Cook Inlet Beluga Whale Research Methods Workshop
November 29-30, 2017
Anchorage, Alaska

Workshop Report
Prepared by the Consensus Building Institute

Table of Contents

1) Background

The Cook Inlet beluga whale (CIB) population is a small population that has experienced a significant decline in numbers, dropping from an estimated 1,300 individuals in 1979 to an estimated 328 individuals in 2016. The most recent 10-year population trend suggests the population is continuing to slowly decline. This endangered distinct population segment (DPS) is not recovering as expected, despite removal of an identified threat (subsistence hunting) that was having population-level effects.

Understanding the characteristics of this beluga population is crucial for effective management. Conducting research that uses invasive methods is one way to collect population data. Recently, NOAA Fisheries, a.k.a. the National Marine Fisheries Service (NMFS), identified the need for continuing population monitoring in both the Species in the Spotlight Action Plan for CIB, and in the Recovery Plan for CIB. The Recovery Plan specifically recommends the following recovery action: "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 analysis." Pursuant to this recovery action, NMFS convened a two-day, facilitated workshop November 29-30, 2017, in Anchorage, Alaska.

The main body of this workshop report provides an overview of the workshop structure, summarizes the upfront context-setting presentations, discusses key themes emerging from workshop discussions, and synthesizes key findings from individual participant assessments of research methods. The appendices provide succinct summaries of individual participant input gathered on each of the pre-identified 47 research methods. A workshop agenda and a list of workshop participants is also provided.

2) Workshop Approach

Given CIB's lack of recovery and the lack of a clear explanation for CIB's continued decline, it is likely that a greater diversity of research methods will be proposed in the future in an attempt to promote recovery of CIBs. In anticipation of new research proposals incorporating various invasive research methodologies, and recognizing the concerns surrounding invasive research for this population, NMFS's Alaska Region sought to proactively obtain an objective assessment of invasive research methods that may be proposed for future studies of CIBs. As such, the purpose of the workshop was to obtain individual input from workshop participants to help inform future management decisions.

The workshop agenda is provided in Appendix A. A list of workshop participants is provided in Appendix B.

In advance of and during the workshop, participants were asked to provide input for each of the following three objectives:

1) Identify research methods that are likely to be proposed in the foreseeable future, especially those which may be considered invasive to CIBs;
2) Discuss the conservation benefits, research benefits, and risks of each identified method to both individual animals and the CIB population; and
3) Provide individual opinions on whether the benefits outweigh the risks each method poses to CIBs, considering:
    a. Whether the method provides conservation benefits to CIBs;
    b. The extent and likelihood of risk to CIBs;
    c. Whether other less invasive methods can provide the same information; and
    d. The feasibility of the method for CIBs.

A six-person Steering Committee was convened to advise NMFS on workshop structure and approach. Steering Committee members included: Frances Gulland, The Marine Mammal Center; Mandy Migura, NMFS Alaska Region; Teri Rowles, NMFS Office of Protected Resources; Amy Sloan, NMFS Office of Protected Resources; Robert Suydam, North Slope Borough; and Paul Wade, NMFS Alaska Fisheries Science Center, Marine Mammal Lab. The facilitation team (Bennett Brooks and Tushar Kansal with the Consensus Building Institute) facilitated Steering Committee discussions, as well as the workshop itself. Workshop logistics were handled by the Pacific States Marine Fisheries Commission.

Prior to the workshop, the Steering Committee developed a list of 47 distinct research methods organized into the following categories: (1) methods which do not require capture, (2) methods necessary for capture, and (3) methods which require capture. (A list of all 47 research methods considered is provided in Appendices C and D.) Based on its review of the CIB Recovery Plan and the Species in the Spotlight Action Plan, the Steering Committee also identified three broad research objectives associated with CIB recovery priorities:

- Understanding CIB life history parameters;
- Understanding health and disease impacts on CIB; and
- Understanding exposure to and effects of identified threats.

In advance of the workshop, participants were asked to share their perspectives on the likelihood for each of the different research methods to improve NMFS's understanding of the three broad research objectives, as well as list the benefits and risks associated with each method.[1] (The results of this pre-workshop survey are discussed in section 2 of this report, "Synthesis of Assessment Findings.") The candidate research methods included those methods currently permitted for use on cetaceans. Workshop participants also were invited to review and suggest revisions to the candidate research methods prior to the workshop.

The workshop did not seek to prioritize across recovery tasks or research objectives. Rather, it drew on the three identified objectives to help participants assess the relative benefits and costs of the various research methods that are most likely to be addressed using invasive methodologies. Workshop participants discussed the challenges of assessing benefits and risks associated with different research methods without having identified clear research objectives associated with each method. In particular, some participants expressed concern about evaluating research methods without this type of clarity. In response, NMFS noted that while regulatory permit issuance criteria require permit applications to address recovery plan objectives, NMFS does not prioritize research objectives when evaluating permit applications or for Section 7 consultations as long as they are consistent with the recovery plan.

Twenty-one individuals participated in the workshop at the invitation of NMFS, representing perspectives from within and outside federal and state government agencies in the United States and Canada. Workshop participants featured the following types of expertise:

1) Conduct research on CIB;
2) Have expertise in implementing invasive research techniques that may be contemplated for use on CIBs;

---

[1] Workshop participants were asked to indicate the likelihood for each research methods to improve the NMFS's understanding of the three broad research objectives by indicating "yes," "somewhat," "no," or "uncertain." Participants were asked to provide their own suggestions for "the most significant potential benefit(s) associated with using" each research method and for "the most significant potential risk(s) to an individual animal from use" of each research method.

3) Use research findings to help promote the management and recovery of CIBs or similar small cetaceans; and/or
4) Have expertise in marine mammal health issues and/or wound healing studies.

3) Context-Setting Presentations

The workshop featured eleven brief presentations about CIB population characteristics and recent research, case studies of beluga capture and tagging projects, other cetacean tagging projects, and stress responses in cetaceans, and specifically, beluga whales. A brief summary of each presentation is provided here; additional detail can be found in the accompanying presentation slides. Owing to the number of presentations delivered, slides are available in a separate, accompanying file rather than being appended to this report.

1. Cook Inlet beluga whale population characteristics, and summary of recent research (Paul Wade, Ph.D., NMFS Alaska Fisheries Science Center, Marine Mammal Lab)

Dr. Wade reviewed recent research studies conducted on CIBs to highlight key information these studies provide about the characteristics of the CIB population. These studies include aerial surveys for abundance and distribution; information about CIB population abundance; habitat modeling and how CIB's preferred habitat has evolved over time; the findings of acoustic monitoring studies regarding seasonal distribution and foraging behavior; combining findings from photo ID, stranding, genetic analysis, and satellite tagging studies to better understand CIB behavior; and exploring possible causes for the lack of CIB recovery, including anthropogenic noise, decline in prey populations, and decline in reproduction due to emerging environmental contaminants. Following Dr. Wade's presentation, it was suggested that many subsistence whale hunters would make the case that commercial aspects of the subsistence hunt during this period, and commercial whaling prior to enactment of the MMPA and ESA – played a significant role in the decline in the CIB population.

