# Cook Inlet Beluga Whale Science Conference

*hosted by* ***National Marine Fisheries Service, Alaska Region***

**October 11 & 12, 2010**

**Anchorage Downtown Marriott, Alaska**

# Agenda and Abstracts

**http://www.alaskafisheries.noaa.gov/protectedresources/whales/beluga.htm**

## INTRODUCTION

Management responsibility for beluga whales in Alaska has been delegated by the Secretary of Commerce to the National Marine Fisheries Service (NMFS), Alaska Region. NMFS designated the Cook Inlet beluga whale stock as depleted under the Marine Mammal Protection Act of 1972, as amended (65 FR 34590) on May 31, 2000. On October 22, 2008, NMFS listed the Cook Inlet beluga whales as an endangered species under the Endangered Species Act of 1973, as amended (73 FR 62919). NMFS plans to publish the final rule on critical habitat designation for the Cook Inlet beluga whales later this month.

In an effort to try to understand the lack of recovery in this population, NMFS has funded Cook Inlet beluga whale research for several years. Many recent studies NMFS funded have been, or shall soon be, published. To share the results from this recent research with the interested community, NMFS is hosting a two-day conference to present information on the Cook Inlet beluga whales. However, these presentations do not represent a comprehensive list on all the Cook Inlet beluga whale research funded by NMFS. NMFS also solicited and accepted abstracts from groups and organizations who did not receive NMFS funding for their research, but whose studies relate to Cook Inlet beluga whales.

Projects that received funding, in whole or part, from NMFS have been identified with a small dollar sign ($) prior to the title of their abstract.

The information and conclusions presented in the following abstracts are those of the researchers and do not necessarily reflect the views and opinions of NMFS.

Further information on Cook Inlet beluga whales can be found at:

http://www.alaskafisheries.noaa.gov/protectedresources/whales/beluga.htm.

# AGENDA

## Monday October 11

9:00-9:15 Welcome, purpose, and status of Cook Inlet beluga whales critical habitat designation (*NMFS*)

***TOPIC: POPULATION STRUCTURE/ABUNDANCE***

9:15-9:45 Genetic analysis of historic and prehistoric beluga whale teeth and bones from Cook Inlet: evidence of a bottleneck? *(Greg O'Corry-Crowe)*

9:45-10:15 Trends in abundance of Cook Inlet beluga whales 2001-2010 *(Rod Hobbs)*

10:15-10:30 *BREAK*

10:30-11:00 Molecular genetic analysis of population structure, dispersal and gene flow of beluga whales, *Delphinapterus leucas*, in the western Nearctic: new findings on the Cook Inlet population (*Greg O'Corry-Crowe*)

11:00-11:30 Estimated annual calving rate indices for Cook Inlet beluga whales 2006-2009 (*Rod Hobbs*)

11:30-12:00 Genetic consequences of population decline in an endangered species: results on MHC diversity in Cook Inlet beluga whales (*Greg O'Corry-Crowe*)

12:00-1:30 *LUNCH on your own*

***TOPIC: PREDATION***

1:30-2:00 Predation by killer whales in Cook Inlet: an integrated approach 2008 (*Craig Matkin)*

***TOPIC: CONTAMINANTS/WATER QUALITY***

2:00-2:30 Current-use and legacy persistent pollutants in Cook Inlet beluga whales: results from the analysis of banked tissues from the Alaska Marine Mammal Tissue Archival Project (*Paul Becker*)

2:30-3:00 Polycyclic aromatic hydrocarbon (PAH) contamination in Cook Inlet belugas (*John Reynolds*)

3:00-3:30 *BREAK*

3:30-4:00 Polycyclic aromatic hydrocarbon (PAH) contamination in sediments and fish of Cook Inlet, Alaska (*Dana Wetzel*)

4:00-4:30 Chemical exposures for Cook Inlet beluga whales (*Usha Vedagiri*)

4:30-5:00 Preliminary evaluation of the effects of wastewater discharge on Cook Inlet beluga whales (*Brett Jokela*)

**6:00-8:00 POSTER SESSION**

## Tuesday October 12

8:30-9:00 Coffee

9:00-9:15 Welcome (*NMFS)*

***TOPIC: DISTRIBUTION/MOVEMENTS***

9:15-9:45 Range contraction in a beluga whale population (*Kim Shelden*)

9:45-10:15 Probabilistic habitat of the endangered beluga whale in Cook Inlet, Alaska (*Rod Hobbs*)

10:15-10:30 *BREAK*

10:30-11:00 Hydrodynamic models and satellite remote sensing data help study the beluga whale habitat in Cook Inlet (*Tal Ezer*)

11:00-11:30 Seasonal distribution of Cook Inlet beluga whales based on passive acoustic monitoring (*Bob Small*)

11:30-12:00 Photo-identification of Cook Inlet beluga whales (*Tamara McGuire*)

12:00-1:30 *LUNCH on your own*

1:30-2:00 Cook Inlet beluga whale monitoring at Eagle Bay, Fort Richardson, Alaska 2008-2009 (*Chris McKee*)

***TOPIC: SOCIAL VALUES/HUMAN INTERACTIONS***

2:00-2:30 Relationship between the Native Village of Tyonek, Alaska and beluga whales in Cook Inlet, Alaska (*Steve Braund*)

2:30-3:00 Interactions between beluga whales (*Delphinapterus leucas*) and boats in Knik Arm, upper Cook Inlet, Alaska: behavior and bioacoustics (*Brent Stewart*)

3:00-3:30 *BREAK*

***TOPIC: STRANDINGS AND HEALTH***

3:30-4:00 Cook Inlet beluga whale strandings (*Barbara Mahoney*)

4:00-4:30 Morbidity and mortality trends in stranded Cook Inlet beluga whales (*Kathy Burek)*

4:30-5:00 Cook Inlet beluga whale diet from stomach content analysis (*Lori Quakenbush*)

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## PRESENTATION ABSTRACTS:

## POPULATION STRUCTURE/ABUNDANCE

### $Genetic analysis of historic and prehistoric beluga whale teeth and bones from Cook Inlet: evidence of a bottleneck?

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The recent decline of the Cook Inlet population of beluga whales, its current small population size (N=375), and its apparent lack of recovery since increased protection in 2000, highlight the need for a better understanding of the abundance, distribution, and genetic diversity of this population in the past. Molecular genetic analyses can theoretically address all three. Estimates of contemporary genetic diversity have been used in other species to estimate historical population size and document past distribution, while analyses of samples collected over the period of a population's decline can chart the loss of important genetic diversity that could compromise individual fitness and influence population viability. Ideally, such analyses would include tissue samples collected over very large time scales. We are using 'ancient DNA' technology combined with radiocarbon dating to investigate historic and pre-historic abundance, distribution, and genetic diversity of beluga whales in Cook Inlet. These methods are also being used to investigate population structure of this species at different times in the past. We report here on preliminary genetic analyses of osteological material, identified as beluga whale based on gross morphology, recovered from historic and pre-historic sites in lower Cook Inlet. In a specially designed clean laboratory, we modified silica-based ancient DNA extraction methods, allowing us to regularly amplify and sequence up to 500bp of mtDNA control region from 0.08 – 0.1g of drilled teeth and bone. A total of 23 specimens were collected. Nine specimens, including material dated to 36-1418 A.D., were analyzed. This highly efficient method, in combination with similarity, distance- and character-based phylogeny reconstruction analyses enabled us to determine species and in some cases mtDNA lineage. Comparison of genetic diversity among different time periods is currently underway. Future research will focus on amplifying, cloning, and sequencing several nuclear DNA markers, including genes from the major histocompatibility complex (MHC), microsatellite loci, and regions of the X and Y chromosome. More material will also be accessed from museum collections.

### $Trends in abundance of Cook Inlet beluga whales 2001-2010

*R. Hobbs[1], K. Shelden[1], D. Rugh[1]*

[1]National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way, NE, Seattle, WA 98115

The Cook Inlet stock of beluga whales is genetically distinct and geographically isolated from beluga populations around Alaska and the Arctic. In 1999 this population was determined to be depleted under the Marine Mammal Protection Act, and in 2008 it was listed as endangered under the US Endangered Species Act. Efforts are underway to develop recovery criteria for this population. Each year 1994-2010 National Marine Mammal Laboratory has conducted an aerial survey to estimate the abundance of the Cook Inlet beluga. We present here the 2010 abundance estimate and review the trends in abundance and the estimates of extinction risk and probability of recovery in light of the addition of the 2010 estimate to the time series.

