcasses is essential for maximizing the quality and quantity of samples that can be collected from a dead CI beluga. In particular, the tissues which are necessary for examining the presence of disease and contaminants, or assessing whether there is damage to the auditory system, decay quickly after death, which can prevent such evaluations. Oftentimes NMFS or a NMFS-authorized stranding responder is not able to get to a dead CI beluga quickly enough to examine these tissues. Reasons include the remoteness of many of the dead whales (either floating away from shore, or in locations limiting easy access), and the timeliness of the response (either because it was not reported to NMFS in a timely manner, or other constraints prevented an immediate response). Some of these factors are uncontrollable, but others can be improved upon. By encouraging immediate reporting of carcasses, the overall time to response can be improved and better quality data (i.e., less decomposed tissues) can be collected. With the highly dynamic tides in Cook Inlet, stranded carcasses rarely stay in one place for long, and floating carcasses can move a mile within 15 minutes. Thus, the best time to secure a carcass is when it is first observed. However, logistical and communications difficulties around Cook Inlet often prevent carcasses from being secured by authorized personnel. In order to achieve maximal use of beached carcasses, the process needs to be streamlined; authorization for observers to secure carcasses should be issued within 15 minutes of the request; and sampling teams should be on site within three hours. A stranding response plan needs to be quick, efficient, effective, and user-friendly. A sufficient number of trained response personnel need to be available, and supplies need to be on hand and ready for deployment. Additionally, to minimize cross-contamination or environmental contamination that can obscure the presence of disease in samples, necropsies are better done in covered areas, ideally within a necropsy laboratory. In the best case situation, the Alaska Marine Mammal Stranding Network would have access to indoor laboratory space sufficient to examine a beluga, and would have the means to transport carcasses to the laboratory.

Moreover, documentation of supplemental information associated with live- and dead-stranded CI belugas should include data such as weather, tidal height, fish run status, acoustic disturbances, and killer whale presence. Also, the CI beluga stranding data should be better integrated with the photo-identification catalog and other CI beluga databases, including incidental sightings. Photo-identification of individual belugas being necropsied may allow life history information in the photo-identification catalog to be linked with necropsy findings, potentially highlighting life stages or other life-history information associated with increased risk of exposure to disease or other stressors. There should also be ongoing (at least annual) analysis of the stranding data, rather than sporadic reviews. Finally, the geographic range of, and participation in, the stranding network in Cook Inlet be expanded, and the establishment and oversight of new network hubs in areas currently lacking coverage should be coordinated by NMFS with assistance from the Cook Inlet Beluga Recovery Coordinator.

12. *Once every five years, reassess the status of the CI beluga population and each of the threats to CI belugas.*

Every five years, the status of the CI beluga population will be reassessed and a determination made if downlisting or delisting may be warranted as required by ESA section 4(c)(2). Thus, at least once every five years, a reassessment should be undertaken of each of the threats to CI belugas (including those ranked of low relative concern) to reevaluate whether they are limiting or precluding recovery, and that information can be used in the CI beluga population status review. For threats ranked as medium or high relative concern, if a reassessment suggests a threat is not limiting CI beluga recovery, then this threat should continue to be monitored and reassessed in the subsequent five years to confirm the previous assessment. Upon confirmation of the previous assessment, such a threat should be re-ranked as “low” relative concern. This confirmation provision is included to ensure that any such re-ranking is addressed conservatively. Alternatively, if a reassessment indicates there is still medium or high relative concern regarding the threat, then the related threats management actions identified in this plan should continue to be implemented or new actions defined.

Given changing conditions in Cook Inlet, either from environmental forces (e.g., as a result of climate change or an increase in predation) or anthropogenic activities (e.g., increased development), threats currently ranked as being of low relative concern may be of greater concern in the future. If a reassessment indicates that the significance of a threat previously ranked as low relative concern has elevated to medium or high relative concern, specific recovery actions should be defined to address that threat. During each five-year review, any new threats not previously identified in the recovery plan can also be addressed. This provision for periodic reassessments of the threats to CI belugas is included to ensure the recovery program remains strategic and effective in addressing the threats that matter most at a given time.

<u>THREATS MANAGEMENT ACTIONS:</u>

<u>Reduction in Prey</u>

A primary uncertainty in trying to understand the failure of the CI beluga population to recover is whether the quantity, quality, and/or seasonal phenology of available prey is limiting population recovery through constraints to CI beluga reproduction and/or survival. It is important to conduct analyses to understand if a reduction in prey is occurring and if so, the effect such reductions are exerting upon CI beluga recovery. To fully understand whether adequate prey is available we must also improve the level of understanding of CI beluga prey dynamics and CI beluga energetic requirements. While belugas are known to eat large amounts of fish in spring and summer, little is known about winter distribution and less about winter feeding. Studies of CI beluga prey should therefore include winter months when possible and pertinent.

Fisheries management (e.g., escapement goals for CI beluga prey species) needs to adequately accommodate CI beluga prey requirements. At this time, there is only limited information on the characteristics of potential prey in CI beluga habitat, and available data are largely from the summer season. To develop appropriate mitigation measures, it is imperative to collect and monitor information on available prey resources to determine which, if any, prey resources may be limiting CI beluga recovery and to ensure implemented mitigation measures have the greatest likelihood of facilitating CI beluga recovery. Throughout this research, it is critical that emphasis be placed on determining prey quality (e.g., energetic content, contaminants, stable isotopes, and fatty acids) because a large quantity of poor-quality prey may have little utility to CI belugas relative to high-quality prey. Increased information allows a focus of mitigation efforts on aspects likely to promote, or not inhibit, CI beluga recovery.

13. *Evaluate how prey abundance and availability has changed over time in comparison to CI beluga abundance and if there are direct correlations between the two suggestive of a positive link between prey abundance or availability and CI beluga abundance, productivity, or mortality.*

Abundance estimates are lacking for many potential prey within the range of CI belugas. However, some information may be generated by examining historical trends in population indices. A retrospective analysis should be conducted to explore correlations among annual deviations in population indices of CI beluga and their potential prey. Any such analysis is likely to be highly qualitative, as data on many of these parameters (especially time series of abundance for non-commercial fish prey species) are lacking. Changes in seasonal phenology of available prey over time should also be considered in such an analysis, although data on this aspect of prey availability are likely limited.

14. *Monitor body condition of living and deceased CI belugas to assess the presence/absence of nutritional distress or nutritional-related mortalities, and determine the percentage of necropsied CI belugas with mortalities attributed to nutritional distress.*

Body condition of individual CI belugas can provide insight to the nutritional status of the whale. For live whales, non-invasive methods such as photo-identification studies or minimally invasive methods such as biopsies may prove useful for assessing body condition over time. Necropsies of dead whales and subsequent analyses of samples will be necessary to determine if nutritional distress was associated with cause of death. A review of the photo-identification catalog and previous necropsy reports looking for evidence of nutritional distress or nutritional-related mortalities may be useful in determining the proportion of the population that may be exhibiting signs of nutritional distress. However, any assessment will have to take into consideration the seasonal changes in CI beluga body condition (animals thin out during the winter and fatten up during the summer). Assessments should also consider that poor body condition of a dead whale may be associated with a condition unrelated to prey abundance. Also, body condition may not be responsive to nutritional stress until that condition becomes severe. This is because a portion of the blubber may be dedicated to insulation rather than active energy storage, and not reduced until other fat reserves are depleted.

15. *Analyze the existing collection of CI beluga teeth to determine if the age at first reproduction for female CI belugas can be determined, and assess if there has been a significant change in this parameter over time.*

In addition to assessing body condition, which may be misleading for various reasons, another pathway to determine whether animals are experiencing nutritional distress is to examine the age at first reproduction. If the age at first reproduction increases over time (i.e., the first reproduction occurs later in life), it may be an indication of nutritional stress adversely affecting reproduction, whereas a decrease in age at first reproduction over time (i.e., the first reproduction occurs earlier in life) may indicate that food is not limiting recovery. Studies have successfully analyzed teeth to determine the age at first reproduction (e.g., see von Biela et al. 2008). This is a non-invasive method that does not require any harassment or harm to living CI belugas, as the teeth are collected only from dead whales and CI beluga teeth have previously been analyzed for age. NMFS is currently in possession of previously collected teeth. This methodology has the potential to improve our understanding of whether nutritional stress is adversely affecting reproduction, and could more accurately and precisely define an important life history parameter (age at first reproduction), which is currently extrapolated for CI belugas from other beluga populations and captive belugas.

16. *Review available data which may provide information about calving rate (population-wide) or calving interval (individual belugas), and assess whether either of these parameters is correlated with prey abundance.*

When animals are nutritionally stressed they may forego or postpone costly reproductive activities until they have the energetic reserves to undertake such a physically costly activity. Like age at first reproduction, changes in the calving rate may be correlated with individual health and food availability. If there is a reduction in prey, the calving rate may decrease, or the calving interval may increase. Thus, information about these parameters (calving rate and calving interval) should be reviewed to determine if there has been a change in these life history parameters over time and if there is any correlation in these parameters with prey abundance.

17. *Research the seasonal, spatial, and size variation in prey diversity and quality to improve assessments of relationships between CI belugas and their prey.*

Because not all CI beluga prey species are created equal and because the nutritional characteristics of a given prey species vary seasonally, research is needed to understand the quantity, quality, distribution, and availability of CI beluga prey, and how these parameters vary spatially and seasonally. Although some information is available on the upstream spawning escapements of some prey species in select Cook Inlet tributaries, this does not provide a clear understanding of the prey available in the marine/estuarine areas. There is also a paucity of information on prey available from late fall to early spring, and on the quality of CI beluga prey resources (e.g., energy content, contaminants, stable isotopes, fatty acids). Standardized surveys are needed to determine the spatial and seasonal distribution of beluga prey in upper Cook Inlet. Data on levels and types of fatty acids and stable isotopes among predator and prey organisms can be used to better understand seasonal trophic linkages (i.e., the relationship between potential predators and potential prey species at different times of the year). This information is an important component of the data needed to understand CI beluga foraging patterns. Data are collected through tissue samples of prey species for comparison to stable isotopes in beluga blubber fatty acids and skin. Belugas swallow their prey whole, so smaller (younger) belugas require smaller prey. Consequently, the size of prey is also a relevant consideration. Further, the smaller body size of young belugas does not allow them to store as much energy as larger, older belugas. Thus, juvenile survival may be particularly influenced by the availability of smaller sized prey in late fall and early spring.

18. *Research the effects of environmental and anthropogenic factors on CI beluga prey to assess if any particular factor is having a significant detrimental effect to the prey and thus a detrimental effect on CI beluga recovery.*

Factors such as tidal mixing, temperature, salinity, sedimentation, and contaminants affect the characteristics of the aquatic environment. Prey species that have high mobility may seek better aquatic habitat conditions in areas not currently exploited by CI belugas. While prey that spend extended periods of time in suboptimal environments are not likely to attain optimal body condition and will not provide optimal CI beluga forage, the relationships among environmental factors and prey distribution and quality remain poorly understood and need further research. This research could include the development of predictive models of prey availability based on changing environmental or anthropogenic factors, and a variety of collaborative studies, for example, to understand the status of upper Cook Inlet salmon stocks, particularly the declines of Chinook salmon. Spatial distribution of many fish species is often associated with aquatic fronts defined by environmental boundaries. Anthropogenic factors can introduce new aquatic fronts, such as boundaries created by chemical releases or downstream plumes resulting from sediment disturbances, sewage outfalls, or other point sources of pollution requiring mixing zones. Given our lack of understanding about how different aquatic fronts determine CI beluga prey distribution, additional research is needed to determine how anthropogenic alterations to the aquatic fronts may affect the timing and distribution of prey.

The impact of fishing pressure on spatial and temporal prey availability within CI beluga habitat is poorly understood, especially for non-salmonid species, such as eulachon and Pacific herring, that are targeted by fisheries, but for which stock assessments are lacking. While fishing can reduce prey availability in CI beluga habitat within the fishing season, the impact on future recruitment is less well known. Also, the impacts of anthropogenic noise on potential prey in CI beluga habitat is poorly understood, rarely considered, and in need of further study. If the result of anthropogenic activities, such as fishing or noise, is a loss of feeding opportunities or reduction in prey for CI belugas, there will likely be an adverse effect to the belugas. Consequently, these effects will be most important to beluga recovery in areas preferred for feeding and during times of the year when energetic demands are greatest (e.g., pregnancy and lactation). Mitigation techniques have already been proposed to reduce impacts upon fish from some sources, such as pile driving. Further research is needed to improve mitigation techniques, especially for noise sources where no mitigation is yet proposed.

19. Determine energetic requirements/metabolic needs of CI belugas at different life stages to determine whether nutritional stress is a function of life stage.

Energetic requirements of belugas and the utility of potential prey items to meet metabolic needs vary seasonally and by CI beluga life stage. For example, newborn CI beluga calves have few fat reserves and are dependent on milk to quickly grow in length and girth and to develop fat reserves over the first year; consequently, inadequate reserves may reduce the ability of calves or juveniles to survive overwinter. Pregnant and nursing females are subjected to additional energetic demands, and all belugas must enter the winter with sufficient energetic reserves to survive several months of presumed low energetic input and high basal metabolic demand. While the rate at which energetic reserves are used presumably varies by CI beluga sex and life stage, details are currently unknown. Sampling to determine seasonal body condition by CI beluga sex and life stage would facilitate a better understanding of potential stressors and how to mitigate against such stressors. Understanding metabolic needs may also be informed through analyses of body condition and food intake by belugas maintained in aquaria.

20. Study the diet selectivity of different CI beluga demographic groups (e.g., age, sex, and reproductive state).

Because CI beluga metabolic needs vary by sex and life stage, dietary needs typically respond to metabolic demand. Diet selectivity would conceivably be a function of caloric return on metabolic investment of foraging. That is, predators target prey providing high nutritional input, but if highly nutritional prey are encountered only infrequently, the predator diet would include less-nutritional but more frequently encountered prey. Smaller (younger) belugas are also limited to smaller-sized prey. Few data exist to understand prey selectivity by CI beluga and how selectivity might change over time and in response to changes in the available prey.

Prey selectivity by CI belugas is also expressed in foraging habitat preferences. For example, foraging may be easier in river mouths with steep banks, in areas of good echolocation conditions (good water mixing and limited suspended sediment), or in areas where prey behavior favors capture (e.g., anadromous fish adapting to changes in salinity when entering rivers). Spatial considerations must be included when examining foraging behavior and developing a foraging model for CI belugas. This action would use stomach contents and other observations to examine what prey are consumed relative to the available prey.

21. Using currently available information, develop a CI beluga foraging model informed by prey characteristics and beluga dietary needs.

Combining data on CI beluga dietary needs, beluga foraging strategies and efficiencies, and prey characteristics will allow development of a CI beluga foraging model. Such a model will allow examination of tradeoffs among potential prey species and the importance of potential prey in different seasons and at different CI beluga life stages. This model would be informed by seasonal fatty acid and stable isotope signatures of prey species, energetic requirements/metabolic needs by life stage, and observed foraging selectivity by different CI beluga life stages. A foraging model would provide insights into whether CI beluga reproduction and survival are being limited by available prey and would help to identify potential mitigation measures to improve CI beluga recovery.

22. *Ensure fisheries management (e.g., escapement goals for CI beluga prey species) adequately accommodates CI beluga prey requirements, and if necessary, expand the number of species with escapement goals.*

Escapement goals and management measures for salmon and other CI beluga prey do not explicitly incorporate CI beluga dietary needs. Salmon production models that provide the basis for ADF&G management measures typically allocate mortality as either human harvests or natural mortality, which implies that CI beluga prey needs are treated as an unspecified component of natural mortality. In addition, natural mortality for salmon is either treated as fixed or assumed to occur across a relatively small range of values. At the simplest, a perceived reduction in a stock targeted for human consumption results in management measures to reduce harvest levels, with the harvest reduction (down to some threshold level) often proportional to the level of stock reduction. However, because the consumptive prey needs are relatively stable for a given CI beluga population size, a declining prey resource base implies a relative increase in the proportion of a prey resource needed for CI beluga consumption. Thus, the aggregate natural mortality rate may actually increase as the prey resource declines.

Consideration of measures to adequately provide for CI beluga prey consumption may be even more important for prey resources for which there are no ongoing stock assessments. For example, many of the salmon stocks returning to Cook Inlet tributaries are not actively assessed, but may be assumed to fluctuate similar to an index salmon stock returning to a nearby tributary. However, in the case of eulachon, there is no assessment program, and any decline in eulachon stock productivity or at-sea mortality rate might not be detected until after several years of fishery harvest declines. ADF&G should ensure the management of anadromous species considers CI beluga dietary needs, particularly in a way that provides for a sustained abundance, density, and temporal availability of returning fish as prey in CI beluga feeding areas. This may require review of the models being used to manage fisheries in Cook Inlet to gain insight about the potential effects of these fisheries on the Inlet's ecosystem.

<u>Disease Agents</u>

Disease agents are considered a threat of medium relative concern, but the degree to which they may be limiting CI beluga recovery is uncertain. There is a need to not only assess if disease agents (pathogens, parasites, harmful algal blooms) are limiting CI beluga recovery, but also to improve our understanding of the sources of disease agents in Cook Inlet. Monitoring living CI belugas via non-invasive methods, such as photo-identification studies, or minimally invasive methods such as biopsies, and deceased CI belugas via necropsies, will provide information regarding the presence/absence of disease agents or disease-related mortalities.

23. *Analyze images from the CI beluga photo-identification catalog for the presence of external signs of disease in photographically identified CI belugas to 1) assess the percentage of identified CI belugas with external indications of disease, and 2) track the persistence of, or changes in, the external indications of the disease agent in individual whales over time.*

The CI beluga photo-identification catalog includes many belugas bearing skin lesions consistent with localized and systemic infections. The number of individual belugas in the photo-identification catalog with such lesions should be quantified, analyzed by disease experts to identify probable cause, and monitored over time to determine trends in the incidence and prevalence of these conditions.

24. Continue examining beach-cast carcasses of CI belugas for disease-related mortalities, assessing the percentage of necropsied CI belugas with mortalities attributed to disease agents, and linking results from examinations of known individual belugas with the CI beluga photo-identification catalog. When feasible, determine the presence and relevance of disease agents in other Cook Inlet marine mammal mortalities.

The current primary method of obtaining samples from CI belugas for disease testing is by sampling of stranded carcasses. Because evidence of disease is quickly obliterated by post mortem decay, it is essential to be able to initiate necropsies as soon as possible after death and specifically look for the presence of disease agents. Identifying the individual whale being necropsied, when possible, will allow life history information in the photo-identification catalog to be linked with disease findings, potentially highlighting life stages or other life-history information associated with increased risk of exposure. Given the limited number of CI belugas available for sampling for disease assessment, researchers should consider alternate methods of inferring disease risk to CI belugas, such as examining other marine mammals found dead in the Inlet that use similar prey resources (e.g., harbor seals or harbor porpoise), which may provide evidence of diseases of concern that may be transmissible to belugas.

25. Using currently available information, compare data on diseases from CI belugas with other beluga populations to determine if there are abnormal levels or atypical types of disease agents present in Cook Inlet affecting CI belugas.

Diseases are present in all animal populations, even healthy ones. Understanding which diseases, and at what levels, are present in other beluga populations is key to understanding which diseases may be negatively impacting this endangered population. Therefore, having disease data that were obtained and analyzed using techniques similar to those used on other beluga populations (e.g., Bristol Bay or Point Lay, Alaska) helps to determine whether CI belugas are experiencing an abnormally high incidence of disease.

26. Determine types and sources of disease agents identified to be of concern specifically to CI belugas and assess management actions targeted at mitigating the disease agents.

Belugas can be exposed to disease agents through ingestion (of prey, or of water consumed with prey), close contact with other mammals, inhalation, and contact with the water in which disease agents are present. Disease agents demonstrated to affect CI belugas should be investigated to determine possible routes of transmission and potential for disease. Investigations should focus first on the most likely disease source or the disease agent that is most readily mitigated. In conjunction with nutritional and toxicological analyses, prey could be analyzed as possible vectors of disease. Transmission from terrestrial sources should also be considered (e.g., sewage outflow, animal waste, anthropogenic contaminants in runoff). Additionally, routine water quality monitoring and disease monitoring in other Cook Inlet mammals should be established or continued. Collaboration contributing to the analysis of such monitoring is encouraged, especially as it relates to CI beluga recovery.

<u>Noise</u>

Given that certain noise levels are a threat of high relative concern, it is important to assess if noise is limiting CI beluga recovery by resulting in behavioral responses such as live strandings or displacement from important habitats. To adequately address the threat posed by noise, there is also a need to improve the understanding of the acoustic environment of Cook Inlet and the management of noise-producing activities in the Inlet.

27. Conduct a retrospective analysis of documented CI beluga live strandings and noise-producing anthropogenic activities in Cook Inlet, possibly to include the development of a database of anthropogenic activities that introduce noise to Cook Inlet, and assess if a correlation exists which may indicate noise is limiting CI beluga recovery.

If certain noise conditions have the potential to trigger CI beluga strandings, it is critical to consider these noise conditions in the CI beluga recovery plan. Although CI belugas are known to strand, the relationship with anthropogenic activities has not been thoroughly evaluated. Because anthropogenic noise may cause mass strandings, this risk needs to be evaluated for CI belugas. Archived information on CI beluga strandings and the timing of historical anthropogenic activities known to introduce acoustic energy into the water should be compared.

A geospatial database should be developed to record data on anthropogenic activities known to introduce acoustic energy into the water (e.g., the timing, duration, acoustic characteristics [source level,[26] spectral contents,[27] tonal,[28] and pulsive[29] nature, etc.], and location of these activities, along with any mitigation applied). This database should be linked to the NMFS CI beluga stranding database to allow detection of potential relationships between anthropogenic noise events and strandings. This open-access database should be developed, maintained, and managed by NMFS in collaboration with university, private, agency, and industry researchers working in Cook Inlet.

Due to the lack of long-term background noise monitoring and the absence of baseline data on background noise in Cook Inlet, historical trends can only be determined by analyzing the history of anthropogenic activities known to introduce acoustic energy into the water. Changes in these activities spatially or temporally over time could have strongly modified the acoustic environment of certain areas. This analysis could also identify anthropogenic activities that have the potential to generate future chronic changes to the acoustic environment of CI belugas.

28. Conduct a retrospective analysis of anthropogenic noise-producing activities in Cook Inlet and information on CI belugas' behavior and distribution to assess if a correlation exists that may indicate noise is limiting CI beluga recovery.

To understand whether noise is limiting CI beluga recovery we need better information on noise-producing activities in Cook Inlet and CI beluga exposure and response to those activities. We know there are both anthropogenic and natural sources of noise in beluga habitat, and belugas in general are very dependent on acoustic communication. But these two things alone do not provide us information useful to determine if anthropogenic noise in Cook Inlet is limiting CI

[26] Sound intensity at the source, normally measured as dB re 1 µPa at a distance of 1 meter from the central part of the sound source.

[27] The distribution of acoustic energy across all frequencies influenced by the noise source.

[28] Narrowband (few frequencies), modulated or not, acoustic signal of long duration (in the order of tenths of seconds to many seconds) (e.g., a whistle).

[29] Broadband (many frequencies), normally sharp, short (in the order of milliseconds to tenths of seconds) acoustic signal (e.g., explosion).

beluga recovery. To attempt to answer that, a retrospective analysis of both noise-producing activities and CI beluga distribution and behavior needs to be compared over time in an effort to determine if noise is having an adverse effect to CI belugas (e.g., does the evidence suggest potential displacement or behavioral disruption of CI belugas due to anthropogenic noise). However, a correlation alone may not be sufficient evidence to indicate noise is limiting CI beluga recovery, and a short-term displacement likely has less recovery implications than a long-term displacement.

29. *Within areas designated as critical habitat Type 1, determine areas with high vs. low levels of anthropogenic noise, if there are significant typical changes (e.g., seasonal differences) in the levels of overall (natural plus anthropogenic) noise in that area, and assess if a correlation exists between CI beluga use of the area and the noise levels in the area.*

NMFS has designated two areas of Cook Inlet as critical habitat, with Type 1 representing the high use areas in the summer where large groups of belugas congregate, and areas which are important to reproduction and foraging activities. Given these areas are of particular importance to the survival and recovery of CI belugas, it is appropriate to focus an assessment of in-water noise on these areas. To understand if noise may be limiting CI beluga recovery requires, in part, a better understanding of the current characteristics of noise in the beluga habitat as defined by critical habitat Type 1. Both natural and anthropogenic noise sources should be assessed when determining the overall noise, taking into consideration that some times of the year may have higher levels of noise than other times (e.g., due to decreased water flows or reduced coastal human activity during the winter season). Once the acoustic environment of critical habitat Type 1 has been assessed, that information should be compared to known CI beluga use of critical habitat Type 1 throughout the year to determine if a correlation exists between beluga use and noise levels of specific areas within critical habitat Type 1. However, a correlation alone may not be sufficient evidence to indicate whether noise is limiting CI beluga recovery. Factors independent of noise (e.g., seasonal anadromous fish runs) may also be influencing CI belugas' use of the area. Sometimes belugas may tolerate high noise levels if the benefits of remaining in an area outweigh the costs of being exposed to noise in that area. If possible, these other parameters should be considered.

30. *Describe the acoustic characteristics of different anthropogenic noise sources in Cook Inlet and rate the potential acoustic impacts from each type of noise source on CI belugas.*

Different anthropogenic noise sources in Cook Inlet should be recorded and their acoustic characteristics (e.g., source level, spectral contents, tonal and pulsive nature, etc.) described. These noise sources should be analyzed to map their temporal and spatial occurrence in CI beluga habitat. All identified noise sources in CI beluga habitat should be rated based on potential impacts to CI beluga hearing; noise sources with higher overlap with beluga hearing, higher source levels, and greater spatial and temporal occurrence should receive the highest rating. This rating system should classify all identified noise sources in CI beluga habitat on a scale ranging from low (unlikely to impede recovery) to high (greatest potential to impede recovery). This effort should identify sources of natural and anthropogenic noise, quantify the overlap with CI beluga hearing, and quantify the magnitude of perturbations over space and time. These data should be used to map seasonal noise that is audible to CI belugas within critical habitat and to create a rated list of sound sources.

31. Conduct long-term and year-round monitoring of natural and anthropogenic noise (level and spectrum) in key areas where CI belugas currently and historically concentrated (including CI beluga critical habitat) to characterize and monitor the acoustic environment and identify sources, levels, and types of anthropogenic noise.

Long-term and year-round monitoring of background noise in both present-day and historical key areas for CI belugas (e.g., Susitna Delta and the Kenai River) has the potential to identify areas where the acoustic environment may no longer be suitable for belugas, either seasonally or year-round. Furthermore, long-term monitoring allows the establishment of present-day baseline levels of background noise, which are required to identify potential changes in the acoustic environment (e.g., periods or areas of increased noise) caused by future anthropogenic activities in Cook Inlet. Similarly, when noise levels increase due to several sources of input, potential cumulative risks can be documented.

32. Work with local, state, and federal agencies and stakeholders to develop methods and plans for reducing or mitigating the levels of anthropogenic noises in Cook Inlet, including incorporation of pre- and post-activity surveys for major noise-producing activities to monitor CI beluga presence.

Entities (including NMFS and industry) involved in oversight and management of noise-generating activities should develop cooperative measures to ensure proper compliance with noise impact mitigation regulations (e.g., sound field verification, schedule and duration of activity, model and validation of exclusion zones, proper shut downs, observers and their working conditions, reporting audit, etc.). The NMFS has a responsibility to audit those noise-generating activities that fall under its purview and to enforce existing regulations.

Most regulatory actions and mitigation efforts focus on the time of the activity, when noise is introduced into the water. However, it is equally important to obtain baseline data on the presence of CI belugas in areas to be affected *before* and *after* the activity. Without the information collected in pre- and post-surveys, it is difficult to quantify the potential impact generated by the activity. Because wildlife displacements due to noise have been documented at distances far beyond the detection ranges of visual marine mammal observers (MMOs) and/or passive acoustic monitoring systems, this impact can only be documented if there is knowledge of the presence of CI belugas before and after the activity. Several monitoring designs have been successfully applied to marine mammals, with before-after/control-impact design (BACI; Underwood 1994) being the most effective.

33. Develop and incorporate into the noise monitoring/mitigation plans a protocol to identify the onset (received levels and distance) of CI beluga behavioral reactions to specific activities.

Behavioral reactions to noise are among the most difficult responses to document. As part of standard mitigation plans, data are collected by MMOs situated on shore or on vessels generating underwater noise. These data can help identify the onset of behavioral reactions. Because these plans normally include the modeling and validation of noise introduced into the water, MMO data can be used to obtain distance and noise exposure levels triggering behavioral reactions. Implementing a requirement during the permitting of all activities in Cook Inlet that introduced noise into the aquatic environment to obtain these data and calculate onset of reactions would generate valuable information needed to update mitigation regulations in CI beluga habitat. Because some noise effects on behavior may be difficult to detect and because such data would not account for effects that are not detectable by observation (e.g., physiological effects), such information would be used and interpreted cautiously.

<u>Habitat Loss or Degradation</u>

Habitat loss or degradation has been identified as a threat of medium relative concern to CI beluga recovery. To better understand the effects of this threat on CI belugas, it is important to assess if habitat loss or degradation has resulted in a significant reduction in the carrying capacity of Cook Inlet for CI belugas, or a loss or degradation of areas important to CI belugas for foraging or reproduction, to the point such loss or degradation is limiting CI beluga recovery. Successful mitigation of this threat will require an improved understanding of the impacts of a changing habitat to CI belugas and the management of habitat degrading activities in Cook Inlet.

While both short and long-term changes occur in ecological systems, characterization of those changes can be difficult. Projection of future changes and ecological response to projected changes is even more uncertain. Characteristics of CI beluga habitat, and changes in that habitat over time, have not been well documented, or the documentation involves proprietary information associated with potential resource development. Mitigation measures to prevent loss or degradation of CI beluga habitat must start with an understanding of existing habitat and changes that have already occurred, particularly over the past 40 years when the documented beluga decline occurred.

Carrying capacity largely depends on environmental conditions over a series of years, or within a given ecological regime, and is likely to change over time. Analytical modeling techniques can be used to estimate current carrying capacity and to quantify the uncertainty of the estimate. However, the ability to estimate carrying capacity accurately depends to a large extent on the quality of available data. Of particular importance are the estimated numbers of CI belugas at different life stages; the distribution, abundance, and availability of prey species; and the distribution and magnitude of habitat features that may influence the productivity of CI belugas. For long-lived species such as belugas, development of a life-stage population model that accounts for differing nutritional and habitat needs across age and sex will be necessary to account for potential life stage variations.

NMFS has previously determined the carrying capacity of Cook Inlet to be 1,300 CI belugas. At the 2014 estimated population size (340 whales), a small reduction in carrying capacity (e.g., from 1,300 to 1,000 CI belugas) is unlikely to have significant impacts to the current CI beluga population given its small size relative to projected carrying capacity. In this hypothetical scenario, the reduction would be unlikely to limit the recovery potential of CI belugas; however, a large reduction in the carrying capacity (e.g., from 1,300 to 500 CI belugas) is likely to be a factor impairing the recovery of CI belugas. Thus, when conducting the assessments recommended below, these factors should be kept in consideration when determining if habitat loss or degradation is limiting CI beluga recovery.

34. *Develop a comprehensive Cook Inlet environmental database using currently available information to conduct a retrospective spatial and temporal evaluation of the biological, physical, and anthropogenic features in CI beluga habitat since the 1970s and assess how the habitat has changed over time, including likely causes of change.*

To address potential measures to facilitate CI beluga recovery, it is first necessary to determine how CI beluga habitat has changed over time, particularly during the last 40 years when the beluga decline has occurred, and the likely causes of the change (e.g., hydrologic, anthropogenic, acidification, siltation, shoaling, temperature, tides, loss of upstream shade, installation of culverts, or other factors). Of particular interest are the biological and physical features of the current CI beluga habitat and how those features change seasonally. For example, siltation, the development or movement of sand or gravel bars, water temperature, and chemical characteristics of the marine and estuarine environment can be affected by localized or upstream drivers. Dredging, in-water construction, dams, and siltation from runoff and erosion can change the currents, flow, and mixing of fresh and salt water and the seasonality of fresh water inflows. These changes in water bodies can impact their value as prey or beluga habitat. Changes in hydrology of the Inlet should be studied to determine if there are impacts to belugas. These characteristics directly impact the suitability of CI beluga habitat, including the carrying capacity. Studies are needed to determine how these habitat characteristics are affected by both ongoing environmental changes (e.g., overall environmental change) and by anthropogenic factors (e.g., in-water construction or other activities).

Comprehensive mapping and spatial analyses of the characteristics of current CI beluga habitat in relation to current and earlier beluga distribution is needed. Analysis of the CI beluga survey and tagging data has been initiated by NMFS, but with limited environmental data. Continuation and expansion of this effort would expand the environmental aspect of this analysis. Unfortunately much environmental data are extremely localized or proprietary in association with resource development around the Inlet. Mechanisms should be developed for sharing and using the proprietary data and extending valuable local data to larger areas. A starting point would be to collect and assess the quality of data that are currently available in the public realm. A comprehensive Cook Inlet environmental database should be established to include both natural environmental data and human impacts and development, and ideally should result from collaborative efforts among a wide variety of public and private organizations.

35. *Compare the changes in habitat availability or quantity over time with changes in CI beluga distribution and abundance over time to assess if a correlation exists which may suggest habitat loss or degradation is limiting the recovery of CI belugas.*

Simply understanding if the habitat has changed over time does not resolve whether observed changes are resulting in detrimental effects on belugas. Even negative changes or loss of habitat may have a limited effect on CI belugas if those changes are in locations only sporadically visited by just a couple of individuals. However, similar changes in locations used by large numbers of belugas or by few belugas all year may have significant effects on the whales. Therefore, there is a need to compare the habitat changes over time with patterns of CI beluga distribution and abundance in order to determine if habitat changes are limiting CI beluga recovery. As previously mentioned, such a comparison will need to consider the seasonality and frequency of use by various whale group sizes when interpreting the results, preferably in a geospatial format.

36. *Review losses or degradation of habitats in areas known to be important to CI belugas for foraging or reproduction, and assess if a correlation exists between habitat changes and changes in CI beluga use of the area, possibly indicating that habitat loss or degradation is limiting the recovery of CI belugas.*

Not all of Cook Inlet has the same value to CI belugas. Some areas are more important for foraging or reproduction, whereas other areas seem to be primarily transit corridors or are only occasionally visited. This variability in degree of use is reflected in the designation of two critical habitat areas. An effort focused on areas most important for foraging or reproduction may provide a better indication of the effect of habitat loss or degradation on the current CI beluga population. While this may be useful for the current population size and distribution, we note that if the population grows and expands its distribution to include more of mid and lower Cook Inlet in the summer, this focused assessment should be expanded in geographic scope to reflect range expansion.

37. *Update the comprehensive Cook Inlet environmental database developed in Action 34 and project the future extent and quality of CI beluga habitat.*

A potentially more complex step in assessing the quality of CI beluga habitat is to project the future extent and quality of CI beluga habitat. Because it is difficult to project the rate and magnitude of future change, given all the contributing factors, this approach should address the range of possible outcomes. Future habitat and development projections would then be informed by our updated understanding of CI beluga habitat characteristics and the temporal and spatial scales on which it appears changes have occurred. It is particularly important to examine ongoing coastal and in-water development trends and determine if anticipated development will negatively impact CI beluga recovery. Data compiled under Action 34 should be updated and analyzed to identify temporal changes in CI beluga habitat and develop ongoing or periodic monitoring program(s) for comparison to this baseline data.