2. Satellite-Tagging and Health Assessments in Cook Inlet, Alaska, 1999 to 2002 (Kim Shelden, NMFS Alaska Fisheries Science Center, Marine Mammal Lab)

In 1995 and 1997, NMFS worked with Canadian scientists and Alaska Native subsistence hunters to adapt capture and tagging methods to conditions in Cook Inlet (muddy water, extreme tides, and extensive mudflats), culminating in successful capture and tracking of a whale during the summer of 1999. This was followed by three more years of capture and tagging studies during which 18 whales were captured and tagged overall. Tags were attached saddle-style to the dorsal ridge of each whale by inserting nylon rods (2-4 depending on tag type) through the blubber layer and securing cables or straps that hung from each tag to the rods. In 1999, tag locations documented summer distribution patterns from late May to mid-September (one male beluga). In 2000, each tag documented fall and early winter movement patterns from September to January (two belugas, a male and female). In 2001, tags were placed on 7 females and 2 males; 5 of these whales had a second tag attached that was duty-cycled, 2 whales had only a duty-cycled tag. Numerous tag failures occurred, though one male documented late summer to spring movement patterns with a tag that lasted from mid-August to March. In 2002, a single tag was placed on 4 females and 4 males and each whale was flipper-banded. Three of the males transmitted locations through the winter into spring with one tag lasting into May. Across all years, 13 of the 18 whales tagged had transmissions lasting over 3 months (94-293 days, average 149 days). Two whales in 2001 had tags that did not transmit, possibly because the tags were not activated prior to attachment. Three whales in 2002 stopped transmitting normal dive data less than 2 days after tagging. One is known to have died based on retrieval of her pectoral flipper band. Tag data from the other two show broken transmissions after periods with no communication and dive data that suggest the tags were submerged for long periods in very shallow water. It appears that some of the tagged whales may have stranded and it is unknown whether some tags were damaged (i.e., if the animals rolled on the rising bore tide). Floating carcasses that were not tagged whales were observed during and after the tagging project. Capture to release times for these three females fell within the range of times provided for 11 whales (3 whales in 2001 did not have release times). One of these females had a higher contaminant burden than most of the males and females, and according to blood work may have been pregnant. With the exception of this whale and another smaller female tagged in 2001, all of the females had lower contaminant loads than the males.

In response to questions posed by other workshop participants, Ms. Shelden noted that updated data and analysis have made less certain NMFS' earlier conclusion that tagging caused the deaths of the animals studied. Workshop participants also discussed diverse scenarios in which tags have stopped transmitting data or have transmitted unusual data and possible reasons for these situations.

3. The Cook Inlet Beluga Whale Photo ID Project (Tamara McGuire, Ph.D., LGL Alaska Research Associates)

Dr. McGuire's presentation gave the highlights of a comprehensive review and synthesis of information about satellite-tagged CIBs contained in databases maintained by the *CIBW*

Photo ID Project and by NMFS (the Alaska Region; AKR) and the Marine Mammal Laboratory (MML), with the following objectives: 1) review photographic data of CIBs contained within the photo ID catalog maintained by the CIBW Photo ID Project for information about both confirmed and suspected tagged individuals; 2) review data collected by NMFS during the capture and tagging of CIBs from 1999-2002; 3) review photographs (from the CIBW Photo ID Project, NMFS, and other sources) of stranded CIBs to determine if any have scars or markings consistent with satellite tags; 4) compare the three datasets (i.e., photo ID, tagging/capture, stranding) to determine if any of the photographically identified whales (confirmed or suspected as previously tagged individuals) can be associated with a specific capture year or known tagged whale; 5) summarize all the photographic data available about the confirmed and suspected tagged CIBs; and 6) provide recommendations for data collection in any future capture/tagging efforts that will improve long-term monitoring and tracking success. Photo-analysts with the *CIBW Photo ID Project* reviewed all photographs in the 2005-2016 *CIBW Photo ID Project* catalog for images of individuals bearing satellite-tag scars. Analysts also reviewed all photographs and associated data provided by NMFS that were taken of CIBs during the 1999-2002 capture and tagging events.

Of the 20 CIBs captured and 18 tagged by NMFS, the *CIBW Photo ID Project* matched the photos from tagging to six individual whales in the catalog. The photo ID project also was able to match one of the captured whales that was not tagged. The photo ID project classified 14 individuals in the CIB Photo ID catalog as confirmed satellite-tagged whales based on tag scars. A 15th individual in the catalog was identified as a whale that had been captured but not tagged. Ten of the 15 confirmed captured/tagged whales in the photo ID catalog were re-sighted as recently as 2015; this represents 50% of the 20 CIBs originally captured and/or tagged between 1999 and 2002. Three satellite-tagged whales were confirmed dead between 2001 and 2015. Photo ID records suggest a fourth whale, tagged in 2002, may have died after its last sighting in 2007. Of the 14 whales identified in the photo ID catalog as satellite tagged whales, four are confirmed females (confirmed via DNA collected during capture) and seven are suspected to be females based on accompaniment by calves. Reproductive histories of these confirmed and suspected females are presented in the full report. Five of the 14 confirmed satellite-tagged whales in the photo ID catalog had visible signs of tag-site infection, and eight had signs of concavity of the dorsal crest above the tag site. Two whales showed signs of damage to the left pectoral fins likely caused by flipper bands applied during tagging.

The photo ID project also showed photos of scars made from remote biopsy of CIBs conducted in 2016 and 2017. Detailed reports about photo ID monitoring of satellite-tagged and biopsied whales can be downloaded from www.cookinletbelugas.com.

4. Bristol Bay Beluga Health Assessment and Methods Development (Lori Quakenbush, Alaska Department of Fish and Game, and Carrie Goertz, D.V.M., Alaska SeaLife Center)

Ms. Quakenbush and Dr. Goertz provided an overview of the research methods used to study Bristol Bay beluga whales. They explained that the objectives are to: 1) obtain samples from healthy Bristol Bay belugas for a baseline and to compare with CIBs, and to 2) develop methods to collect samples from wild belugas that can be used to evaluate health and other information. They also showed how various types of research methods are implemented on Bristol Bay beluga whales, including capture; placing a tail rope and using a belly band; collecting samples, including blood, blow and swabs from blowholes, photos and biopsy of skin samples; ultrasound for blubber thickness; audiograms; and tagging including satellite tags, acoustic tags, and LIMPET tags.