### $Molecular genetic analysis of population structure, dispersal and gene flow of beluga whales, *Delphinapterus leucas*, in the western Nearctic: new findings on the Cook Inlet population

*G. O'Corry-Crowe[1, 2], R. Suydam[3], A. Frey[2], B. Mahoney[4], L. Quakenbush[5], L. Harwood[6], W. Goodwin[7], R. Hobbs[8]*

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A primary impetus for genetic investigations of dispersal, gene flow, and population subdivision in beluga whales has been the identification of management units. Concerns over the effects of climate change and the failure of small populations to recover has added greater urgency. Earlier work focused on patterns of variation within mitochondrial DNA (mtDNA). While this marker documents patterns of female dispersal over time, and is sufficient to resolve the demographic relationships among beluga groupings, the resolution of male dispersal and breeding behavior requires the examination of variation within nuclear DNA (nDNA) markers. Here, we expand on the earlier mtDNA work and add an analysis of nDNA variation in beluga whales from the Gulf of Alaska, and the Bering, Chukchi and Beaufort Seas. Analysis of mtDNA variation in 674 belugas revealed a pattern of strong female-mediated philopatry to traditional summering grounds. Of the five major beluga whale concentrations in the western Nearctic, the small population in Cook Inlet was found to be the most distinct ($F_{st}$ ≥0.39 and $\Phi_{st}$ ≥0.41, $P$ <0.0001). Further, the slow rate at which populations diverge for mtDNA suggests that this population may be demographically distinct from other populations for a long time. Analysis of polymorphism within 8 nuclear loci in 538 whales revealed limited male- as well as female-mediated gene flow. As with mtDNA, Cook Inlet was the most distinct ($F_{st}$ =0.057; $R_{st}$ =0.113, P<0.0001). Non-spatial Bayesian inference revealed that two genetically discrete clusters ($K$=2), corresponding to Cook Inlet and the Bering-Chukchi-Beaufort areas combined, were most consistent with the data, while spatial clustering also identified the primary break between Cook Inlet and all other populations. This study presents a more complete picture of beluga whale dispersal and breeding patterns in the western Nearctic. Knowledge gained on male and female behaviors will facilitate management decisions and the modeling of the impacts of environmental change. Regarding one of the most pressing management issues, this study indicates that while immigration may occur, the small population in Cook Inlet is essentially isolated on management timescales.

### $Estimated annual calving rate indices for Cook Inlet beluga whales 2006-2009

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The Cook Inlet stock of beluga whales is genetically distinct and geographically isolated from beluga populations around Alaska and the Arctic. In 1999 this population was determined to be depleted under the Marine Mammal Protection Act, and in 2008 it was listed as endangered under the US Endangered Species Act. Efforts are underway to develop recovery criteria for this population. An early indicator of change in the growth or decline of a population is a change in the calving rate. To develop a calving rate index, NMML has conducted aerial surveys each August since 2005. These surveys are dedicated to

seeking out groups of beluga whales. Video recordings are collected during multiple passes over the whale groups. Group sizes are estimated from a wide angle video while ratios of calves to adults are estimated from high resolution zoomed in video or still photos sampling a portion of the group. Ratios from each sampled group are averaged. These averages are then applied to estimated group sizes to estimate a calving rate index for the population each year. The calving rate indexes are used in an age and sex structured population model to estimate population growth rates and assess the value of the in information the calving rate indices to the assessment of extinction risk and intrinsic growth rate.

### $Genetic consequences of population decline in an endangered species: results on major histocompatibility complex (MHC) diversity in Cook Inlet beluga whales

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The apparent failure of the small, endangered population of beluga whales (*Delphinapterus leucas*) in Cook Inlet to recover from a dramatic population decline in the 1990s, despite the cessation of the known cause of the decline, raises the question of whether there may be intrinsic factors associated with this failure to thrive. We recently initiated a study to investigate changes in the genetic components of individual fitness and population viability of the Cook Inlet whales over time. One important question is whether the recent decline resulted in the loss of biologically relevant genetic variability. Our initial research has focused on characterizing genetic diversity within the major histocompatibility complex (MHC), a suite of genes involved in the immune response where diversity at the population level has been linked to population viability in a number of species. We report on our preliminary findings here. The peptide binding regions of the DQβ and DRB genes from a number of beluga whales from Cook Inlet and two other populations were successfully amplified and sequenced. Amplicons were cloned into a plasmid vector and screened for allelic diversity using Invitrogen's TOPO®-TA cloning kit. Ligation, transformation, and colony screening were performed multiple times and both strands were sequenced using M13 primers. Allelic characterization is ongoing but initial results are yielding multiple alleles. Future work will involve mass screening of samples from Cook Inlet and two other populations: a small, stable, sub-arctic population and large, arctic population. Historic and pre-historic samples will also been screened using ancient DNA methods, and individual MHC profiles will be compared to independent estimates of reproductive success and survivorship.

## PREDATION

### $Predation by killer whales in Cook Inlet: an integrated approach

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Killer whales are listed as a possible factor in the lack of recovery of the endangered Cook Inlet, Alaska beluga whales and have been suggested as agents in the decline of other marine mammal species as well. In this pilot study we initiated work to photo-document individuals and observe killer whale feeding ecology when they enter Cook Inlet. In 15 encounters with killer whales in lower Cook Inlet, five were with mammal eating transients. Sightings/photographs were also contributed by charter boats. Observed prey included non-calf humpback whales, minke whale, and sea otter. Weather, tidal conditions, and the infrequent encounter rates make work on killer whales entering lower Cook Inlet problematic. A sighting network, rapid response capabilities, and a systematic observer network in upper Cook Inlet are suggested in future examination of killer whale predation on beluga.

## CONTAMINANTS/WATER QUALITY

### $Current-use and legacy persistent pollutants in Cook Inlet beluga whales: results from the analysis of banked tissues from the Alaska Marine Mammal Tissue Archival Project (AMMTAP)

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The Alaska Marine Mammal Tissue Archival Project (AMMTAP) has been collecting and banking tissues from Alaskan beluga whales, *Delphinapterus leucas*, for the last 20 years. Recently, liver and blubber samples collected and banked from both the Cook Inlet and the Bering Sea beluga populations were analyzed for a variety of current-use and legacy persistent pollutants (POPs), heavy metals and trace elements. POPs determined in the samples included polychlorinated biphenyl (PCBs) congeners, toxaphene congeners, legacy organochlorine pesticides, polybrominated diphenyl ether (PBDE) congeners, and hexabromocyclododecane (HBCD) isomers in blubber and perfluorinated compounds (PFCs) in liver samples. The liver samples are also being analyzed for 20 trace elements, including mercury. Results of this study provide a good basis for direct comparison of contaminant levels in the Cook Inlet animals with belugas occurring in a region thought to be less influenced by anthropogenic pollutants. Concentrations of most POPs were influenced by both collection year and population (Cook Inlet vs Eastern Chukchi Sea). For example, total HBCDs increased significantly with collection year in blubber samples as did seven of the PFCs measured in liver samples. Also the pattern of contribution of individual PFCs to the total PFC concentration was much different in the Cook Inlet belugas as compared to that of the Eastern Chukchi Sea animals. These and other differences between the two beluga populations will be presented and discussed.