38. *Conduct a detailed habitat survey to begin long-term habitat monitoring (quality and quantity), including the use of volunteers and community members.*

While the critical habitat of the CI beluga has been identified, there is very limited information, since critical habitat designation, on the current status of the habitat, existing impacts, and the prey available to the CI beluga. In addition, seasonal variation of many features is poorly known. A comprehensive survey of the habitat available to CI beluga should be conducted to identify available prey species, to estimate the prey biomass density by season and area, and to determine the seasonal levels by area of anthropogenic impacts to CI beluga habitat and prey. A survey of the prey habitat and anthropogenic changes would provide a baseline for the current level of impacts to CI belugas and provide a basis of comparison for future improvements to, or losses of, that habitat. Given the projected future extent and quality of CI beluga habitat (described in Action 37) and the suitability of those future habitat conditions for CI beluga recovery, long-term monitoring will be critical to guide potential mitigation measures.

Given the remoteness of CI beluga habitat, knowledge acquisition and ongoing baseline monitoring of CI beluga habitat use could occur to some extent at the local level. A community-based beluga monitoring program should be developed and implemented throughout Cook Inlet. This could be modeled after the Alaska Native Sentinel Program. Much of the monitoring and assessment of current and future CI beluga habitat characteristics will involve periodic collection of index data. To some extent, much of the required data can be collected either directly in CI beluga habitat or at index sites serving as proxies to nearby CI beluga habitat. Contingent on the frequency and location of data collection, the community-based CI beluga monitoring program could serve as a mechanism to increase stakeholder involvement in the sampling program while reducing overall costs of the sampling program. Program members could include pilot organizations, boaters, fishing groups, hunters, school groups, and senior groups, as well as existing sighting networks (e.g., Friends of the Anchorage Coastal Wildlife Refuge Beluga

Surveys, Cook Inletkeeper, the Alaska Ocean Observing System, and the CI beluga photo-identification project's "Seen Belugas?" sighting program). The monitoring program could be organized and supported by the NMFS Cook Inlet Beluga Recovery Coordinator (see Action 2).

39. *Evaluate impacts on CI belugas from anthropogenic activities with potential to result in degradation or loss of CI beluga habitat, with emphasis in known and historic feeding areas.*

Construction and operation of new physical structures (e.g., bridges, docks, dams, etc.) and increased numbers of vessels in CI beluga habitat can potentially affect the distribution, migration, or behavior of CI belugas and their prey. However, a lack of understanding of distribution, migration, and behavior patterns of prey inhibits potential mitigation measures and argues for a more precautionary approach to maximize opportunity for CI beluga recovery. Additional information is needed on the impacts to CI belugas from construction and operation of physical structures, including structures located both within Cook Inlet proper and upstream of CI beluga habitat (which could affect beluga prey). Particular emphasis should be given to areas of known and historic feeding importance (e.g., Susitna River and Delta; Kenai River; Knik Arm).

40. *Assess the biological benefits, costs, and implementation feasibility of potential protection or restoration measures for particular habitats important to CI beluga recovery and implement such measures if determined warranted.*

Considering the ecological value, stability, and resiliency of habitats important for CI beluga recovery, including habitats that support foraging or reproduction, an analysis will be needed to determine if protection or restoration measures are warranted and whether previous mitigation measures may no longer be needed. Throughout the long term, a variety of potential mitigation measures may be applied, representing a range of likely outcomes for CI beluga habitat and future CI beluga recovery. An analysis must first be conducted to evaluate the costs, biological benefits, and implementation feasibility, of potential protection or restoration measures. For some potential measures, realistic benefits may be achieved at little cost, whereas other measures may be expensive to implement and are likely to offer questionable or limited positive results. Implementation of any protection or restoration measures must be accompanied by long-term monitoring to determine the effects on CI beluga recovery. Because CI beluga recovery is likely to be an ongoing process, the array of potential protection or restoration measures should be periodically examined and the implemented measures revised as needed.

41. *Work with local, state, and federal agencies and stakeholders to develop a comprehensive Cook Inlet habitat database, and methods and plans for reducing or mitigating the levels of habitat loss or degradation in areas of known importance to CI belugas for foraging and reproduction, including restoration of habitats if necessary.*

Ongoing and future coastal development projects that are deemed likely to degrade CI beluga habitat should be mitigated. Potential effects of individual development projects should be evaluated on the basis of the aggregate and comprehensive impacts on beluga habitat, taking into account existing projects and disturbance, and not simply as the incremental impact of an additional individual project. Such mitigation efforts will be most effective if they are developed collaboratively between government and non-government entities. For instance, collaborative work with municipalities or other entities could be undertaken to help minimize runoff and stormwater pollution and to reduce the incidence of toxic spills into Cook Inlet.

42. Identify potential likely sources of contamination and evaluate their potential to discharge contaminants.

Given the potential for adverse cumulative impacts on CI belugas from the multiple human activities occurring in Cook Inlet, it is important to have a detailed understanding of exactly where those activities are occurring, if activities involve contaminants of concern that may be purposefully or accidentally discharged, and the proximity across time or space to other activities. Although some individual discharges might be deemed insignificant, combinations of discharges, or discharges in combination with other dissimilar threats, could cause adverse effects at the individual and population levels. Although assessing cumulative impacts from multiple activities is challenging, such impacts might be particularly relevant in the case of CI belugas given the population's failure to recover despite the curtailment of hunting. A comprehensive inventory or database should map the following: activities producing chemicals of concern; sites containing chemicals of concern; and other stressors with a potential synergism with chemicals (e.g., predators, noise; see Action 56). This inventory or database should be developed and updated annually.

Unauthorized Take

The full extent of unauthorized take is likely unknown, and activities that may result in injury or harassment of CI belugas may be under-reported. There is a need to assess if unauthorized take is limiting CI beluga recovery as a result of injury or harassment of CI belugas, especially in areas important to CI belugas for foraging or reproduction. To effectively manage the effects of this threat on CI beluga recovery, there is also a need to improve the understanding of the causes of unauthorized take in Cook Inlet and to improve management of activities that may result in unauthorized take of CI belugas. Below are recommended actions to address this threat.

43. Review available data which may provide information about the types and level of unauthorized take in living and dead CI belugas to improve knowledge about the prevalence, frequency, and severity of effects on CI belugas from these activities.

While infrequent, there has been evidence of unauthorized take of CI belugas in recent years. There have been sporadic reports of CI beluga entanglements either in fishing gear or marine debris, photographic evidence of scars from boat propellers and possible bullet wounds, and necropsies documenting signs of blunt force trauma, possibly as a result of vessel strikes. In addition, there were possibly three research-induced CI beluga mortalities in 2002. Examples of other activities with potential to result in unauthorized take include recreational or sightseeing operations targeting CI belugas in a manner that causes a change in the behavior of the animals. However, there has been no systematic review of all available take-related information, especially for activities that are not the subject of specific regulatory or management reviews regarding effects on CI belugas, and for which there is no clear regulatory mechanism requiring reporting of take. This information should be reviewed and compiled to improve knowledge about the prevalence of the different types and levels of unauthorized take, and to determine the frequency and effects of this take on CI belugas.

44. Review and continue to monitor for signs of trauma in living and deceased CI belugas to assess the presence/absence of indications of trauma from entanglements or vessel strikes in living whales, and the percentage of necropsied CI belugas with mortalities attributed to or associated with anthropogenic trauma.

In order to understand if unauthorized take is limiting the recovery of CI belugas, information is needed to determine the prevalence of signs of injury or trauma in living whales and the number of mortalities associated with anthropogenic activities (as determined via necropsy). For living whales, non-invasive methods such as a review of the photo-identification catalog should be employed to determine past signs of trauma, and can be used to continue to monitor signs in the future. This type of monitoring may also help determine the effects of any particular trauma to the individual whale. For deceased whales, necropsies will be necessary to determine if the cause of death is related to unauthorized take, and a review of past necropsy reports may help determine the percentage of whales suffering mortalities due to anthropogenic activities. These types of monitoring activities should be continued into the future to help determine if the levels and/or effects of this threat are changing over time.

45. *Refine research techniques, evaluate alternatives, and implement research methods which minimize harassment, harm, and general adverse impacts on CI belugas. Only conduct research on CI belugas that has a clear connection to their recovery.*

Research activities conducted in Cook Inlet have the potential to result in unanticipated mortalities or harassment of CI belugas. The potential impacts of various research methods (e.g., crossbow biopsy, breath analysis, live captures, and accessing live strandings) needs to be evaluated and the method with the least adverse impact to the animals should be used as much as possible. Existing and new research techniques and mitigation strategies should be reevaluated to minimize their impact. Minimally invasive techniques, such as collection of floating fecal or skin material, or well-designed skin/blubber biopsy surveys, should be given priority over more invasive methods with higher potential for harassment or harm (e.g., activities involving chase, or requiring capture of animals). For invasive research techniques, the use of surrogate sympatric species within Cook Inlet (harbor seal and/or harbor porpoise) and other healthy beluga populations should be considered for testing protocols and obtaining comparative data prior to use on CI belugas. Criteria to determine whether particular research methods should not be authorized need to be developed.

46. *Evaluate the relative effect of different types of vessels and speed on CI belugas.*

Vessel activity around whales needs to be monitored and evaluated to determine the relative effect of different types of vessels and traveling speed on CI beluga behavior as well as the potential for collision (indirect and direct effect). Efforts should be focused in areas of high vessel traffic, such as the Port of Anchorage, Cook Inlet shipping lanes, the Susitna Delta and the lower reaches of the Kenai River.

47. *Work with local, state, and federal agencies and stakeholders to: 1) monitor vessel activity in areas of known importance to CI belugas for foraging and reproduction; 2) develop a cooperative program to reduce whale interactions with vessels and fisheries; and 3) develop methods and plans for reducing or mitigating the levels of entanglements, vessel strikes, or other sources of anthropogenic trauma for areas of critical importance to CI belugas for reproduction and foraging.*

There are multiple photos of individual CI belugas with scars consistent with boat strike indicating direct impact, but the relative importance of the effect of boat-induced injury is poorly understood. Indirect impacts could include acoustic impacts, inhalation of harmful engine exhaust, and disruption of critical behavioral activities (e.g., foraging, breeding, and calving). Data on vessel traffic in Cook Inlet, monitoring of vessel activity, and consideration of the development of regulations regarding vessel speed and route may be necessary. At a minimum, whale-safe boating recommendations should be developed that include advisories to forewarn operators of times and areas with heightened risk of CI beluga encounters. Boating guidelines based on observed effects of boating on belugas and knowledge of preferred beluga habitat should be developed to minimize interactions (e.g., reduced speed areas and temporal and spatial restrictions to traffic).

Catastrophic Events

Catastrophic events have the potential to affect a large portion of the CI beluga population, and are considered a threat of high relative concern. To fully understand if catastrophic events are limiting CI beluga recovery as a result of injuries or mortalities, especially in areas important to CI belugas for foraging or reproduction, there is a need to improve the understanding of the causes and sources of catastrophic events; to include potential effects on CI belugas; and to improve the management of the causes, responses to, and prevention of catastrophic events resulting in injuries or mortalities of CI belugas. Below are recommended actions to address this threat.

48. Using currently available information, conduct a retrospective spatial and temporal evaluation of known catastrophic events in Cook Inlet since the 1970s, and assess if there are changes in the frequency, distribution, or types of catastrophic events over time.

Currently there is no single place to obtain information about catastrophic events in Cook Inlet (e.g., natural disasters, oil spills, mass CI beluga strandings, key prey run declines, etc.) and no assessment conducted to determine if the frequency, distribution, or types of catastrophic events are changing over time or are influencing the CI beluga population. As such, an analysis needs to be conducted examining the available information regarding catastrophic events in Cook Inlet since the 1970s to determine if the frequency, magnitude, or severity of these events is changing over time. Such changes, especially in important CI beluga foraging or reproduction areas, could indicate that this type of threat may have greater impacts to CI beluga recovery.

49. Review catastrophic events in areas known to be important to CI belugas for foraging or reproduction and assess if a correlation exists with CI beluga distribution, abundance, or reported mortalities that may suggest catastrophic events are limiting recovery.

Catastrophic events have resulted in adverse effects on other cetaceans (e.g., killer whale mortalities after the *Exxon Valdez* oil spill), but with the exception of information about CI beluga mass strandings, there has been no comprehensive review of catastrophic events in Cook Inlet. While the effects of catastrophic events are variable, population modeling indicates that any additive mortality of CI belugas will have a significant negative effect to the recovery potential of these whales. Non-stranding related catastrophic events that occur in areas known to be important to CI belugas for foraging, reproduction, or where large groups of belugas congregate (e.g., Susitna Delta) have a greater potential for negative effects on the whales than do catastrophic events in areas less frequently used by belugas or occupied by only a small number of belugas at a given time (e.g., areas south of the Forelands during summer). Therefore, to restrict the spatial extent of this action to the most important areas with the greatest potential for adverse effects, an analysis should examine if a correlation exists between catastrophic events north of the Forelands and CI beluga distribution, abundance, and reported mortalities.

50. Conduct a retrospective analysis of documented CI beluga live strandings and catastrophic events in Cook Inlet and assess if a correlation exists which may indicate catastrophic events are limiting recovery by causing mass strandings.

The causes of live mass strandings of CI belugas are not clearly known, and may result from a variety of factors including tidal stage or the presence of predators in the vicinity. However, it is also possible that catastrophic events may also lead to mass strandings for reasons unknown. Although the reasons may not be clear, it is clear that some animals are found dead after a mass stranding. Thus, even if a catastrophic event itself does not directly lead to mortality, if that event leads to a mass stranding, the potential for mortality increases. Loss of individuals from the population has the greatest immediate effect to the recovery potential of the population. A retrospective analysis examining a correlation between catastrophic events and mass strandings may help determine if catastrophic events are limiting CI beluga recovery.

51. Review available data which may provide information about mortality rates (e.g., CI beluga stranding records) and assess if the occurrence of mortality is correlated with known catastrophic events.

Given that additive mortalities reduce the recovery potential of CI belugas, any additive mortalities associated with catastrophic events must limit CI beluga recovery. The information obtained from Actions 48–50 should provide the basis for a review to determine if catastrophic events are limiting CI beluga recovery by resulting in increased mortalities.

52. Assess CI belugas for signs of catastrophe-induced distress to determine whether mortalities or reduced fitness can be directly or indirectly attributed to catastrophes.

Although mortalities have the most immediate effect to recovery, catastrophic events that lead to injuries and reduced health or fitness can lead to reduced recovery potential for the population. In anticipation of future catastrophic events, actions should be taken to monitor CI belugas, via non-invasive methods, for signs of distress which may indicate compromised health. Any mortalities in the months following a catastrophic event should undergo a thorough necropsy to assess if the catastrophic event contributed to the cause of death. Results from examinations of dead CI belugas should be linked with the CI beluga photo-identification catalog, if possible. If there is sufficient available information from previous catastrophic events, that information should be considered when determining if catastrophic events are limiting CI beluga recovery.

53. Review and update oil and hazardous substance spill response plans to minimize effects of spills on CI belugas, including strategies to deter CI belugas from entering oiled areas.

NMFS should work with the U.S. Coast Guard and industry groups to develop and test wildlife response plans and to acquire and maintain the necessary equipment and supplies to deter belugas from entering oiled and/or contaminated habitat, move animals back out of oiled and/or contaminated habitat should they enter it, and monitor, and if necessary, rehabilitate belugas directly impacted by an oil or hazardous substance spill.

54. Evaluate and test deterrent or hazing strategies aimed at preventing belugas from entering specific areas of concern.

When responding to an oil or chemical spill, primary strategies focus on spill containment. Secondary strategies seek to prevent wildlife from entering areas affected by the spill and dispersants. Such secondary strategies may also be potentially useful for deterring CI belugas from using areas with a high risk of live stranding. Various hazing methods have been used successfully with other marine mammals but have not been evaluated for use on belugas. Their routine exposure to high ambient noise and boat traffic may make CI belugas more resistant to acoustic techniques used to deter other species or populations. Existing techniques should be evaluated for deterring belugas from specific areas of concern, preferably using other (non-CI) beluga populations.

55. Hold annual drills to respond to belugas impacted by catastrophic events.

Plans are only as effective as the training and preparedness of those who execute those plans. While the risk of an accidental discharge of a hazardous substance from any single anthropogenic activity is considered to be low, the probability of a toxic spill increases with the number of anthropogenic activities, increasing the potential for catastrophic loss of CI belugas. Therefore, it is important to develop plans to respond to incapacitated belugas involved in such an event and to train and rehearse for actual responses. Such training and drills should be combined with drills to respond to live strandings due to natural causes.

The development of methods to support whales that have live-stranded and better monitor their disposition could help to reduce mortality and enhance recovery. As such, regular trainings and drills for live stranding responses should be conducted to maintain skills of responders to provide supportive care to the whales during live stranding events. During such trainings and drills, stranding response kits that include cameras and measuring, recording, and sampling equipment should be distributed.

Cumulative Effects of Multiple Stressors

Cumulative effects of multiple stressors are considered to be a high concern for the recovery of CI belugas. In the absence of a single threat clearly limiting recovery, the cumulative effects (including any synergistic effects) from multiple stressors limiting recovery is a most plausible explanation for why the CI beluga population has not recovered.

The compounded effect of multiple stressors in constraining CI beluga recovery can be greater than the effect of any single stressor or sum of stressors. Thus, recovery actions to address cumulative effects of multiple stressors require a complex approach. A first step is to identify single factors contributing to stress, followed by the identification of additive accumulation of stress (cumulative impacts), including interactions between factors that produce a combined effect greater than the sum of their separate effects (synergisms). Following identification of these components of multiple stress factors, mitigation measures can be identified and potentially implemented. Identifying and monitoring cumulative effects will depend on accumulation of individual beluga life-history data and associated environmental data; in addition, this will depend on the analyses of these data using the techniques of epidemiology and population modeling to identify and characterize the population level impact of these effects. Improvements in the understanding of the causes, relationships, and impacts of cumulative effects on CI belugas can also contribute to improvements in management of the causes and prevention of cumulative effects on CI belugas. Below are recommended recovery actions to address cumulative effects.

56. Conduct a temporal and spatial analysis of all types and sources of threats to CI belugas, documenting times and areas where threats overlap, and assess if a correlation exists with

CI beluga abundance or distribution which may suggest the effects of multiple stressors are limiting CI beluga recovery.

CI belugas exist in a dynamic environment, in which specific conditions may persist throughout the year, may occur seasonally over a series of years, or may occur infrequently over an indeterminate time frame. The identification of potential multiple or cumulative effects that may have constrained productivity or recovery of CI belugas will help to identify factors that may be critical to CI beluga recovery in the future. These factors may become important due to short or long-term changes in ecological, environmental, or anthropogenic conditions, and may also operate across changing spatial scales. Evaluation of changes and subsequent impacts on CI beluga recovery will need to consider both sequential effects and co-occurring factors. There is a need for coordinated spatial and temporal analyses of how natural and anthropogenic stressors influence beluga habitat use. On a single day, a single beluga moving through Cook Inlet may be exposed to multiple stressors from multiple sources, and the course of a beluga lifetime may encompass exposure to threats from numerous natural and anthropogenic stressors.

Threats identified in this recovery plan should be analyzed both independently and cumulatively. This may require the generation of a comprehensive, geospatial database of past and present anthropogenic activities (e.g., development, industry, transportation, military, and research projects) in Cook Inlet. CI belugas are exposed to many threats and the risk of accumulation of negative effects is high. Increasing the number of threat sources also increases the probability for synergistic effects to occur. Because exposure could occur during a given time period (e.g., summer) or in specific areas (e.g., near Anchorage), a temporal and spatial analysis of the distribution of all the threats would allow identification of peak periods or areas of higher risk of cumulative effects. Furthermore, movements of CI belugas throughout the Inlet are not random, but are driven by tide cycles, the seasonal presence of beluga prey, and winter ice. If temporal presence of threats in different areas overlaps with CI beluga movement patterns (i.e., belugas move among areas but encounter different threats in each area), impacts could accumulate with spatial overlap. Similarly, cumulative effects could derive from the exposure to multiple stressors accumulated within a specific time period or in a specific area.

For example, information regarding the types of anthropogenic activities known to introduce acoustic energy into the water, the timing and location of these energy sources, any mitigation applied, and acoustic characteristics should be logged into a database to track all potential noise stressors and their temporal and spatial coverage. These data should be linked to the NMFS CI beluga stranding database to allow detection of potential relationships between anthropogenic noise events and strandings. This open-access database should be developed, maintained, and managed by NMFS, with contributions from university, private, agency, and industry researchers in Cook Inlet.

Analyses of identified threats in a geographic information system (GIS) format would help determine spatial and temporal associations and overlaps. For example, patterns in historical or prolonged coastal or upstream development could be identified as a combination of factors associated with anthropogenic development. Such overlaps could be examined for correlations to changes in CI beluga distribution patterns to better understand factors with the greatest potential to impact CI beluga recovery.

57. Conduct a meta-analysis of previously documented cumulative effects for other populations and species, based on known threats for CI belugas, and prioritize risk to CI belugas based *on how these threats have been shown to negatively affect other beluga populations, other odontocetes, or other marine mammals.*

Because many potential factors may be impeding CI beluga recovery, it is important to narrow the list by identifying spurious correlations (e.g., haphazard or non-causal relationships) between given factors and a lack of recovery. Available data on potential cumulative factors are often limited, so an initial step would be to examine historical data from other marine mammal populations. Such research would require a meta-analysis of available data, prioritized to focus first on other beluga populations, then other odontocetes, then other cetaceans, and, finally, other marine mammal populations.

Based on results of the meta-analysis described above, the next step would be to evaluate whether the combinations of threats found to be constraining productivity in other marine mammal populations might be similarly impeding the recovery of CI belugas. This step would require characterization of potential threats in Cook Inlet such that co-occurrences of these threats in time, space, or both may be examined.

58. Analyze the potential synergism among noise exposure, chemical pollutants, and potential predation to identify if there are activities, locations, or periods of time for which CI belugas may be at high risk for synergistic effects.

It has been shown in other vertebrates that even weak stressors, when combined with other equally weak though dissimilar stressors, can have negative, synergistic impacts on reproduction and survival. Synergistic effects have not been studied for cetaceans, but there is evidence in other species of synergism associated with noise in combination with the presence of chemical pollutants and predators. All these factors are present in CI beluga habitat. By analyzing the potential synergism among noise exposure, chemical pollutants, and potential predation in CI belugas, specific locations, time periods, and certain human activities could result in unexpected severe threats because of synergism with other concurrent or sequential threats.

59. Review the CI beluga stranding records for co-occurrence of multiple stressors.

To date, the CI beluga stranding database has been examined to only a limited extent for the primary factors potentially related to observed CI beluga strandings. Additional information may be extrapolated from the CI beluga stranding database by reviewing stranding records for indications of multiple or secondary factors such as gunshot or propeller wounds, poor body condition (e.g., little blubber, muscle atrophy, etc.). Such an analysis would facilitate a better understanding of the prevalence of multiple stressors and the contribution of co-occurring stressors to overall CI beluga mortality.

60. Evaluate sequential effects compared to effects of multiple co-occurring stressors.

Evaluations of the effects of multiple stressors on organisms have often focused on factors that occur simultaneously. However, the aspect of latent effects due to sequential, but not co-occurring, stressors is often difficult to evaluate. The results from the meta-analysis of potential threats in CI beluga (see Action 57) and related species will provide guidance on sequential factors that may be detrimental to CI beluga recovery.

61. Develop a PVA model component to incorporate covariance effects of multiple stressors.

The current approach for predicting trends in CI beluga abundance is through a PVA model. The PVA population model should be: transparent, publicly available, and well documented with meta-data embedded in its code or as a separate document. It should include risk of cumulative stressors impacting individual survival or reproduction. This could then be used to evaluate the potential interaction of multiple stress factors, and their impacts on the risk of extinction and potential for recovery of the population.

62. *Review the current system for allocation of takes (by harassment) of CI belugas to see if a comprehensive approach, rather than by individual project, increases managers' ability to reduce the cumulative effects of harassment takes by numerous projects.*

Although individual activities might be deemed insignificant when considered independently, creeping normality[30] (e.g., death by a thousand cuts) can cause substantial adverse effects to nearly any entity, including CI belugas, at both individual and population levels. Applications for Incidental Harassment Authorizations (IHAs) historically have been reviewed on the basis of an individual activity in isolation. But the high level of human activity in Cook Inlet has increased such that cumulative effects of multiple activities must be appropriately accounted for. Although assessing cumulative impacts from multiple activities is challenging, results of such an assessment might be particularly relevant for understanding the lack of recovery for CI belugas. A framework should be developed by NMFS for assessing cumulative impacts to belugas from the numerous activities occurring in Cook Inlet.

In 2012, the CI beluga population was estimated at 312 whales, and over 2,700 takes were requested for research and development projects (NMFS, unpub. data). To monitor how many allocated takes are actually used (as opposed to how many takes are granted), the process for reporting takes needs to be streamlined and expedited. For example, research takes occurring in the summer are not required to be reported until fall of the following year. Requiring more frequent reporting of takes and better tracking of take will better inform NMFS of how many takes are actually occurring, and will allow better take allocation in subsequent years. However, this process will not account for take by activities that either do not properly report take or that do not undergo review by NMFS to authorize take.

In the future, NMFS could also establish a limit for annual takes granted to development projects, research projects, and all projects combined. The total allocated take could be capped annually at some fraction of the population estimate from the previous year.

63. *Encourage the resources users/development community in Cook Inlet to create a joint industry program to gather and compile data to share for consultation, permitting, and mitigation processes, and to fund research to improve mitigation of impacts on CI belugas and their habitat.*

Individually, several development projects in Cook Inlet have conducted a variety of studies to define baselines for the distribution, abundance, and habitat use of CI belugas in project areas. Many of these areas are within CI beluga critical habitat. In some cases, study results have been made public, but others remain proprietary. The E&P Sound and Marine Life Joint Industry Programme[31] (JIP) is used elsewhere by the oil and gas industry to direct research that will help

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[30] Creeping Normality: the way a major negative change, which happens slowly in many unnoticed increments, is not perceived as objectionable. For more information about the concept of creeping normality, see the book "Collapse: How Societies Choose to Fail or Succeed" by Jared Diamond.

[31] The E&P Sound and Marine Life Joint Industry Programme website can be found at: http://www.soundandmarinelife.org/

industry and managers identify effective and efficient mitigation measures for oil and gas development, and may be a useful model for all development projects (not just the oil and gas industry) in Cook Inlet. Such a coalition would allow participants to pool their administrative resources and efficiently focus their efforts on environmentally responsible development that will not impede the recovery of CI belugas.

64. Consider analysis of results for cumulative effects of multiple stressors to update regulations.

Regulations should not only consider the noise type and overall levels introduced into CI beluga habitat by each activity independently, but also the potential effects of different stressors (acoustic and non-acoustic) occurring concurrently or sequentially over time or space. Research results on cumulative (including synergistic effects) could inform appropriate revisions to existing regulations that would improve management of acoustic impacts to CI belugas.

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VII. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the recovery program for CI belugas as set forth in this recovery plan. It is a guide for meeting the recovery goals outlined in the plan. This schedule indicates action numbers, action descriptions, recovery priorities, the potential parties responsible for actions (either funding or carrying out), duration of actions, and estimated costs.

Priority: Priorities are assigned to each action in the Implementation Schedule. Assigning priorities does not imply that some recovery actions are of low importance; instead it implies they may be deferred while higher priority recovery actions are being implemented. It is important to remember that we have focused this section only on the threats identified as of medium or high relative concern.

- Priority 1 – Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly.
- Priority 2 – Actions that must be taken to prevent a significant decline in species population/habitat quality or in some other significant negative impact short of extinction.
- Priority 3 – All other actions necessary to provide for full recovery of the species.

The definitions for priority 1, 2, and 3 are defined in the *Endangered and Threatened Species Listing and Recovery Priority Guidelines* (55 FR 24296, June 15, 1990) developed by NMFS. Based on these definitions and based on the fact that we do not know which threats are preventing CI belugas from recovering to the point where they are not in danger of becoming extinct in the foreseeable future, there are few priority 1 actions in this plan. We have limited priority 1 actions to those associated with monitoring the population's status since doing so is crucial to determine the effectiveness of this recovery plan. As the results of research and reassessments become available, we recognize the levels of concern for the threats, as well as the priorities, may change. This plan is meant to be adaptive to allow for such changes.

Potential Responsible Parties: The group(s) identified as "Potential Responsible Parties" have been identified as the best lead party/parties to implement discrete recovery actions. When more than one party has been identified, the proposed lead party is listed first. Many lead parties are agencies or organizations with authority, responsibility, or expressed interest to implement a specific conservation action. Inclusion as a Responsible Party does not commit any entity to taking action. Rather, it conveys who may be best suited for completing the action. The listing of a party in the Implementation Schedule does not require the identified party to implement or fund the implementation of any action.

Estimated Costs and Duration: Costs are estimated for the fiscal year in thousands of 2016-value U.S. dollars ($K) and are not adjusted for inflation. Estimates of costs were derived from a variety of sources, including government agencies and other organizations. Tabular cost estimates do not imply that funding will be available for accomplishing that recovery task. Costs were estimated in accordance with the number of years necessary to complete the task once implementation has begun. The table below covers a five-year period, in accordance with the standard five-year cycle of review and update/revision for all recovery plans.

The total time and cost to recovery are very difficult to predict with the current information, and the total cost to recovery will be largely dependent upon the number of threats management actions requiring implementation. Since that cannot be determined prior to implementation of portions of this plan, the total cost presented here assumes implementation of all recovery actions. Thus, we expect the total estimated cost to achieve recovery presented here is high; actual costs will be lower if actions addressing some threats are not implemented because those threats have been determined not to be limiting the recovery of CI belugas. It is expected that recovery may take at least two generations (50 years); therefore, for ongoing actions costs have only been given for the next 50 years. If every identified recovery action must be implemented, and if it takes 50 years to recover CI belugas, then the estimated cost of implementing this entire recovery program is approximately $76.8 million.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
POPULATION MONITORING, RECOVERY PLAN IMPLEMENTATION, AND EDUCATION/OUTREACH ACTIONS:											
1.	Continue to conduct surveys to estimate abundance, and analyze population trends, calving rates, and distribution.	1	NMFS, LGL	500	200	500	200	500	ongoing	17500	Currently, NMFS conducts biennial aerial surveys for population estimate purposes (began in 1993), and LGL conducts annual photo-identification studies (began in 2005).
2.	Create and support a CI Beluga Recovery Coordinator position.	1	NMFS	150	150	150	150	150	ongoing	7500	This estimate includes fringe benefits as well as salary.
3.	Create and support a CI Beluga Recovery Implementation Task Force.	1	NMFS	50	50	50	50	50	ongoing	2500	
4.	Increase efforts to identify and monitor individual CI belugas, coordinating photo-identification, stranding data, genetic studies, and body condition assessments via biopsy samples of skin and blubber.	2	NMFS, ADFG, LGL	0	100	0	0	0	once, with updates every 5 years	325	This effort is targeted at compiling different datasets and does not include data collection. The initial effort is likely to be more costly than subsequent updates (estimated at $25K). Results to be integrated into annual reviews and coordination meetings per Action 7.
5.	Determine annual mortality and reproductive rates of CI belugas.	2	NMFS, AVPS, ASLC	0	0	0	0	0	ongoing	0	Costs associated with this effort are incorporated into other actions (e.g., Actions 1, 7, 16, 24).

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
6.	Conduct regular biopsy surveys of CI belugas to monitor changes in condition and reproductive success in relation to environmental changes.	2	NMFS, ADFG	300	300	300	300	300	yearly for 5 years, then once every 5 years	2700	Biopsy surveys during the first five years will build the dataset and allow for initial analyses, with subsequent surveys allowing for population monitoring.
7.	Organize an annual review and coordination workshop to review existing data on individual CI belugas, plan expansion of future data collection and analyses, and facilitate linkage of all existing and new CI beluga-related research.	1	NMFS	50	50	50	50	50	yearly	2500	All new information from other recovery actions should be shared during these annual meetings.
8.	Hold a workshop to consider the feasibility, risks, and benefits of different sampling techniques such as breath capture, remote ultrasound, and live captures to obtain samples and measures for further analyses.	3	NMFS	50	0	0	0	0	once	50	In April 2014, NMFS hosted a workshop of experts in the field of biopsy. The workshop report is recommended for use in planning any biopsy-related study, and is available on the NMFS AKR website.
9.	Conduct a workshop to update a model to determine the probability of extinction of CI belugas.	2	NMFS	75	0	0	0	0	once every 5 years	750	This may be a single workshop, or a series of workshops held within the same year.
10.	Engage in education and outreach efforts targeted at informing the public of the status of CI belugas and their threats, and promoting more public involvement in reporting CI belugas.										