In response to questions from other workshop participants, Ms. Quakenbush and Dr. Goertz explained that their team generally has animals in hand for 80 minutes before releasing them and does not hold animals for longer than 120 minutes. They have not conducted long-term tracking of scarring from tagging. They also explained that there are various differences between Bristol Bay and Cook Inlet, including the lack of extreme tides (e.g., -6 ft. to 30+ ft.) in Bristol Bay, which make research efforts comparatively more challenging in Cook Inlet.

5. Post Mortem Findings of Tagged Belugas, 3 Cases (Carrie Goertz, D.V.M., Alaska SeaLife Center and Kathy Burek, D.V.M., D.A.C.V.P., Alaska Veterinary Pathology Services)

Dr. Goertz presented post-mortem findings about three tagged beluga whales, with the following conclusions for the three cases, respectively:

- Adult male, found close to pregnant female in Cook Inlet (2014) – This whale live stranded during a relatively extreme low tide. Subsequently, the whale aspirated a large amount of mud which blocked its airways. Additionally, the whale had cardiac changes associated with age in other belugas which may have impaired its ability to handle the cardiovascular stresses of live stranding.

- Adult male in Cook Inlet (2015) – This whale's lung had a chronic infection of *Staph aureus* with multiple abscesses. Rupture of abscesses would have caused sepsis and seeding of additional tissues including kidneys, multiple lymph nodes, and the skin. Scars and significant deterioration resulting from poor healing and negative reaction to tagging would have been especially susceptible to secondary infection because disrupted capillaries would 'trap' bacteria.
- Adult male in Bristol Bay (2016) – The extensive post-mortem changes make it difficult to assign a specific cause of death. The following are possible contributors to death.
  - Illness secondary to *Strep uberis* (found at tag site and in abscess)
  - Orca attack (unusual pod sighting, additional beluga carcasses found, bruising consistent with blunt force trauma, change in the tag's pressure transducer 'baseline')
  - Debilitation secondary to live stranding (laceration due to set net anchors, debris packed in upper airway)
  - Anomalous weather including winds and lightning

Following Dr. Goertz' presentation, workshop participants observed that it is surprising that heart disease was found in the first two animals presented, since they were relatively young (in their 20s) at the time of death. In response to a question about the third case, Dr. Goertz explained that it was difficult to determine the significance of the *Strep uberis* found at the tag site and in the abscess due to the extensive decomposition and scavenger damage that had already occurred by the time of the necropsy. Dr. Goertz also noted that, in all three cases, the pins from tagging did not penetrate beyond the animals' blubber.

6. Early In-Field Experience Perspective (Barbara Mahoney, NMFS Alaska Region)

Ms. Mahoney explained that research on CIBs in Cook Inlet is difficult for a number of reasons: access to the water, air and water temperatures, ice, weather, etc. But she noted that nothing is more hazardous for access to and safety in Cook Inlet than its tides. Cook Inlet will experience tide flows that sometimes exceeds 30 feet (9 meters), with currents about 6 knots (almost 7 miles per hour). To be safe, research always has to work with and around the tides, needing: detailed tide schedules, daylight hours, and water depths at the boat launch.

In 1995, the Marine Mammal Lab., Alaska Native hunters, and the NMFS Alaska Region began an effort to chase CIBs and were successful in placing suction cup tags on CIBs. This partnership continued through the years, allowing for CIBs to be successfully captured and satellite tagged. In 1999, two CIBs were captured, with the white beluga tagged and released after waiting for high tide. In 2000, three CIBs were caught, and two whales were tagged and immediately released. In 2001, seven whales were captured and tagged, and all but one whale was immediately released. In 2002, eight whales were caught and satellite tagged, with a plastic band place around their pectoral flipper. One beluga was soon found dead by a fisherman, and two other belugas, with similar diving and satellite tag transmission behaviors, were thought to have died following the capture, tagging, biopsy, and/or blood collection efforts.

7. Southern Resident Killer Whale L95 Case Review (Deborah Fauquier, D.V.M., Ph.D., NMFS Office of Protected Resources)

Dr. Fauquier provided a summary of investigation by NMFS, the Department of Fisheries and Oceans, Canada, and the Animal Health Center, British Columbia Ministry of Agriculture and Lands, Canada, into the stranding of an endangered Southern Resident killer whale in 2016. This adult male killer whale was identified as L95, a 20-year-old whale. The whale had been tagged by NMFS using a satellite-linked limpet-style tag approximately 5 weeks prior to death. After a thorough necropsy and investigation, including an expert review of findings, it was determined that even though the killer whale presented in moderate to advanced decomposition at the time of necropsy there was sufficient evidence, as determined by gross dissection, radiographs, MRI, and histopathology of the tag site, to implicate the tag attachment site as a source of fungal infection in the whale. This fungal infection contributed to illness and, eventually, the death of this whale. Seven Southern Resident killer whales were tagged previously with similar tags that did not result in death. There were several factors in L95's case that predisposed this whale to a fungal infection at the tagging site including:

- Incomplete disinfection of the tag after seawater contamination;
- Retention of the tag petals (i.e., metal barbs) which may have allowed for formation of a biofilm or direct pathogen implantation;
- Placement of the tag lower on the body and near large-bore blood vessels which increased the chance of fungal dissemination through the blood system;
- Poor body condition/malnutrition of the whale; and
- Possible immunosuppression.

NMFS is reviewing the findings from this case and developing mitigation factors to limit the impacts of future tags and tagging on Southern Resident killer whales.

8. Humpback whale deep implant tagging review (Alex Zerbini, Ph.D., NMFS Alaska Fisheries Science Center, Marine Mammal Lab / Cascadia Research Collective, and Frances Gulland, Vet MB, Ph.D., The Marine Mammal Center)

Dr. Zerbini and Dr. Gulland presented the results of a follow-up study conducted in the Gulf of Maine from 2011-2015 to assess tag performance and impacts in North Atlantic humpback whales (*Megaptera novaeangliae*) and to develop robust large whale satellite tags. During this study, sixty-five "implantable" satellite tags were deployed on well-studied individuals with strong prior residency characteristics and known demographic traits. Short-term responses to tagging were assessed during a one-hour focal follow and a control sample was established from comparable whales that were also identified in the tagging area. Tagged whales were regularly re-encountered to assess the state of the tag, tissue responses and the overall condition of the whale. A scoring system was developed to quantify tissue responses at the tag site and statistical modeling was employed to identify variables influencing tag duration and potentially responsible for a range of host responses. Mark-recapture statistical analysis was used to compare survival, detection probabilities and calving probabilities of tagged whales and controls. This was a designed study of tag performance and impacts intended to address: 1) physical and physiological responses to satellite tags; 2) deployment and design factors as they relate to tag performance and the potential for impact on tagged individuals; 3) behavioral responses to tagging, including the potential for post-tagging shifts in distribution; and 4) movements and habitat use of humpback whales in the Gulf of Maine.