### $Polycyclic aromatic hydrocarbon (PAH) contamination in Cook Inlet belugas

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Despite protective legislation and certain regulations of human activities including subsistence hunting, the population of belugas occupying Cook Inlet has not shown signs of recovery for a decade or longer. A Conservation Plan prepared by the National Marine Fisheries Service identified potential threats that might impede recovery. Our study addresses one concern identified in the Plan: pollution associated with oil and gas development and other activities that could introduce polycyclic aromatic hydrocarbons (PAHs) into the habitat and wildlife of Cook Inlet. Although levels and effects of PAHs have received relatively little attention among marine mammal scientists and managers, PAHs represent the most toxic components of oil, and include 16 compounds considered priority pollutants by the World Health Organization and the US Environmental Protection Agency. One PAH (benzo-a-pyrene; BAP) has been identified as the cause of high numbers of cancers in belugas from the St. Lawrence Seaway, and PAHs have numerous known effects besides carcinogenesis in mammals; these include effects on reproduction

and survival of offspring. Our study assessed PAH levels in liver and blubber from deceased Cook Inlet belugas (samples archived and provided by NIST). The Cook Inlet belugas appear to be bioaccumulating PAHs from the environment or prey. In liver, total PAH levels reached ~ 10µ/g lipid in a large male; anthracenes and phenathrenes were the dominant PAHs found, and no BAP was detected. The highest PAH levels in Cook Inlet beluga livers were found in 3 adult males and a female fetus. In blubber, total PAH levels were highest in an adult female (~80 µ/g lipid), and the predominant PAHs were diverse: naphthalenes, anthracenes, fluorines, and fluoranthracenes. The highest total PAH levels in blubber were from females and fetuses. Small amounts of BAP were detected in some blubber samples. Cook Inlet animals have much higher PAH levels than do subsistence-harvested belugas from the MacKenzie River delta. Our study confirms that concerns about PAH levels and effects on Cook Inlet beluga reproductive success and recovery are justifiable and warrant further study and, likely, mitigation.

### $Polycyclic aromatic hydrocarbon (PAH) contamination in sediments and fish of Cook Inlet, Alaska

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Relative to other classes of organic contaminants, levels and effects of polycyclic aromatic hydrocarbons (PAHs) have received little attention among marine mammal scientists and managers. Nonetheless, PAHs represent the most toxic components of oil, and include 16 compounds considered priority pollutants by the World Health Organization and the US Environmental Protection Agency. One PAH (benzo-a-pyrene; BAP) is sufficiently toxic to be considered one of the most hazardous chemical compounds (among the worst 10%) in existence to both human and ecosystem health (www.**scorecard.org**/chemical-profiles/summary.tcl?edf), and the Stockholm Convention (signed in 2001) considered BAP to be a priority chemical contaminant. BAP, specifically, has been identified as the cause of high numbers of cancers in belugas from the St. Lawrence Seaway, and PAHs have numerous known effects besides carcinogenesis in mammals, including impacts on reproduction and survival of offspring. Our study assessed PAH levels in sediments and beluga prey from four locations in Cook Inlet where endangered belugas are commonly observed. Highest PAH levels in sediments were found in Eagle Bay. Although naphthalenes, anthracenes, and phenanthrenes were the most ubiquitous/abundant classes of PAHs found, BAP was detected in all sediment samples, albeit at low levels (i.e., $\leq$ 0.02 µdry weight). The data suggested inputs from both combustion and fresh oil. The same general patterns occurred in the salmon and other fish, but the fish contained slightly higher amounts of pyrene and fluorine constituents than sediments did, and little to no BAP. The highest total PAH values were in hooligan from the Little Su River. King salmon from Ship Creek contained notable levels of total PAHs in their meat; roe from some sockeye salmon was also notably high in total PAHs. It is difficult to relate sediment levels of PAHs with particular problems for human or environmental health. For humans, the major routes of exposure to PAHs are via food and inhalation (including cigarette smoking). PAHs in food can arise from a number of possible sources: environmental contamination (e.g., deposition following combustion, oil spills) or via preparation and cooking (e.g., drying, smoking, grilling). Thus, there is often not a clear relationship between PAH levels in the environment and those to which humans and wildlife are exposed.

### $Chemical exposures for Cook Inlet beluga whales

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Cook Inlet beluga whales (CIB) may be exposed to a variety of legacy and emerging chemicals through multiple exposure pathways related to sediment, water and dietary intake. A review of literature was conducted to evaluate the potential for chemicals to adversely impact the reproductive success and

recovery of the CIB population. In general, information to characterize CIB exposures to the evaluated chemicals was very limited, particularly with respect to Cook Inlet-specific chemical data. Relevant and marine mammal-specific toxicological information was abundant for organochlorine chemicals, sparse for other common chemicals and very limited for the majority of the emerging chemicals and products. The available chemical data indicate that concentrations of the chemicals detected in CIBs are typically lower than those observed in marine mammals from other areas in the Arctic. However, the potential exists for some of the detected chemicals in CIBs, to be present at concentration ranges associated with endocrine disruption, immune functions, and other effects in marine mammals. Within the limits of the available information and to assist in further assessment, the evaluated chemicals were designated as probable, possible, or unlikely chemicals of potential concern with respect to the recovery of the CIB population. The purpose of this designation was only to identify which chemicals may warrant further evaluation and is not meant to imply causal relationships of adverse effects. A phased approach is recommended for further evaluation.

### Preliminary evaluation of the effects of wastewater discharge on Cook Inlet beluga whales

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The National Marine Fisheries Service has identified Cook Inlet beluga whales as a distinct population segment of the circumpolar distribution of the beluga whale species. The population of these whales fell dramatically in the 1990s, presumably as result of subsistence harvest, but has not recovered to an abundance that would generally be considered a sustainable population. Wastewater discharge from Publicly-owned Treatment Works (POTW) has been suggested in the Federal Register Endangered Species Listing as a potential source of contaminants that may be impeding the recovery of the population. The John M. Asplund Water Pollution Control Facility at Point Woronzof is the largest POTW in the region, discharging approximately 28 million gallons per day. The Asplund Facility provides screening, grit removal, sedimentation, and disinfection treatment processes, and effectively removes greater than 70% of the total mass of suspended solids carried by flow coming into the plant, as well as 40% of the biochemical oxygen demand (a measure of organic matter) associated with the flow.

Anchorage Water and Wastewater Utility (AWWU), the operator of the Asplund Facility, has closely monitored the water quality of its discharge for more than two decades, and has consistently met the conditions of its discharge permit administered by the US Environmental Protection Agency (EPA). Through its permitting program, EPA has repeatedly determined that the discharge allows for maintenance of a balanced indigenous population of aquatic wildlife and that the discharge does not degrade water quality criteria in Cook Inlet.

In 2009, AWWU and EPA embarked on additional analysis of the effects of the discharge, modeling the fate and transport of effluent discharge throughout upper Cook Inlet, identifying potential for exposure to beluga whales, and calculating the potential toxicological hazard associated with trace contaminants found in the wastewater effluent.

Recently, advances in environmental chemistry have allowed for detection of a host of unregulated anthropogenic materials existing at very low concentrations in ambient water resources as well as wastewater flows. In 2010, AWWU has performed additional state-of-the-art sampling and laboratory testing for over 280 such “emerging pollutants of concern” in its untreated inflow as well as the treated wastewater discharge. Preliminary indications are that the additional laboratory work corroborates conclusions of the toxicological analysis that wastewater discharge is not likely to adversely affect the Cook Inlet beluga whale population.

## DISTRIBUTION/MOVEMENTS

### $Range contraction in a beluga whale population

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The small, isolated population of beluga whales *Delphinapterus leucas* in Cook Inlet, Alaska, has had a distinct contraction in range over the past 3 decades. This contraction is a function of a decline in abundance, evidently caused, at least in part, by high takes during unregulated subsistence hunting. During the 1990s, hunting resulted in takes of over 50 whales per year, all of which occurred in the northern portion of Cook Inlet. Concurrent with the decline in abundance, sightings became rare in the southern inlet, even though human impact had been relatively low there. Curiously, the density of whales in the northern inlet remained high in spite of the hunts. Significant changes in beluga whale distribution are evident across 3 periods: 1978–1979 (the earliest well-documented data); 1993–1997 (during the recorded decline in abundance); and 1998–2008 (when hunting was regulated and recovery was anticipated). The center of the summer range of beluga whales contracted northeastward into upper Cook Inlet from the 1970s to the 1990s (38 km; $p = 0.042$) and continued into the 2000s (total of 53 km; $p = 0.022$) with a longitudinal shift east towards Anchorage (the largest city and port in Alaska) occurring between the 1990s and 2000s (17 km; $p = 0.025$). The result is a reduced range (>7000 to <3000 km2) in all but the area with the highest degree of human disturbance. If and when the Cook Inlet beluga whale population begins to increase, a reoccupation of peripheral habitats may be the first indication of recovery.