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
10a.	Provide information regarding threats to CI belugas and ways the public can help mitigate those threats.	3	NMFS	1	1	1	1	1	ongoing	50	Could be organized and supported by the NMFS CI Beluga Recovery Coordinator (Action 2); and implemented as part of ongoing management processes or in association with other workshops. Nominal costs associated with outreach activities are identified.
10b.	Develop and broadcast annual announcements promoting the use of citizen science and encouraging reporting of strandings and sightings by the public.	3	NMFS	5	5	5	5	5	yearly	250	Could be organized and supported by the NMFS CI Beluga Recovery Coordinator (Action 2); implemented as part of ongoing management processes or in association with other workshops.
10c.	Create an annual Cook Inlet Beluga Watch Day.	3	NMFS, ADFG, NGO, ASLC, DOW	25	25	25	25	25	yearly	1250	
11.	Improve the stranding response program for both live and dead CI belugas.	2	NMFS, ASLC, AVPS, other CI beluga stranding partners	0	50	50	50	50	yearly	2450	

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
12.	Once every five years, reassess the status of the CI beluga population and each of the threats to CI belugas.	2	NMFS	0	0	0	0	500	once every 5 years	5000	These should be reviewed in association with the 5-year status reviews.
THREATS MANAGEMENT ACTIONS:											
REDUCTION IN PREY											
13..	Evaluate how prey abundance and availability has changed over time in comparison to CI beluga abundance and if there are direct correlations between the two suggestive of a positive link between prey abundance or availability and CI beluga abundance, productivity, or mortality.	2	NMFS, ADFG	80	0	0	0	0	once every 5 years	800	
14.	Monitor body condition of living and deceased CI belugas to assess the presence/absence of nutritional distress or nutritional-related mortalities, and determine the percentage of necropsied CI belugas with mortalities attributed to nutritional distress.	2	NMFS, LGL, ASLC, AVPS	30	0	0	0	0	once every 5 years	300	Much of the costs for collecting this information are associated with other actions, notably stranding response and photo-identification efforts.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
15.	Analyze the existing collection of CI beluga teeth to determine if age at first reproduction for female CI belugas can be determined, and assess if there has been a significant change in this parameter over time.	2	NMFS, ADFG, UA	40	0	0	0	0	once every 5 years	400	NMFS will need to be contacted regarding access to the teeth collected from dead belugas.
16.	Review available data which may provide information about calving rate (population-wide) or calving interval (individual belugas), and assess whether either of these parameters is correlated with prey abundance.	2	NMFS, LGL	50	0	0	0	0	once every 5 years	500	NMFS has some data available from previous aerial surveys in August looking at a calving index. Long-term photo-identification studies may provide information useful in the assessment of calving rates/intervals.
17.	Research the seasonal, spatial, and size variation in prey diversity and quality to improve assessments of relationships between CI belugas and their prey.	2	NMFS, ADFG, UA	0	300	300	300	300	yearly for 5 years, then once every 5 years	4200	
18.	Research the effects of environmental and anthropogenic factors on CI beluga prey to assess if any particular factor is having a significant detrimental effect to the prey and thus a detrimental effect on CI beluga recovery.	2	NMFS, ADFG, UA, CIRCAC	0	70	70	70	70	yearly for 5 years, then once every 5 years	910	Supplemental to Action 17; partly implemented as part of Noise actions.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
19.	Determine energetic requirements/metabolic needs of CI belugas at different life stages to determine whether nutritional stress is a function of life stage.	2	ADFG, UA, NMFS, ASLC, APU	0	150	150	0	0	2 years	300	Study Cook Inlet and Bristol Bay belugas, and potentially captive belugas in aquaria, in conjunction with other projects.
20.	Study the diet selectivity of different CI beluga demographic groups (e.g., age, sex, and reproductive state).	2	ADFG, NMFS, UA, APU	0	100	100	50	50	4 years	300	Consider aquaria studies.
21.	Using currently available information, develop a CI beluga foraging model informed by prey characteristics and beluga dietary needs.	2	NMFS, UA, ADFG, APU	0	0	0	60	0	once, with updates every 5 years	330	The initial effort is likely to be more costly than subsequent updates (estimated at $30K).
22.	Ensure fisheries management (e.g., escapement goals for CI beluga prey species) adequately accommodates CI beluga prey requirements, and if necessary, expand the number of species with escapement goals.	2	ADFG, NMFS	0	0	0	0	0	5 years	0	Implemented as part of ongoing management processes; assumes no additional costs.
DISEASE AGENTS											

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
23.	Analyze images from the CI beluga photo-identification catalog for the presence of external signs of disease in photographically identified CI belugas to 1) assess the percentage of identified CI belugas with external indications of disease, and 2) track the persistence of, or changes in, the external indications of the disease agent in individual whales over time.	2	NMFS, ASLC, AVPS, LGL	50	0	0	0	0	once every 5 years	500	Costs also include analyses for action.
24.	Continue examining beach-cast carcasses of CI belugas for disease-related mortalities, assessing the percentage of necropsied CI belugas with mortalities attributed to disease agents, and linking results from examinations of known individual belugas with the CI beluga photo-identification catalog. When feasible, determine the presence and relevance of disease agents in other Cook Inlet marine mammal mortalities.	2	NMFS, ASLC, AVPS, LGL	8	8	8	8	8	ongoing	400	NMFS already provides separate funding to specific Marine Mammal Stranding Network responders for necropsies; photo-identification component associated with Action 23; linkage of results can be associated and incorporated in Action 7.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
25.	Using currently available information, compare data on diseases from CI belugas with other beluga populations to determine if there are abnormal levels or atypical types of disease agents present in Cook Inlet affecting CI belugas.	2	NMFS, AVPS, ASLC	15	0	0	0	0	once every 5 years	150	
26.	Determine types and sources of disease agents identified to be of concern specifically to CI belugas and assess management actions targeted at mitigating the disease agents.	2	NMFS	0	10	0	10	0	every other year	250	
NOISE											
27.	Conduct a retrospective analysis of documented CI beluga live strandings and noise-producing anthropogenic activities in Cook Inlet, possibly to include the development of a database of anthropogenic activities that introduce noise to Cook Inlet, and assess if a correlation exists which may indicate noise is limiting CI beluga recovery.	2	NMFS	250					once with updates every 5 years	700	Year 1 funds include the development of the anthropogenic activities database, linkage of that dataset to the NMFS stranding database (which is being finalized and available on the NMFS AKR website soon), and for conducting the retrospective analysis. The funds for the 5 year updates ($50K each) include costs for updating the database with new data and updating the analysis.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
28.	Conduct a retrospective analysis of anthropogenic noise-producing activities in Cook Inlet and information on CI belugas' behavior and distribution to assess if a correlation exists that may indicate noise is limiting CI beluga recovery.	2	NMFS, ADFG, CIBA	0	75	0	0	0	once with updates every 5 years	525	This action's funding is for the initial retrospective analysis estimated at $75K, with 5-year updates estimated at $50K each.
29.	Within areas designated as critical habitat Type 1, determine areas with high vs. low levels of anthropogenic noise, if there are significant typical changes (e.g., seasonal differences) in the levels of overall (natural plus anthropogenic) noise in that area, and assess if a correlation exists between CI beluga use of the area and the noise levels in the area.	2	NMFS, ADFG, CIBA	250	0	0	0	0	once with updates every 5 years	1600	Five-year updates are estimated at $150K each.
30.	Describe the acoustic characteristics of different anthropogenic noise sources in Cook Inlet and rate the potential acoustic impacts from each type of noise source on CI belugas.	2	NMFS, ADFG, CIBA	0	300	0	0	0	once every 10 years	1500	Costs associated with data collection are mostly captured in Action 31. These costs include data analysis and rating the potential impacts to CI belugas.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
31.	Conduct long-term and year-round monitoring of natural and anthropogenic noise (level and spectrum) in key areas where CI belugas currently and historically concentrated (including CI beluga critical habitat) to characterize and monitor the acoustic environment and identify sources, levels, and types of anthropogenic noise.	2	NMFS, ADFG, CIBA	0	600	600	600	600	5 years	3000	The costs presented for data collection in this action supplement Action 30.
32.	Work with local, state, and federal agencies and stakeholders to develop methods and plans for reducing or mitigating the levels of anthropogenic noises in Cook Inlet, including incorporation of pre- and post-activity surveys for major noise-producing activities to monitor CI beluga presence.	2	NMFS, ADFG	0	85	0	0	0	once every 5 years	850	Costs depend on each activity to be monitored/mitigated; these costs assume logistics of working with all pertinent agencies and stakeholders to develop methods and plans.
33.	Develop and incorporate into the noise monitoring/mitigation plans a protocol to identify the onset (received levels and distance) of CI beluga behavioral reactions to specific activities.	2	NMFS, CIBA	255	255	255	255	0	4 years	1020	
HABITAT LOSS OR DEGRADATION											

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
34.	Develop a comprehensive Cook Inlet environmental database using currently available information to conduct a retrospective spatial and temporal evaluation of the biological, physical, and anthropogenic features in CI beluga habitat since the 1970s and assess how the habitat has changed over time, including likely causes of change.	2	NMFS, ADFG, ADEC, ADNR, UAF	400	0	0	0	0	once every 5 years	850	Year 1 funds include the development of the environmental database and for conducting the retrospective analysis. The funds for the 5 year updates ($50K each) include costs for updating the database with new data and updating the analysis.
35.	Compare the changes in habitat availability or quantity over time with changes in CI beluga distribution and abundance over time to assess if a correlation exists which may suggest habitat loss or degradation is limiting the recovery of CI belugas.	2	NMFS, ADEC, CIK, DOW	85	0	0	0	0	once every 5 years	850	
36.	Review losses or degradation of habitats in areas known to be important to CI belugas for foraging or reproduction, and assess if a correlation exists between habitat changes and changes in CI beluga use of the area, possibly indicating that habitat loss or degradation is limiting the recovery of CI belugas.	2	NMFS, ADEC, CIK, DOW	85	0	0	0	0	once every 5 years	850	

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
37.	Update the comprehensive Cook Inlet environmental database developed in Action 34 and project the future extent and quality of CI beluga habitat.	2	NMFS, UAF, ADEC	0	0	50	50	20	3 years	120	Will require data acquisition through other action items, coupled with predictive modeling.
38.	Conduct a detailed habitat survey to begin long-term habitat monitoring (quality and quantity), including the use of volunteers and community members.	2	NMFS, ADFG, UAF, NGOs, CIRCAC	0	0	125	125	125	5 years	625	Supplemental to Action 34 by focusing on habitat characteristics. Could be organized and supported by the NMFS Cook Inlet Beluga Recovery Coordinator (Action 2).
39.	Evaluate impacts on CI belugas from anthropogenic activities with potential to result in degradation or loss of CI beluga habitat, with emphasis in known and historic feeding areas.	2	NMFS, UAF	0	50	50	0	0	2 years	100	Perhaps involving aquaria studies.
40.	Assess the biological benefits, costs, and implementation feasibility of potential protection or restoration measures for particular habitats important to CI beluga recovery and implement such measures if determined warranted.	2	NMFS, UAF	0	0	40	40	40	3 years	120	Costs for this action item address only the analyses of the biological benefits, costs, and feasibility of potential protection and restoration measures and not the implementation of such measures.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
41.	Work with local, state, and federal agencies and stakeholders to develop a comprehensive Cook Inlet habitat database, and methods and plans for reducing or mitigating the levels of habitat loss or degradation in areas of known importance to CI belugas for foraging and reproduction, including restoration of habitats if necessary.	2	NMFS, ADFG, NGOs	0	0	0	0	0	5 years	0	Implemented as part of ongoing management processes; assumes no additional costs apart from those identified in Action 34. Could be organized and supported by the NMFS Cook Inlet Beluga Recovery Coordinator (Action 2).
42.	Identify potential likely sources of contamination and evaluate their potential to discharge contaminants.	2	NMFS, EPA, CIK	0	0	50	0	0	once every 5 years	500	Costs associated with developing a comprehensive inventory or database.
UNAUTHORIZED TAKE											
43.	Review available data which may provide information about the types and level of unauthorized take in living and dead CI belugas to improve knowledge about the prevalence, frequency, and severity of effects on CI belugas from these activities.	2	NMFS, ASLC, AVPS, LGL		70	0	0	0	once every 5 years	700	

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
44.	Review and continue to monitor for signs of trauma in living and deceased CI belugas to assess the presence/absence of indications of trauma from entanglements or vessel strikes in living whales, and the percentage of necropsied CI belugas with mortalities attributed to or associated with anthropogenic trauma.	2	NMFS, ASLC, AVPS, LGL	50	0	0	0	0	once every 5 years	500	AVPS and ASLC conduct majority of CI beluga necropsies and document signs of trauma in dead whales; LGL documents signs of trauma in living whales. Costs are associated with reviewing the information to determine levels of injury/mortality from anthropogenic causes.
45.	Refine research techniques, evaluate alternatives, and implement research methods which minimize harassment, harm, and general adverse impacts on CI belugas. Only conduct research on CI belugas that has a clear connection to their recovery.	2	NMFS	0	0	0	0	0	yearly	0	These evaluations and decisions can be associated with the annual meetings recommended in Action 7.
46.	Evaluate the relative effect of different types of vessels and speed on CI belugas.	2	NMFS, ADFG	0	0	60	0	0	once	60	

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
47.	Work with local, state, and federal agencies and stakeholders to: 1) monitor vessel activity in areas of known importance to CI belugas for foraging and reproduction; 2) develop a cooperative program to reduce whale interactions with vessels and fisheries; and 3) develop methods and plans for reducing or mitigating the levels of entanglements, vessel strikes, or other sources of anthropogenic trauma for areas of critical importance to CI belugas for reproduction and foraging.	2	NMFS, ADFG	0	20	20	30	30	yearly for 5 years, then once every 5 years	550	Discussions should start in Year 1 (at no additional costs); monitoring vessel activity starts in Year 2; and assessing the need for boating guidelines and plans for mitigation begin in Year 4. Initial 5 years estimated at $100K, with a 5-year review cost of $50K.
CATASTROPHIC EVENTS											
48.	Using currently available information, conduct a retrospective spatial and temporal evaluation of known catastrophic events in Cook Inlet since the 1970s, and assess if there are changes in the frequency, distribution, or types of catastrophic events over time.	2	NMFS, ADEC	100	0	0	0	0	once every 5 years	1000	

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
49.	Review catastrophic events in areas known to be important to CI belugas for foraging or reproduction and assess if a correlation exists with CI beluga distribution, abundance, or reported mortalities that may suggest catastrophic events are limiting recovery.	2	NMFS, ADEC	50	0	0	0	0	once every 5 years	500	May be informed by results of Action 48.
50.	Conduct a retrospective analysis of documented CI beluga live strandings and catastrophic events in Cook Inlet and assess if a correlation exists which may indicate catastrophic events are limiting recovery by causing mass strandings.	2	NMFS, ASLC	50	0	0	0	0	once every 5 years	500	May be informed by results of Action 48.
51.	Review available data which may provide information about mortality rates (e.g., CI beluga stranding records) and assess if the occurrence of mortality is correlated with known catastrophic events.	2	NMFS, ASLC	50	0	0	0	0	once every 5 years	500	May be informed by results of Action 48.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
52.	Assess CI belugas for signs of catastrophe-induced distress to determine whether mortalities or reduced fitness can be directly or indirectly attributed to catastrophes.	2	NMFS, LGL, ASLC	30	0	0	0	0	review is once every 5 years; monitoring is ongoing	300	Funds for monitoring are assumed to be included in other actions that fund population monitoring (e.g., Action 1).
53.	Review and update oil spill response plans to minimize effects of spills on CI belugas, including strategies to deter CI belugas from entering oiled areas.	2	NMFS, USCG, ADEC, EPA, CISPRI	0	25	0	0	0	once every 5 years	250	
54.	Evaluate and test deterrent or hazing strategies aimed at preventing belugas from entering specific areas of concern.	2	NMFS, USCG, ADEC, EPA, CISPRI	0	20	20	25	0	3 years then once every 5 years (at $25K)	290	
55.	Hold annual drills to respond to belugas impacted by catastrophic events.	2	NMFS, USCG, EPA, ADEC, CISPRI	0	20	20	20	20	yearly	980	Could be coordinated with the annual Alaska Marine Mammal Stranding Network meeting.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
CUMULATIVE EFFECTS OF MULTIPLE STRESSORS											
56.	Conduct a temporal and spatial analysis of all types and sources of threats to CI belugas, documenting times and areas where threats overlap, and assess if a correlation exists with CI beluga abundance or distribution which may suggest the effects of multiple stressors are limiting CI beluga recovery.	2	NMFS	150	0	0	0	0	once every 5 years	1500	
57.	Conduct a meta-analysis of previously documented cumulative effects for other populations and species, based on known threats for CI belugas, and prioritize risk to CI belugas based on how these threats have been shown to negatively affect other beluga populations, other odontocetes, or other marine mammals.	2	NMFS	100	0	0	0	0	once every 5 years	1000	
58.	Analyze the potential synergism among noise exposure, chemical pollutants, and potential predation to identify if there are activities, locations, or periods of time for which CI belugas may be at high risk for synergistic effects.	2	NMFS	100	0	0	0	0	once every 5 years	1000	

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
59.	Review the CI beluga stranding records for co-occurrence of multiple stressors.	2	NMFS, ASLC	0	10	5	5	5	yearly	250	
60.	Evaluate sequential effects compared to effects of multiple co-occurring stressors.	2	NMFS	0	10	10	10	10	yearly for 5 years, then once every 5 years	140	
61.	Develop a PVA model component to incorporate covariance effects of multiple stressors.	2	NMFS	0	0	0	50	0	once	50	Similar to other PVA model parameters, once developed, this parameter will be incorporated into the model.
62.	Review the current system for allocation of takes (by harassment) of CI belugas to see if a comprehensive approach, rather than by individual project, increases managers' ability to reduce the cumulative effects of harassment takes by numerous projects.	2	NMFS	0	0	300	0	0	once	300	
63.	Encourage the resources users/development community in Cook Inlet to create a joint industry program to gather and compile data to share for consultation, permitting, and mitigation processes, and to fund research to improve mitigation of impacts on CI belugas and their habitat.	2	MMC, AOGA, NGOs, Cook Inlet resource users	0	30	25	20	20	yearly	995	Assumes higher costs initially to start program, then $20K annually.

Action #	Action description	Priority	Potential resp. parties[a]	FY1 $K	FY2 $K	FY3 $K	FY4 $K	FY5 $K	Duration or frequency of action	50-year cost ($K)	Comments
64.	Consider analysis of results for cumulative effects of multiple stressors to update regulations.	2	NMFS, MMC	0	0	0	0	85	once	85	

[a] Potential Responsible Parties: ADEC = Alaska Department of Environmental Conservation; ADFG = Alaska Department of Fish and Game; ADNR = Alaska Department of Natural Resources; AOGA = Alaska Oil and Gas Association; ASLC = Alaska SeaLife Center; AVPS = Alaska Veterinary Pathology Services; CIBA = Cook Inlet Beluga Acoustics group; CIK = Cook Inletkeeper; CIRCAC = Cook Inlet Regional Citizens Advisory Committee; CISPRI = Cook Inlet Spill Prevention Response, Inc.; DOW = Defenders of Wildlife; EPA = Environmental Protection Agency; LGL = LGL Alaska Research Associates, Inc.; MMC = Marine Mammal Commission; NGOs = Non-governmental Organizations; NMFS = National Marine Fisheries Service; UA = University of Alaska; USCG = United States Coast Guard.

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IX. APPENDICES

A. Federal Actions and Regulations for CI Belugas

B. Existing Conservation Efforts

C. Recovery Planning for CI Belugas

D. CI Beluga Life History Supplement

E. CI Beluga Hearing, Vocalizations, and Noise Supplement

F. CI Beluga Prey Supplement

G. CI Beluga Pollution and Contaminants Supplement

H. Cause of Death Analysis

I. Common and Scientific Names

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A. Federal Actions and Regulations for CI Belugas

Date	Action	Regulation
August 31, 1988	CI belugas included in the List of Candidate Vertebrate and Invertebrate Marine Species for possible listing under ESA	53 FR 33516
November 19, 1998	NMFS initiated a status review of CI belugas to determine whether designation as depleted under MMPA or listing as threatened or endangered under ESA is warranted	63 FR 64228
January 21, 1999	NMFS received petition to designate CI belugas as depleted under MMPA	Not applicable
March 3, 1999	NMFS received petitions to list CI belugas as endangered under ESA	N/A
April 9, 1999	NMFS determined petitions presented substantial information indicating the petitioned actions may be warranted	64 FR 17347
May 21, 1999	MMPA amended to require cooperative agreements to harvest CI belugas between NMFS and affected Alaska Native organizations	Pub. L. No. 106–31, Section 3022, 113 Stat. 57, 100
October 19, 1999	NMFS proposed designating the CI beluga stock as depleted under MMPA	64 FR 56298
May 31, 2000	CI beluga stock listed as depleted under MMPA	65 FR 34590
June 22, 2000	NMFS determined ESA listing not warranted; established CI beluga stock as a DPS and thus as a “species” as defined under ESA	65 FR 38778
October 4, 2000	NMFS proposed regulations to regulate subsistence harvest of CI belugas by Alaska Natives	65 FR 59164
December 21, 2000	MMPA amendment (May 21, 1999) on subsistence harvest of CI belugas by Alaska Natives made permanent	Pub. L. No. 106–553, 114 Stat. 2762, 2762A–108
September 26, 2003	Notice of Availability published for the *Subsistence Harvest Management of CI Beluga Whales Final Environmental Impact Statement (EIS)*	68 FR 55604
April 6, 2004	NMFS released final interim regulations to govern subsistence harvest of CI belugas by Alaska Natives	69 FR 17973
April 15, 2004	CI belugas transferred from ESA Candidate Species List to newly created Species of Concern List	69 FR 19975
March 16, 2005	NMFS published a Notice of Availability of the MMPA *Draft Conservation Plan for the CI Beluga Whale*	70 FR 12853
March 24, 2006	NMFS initiated a status review to determine if CI belugas should be listed under ESA	71 FR 14836
March 29, 2006	NMFS published a Notice of Intent to prepare a supplemental EIS (SEIS) for long-term management of CI beluga subsistence harvest by Alaska Natives	71 FR 15697
April 2006	NMFS received a petition to list CI belugas as endangered under ESA	Not applicable
August 7, 2006	NMFS determined petition presented substantial information indicating that the petitioned action may be warranted	71 FR 44641
April 20, 2007	NMFS published proposed rule to list CI belugas as endangered under ESA	72 FR 19854

Date	Action	Regulation
December 28, 2007	Notice of Availability published for the *CI Beluga Whale Subsistence Harvest Draft SEIS*	72 FR 73798
April 22, 2008	NMFS extended the deadline for ESA listing decision six months	73 FR 21578
June 20, 2008	Notice of Availability published for the *CI Beluga Whale Subsistence Harvest Final SEIS*	73 FR 60976
October 15, 2008	NMFS published final regulations establishing long-term management of subsistence harvest of CI belugas by Alaska Natives	73 FR 60976
October 22, 2008	NMFS issued final rule to list the DPS of the beluga whale found in Cook Inlet, Alaska, as endangered under ESA	73 FR 62919
October 22, 2008	NMFS published a Notice of Availability of the final MMPA Conservation Plan for the Cook Inlet Beluga Whale	73 FR 62961
December 2, 2009	NMFS proposed to designate critical habitat for CI belugas under ESA	74 FR 63080
January 28, 2010	NMFS published a Notice of Intent to prepare a recovery plan for CI belugas	75 FR 4528
April 11, 2011	NMFS issued the final rule designating critical habitat for CI belugas under ESA	76 FR 20180
May 15, 2015	NMFS published a Notice of Availability of the *Draft Recovery Plan for the Cook Inlet Beluga Whale* and opened a 60-day public comment period	80 FR 27925

B. Existing Conservation Efforts

NOTE TO READER: The text below was included in the draft recovery plan developed by the CIBRT, with minor updates, as a detailed description of existing conservation efforts that cover CI belugas, although we note that existing measures have been inadequate to date to effectively ensure the recovery of CI belugas. We also note that this Appendix is not intended to provide an exhaustive review of every existing protective measure that may apply to threats that may be limiting CI beluga recovery. Other such protections not detailed here include federal statutes such as the Oil Pollution Act of 1990, Magnuson-Stevens Fishery Conservation and Management Act, and Outer Continental Shelf Lands Act; and state statutes such as the Anadromous Fish Act and Oil and Hazardous Substance Pollution Control Act. All of the information in this Appendix is reproduced from publicly available laws, reports, or other sources of information. In an effort to improve readability of the recovery plan and to give the reader the basic information necessary to understand the recovery criteria and actions, we removed the following text from the body of the document. However, we have preserved this text to present to readers interested in the details of the discussion.

1. Federal Protections

The Department of Commerce, through the National Oceanographic and Atmospheric Administration's (NOAA) NMFS, is charged with protecting whales, dolphins, porpoises, seals, and sea lions. Management responsibility for belugas in Alaska has been delegated by the Secretary of Commerce to NMFS, and NMFS Alaska Region (AKR) assumes primary responsibility for CI beluga recovery.

Walrus, manatees, otters, and polar bears are protected by the Department of the Interior through the U.S. Fish and Wildlife Service (USFWS). The Animal and Plant Health Inspection Service, a part of the Department of Agriculture, is responsible for regulations managing marine mammals in captivity.

a. The Marine Mammal Protection Act

All marine mammals in U.S. waters, including CI belugas, are federally protected under the MMPA of 1972, as amended. The MMPA established a national policy to prevent marine mammal species and population stocks in U.S. waters from declining to the point where they cease to be significant functioning elements of the ecosystems of which they are a part. The MMPA presents a single comprehensive federal program to take the place of formerly state-run programs, and includes protection for population stocks in addition to species and subspecies. Nowhere else in the world had a government made the conservation of healthy and stable ecosystems as important as the conservation of individual species

The MMPA was enacted in response to increasing concerns that some marine mammal species or stocks may be in danger of extinction or depletion as a result of human activities and that measures should be taken to replenish these species or stocks so that they did not fall below their optimum sustainable population (OSP) level, thus resulting in a "depleted" population. The MMPA established the concept of OSP to ensure healthy ecosystems.

The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and prohibits the importation of marine mammals and marine mammal products into the U.S.

The MMPA has been amended several times since 1972, but the most substantial amendments were in 1994 and provided:

- Certain exceptions to the take prohibitions, including: small takes incidental to specified activities; when access by Alaska Natives to marine mammal subsistence resources can be preserved; and permits and authorizations for scientific research;
- A program to authorize and control the taking of marine mammals incidental to commercial fishing operations;
- Preparation of stock assessments for all marine mammal stocks in waters under U.S. jurisdiction; and
- Studies of pinniped-fishery interactions.

The MMPA is organized into five "titles." Title I, Conservation and Protection of Marine Mammals, is the most comprehensive. Title I established a moratorium on the taking of marine mammals in U.S. waters. "Take" is defined by section 3(13) of the MMPA (16 U.S.C. § 1362(13)) as "to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal." Under the 1994 amendments to the MMPA, harassment is further defined as any act of pursuit, torment, or annoyance which:

- ***(Level A Harassment)*** has the potential to injure a marine mammal or marine mammal stock in the wild; or,
- ***(Level B Harassment)*** has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

The moratorium generally does not apply to Alaska Natives who live on the Alaskan coast. Section 101(b) of the MMPA (16 U.S.C. § 1371(b)) contains provisions allowing for take by Alaska Natives for subsistence use or to create and sell "authentic native articles of handicrafts and clothing" without permits or authorizations. However, the taking must not be "accomplished in a wasteful manner," and the Secretaries of Commerce and the Interior may regulate the taking of a depleted species or stock, regardless of the purpose for which it is taken. Exceptions to the moratorium can be made through permitting actions for take incidental to commercial fishing and other nonfishing activities (section 118), for scientific research (section 104), and for public display at licensed institutions such as aquaria and science centers (section 104). The MMPA shifts the burden from resource managers to resource users to show that proposed taking of living marine resources will not adversely affect the resource or the ecosystem.

Section 115 of Title I requires that the Secretary of Commerce make a determination if a species or stock should be designated as depleted, or should no longer be designated as depleted, on the basis of the best scientific information available. For any species or stock designated as depleted under the MMPA and for which NMFS has management responsibility, section 115 also requires the Secretary of Commerce to prepare a Conservation Plan. Conservation Plans should be prepared as soon as possible for any species or stock designated as depleted. Each plan shall have the purpose of conserving and restoring the species or stock to its OSP. The MMPA requires that Conservation Plans to be modeled after recovery plans required under section 4(f) of the ESA of 1973. In May 2000, NMFS designated the CI beluga stock as depleted under the

MMPA. In October 2008, NMFS published the *Conservation Plan for the Cook Inlet Beluga Whale* and identified 780 belugas as the OSP required to reconsider the depleted designation.

Section 119 of Title I (Marine Mammal Cooperative Agreements in Alaska) states that the Secretary may enter into cooperative agreements with Alaska Native organizations to conserve marine mammals and provide co-management of subsistence use by Alaska Natives. The MMPA also authorizes NMFS to implement subsistence harvest limits through regulation of depleted marine mammal stocks, following an administrative hearing on the record. In October 2000, NMFS proposed regulations to limit the beluga subsistence harvest in Cook Inlet, Alaska. An administrative hearing was held in December 2000, and interim subsistence harvest regulations for 2001 to 2004 were developed. In August 2004, a second administrative hearing was held to determine the long-term subsistence harvest regime. NMFS signed a co-management agreement with the CIMMC in 2005 and 2006, allowing two belugas to be successfully harvested in those years. In June 2008, NMFS published the *Cook Inlet Beluga Whale Subsistence Harvest Final Supplemental Environmental Impact Statement* (EIS); in September 2008, the record of decision associated with this EIS was signed. Final regulations governing long-term management of the subsistence harvest of CI belugas by Alaska Natives were published in October 2008.

Title II established the Marine Mammal Commission (MMC), an agency of the U.S. Government responsible for providing independent oversight of the marine mammal conservation policies and programs being carried out by federal regulatory agencies. The MMC is charged with the following duties:

- Undertake a review and study of the activities of the United States pursuant to existing laws and international conventions relating to marine mammals, including, but not limited to, the International Convention for the Regulation of Whaling, the Whaling Convention Act of 1949, the Interim Convention on the Conservation of North Pacific Fur Seals, and the Fur Seal Act of 1966.
- Conduct a continuing review of the condition of the stocks of marine mammals, of methods for their protection and conservation, of humane means of taking marine mammals, of research programs conducted or proposed to be conducted under the authority of the MMPA, and of all applications for permits for scientific research, public display, or enhancing the survival or recovery of a species or stock.
- Undertake or cause to be undertaken such other studies as it deems necessary or desirable in connection with its assigned duties as to the protection and conservation of marine mammals.
- Recommend to the Secretary of Commerce and to other federal officials such steps as it deems necessary or desirable for the protection and conservation of marine mammals.
- Recommend to the Secretary of State appropriate policies regarding existing international arrangements for the protection and conservation of marine mammals and suggest appropriate international arrangements for the protection and conservation of marine mammals.
- Recommend to the Secretary of Commerce such revisions of the endangered species list and threatened species list published pursuant to section 4(c)(1) of the ESA of 1973 as may be appropriate with regard to marine mammals.

- Recommend to the Secretary of Commerce, other appropriate federal officials, and Congress such additional measures as it deems necessary or desirable to further the policies of the MMPA, including provisions for the protection of the Indians, Eskimos, and Aleuts whose livelihood may be adversely affected by actions taken pursuant to the MMPA.

The MMC is primarily an oversight and advisory body. Although federal agencies are not required to adopt the MMC's recommendations, the MMPA specifies that an agency that declines to follow any such recommendations is required to provide detailed written explanations to the MMC within 120 days.

Title III of the MMPA focuses on the International Dolphin Conservation Program. Title IV is the origination of the Marine Mammal Health and Stranding Response program, and includes information about stranding response agreements, the National Marine Mammal Tissue Bank, and the John H. Prescott Marine Mammal Rescue Assistance Grant Program. Title V is dedicated to polar bears.

b. The Endangered Species Act of 1973

Congress passed the ESA on December 28, 1973, recognizing that the natural heritage of the United States was of "esthetic, ecological, educational, recreational, and scientific value to our Nation and its people" (ESA section 2(a)(3)). It was understood that, without protection, many of our nation's living resources would become extinct. The ESA provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The USFWS and NMFS share responsibility for implementing the ESA. There are more than 1,900 species listed under the ESA. NMFS is responsible for 74 marine species, including CI belugas.

A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become endangered in the foreseeable future. The listing of a species as endangered makes it illegal to "take" (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to do these things) that species (ESA section 9(a)(1)). Similar prohibitions are usually extended to threatened species. Federal agencies may be allowed limited take of species through interagency consultations with NMFS or USFWS. Non-federal individuals, agencies, or organizations may have limited take through special permits under conservation plans. Effects to the listed species must be minimized, and in some cases conservation efforts are required to offset the take. The NMFS Office of Law Enforcement works with the U.S. Coast Guard and other partners to enforce and prosecute ESA violations.

NMFS conserves and recovers marine resources by implementing the different programs provided for by the ESA. The ESA is divided into 18 sections; only a few will be highlighted here, with emphasis placed on sections 4, 6, and 7.

Under the authority provided by section 4 of the ESA (Determination of Endangered Species and Threatened Species), NMFS lists species as endangered or threatened, designates critical habitat, and develops and implements recovery plans for listed species. NMFS conducts periodic reviews of species to ensure that they are listed appropriately. Because the ESA requires such reviews to be conducted at least once every five years, these reviews are referred to as five-year reviews. Section 4(f) of the ESA directs NMFS to develop and implement recovery plans for threatened and endangered species, unless such a plan would not promote conservation of the species. According to the statute, these plans must incorporate, at a minimum:

- A description of site-specific management actions necessary to achieve the plan's goal for the conservation and survival of the species;
- Objective, measurable criteria which, when met, would result in a determination that the species may be removed from the list; and
- Estimates of the time and cost required to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

The NMFS is authorized to procure the services of public and private entities to assist in the development and implementation of recovery plans, including the appointing of recovery teams. Many, but not all, recovery plans are written by recovery teams and, in some cases, implementation of plans is guided by recovery teams. NMFS has made a concerted effort in recent years to include representative stakeholders (those with an interest in the species) on recovery teams and to involve the public in recovery planning. All recovery plans are made publically available in draft form and public comments are solicited before the plan is finalized, ensuring that the public has an opportunity to provide input in the recovery planning process. Implementation of recovery actions is the responsibility of all Americans, but tends to fall largely on federal, state and local agencies, tribes, interested organizations, and individuals within the range of the species.

Section 6 of the ESA (Cooperation with States) provides a mechanism for cooperation between NMFS and states in the conservation of threatened, endangered, and candidate species. NMFS is authorized to enter into agreements with any state that establishes and maintains an "adequate and active" program for the conservation of endangered and threatened species. Once a state enters into such an agreement, NMFS is authorized to assist in, and provide federal funding for, implementation of the state's conservation program. In 2009, the State of Alaska and NMFS formalized a limited cooperative conservation partnership agreement for the conservation and protection of endangered and threatened species pursuant to section 6 of the ESA.[32] This agreement gives the State of Alaska eligibility to compete against other states for section 6 funding under the Species Recovery Grant Program, an annual national competition. This federal grant funding is to be used to support management, outreach, research, and monitoring projects that have direct conservation benefits for listed species, recently de-listed species, and candidate species that reside within that State. To date, no funding has been awarded to the State of Alaska specifically for CI belugas under this program. Section 6 of the ESA also allows state laws to be more restrictive than the ESA regarding taking of listed species; however, state laws cannot be less restrictive.

Section 7 of the ESA (Interagency Cooperation) requires federal interagency cooperation as another means to conserve federally listed species and designated critical habitat. Section 7(a)(1) requires NMFS to review other programs administered by NMFS and utilize such programs to

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[32] A copy of the agreement can be viewed on the NMFS AKR website at: http://alaskafisheries.noaa.gov/pr/section-6-agreements.

further the purposes of the ESA. It also directs all other federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of listed species. Under section 7(a)(2), federal agencies must consult with NMFS on activities that may affect a listed species or its designated critical habitat. These interagency, or section 7, consultations are designed to assist federal agencies in fulfilling their duty to ensure any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. In fulfilling these requirements, each agency must use the best scientific and commercial data available.

Section 8 (International Cooperation) allows NMFS to partner with other nations to ensure that international trade does not threaten species. Section 9 (Prohibited Acts) addresses enforcement of the ESA and investigations of violations. Section 10 (Exceptions) allows NMFS to cooperate with non-federal partners to develop conservation plans for the long-term conservation of species, as well as permitting research to learn more about protected species. States, local agencies, and private entities may conduct conservation actions as a means to minimize or mitigate incidental take of a species as part of a Conservation Plan under section 10 of the ESA. Any entity or individual may also take proactive measures to promote recovery of listed species, although some of these activities may require a section 7 consultation or section 10 permit.

c. The Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) of 1934 (16 U.S.C. 661 et seq.), as amended, requires that fish and wildlife resources receive equal consideration to other project features and that all federal agencies consult with NMFS, USFWS, and state wildlife agencies when proposed actions might result in modification of a natural stream or body of water. Thus, FWCA provides the basic authority for NMFS and USFWS involvement in evaluating impacts to fish and wildlife from proposed water resource development projects.

Specifically, consultation is required in instances where the “waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted, or otherwise controlled or modified” by any agency under a federal permit or license. The purpose of the consultation is to prevent “loss of and damage to wildlife resources” by determining the possible harm to fish and wildlife resources, and the measures that are needed to both prevent the damage to and loss of these resources, and to develop and improve the resources, in connection with water resource development.