Whales were relatively resilient to the tag designs and deployment practices applied in this study, at least through the observations made to date. All females tagged through 2013 survived through 2016. They were less likely than controls to calve in the first year after tagging than females, but this effect may have been related to tag breakage versus proper tag function. Mark-recapture statistical results were equivocal regarding reduced survival among adult males versus controls, but possible effects were limited to years of tag breakage. Tag-site tissue responses tended to diminish over time. One of the most consistent predictors of host response was the location of the tag on the body, which appeared to influence both tag site tissue responses and animal behavior. This study highlights the importance of follow-up studies to evaluate and improve satellite-tagging technology.

In response to questions from other workshop participants, Dr. Zerbini and Dr. Gulland clarified that at least four animals were tagged with the integrated tags. They also explained that they know that some of the females tagged with the flawed tags were pregnant at the time of tagging, and, assuming that a similar percentage of females was pregnant in the experimental and control groups, a lower percentage successfully gave birth in the experimental group.

9. Tagging Workshop summary and recommendations (Russ Andrews, Ph.D., Marine Ecology and Telemetry Research)

Dr. Andrews provided an overview of the "Workshop on Cetacean Tag Development, Tag Follow-up and Tagging Best Practices", sponsored by the International Whaling Commission (IWC), the Office of Naval Research, and NMFS, held in Silver Spring, MD, from 6-8 September 2017. In addition to formal presentations and round-table discussions of the current state of tag attachment technology and methods for assessing tagging impacts, workshop participants reviewed a draft of the 'Cetacean Tagging Best Practice Guidelines'. These "Guidelines" were written to serve as a global resource to assist researchers, veterinarians, animal care committee members, and regulatory agency staff in the interpretation and implementation of current standards of practice and to promote the training of specialists in this area. Feedback from the Silver Spring workshop participants resulted in recommended revisions to the Guidelines, which are now being considered for endorsement by the IWC Scientific Committee. Following the next IWC meeting, the Guidelines and the workshop report are expected to be published in the Journal of Cetacean Research and Management, likely in summer of 2018. Workshop participants discussed, and the Guidelines include, a matrix for diagnosing causes of the lack of transmissions from tags, including tag failure modes and the unlikely but possible lethal impacts of tagging. Key recommendations of the Guidelines that are relevant to beluga whale tagging included insistence upon high standards of sterilization of trocars and implanted pieces of tag attachment hardware and a formal decision-making process for determining when tagging is justified, especially for endangered species.

Responding to a question, Dr. Andrews also noted that the presenter at the Tagging Workshop who was scheduled to speak about spider tags (which are typically the tag of choice for belugas) became ill and was unable to attend this workshop.

10. Physiological stress responses in odontocetes (Frances Gulland, Vet MB, Ph.D., The Marine Mammal Center)

Dr. Gulland explained that stress can be defined as an organism's response to a noxious factor (a "stressor") that aims to restore homeostasis. In the 1970s, Hans Selye developed the concept of "eustress" (a small amount of stress that resulted in improved well-being), and "distress", an increased amount of stress that is harmful. Since then, this concept has been expanded to consider allostasis, with allostatic load defined as the cumulative impact of repeated stress responses. The mammalian stress response consists of 1) the neural axis (seconds), with direct activation of the sympathetic nervous system and the neuromuscular system; 2) the neuroendocrine axis (minutes), with responses from the brain (amygdala, hippocampus), spinal cord, and adrenal medulla resulting in catecholamine release; 3) the endocrine axis (hours, days, weeks), involving the hypothalamus and pituitary releasing ACTH (which stimulates the adrenal cortex to release cortisol and aldosterone), TSH (which stimulates thyroid hormone release, growth hormone, ADH, and oxytocin); and 4) the cellular components (seconds to weeks) such as upregulation of oxidative stress pathway and altered telomerase activity. Mild stress typically activates cellular mechanisms; moderate to severe stress activates neuroendocrine responses; and short (acute) responses are typically neural, whereas long (chronic) responses are endocrine. As the stress response is complex, stressors activating common pathways can be synergistic or additive, increasing intensity and/or duration of responses. Complex feedback mechanisms exist, altering gene expression, hormone production and secretion, and neural activity.

In cetaceans, few components of the stress response have been well studied. Changes in circulating blood levels of catecholamines have been investigated following known stressors. These include increases in dopamine levels in *Stenella* post chase in the Eastern Tropical Pacific tuna fishery, increased epinephrine and norepinephrine levels in beluga post capture and transport, and in a captive beluga exposed to noise. Surges in blood levels of catecholamines have been suggested as cause of cardiomyopathy observed in dead odontocetes. More data exist on cetacean endocrine responses. Chase and capture increases blood levels of cortisol in bottlenose dolphins and belugas, and stranding causes a four-fold increase in blood cortisol levels in pilot whales. Lack of exposure to ship noise is associated with lowered fecal cortisol and metabolites in North Atlantic right whale feces, and cold exposure increases blood cortisol and aldosterone in bottlenose dolphins. Seasonal changes in blood thyroid hormones have been documented in bottlenose dolphins and killer whales.

The potential life history consequences of stress include effects on growth (cortisol, thyroid, and growth hormones alter lipid metabolism, gluconeogenesis, and moult; oxidative stress alters fat metabolism, immunity, telomerase activity); effects on reproduction (catecholamines cause uterine contraction, abortion; oxytocin can cause premature parturition, and alter milk let-down); and effects on mortality (catecholamines can cause acute cardiomyopathy, decreased immunity increases susceptibility to infectious disease, and toxins interact cumulatively via oxidative stress pathways).

11. Measures of stress response in odontocetes and its implications (Tracy Romano, Ph.D., Mystic Aquarium)

Dr. Romano presented that environmental and anthropogenic stressors (e.g. noise, shipping traffic, climate change) are an increasing concern for marine mammals, especially those that are endangered such as the CIB population. In her presentation, Dr. Romano underscored the importance of understanding the physiological response to stressors in cetaceans and the impact on the immune and reproductive systems, which are crucial for health, viability, and fitness. She noted that the research team at Mystic Aquarium has been studying the physiological response to stress and impact on the immune system in belugas utilizing tools that have been developed and/or adapted for belugas.