### $Probabilistic habitat of the endangered beluga whale in Cook Inlet, Alaska

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In recognition of the critically low numbers of beluga whales remaining in Cook Inlet, Alaska, the US federal government listed this isolated population as endangered in 2008. When a species is listed as endangered under the US Endangered Species Act, habitat that is critical for the survival of the species must be identified and protected. Despite the voluntary curtailment of subsistence hunting in 1999, the abundance of Cook Inlet belugas has remained low with no notable signs of recovery. We analyzed sightings and trackline data from summer aerial surveys conducted between 1994 and 2008 to construct a habitat model using physical and anthropogenic covariates, some of which represent proxies for prey. We fit a two-part hurdle model to these data; the first part using beluga presence against a temporal logistic regression and the second part using beluga count data against a temporal Poisson regression. Distances to human communities, high and medium flow accumulation rivers, exposed tidal flats, rock, sand, and oil platforms, as well as distances to rivers with chum (*Onchorhynchus kisutch*) and Chinook (*Onchorhynchus tshawytscha*) salmon were significant ($p<0.05$) in determining beluga presence. Distances to high flow accumulation rivers, tidal flats, and sand were significant ($p<0.05$) in determining group size. From these results we generated probabilistic habitat maps for beluga presence and beluga group size in Cook Inlet, Alaska. The product of these two probabilistic habitats resulted in a final map showing the expected number of belugas in each 1 $km^2$ cell based on the probability that they were present. Habitat models such as the one developed here, are useful for identifying factors that may play a large role in the sustainability and recovery of a species. Recognizing important habitat areas for beluga whales in Cook Inlet is especially critical due to their low abundance and recent endangered listing.

### $Hydrodynamic models and satellite remote sensing data help study the beluga whale habitat in Cook Inlet

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Hydrodynamic/inundation models and satellite remote sensing data are combined to investigate how the environmental conditions in Cook Inlet may impact the behavior and survival of the beluga whales. Preliminary short term comparisons of the movements of 2 beluga whales (tracked by satellite) with an inundation model of Cook Inlet show how the belugas adapt their behavior to the tidal dynamics. They move to the upper, shallow inlet during tidal floods (probably to feed near river mouths that were inaccessible during low tides and to avoid predators) and moved back to deeper waters during ebb. However, a whale in Knik Arm moved differently than a whale in Turnagain Arm due to the difference in the dynamics of the flooding process in the two Arms. The study demonstrates the potential to predict the location of the whales given the observed sea level in Anchorage. Future studies will focus on how environmental conditions such as water depth, fronts, and ice cover, may affect the beluga movements and survival over long periods. For example, satellite remote sensing data have been used to map the changing morphology of the mudflats and shorelines of Cook Inlet over the years; further studies with these data can be used to investigate whether or not such changes can be linked to beluga stranding events.

### $Seasonal distribution of Cook Inlet beluga whales based on passive acoustic monitoring

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The current seasonal distribution of Cook Inlet beluga whales (CIB) (*Delphinapterus leucas*) is essentially unknown. The summer distribution of CIB has been estimated through aerial surveys and limited information from satellite tagged CIB, obtained prior to their listing under the ESA as endangered, indicates an over-winter distribution in the upper inlet; i.e., north of Kalgin Island. Beginning in 2007, a cooperative research project began to acquire new information on the seasonal presence of CIB throughout Cook Inlet using passive acoustic monitoring. Mooring packages containing Ecological Acoustic Recorders (EARs) and echolocation click detectors (C-PODs) have been deployed at 10 sites in Cook Inlet to monitor the presence of CIB continuously. Typically, moorings were refurbished and re-deployed in the fall, in advance of seasonal ice cover, and then again in the spring following ice thaw. Based on preliminary analyses, CIB have been detected at sites in the upper and mid-inlet, and the presence of CIB does not appear consistent across months. CIB were not detected at the two most southern sites (Tuxedni Bay and Homer Spit). Noise from water flow, shipping traffic, and industrial activities varied among locations and often made beluga call detection challenging due to masking. Detection of beluga calls was surprisingly low at Cairn Point, considering CIB must pass this site in transit to, and from, Knik Arm. Cairn Point is the noisiest of the monitored locations due to heavy industrial activity, so more masking may occur there; alternatively, belugas may suppress calling while in this area. There is some evidence that belugas persist in the upper Inlet during the winter freeze, although their range may extend further south than in summer. Signals produced by killer whales (*Orcinus orca*),

tentatively identified as residents, were detected mostly in the lower inlet, but were detected further north in the fall, and harbor porpoise (*Phocoena phocoena*) were detected throughout the inlet. More detailed and recent results will be presented on the assessment of CIB seasonal distribution.

### Photo-identification of Cook Inlet beluga whales

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Alaska's Cook Inlet beluga whale (CIBW) population was listed as an Endangered Species in 2008. As part of the listing process, the National Marine Fisheries Service (NMFS) is in the process of designating critical habitat for the survival and recovery of CIBWs. NMFS must also develop and implement a species recovery plan. Information needs for critical habitat designation and the recovery plan include habitat preferences and life-history characteristics of CIBWs. Over six field seasons (2005-2010) we have developed a catalog containing photographs of individual Cook Inlet beluga whales that were identified using natural markings. We have demonstrated that a large number of CIBWs possess distinct natural marks that persist across years, allowing us to "track" individual whales throughout upper Cook Inlet. Data obtained using photo-identification methods provide information about individual Cook Inlet beluga whales and the population as a whole, including distribution, habitat association, residency/movement patterns, social structure, evidence of disease and trauma, and life history characteristics (e.g., births, mother/calf associations, and survival). Here we present a summary of project objectives, methods, and results from 2005 through 2008. The project is ongoing; data from 2009 are being analyzed, and data from 2010 are still being collected.

### Cook Inlet beluga whale monitoring at Eagle Bay, Fort Richardson, Alaska 2008-2009

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Army conservation personnel have been conducting observations of beluga whales since 2005. Observations between 2005 and 2007 utilized an *ad libitum* sampling scheme. Beginning in 2008, a systematic sampling design was developed consisting of a group follow and focal group sampling over the course of a 20 minute sampling round. Within each sampling round, whale numbers were estimated and classified (white, gray, calf). Group behaviors were also quantified following strict definitions. Statistical analysis was used to determine differences in the number of whales observed from month to month and over the course of a day and to compare beluga abundance estimates between years for all whales and for whale class composition. A total of 538 observation hours were spent on this effort in 2008 and 2009. Whales were observed for a total of 97 hours (18%) of the total observation period for both years. There was a significant decrease in the mean number of whales observed between years but no significant difference in the mean number of whales observed per month or over the course of the observation day. Analysis revealed a significant difference in the percentage and number of white whales and calves observed between years, but no difference for grays. Milling and travelling accounted for the greatest proportion of observed behaviors. Milling was more commonly observed during the morning hours while the proportion of time spent travelling increased over the course of the day. These differences are thought to be associated with tidal influences.

## SOCIAL VALUES/ HUMAN INTERACTIONS

### $Relationship between the Native Village of Tyonek, Alaska and beluga whales in Cook Inlet, Alaska

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The purpose of the study is to document the relationship between the residents of Tyonek, Alaska and beluga (*Delphinapterus leucas*) whales in Cook Inlet. The study team conducted a literature review in addition to fieldwork in the community of Tyonek. A review of the literature revealed documentation of the hunting and use of beluga by upper Cook Inlet Dena'ina, including the people of Tyonek, since at least the 1700s until present. To document residents' current relationship with beluga whales, researchers interviewed 28 Tyonek residents who either had experience with or knowledge about hunting beluga whales. These individuals provided descriptions of the methods of preparing for, hunting, butchering, and processing beluga, in addition to observations about the historical, social, and cultural aspects of beluga hunting. While there have been periods of time with few or no documented harvests of beluga by Tyonek people, Tyonek residents maintain the traditions and values associated with beluga whales and beluga hunting. Cultural continuity is evident in Tyonek's relationship with beluga whales through the passing on of traditional knowledge associated with beluga whales and beluga whale hunting and the continued hunting, harvesting, processing, and sharing of this resource. Tyonek residents still regard beluga as a highly valued subsistence food and hope to continue hunting beluga in the future. Their responses indicated that the relationship between Tyonek residents and Cook Inlet beluga remains strong despite recent restrictions on their hunting activities. The future of Tyonek's cultural relationship to beluga whales will rely on the continued opportunity to pass traditional knowledge about belugas on to the younger generations, and the continued documentation of this knowledge and of residents' beluga hunting and associated activities.