FWCA allows NMFS to submit comments and recommendations to federal licensing and permitting agencies and to federal agencies conducting construction projects on the potential harm to living marine resources caused by the proposed water development project, and submit recommendations to prevent harm. NMFS routinely provides comments to the Corps during review of projects under section 404 of the Clean Water Act (CWA) (governing the discharge of dredged materials into navigable waters) and section 10 of the Rivers and Harbors Act of 1899 (governing obstructions in navigable waterways).

d. The Coastal Zone Management Act of 1972

The U.S. Congress recognized the importance of meeting the challenge of continued growth in the coastal zone by passing the Coastal Zone Management Act (CZMA) (16 U.S.C. 1451 et seq.) in 1972. The Act, administered by NOAA's Office of Ocean and Coastal Resource Management, provides for management of the nation's coastal resources, including the Great Lakes, and balances economic development with environmental conservation.

The CZMA outlines two national programs, the National Coastal Zone Management Program and the National Estuarine Research Reserve System. The coastal programs aim to balance competing land and water issues in the coastal zone, while estuarine reserves serve as field laboratories to provide a greater understanding of estuaries and how humans impact them. Through the CZMA, Congress declared it is national policy "to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations."

The National Coastal Zone Management Program is a voluntary partnership between the federal government and U.S. coastal and Great Lake states and territories authorized by the CZMA to address national coastal issues. The CZMA provides the basis for protecting, restoring, and responsibly developing our nation's diverse coastal communities and resources. To meet the goals of the CZMA, the National Coastal Zone Management Program takes a comprehensive approach to coastal resource management—balancing the often competing and occasionally conflicting demands of coastal resource use, economic development, and conservation. Some of the key elements of the National Coastal Zone Management Program include:

- Protecting natural resources;
- Managing development in high hazard areas;
- Giving development priority to coastal-dependent uses;
- Providing public access for recreation; and
- Coordinating state and federal actions.

In 2015, 34 states and territories had approved coastal management programs that address a wide range of issues, including coastal development, water quality, public access, habitat protection, energy facility siting, ocean governance and planning, coastal hazards, and climate change. By using both federal and state funds, the program strengthens the capabilities of each partner to address coastal issues. While the Act includes basic requirements for state partners, it also gives them the flexibility to design programs that best address their unique coastal challenges and laws and regulations.

The Alaska Coastal Management Program (ACMP) was discontinued July 1, 2011. This program was previously under the Alaska Department of Natural Resource's Division of Coastal and Ocean Management, and set forth statewide standards governing natural resource development and conservation in Alaska's coastal zones, including specific standards for habitats and subsistence. Section 307 of the CZMA requires the state to review most federal activities and federally-permitted activities affecting resources within the state's coastal zone and to ensure that state-permitted activities are consistent with standards and policies of the ACMP. However, on May 14, 2011, the Alaska State Legislature adjourned a special legislative session without passing legislation necessary to extend the ACMP (AS 44.66.030). Alaska is the only coastal state in the United States without a Coastal Management Program.

e. The Clean Water Act

The primary objective of the Federal Water Pollution Control Act of 1948, more commonly known as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's surface waters. The EPA is the federal agency responsible for creating and enforcing national water quality regulations under the CWA. The CWA regulates the discharges of pollutants into the waters of the U.S., and in doing so, is aimed at ensuring that the Nation's waters are fishable, swimmable, and drinkable.

The EPA, the Corps, and the State of Alaska all have a role in the implementation and enforcement of the CWA in Alaska. Section 303(d) of the CWA requires states to prepare a list of all impaired waters within their jurisdiction. The State of Alaska's Department of Environmental Conservation (ADEC) assesses the quality of Alaska's water bodies by utilizing a multi-agency task force, and reviews information provided on water bodies through a nomination and public solicitation process. Each nominated water body is then analyzed to determine if the existing protections are sufficient to meet water quality, water quantity, and habitat needs. These reviews occur every two years, and, after a public review, the assessments are presented to the EPA for approval.

Section 401 of the CWA requires that any applicant for a federal permit that may result in effluent being discharged into navigable waters must first be granted certification by the state that the proposed action will not violate state water quality standards. Such certification will define effluent limitations and monitoring requirements necessary for ensuring that: 1) the water quality sections of the CWA are upheld, and 2) applicable state laws are complied with. These requirements are to be incorporated as requirements in the federal permit. The purpose of this section is to allow the states, who define water quality standards, the opportunity to ensure that the Federal permits issued are protective of the designated use(s) of the receiving waters. Thus, this section gives significant authority to the states to have a say in compliance with water quality issues for waters within their jurisdiction.

Section 402 of the CWA requires that all discharges to surface waters be permitted under the National Pollutant Discharge Elimination System (NPDES) permit program. All dischargers from point sources are required to obtain a permit from the EPA under the NPDES program, which outlines effluent limitations based on two levels of control: technology-based criteria and water quality-based criteria. The more stringent of the two criteria apply. Discharging without an NPDES permit is unlawful. The CWA allows for states to implement (to have "primacy" for) the NPDES program with the EPA acting in an oversight role.

The State of Alaska's application for a state-run section 402 program was approved by the EPA on October 31, 2008. The State of Alaska's program is referred to as the Alaska Pollutant Discharge Elimination System Program (APDES). The transfer of authority for permitting, compliance, and enforcement of the section 402 program to the ADEC includes an implementation plan that transfers the administration of specific program components from EPA to the ADEC in phases over a multi-year period. Phases I–III have successfully transferred from EPA to ADEC. Transfer of the final phase, Phase IV, was scheduled for October 31, 2011. In March 2011, ADEC proposed a one year extension of the transfer of Phase IV. ADEC assumed full authority to administer the wastewater and discharge permitting and compliance program for Alaska on October 31, 2012.

Section 404 prohibits the discharge of dredged or fill material into the waters of the U.S., including wetlands, without specific authorization from the Federal Government. Section 404 of the CWA describes how such discharge is to be regulated and authorized. A primary goal of this section is the preservation of the nation's wetlands. The EPA is responsible for general oversight of the program, while the Corps issues the permits authorizing discharge of dredged or fill materials into navigable waters of the United States, including wetlands. The EPA may authorize states to issue 404 permits (but the EPA/Corps still retain section 404 authority in the State of Alaska). All authorized discharges must avoid and minimize, to the extent practicable, adverse impacts to wetlands, streams, and other aquatic resources. If impacts are unavoidable, then the Corps may require the permittee to replace the loss of the function of that wetland or resource in the form of compensatory mitigation.

In Alaska, NMFS provides direct consultations to the EPA and the Corps regarding impacts to marine mammals, fish, and their habitats as a result of proposed activities and methods for avoiding such impacts.

f. Treaty Trust Responsibilities

The NMFS must also consider treaty trust responsibilities to recognize the rights and authorities of tribes related to the ESA and CI beluga recovery. Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments) outlines the responsibilities of the Federal Government in matters affecting tribal interests. In addition, Secretarial Order "American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act" outlines NMFS's responsibilities regarding Indian tribal rights and federal trust responsibilities when implementing the ESA.

2. State of Alaska Protections

In addition to the State of Alaska's involvement under the federal laws previously discussed, the State also has regulatory protections in place to protect the habitat of belugas, as well as other fish and wildlife populations. Article 8 of the Alaska Constitution ("Natural Resources") outlines the framework for management of Alaska's renewable resources and emphasizes Alaska's regard for its natural resources.

The ADF&G is responsible for determining and maintaining a list of endangered species in Alaska under Alaska Statute 16.20.190. A species or subspecies of fish or wildlife is considered a State of Alaska endangered species when the Commissioner of ADF&G determines that its numbers have decreased to such an extent as to indicate that its continued existence is threatened. The State Endangered Species List does not currently include CI belugas, although ADF&G has designated the belugas in Cook Inlet as a "species of special concern." This designation provides ADF&G with management responsibility and authority that includes: habitat management and guidelines; monitoring; information gathering and dissemination; management research on beluga prey species including Pacific salmon; and the recommendation and imposition of mitigation requirements on state-regulated activities. Because the species of special concern list has not been reviewed or revised since 1998, as of August 15, 2011, ADF&G instead uses the Alaska Comprehensive Wildlife Conservation Strategy (a.k.a. the Wildlife Action Plan)[33] for

[33] Alaska's Wildlife Action Plan can be viewed on the ADF&G website at:

management of species with conservation concerns, including CI belugas. The Wildlife Action Plan, finalized in August 2005 and updated since, contains conservation measures, including co-management with Alaska Native populations and cooperation with other government agencies for the protection and conservation of wildlife, including CI belugas. The Plan also provides the basis for the development of stipulations or conditions on State-issued permits to protect belugas and their habitat.

More than 15 million acres of protected land surrounding Cook Inlet, including State game refuges, critical habitats, and special legislated management areas, support healthy populations of fish on which belugas prey. Each of these protected areas has a detailed management plan in effect that incorporates management guidelines, regulations, and permit stipulations implemented by Alaska's resource conservation agencies.

Many of the municipal governments of the communities within the Cook Inlet watershed have also enacted laws and regulations affecting land use, development, and other matters providing important local protection.

3. International Protections

a. The Convention on International Trade in Endangered Species of Wild Fauna and Flora

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a voluntary international agreement among governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. The CITES was drafted as a result of a resolution adopted in 1963 at a meeting of members of the International Union for the Conservation of Nature and Natural Resources (IUCN) and finalized in 1975.

Countries that have agreed to be bound by CITES are known as Parties. The treaty now has 166 Parties, including the United States. Although CITES is legally binding on the Parties, it does not take the place of national laws, but instead provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level. All import, export, re-export, and introduction of species covered by the Convention has to be authorized through a licensing system.

The structure of CITES is similar to the ESA, in that species are listed in appendices according to their conservation status. However, listed CITES species must also meet the test that trade is at least in part contributing to their decline. The CITES regulates international trade in species of animals and plants according to their conservation status, and does not protect species from other factors that may contribute to a species' decline, as would the ESA.

CITES lists the species covered in three appendices according to the degree of protection needed. CITES Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. CITES Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order

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http://www.adfg.alaska.gov/index.cfm?adfg=species.wapabout.

to avoid utilization incompatible with their survival. CITES Appendix III contains species that are protected in at least one country that has asked other CITES Parties for assistance in controlling the trade. Countries may unilaterally list species for which they have domestic regulation in CITES Appendix III at any time. Decisions concerning CITES Appendix I and II species listings and resolutions are made at meetings of the Conference of the Parties, which are convened approximately every two years.

For the United States, the USFWS is the lead agency for implementation of the Convention since the bulk of CITES-listed species are under USFWS jurisdiction. However, many species under the jurisdiction of NMFS are also listed, either on CITES Appendix I or II. CI belugas are listed in CITES Appendix II.

b. The International Union for the Conservation of Nature and Natural Resources

The International Union for the Conservation of Nature and Natural Resources, commonly referred to as the IUCN or World Conservation Union, is the oldest and largest global environmental organization. The IUCN is composed of over 1,200 member organizations, of which more than 200 are government groups, including NOAA. The IUCN Red List assesses the extinction risk of species with the overall aim "to convey the urgency and scale of conservation problems to the public and policy makers, and to motivate the global community to work together to reduce species extinctions."[34]

The IUCN classified CI belugas as "critically endangered" in 2006 having met IUCN criterion C2a(ii): "The population is estimated to number 207 mature individuals. There is a 71% probability that the growth rate of the population is negative, with the best estimate indicating that the population is declining by 1.2% per year. All of the mature individuals are in one subpopulation."[35]

4. Management Measures Implemented by NMFS

The following discussion describes several of the protective management measures implemented by NMFS for CI belugas. See Appendix IX.A. for a summary of federal regulations specifically related to CI belugas.

a. Subsistence Harvest Management

The MMPA authorizes NMFS, acting on behalf of the Secretary of Commerce, to implement subsistence harvest limits through regulation of depleted marine mammal stocks, following an administrative hearing on the record. In accordance with Public Laws 106–31 (1999) and 106–553 (2000), the annual subsistence harvest of CI belugas is allowed only under cooperative management agreements between NMFS and affected Alaska Native organizations. On October 4, 2000, NMFS proposed regulations to limit the beluga harvest in Cook Inlet, Alaska. An administrative hearing was held in December 2000 and interim harvest regulations for 2001 to

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[34] See IUCN's website (http://www.iucn.org) and the Red List Classification for CI belugas: (http://www.iucnredlist.org/details/61442/0).

[35] Guidelines and criteria for IUCN's Red List classifications are available at: http://www.iucnredlist.org/technical-documents/red-list-training/red-list-guidance-docs.

2004 were developed and published in the Federal Register in 2004. These interim harvest regulations allowed for a limited harvest (1–2 belugas annually), regulated the use of beluga products, and established requirements for the harvests within a co-management agreement. With the collection of more information pertaining to CI belugas, a second administrative hearing was held in August 2004 to determine the long-term harvest regime (2005 and subsequent years, until the population recovered). Following the long-term harvest plan as recommended by the administrative law judge, NMFS signed a co-management agreement with CIMMC in 2005 and 2006 for the harvest of CI belugas, which resulted in two belugas harvested in 2005. NMFS published the *Cook Inlet Beluga Whale Subsistence Harvest Final Supplemental Environmental Impact Statement* in June 2008 (NMFS 2008b; 73 FR 60976), in which four harvest alternatives were considered. A Record of Decision and harvest regulations were published in October 2008, and provide a subsistence harvest plan for Alaska Natives until the CI beluga stock recovers.

CIMMC was disbanded by unanimous vote by the CIMMC member Tribes' representatives on June 20, 2012. CIMMC was the only Alaska Native organization to obtain a co-management agreement with NMFS for CI beluga subsistence harvest. Currently, NMFS has no co-management agreements with any Alaska Native organization pertaining to CI belugas. This lack of a co-management agreement for CI belugas precludes the authorization of subsistence harvest of this stock.

b. Project Review, Environmental Analyses, and Mitigation Identification

Any action that may "take" a CI beluga requires authorization from NMFS under the MMPA and ESA (i.e., via an Incidental Harassment Authorization [IHA] or Letter of Authorization [LOA] as per the MMPA, or by an Incidental Take Statement [ITS] as per the ESA). MMPA authorizations for take can only be granted if an activity, by itself or in combination with other activities, would not cause a significant adverse impact on the stock. ESA authorization for take can only be issued if such take does not jeopardize the continued existence of the species or destroy or adversely modify designated critical habitat. NMFS works with agencies and applicants to determine whether their actions could harm CI belugas or damage habitats essential to their survival and to identify measures to avoid or minimize possible adverse effects. In addition to MMPA and ESA reviews, activities with authorized takes are analyzed under the National Environmental Policy Act (NEPA).

Research projects may be conducted at federal, state, and/or private levels. Any research that may take a CI beluga requires authorization under the MMPA and ESA. NMFS will continue to provide specific recommendations under its authorities provided by the MMPA, ESA, and FWCA to minimize and mitigate effects of anthropogenic actions in an effort to conserve CI belugas.

c. Noise Guidelines

From what is known about the hearing sensitivity of belugas and the movements, distribution, and habitat use of CI belugas, the ESA and MMPA require steps be taken to minimize the likelihood of noise adversely impacting these whales and to minimize the possibility of injury or possible abandonment of critical habitats. NMFS regularly reviews and comments on applicable permits and recommends specific conditions to reduce or avoid potential impacts from noise. Mitigation measures may be incorporated into project permits to avoid incidental taking of belugas. Such taking is prohibited by the MMPA and ESA, unless authorized by NMFS. NMFS has developed comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary threshold shifts (PTS and TTS; Level A harassment) (81 FR 51694; August 4, 2016). NMFS is in the process of developing guidance for behavioral disruption (Level B harassment). However, until such guidance is available, NMFS uses the following conservative thresholds of underwater sound pressure levels,[36] expressed in root mean square (rms),[37] from broadband sounds that cause behavioral disturbance, which is referred to as Level B harassment under section 3(18)(A)(ii) of the Marine Mammal Protection Act (MMPA): 120 dB re 1μPa_{rms} for continuous sound or 160 dB re 1 μPa_{rms} for impulsive sound. Under the PTS/TTS Technical Guidance, NMFS uses thresholds for underwater sounds that cause injury, which is referred to as Level A harassment under section 3(18)(A)(i) of the MMPA (NMFS 2016). These acoustic thresholds are presented using dual metrics of cumulative sound exposure level (L_E) and peak sound level (PK) for impulsive sounds and L_E for non-impulsive sounds (see NMFS 2016).

[36] Sound pressure is the sound force per unit microPascals (µPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. Sound pressure level is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in acoustics is 1 µPa, and the units for underwater sound pressure levels are decibels (dB) re 1 µPa.

[37] Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.

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C. Recovery Planning for CI Belugas

Section 4(f) of the ESA requires NMFS to develop a recovery plan for listed species, unless such a plan will not promote the conservation of the species. On January 28, 2010, NMFS filed a notice of intent to prepare a recovery plan for CI belugas (75 FR 4528).

The Cook Inlet Beluga Whale Recovery Team (CIBRT) was appointed by NMFS's Alaska Regional Administrator to assist in developing a recovery plan, and to act as an advisory group to identify priority recovery actions and provide input and recommendations on specific recovery issues. NMFS may adopt the team's draft plan in whole or modify it. Prior to the final approval of any recovery plan, NMFS must provide the public with notice and an opportunity for comment.

The CIBRT was composed of two advisory groups: a Scientific Panel and a Stakeholder Panel. The goal was to produce a science-based plan to foster recovery of the CI beluga. In accordance with national policy, CIBRT members were selected based on their expertise and ability to advance CI beluga recovery.

Given that the ability to effectively manage and recover this population requires an in-depth understanding of the biological and ecological processes of Cook Inlet and the CI beluga, NMFS relied heavily on scientists when developing the recovery plan. The Scientific Panel was composed of beluga experts, scientists, and co-management partners who were appointed as independent experts based upon their specific areas of expertise. Science Panel members did not represent their agency or organization while serving on the panel. The primary functions of the Scientific Panel were to advise NMFS about key scientific data gaps and to draft the recovery plan.

NMFS also recognized there is public interest in CI beluga recovery. For this reason, in addition to utilizing a scientific panel to draft a recovery plan, NMFS invited organizations to be represented on a stakeholder panel to participate in aspects of the recovery planning process. The Stakeholder Panel consisted of representatives of organizations with identified interests in the recovery of CI belugas, or those who may be affected by particular actions taken to recover CI belugas. The function of the Stakeholder Panel was to provide additional information to the Science Panel and NMFS for consideration when drafting the recovery plan. The Stakeholder Panel was also given the opportunity to provide feedback on interim drafts of the recovery plan before the CIBRT submitted its draft plan to NMFS.

The first of several CIBRT meetings took place during March 2010 in Anchorage. Following each meeting and prior to the next meeting, a meeting summary was posted on the NMFS Alaska Region's (AKR's) webpage dedicated to the CI beluga recovery planning process, available at: http://alaskafisheries.noaa.gov/pr/cib-recovery-plan. Additional information on the website includes the CIBRT Terms of Reference, meeting dates and topics, and other recovery team and recovery planning documents.

The submission of a draft recovery plan to NMFS by the CIBRT in March 2013 culminated a three year process, and represented thousands of hours of volunteer effort from a team comprised of 12 Science Panelists and 19 Stakeholder Panelists. At that time, and with the thanks of NMFS's Alaska Regional Administrator, the Recovery Team was disbanded and NMFS took responsibility for finalizing the recovery plan.

NMFS reviewed the CIBRT's draft version of the recovery plan, and made modifications deemed necessary to meet applicable requirements and to ensure a functional plan. Some modifications were minor (e.g., addition of an executive summary and a literature cited section; formatting the document for consistency), whereas other modifications were more substantial. Some of the more substantial modifications included streamlining the background section by moving some of the more detailed, but not necessarily essential, information to the appendices; adding section summaries for the different components of the background section; editing the threats assessment section; and modifying the list of recovery criteria and recovery actions. The modifications to the recovery criteria and recovery actions sections included, for example, a reduction in the redundancy of some criteria/actions; removal of some criteria/actions that did not provide a clear recovery benefit or that required a commitment of resources, authorizations, or continuation of programs that could not be guaranteed; an emphasis on criteria/actions pertaining to threats ranked as medium or high relative concern; a reassessment of some criteria that were not objective or measurable; and a restructuring of the list of recovery actions into a format that helps to focus limited resources on threats that have evidence of limiting the recovery of the CI beluga population. The restructuring of the recovery actions also led to a similar restructuring of the information presented in the implementation table. The intent of these revisions was to make this recovery plan a useful management document for NMFS, while also providing a clear path forward for others to promote the recovery of CI belugas.

NMFS announced the availability of the *Draft Recovery Plan for the Cook Inlet Beluga Whale* on May 15, 2015, and solicited public comment (80 FR 27925). During the comment period, NMFS received 23 unique public comment submissions from a variety of sources, including conservation groups, industry and industry associations, government agencies, scientists, Alaska Native organizations and tribal members, and interested citizens. NMFS also obtained independent peer review of the draft recovery plan from five reviewers not affiliated with the CIBRT or NMFS. NMFS considered all of the peer review and public comments and information received on the draft recovery plan in developing this final plan. Wherever possible, comments and suggestions were addressed directly as clarifications or refinements to the text. We also made minor updates or added information in this final plan based on scientific references we received or reviewed since the draft recovery plan was released.

Commenters with different interests expressed differing perspectives on certain topics that were in opposition to each other; in particular, they disagreed regarding the emphasis placed on particular threats and related recovery actions. For instance, some industry groups commented that certain threats ranked as medium or high relative concern (e.g., noise, catastrophic events such as oil spills) should not be considered as such until additional scientific data demonstrate those threats are clearly limiting recovery. These commenters also emphasized existing regulations and programs that they considered sufficient to address certain threats. In contrast, conservation groups and some interested citizens argued that a precautionary approach should be taken to address all potential threats until scientific data demonstrates that a particular threat is not limiting recovery. In addition, some of these commenters argued that certain threats ranked as low relative concern, such as pollution, should be ranked higher. Virtually all of the threat types identified in the plan were suggested to be of medium or high relative concern by at least one commenter, but some commenters expressed the view that some threats were ranked too high and should be downgraded. This final plan reflects updates to the background section and analysis of threats to include information submitted by commenters and other references that became available after the draft plan was released. However, after considering the available information, we determined that the comments submitted did not provide a strong basis for changing the assessment of relative concern of potential threats. Therefore, in the final plan we continue to use this threats assessment, which NMFS has determined, based on the best scientific data available, will facilitate addressing threats in a manner likely to lead to recovery of the Cook Inlet beluga.

Given the lack of clear reasons for the failure of CI belugas to recover as expected following a dramatic reduction in subsistence harvest (beginning in 1999), and in an effort to avoid expending limited resources on actions that may have little benefit to the recovery of CI belugas, the plan focuses on addressing threats of medium or high relative concern. To ensure the recovery plan remains strategic, the status of threats ranked as low relative concern will be reassessed periodically to determine if the significance of one or more of those threats has elevated to the point that specified recovery actions need to be defined. The draft plan included recovery actions to improve the understanding and management of a threat, or to eliminate or mitigate the threat, dependent upon evidence strongly suggestive that the threat is limiting CI beluga recovery. In response to comments questioning that provision, we removed the proposed evidentiary requirement for those threat-based recovery actions, and we instead present recovery actions in the final plan based on the best scientific data available. In developing the final plan, we noted that the draft plan contained a number of proposed recovery actions that similarly addressed strandings, public education/outreach activities, and periodic review of the species' status and threats. To reduce redundancy and simplify the plan, we consolidated the related/overlapping proposed recovery actions for each of these three topics, and included these consolidated actions within an expanded category of recovery actions that address population monitoring, recovery plan implementation, and public education/outreach.

Commenters also expressed differing points of view regarding certain aspects of the recovery criteria proposed in the draft plan, in particular the demographic criteria. While two peer reviewers and a few public commenters questioned the exclusion of population viability analysis (PVA) from the demographic criteria, conversely, the Marine Mammal Commission expressed the view that, given the considerable uncertainty that exists regarding PVA model inputs, basing the criteria on abundance thresholds and trend information is appropriate. Considerable uncertainty remains around some of the PVA model parameters and the existing data, and the sensitivity of the models to rare and unpredictable, but catastrophic events, such as mass strandings. Furthermore, we do not yet understand the parameters that have resulted in the failure of the CI beluga population to exhibit recovery following removal of the most prominent population-limiting threat (unregulated and unsustainable harvest). While we recognize that a better understanding of the factors affecting carrying capacity is also needed, we continue to conclude based on the best scientific data available at this time that demographic recovery criteria based on percent estimated carrying capacity and an abundance trend are more meaningful and effective for this species than the PVA approach. Eventually, as more data become available, a more robust PVA model and more detailed data input could be used to revise the recovery criteria as appropriate. A recovery action is identified in this plan to periodically review, and if appropriate, update a model to determine the probability of extinction of CI belugas, following a schedule that is compatible with the five-year update requirement for NMFS ESA status reviews.

We note that some commenters also questioned defining the current carrying capacity for CI belugas based on the historical abundance estimate of 1,300 whales. As discussed in the plan, this is the best available estimate of historical beluga abundance in Cook Inlet, and represents the maximum estimate of this population based on survey data. Native subsistence harvest (enumerated through hunter interviews) was significant during the 1970s and 1980s and may have been at levels similar to the hunts reported in the mid-1990s, but there was no comprehensive count of subsistence harvest until the 1990s. Commercial and sport hunts also occurred during the 1960s and 1970s, but no information is available to assess whether the 1979 abundance estimate of 1,293 may represent a partially depleted population, and thus a conservative estimate of Cook Inlet carrying capacity for belugas. While we recognize that carrying capacity could change, we have no data at this time to indicate whether carrying capacity may have increased or decreased. Therefore, in the absence of better information, NMFS considers the historical abundance estimate of 1,300 whales to be the carrying capacity of CI belugas.

After considering the comments received along with available data, we also made some minor changes to the threats-based recovery criteria proposed in the draft plan, including: 1) We refined some of the proposed criteria such that they more clearly represent progress toward achieving recovery; 2) We recognized that some of the proposed downlisting criteria represented conditions of a recovered population, so we reclassified those as delisting criteria (e.g., summer range has expanded to reach the documented historical range); and 3) We eliminated a few proposed criteria that we concluded were actions to be taken toward recovery, rather than indicators of recovery (e.g., an outreach program has been implemented that provides voluntary guidelines to reduce/avoid human-caused trauma or harassment of CI belugas).

D. CI Beluga Natural History Supplement

NOTE TO READER: The text below was developed by the CIBRT and reproduces information readily available in other reports. In Section II.B of this document, we provided natural history information sufficient to justify the recovery criteria and actions. Additional natural history information follows.

1. Body Size

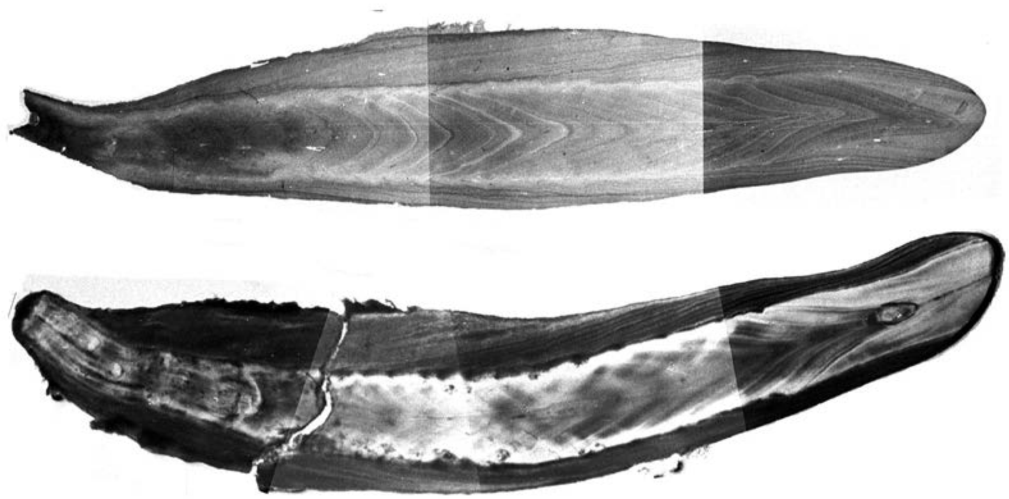
Geographic variation in body size has been documented across the beluga's range (Kleinenberg et al. 1969; Sergeant and Brodie 1969) and may be indicative of ecological differences, such as the availability of winter prey. Sergeant and Brodie (1969) documented a positive correlation between beluga size and marine productivity, with belugas in estuarine and Arctic waters being the smallest, whereas belugas in the subarctic were the largest. Furthermore, Native hunters remarked that CI belugas are larger than belugas in other parts of Alaska (Huntington 2000), but a systematic analysis of body size across Alaskan populations has not been completed. However, belugas from Cook Inlet and Bristol Bay (both estuarine areas) and the eastern Chukchi Sea (the high Arctic) were documented to be of similar size (Suydam 2009). An examination of five beluga populations of the Canadian Arctic showed that body length was positively correlated with latitude (Luque and Ferguson 2010), with belugas harvested at the highest latitude attaining the longest adult body lengths. Luque and Ferguson (2010) postulated that this latitudinal variation in body size may result from the seasonality of important environmental resources. From a preliminary analysis of a small number of specimens, Murray and Fay (1979) suspected there may be differences in skull morphology between CI belugas and other beluga populations. Similarly, differences in vocal repertoires and acoustic signatures among CI belugas and other Alaskan populations were investigated by Angiel (1997), but results are inconclusive.

2. Distribution

A review by Laidre et al. (2000) of cetacean surveys conducted from 1936 to 2000 in the Gulf of Alaska (Unimak Pass to Dixon Entrance) confirmed that beluga sightings are rare outside Cook Inlet. During dedicated surveys covering over 150,000 km (93,205 mi) of the Gulf of Alaska (including Cook Inlet), only five belugas (four sightings) were reported outside of Cook Inlet (four near Kodiak Island and one in Prince William Sound) out of over 23,000 individual cetacean sightings (Laidre et al. 2000). In addition to these dedicated surveys (with records of effort and other cetaceans seen), the NMFS Platforms of Opportunity database (data from surveys without defined effort) contained only 39 individual belugas (from five sightings) out of over 100,000 individual cetaceans sighted (Laidre et al. 2000). Other incidental sightings from 1936 and 2000 (from commercial or recreational fishing boats, tourists, and bird surveys with no information about survey effort or other cetaceans seen) documented over 260 individual belugas (from approximately 19 sightings) (Laidre et al. 2000), with only 28 sightings of belugas outside of Cook Inlet (nine near Kodiak Island, 10 in or near Prince William Sound, eight in Yakutat Bay, and one sighting well south of the Gulf of Alaska).

3. Age Determination

There has been recent discussion about the deposition rate of growth layer groups (GLGs) in beluga teeth (Figure D1), including questions on whether belugas produce one or two GLG per



Notes: Photo of a beluga whale tooth cross section showing the pulp cavity at the left and progressive layers of dentin towards the right. The oldest dentin layers are on the outer margins of the tooth with progressively thinner layers of dentin deposited in later years near the central pulp cavity. Each layer is considered a growth layer group and is used for aging the individual.

Source: The North Atlantic Marine Mammal Commission; image acquired 24 July 2013 from report of the workshop on age estimation in monodontids at: http://www.nammco.no/publications/scientific-committee-reports/report-of-the-19th-meeting-of-the-nammco-scientific-committee/report-of-the-workshop-on-age-estimation-in-monodontids/.

Figure D1. Photo of beluga tooth cross section.

year. The initial hypothesis was that two GLGs were deposited annually (Sergeant 1959), which was supported by many successive studies (Brodie 1971, 1982; Sergeant 1973; Burns and Seaman 1986; Goren et al. 1987; Brodie et al. 1990; Heide-Jørgensen et al. 1994). This deposition rate was previously assumed for most odontocetes. Although further investigation revealed that other odontocetes deposited only one GLG per year, the notion of two GLGs per year persisted for belugas. After re-evaluation of previous studies, analyses of teeth of two captive belugas, and examination of tetracycline-marked teeth, several studies concluded that belugas deposited only one GLG per year (Hohn and Lockyer 1999; Stewart et al. 2006; Lockyer et al. 2007; Luque et al. 2007; NAMMCO 2011). Deposition of a single GLG per year among belugas would double most of the previous estimates of age, with associated changes to vital rates (such as longevity, age at sexual and physical maturity, age at first birth, etc.). Here, it is assumed that one GLG is deposited annually and some of the estimates in Table 1 have been revised to reflect this change.

E. CI Beluga Hearing, Vocalization, and Noise Supplement

NOTE TO READER: The text below was developed by the CIBRT and reproduces information readily available in other reports. In Sections II.B.6 and III.A.3 of this document, we provided information sufficient to justify the recovery criteria and actions addressing noise. Additional CI beluga hearing, vocalization, and noise information follows.

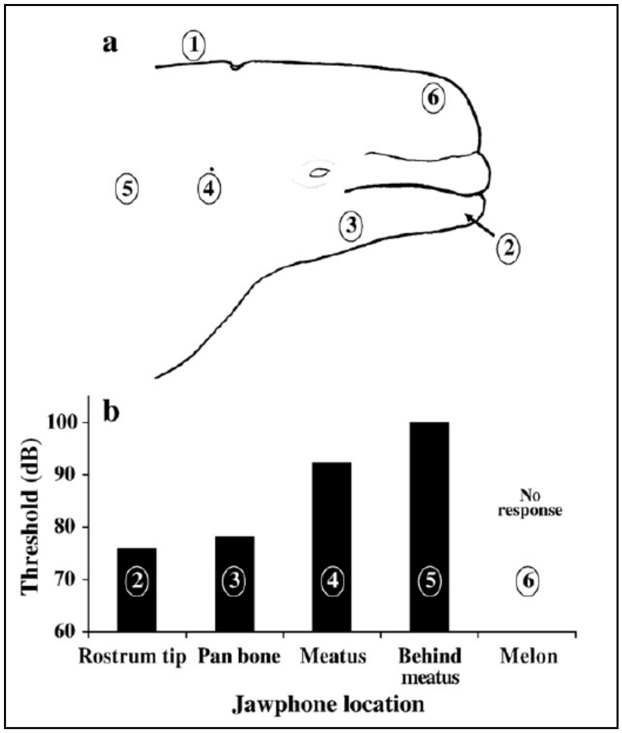
1. Beluga Hearing

Having evolved from land based mammalian ancestors, cetaceans have inherited an ear that was first adapted to hearing sounds through air, which then readapted to receiving sounds through water (Thewissen and Hussain 1993). Cetaceans have retained the ear drum, ossicles, Eustachian tube, and middle ear structures, including an air-filled cavity within the temporal bone or bulla, connected by the Eustachian tube to the nasal cavity for equalization of pressure during dives (Gingerich et al. 1983; Thewissen and Hussain 1993; Ridgway et al. 2001). As a consequence, it was hypothesized that cetacean hearing might attenuate at depth due to the increased air pressure and density of air in the middle ear, which might make them less susceptible to the impacts of loud underwater sounds. This has been shown not to be the case in belugas, as their hearing was determined to be as good at 300 m (984 ft) depth as at the surface (Ridgway et al. 2001). This is consistent with the theory that sound may be received through odontocetes' lower jaw "acoustic window" and transmitted directly to the ear (Norris 1968; Cranford et al. 2008). In fact, a study conducted with a captive beluga showed that the most efficient hearing pathway is from the rostrum tip (Figure E1), and may indicate that there are acoustic fat channels that begin at the beluga rostrum tip that effectively guide sound to the inner ear (Mooney et al. 2008). To date, belugas are the only odontocetes known to hear from the rostrum tip, although a similar pathway has been recently proposed for Cuvier's beaked whale (Cranford et al. 2008). This feature probably gives belugas greater directional hearing abilities than other odontocetes. It is possible that belugas' unfused vertebrae, which allows for a highly movable head, facilitates increased hearing directionality.