Measurements include various hormones, immune function, and gene expression. These measurements have been carried out on three different groups of belugas: aquarium belugas under controlled conditions; wild belugas live captured and released as part of tagging or health assessment studies; and subsistence hunted belugas. Transport studies and out of water examination experiments with aquarium belugas have enabled data on the characterization, time course and duration of the physiological response. On live capture release belugas, these same measures were carried out on whales immediately after capture and then after health assessment and tagging prior to release, to look at differences between pre- and post-sampling times. Blood was utilized in subsistence hunted whales to determine what tests could reveal information post mortem. From these studies, Dr. Romano and others are beginning to be able to put various stressors into context and to look at the magnitude of the response to different stressors, with stranding showing the highest physiological response. They can also begin to compare the measures among different beluga groups. The laboratory has also been investigating non-invasive techniques for measuring hormones and immune function in different tissue matrices such as blow, feces and skin. Results show the ability to detect hormones and biomarkers in all three tissue matrices with promise for adapting to monitor free ranging populations.

Responding to questions about the differences in findings between Bristol Bay and aquarium animals, Dr. Romano explained that wild animals are exposed to more pathogens and stressors than aquarium animals. She also noted that there are different "challenges" for whales in Bristol Bay vs. the Chukchi Sea which could account for differences in immune competence, but further analyses are warranted.

4) Key Themes from Workshop Discussion

The workshop was structured to provide participants with multiple opportunities to discuss the conservation and research benefits and risks associated with key research methods that might be used to study CIBs. The following key themes emerged over the course of the two-day workshop. A more detailed synthesis of individual feedback on each of the 47 research methods is provided in Appendix D.

1. Valuable alternatives exist – including strandings, archived samples, photo ID, and passive acoustic monitoring – compared to various intrusive methods and should be prioritized.

At numerous points during the course of the two-day workshop, participants strongly suggested that less-intrusive methods are available and should be more highly prioritized rather than putting CIBs under stress or at risk. In particular, workshop participants focused on information that can be collected from both live and dead strandings and from existing stores of data (such as archived blood samples) that could be subject to further analysis. Increasing efforts for these sources of information could provide valuable insight into CIBs without subjecting animals to the stressors and risks associated with various invasive research methods. For example, additional focus on improving stranding responses for dead animals, and conducting more necropsies in a laboratory vs. the field could deepen understanding about life history parameters and causes of mortality (although locating and retrieving dead animals in a timely fashion before they have been scavenged and have decomposed has been challenging to date). Some participants suggested that understanding causes of death from necropsies should be a higher priority for the species' recovery than live animal investigations by capture and sample collection.

Many workshop participants also suggested that passive acoustic monitoring and photo-identification could be reasonably substituted for tagging belugas in Cook Inlet to understand animal movement and exposure to anthropogenic sounds and threats. Many workshop participants also identified significant promise in greater use and improved analysis of photo-ID data for purposes such as visual health assessment, understanding social structures, and inferring mortality rates by comparing photos over time.

While there was a strong sentiment expressed in favor of exploring less-invasive alternatives, some voices around the table did make the case that the quantity and richness that can be collected from some techniques, such as capture and tagging, cannot be replicated using alternative techniques.

2. **The relative benefits and risks of diverse research methods must be considered within context – e.g., the context of how the research method is implemented, sample size, and overall species-recovery goals.**

Workshop participants noted that animals are almost always captured in order to collect a variety of different samples and implement various other research methods. As such, while a given research method may not be independently "worth" the associated risk of chase and/or capture, it may only make sense to perform the research method as part of a suite of methods on a captured animal. For example, participants suggested that while blood samples can be very useful for understanding animal health, it would generally not be worth the risk involved to capture an animal primarily to collect blood. Participants also emphasized that, while a given research method (e.g., ultrasound or blood sampling) may allow for the collection of important information, that information may not be useful for species recovery unless the sample size employed for that research method is sufficiently large to allow for meaningful inferences to be drawn. Given this, the risk associated with a research method such as capture should be weighed against the real value of the information collected and how it can contribute to the species' recovery.

3. **Research methods and the information that they produce are complementary and, treated accordingly, can greatly expand our understanding about CIBs.**

Workshop participants emphasized that the information gleaned from the use of diverse research methods can complement one another. For example, tagging, passive acoustic monitoring, and photo-ID can together greatly improve understanding about CIBs' movements. Participants also suggested that, while blood samples on their own will not provide sufficient information to recover CIBs, health and disease information gleaned from blood samples can complement other types of information to build a more comprehensive understanding of CIBs (for example, blood and biopsy samples can provide different information for individual animal health assessments; blood samples paired with passive acoustic monitoring may provide information to help determine whether animals were exposed to and exhibited a stress response to anthropogenic noise). Similarly, the information gained from photo-ID can be more useful when combined with biological information secured using other research methods (such as blood sampling). Participants also spoke to the complementary value of combining visual identification with passive acoustic monitoring to confirm animal movements and distribution.

Greater coordination among researchers and across research methods is needed to leverage these types of synergies among diverse research methods. At present, researchers often are not specifically aware of other types of research being conducted or what data sets exist. In light of this, workshop participants urged that a shared repository for research findings (such as is available for North Atlantic right whales) be created so that researchers can better build on existing research and so that analysis can more easily be conducted across different data sets.

4. Spatial/mapping data can be particularly helpful for management decision-making.

To the extent that information from diverse methods and sources can be represented spatially and synthesized with other spatial representations, maps are a particularly valuable tool for researchers to understand the movement of animals. Spatial information can help identify feeding grounds (including differences between males and females with calves) which can help inform understanding of diet as well as exposure to areas of risk (such as ports and oil rigs). Maps can also be very useful for Federal managers, including for use in communicating with other stakeholders and in ESA section 7 consultations.

While tagging data is often used to create maps showing CIB location and movement, participants suggested that other research methods, such as passive acoustic monitoring and photo-ID, can also be used to improve understanding about CIBs' movements.

5. The value of research methods must be considered in the specific context of Cook Inlet.

While valuable parallels can be drawn from work with beluga whales and other odontocetes in other locations, the use and value of research methods must be considered in the specific context of Cook Inlet. Particular characteristics of the inlet, including the muddy and opaque water, large tidal range, the relatively small range of habitat, presence of extensive mud flats on which CIBs forage (and become stranded), large amount of human activity, and location adjacent to Anchorage (where functional analyses of blood samples could be conducted), mean that the benefits and risks (both to CIBs and to researchers due to the tides and mudflats, for example) associated with various research methods may be different than when those methods are used in other locations. Specific research methods discussed in this context include capture and tagging (which may pose greater population-level risk to CIBs than to larger beluga populations in other locations) and photo-ID and passive acoustic monitoring (which may be more useful in Cook Inlet due to the inlet's relatively small size).

6. Extensive discussion about tagging

Certain research methods prompted extensive discussion among workshop participants. In particular, tagging was a point of focus during different points of the workshop. Participants identified tagging as one of the few research methods that can provide longitudinal data about specific animals. In particular, dorsal fin/ridge tags (such as spider tags) will stay on animals and provide information about animals' locations and movements over a longer time than will dart/barb tags or suction-cup tags. Participants highlighted that tags provide information about whether animals are in proximity to hazards (such as oil rigs), about feeding behavior, and how animal movements change when their environment is disrupted (e.g., due to pile driving).