### $Interactions between beluga whales *(Delphinapterus leucas)* and boats in Knik Arm, upper Cook Inlet, Alaska: behavior and bioacoustics

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I conducted opportunistic behavioral and acoustic observations of beluga whales in the lower Knik Arm (LKA; Cairn Point to Eagle Bay) from shore daily and from a small boat periodically from 15 August through 14 September 2007. The objectives of behavioral studies were to 1) document patterns of movement, associations with particular habitats, and behavior of undisturbed beluga whales when passing through and lingering in the narrow reach of LKA, 2) document patterns of boat movement and activity in the LKA, 3) document nominal interactions between boats and beluga whales in the LKA, 4) document the behavioral responses of whales in the LKA, and 5) evaluate the potential effects of boat activity, boat noise, and construction of the proposed Knik Arm crossing bridge on the use of marine habitats in upper Cook Inlet and Knik Arm by beluga whales. The objectives of supplemental acoustic studies, in collaboration with Dr. Tomonari Akamatsu (Japan National Research Institute of Fisheries Engineering), were to 1) estimate the number of beluga whales present in observed groups from detection of their vocalizations using a stereo hydrophone array and acoustic data loggers and 2) estimate the distance to observed beluga whales by triangulating to sounds produced by phonating beluga whales.

Beluga whales were observed transiting Knik Arm, generally associated with tidal flow, and lingering at times at several locations (e.g., Eagle Bay, Six Mile Creek, Point McKenzie, Port of Anchorage, and Ship Creek) on most days. The sites where they lingered appear to be important foraging sites at times but also important places for whales to regroup and socialize after periods of broken contact. Small boats

rarely occurred in the lower Knik Arm, the presence of the few that did was brief. Consequently, interactions between small boats and beluga whales were uncommon, but whales did respond to close moving or approaching boats (up to several hundred meters away) with a change in behavior when boats passed.

The behavioral responses of beluga whales to those boats varied with the distance, speed, and bearing of the boats relative to them and the behavior of whales prior to contact. Whales either continued course but swam quickly away from stationary or pursuing boats or evaded them and changed swim direction. In both cases whales spent more time underwater while boats were nearby than before the encounters. An increase in boat traffic, and associated motor noise, might disrupt the use of key areas in the lower Knik Arm by beluga whales though the threshold number and type that might cause any disruption is not clear.

Beluga whales were detected up to 470 m away from the towed hydrophone array and acoustic data loggers and their locations relative to one another could be triangulated to identify individuals. If more than two whales were in close contact then the additional whales could not be distinguished. Consequently, the number of whales in traveling or milling groups could be estimated as long as they were about at least a body length apart.

## STRANDINGS AND HEALTH

### $Cook Inlet beluga whale strandings

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Cook Inlet, Alaska, supports a genetically-distinct group of beluga whales (*Delphinapterus leucas*) which was listed as “endangered” under the U.S. Endangered Species Act in 2008 by the National Marine Fisheries Service (NMFS). The extreme tidal fluctuations of upper Cook Inlet and the belugas’ preferences for shallow coastal waters predispose these animals to strandings. A stranding may include either living or dead whales found on the beach (or on mudflats during low tide), or floating dead whales. Although the exact causes for strandings are unknown, it is believed that Cook Inlet belugas generally strand due to: 1) an inability to continue swimming as a result of a disease, illness, or injury; 2) an accidental error in navigation by an otherwise healthy individual; or 3) an intentional effort to avoid predation by killer whales.

From 1999–2010 there were 127 confirmed dead beluga whale strandings in Cook Inlet, averaging 11 dead stranded belugas per year. During that same time span, NMFS recorded 16 live stranding events, involving 1–58 belugas per event, with a total of 14 live stranding-associated deaths. Killer whales have been associated with only two live stranding events (August 1999 and September 2000), but at least four dead beluga whales had evidence of killer whale predation (September 2000 = 2 whales, August 2003 = 1 whale, September 2008 = 1 whale).

Given the physical environment of Cook Inlet and human safety concerns, the majority of dead beluga whales are noticeably decomposed by the time they can safely be accessed, thus only minimal samples are commonly collected (e.g., teeth for age estimates; skin/bone for genetics). However, in rare circumstances, a freshly dead Cook Inlet beluga whale will be in a safely accessible location which allows for many more biological samples (e.g., viral/bacterial cultures; reproductive organs; stomachs; organ tissues; etc.) to be collected for analysis. With the intent to collect as much biological information as feasible to improve our understanding and management of this endangered population, NMFS will continue recording all reported stranding events and responding to all beached Cook Inlet beluga whales.

### $Morbidity and mortality trends in stranded Cook Inlet beluga whales

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The endangered Cook Inlet beluga whale population is estimated to have declined from 1,300 animals in 1979 to 375 animals in 2008 (Hobbs and Sheldon 2008). Currently, necropsies from dead stranded and hunter harvested beluga whales provide the only source of information on morbidity and mortality. Thirty-four dead stranded belugas were necropsied to varying degrees from 1998 - 2009. Carcasses appropriate for necropsy were found beached from April to October. The majority of animals were mature animals (n=21), followed by calves (6), Subadults (3) and fetuses (4). Of the mature animals, 10 were females, 8 males and 3 unknown sex. Seven of these mature females were either pregnant, post-partum, or lactating. The coding system developed by Bogomolni *et al.* (2010) to categorize causes and probable causes of death (COD) was adapted for use in this study. Each animal had a COD or probable COD assigned within the broad categories of: unknown, single stranding - no significant finding (SS - NSF), mass stranding no significant findings (MS- NSF), perinatal mortality, trauma, disease, or nutrition. Many (82%) of these whales were in moderate to advanced autolysis making determination of a definitive cause of death difficult. CODs were distributed as follows: unknown COD – 35%, single stranding NSF - 15%, mass strandings NSF -15%, disease – 6%, perinatal mortality - 12%, nutrition – 9% and trauma - 9%. Two out of the three trauma cases were confirmed killer whale predations. Several of the mass strandings also had associated reports of killer whale activity in the area. Major findings were similarly coded as: contributory, possible contributory, and incidental to COD. There could be multiple major findings per animal. For contributory/possible contributory factors, disease was represented 24 times, dystocia once, and poor nutrition 3 times. Incidental findings included a few minor diseases. Types of diseases that were described included a systemic herpesvirus infection (n=1), systemic mixed inflammatory reaction (1), herpesvirus dermatitis (1), a nematode infection of the kidneys - Crassicauda giliakiana (15), cardiomyopathy (2), lungworm pneumonia (10), meningoencephalitis (1), Lung abscess (1), protozoal myositis (1), Subcutaneous abscess (1), and panniculitis (1).

With the data available, mass single strandings NSF were the most significant factors followed by perinatal mortality, then nutrition, trauma and disease as causes of death. Disease as cause of death could easily have been missed with autolyzed carcasses. With a third of the fresh carcasses having disease as the COD, efforts should be made to improve investigation of disease factors.