2. Beluga Echolocations and Vocalizations

Belugas utilize an alternative echolocation strategy compared with the bottlenose dolphin when performing identical echolocation tasks (Turl and Penner 1989; Rutenko and Vishnyakov, 2006). Bottlenose dolphins will emit a click and wait until the echo returns before emitting the next signal (i.e., the inter-click interval is always greater than the two-way time travel). Belugas appear to be able to transmit, receive, and process signal packets simultaneously, with the first click about two dB higher than the other clicks that follow, which may serve to identify the beginning of each signal packet (Turl and Penner 1989).

The first vocal repertoire description of belugas was made in the Canadian high Arctic by Sjare and Smith (1986a). They classified a total of 807 tonal calls (whistles) into 16 contour types and some 436 pulsed calls into three major categories that they describe as "click series," "pulsed tones," and "noisy vocalizations." Subsequent studies have obtained varied results. The vocalizations of adult male beluga groups in Svalbard, Norway, were subjectively classified into 21 call types, which were dominated by a variety of whistles (Karlsen et al. 2002). Karlsen et al. (2002) highlighted the highly graded nature of these beluga calls, as one "call type" can merge into another type with very subtle changes, making the classification very challenging. A



Notes: 1, location of active Auditory Evoked Potential electrode; 2, rostrum tip; 3, pan bone; 4, external auditory meatus; 5, behind meatus; 6, melon. Thresholds are presented in dB re 1 µPa using p-p SPLs measured at 1 m.

Source: Mooney et al. 2008.

Figure E1. Diagram of beluga's head for electrophysiological hearing tests with points of acoustic stimulation.

reproductive gathering of belugas in the White Sea, Russia, has been the subject of several repertoire studies (Belikov and Bel'kovich 2001, 2003; Bel'kovich and Kreichi 2004; Belikov and Bel'kovich 2007, 2008). Whistle-like signals were found to comprise approximately 10% of the total vocal production of this whale group. Of these, 750 signals were divided into 43 classes (Belikov and Bel'kovich 2001) with at least 16 whistle types (Belikov and Bel'kovich, 2007) and vowel-like signals and pulsed signals (Bel'kovich and Kreichi 2004; Belikov and Bel'kovich 2008).

The response of a decrease or cessation in acoustic activity has been observed in both captive and free-ranging belugas (Morgan 1979; Lesage et al. 1999; Karlsen 2002; Van Parijs et al. 2003; Castellote and Fossa 2006) and free-ranging narwhals (Finley 1990); the response has been associated with threat, startle, fright, alarm, or stress contexts and interpreted as a survival strategy to avoid detection by predators (Schevill 1964; Fish and Vania 1971; Morgan 1979; Finley 1990; Lesage et al. 1999). A broad band pulsed call labelled "Type A" (Vergara and Barrett-Lennard 2008) was identified as a contact call between mothers and their calves in a captive environment. It is thought that these calls, both in captivity and in the wild, function to maintain group cohesion, and the variants shared by related animals are used for mother-calf recognition (Vergara et al. 2010). The only study on vocal development in belugas suggests that neonates only produce pulse trains before they acquire rudimentary whistles at two weeks of age (Vergara and Barrett-Lennard 2008), although this is based on observations of one captive male beluga calf. Similarly, sound production of another neonate captive beluga consisted exclusively of low-frequency, short duration pulse trains that were not part of the adult's repertoire

(Castellote et al. 2007). Despite differences in populations of origin, captive facilities, health, and in acoustic context, the sound production observed in these two neonate belugas suggests a species-specific pattern of developmental stages in sound acquisition. Whether these observed captive neonate vocalization characteristics may prove useful in detecting the presence of wild neonates is still to be determined.

The most recent study on beluga social signals (Vergara et al. 2010) emphasized the two persistent problems commonly encountered in the study of animal communication: first, the great variability in the physical features of the sounds, with general call types grading into each other (Recchia 1994), introduces great uncertainty in the categorization schemes; second, the inherent difficulty in categorizing sounds that are biologically meaningful without testing how belugas themselves perceive or use them (Tyack and Clark 2000). Despite the challenges, some progress has been made in the attempt to correlate vocalization rate and call type with specific beluga behavioral states.

3. Effects on Beluga Hearing and Behavior from Anthropogenic Noise

There is an extensive body of literature regarding the effect of anthropogenic noise on marine mammal behavior. Most of the studies addressing this problem have used behavioral attributes such as changes in site fidelity, dive patterns, swimming speed, orientation of travel, herd cohesiveness, and dive synchrony to indicate possible disturbance or stress caused by noise (Richardson et al. 1995). However the current knowledge of the effects of anthropogenic noise to marine mammal acoustic behavior is more limited, and only a few studies have focused on belugas.

Their high auditory sensitivity, wide frequency bandwidth, and dependence upon sound to navigate, communicate, and find prey make belugas vulnerable to noise pollution. Noise pollution may mask beluga signals, or if intense, may lead to temporary or permanent hearing impairment (Awbrey et al. 1988; Finley 1990; Green et al. 1994; Richardson et al. 1995, 1988). Exposure to intense sound can produce an elevated hearing threshold, referred to as a threshold shift (TS). If the threshold later returns to normal it is considered a temporary threshold shift (TTS), but if not, it is considered a permanent threshold shift (PTS). Studies of TTS and PTS have helped to establish noise exposure limits in humans. There are no PTS data for cetaceans, yet a few studies have attempted to establish the TTS for belugas (Finneran et al. 2000, 2002a; Schlundt et al. 2000). Finneran et al. (2000) simulated sounds resembling signatures of underwater explosions from 5 or 500 kg HBX-1 charges at ranges from 1.5 to 55.6 km (0.9–34.5 mi), and while the simulated sounds were not intense enough to affect the beluga hearing capabilities, sound levels simulating explosions of 500 kg (1,102 lb) at 1.9 km (1.2 mi) and closer did disrupt the behavior of the belugas. However, they found no TTS after exposure to the highest level the underwater sound projector could produce. Finneran et al. (2002a) reported behaviorally measured TTS in a bottlenose dolphin and a beluga exposed to single pulses from a seismic water gun. Also, Schlundt et al. (2000) performed a study exposing five bottlenose dolphins and two belugas (same individuals as Finneran's studies) to intense 1 second tones at different frequencies. The resulting levels of fatiguing stimuli necessary to induce 6 dB or larger masked TTSs were generally between 192 and 201 dB re 1 microPascal (µPa). Dolphins began to exhibit altered behavior at levels of 178–193 dB re 1µPa and above; belugas displayed altered behavior at 180–196 dB re 1 µPa and above. At the conclusion of the study, all thresholds were at baseline values. Results of this study indicate that at least these two odontocetes species are susceptible to TTS, but that they seem to recover from at least small levels of TTS.

A number of studies have examined other characteristics of beluga hearing. Johnson (1991) analyzed hearing thresholds, bandwidths, and integration times (basic descriptive parameters of the cetacean sonar system) for single pulsed tones and multiple pulsed tones of 60 kHz in the presence of noise. He found negative correlations between hearing thresholds and pulse repetition rate with abrupt 5–6 dB steps, and linear correlations between pulse repetition rate and integration times. The author related the abrupt hearing steps to a change in the echolocation strategy based on target distance, as has been described in some beluga echolocation studies, and is discussed in the next section. This result, together with a variable integration time and a constant system bandwidth of 1,000 Hz (much lower than previously reported), led the author to suggest that beluga sonar systems could not be fully described by a single filter model. In essence, this conclusion was a technical appreciation of the complexity of the beluga biosonar system. Finneran et al. (2002c) analyzed beluga sensitivity to acoustic particle motion, which is one of the two physically linked components of sound in water (together with pressure waves), and the main feature detected by all fish species (Fay and Popper 1975). Results suggested that the two belugas tested responded to changes in the acoustic pressure alone and were not able to use acoustic particle motion cues.

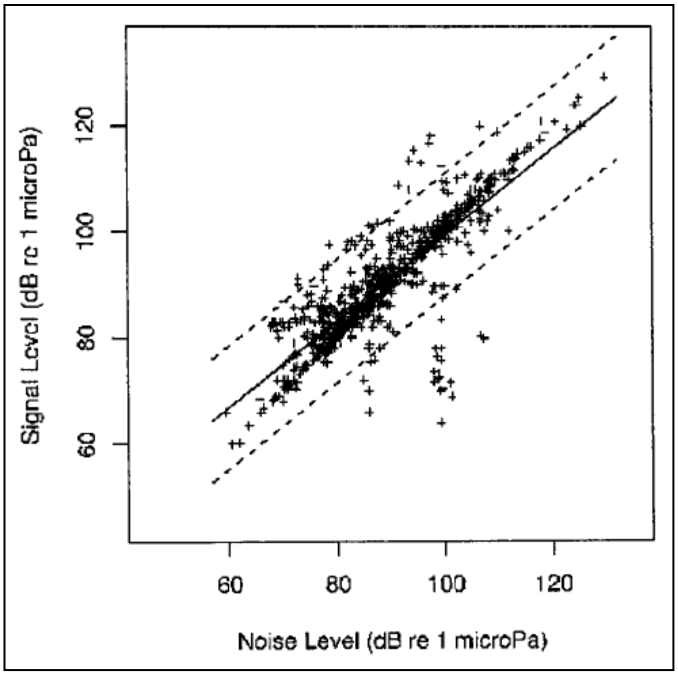
The possibility that noise conditions might mask the ability of animals to hear and decipher specific sounds has been studied in belugas in order to understand the potential impacts of anthropogenic noise on belugas. When a tonal signal is played in a broad spectrum of white noise (noise with equal loudness across all frequencies), only the noise energy in a relatively narrow band on either side of the tone frequency is effective in masking the signal, and the rest of the noise spectrum contributes little or nothing to the masking effect. Johnson et al. (1989) analyzed this feature in the hearing of a beluga in a wide frequency range (40–115 kHz) and found that the whale’s ability to detect the signal in noise was slightly better than results previously reported for bottlenose dolphins. Erbe et al. (1999) and Erbe (2000) analyzed the effect of masking of beluga calls by exposing a trained beluga to icebreaker propeller noise, an icebreaker’s bubbler system, and ambient Arctic ice cracking noise, and found that the latter was the least problematic for the whale detecting the calls. Finneran et al. (2002b) analyzed the ability of a beluga to detect acoustic signals in noise. A primary feature of the auditory system in these animals is the ability to resolve a complex sound into its individual frequency components by a set of auditory filters, and the filter shape and size affect the loudness and detectability of complex sounds and broadband signals (Scharf 1970). The authors analyzed 20 and 30 kHz pure-tone underwater hearing thresholds in one beluga and two bottlenose dolphins in the presence of broadband noise at two intensities: 90 and 105 dB re 1 $\mu Pa^2/Hz$. The filter shapes obtained for the dolphins and beluga were similar, but the filter width was consistently smaller for the beluga, conferring better ability to detect acoustic signals in noise.

Sheifele et al. (2005) studied a population of belugas in the SLE to determine whether beluga vocalizations showed intensity changes in response to shipping noise. This type of behavior has been observed in humans and is known as the Lombard vocal response (Lombard 1911). Sheifele et al. (2005) demonstrated that shipping noise did cause belugas to vocalize louder (Figure E2). The acoustic behavior of this same population of belugas was studied in the presence of ferry and small boat noise. Lesage et al. (1999) described more persistent vocal responses when whales were exposed to the ferry than to the small-boat noise. These included a progressive reduction in calling rate while vessels were approaching, an increase in the repetition of specific calls, and a shift to higher frequency bands used by vocalizing animals when vessels were close to the whales. The authors concluded that these changes, and the reduction in calling rate to almost silence, may reduce communication efficiency, which is critical for a species of a gregarious nature. However, the authors also stated that, because of the gregarious nature of belugas, this "would not pose a serious problem for intraherd communication" of belugas given the short distance between group members; the authors further concluded a noise source would have to be very close to potentially limit any communication within the beluga group (Lesage et al. 1999).

The fact that SLE belugas alter their vocal behavior by increasing the intensity or repetition rate, or by shifting to higher frequencies when exposed to shipping noise (from merchant, whale-watching, ferry and small boats), is indicative of an increase of energy costs (Bradbury and Vehrencamp 1998). If noise exposure is chronic, long-term adverse energetic consequences could occur for belugas, as it has been shown for birds (Oberweger and Goller, 2001). Chronic noise exposure could also increase stress levels for CI belugas, as has been shown in North Atlantic right whales (Rolland et al. 2012). Definitively linking adverse energetic consequences and chronic stress responses to detrimental health effects in belugas or other cetaceans is extremely difficult because of the logistics of studying free-swimming whales and the inability to conduct a controlled study. However, a large body of literature has demonstrated that chronic stress can lead to detrimental effects on health and reproduction across a variety of vertebrate taxa (Rolland et al. 2012). Both the degradation of the beluga acoustic communication and echolocation space, as well as the noise-induced chronic increase of signaling costs and stress, could lead to negative biological consequences at the population level. Even if these consequences are not yet well understood, there is sufficient evidence to suggest that the reproductive success and survival of cetaceans can be negatively impacted by noise (NRC 2000, 2003, 2005; Cox et al. 2006; Southall et al. 2007; Clark et al. 2009; Payne and Webb 1971; Tyack and Clark 2000).

While exhibiting a Lombard response provides a mechanism for animals to cope with varying levels of noise, the need for and use of this response suggests that the animal is attempting to cope with noise levels that are near a point where masking will occur. The effect of shipping noise in the acoustic environment of the endangered SLE beluga was studied recently by Gervaise et al. (2012) in the lower SLE. Noise from a car ferry line as well as a seasonal whale watching fleet were analyzed. The study found both beluga communication and echolocation bands were dramatically affected by these noise sources. Based on the background noise levels, spectra, and periodicity reported and based on the assumption of no behavioral or auditory compensation, beluga communication and echolocation signals could be masked 50% of the time with a reduction of potential communication ranges to less than 30% of their values under natural ambient noise conditions. Similarly, echolocation could be reduced to 80% of their range under natural ambient noise conditions. The study concludes that noise from these sources could easily limit long-range communication (in the order of 1–2 mi [1.6–3.2 km]) among scattered individuals or pods and affect echolocation efficiency in all exposed belugas.

There are some documented beluga spatial displacements caused by loud sources of noise. Two different research teams and data from several years showed that belugas typically avoided icebreakers at distances of 35–50 km (22–31 mi), at the point where they could probably just detect them. They travelled up to 80 km (50 mi) from the ship track and usually remained away



Notes: Beluga signals are louder when background noise level is higher.
Source: Scheifele et al. 2005.

Figure E2. Regression of beluga vocalization level versus changing noise levels from extracted beluga vocalizations in the presence of noise.

for 1–2 days (Finley et al. 1990, Cosens and Dueck 1993). When drilling sounds were played to belugas in industry-free areas, the belugas only showed a behavioral reaction when received levels were high (Richardson et al. 1997). Belugas have been observed to show startle responses when drilling noises were played with a received level greater than or equal to 153 dB re 1 µPa. Considerable displacements have also been suggested for noise from air guns typically used during seismic surveys. One seismic survey in the Canadian Beaufort Sea determined behavioral reactions of belugas occurred when two 24 gun arrays of 2,250 in^3 were operating (Miller et al. 2005). Results of the analysis of the differences between vessel-based and aerial-based beluga sighting distributions provided evidence of reactions of belugas to seismic operations at distances above 20 km (12.4 mi), beyond the effective visual range of the MMOs on the seismic vessel (Miller et al. 2005). Aerial surveys conducted in the southeastern Beaufort Sea in summer found that sighting rates of belugas were significantly lower at distances of 10–20 km compared with 20–30 km from an operating airgun array (Miller et al. 2005). The low number of beluga sightings by marine mammal observers on the vessel seemed to confirm there was a strong avoidance response to the 2250 in^3 airgun array; however, it is unclear if the observed movement of the belugas was a direct consequence of the seismic surveys or related to the natural offshore migration at that time of year. More recent seismic monitoring studies in the same area seem to confirm that the apparent displacement effect on belugas extends farther than has been shown for other small odontocetes exposed to airgun pulses (e.g., Harris et al. 2007).

Similarly, aerial survey results from another seismic (array specifications unknown) and exploratory drilling activity conducted in the same area and same season in 2007 to 2008 showed belugas widely distributed offshore during the operation period, yet rarely sighted from seismic ships. This was interpreted as a tendency to temporarily avoid areas of seismic activity by greater distances than the range covered by MMOs on board seismic vessels (Harwood et al. 2010). However, the authors highlighted the temporary nature of these displacements, as belugas were observed back in the seismic operation area within days after the end of the seismic operations.

Belugas have been shown to have greater displacement in response to a moving sound source (e.g., air gun activity on a moving vessel) and less displacement or behavioral change in response to a stationary sound source. The presence of belugas has been documented within ensonified zones of industrial sites near platforms and stationary dredges, and the belugas did not seem to be disturbed by the activity (Richardson et al. 1995).

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F. CI Beluga Prey Supplement

NOTE TO READER: The text below was developed by the CIBRT, with a few minor updates, and reproduces information readily available in other reports. Additional details regarding the State of Alaska's fisheries management practices and fisheries harvest information can be found in ADF&G publications, such as annual commercial fisheries management reports (e.g., Shields and Dupuis 2016).[38] *In Sections II.B.10 and III.A.6 of this document, we provided information sufficient to justify recovery criteria and actions addressing CI beluga prey. Additional CI beluga prey information follows.*

1. Prey Abundance and Distribution

Eulachon is a primary prey item of CI belugas from May to early June. They enter glacial rivers to spawn shortly after the river ice has melted and the water flows freely. Eulachon have high oil-content (17–21% of the wet weight; Payne et al. 1999) and migrate in dense schools. Large eulachon runs in Cook Inlet occur in the Susitna River and at Twenty Mile River in Turnagain Arm, with smaller runs in other glacial rivers entering Cook Inlet (Figure F1). Eulachon biomasses in these rivers are unknown. The NMFS biennial bottom trawl survey estimates of eulachon biomass in the central Gulf of Alaska are highly variable (5,255 short tons in 1984, 104,709 tons in 2003, and 54,246 tons in 2011) (Ormseth 2011). In the Susitna River and Twenty Mile River, the eulachon spawning migration peaks in late May and is largely completed by mid-June (Barrett et al. 1984; Spangler et al. 2003). Commercial fishing for eulachon/smelt (eulachon are not distinguished from other smelt in ADF&G harvest reporting) occurs annually in saltwater between the mouths of the Chuitna and Susitna rivers (Figure F1). Harvests have ranged from 41–97 metric tons (45–107 short tons) since 2006 (Table F1) (Shields and Dupuis 2016). Commercial harvest of eulachon has increased substantially in recent years (Table F1).

Personal use harvests in Cook Inlet are summarized by ADF&G Division of Sport Fish reporting areas (Figure F2). Although fishing effort for personal use harvests of smelt responds to socioeconomic variables (e.g., gasoline prices), recreational effort likely reflects population abundance of spawning smelt. Thus, strong spawning returns likely generate increased fishing effort such that recreational harvests index the relative magnitude of the spawning populations. Recreational harvests for Cook Inlet during 1996 to 2011 showed high interannual variability within and among harvest reporting areas (Figure F3). Although the late 1990s and mid-2000s exhibited generally higher smelt harvests, the correlation of annual harvests among reporting areas was relatively low (the maximum correlation was 0.50 between log transformed values for the Susitna River drainage and the Kenai Peninsula freshwater). In general, the largest personal use harvests occurred in the Anchorage area, mainly represented by Twenty Mile River in Turnagain Arm. Harvests in most areas increased in recent years, particularly for the Anchorage area.

From June to September, salmon are the primary beluga prey in Cook Inlet. Quakenbush et al. (2015) found primarily coho, chum, and Chinook salmon in analyses of salmon remains in

[38] For more information, visit ADF&G's website at: http://www.adfg.alaska.gov/index.cfm?adfg=home.main.

Table F1. Commercial eulachon/smelt harvests in Cook Inlet.

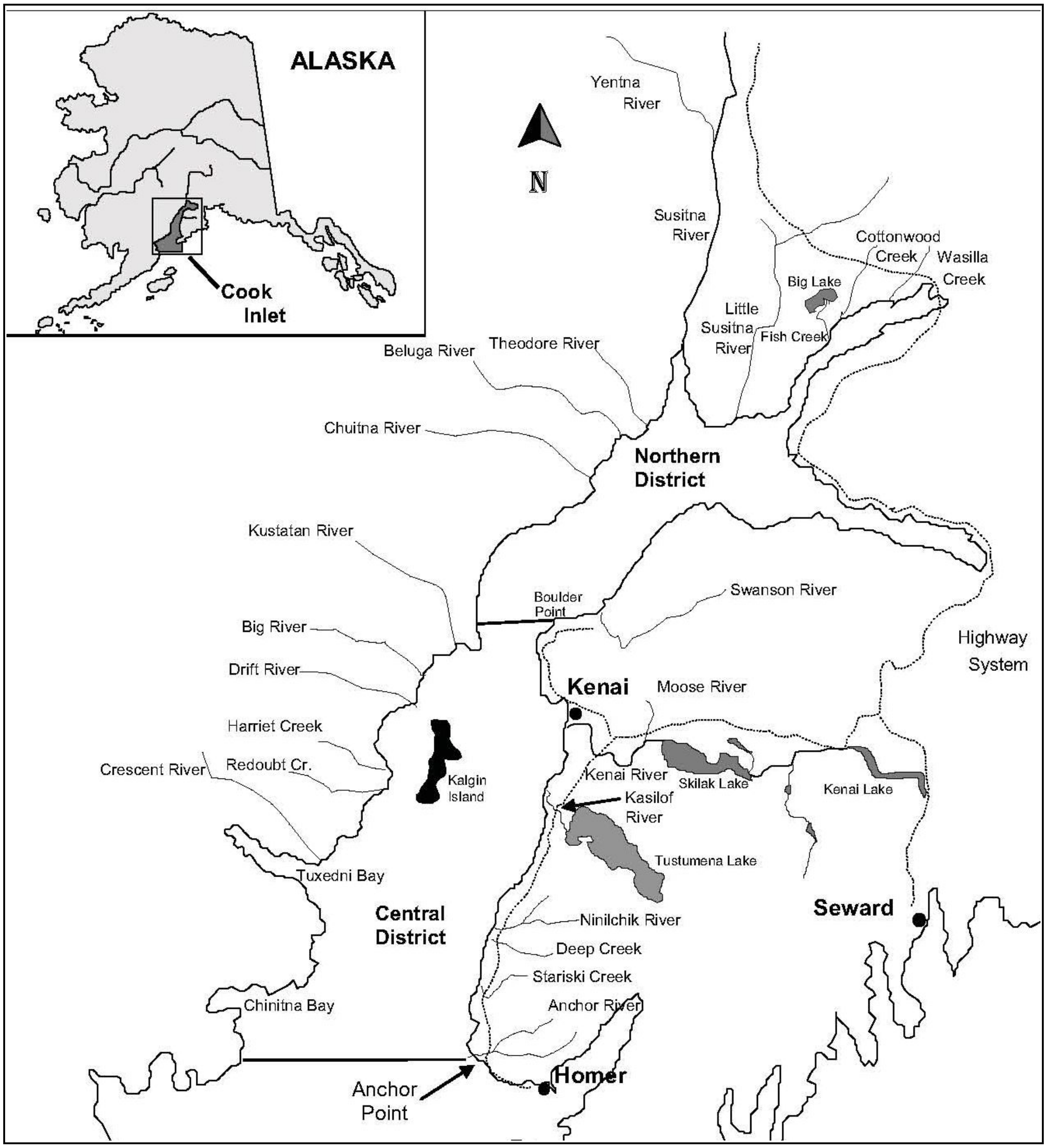
Year	Harvest		Permits issued
	Pounds	Metric tons	
1978	300	0.1	NA
1980	4,000	1.8	NA
1998	18,610	8.4	2
1999	100,000	45.4	NA
2006	90,783	41.2	8
2007	125,044	56.7	11
2008	127,365	57.8	6
2009	78,258	35.5	6
2010	126,135	57.2	3
2011	201,570	91.4	5
2012	195,910	88.9	4
2013	190,830	86.6	4
2014	198,814	90.2	4
2015	213,934	97.0	4

Source: Shields and Dupuis 2016.

stomach contents, indicating that some salmon species may be of greater importance (Table 2). During this period, belugas are often found from Tyonek to the Little Susitna River and in river mouths of Knik and Turnagain arms. The largest salmon runs in Cook Inlet enter the Kenai, Kasilof, and Susitna rivers. Chinook salmon runs peak in the Susitna and Little Susitna rivers in mid-June, in the Kenai River in mid-July, and in the Kasilof River in late June to early July (Figure F4). Sockeye salmon runs typically peak in mid-July, pink salmon and chum salmon runs peak in late July or early August, and coho salmon runs peak in August (Figure F4). However, run timing differs among species, streams, and years.

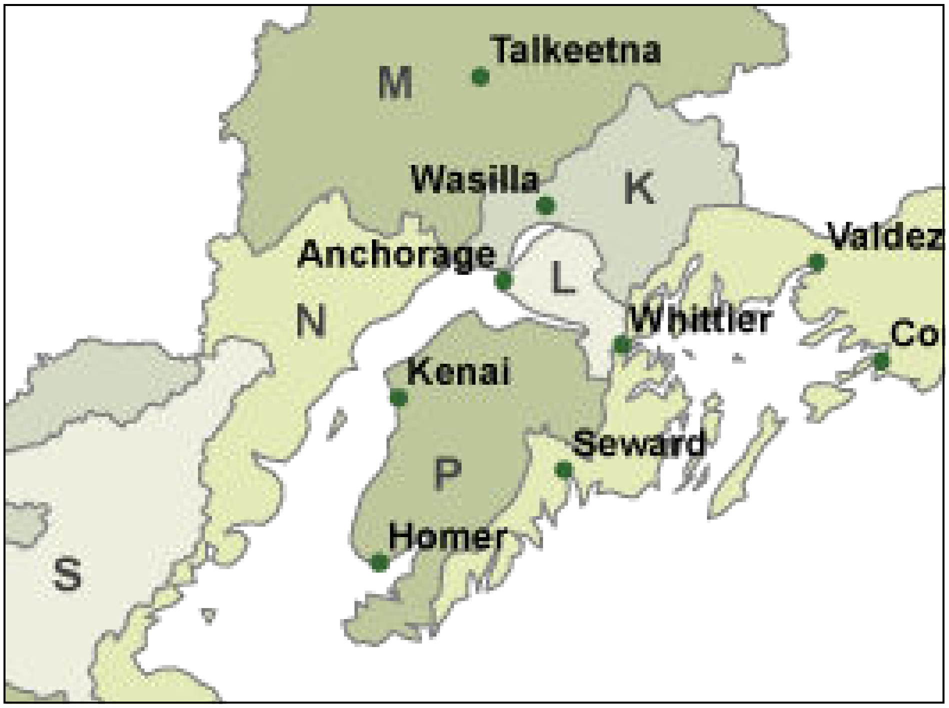
Sockeye salmon are the dominant species in the Kenai and Kasilof rivers with significant numbers of Chinook, coho, and pink salmon also spawning in the Kenai River. The Chuitna, Beluga, Theodore, and Lewis rivers support relatively small runs of Chinook salmon and somewhat larger runs of coho salmon (Figure F5). The Susitna River drains the largest watershed entering Cook Inlet and supports substantial runs of all five salmon species (Figure F5). The Little Susitna River supports moderately sized runs of pink, chum, and coho salmon (Figure F5). Numerous small streams along Knik and Turnagain arms support relatively small runs of all five salmon species.

Indices for upper Cook Inlet since the early 1970s show general increases in sockeye and coho salmon return abundances, an odd/even year cycle in pink salmon abundances, and a



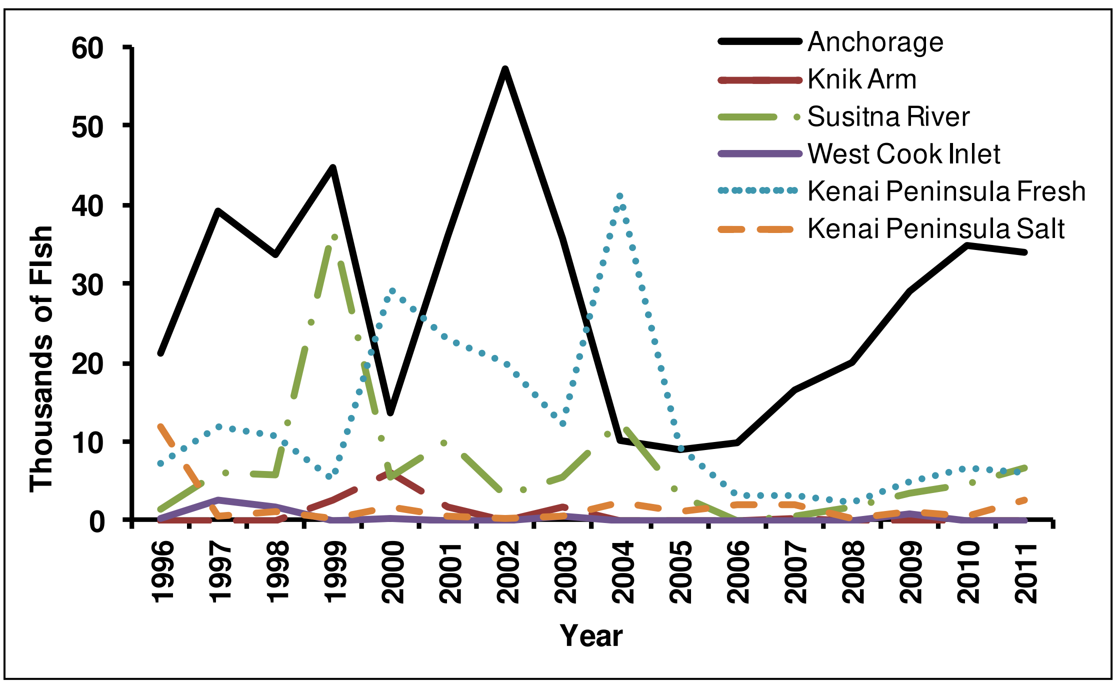
Source: Shields and Dupuis 2012.

Figure F1. Major tributaries of the Cook Inlet Basin relative to the two fishery management district boundaries.



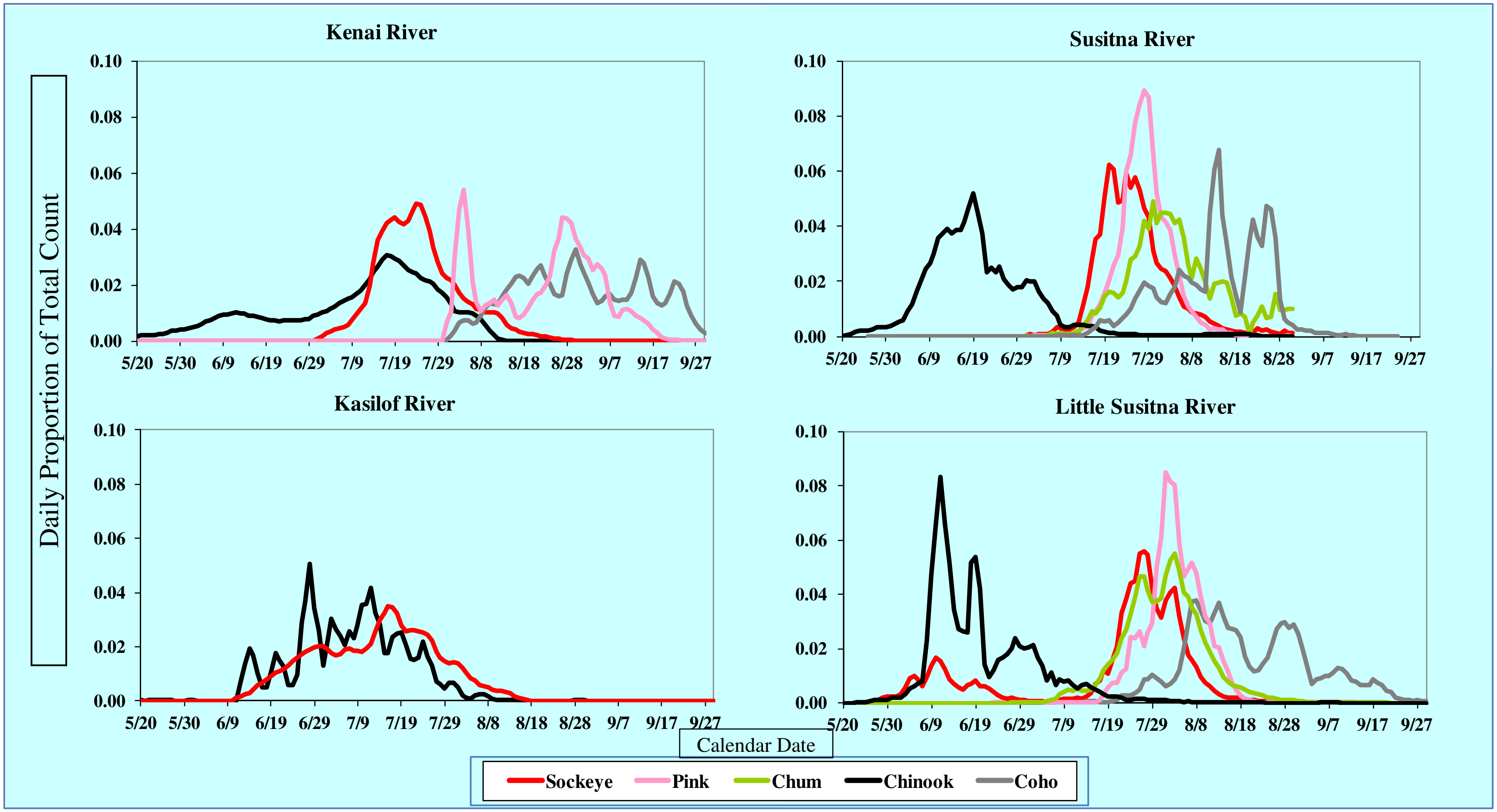
Source: ADF&G website at: http://www.adfg.alaska.gov.

Figure F2. Cook Inlet reporting areas for the ADF&G statewide survey of recreational and personal use harvests.



Source: Adapted from ADF&G Alaska Sport Fishing Survey website at: http://www.adfg.alaska.gov/sf/sportfishingsurvey.

Figure F3. Personal use harvest of smelt (eulachon) by reporting areas from the ADF&G statewide harvest survey, 1996 to 2011.



Source: Westerman and Willette 2010.