Along with these benefits, workshop participants also raised questions about the risks associated with tagging (and particularly with dorsal fin/ridge tags) and about whether the benefit to the population as a whole from information gathered from tagging outweighs the risk to the animals that are tagged. Workshop participants noted that, while practices around tagging (and particularly around sterilizing equipment so as not to expose animals to risk of infection) have improved during the past twenty years, the level of risk posed to animals from dorsal fin/ridge tags still needs further investigation. While some participants attested to the general safety of dorsal fin/ridge tagging, others strongly called for follow-up monitoring of tagged beluga whales to determine what sub-lethal and lethal effects might emerge.

Some participants suggested that less-invasive alternatives such as passive acoustic monitoring should be prioritized over tagging, particularly in the context of Cook Inlet where the beluga whales' range of movement is known and limited, the Inlet is itself relatively small, and key areas of risk to the animals could be prioritized for placing passive acoustic monitors. Participants also discussed the benefits and downsides of substituting LIMPET tags for spider tags, including that spider tags provide information over a longer time period and that LIMPET tags may be less stressful to apply since they can be applied remotely (although it was noted that one must closely approach a beluga whale to apply a LIMPET tag).

Workshop participants suggested that suction-cup tags are not as useful as they used to be because, if one is going to closely approach a beluga whale, a dart/barb tag will stay with the animal over a longer time period and provide more information than a suction-cup tag.

5) Individual Assessment Findings

Surveys completed by workshop participants prior to the workshop and during the workshop provided valuable individual input about the benefits and risks associated with each research method.

1. Methodology

As noted earlier, the pre-workshop survey asked participants to indicate the extent (i.e., yes, somewhat, no, uncertain) to which each research method generally provides the type of information that would improve understanding of CIBs in each of the following areas: 1) CIB life history parameters, 2) health and disease, and 3) exposure to and effects of identified threats. The pre-workshop survey also asked participants to list the most significant potential benefits and potential risks associated with each research method. Given that some research methods can be accomplished either remotely (i.e., without requiring capture) or with an animal in-hand (i.e., requires capture), these methods were analyzed separately by workshop participants. For the methods that can be accomplished either remotely or with an animal in-hand, italicized parenthetical notes *"(remote method)"* indicate the specific form of the method. As such, some methods may appear to be on the list twice, but they were analyzed separately based upon whether they were employed remotely or with an animal in-hand.

The main survey – completed by participants at the conclusion of the workshop – asked them to indicate whether the benefit and risk levels associated with each research method are "high," "medium," or "low" for CIBs, as well as indicating whether the benefit of using the research method outweighs the risk.[2] For those research methods that require a preceding action (e.g., chase or capture), respondents were asked to *exclude* the risk

---

[2] In addition to the pre-workshop survey, participants completed one survey during the course of the workshop and another at the conclusion of the workshop. The in-workshop survey was used simply to identify priority research methods for discussion during a specific portion of the workshop while the survey conducted at the conclusion of the workshop asked participants to assess the levels of benefit and risk associated with each research method along with providing reasoning and commentary to accompany their assessments.

associated with the preceding action in an attempt to get a better understanding of each individual's perspective on that specific research method (e.g., ultrasound) separated from the method employed to get an animal "in-hand". Discussion following the completion of the individual assessment, however, indicated the following caveats that should be kept in mind when reviewing the survey results:

- Some respondents incorporated the risk associated with the preceding action (e.g., chase or capture) in their assessment of risk posed by the research method itself.
- In the context of the survey, "benefit" and "risk" were somewhat subjective concepts. Individual respondents each had their own understandings of what constitutes "high," "medium," and "low" when it comes to assessing benefit and risk.
- Participants noted that they may be more likely to understand and highlight the benefits of those research methods with which they are most familiar.
- In some cases, participants noted that their understanding of what is involved with a particular research method may have differed from that of other participants. For example, some participants explained that they had interpreted the research method listed as "Imaging, thermal" to mean remote thermal imaging while other participants interpreted the same listed research method to mean imaging of animals in-hand (in this case, the former was the intended research method).
- Some participants incorporated considerations that other participants did not contemplate – for example, the (low) practicality of successfully conducting a research method in assessing the level of benefit or the risk posed to humans (as opposed to just the risk posed to CIBs).
- Finally, and perhaps most significantly, NMFS and other readers should be mindful about how they interpret the survey results. Almost all participants articulated a preference for having clearer research objectives delineated when considering benefits and risks associated with the research methods and many participants stated that their characterization of benefits was based on assumptions about research objectives and could change if the research objectives were different than assumed. As such, characterizations in this report about benefits and whether benefits > risks in the survey results should be treated with due caution.

2. Synthesis of Assessment Findings

While the pre-workshop and in-workshop individual survey assessments were intended primarily to reflect each participant's unique perspectives on the research methods under consideration, and to focus discussion topics, a look across the individual responses suggests a few noteworthy trends (summarized directly below).[3] More detailed outputs are synthesized for each individual research method and presented in Appendices C and D.

Participants identified the following methods as the top-three "most promising" methods (considering both the benefits and risks involved) for addressing the following three core research needs:

- For *"understanding CIB life history parameters"*
  - Photo ID *(remote method)*
  - Sample, biopsy (skin and blubber) *(remote method)*
  - Count/survey *(remote method)*
- For *"understanding health and disease"*
  - Photo ID *(remote method)*
  - Sample, biopsy (skin and blubber) *(remote method)*
  - Sample, blood *(involves capture)*
- For *"understanding exposure to and effects of identified threats"*
  - Sample, blood *(involves capture)*
  - Acoustic, passive recording *(remote method)*
  - Instrument, dorsal fin/ridge attachment *(involves capture)*

Based on a tally of the individual responses, the majority of participants highlighted the following research methods as "worth doing" in that the benefits are greater than the risks (i.e., at least 80 percent of respondents identified the benefits of the method outweighing the risks):[4]

---

[3] The below survey results are based on tallies of individual responses. As a result, survey outcomes contain some outcomes that may be in tension or may not be fully consistent. For example, while a majority of workshop participants individually identified "dart/barb tags" as potentially beneficial once a CIB has already been captured or has been live stranded, in a different survey question participants also identified the same research method as "requiring further study of benefits and/or risks to determine whether they should be used for CIB."