### $Cook Inlet beluga whale diet from stomach content analysis

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Understanding the diet of the endangered population of Cook Inlet beluga whales is important in determining whether changes in prey availability were a factor in their decline or are currently a factor in their recovery. Although diet information is important, data sources for this population are limited and not comparable. Traditional knowledge from beluga hunters indicated that beluga whales eat all fish species available in the inlet including several freshwater species, physical evidence, however, is limited to partial samples from 24 stomachs (7 of which were empty) collected during 1992–2001 and mostly complete stomachs from 26 beluga whales (9 of which were empty) collected during 2002–2009. The partial stomachs from the earlier time period were reported to contain fish and only eulachon and king salmon were identified to species. We suspect that these were mostly visual inspections of unsorted contents because no invertebrates were reported. Of the 17 mostly complete stomachs with food, 14 contained fish, mainly salmon (71% by frequency of occurrence), cod (43%), smelt (14%), and flounder (14%). Salmon that could be identified to species included Coho (36%), chum (21%), and Chinook (7%). Cod species included saffron cod and walleye Pollock at 21% each, and Pacific cod at 7%. Smelt was eulachon only, and flounder included yellowfin sole (14%) and starry flounder (7%). One longnose sucker

was the only freshwater fish found. Nine stomachs contained invertebrates, mostly shrimp (78%); but polychaetes, amphipods, mysids, crab, echiurids, and sponges were also found. Even though samples are limited and sampling methods are not comparable, documenting fish and invertebrate prey species from stomach contents will help guide future diet studies that may be able to employ methods such as stable isotopes, fatty acids, and genetic prey identification to further describe Cook Inlet beluga diet.

## POSTER ABSTRACTS:

### Comparison of hormone profiles from Cook Inlet and captive beluga whales

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Cook Inlet beluga whales (CIB) are a genetically distinct small population that has experienced dramatic declines in the last 2-3 decades, resulting in its listing as endangered in 2008. While over-hunting for subsistence was thought to be responsible for the population's initial collapse, the continued decrease in the 10 years following the moratorium on hunting challenged current hypotheses for the decline. The ability to collect longitudinal samples from captive beluga whales provided an opportunity to evaluate reproductive and metabolic hormones profiles from healthy animals that reside in a stable environment and use those data as a benchmark for free-ranging animals. Towards this effort, three reproductive hormones (progesterone, testosterone and total estrogens) and two metabolic hormones (cortisol and 4 forms of thyroid hormones) were validated for beluga whales and samples from captive animals, collected from January to May, were analyzed. Additionally, samples from 12 free-ranging belugas (7 CIB and 5 from Bristol Bay), were compared to the captive belugas to detect any differences that may be useful in the development of health assessments that include hormonal profiles. Estrogen and progesterone profiles from captive belugas were typical of non-pregnant, ovulatory females and included apparent ovulations that occurred in May and non-detectable testosterone. Free-ranging CIB progesterone concentrations were 7-fold higher than those of the captives and likely represent concentrations indicative of early pregnancy. Seasonally enhanced production of testosterone in a male captive beluga had a parallel progesterone profile that was an order of magnitude lower in concentration. The testosterone rise was coincident with a 60-75% reduction in total estrogen concentrations reflecting a seasonal suppression of aromatase enzyme activity. Concentrations of testosterone in free-ranging CIB were similar to the captive animals. While $TT_4$ and $TT_3$ concentrations were similar between captives and free-ranging CIB, the free ranging animals had elevated concentrations of cortisol when compared to captive belugas, likely reflecting the metabolic stressors in their environment. These results indicate that analysis of reproductive and metabolic endocrine parameters can provide useful diagnostic information on free-ranging CIB physiology, such as the detection of pregnancy and assessment of metabolic state. We conclude that endocrine assessment ought to be incorporated as part of any future health evaluations of CIB and stress the need for development of complete annual hormone profiles in captive animals as a comparative baseline.

### Color analysis of Cook Inlet beluga whales in the 2008 photo-id catalog

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The color and body size of Cook Inlet beluga whales (CIBW) have been used to estimate age-class composition of groups encountered during aerial and photo-identification surveys. However, the process of categorizing an individual whale as white or gray (or some shade thereof) is complicated by several factors including: (i) lighting conditions (ii) camera exposure settings when images are captured and (iii) inter-observer differences in color assignment. In previous years (2005-2007) of the CIBW photo-id study, color classification was subjective (i.e., whales were classified as gray or white depending on how their photographs appeared to an observer), resulting in high variation of color assignments. We have developed a method of quantifying whale color from digital photographs in which brightness values are calculated and used to determine if there are any changes in individual whale color over time. Photographs from 30 whales photographed during the 2008 field season were analyzed to compare

variability among days and an entire season. A three-whale subset was then compared across all four years of the study to assess inter-annual variability in brightness values. By comparing the brightness values of individual whales in photographs with their qualitative color classifications, we were able to assign whale colors to ranges of brightness values. We found that the range of brightness values for any given whale increased with the number of days it was photographed. However, this did not occur in a gradually-increasing way that would indicate we were documenting a whale changing color with age (e.g., we did not document individual gray animals with low brightness values that gradually lightened with time). The brightness range of a gray card photographed in 2008 was broad, demonstrating the wide variation in the ambient lighting conditions and exposures of a known constant. This further indicates that it is important to develop a means of controlling and correcting for environmental variability. Future efforts will include measures to account for the variability of lighting conditions encountered in the field.

### Studying Cook Inlet beluga whales using acoustic monitoring and traditional knowledge

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Cook Inlet beluga whales are a geographically and genetically isolated population. Their population decreased by forty-seven percent between 1994 and 1998 and has continued to decline. In 2008, the population was listed as endangered under the Endangered Species Act. In 2009, the population estimate for Cook Inlet belugas was 321 individuals. The cause of this dramatic population decline remains unknown. For my PhD project, I will be conducting acoustic monitoring of belugas in Cook Inlet. Hydrophones deployed within Cook Inlet provide acoustic data to determine presence of beluga whales at these sites. One goal of the project is to define and characterize the vocal repertoire of the Cook Inlet belugas. Secondly, I will evaluate ambient noise within the inlet to establish the belugas' acoustic environment. In this evaluation, I will focus on anthropogenically generated noise in an effort to understand human impacts on the Cook Inlet beluga population. Thirdly, I will evaluate the socioeconomic impacts of the listing of Cook Inlet beluga whales as endangered. Finally, using archaeological records and traditional knowledge of beluga subsistence hunting, I will establish historic and modern uses of beluga whales in Cook Inlet and hopefully gain insight on the population dynamics of this species. Combining all this information, I hope to propose possible drivers of the troubling population decline of Cook Inlet beluga whales. Belugas, as top predators, serve an important role in the marine ecosystem. A better understanding their population dynamics will improve management of the species to ensure sustainability of the Cook Inlet ecosystem.

### Land-based beluga observations from Northwest Fire Island, upper Cook Inlet, Alaska, June-November 2009 and May-Sept. 2010

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The Cook Inlet beluga whale (*Delphinapterus leucas*) Distinct Population Segment was recently listed as endangered by NOAA under the Endangered Species Act (ESA). Information on beluga whale presence, habitat use, and behavior in the Ocean Renewable Power Company's (ORPC) proposed Cook Inlet Tidal Energy Project Deployment Area near Fire Island, Alaska is critical for evaluating potential project effects and for meeting regulatory requirements under the ESA, the Marine Mammal Protection Act, and under the Federal Energy Regulatory Commission's regulations for hydropower licensing. Surveys of beluga

whales in the upper parts of Cook Inlet have been conducted as part of the environmental studies for the Port of Anchorage, Knik Arm Bridge, and Seward Highway Projects.

In addition, NOAA conducts annual aerial surveys to estimate and monitor population levels of Cook Inlet belugas. However, there is limited information specific to the area near Fire Island. The primary objective of the baseline monitoring is to assess the distribution and movement of beluga whales in and around ORPC's Deployment Area near Fire Island. The proposed baseline monitoring study was adapted from similar shore-based visual observation studies as referenced above. The baseline monitoring took place over the course of the 2009 (June-November) and the 2010 (May-September, scheduled to run through November) field seasons. Shore-based observers recorded beluga whale sighting information, including whale location, direction of travel, group number, behavior, and number and relative age class of whales. Observations of other marine mammals in the project area were noted. Beluga whale locations were recorded using a theodolite with a laptop computer, and with a grid-cell map of the study area. Here we present monthly sighting rates and locations of beluga whales and other marine mammals seen during the 2009 and 2010 field seasons.