Figure F4. Mean run timing of sockeye, pink, chum, Chinook, and coho salmon entering the Kenai, Kasilof, Susitna, and Little Susitna Rivers, 1982 to 2009.

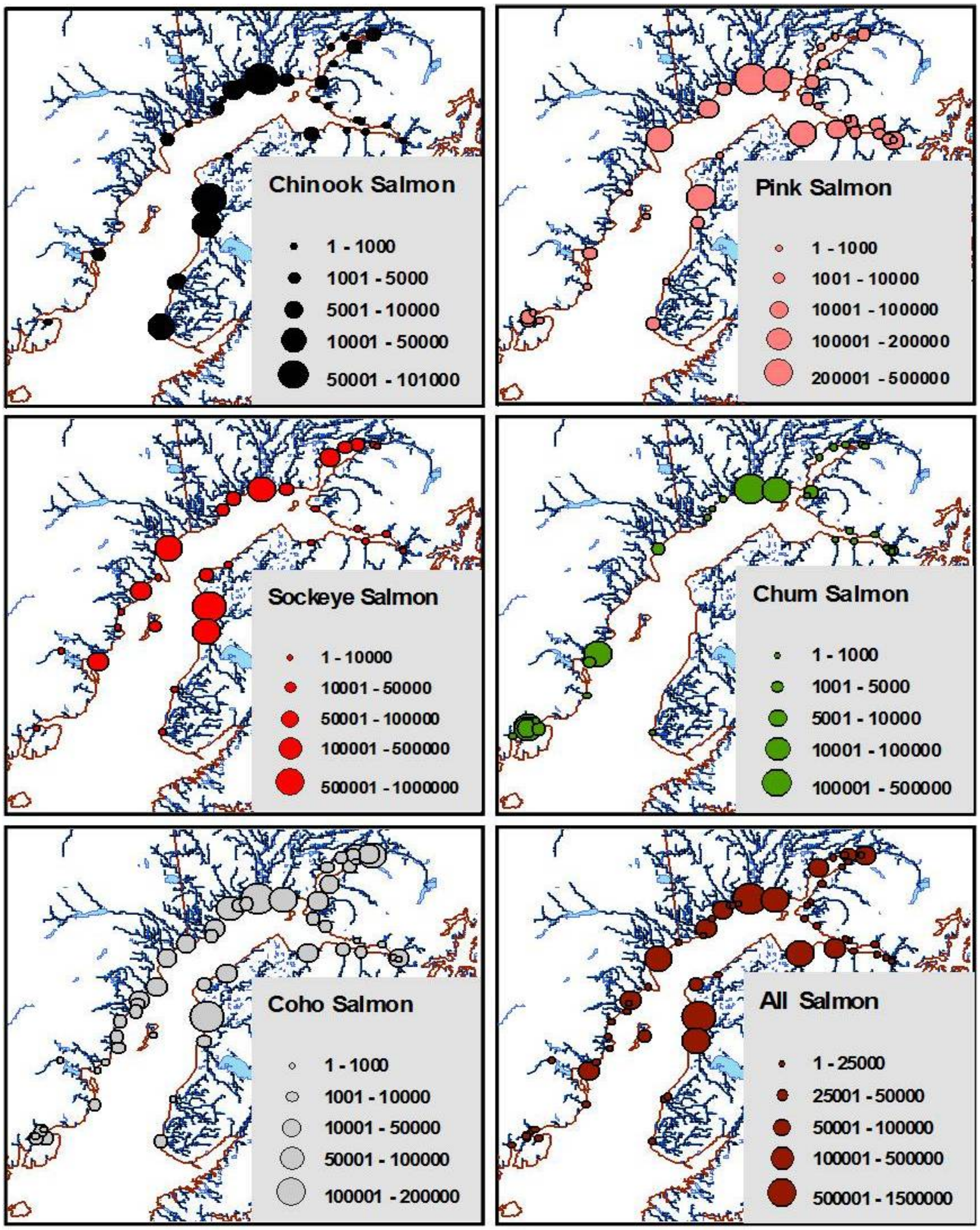
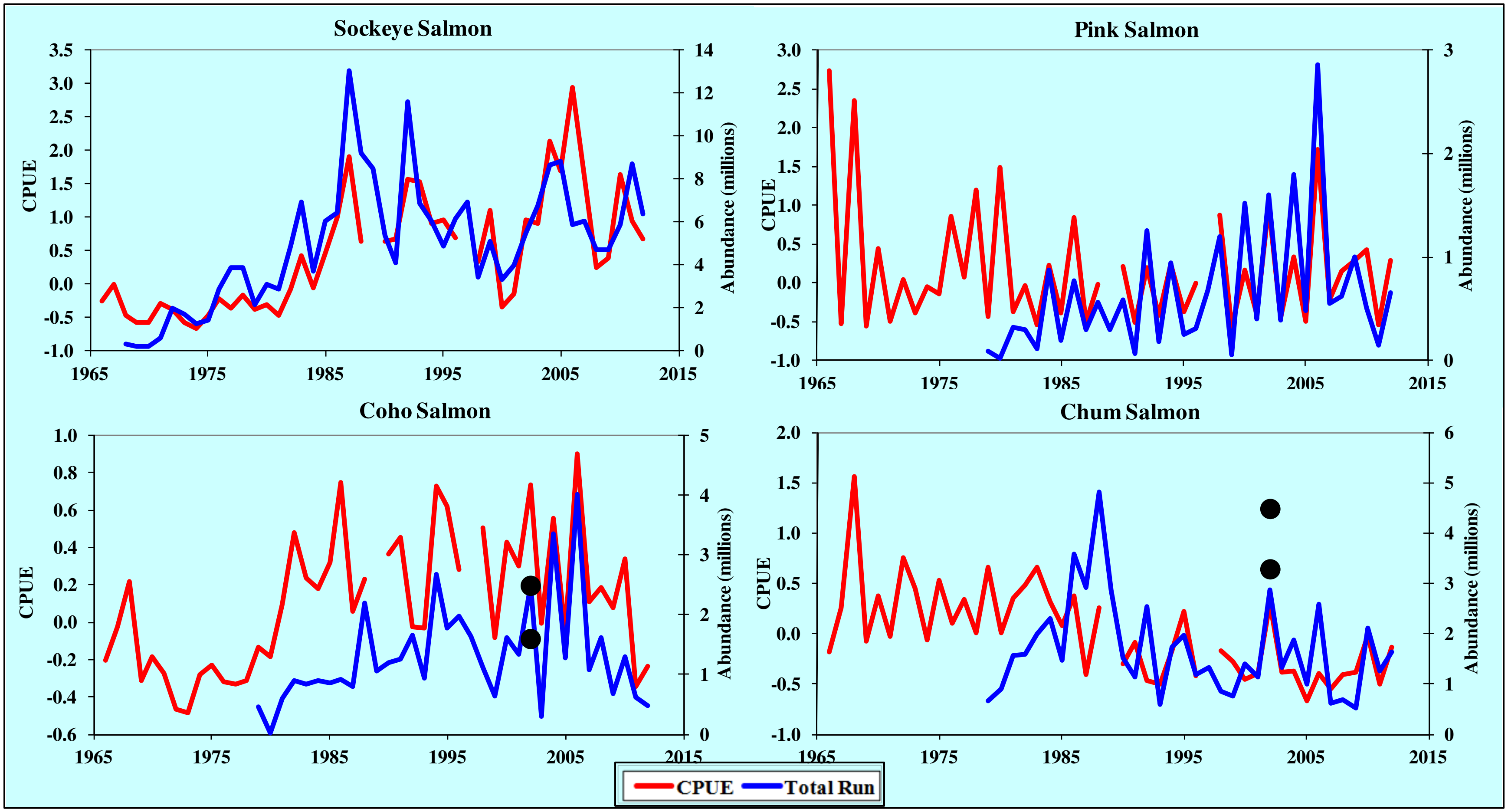


Figure F5. Historical mean in-river abundances of Chinook, sockeye, coho, pink, and chum salmon entering the major Rivers flowing into Cook Inlet.



Notes: The commercial drift gillnet fishery catch per unit effort indicates annual deviations from long-term mean catch after standardizing for fishing time and gear length. Abundance estimates represent offshore test fishery catches extrapolated to total run size assuming equal catchability among species (Shields and Willette 2010; M. Willette, ADF&G, pers. comm.). For comparison, mark-recapture estimates of coho and chum salmon run sizes are shown as black dots for 2002.

Source: Willette et al. 2003.

Figure F6. Trends in abundance indices for sockeye, coho, pink, and chum Salmon returns to upper Cook Inlet, 1966 to 2012.

decline in chum salmon abundances (Figure F6). Sockeye salmon run sizes, indexed as catches and escapements into major river systems, increased primarily due to larger returns to the Kenai and Kasilof rivers. Pink, coho, and chum salmon indices, derived from test fishery catches, provide temporal trends, but give only an order of magnitude indication of abundances. Mark-recapture abundance estimates for coho and chum salmon are more accurate, but are only available for 2002. Although commercial drift gillnet catch per unit effort is based on harvests by several hundred boats and test fishery estimates are based on catches of a single boat, these indices show similar trends (Figure F6).

Commercial salmon catches in northern Cook Inlet (above the Forelands), where belugas have concentrated in recent years, were relatively low in the late 1960s and early 1970s, relatively high in the 1980s, and have subsequently declined (Figure F7). This catch decline is partly attributed to fisheries management constraints on fishing effort in order to increase escapements of primarily Chinook, sockeye, and coho salmon. Although salmon returns to the major river systems of northern Cook Inlet have exhibited broad swings in return abundance, many stocks and systems have shown declines in recent years. Sonar estimates of total salmon entering the Yentna River (a Susitna River tributary) ranged from about 0.4 to 1.6 million fish, with no clear temporal trend during 1982 to 2009 (Figure F8). However, the contribution of most species to fish wheel catches in the Yentna River declined as the run was increasingly comprised of pink salmon after 2005 (Figure F8). Chinook and coho salmon weir counts on the Deshka River (a major tributary of Susitna River) and coho salmon weir counts on Little Susitna River peaked in 2004 and have since declined (Figure F9). Sockeye salmon weir counts on Fish Creek (Knik Arm) have been weak in some recent years, but the 2010 weir count was the highest since 1985 before declining dramatically in 2011 and 2012. Coho salmon entering Jim Creek (Knik Arm) increased from the late 1990s to 2006, but have decreased since 2008 (S. Ivey, ADF&G, pers. comm.; Figure F9).

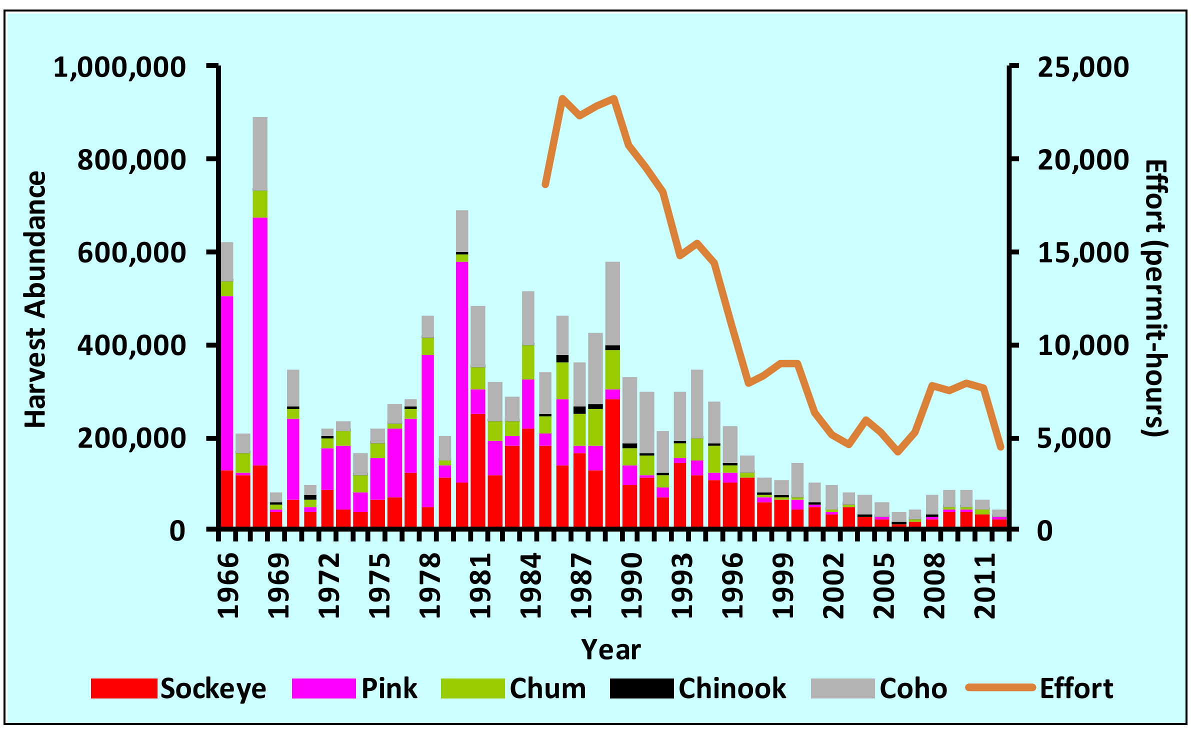
An important concern is that salmon are an essential feature of CI beluga critical habitat, and some species of salmon, most notably Chinook, have had reductions in run strength in Cook Inlet and throughout Alaska. Responding to a request from Alaska Governor Sean Parnell, Acting U.S. Secretary of Commerce Rebecca Blank determined that commercial fishery failures due to fishery resource disasters had occurred for Chinook salmon stocks in the Yukon (2010, 2011, 2012), Kuskokwim (2011, 2012), and Cook Inlet (2012) regions.[39] The declaration acknowledged hardships for commercial, sport, and subsistence users as a result of the Chinook fishery failures. To identify key knowledge gaps and discuss how best to address those gaps, ADF&G sponsored a Chinook salmon symposium, "Understanding the Abundance and Productivity Trends of Chinook Salmon in Alaska," in Anchorage during October 22–23, 2012.[40] Subsequently, ADF&G worked collaboratively with federal agencies and academic partners to develop a stock assessment and research plan with recommended studies to address critical knowledge gaps (ADF&G Salmon Research Team 2013).

[39] See news release at: http://www.nmfs.noaa.gov/stories/2012/09/09_13_12disaster_determinations.html; A copy of the letter from Acting Secretary Blank to Governor Parnell can be viewed at: http://www.nmfs.noaa.gov/stories/2012/09/docs/blank_parnell_9_13_12.pdf.

[40] For more information about the Chinook salmon symposium, visit ADF&G's website at: http://www.adfg.alaska.gov/index.cfm?adfg=chinook_efforts_symposium.information.

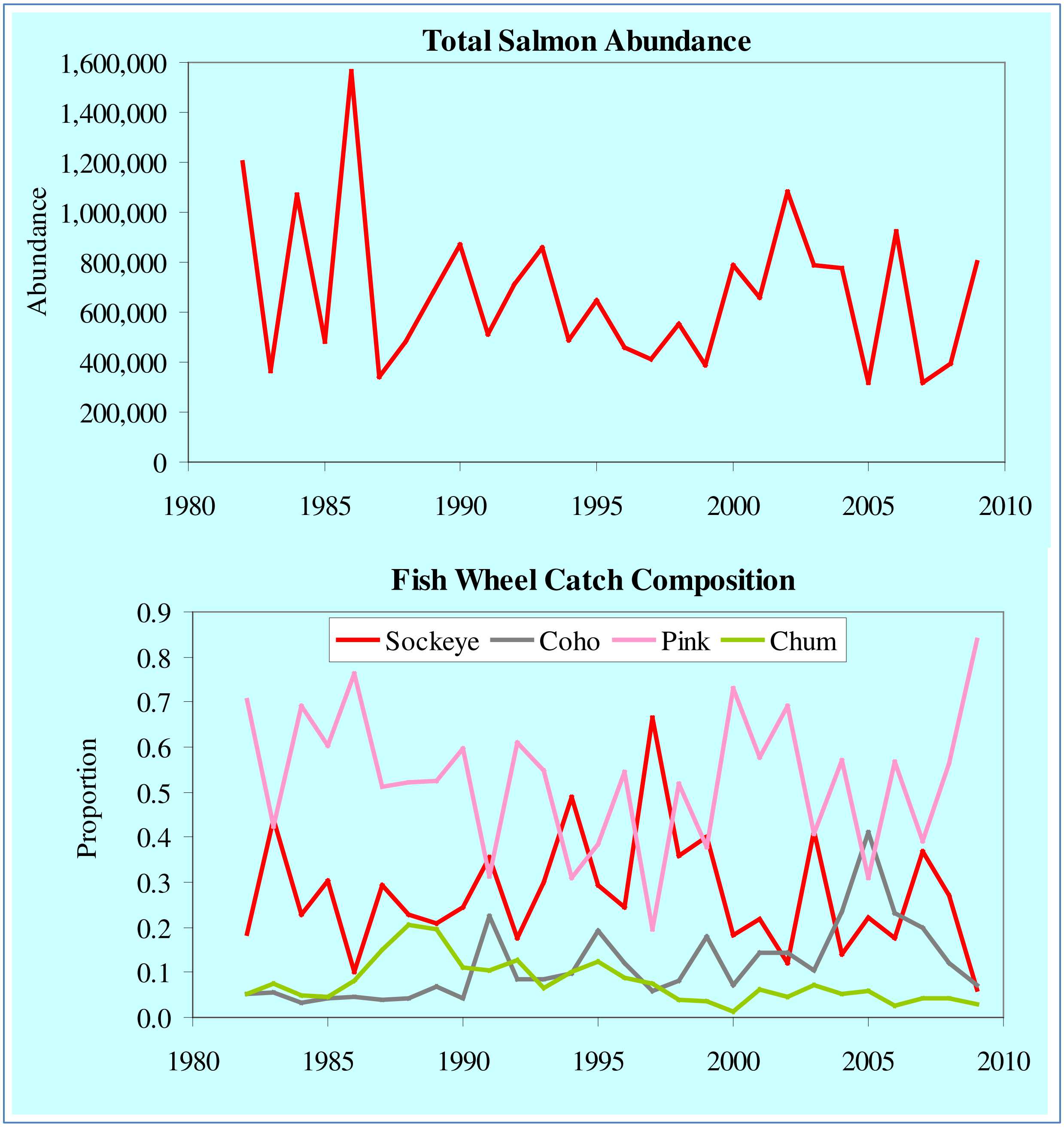
Northern pike were not found in any Cook Inlet streams until being illegally introduced in the 1960s. The spatial distribution of pike has since expanded to include many northern Cook Inlet streams and lakes. In the Susitna watershed, invasive northern pike have impacted many salmonid populations (e.g., Alexander Creek, Shell, and Hewitt lakes) and have largely eliminated salmon from some lakes (e.g., Trapper, Red Shirt, Sucker, and Caswell). The capture of northern pike by commercial salmon fishermen in upper Cook Inlet waters also indicates a potential expansion to other watersheds. Although we do not know to what extent salmon production in Cook Inlet has been impacted by northern pike, pike have clearly reduced salmon production in some areas.

Prior to 1990, belugas were often found in central and lower Cook Inlet, but it is not known what prey were consumed in these areas. In the 1970s, Kamishak Bay supported large commercial catches of Tanner and red king crabs, and summer concentrations of Pacific halibut were found north of Augustine Island (NOAA 1977; Bechtol et al. 2002). While commercial fisheries have not occurred since the early 1980s for red king crab and the early 1990s for Tanner crab, Pacific halibut still support fisheries extending north into central Cook Inlet (Meyer et al. 2008). In spring, Pacific herring aggregate in shallow, nearshore areas of Kamishak Bay to spawn. Peak biomass reached 35,513 short tons in 1983 (Figure F10), declined to 2,906 tons in 2004, and has subsequently ranged from 3,100 to 4,100 tons (Otis and Hammarstrom 2004; Hammarstrom and Ford 2011; Hollowell et al. 2012). Due to low spawning biomass, the commercial herring fishery in lower Cook Inlet has remained closed since 1999. Although herring resources in upper Cook Inlet are not formally assessed, low-level commercial fisheries occur, with annual harvests generally totaling less than 20 tons over the past 15 years (P. Shields,



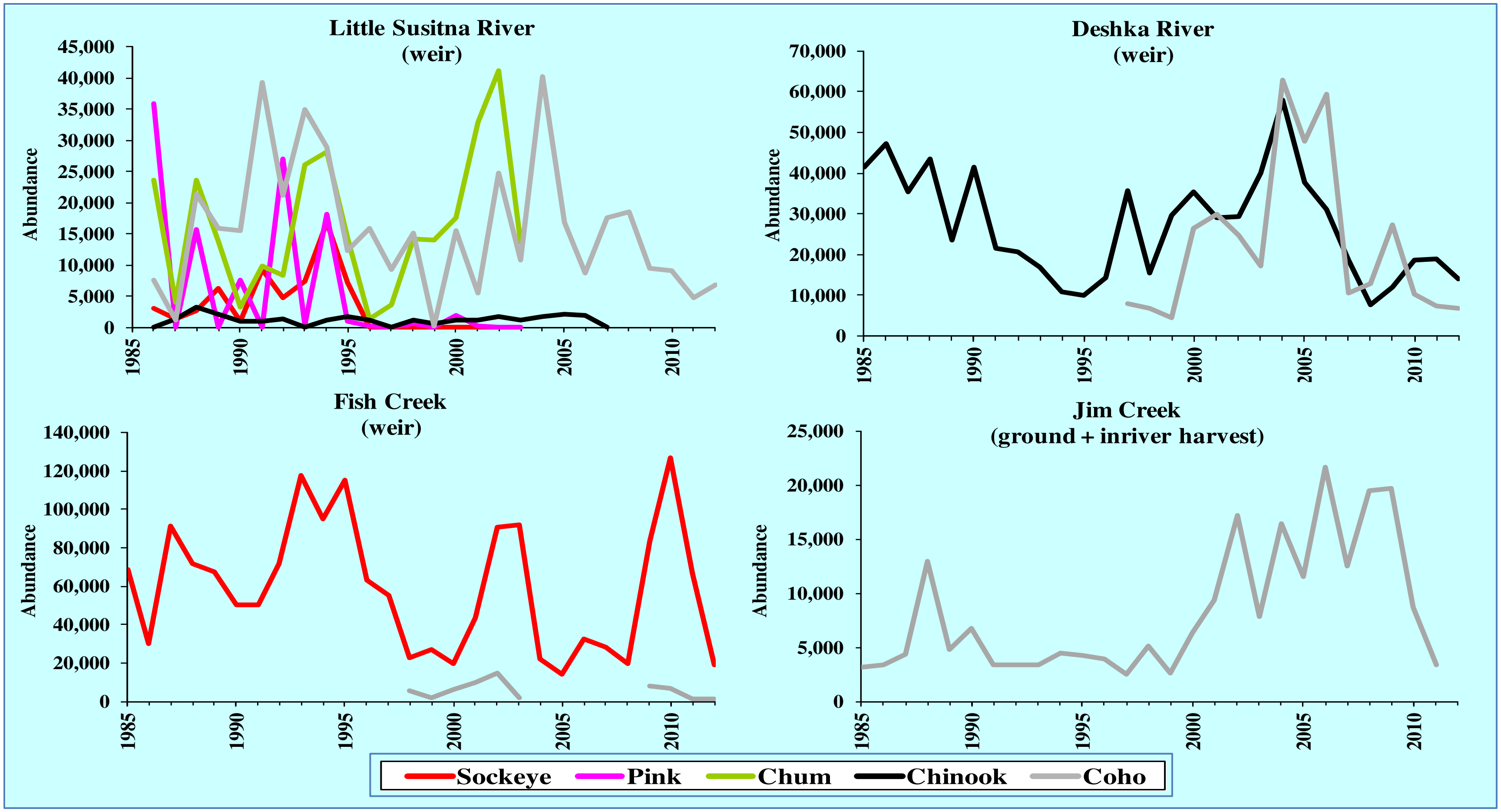
Source: Shields and Dupuis 2012; M. Willette, ADF&G, pers. comm.

Figure F7. Commercial salmon catch (numbers of fish) and fishery effort (permit-hours) in the Cook Inlet Northern District, 1966 to 2012.



Source: Westerman and Willette 2010.

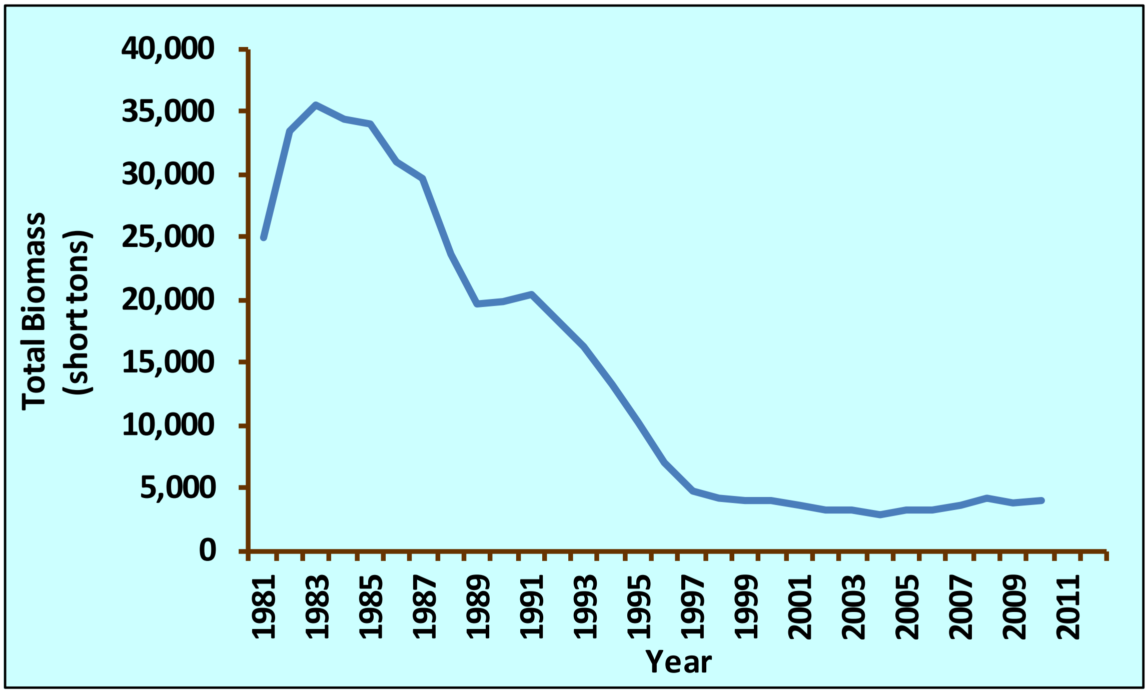
Figure F8. Sonar estimates of total salmon return entering the Yentna River (a Susitna River tributary) and fish wheel catch composition at the sonar site, 1982 to 2009.



Notes: Little Susitna weir counts for species other than coho salmon are uncertain because the weir was moved to a different upstream location in 1996 and the weir operations did not always encompass the entire run (Sweet et al. 2003).

Source: ADF&G Fish Counts webpage at: http://www.adfg.alaska.gov/sf/FishCounts/; S. Ivey, ADF&G, pers. comm.; M. Willette, ADF&G, pers. comm.

Figure F9. Salmon run sizes entering the Little Susitna River, Deshka River, Fish Creek, and Jim Creek, 1985 to 2012.



Source: Otis and Hammarstrom 2004, Hollowell et al. 2012.

Figure F10. Historical biomass (short tons) of spawning Pacific herring in Kamishak Bay, 1981 to 2010.

ADF&G, pers. comm.). At Chisik Island, large shallow schools of eulachon, herring, and crangonid and pandalid shrimps were found in May 1997 and 1998, while lower density schools of herring, eulachon, and longfin smelt were found deeper in this area during summer (Fechhelm et al. 1999). Piatt (2002) found cold, nutrient-rich Gulf of Alaska waters upwelling at the entrance to lower Cook Inlet supported high densities of juvenile pollock, sandlance, and capelin. Demersal fish resources in this area were dominated by walleye pollock, Pacific cod, butter sole, and Pacific halibut (Blackburn et al. 1980).

Historically, belugas were often observed in the fall along the northern shore of Kachemak Bay. Pacific sandlance, which spawn on beaches in the fall, were the most abundant nearshore fish species found in Kachemak Bay (Robards et al. 1999), but it is unknown if these fish were beluga prey. An abundant shallow subtidal fauna largely comprised of polychaetes and clams has also been found along this northern shore (NOAA 1977). Offshore, the benthic invertebrate community in Kachemak Bay was dominated by hermit crabs, pandalid shrimp, and Tanner, Dungeness, and king crabs (NOAA 1977). Halibut, rock sole, yellowfin sole, and weathervane scallops were abundant in outer Kachemak Bay (NOAA 1977).

Belugas have been observed around Kalgin Island in both summer and winter (Hansen and Hubbard 1999; Hobbs et al. 2005), although the summer occurrence around Kalgin Island appears to have diminished with the concurrent summer range contraction of the population (NMFS 2008a). The Upper Subdistrict, located east of Kalgin Island to the Kenai Peninsula, can account for 60% or more of the commercial salmon harvests from upper Cook Inlet (Shields and Dupuis 2012). This area may be very productive due to current convergence/divergence and associated upwelling with shrimp, crabs, and clams found offshore (NOAA 1977).

Belugas have also been observed in the Kenai River Estuary, likely feeding on eulachon or adult salmon. In 2003, 31 taxonomic groups of fishes and macroinvertebrates were found in this area (Willette et al. 2004). In April, epibenthic invertebrates (*Crangon* spp., *Neomysis* spp., and *Saduria* spp.) were most abundant, and finfish (mostly longfin smelt) were present, but rare. In June, finfish (mostly eulachon, juvenile sockeye, coho, and Chinook salmon, Pacific staghorn sculpin, snake prickleback, and starry flounder) were most abundant. In September, eulachon, juvenile coho salmon, Pacific herring, Pacific sandfish, and starry flounder were most abundant. In deep mid-channel habitats, spiny dogfish and starry flounder were most abundant. Thus, there appears to be high species diversity with species abundance dependent on season and habitat.

Belugas have frequented Knik Arm where they likely feed on migrating adult salmon (Huntington 2000, NMFS 2008a). However, Pacific staghorn sculpin also occur in Knik Arm at low densities, primarily nearshore from July to November and offshore from April to July (KABATA 2006). Walleye pollock also occur in Knik Arm at low densities in nearshore habitats from April to July. Eulachon, mostly post-spawning fish, were found primarily in nearshore habitats from May to July (KABATA 2006). Pentec Environmental (2005) identified 19 fish species in Knik Arm, and Morsell et al. (1983) identified 18 fish species in upper Knik Arm. All five species of juvenile salmon use Knik Arm as a migratory corridor. Chinook and coho salmon enter the Arm at a larger body size, reside in nearshore habitats, and remain in the Arm during May to November. Chum, sockeye, and pink salmon juveniles enter the arm at a smaller body size and reside in more offshore habitats for May to August. In recent years, belugas have also been found along the northern shore of Cook Inlet between Tyonek and the Little Susitna River, likely feeding on migrating eulachon and adult salmon. While surveys for juvenile fish identified 19 species in this area, herring and pink salmon were the most abundant (Moulton 1997).

2. Fisheries Management

For commercially fished species, the availability of potential beluga prey in upper Cook Inlet during spring and summer can be somewhat inferred from the timing and location of fishery harvests and upriver spawning migrations (also referred to here as “escapements”). However, actual quantitative data on the spatial and temporal distribution of these beluga prey in upper Cook Inlet are limited. For example, long-term salmon escapement estimates are available for the three large middle Inlet rivers, the Kenai, Kasilof, and Crescent river systems, and for the Yentna River, a tributary of the Susitna River, with less frequent estimates available for some other Cook Inlet tributaries (Westerman and Willette 2011). Because sockeye salmon returns to the Kenai and Kasilof rivers comprise the largest component of upper Cook Inlet salmon returns, the bulk of fishing pressure by humans occurs south of these two river systems and, thus, “downstream” of the current primary beluga summer habitat. While more salmon are available in the central Cook Inlet areas, few belugas venture into the central Cook Inlet area in most years. Belugas in northern Cook Inlet likely benefit from the tendency of anadromous prey species to be concentrated by shallow water and the time required to transition from salt water to fresh as they enter the stream mouths, which presumably makes these prey easier to capture.

Management of anadromous fish populations in Alaska attempts to constrain harvests to be no greater than the level of surplus production, defined as returning adult salmon in excess of the spawning production needed to maintain productive salmon populations (Quinn and Deriso 1990). In addition to reproductive needs, harvest considerations must include upstream consumptive uses such as recreational and subsistence fisheries (Shields 2010), as well as allowances for natural mortality, which includes predation by beluga whales, bears, and other species. Stock productivity and the level of surplus production are notoriously difficult to predict and estimate accurately due to high annual variation in factors such as freshwater and marine survival. To account for this uncertainty, for targeted species, fisheries are managed with in-season reductions or closures if those fish stocks appear to be weak. However, the potential for overfishing exists annually, and it is unlikely that escapement goals will be met in all tributaries across all years. While corrective management measures are typically implemented in any year following an under-escapement, prediction of future fish returns and managing for optimal harvest of those returns remains uncertain. Thus, while fishery management, on average, should provide sufficient total numbers of prey for belugas, the timing of prey concentration or densities in the river mouths may not be adequate for efficient feeding by belugas. In addition, a fishery would not be reduced or closed if escapement goals are met. But if the escapement goal arrived in a shorter time period (e.g., 30 days instead of 90 days), the benefit of optimal returns to CI beluga energetics may be very different.

A contrasting management situation for beluga prey exists with eulachon, which also return to freshwater to spawn. Although eulachon spawning stocks can be found in numerous central Cook Inlet rivers, human fishing effort occurs primarily in tributaries in Knik and Turnagain arms. Because fishing tends to occur near the river mouths or upriver, this fishing effort often occurs “upstream” of beluga foraging, such that population level effects of overfishing would be reflected by poor spawning escapement and reduced prey availability in subsequent years. Eulachon populations are not assessed or monitored, but ADF&G uses the Statewide Harvest Survey to derive recreational harvest estimates post-season. These estimates are presumed to be somewhat related to eulachon population abundance. If a decline in annual harvests occurs and is suspected of indicating a substantive decline in eulachon abundance, ADF&G may implement more restrictive fishing measures in subsequent years. There had been a sporadic commercial fishery for eulachon since 1978 (taking from 300–100,000 pounds in 1978, 1980, 1998 and 1999; Shields 2005). Based on a concern that a reduction in the availability of eulachon could be detrimental to belugas, NMFS recommended to the Alaska Board of Fisheries that this fishery be discontinued effective beginning in 2000, in part due to the lack of data on the eulachon runs into the Susitna River, and due to the absence of any evaluation of the effect of this fishery on belugas in terms of disturbance/harassment or competition for these fish. Additionally, it was noted: belugas may be heavily dependent on the oil-rich eulachon early in the spring (preceding salmon migrations), the runs are very short in duration, and large eulachon runs may occur in only a few upper Inlet streams. The commercial fishery for eulachon was closed in 2000, but reopened in 2005, under restrictions to hand-operated dip nets in saltwater between the Chuitna River and the Little Susitna River, with a total harvest of 100 tons or less (Shields 2005, Shields and Dupuis 2012; Shields and Dupuis 2016; P. Shields, ADF&G, pers. comm.).