[4] For those research methods that require a preceding action (e.g., chase or capture), respondents were asked to *exclude* the risk associated with the preceding action in an attempt to get a better understanding of each individual's perspective on that specific research method (e.g., ultrasound) separated from the method employed to get an animal "in-hand." Some respondents indicated that

- Acoustic, passive recording *(remote method)*
- Count/survey *(remote method)*
- Instrument, suction-cup tag *(remote method / requires capture)*
- Observation, behavior or monitoring *(remote method)*
- Photo ID *(remote method)*
- Photogrammetry *(remote method)*
- Photograph/video *(remote method)*
- Remote vehicle, aerial (unmanned aircraft - UAS) *(remote method)*
- Sample, biopsy (skin and blubber) *(remote method / requires capture)*
- Sample, exhaled air *(remote method / requires capture)*
- Non-chase close approach
- Stranding response

A majority of participants individually identified the following research methods as <u>potentially beneficial once a CIB has already been captured or has been live stranded</u> but raised caution about capturing animals with these methods as the driving motivation:

- Dart/barb tag *(remote method)*
- Auditory brainstem response test *(require capture)*
- Instrument, suction-cup tag *(require capture)*
- Mark, freeze brand, or roto tag *(require capture)*
- Measure and weigh *(require capture)*
- Sample, blood *(require capture)*
- Sample, biopsy (skin and blubber) *(remote method / requires capture)*
- Sample, exhaled air *(require capture)*
- Sample, swab (anal, blowhole, oral, or vaginal) *(require capture)*
- Sample, other (milk, urine, fecal, or sperm) *(require capture)*
- Ultrasound *(require capture)*

The majority of participants also individually highlighted the following research methods as <u>"not worth doing"</u> in that the benefits fall short of the risks (i.e., at least 80 percent of respondents identified the benefits of the method *not* outweighing the risks):

- Instrument, belt/harness tag *(require capture)*

---

they nevertheless incorporated the risk associated with the preceding action (e.g., chase or capture) in their assessment of risk posed by the research method itself.

- Sample, biopsy (muscle) *(require capture)*
- Sample, tooth extraction *(require capture)*
- Transport *(require capture)*

Participants individually identified the following research methods as requiring further study of benefits and/or risks to determine whether they should be used for CIB:

- Dart/barb tag *(remote method / requires capture)*
- Capture
- Restraint
- Insert ingestible telemeter pill *(require capture)*
- Instrument, dorsal fin/ridge attachment *(require capture)*
- Transport *(require capture)*

3. Prioritizing Research Efforts

In their individual written comments and in the workshop discussions, workshop participants provided suggestions about how limited resources should be prioritized among diverse types of research and other activities to better understand the CIB population and promote its recovery.

Archived Data: Many workshop participants emphasized that researchers have extensive existing (archived) data that should be more fully analyzed. Particularly in the context of the many invasive research methods that were discussed during the two-day workshop, participants strongly urged that more resources and attention be dedicated to taking advantage of this *non-invasive* approach in order to learn more about CIBs and what factors could be contributing to the population's challenges. This is consistent with the CIB Recovery Plan, which includes recommendations for use of existing data in some of the proposed recovery actions.

Strandings: Many workshop participants also highlighted the importance of focusing on stranded whales (both live and dead) because they have already been "captured" by the mud or have died, thereby reducing the additional stress that researchers would place on the CIB population by chasing and capturing live animals. Specific suggestions for stranding include: retrospective analysis; organize data in a comprehensive database; dedicated systematic carcass surveys; expand volunteer network for all aspects of stranding work (recovery, searching, recovering, data); citizen science; make response to live-stranded and dead animals faster, better equipped, and more able to process and analyze samples and pull together annual reports on all animals found and synthesizing knowledge gained on life-history, health, and stressors.

Photo ID: A third key area of focus among many workshop participants was on photo ID, which was also seen as a non-invasive method with potential to provide significant understanding of the CIB population. Specific suggestions around photo ID included more people taking photos to provide to the photo ID project (including citizen science efforts); move the photo ID program into near real-time analysis based on both lateral and aerial photos; place greater emphasis on mining data to construct individual life history and survivorship; place greater emphasis on relating ID and photogrammetric photos to biopsy and genetic information to build life history and health profiles of individual animals; place greater emphasis on analysizing photos to look at mortality and fecundity rates; conduct a proper mark-recapture study; and generate a visual health assessment score for individuals.

Passive Acoustic Monitoring: The last priority area that received broad support among many workshop participants was enhancing the passive acoustic monitoring array in Cook Inlet. For example, a specific suggestion provided was to map the potential stressors in Cook Inlet and build an acoustic monitoring network to document beluga presence (year-round) in both impacted and unaffected areas and develop a real-time visually supported ability to document movements in the areas of suspected stressors.

Additional research areas that smaller numbers of workshop participants suggested prioritizing include:

- Developing a database for community data sharing and real-time data input.
- Investigating reproductive rate/failure. This would include contaminant load, hormone levels, endocrine disruption, and could be paired with investigating the number of calves and calving intervals.
- Evaluating the efficacy of mitigation measures related to industrial activities to determine whether those mitigation measures are based on data or supposition and whether additional mitigation measures should be implemented.
- Hosting regular meetings to review data and plan research in an adaptive fashion depending on research results.

Appendix A – Workshop Agenda

Cook Inlet Beluga (CIB) Research Methods Workshop Agenda
Captain Cook Hotel, Aft Deck
November 29-30, 2017

DAY 1 (8:15 am-5:45 pm)

8:15 AM Arrival and Coffee

8:30 AM Welcome and Introduction

- Welcome *(Greg Balogh)*
- Self introductions

8:50 AM Workshop Overview and Background

- Overview of workshop need, objectives, and intended work products *(Mandy Migura)*
- Review of workshop agenda, structure, and approach *(Bennett Brooks)*

9:10 AM Context Setting and Case Studies

- Overview - CIB distinctive population characteristics *(9:10-9:30) (Paul Wade)*
- Case Studies: Cook Inlet and Bristol Bay Beluga Capture/Tagging Projects (9:30-10:45)
    - o CIB project overview *(Kim Shelden)*
    - o CIB post-tagging photo-ID monitoring *(Tamara McGuire)*
    - o BBB project overview *(Lori Quakenbush)*
    - o Information from necropsies of tagged belugas *(Carrie Goertz)*
    - o Early in-field experience perspective *(Barbara Mahoney)*

--- Break (10:45-11:00) ---

- Case studies: Other Cetacean Tagging Projects *(11:00-12:00)*

    - Southern Resident Killer Whale L95 *(Deb Fauquier - remotely)*
    - Humpback whale deep implant tagging review *(Alex Zerbini and Frances Gulland)*
    - Tagging Workshop summary and recommendations *(Russ Andrews)*
- Overview of Stress in Odontocetes *(12:00-12:30)*
    - Physiological stress responses *(Frances Gulland)*
    - Measures of stress response and its implications *(Tracy Romano)*

12:30 PM Lunch *(on your own)*

1:45 PM Overview of Survey Findings

- Summarize pre-workshop survey results: areas of consistent and divergent views, top 10 research methods to discuss in-depth (as time allows), additional methods identified in surveys *(Mandy Migura/Amy Sloan)*

2:15 PM Discussion: Individual Research Method Risks and Benefits
(includes 20 min break)

- For each of the research methods identified for in-depth discussion via pre-workshop surveys:
    - Highlight and understand views regarding risks and benefits
    - Discuss state of knowledge regarding both risks and benefits
    - Consider the potential of alternative research methods
        - Are there other less invasive or stressful ways to get similar info?
        - Are there new emerging methods or technologies that can be employed (including analysis or re-analysis of existing data/samples)?