### Exploring ecological changes in Cook Inlet beluga whale habitat through traditional and local ecological knowledge.

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The Cook Inlet beluga whale, one of five Alaskan stocks, is genetically distinct and geographically isolated from other populations. Historically, Cook Inlet whales were hunted commercially, for sport, and for subsistence uses. The Marine Mammal Protection Act (MMPA) of 1972 ended commercial and sport hunting; in 1999, subsistence hunting voluntarily ended. In 2008, Cook Inlet beluga whales were listed as endangered under the Endangered Species Act after annual aerial surveys indicated the population was not recovering as expected. A combination of natural and anthropogenic factors may be affecting this population's recovery. This study documented traditional and local ecological knowledge of Alaska Native subsistence hunters and fishers and commercial fishers through participatory research to explore ecological changes in Cook Inlet over time and to identify potential factors impacting this beluga whale population. Study results identified potential environmental and climate change factors including prey competition, health of beluga and their prey, and the presence of killer whales, the majority of which may indicate an ecosystem regime shift in the Cook Inlet region. Human-related factors included fisheries management and related prey reduction, water contamination, and anthropogenic-related noise.

### Mapping the social values of stakeholders in Cook Inlet beluga whale conservation

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All conservation decisions are based on social values and it is therefore critical to understand those values and how they are manifested in society as we make decisions about conservation strategies such as resource allocation or prioritization of conservation investments. The 2008 listing of Cook Inlet beluga (CIB) whales as an endangered species has generated strong public reaction – both positive and negative. This is not surprising given the many competing conservation and development interests in Cook Inlet, the nature of the ESA listing process, and the diversity of stakeholders involved in the CIB conservation process over the past decade. It is exacerbated by the many uncertainties associated with the long term decline in Cook Inlet beluga populations and the diverse goals of wildlife management in

Alaska. The latter reflect a diversity of social values that must be taken into account in any species management process in Alaska and yet are inadequately understood in relation to CIB.

Social values research can play a catalytic role in convincing decision-makers to establish appropriate policy, allocate adequate resources to conservation efforts, implement effective regulations that the public understands and supports and to ultimately build a broad constituency for conservation efforts. Key questions that social values research can address in relation to CIB conservation include:

- What do various stakeholder groups know about CIB (and how do perceptions differ)?
- What does the public understand about CIB conservation and why do they feel that way?
- What is the perception of CIB relative to other Alaskan wildlife?
- How well informed is the public about the CIB listing process and what are key education needs?
- What conservation strategies might the public voluntarily support?
- What proposed strategies are poorly or misunderstood and so might need further explanation?
- How might the public be willing to assist with species recovery/conservation?

This poster will introduce initial observations that have informed research design and outline plans for a pilot scale CIB social values research project commencing in summer 2011 involving field observational studies, in situ and ex situ visitor and resident surveys and focal topic engagement via social media. The poster will provide opportunities for stakeholders to shape the research to be undertaken and to ensure that topics and issues of wider interest and relevance are incorporated into the research methods.

### [$]Quantifying impacts of habitat loss on extinction risk and recovery potential for the endangered Cook Inlet beluga

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Cook Inlet belugas were listed as endangered by the U.S. government in 2008, following a population decline in the 1990s of 47% with no subsequent sign of increase. This isolated population occupies a limited range in Cook Inlet, with the majority of the population found year-round only a few kilometers from Anchorage, the largest city in Alaska. A population viability analysis indicated probabilities of continued decline at approximately 70% and of extinction in 100 years at over 20%, but assumed a constant environment. We consider changes in these probabilities that would result from changes in the environment, particularly by temporary and long-term habitat losses. Temporary losses include point-source events (e.g., oil or toxic spills), loss of access to key habitats (e.g., in-water construction such as pile-driving or dredging, or a natural event such as volcanic ash fall or mudflows) or short-term shifts in prey availability. Long-term losses have similar origins but also include climate change and cumulative effects. While the belugas can compensate to some extent by changing behaviors and using alternate areas, these alternatives are likely to be less efficient and habitats will either be of lower quality or present greater risks than the preferred habitat. Also, there are costs associated with stress and reductions in efficiency as the population learns to function in the changed circumstances. We used data from other large mammal populations as examples of population response and information on habitat quality in Cook Inlet to develop model parameters for the Cook Inlet beluga so that population responses to different types of events could be compared. Preliminary results indicate a significant increase in risk resulting from the interaction between the tendency of this population to aggregate into a few large groups and the risk of point source events.

### $Development of *Mytilus sp* bioindicators to monitor microbial water quality in marine environments

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In the marine environment, reduction in water quality relating to factors such as changing bathymetry, water circulation, water chemistry, contamination, or microbiology of the water may contribute to habitat loss. Coliforms have been widely used as indicator organisms of microbial water quality and laboratory methods are available for detection in environmental samples. However, in areas of large water mass and dynamics, direct measurement of coliforms in water may pose challenges and accrue high cost. The focus of this study is to develop experimental tools to efficiently sample the environment to determine the degree of microbial water quality. We are developing an experimental procedure using *Mytilus sp.* mussels as a bioindicator of fecal coliform presence and concentrations in the aquatic environment, and potentially as test organisms to measure physiological responses to environmental samples that may contain contaminants. The goal of the study is to provide new tools for marine coastal habitat monitoring in large, dynamic water bodies such as Cook Inlet.

### Group structure of Cook Inlet beluga whales: insights from photo-identification

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The Cook Inlet beluga whale photo-identification study provides information about group structure, distribution, movement patterns, and life history characteristics of individually identified beluga whales. One hundred and twenty eight photo-id surveys of upper Cook Inlet, Alaska were conducted May through October, 2005-2008 and 362 beluga groups were encountered. Sighting histories were compiled for all identified individuals, including mothers and calves. The study area was divided into five subsections, and occurrence and movements of identified belugas among sections were examined. Coefficients of association were calculated for 30 whales cataloged in all four years of the study, and a cluster analyses was performed to determine if distinct clusters or subgroups of belugas occurred within this data set. An estimate of social differentiation was calculated to provide a measure of the variation of association patterns within the sample. Whales identified in all four years of the study did not display fidelity to any single area of upper Cook Inlet. Sighting histories indicated that all of these whales moved among different areas of upper Cook Inlet. There was no evidence that this population was divided into clusters or subgroups. None of the belugas cataloged in all four years of the study were found in groups that were comprised of solely white or gray animals, and all of these belugas were found in groups that contained calves. Calves and neonates were seen in all areas of upper Cook Inlet where beluga groups were encountered during photo-identification surveys. To date, the photo-identification study has not found evidence that beluga groups in upper Cook Inlet are highly structured in terms of location, individual association patterns, color, or age-class. Although results are preliminary, all re-sighting information so far indicates the portion of the population we have identified is homogenous with respect to the factors above. Results from field work continued in 2009 and 2010 will be included in future analyses.

### The use of photo-identification to study associations and distribution of beluga whale mothers and calves in upper Cook Inlet, Alaska

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Photo-identification techniques were used to develop a catalog of individually identified beluga whales from upper Cook Inlet, Alaska. Beluga whale groups were counted and photographed during 140 surveys

conducted from the spring of 2005 through the fall of 2008. Group color composition (i.e., white, gray) varied according to location and season. Eighty-four identified beluga whales were presumed to be mothers, based on the close proximity of calves. Twenty-two identified belugas were photographed with calves in more than one year. Ten identified belugas were seen in more than one year with maturing calves. Several presumed mothers were gray in color. Localized areas for calving and calf rearing were not detected, as calves were seen in all locations surveyed, and several identified mothers were seen to move among Knik Arm, the Susitna River Delta and Turnagain Arm.

Calves were encountered in all months surveyed (April through October), although neonates were first observed in July of each field season. This study is ongoing, as establishment of a long-term data-set that provides insight into the population dynamics and life history of Cook Inlet beluga whales can help to identify appropriate conservation measures to preserve and recover the population in Cook Inlet.

### Photo-identification as a tool to study disease, injury, and survivorship of Cook Inlet beluga whales

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Photo-identification provides information about individual Cook Inlet beluga whales and the population as a whole, including residency/movement patterns, habitat use, reproduction, and abundance. Over six field seasons (2005-2010) we have developed a photo-catalog containing digital images of individual Cook Inlet beluga whales that were repeatedly identified during the course of the study using natural markings that persist over time. Many photographs of whales contain marks indicative of disease and injury. By documenting the occurrence and frequency of these marks and attempting to identify mark sources, we can learn more about disease and injury affecting the endangered Cook Inlet beluga whale population. We also use long-lasting marks caused by satellite tags applied by NMFS 1999-2002 to track individual whales and to study survivorship (and reproduction of females) during the intervening 3-11 years. We present a summary of the types of marks indicating disease and injury that we encounter, and sighting histories of previously-tagged whales. We discuss the importance of continued collaboration among research projects in the area to increase the documentation and understanding of disease, injury, and survivorship of Cook Inlet beluga whales.