Beluga prey resources, such as salmon and eulachon, typically represent a mixture of spawning stocks that are also harvested in mixed-stock fisheries (Shields 2010; Westerman and Willette 2011; Shields and Dupuis 2016). Effects of overfishing by humans on beluga foraging success are not well known, yet likely include spatial and temporal components for any specific prey resource that is overfished. Stock composition is dynamic and varies annually in both the run strength and run timing of individual contributing stocks. For major stocks or indicator stocks, harvest managers have tried to determine the relationship between annual escapements and returns in subsequent years. These relationships often have an optimal range such that escapement larger or smaller than this range are presumed to generate reduced adult salmon returns in future years. Harvest managers attempt to regulate fishing effort, typically in mixed-stock fisheries, to ensure that spawning escapement goals are achieved for each monitored salmon stock. However, it is not always possible to ensure that all target stocks are under fished, without exceeding the upper bound (over fishing) on some stocks.

3. Competition for CI Beluga Prey Resources

Over time, selective fishing pressure, or other factors, can alter reproductive migration timing of some prey species. For instance, intensive fishing during the early part of a salmon run can reduce the portion of the stock that returns early in the run and slightly shift future run timing, but the extent of that shift is limited as survival decreases outside of an optimal migration timing (Smoker et al. 1998). Thus, the timing of prey concentration or densities in the river mouths may not be adequate for efficient feeding by belugas. Chronic and persistent overharvesting of one or more unique salmon stocks or stocks from a specific spatial and/or temporal component (e.g., repeated overharvesting of upper Cook Inlet, early season runs) also has the potential to restructure the ecosystem. Such a pattern could cause a shift in beluga foraging toward less-nutritious prey items or a geographic displacement from the optimal foraging habitat, ultimately with reduced survival and reproductive success. However, the time frame over which such shifts could occur is unknown, and no baseline data currently exist to detect such shifts.

Although there is no definitive analysis of competition between CI belugas and other marine mammals that consume the same prey, the possibility of competitive overlap in prey exists. For example, Chinook and coho salmon were found to be prey items for CI belugas (Quakenbush et al. 2015), so that any predator (including humans) that takes these species from stocks used by belugas are potential competitors. Resident (fish-eating) killer whales along the north Gulf Coast of Alaska are known to focus on salmonids, particularly Chinook, chum, and coho salmon (Matkin et al. 2010). These fish-eating resident killer whales are common in lower Cook Inlet and may intercept salmon destined for rivers and streams in the upper Inlet that are potential beluga prey; however, resident killer whales are not known to range into the upper Inlet where they might compete directly with CI belugas for prey. Harbor seals and Steller sea lions are also known salmonid predators that occur within the range of CI belugas and could compete with belugas and each other for these prey. Harbor seals, Steller sea lions, killer whales, humpback whales, gray whales, minke whales, harbor porpoises, sea birds, sea otters, and humans may also have competition effects on belugas through their consumption of eulachon.

The estimated annual rate of increase in sea otters in Kachemak Bay between 2002 and 2008 was 26% per year, exceeding the estimated maximum productivity rate for this species and is presumably due in part to immigration from other areas (Gill et al. 2008). Sea otters have been found as far north as Ninilchik (V. Gill, USFWS, pers. comm.). Systematic surveys have not been done for several years and trends are unknown for Cook Inlet/Shelikof stocks of harbor seals, the Gulf of Alaska stock of harbor porpoise, the Alaska stock of Dall’s porpoise, or the Alaska stock of minke whales (Allen and Angliss 2012). The Eastern North Pacific gray whale stock and both the Western and Central North Pacific stocks of humpback whales have been increasing based on recent abundance estimates (Allen and Angliss 2012). None of these potential competitive effects have been quantified.

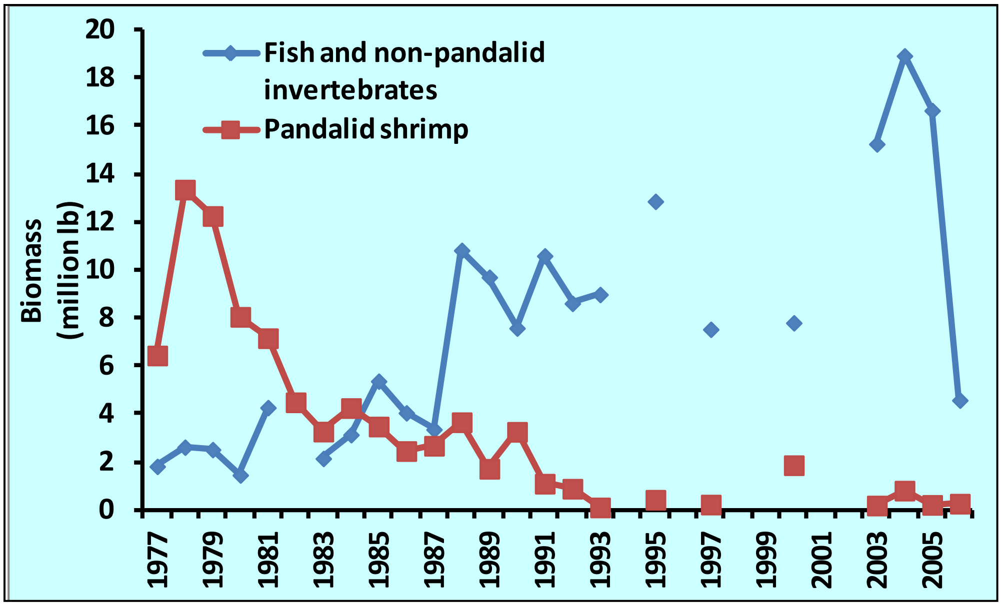
Resident killer whales likely do not directly compete for prey resources within the range of CI belugas, given limited to no overlap in their distribution with CI belugas (Lammers et al. 2013). Similarly, sea otters and Steller sea lions are likely not effective competitors with CI belugas, as they overlap with belugas in only a small portion of their range in lower Cook Inlet. While likely not in direct competition for adult salmon, the introduction of northern pike, an invasive species found in freshwaters of northern Cook Inlet, has likely reduced local salmon stocks, particularly Chinook, through predation on juveniles (Oslund and Ivey 2010).

4. Ecosystem Shifts and CI Beluga Prey

Both the relative and total abundances of any beluga prey item are not constant and can be expected to change over both space and time. Productivity of many marine species, including, but not limited to, potential beluga prey, may have responded to decadal-scale climate shifts in the North Pacific (Hollowed and Wooster 1992; Beamish and Bouillon 1993; Hare and Mantua 2000). Recognized climate regime shifts that occurred around 1976 and 1989 (Anderson and Piatt 1999; Zheng and Kruse 2000; Hare and Mantua 2000; Kruse 2007; Mueter et al. 2007) may have affected the productivity of marine species in the North Pacific, although response to ecological changes can vary temporally by species, with some responding sooner than others, or in different trends, or greater magnitudes (Rodinov and Overland 2005). For example, the northern Gulf of Alaska changed from an ecosystem dominated largely by invertebrate (crabs and shrimps) biomass in the 1960s to 1970s to dominance by gadids and flatfishes. Robards et al. (1999) found a 1,000-fold increase in gadid abundance in lower Cook Inlet between the 1970s and 1990s, and a lesser increase in abundances of pleuronectids and salmonids. Small-mesh trawl surveys in Kachemak Bay documented a decline in pandalid shrimps and an increase in demersal fishes since the 1970s (Figure F11). Walleye pollock, flathead sole, and starry flounder became the dominant demersal fishes, comprising over 40% of the survey catch in 2004 to 2006 (Goldman et al. 2007). A similar change was observed in small-mesh surveys from Kodiak Island to Pavlof Bay (Anderson and Piatt 1999), with ongoing surveys indicating continued low levels of stock biomass for many potential forage species including shrimp, juvenile pollock, and herring (Figure F12; D. Urban, NMFS, pers. comm.). Eulachon exhibited a resurgence in the 2000s, but declined in 2010, coincident with an increase in commercial harvest. The climate regime shift in the North Pacific during the late 1970s was associated with aspects such as increased ocean temperatures and increased abundances of predatory fishes, such as Pacific cod. A study of the decline in the Kachemak Bay stock of northern shrimp found that a strong increasing trend in natural mortality followed the 1976 to 1977 regime shift, paralleling trends in increased Pacific cod abundance (Fu and Quinn 2000; Fu et al. 2000). A study of red king crab around Kodiak Island attributed the initial population crash to overfishing, but suggested that, despite a fishery closure since 1983, the stock has failed to recover due to increased juvenile mortality associated with higher ocean temperatures and greater abundance of predatory fishes, such as Pacific cod (Bechtol and Kruse 2010). Pacific cod and walleye pollock, while not historically “rare” in Cook Inlet, occurred at much lower levels of biomass and abundance prior to the late 1980s, when recent commercial fisheries developed (Bechtol 1995). Surveys show biomass of Pacific cod and walleye pollock remained relatively high through the 1990s (Figure F13; R. Gustafson, ADF&G, pers. comm.). Meanwhile, Tanner crab data from lower Cook Inlet indicate dramatic declines in abundance of harvestable crabs after the mid-1970s (Figure F14; Bechtol et al. 2002; R. Gustafson, ADF&G, pers. comm.); these crabs are seasonally important to belugas in upper Cook Inlet.

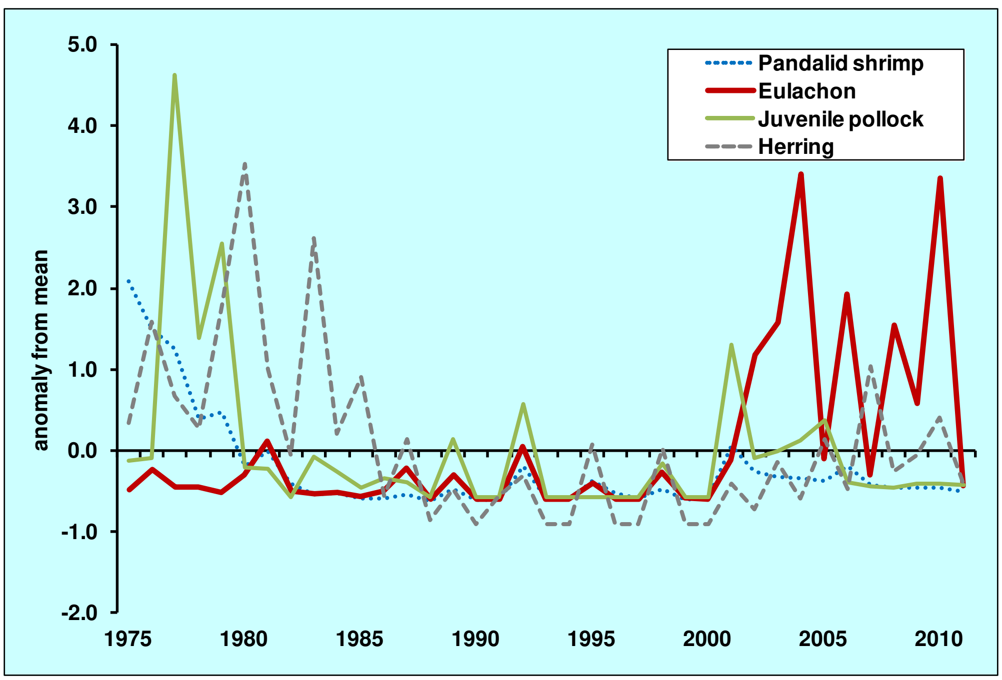
While ecosystem response to environmental forcing is likely nonlinear (Hare and Mantua 2000), evidence exists for climate-driven changes in the physical environment affecting other fish populations in the Gulf of Alaska and eastern Bering Sea. For example, strong pollock recruitment in the eastern Bering Sea appears connected to above normal air and bottom temperatures and reduced sea ice cover, factors that promote zooplankton production (Quinn and Niebauer 1995). Solid sea ice is not a factor in the northern Gulf of Alaska, but the pre-1976 regime was associated with low sea surface temperature and low biomasses of predatory fishes, such as flatfishes and Pacific cod. During and following the 1976 regime shift, high sea surface temperatures enhanced zooplankton production in the Gulf of Alaska, supporting strong pollock recruitment amid low demersal fish predation (Bailey 2000; Ciannelli et al. 2005). However, high zooplankton populations may have been detrimental to phytoplankton needed for first-feeding larvae of many species. Sea surface temperatures declined somewhat following the regime shift, but ecosystem "maturation" in the subsequent decade resulted in increased biomass of predatory fishes, particularly Pacific halibut, arrowtooth flounder, flathead sole, and Pacific cod (Bailey 2000). The North Pacific ecosystem has been generally characterized by moderate sea surface temperature in recent decades, but relatively high demersal fish biomass (Hare and Mantua 2000; Mueter and Norcross 2002; Ciannelli et al. 2005). As a result, a compromised feeding environment for many larval forage species was coupled with intensified groundfish predation.

A cautionary note is warranted regarding interpretation of the role of long-term environmental effects as drivers of potential ecological change. Ecological systems are complex, and trends in abundance and biomass are typically the result of a variety of factors. A first step in understanding ecosystem change is to have a sufficiently long time series of indices for both potential ecosystem drivers and the species of interest. Unfortunately, these indices are often discontinuous over time or of an inappropriate spatial coverage. Surveys of potential CI beluga prey in marine or estuarine areas of upper Cook Inlet have been infrequent and short-term, typically implemented to address *ad hoc* environmental assessment needs for resource development. Use of commercial harvests to represent potential CI beluga prey is likely biased because harvests typically occur "downstream" of feeding CI beluga. Use of salmon escapements to represent CI beluga prey is also biased because escapements occur "upstream" of CI beluga foraging areas. In addition, many escapement indices are discontinuous over time as monitoring techniques or tributaries change in response to management priorities and agency budget limitations. The small-mesh trawl survey in Kachemak Bay dates to 1977 and provides a basis for long-term ecosystem changes, but was reduced in frequency and then discontinued after 2006 due to financial priorities. A multi-species trawl survey, focused on Tanner crab, but also providing population estimates of species like Pacific cod, walleye pollock, and arrowtooth flounder in lower Cook Inlet, dates to 1990 but has also been reduced in frequency due to budget priorities.



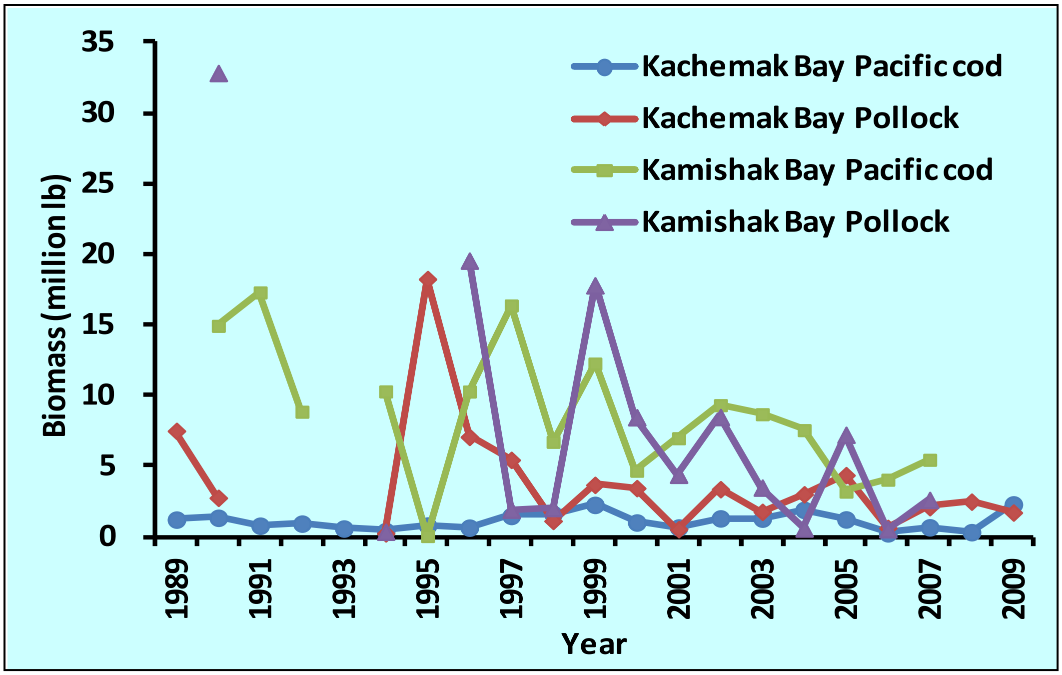
Source: Gustafson and Bechtol 2005; Goldman et al. 2007; R. Gustafson, ADF&G, pers. comm.

Figure F11. Historical biomass (millions of pounds) of pandalid shrimps, demersal fishes, and other invertebrates from small-mesh trawl surveys in Kachemak Bay.



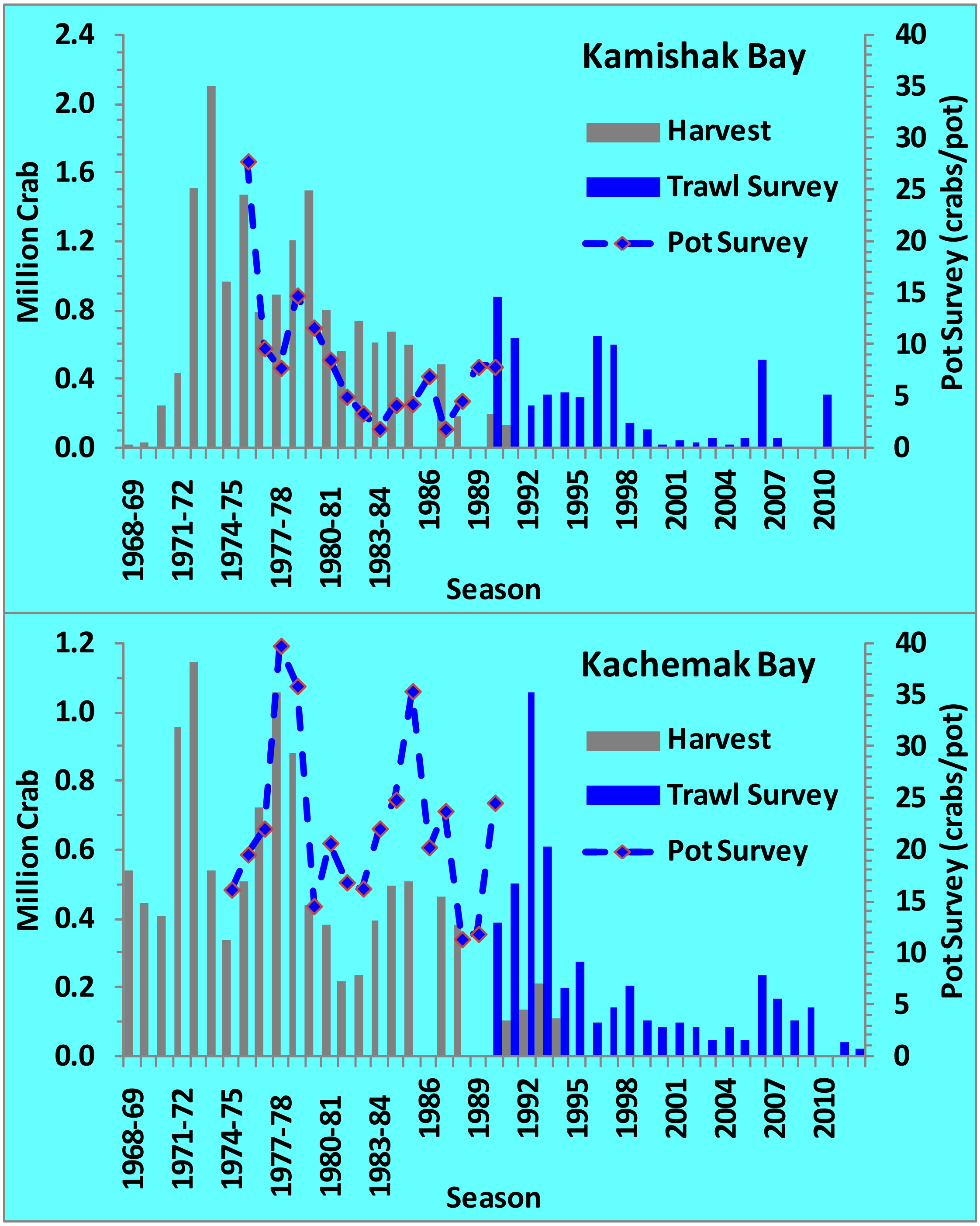
Source: D. Urban, NMFS, pers. comm.

Figure F12. Anomalies in the mean catch of dominant forage species in the Kodiak small-mesh trawl surveys, 1975 to 2010.



Source: R. Gustafson, ADF&G, pers. comm.

Figure F13. Bottom trawl survey biomass estimates of Pacific cod and walleye pollock in Kachemak Bay and Kamishak Bay, lower Cook Inlet, 1989 to 2009.



Source: Bechtol et al. 2002; R. Gustafson, ADF&G, pers. comm.

Figure F14. Pot and trawl survey estimates, and subsequent harvests, for legal (i.e., legal size to harvest) male Tanner crabs in the Kamishak and Barren Islands Districts (top panel) and the Southern District (Kachemak Bay, lower panel), 1968 to 2012.

G. CI Beluga Pollution and Contaminants Supplement

NOTE TO READER: The text below was developed by the CIBRT and reproduces information readily available in other reports. In Section III.A.9 of this document, we provided information sufficient to justify recovery criteria and actions addressing pollution. Additional information about pollution and contaminants reviewed for Cook Inlet and CI belugas follows.

Pollution is the introduction of contaminants into the environment that causes adverse change. For the purpose of this review, pollution is synonymous with acute or chronic events that release notable/reportable quantities of chemicals or substances into the environment. Exposure to industrial chemicals as well as to natural substances released into the marine environment is a potential health threat for CI belugas and their prey.

Available literature was reviewed by NMFS for the *Cook Inlet Beluga Whale Conservation Plan* (NMFS 2008a) and by URS Corporation (2010). The reviewed publications vary in their use of terminology regarding lipid, blubber, dry weight, and wet weight. In particular, some authors consider blubber and lipid to be synonymous and interchangeable terms, whereas others consider blubber to be a combination of lipids and water. Therefore, it is important to ensure that comparisons of tissue concentrations and threshold levels are based on consistent assumptions of measurement media and units.

There is little information on the potentially deleterious effects of chemicals on CI belugas. Potential sources of anthropogenic contaminants include wastewater treatment, freshwater runoff, airport de-icing chemicals, ballast water discharges, gas and oil releases or spills, military training areas, and other industrial development and activities. While NMFS has some data about levels of traditionally studied contaminants in CI belugas (e.g., Dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCBs], polycyclic aromatic hydrocarbons [PAHs], etc.), virtually nothing is known about other emerging pollutants of concern and their effects on CI belugas. The emerging pollutants of concern include endocrine disruptors (substances that interfere with the functions of hormones), pharmaceuticals, personal care products, and prions (proteins that may cause a disease), amongst other bacterial and viral agents that are found in wastewater and biosolids.

URS (2010) evaluated the level of concern for various classes of chemicals that were of probable, possible, or unlikely concern. Chemicals of concern for which data are available are described in Table 8, and representative values from various beluga populations and marine mammals in Cook Inlet are listed in Table G1. Table G2 lists those chemicals of possible concern for which there are no data available for any beluga population. Chemicals considered by URS (2010) to be unlikely of concern for CI belugas include: hydrocarbons (other than PAH compounds), glycols, diagnostic agents, dietary supplements, personal care products, engineered particles (<100 nanometers), or prions. Figure G1 summarizes data for known concentrations of various contaminants found in the blubber of male belugas from North America.

1. Organochlorines

PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. Though their

Table G1. Tissue concentrations of analyzed substances for belugas from Cook Inlet and other regions.

Group	Group[a]	Male	Female	Tissue
		Mean or median concentration ± 1SD (range)	Mean or median concentration ± 1SD (Range)	
Organochlorides (mg/kg wet)				
Total PCBs	CI (1992–97) [b]	1.49 ± 0.70	0.79 ± 0.56	blubber
	Pt Lay (1990, 1996) [b]	5.20 ± 0.90	1.50 ± 1.12	blubber
	SLE (1986–87) [b]	75.8 ± 15.3	37.3 ± 22.0	blubber
Total DDTs	CI [b]	1.35 ± 0.73	0.59 ± 0.45	blubber
	Pt Lay [b]	3.63 ± 0.90	0.93 ±0.85	blubber
	SLE [b]	101 ± 32.6	23.0 ± 17.3	blubber
Toxaphene	CI [b]	2.40 ± 1.06	2.02 ± 0.46	blubber
	Pt Lay [b]	3.93 ± 1.16	2.62 ± 2.07	blubber
	SLE [b]	14.7 ± 2.46	6.34 ± 3.51	blubber
Chlordane compounds	CI [b]	0.56 ± 0.25	0.30 ± 0.22	blubber
	Pt Lay [b]	2.42 ± 0.46	0.79 ± 0.61	blubber
	SLE [b]	7.43 ± 0.63	3.55 ± 1.99	blubber
Dieldrin	CI [b]	0.09 ± 0.05	0.06 ± 0.05	blubber
	Pt Lay [b]	0.39 ± 0.09	0.12 ± 0.10	blubber
	SLE [b]	0.93 ± 0.12	0.56 ± 0.31	blubber
Hexachlorobenzene (HCB)	CI [b]	0.22 ± 0.09	0.15 ± 0.13	blubber
	Pt Lay [b]	0.81 ± 0.12	0.23 ± 0.28	blubber
	SLE [b]	1.34 ± 0.44	0.60 ± 0.43	blubber
Hexachlorocyclohexane (Sum HCH)	CI [b]	0.21 ± 0.07	0.17 ± 0.05	blubber
	Pt Lay [b]	0.33 ± 0.76	0.25 ± 0.12	blubber
	SLE [b]	0.37 ± 0.11	0.24 ± 0.10	blubber
Mirex	CI [b]	0.01 ± 0.01	0.01 ± 0.00	blubber
	Pt Lay [b]	0.06 ± 0.02	0.02 ± 0.01	blubber
	SLE [b]	1.00 ± 0.64	1.11 ± 0.99	blubber
Perfluorinated compounds				
Perfluorooctane sulfonate ng/g ww (PFOS)	CI 1992 to 2006 [c]	22.5 (14.4–30.4)	13.0 (4.61–70.3)	liver
	E. Chukchi 1989 to 2000 [c]	9.2 (4.29–28.4)	4.76 (1.81–38.1)	liver
Perfluorooctane sulfonamide (PFOSA)	CI 1992 to 2006 [c]	11.4 (4.52–17.9)	18.4 (10.4–27.8)	liver
	E. Chukchi 1989 to 2000 [c]	31.8 (17.7–63.8)	27.8 (11.2–65.7)	liver
Perfluorononanoic acid (PFNA)	CI 1992 to 2006 [c]	1.79 (0.454–3.08)	1.66 (<0.502–5.67)	liver
	E. Chukchi 1989 to 2000[c]	0.670 (0.170–2.55)	0.960 (<0.180–5.46)	liver
Polycyclic aromatic hydrocarbons (PAHs) µg/g lw				
Total PAHs	CI [d]	2.6 ± 3.8	1.2 ± 1.9	liver
	CI [d]	6.9 ± 7.4	27.8 ± 29.4	blubber

Group	Group[a]	Male: Mean or median concentration ± 1SD (range)	Female: Mean or median concentration ± 1SD (Range)	Tissue
Polybrominated diphenyl ethers (PBDEs) (ng/g lipid)				
	CI 1989 to 2006 [e]	13.8 (6.56–45.6)	14.6 (7.40–32.0)	blubber
	E. Chukchi 1989 to 2000[e]	12.8 (4.33–32.2)	5.05 (1.90–19.4)	blubber
	SLE 1988 to 1999 [f]	430 (170–780)	540 (300–1060)	blubber
	SLE 2000 to 2003[g]		2,210 (246–3030)	liver
Metals/Inorganics (mg/kg dry)				
Cadmium (Cd)	CI [b]	2.39		liver
	Pt Lay [b]	9.38 ± 3.39		liver
	SLE [b]	0.53 ± 0.41		liver
Mercury (Hg)	CI [b]	16.3 ± 13.0		liver
	Pt Lay [b]	179 ± 78.6		liver
	SLE [b]	126 ± 161		liver
Copper (Cu)	CI [b]	162 ± 130		liver
	Pt Lay [b]	61.6 ± 42.3		liver
	SLE [b]	0.58 ± 0.41		liver
Mercury (Hg)	CI [b]	16.3 ± 13.0		liver
	Pt Lay [b]	179 ± 78.6		liver
	SLE [b]	126 ± 161		liver
Selenium (Se)	CI [b]	14.3 ± 7.0		liver
	Pt Lay [b]	97.2 ± 76.7		liver
	SLE [b]	79.2 ± 110		liver

[a] CI - Cook Inlet belugas, Pt. Lay - Point Lay belugas, SLE - St. Lawrence Estuary belugas.

Sources: b. Becker et al. 2000 (males, *n* = 10; females, *n* = 10); c. Reiner et al. 2011 (CI, PFOS and PFOSA: males, *n* =11, females, *n* = 16; CI, PFNA: males, *n* = 11, females, *n* = 15; E. Chukchi PFOS and PFOSA: males, *n* = 25, females, *n* = 16; E. Chukchi, PFNA: males, *n* = 25, females, *n* = 13); d. Wetzel et al. 2010; e. Hoguet et al. 2013 (CI: males, *n* = 15, females, *n* = 12; E. Chukchi: males, *n* = 25, females, *n* = 15); f. Lebeuf et al. 2004 (males, *n* = 15; females, *n* = 14); g. McKinney et al. 2006 (males, *n* = 3, females, *n* = 3).

production has been banned in North America since 1979, PCBs still pose a risk to humans and wildlife because they are highly toxic and persist in the environment. These and other organochlorines such as DDT have high-fat, low-air, and poor-water solubility, allowing them to accumulate in fatty tissues. Being highly persistent in the environment, these compounds bioaccumulate through trophic transfer, resulting in higher concentrations in upper level predators such as marine mammals. High concentrations in animals are associated with poor health and reproduction. Concentrations of various organochlorines in CI belugas were consistently lower than levels observed in belugas from Point Lay and one to two orders of magnitude lower than levels seen in SLE belugas (Becker et al. 2000). The PCB values for CI belugas were at levels associated with endocrine disruption, lower than established thresholds for immunosuppression, but close to levels that disrupted immune function in free ranging harbor seals (as low as 2.5 milligrams [mg] per kilogram [kg] of PCBs; Levin et al. 2005, Shaw 2005).

Table G2. A brief description of compounds of possible concern to CI belugas, but for which no data are available for Cook Inlet or other beluga populations.

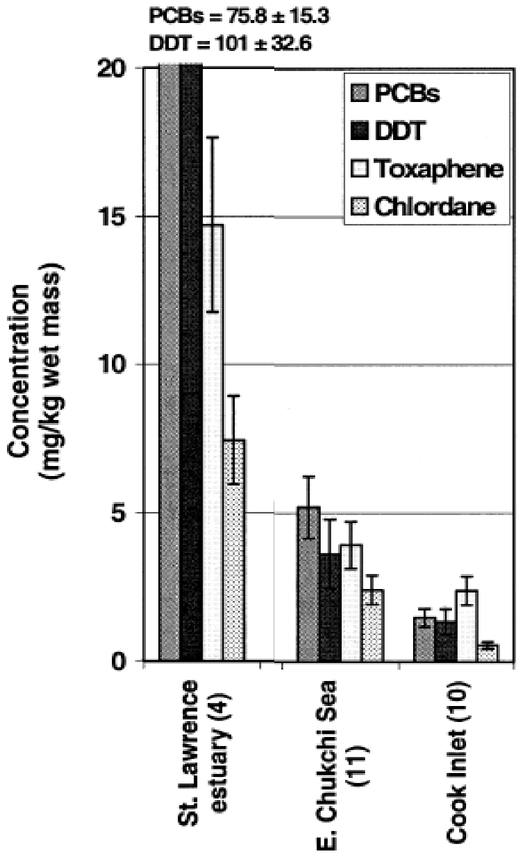
Class Of Substance	Specific Examples
Organophosphates[a]/carbamates	Commonly used as broad-spectrum insecticides: Malathion[a], methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb
Phthalates	Commonly used in vinyl softeners in flooring and in adhesives, plastic clothing, toys, and kitchen ware: Diethyl phthalate, butyl benzyl phthalate
Prescription and over the counter drugs	Commonly used medicinally for humans and animals: Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac, agricultural animal growth promoters, aminoglycosides[a], aspirin[a], furosemide[a]
Alkylphenols	Commonly used in detergents and cleaning agents: Nonylphenol, octylphenol
Consumer plastics	Commonly used in CDs, DVDs, eyeglasses lenses, and bottles: Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)
Natural and synthetic hormones	Commonly used medicinally for humans and animals: Estradiols, thyroxine analogs
Surfactants	Commonly used in detergents, cosmetics, and spermicides: 4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol
Pesticides/Herbicides	Commonly used to control “pests” including insects, fungi, plants, rodents, birds, spiders, mites: Lindane, methyl-parathion; permethrin; triazines, bifenthrin, cypermethrin, esfenvalerate; pyrethroids[a], paraquat[a]

[a] Denotes compounds with known ototoxic effects.
Source: URS 2010.

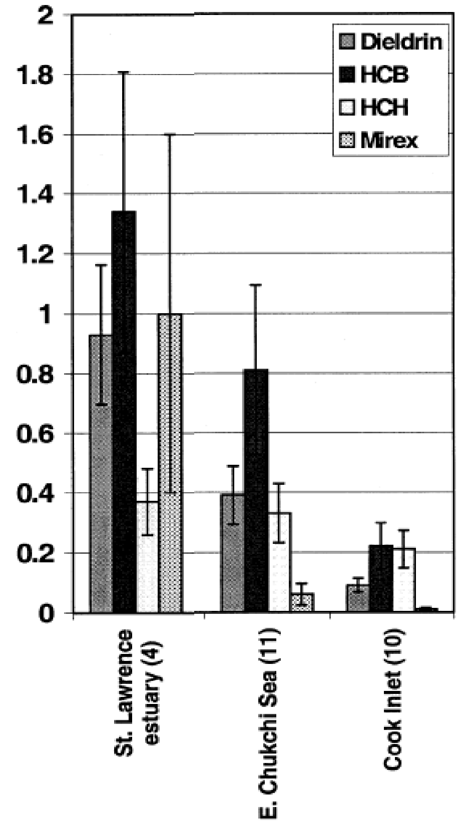
In a study of California sea lions, LeBoeuf et al. (2003) did not find any evidence that population growth or the health of individual sea lions had been compromised at mean total PCB concentrations of 12 mg/kg blubber weight and mean total DDTs concentrations of 37–41 mg/kg blubber wet weight, which are substantially higher than levels seen in CI belugas. Bristol Bay and CI beluga populations appear to carry very similar body burdens of most persistent organic pollutant contaminants, although CI belugas may be exposed to a larger amount of PCBs of aroclor origin (Northwest Fisheries Science Center, NMFS, unpub. data). Additionally, contaminant signatures were consistent with Bristol Bay belugas consuming prey originating from Asia and the Arctic, whereas the signatures in CI belugas did not exhibit indications of consumption of prey originating from outside Cook Inlet and the Gulf of Alaska (Herman et al., NMFS, unpub. data).