### Educating the public about Cook Inlet belugas: opportunities for better research dissemination

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As was evident at the Cook Inlet Beluga (CIB) Science Symposium on 7 February, 2009 most research effort is currently directed towards understanding the biology, behavior, and management needs of the CIB. However, as has been equally evident in subsequent public hearings and debate about the future of CIB, there has been a notable lack of education effort both in a formal sense (public and school-based education programs, information displays in aquaria and museums, etc.) and in an informal manner (agency outreach, media features, etc.).

Cook Inlet belugas are highlighted on signs at several points along the Seward highway and in the Anchorage downtown area. However as is common with most 'ad hoc' interpretation efforts, there is little uniformity of information presented, significant gaps in key information about the conservation and life history of belugas, and relatively few opportunities to learn more about CIB in ways that meet the diverse demands of key stakeholders. Casual observation of visitor interactions with these signs over the past two years suggests that most readers gain little from currently available sources of public display information, are often disappointed by the incompleteness of information provided, and have relatively

few opportunities for follow up (e.g. to access current research on websites). Equally significant is the lack of comparable interpretation in the Mat-Su and Kenai Peninsula Boroughs.

There are also surprisingly few opportunities for the public to learn more about CIB at local learning centers such as museums, zoos, aquaria, and visitor centers. For a range of reasons, CIB have never received the local prominence they deserve in those education centers and there has been a relative lack of targeted learning opportunities until very recently. There is an urgent need for more extensive, timely, and accurate public education materials about the Cook Inlet beluga.

This poster will outline a range of media options for improving dissemination of CIB research results to the public and seek to more actively engage researchers in outreach efforts. Results will be incorporated in the design of both a new CIB exhibit and education program at the Alaska SeaLife Center and in formal and informal community education and outreach programs throughout Alaska.

### Ambient noise measurements in the Knik Arm near the proposed Knik Arm crossing site

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The Alaska Division of the Federal Highway Administration and the Knik Arm Bridge and Toll Authority (KABATA) plan to construct a new bridge (Knik Arm Crossing [KAC]) spanning Knik Arm. Knowledge of the magnitude, variability, and predictability of the ambient noise levels is important for understanding the natural environmental constraints on the beluga whale's ability to communicate, and otherwise use their own sounds in a noisy environment.

In 2010, KABATA commissioned an acoustic monitoring study that had the goals of: (1) collecting underwater acoustic recordings of ambient noise in the vicinity of the proposed KAC during different stages of the tidal cycle; and (2) describing the magnitude and variability of ambient noise in the vicinity of the proposed KAC. Ambient noise recordings were made at 3 locations across the width of the proposed construction site. Recordings were made during the 4 stages of the tidal cycle: high, ebb, low, and flood for 5 consecutive days during May and again in July.

The overall recorded ambient noise levels in the Knik Arm are consistent with previously conducted studies in the area. Mean ambient noise levels for May and July were 124+ S.D. =10 dB re 1 μPa and 136+ S.D. =7.9 dB re 1 μPa, respectively. The 95th percentile ambient noise levels ("loud" condition) for May and July were 145 and 146 dB re 1 μPa, respectively. The 5th percentile ambient noise levels equating to the "quiet" condition for May and July were 109 and 119 dB re 1 μPa, respectively.

### [$]Cook Inlet beluga whale diet using stable isotope analysis

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Understanding changes in the diet of the endangered population of Cook Inlet beluga whales through time is important to determine whether a change in prey availability was a factor in their decline or is currently a factor in their recovery. Using bone from the skulls of Cook Inlet beluga whales in the University of Alaska, Museum of the North collection, we determined the Carbon and Nitrogen isotope signatures for 24 belugas collected between 1965 and 2007. Although stable isotope analysis does not allow for prey to be identified to species, it can detect general changes in diet. C and N isotopes values in bone are an average across an individual's lifetime. If beluga diet changed significantly over time we may be able to detect those changes by analyzing stable isotopes in the bones of belugas that lived before, during, and after the change. For example, if belugas switched from eating mostly Chinook salmon (high trophic level) to mostly shrimp (low trophic level), we would be able to detect the change in the N isotope signatures of the bone from belugas collected before and after the switch. Preliminary

results show that there has been a decrease in the trophic level at which Cook Inlet beluga whales have been feeding from 1965 to present that could indicate a change in prey availability. Further research will determine more precisely what species of prey may be involved.

### $Advanced techniques to determine age categories of beluga whales

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A small, isolated population of beluga whales resides year-round in Cook Inlet, Alaska. Learning more about this population's age structure, as an indication of reproduction and potential for growth, is fundamental to the management of this endangered stock of beluga whales. Generally the small, dark gray beluga calves and intermediate-sized, gray juveniles are easily distinguishable from large, white adult whales. Since 2003, techniques using digital photographs and video recordings have been developed to document the proportion of calves and juveniles relative to adults. During annual aerial surveys, a system of paired video or digital cameras was used with one camera collecting a zoomed-in image or recording to detect calves, while a second camera documented a wide-angle view to capture the entire beluga group. During surveys between June 2003 and August 2005, a digital Nikon D1X still camera was paired with a digital video camera to collect relevant beluga whale information. This configuration was replaced with a pair of High-Definition (HD) JVC video cameras in May 2006. Although the HD video was of lower resolution than the digital still camera, the HD video allowed for a larger sample area to be captured during a continuous video segment. In addition to the video analysis for abundance estimate, zoomed images or video were studied to obtain counts of dark vs gray vs white whales. A specialized computer program expedites the search for whales in the video providing technicians a convenient method to follow individual whales frame by frame and categorize each whale by size and coloration. Results indicate that techniques using high-resolution cameras from an aircraft and computer analysis can adequately sample a beluga population for age-structure information. With beluga coloration as a representation of age categories, further analysis will focus on comparing color proportions to document inter-year trends, possibly indicating stock recovery and spatial comparisons will help better define areas occupied in Cook Inlet.

### $The Cook Inlet beluga whale opportunistic sightings database: a summary of opportunistic sightings during the past 30 years

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Cook Inlet, Alaska, supports a genetically-distinct and isolated group of beluga whales (*Delphinapterus leucas*) that in 2008 was listed as Endangered under the U.S. Endangered Species Act. In 1999, the Alaska Regional Office in Anchorage initiated public outreach efforts to encourage reporting of opportunistic sighting information on Cook Inlet belugas. In conjunction with this objective, the National Marine Mammal Laboratory maintains a database of these sightings as a resource for whale distribution and habitat use. Since its inception, the Cook Inlet Beluga Opportunistic Sightings Database has logged recent sightings as well as historic reports of beluga whales collected throughout the Inlet. Currently the database holds 1,413 records collected from 1977 to 2008 and is our best resource on beluga distribution in the lower inlet. Most records include date, time, location, approximate number of beluga whales, and, in some cases, behavioral data. The sighting location from opportunistic reports can range from a specific latitude and longitude position taken from a Global Positioning System to an estimated location in relation to nearby landmarks. The sighting reports have come from a variety of sources ranging from observations

by the Alaska Department of Fish and Game during systematic aerial surveys for other target species to casual observations from the shore or from small boats and planes. Recently, a table was added to the database to include reports when efforts to find beluga whales provided no sightings. These effort data provide some indication on where and when beluga whales were absent. Currently, the database serves as an aid to the Alaska Regional Office for management purposes, such as determining when Federally-funded or permitted activities may occur in areas occupied by Cook Inlet beluga whales. In addition, interest in the database has been expressed by non-government groups. Future plans include providing web-based access and mapping capabilities. This poster summarizes types of observation platforms, the sources of reports, and distinguishes dedicated survey effort from opportunistic reports. Sightings are mapped by month and grouped in geographic regions of Cook Inlet.

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