In a study of PCBs and organochlorine pesticides from blubber biopsies of free-ranging SLE belugas, concentrations had overlapping but lower ranges when compared to samples obtained from dead stranded belugas from Cook Inlet (Hobbs et al. 2003). The authors suggest that the differences observed are due to different feeding habits, particularly with regard to eels, and that elevated organochlorines were having an effect on the health of the SLE whales to an extent that led to higher mortality. Additionally, the authors caution that relying only on samples from stranded whales could bias study results because contaminant concentrations are likely elevated in stranded whales relative to what occurs in the population as a whole. Interestingly, this study also compared values to those obtained from SLE harbor seals, noting that most major compounds in the biopsied belugas occurred at similar levels in the seals, and followed similar age and sex-related trends (Bernt et al. 1999). This suggests sampling Cook Inlet harbor seals may be a viable surrogate species for investigating contaminant loads in CI belugas.

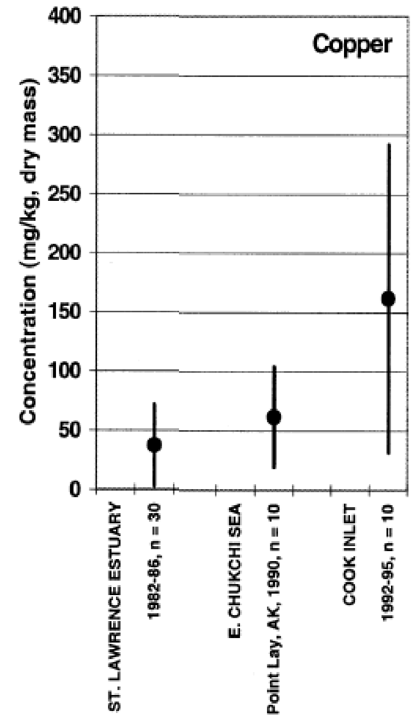
a) PCBs, DDT, toxaphene, and chlorane



b) Dieldrin, HCB, HCH, and mirex



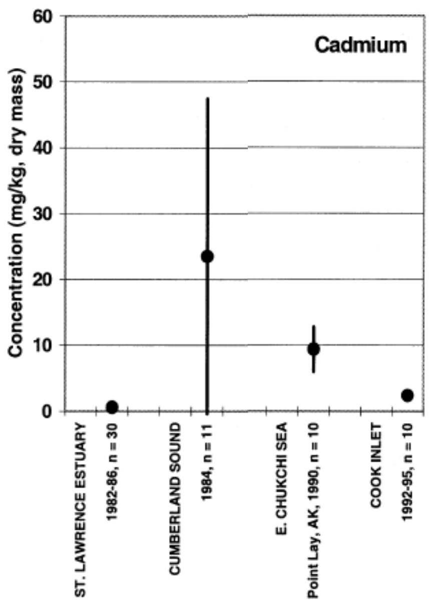
c) Copper



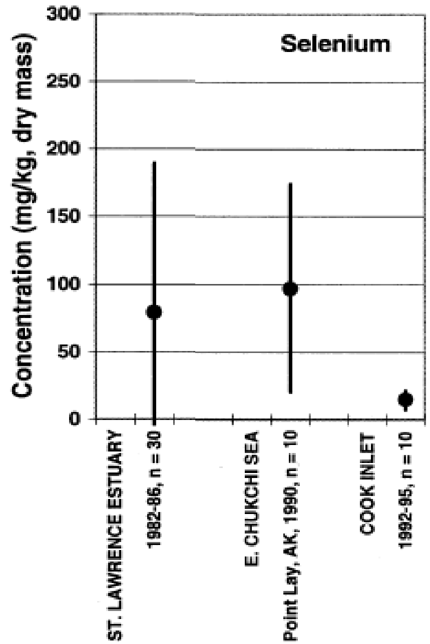
Notes: When available, geographic locations, dates of sample collections, and number of animals are shown on the X axis.
Source: Becker 2000.

Figure G1 (a-f). Concentrations (mean +/- 1 standard deviation) of various contaminants in the blubber of male North American belugas.

d) Total Mercury



e) Selenium



f) Cadmium

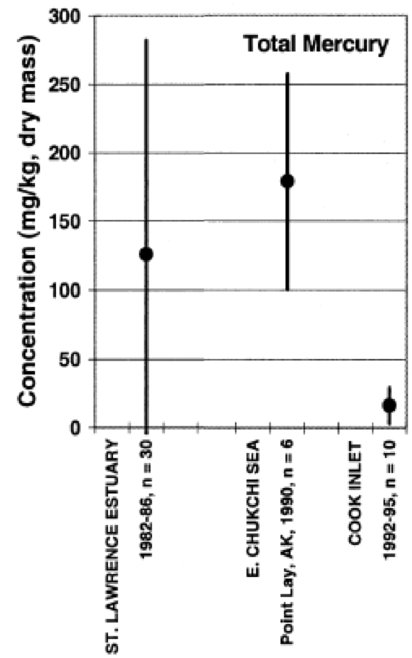


Figure G1 (a–f). Continued.

2. Perfluorinated Compounds

The perfluorinated compounds (PFCs), which include Teflon, are compounds commonly used as water and oil repellants in protective coatings in food packaging, textiles, and carpeting. While PFCs are not well studied in marine mammals, PFCs have recently become contaminants of possible concern. CI belugas had higher concentrations of most PFCs compared to beluga from the eastern Chukchi but a lower median concentration of one particular type of PFC, namely perfluorooctane sulfonamide (Reiner et al. 2011). Temporal trends indicated most PFC concentrations have steadily increased from 1989 to 2006, whereas a study involving sea otters from lower Cook Inlet has shown a general decrease since about 2001 (Hart et al. 2009). Previous studies examining PFCs in beluga livers from the Canadian Arctic have found individual PFC concentrations >150 ng/g (Kelly et al. 2009 and Tomy 2009 as cited in Reiner et al. 2011), notably higher than values from CI belugas. Differences suggest different sources or transport pathways for these compounds, which can be related to the geographic differences in the long-range atmospheric transport of PFCs, oceanic transport of PFCs, local releases, and/or feeding habits (Reiner et al. 2011).

3. Polycyclic Aromatic Hydrocarbons

This class of compounds is naturally occurring in fossil fuels and is also released from forest fires, industrial products (e.g., asphalt and coal tar), and the incomplete combustion of coal, oil, gas, or organic waste (compounds of particular concern are benzo(a)pyrene, anthracene, and pyrene). These are some of the most widespread organic pollutants. The PAH compounds are lipophilic (oil-loving), with larger compounds even less water-soluble and less volatile. Because of these properties, PAHs in the environment are found primarily in soil, sediment, and oily substances, as opposed to water or air. However, they are also a component of concern in particulate matter suspended in air. Representing the most toxic components of oil, and including 16 compounds, PAHs are considered priority pollutants by the World Health Organization and the U.S. Environmental Protection Agency (EPA). The PAHs can enter the environment in a number of ways, including, but not limited to: oil and gas development activities; run-off from streets or parking areas; leakage from watercraft; oil spills; natural oil seeps and forest fires. One PAH, benzo(a)pyrene, has been identified as the most likely cause of high numbers of cancers in belugas from the SLE; in addition, PAHs have numerous known effects besides carcinogenesis in mammals, and these include effects on reproduction and survival of offspring.

A study analyzed PAH levels in belugas, prey species, and sediments from Cook Inlet. The highest PAH levels in the sampled sediments were found in Eagle Bay (Wetzel et al. 2010). Although naphthalenes, anthracenes, and phenanthrenes were the most ubiquitous classes of PAHs found, benzo(a)pyrene was also detected in all sediment samples (Wetzel et al. 2010). The data suggested inputs from both combustion and fresh oil. Total PAH levels were moderate, relative to those found in other locations known to have environmental problems with PAH contamination (Wetzel et al. 2010). The same general patterns occurred in the salmon, eulachon and saffron cod, but the fish contained slightly higher amounts of pyrene and fluorine constituents than did the sediments (Wetzel et al. 2010). The highest PAH values were in eulachon taken from the Little Susitna River (Wetzel et al. 2010). Some Chinook salmon from Ship Creek contained notable levels of total PAHs in their flesh; roe from some sockeye salmon was also notably high in total PAHs (Wetzel et al. 2010).

As noted above, an especially strong correlation was found between high levels of PAHs and illness and mortality of belugas in the SLE and humans living in the vicinity (Martineau et al. 1994, 2002), underscoring the susceptibility of both species to this class of contaminants. Although the correlation suggests a cause and effect relationship, none has been proven for the beluga. The chronic PAH contamination in SLE represents a clear threat to the health status of resident species; SLE belugas have shown a greater prevalence of cancer than any other group of cetaceans in the world (Martineau et al. 2002). One particular PAH, benzo(a)pyrene, appears to be the primary culprit.

CI belugas appear to bioaccumulate PAHs from the environment, including from their prey. CI belugas have much higher PAH levels than do subsistence-harvested belugas from MacKenzie River Delta (Wetzel et al. 2010). Highest PAH levels in CI beluga livers were found in three adult males and a female fetus; the highest levels in blubber were from adult females and fetuses (Wetzel et al. 2010). The most prevalent types of PAHs found in beluga liver samples were fluorenes, anthracenes, and phenanthrenes (Wetzel et al. 2010). No benzo(a)pyrene was detected. PAH concentrations in the blubber of females were statistically higher than in males (Wetzel et al. 2010). The most prevalent types of PAHs found in beluga blubber were naphthalenes, fluorenes, anthracenes, and fluoranthracenes; small amounts of benzo(a)pyrene were found in some blubber samples (Wetzel et al. 2010).

4. Metals

CI belugas had lower levels of metals of concern than other beluga populations, including mercury, which was below the liver threshold value of concern of 60mg/kg. The one element that did not follow this pattern was copper; copper levels in livers of CI belugas were two to three times higher than in Arctic Alaska belugas and similar to Hudson Bay belugas (Becker 2000). While copper has not been associated with toxic effects in CI belugas, these levels are substantially higher than the renal damage values (29 mg/kg) reported for Australian bottlenose dolphins (Lavery et al. 2009).

5. Emerging Chemicals

Becker (National Institute of Standards and Technology, pers. comm.) reported that CI belugas have significantly higher total levels of the brominated flame retardant Hexabromocyclododecane than the Eastern Chukchi Sea belugas from Point Lay, but demonstrated that levels in Alaskan belugas are lower than those measured in SLE belugas (Lebeuf et al. 2004) and California sea lions (Stapleton et al. 2006). However, other studies report that another class of flame retardants, PBDEs, are increasing over time in Chukchi Sea belugas and in CI Inlet belugas (Hoguet et al. 2013) as they are in SLE belugas (Lebeuf et al. 2004).

Data for the other chemicals of possible concern (Table G2) are either not available or could not be evaluated at this time due to a lack of readily available threshold concentrations. However, toxicity reference values are available for some non-cetacean marine mammals, and these could be used to develop body burden-based screening levels for belugas.

In general, for the contaminants that have been studied, CI belugas appear to have lower levels of contaminants stored in their bodies than do other populations of belugas. Additionally, chemical analyses of water and dredging sediments from Cook Inlet found that contaminants analyzed were below management levels, and some were below detection limits (Frenzel 2002;

U.S. Army Corps of Engineers [Corps] 2003). However, new chemicals of concern are developed or recognized on a regular basis. One study of organohalogen contaminants in Canadian beluga whale liver contained previously unidentified compounds and metabolites which may be impacting the health of Canadian beluga whale populations (McKinney et al. 2006).

6. Ototoxic Compounds

Ototoxins are substances that temporarily or permanently damage hearing. These compounds include several chemicals already discussed (Table 8 and G2) and come from several classes of chemicals including: organic solvents (carbon disulphide, heptane, hexane, perchloroethylene, Stoddard solvent, trichloroethylene); pesticides; alcohols (butanol, ethanol); heavy metals (arsenic, lead, manganese, mercury, organic tin); drugs (aminoglycosides, aspirin, furosemide); PAHs (toluene, benzene, styrene, xylene); and other miscellaneous compounds (acrylonitrile, carbon monoxide, cyanide, organophosphates, paraquat) (Morata and Little 2002, Teixeira et al. 2002, Steyger 2009). Organic solvents include alcohols, paints, adhesives, and fuels, including jet fuel (both commercial and military grade), which contain a variety of ototoxic aromatic hydrocarbons including toluene, styrene, ethyl benzene, and xylene (Steyger 2009). These chemicals can be absorbed through the respiratory tract, the skin, or the gastrointestinal tract. Our understanding of the effects of these compounds on the hearing of marine mammals is limited; however, hearing deficits have been established in cetaceans, including belugas, which were treated with aminoglycosides, a class of antibiotics known to be ototoxic (Finneran et al. 2005). When exposure to ototoxic chemicals is combined with exposure to noise, hearing loss is exacerbated by increasing both the breadth and severity of permanent threshold shifts; hearing loss can even occur at subtoxic chemical and sub-traumatic noise levels, which would cause little or no hearing loss in the absence of the other agent (Steyger 2009). The synergistic effect of noise and organic solvents is more serious after repeated exposure at lower levels (Steyger 2009).

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H. Summary of a Cause of Death Analysis of 34 Necropsied CI Belugas

NOTE TO READER: The text below was developed by the Cook Inlet Beluga Whale Recovery Team and is a detailed description of an analysis of necropsies of 34 CI belugas conducted by Burek-Huntington et al. (2013) from 1998–2009. In Section II.D.3 of this document, we provided information on causes of death in necropsied CI belugas sufficient to justify recovery criteria and actions, including new information for necropsies of four CI belugas conducted from 2010–2013 (for those four belugas, trauma was determined to be the cause of death; for additional details, see Huntington-Burek et al. 2015). Additional information about the necropsy results from 1998–2009 follows.

From 1998 to 2009, only 34 carcasses out of 136 observed dead stranded belugas (Table H1) were subjected to some degree of post-mortem examination or necropsy. These carcasses were concentrated close to Anchorage and along the road system (Figure H1). In the 34 CI beluga carcasses examined between 1998 to 2009, the cause of death was not identified in a third of the cases examined, primarily because the vast majority were in an advanced state of decomposition (Burek-Huntington et al. 2013). Categories of identified causes of death in CI belugas are discussed below.

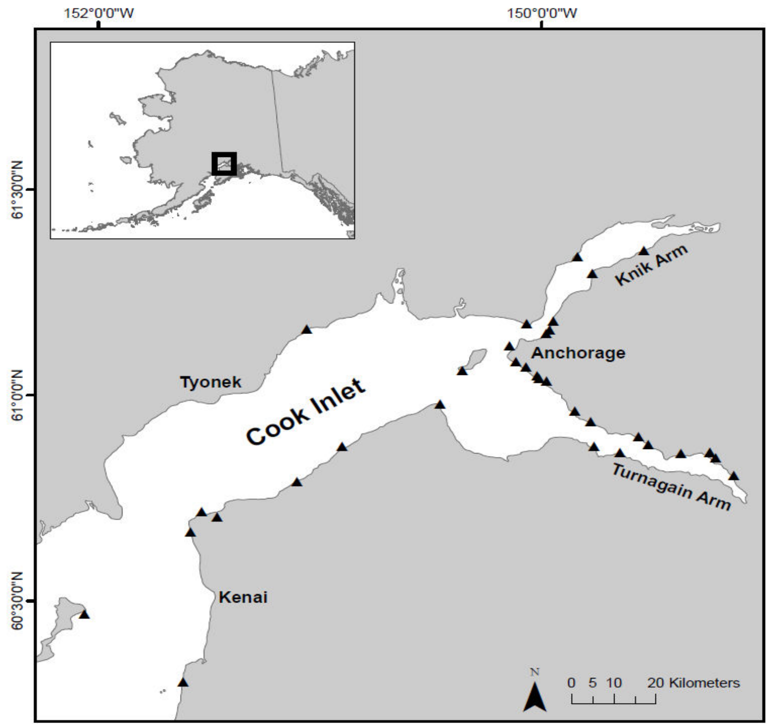
1. Perinatal/Neonatal Mortality

Perinatal mortalities included deaths of four fetuses and one neonatal beluga calf in Cook Inlet (Burek-Huntington et al. 2013). All four fetuses were in an advanced state of decomposition and a clear cause for the abortion or stranding was not found. It is noteworthy that all four fetuses were recovered in 2008, which may suggest a common cause, but the sample size and insufficient common findings from postmortem exams and testing makes it impossible to support such a conclusion. Neonatal mortalities and dystocia (complications during birth) have also been observed in aquariums and in animals from the SLE (Table H2). In the wild, carcasses of young animals would be harder to find due to their small size and tendency to sink, so perinatal mortalities are undoubtedly underreported. Olesiuk et al. (1990) inferred that mortality during the first few months of life of killer whales in British Columbia could be as high as 37–50%. Hammill (2007) reported a fairly low rate of neonatal mortalities in SLE belugas during the time period covered by the report; however, in 2010 to 2012 there has been a notable increase in perinatal morality for SLE beluga adult females and calves (P. Béland, St. Lawrence National Institute of Ecotoxicology, unpub. data).

2. Infectious Diseases

Nineteen of the 34 examined stranded CI belugas had at least one disease and 11 had two or more diseases considered contributory to death, including bacterial, viral, and parasitic diseases (Table H3). However, diseases are easily missed in decomposed carcasses, which describes most of those examined from Cook Inlet. Therefore, the reported contribution of disease to overall mortality rates represents a minimum (Burek-Huntington et al. 2013). A greater proportion of deaths due to infectious diseases was seen in SLE, 32% (S. Lair pers. comm. to C. Goertz), and in oceanaria, 51% (L. Dunn, pers. comm. to C. Goertz), where carcasses are more reliably accessed in a timely manner.

Bacteria: Bacterial infections implicated as the cause of death in examined CI belugas included a systemic infection, pneumonia, and lung abscess (Burek-Huntington et al. 2013).



Source: Burek-Huntington et al. 2013.

Figure H1. Distribution of 34 CI beluga carcasses examined (1998–2009).

Culture of specific bacteria was not possible because of advanced decomposition, but organisms were seen on microscopic examination of tissues. Bacterial infection was the major cause of mortality in captive belugas (L. Dunn, pers. comm. to C. Goertz). Pathogenic bacteria isolated from captive beluga include *Nocardia* spp. (MacNeil et al. 1978), *Erysipelothrix* (Calle et al. 1993), *Vibrio parahaemolyticus* (Higgins 2000), *Edwardsiella* (Higgins 2000), and *Mycobacterium* (Bowenkamp et al. 2001). Several bacteria (*Edwarsiella tarda*, *Aeromonas hydrophila*, *Vibrio cholera*, *Vibrio fluvialis*, *Kingella kingae*, *Morganella morganii*, *Pleisiomonas shigelloides*, *Shewanella putrefaciens*, *and Nocardia* spp.*)* that affected SLE beluga are generally found in water with high loads of organic pollutants (L. Dunn, pers. comm.to C. Goertz; Martineau et al. 1988; De Guise et al. 1995a; Martineau 2003). The high bacterial load of the SLE likely contributes to these bacterial infections (St. Lawrence Centre 1996). Bacteria identified in the deaths of SLE belugas were typically opportunistic, normally found in the environment and/or healthy hosts, but usually only causing disease when the host's immunological defenses were compromised. Any factor that results in a compromised immune system may render SLE belugas, and presumably other belugas, more susceptible to opportunistic bacteria.

Viruses: The only virus identified in CI belugas was the herpes virus, which was the cause of death in one case (Burek-Huntington et al. 2013). Herpes viral dermatitis was an incidental finding in other CI belugas examined post-mortem, and herpes-like marks have been observed in photographs of live CI belugas (T. McGuire, LGL, pers. comm.). This type of herpes infection is typically localized, usually not significant to the overall health of the animal, and eventually becomes latent leaving a distinctive scar. However, latent infections can be reactivated by such factors as stress and immune-suppression and can further compromise the individual (Kennedy et

Table H1. Synthesis of primary cause of death of animals from different beluga populations as assessed by the references.

Cause of death	CI beluga (1998 to 2009, *n* = 34) [a] (%)	St. Lawrence Estuary beluga (1983 to 2012, *n* = 222) [b] (%)	North American oceanaria beluga (1974 to 2000, *n* = 45) [c] (%)
Degenerative	0	4	7
Neonatal/perinatal	15	7	11
Infectious disease	9	32	51
o Bacterial	0	14	31
o Viral	3	0	7
o Combined bacterial / parasitic	6	0	0
o Parasitic	0	18	2
o Fungal	0	0	7
o Not determined	0	0	4
Nutritional	9	—	—
Neoplasia	0	15	5
Trauma	9	6	2
Post live stranding	30	—	Not applicable
Miscellaneous	0	8	11
Not determined	32	28	13

Notes: Infectious disease causes are further broken down into different types of pathogens when possible. Parasitic diseases include those due to protozoa and to metazoan parasites. When a specific pathogen could not be isolated but the lesions were consistent with an infectious etiology, the cause of death was categorized as "Infectious disease-Not determined." Miscellaneous causes of death included conditions with vague causation or conditions that did not fit well in the other categories including anaphylaxis and drowning in captive belugas, dystocia (abnormal labor or birth) in wild belugas, and fishing gear entanglement.

Sources: [a] Burek-Huntington et al. 2013; [b] S. Lair, pers. comm. to C. Goertz; [c] L. Dunn, pers. comm. to C. Goertz.

Table H2. Summary of causes of death, contributing factors, and incidental findings from carcasses of 34 CI belugas examined (1998–2009).

Diagnostic category	Cause of death (*n*)	Cause of death (%)	Contributing factor	Incidental
Unknown	11	32	0	0
Perinatal	5	15	0	0
Mass Stranding	5	15	0	0
Single Stranding	4	12	0	0
Trauma	3	9	1	1
Nutrition	3	9	3	0
Disease	3	9	33	31
Environmental	0	0	5	0
Total	**34**	**100**	**42**	**32**

Source: Burek-Huntington et al. 2013.

al. 1992). Serological testing for antibodies to viral diseases of concern is only possible with blood from a live or very freshly dead animal, which does not include any of the carcasses in the CI beluga mortality study; in addition, serological testing has not been done on samples from live-captured CI belugas, so it is unknown what other viruses may be active in this population. Viruses have been implicated in the death of three captive belugas including one with herpes virus-like particles identified by transmission electron microscopy (L. Dunn, pers. comm. to C. Goertz). A few SLE animals had microscopic lesions of non-suppurative encephalitis, most consistent with a viral etiology; however, a subsequent test could not identify a specific virus, and the clinical significance of these lesions was not always clear, even if this inflammation of the brain was believed to have been the cause of the stranding in the most severe cases (S. Lair, pers. comm. to C. Goertz).

Parasites: Significant parasitic infestations were noted in the lungs and kidneys of many necropsied CI belugas, sometimes in both sets of organs in the same individual. Thirteen animals (38%) had varying degrees of lungworm infection from incidental infection to association with bronchopneumonia. The species of pulmonary nematodes or roundworms in CI belugas has not been identified; species known to affect belugas include *Pharurus pallasii*, *Stenurus artomarinus*, *Halocercus monoceris*, and *Stenurus minor* (Measures 2001). In some beluga populations, infection with pulmonary nematodes was found in otherwise healthy robust animals, possibly suggesting a commensal relationship (Woshner et al. 2001). However, in SLE belugas, lungworms were listed as a significant factor in stranding mortalities (Martineau et al. 2003), and pneumonia, usually of parasitic origin, was one of the most common causes of death (De Guise et al. 1995b).

Single kidneys from 19 of 26 CI belugas contained a nematode identified as *Crassicauda giliakiana*, which has been only rarely observed in other beluga populations (Martineau et al. 1988, De Guise et al. 1995a, Vlasman and Campbell 2003, Burek-Huntington et al. *2013*). While extensive damage and tissue replacement has been noted in some kidneys from CI belugas, it is unclear whether this change results in functional damage since up to 75% of a kidney can be damaged in other species before causing renal failure. However, heavy burdens could compromise young animals or individuals stressed by other conditions. The life cycle of *C. giliakiana* is not well understood. If an intermediate host is involved, the relatively high prevalence of kidney nematodes in CI belugas likely reflects a variation in their diet as compared to other beluga populations.

Other parasites found in CI belugas includes nematodes in the gastrointestinal tract (*Anisakis* or *Contracaecum* sp.) and in blubber (a *Crassicauda* sp.) as well as protozoa in muscle (*Sarcosystis* sp.), but were considered incidental and did not contribute to death (Burek-Huntington et al. 2013). One instance of a trematode infection, most likely a *Campulid*, was noted in a liver. Endoparasites found in other beluga populations include: gastrointestinal nematodes (*Contracaecum* spp., *Anisakis simplex* sometimes in association with ulcers, *Leucastella arctica*) (Klinkhart 1966; Department of Fisheries and Oceans [DFO] and World Wildlife Fund 1995); trematodes or flukes (*Hadwenius seymouri*); and protozoa (*Toxoplasma* and *Sarcocysitis* spp.) (Kenyon and Kenyon 1977, Wazura et al. 1986, De Guise et al. 1993, Martineau et al. 1994, Mikaelian et al. 2000, Measures 2001, Woshner 2001, Houde et al. 2003). *Trichinella spiralis*, a nematode found in muscle, was reported from one beluga from the Arctic coast of Alaska (Brandly and Rausch 1950). Many of these parasites are transmitted primarily

Table H3. Types of diseases described in stranded CI belugas and their coded significance from 34 carcasses of CI Belugas that were examined (1998–2009) as part of mortality and morbidity study.

Type of disease	Cause of death	Contributing factor	Incidental
Combined bacterial / parasitic infections	2		
Herpesviral infection	1		3
Parasites			
Protozoa-muscle			3
Metazoan parasites:			
Nematode - kidney		14	5
Nematode - blubber			9
Nematode - lung		11	2
Nematode - stomach			5
Trematode - liver		1	
Cardiopulmonary disease		6	2
Inflammatory, misc.		1	2
Total	**3**	**33**	**31**

Source: Burek-Huntington et al. 2013.

through the ingestion of infected prey and often do not affect the host's general health. Parasitic disease in captive animals is rarely seen due to the use of anthelminthics (i.e., drugs that expel parasitic worms from the body) and the practice of feeding restaurant-quality, frozen fish, which disrupts parasitic life cycles.

Fungi: Fungal organisms, including candida and *Aspergillus fumigatus*, have been implicated in the deaths of some captive animals but may be related to the use of antibiotics, which, in addition to suppressing pathogenic bacteria, can also suppress normal flora that helps protect against fungal diseases. Additionally, captive facilities put belugas in closer proximity to environmental sources of fungal organisms, which are not normally found in open waters. However, fungal and other infectious organisms can be liberated during major earth-moving operations and may travel airborne some distance (Bowenkamp et al. 2001). There have been no reports of fungus-related death in Cook Inlet or SLE animals.

Harmful Algal Blooms (HABs): HABs have the potential of producing toxins that can kill marine mammals or make them more susceptible to death due to other causes, such as predation or boat strikes. Additionally, algal blooms are expected to increase with the warmer ocean conditions anticipated for Alaska in the coming years. As part of Food and Drug Administration requirements, the ADEC tests all commercial shellfish for Paralytic Shellfish Poisoning (caused by harmful algae) as part of their Marine Biotoxin Program. However, commercial shellfish harvesting in Cook Inlet is limited to the area between Polly Creek and Crescent River in upper Cook Inlet and to Kachemak Bay in lower Cook Inlet, leaving large areas unmonitored. Furthermore, ADEC does not routinely test for other harmful algal toxins. The Kachemak Bay Research Reserve participates in NOAA's Phytoplankton Monitoring Network, though participation is relatively new and has been sporadic. A high-mortality event of SLE belugas was caused by an algal bloom in 2008 (Lair et al. 2009).

Findings of disease in other marine mammals in Cook Inlet: There is limited evidence of disease transfers among marine mammal species. However, because beluga and other species may be exposed to the same disease source via prey or the environment, understanding conditions that affect other marine mammals in Cook Inlet could provide insight into pathogens that might also affect belugas. Stranded harbor seals (n = 59) found in Cook Inlet during 1997 to 2011 were screened for a variety of diseases (Goertz, in prep). Most seals were young of the year and found by serology to be negative for evidence of exposure to the following diseases: avian influenza, canine distemper virus, dolphin morbillivirus, porpoise morbillivirus, *Leptospira canicola*, *L. grippotyphosa*, *L. pomona*, *Neospora*, *Sarcocystis*, and *Toxoplasma*. One animal tested positive for antibodies against *Brucella* spp. and another was positive for phocine distemper virus. A few animals tested positive for antibodies to seal herpesvirus-1, *L. Bratislava*, *L. hardjo*, *and L. icterohemorrhagiae*. All titers were stable or declining, suggesting waning maternally derived antibodies, except one animal had an increasing titer for seal herpesvirus-1. Fecal pathogen screenings yielded low levels of pathogenic and opportunistic bacteria, though none of concern for seal health. Causes of mortality and morbidity of Northern sea otters in Cook Inlet have also been intensely investigated, in part because of an unusual mortality event in lower Cook Inlet involving a streptococcal infection associated with heart damage, encephalitis, and sepsis. The source of the highly pathogenic bacteria and the conditions that may predispose sea otters to infection were not determined (Counihan-Edgar et al. 2012).

3. Trauma

Trauma was the cause of death in three (9%) of the cases that formed the basis of the mortality review in Cook Inlet (Burek-Huntington et al. 2013); two cases involved killer whale interactions, and one was blunt trauma from an unknown source. Two lactating females were found dead with rake marks consistent with killer whale attacks, following an observed interaction between killer whales and a large group of belugas on 23–26 of September 2000 (Vos et al. 2005). Only one of these lactating females was necropsied and included in the mortality review. Another adult female found in 2007 had extensive blunt trauma, and the final trauma case was coded based on tissues collected in September 2008 from the site of a witnessed killer whale attack on a beluga. Net entanglements or propeller injuries were not confirmed in nonspecific trauma cases, which may have been due to the poor carcass conditions. Photo-identification studies have documented several live CI belugas with scars consistent with propeller injuries and rake marks (LGL 2009). Shelden et al. (2003) estimated killer whales kill an average of one beluga/year, although this could be an underestimate. Additional information about killer whale interactions is included in Sections II.D.1.and III.A.9. Of the 6% of SLE deaths attributed to trauma, the majority were due to boat strike (S. Lair, pers. comm. to C. Goertz). One beluga from an aquarium was euthanized due to complications associated with a mandibular infection secondary to a traumatic injury (L. Dunn, pers. comm. to C. Goertz).

4. Nutritional Stress

Six belugas from Cook Inlet included in the mortality review were in poor body condition; namely, they were so thin that poor nutrition was considered either the cause of, or a contributing factor to, death (Burek-Huntington et al. 2013). One of the contributory cases involved a fetus with no measurable blubber layer, implying poor nutritional status of the mother. Causes of poor nutrition could be due to lack of appropriate prey, inability to obtain prey due to debilitation from secondary injury or infection, or a disease process itself. Most of these animals were young;

only one was a mature whale. This category was not used in assigning cause of death in the SLE data that were provided; however, primary starvation is being considered as a cause of death in some cases currently assigned to the "other" category (S. Lair, pers. comm. to C. Goertz).

5. Degenerative Conditions

Cardiomyopathy, or heart damage, was noted but not considered a cause of, or contribution to, death in three older CI belugas and may have been age related. Ruptured vessels have been diagnosed in a captive animal with an aortic rupture (Bowenkamp et al. 2001) and in three SLE adult males with pulmonary trunk aneurysms (Martineau et al. 1986). Central nervous system abnormalities, namely encephalomalacia (softening of the brain) and encephalopathy (brain degeneration) of unknown cause, have been diagnosed in captive animals (L. Dunn, pers. comm. to C. Goertz). Due to the difficulties involved in opening a beluga skull in the field, it is rare that the brain of CI beluga is examined.

6. Miscellaneous

Ice entrapment: While reported in other cetaceans and other populations of belugas (Armstrong 1985, Heide-Jørgensen et al. 2002), there have not been reports of ice entrapment of CI belugas nor of mortalities that may have been due to such an event. Given the environmental conditions during the winter and decreased human presence in the Inlet, such an event may go unnoticed.

Cancer: Cancer is a major cause of mortality in SLE beluga (15%) and may relate to their heavy contaminant loads (Martineau et al. 2002). Cancers have also been observed in captive belugas (Ridgway et al. 2002) and accounted for 5% of the deaths in oceanaria (L. Dunn, pers. comm. to C. Goertz). There have been no reports of cancer in CI belugas.

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I. Common and Scientific Names of Species

The following is a list of common and scientific names of species identified in this recovery plan.

Common Name	Scientific Name
Amphipod	Crustaceans, Order Amphipoda
Beluga whale	*Delphinapterus leucas*
Blue whale	*Balaenoptera musculus*
Bottlenose dolphin	*Tursiops truncatus*
Budgerigar	*Melopsittacus undulates*
Butter sole	*Isopsetta isolepis*
California sea lion	*Zalophus californianus*
Capelin	*Mallotus villosus*
Chinook (king) salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Clams	Animals of the class Bivalvia
Coho salmon	*Oncorhynchus kisutch*
Cuvier's beaked whale	*Ziphius cavirostris*
Dall's porpoise	*Phocoenoides dalli*
Eulachon	*Thaleichthys pacificus*
Flathead sole	*Hippoglossoides elassodon*
Gray whale	*Eschrichtius robustus*
Grayling	*Thymallus thymallus*
Great white shark	*Carcharodon carcharias*
Greenland shark	*Somniosus microcephalus*
Harbor porpoise	*Phocoena phocoena*
Harbor seal	*Phoca vitulina*
Hermit crab	Crabs, superfamily Paguroidea
Humpback whale	*Megaptera novaeangliae*
Killer whale	*Orcinus orca*
Longfin smelt	*Spirinchus thaleichthys*
Minke whale	*Balaenoptera acutorostrata*
Narwhal	*Monodon monoceros*
North Atlantic right whale	*Eubalaena glacialis*
Northern pike	*Esox lucius*
Northern shrimp	*Pandalus borealis*
Pacific cod	*Gadus macrocephalus*
Pacific halibut	*Hippoglossus stenolepis*

Common Name	Scientific Name
Pacific herring	*Clupea pallasi*
Pacific sandfish	*Trichodon trichodon*
Pacific sandlance	*Ammodytes hexapterus*
Pacific sleeper shark	*Somnoisus pacificus*
Pacific staghorn sculpin	*Leptocottus armatus*
Pacific tomcod	*Microgadus proximus*
Pink salmon	*Oncorhynchus gorbuscha*
Polar bear	*Ursus maritimus*
Red king crab	*Paralithodes camtschatica*
Saffron cod	*Eleginus gracilis*
Salmon shark	*Lamna ditropis*
Sea otter	*Enhydra lutris*
Snake prickleback	*Lumpenus sagitta*
Sockeye salmon	*Oncorhynchus nerka*
Spiny dogfish	*Squalus suckleyi*
Sponges	*Animals of the phylum Porifera*
Starry flounder	*Platichthys stellatus*
Steller sea lion	*Eumetopias jubatus*
Tanner crab	*Chionoecetes bairdi*
Trout	*Freshwater fish, subfamily Salmoninae*
Walleye pollock	*Theragra chalcogramma*
Weathervane scallops	*Patinopecten caurinus*
Whitefish	*Freshwater fish, subfamily Coregoninae*
Yellowfin sole	*Limanda aspera*