5:30 PM Wrap-up and Preview of Day Two

5:45 PM Adjourn

6:00 PM No-host social at Whale's Tail Bistro and Wine Bar (inside Captain Cook)

<u>DAY 2 (8:30 am-5:15 pm)</u>

8:30 AM Arrival and Coffee

8:45 AM Recap Day 1 and Review Plan for Day 2

9:00 AM Discussion: Comparing Risks and Benefits Across Research Methods
(includes 20 min break)

- Participant Polling *(**Computers Required**)*: For each of the following core research needs, identify your top 3 methods for which you think the benefits outweigh the risks:
  - understanding CIB life history parameters,
  - understanding health and disease, and
  - understanding exposure to and effects of identified threats
- In-depth discussion (1 hour per core research need) to understand participants' perspectives on selected research methods.

12:30 PM Lunch *(on your own)*

1:45 PM Individual Personal Assessments: Research Method Risks/Benefits
(**Computers Required**)

- Introduce method for characterizing individual assessments of research method risks and benefits
- Each participant to independently document their personal opinions regarding the extent of risks and benefits of each method as it pertains specifically to Cook Inlet beluga whales
  - A digital template will be provided to each workshop participant to foster individual personal assessments

3:45 PM Break *(facilitators aggregate ranking results)*

4:05 PM Taking Stock of Individual Assessments

- Review results of individuals' rankings, highlighting cross-cutting and divergent perspectives; opportunity for final discussion and reflections on rankings

4:45 PM Next Steps

- Review process for workshop summary drafting and review
- NMFS's intended next steps for using workshop results to inform future decisions

5:00 PM Final Reflections

5:15 PM Adjourn

NOTE: Due to the diversity of participants' expertise, we are using generic definitions for some phrases that may have specific meanings to some participants, specifically "invasive" and "risk". While we recognize that the term "invasive" literally means the introduction of an object into the body, for the purposes of this workshop we are using the term as a shorthand for both truly invasive methods, such as attaching tags that penetrate the body, but also for research methods with the potential to be highly stressful to the animals, such as chasing and/or capturing the animals. Similarly, for the purposes of this workshop, the word "risk" should be interpreted in its most basic form, consistent with a generic dictionary definition.

Appendix B – Participant List

CIB Research Methods Workshop – Participant List

* = Steering Committee member

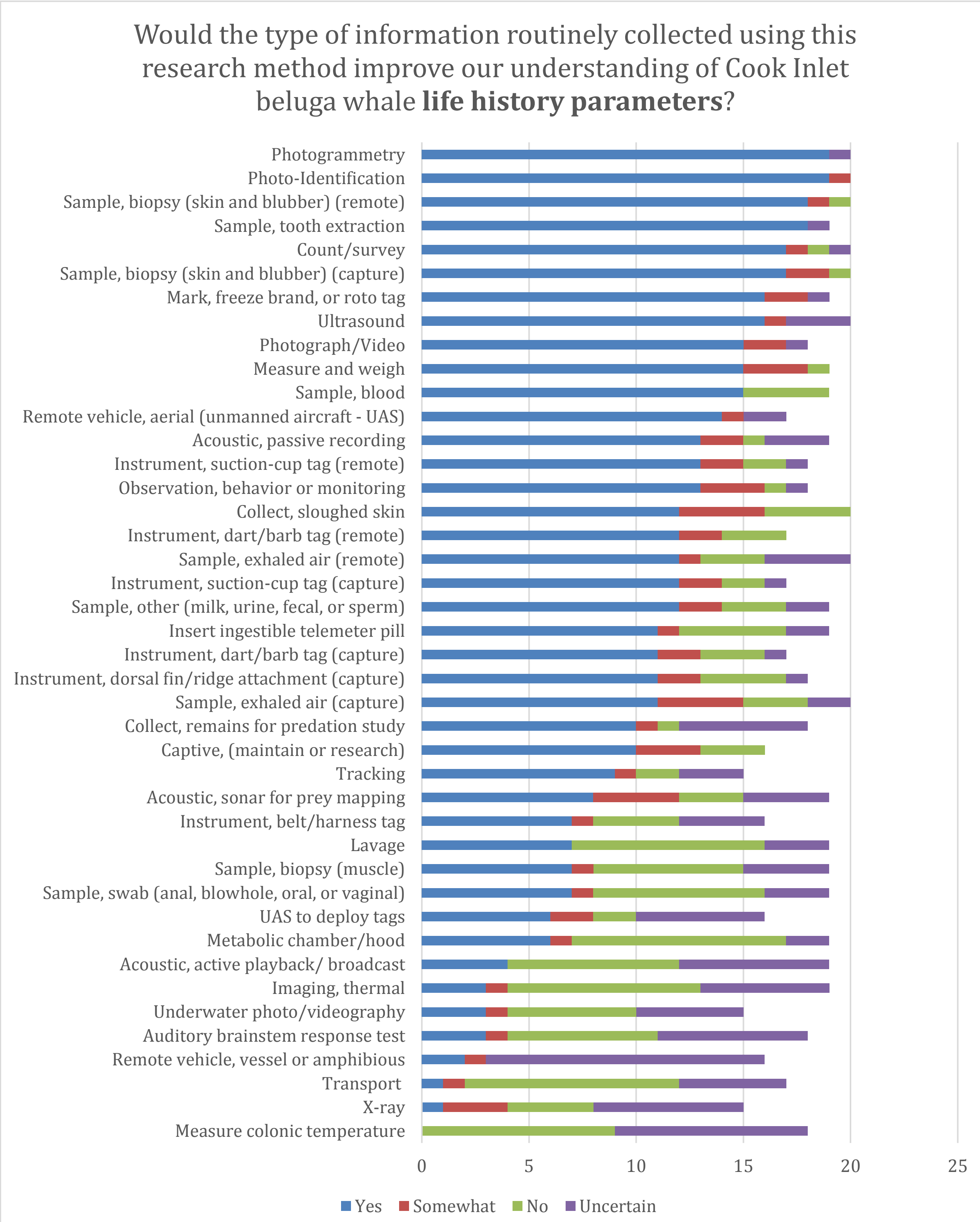
† = Provided input to the pre-workshop surveys but did not participate in the workshop and in-workshop discussions and results do not reflect their opinions

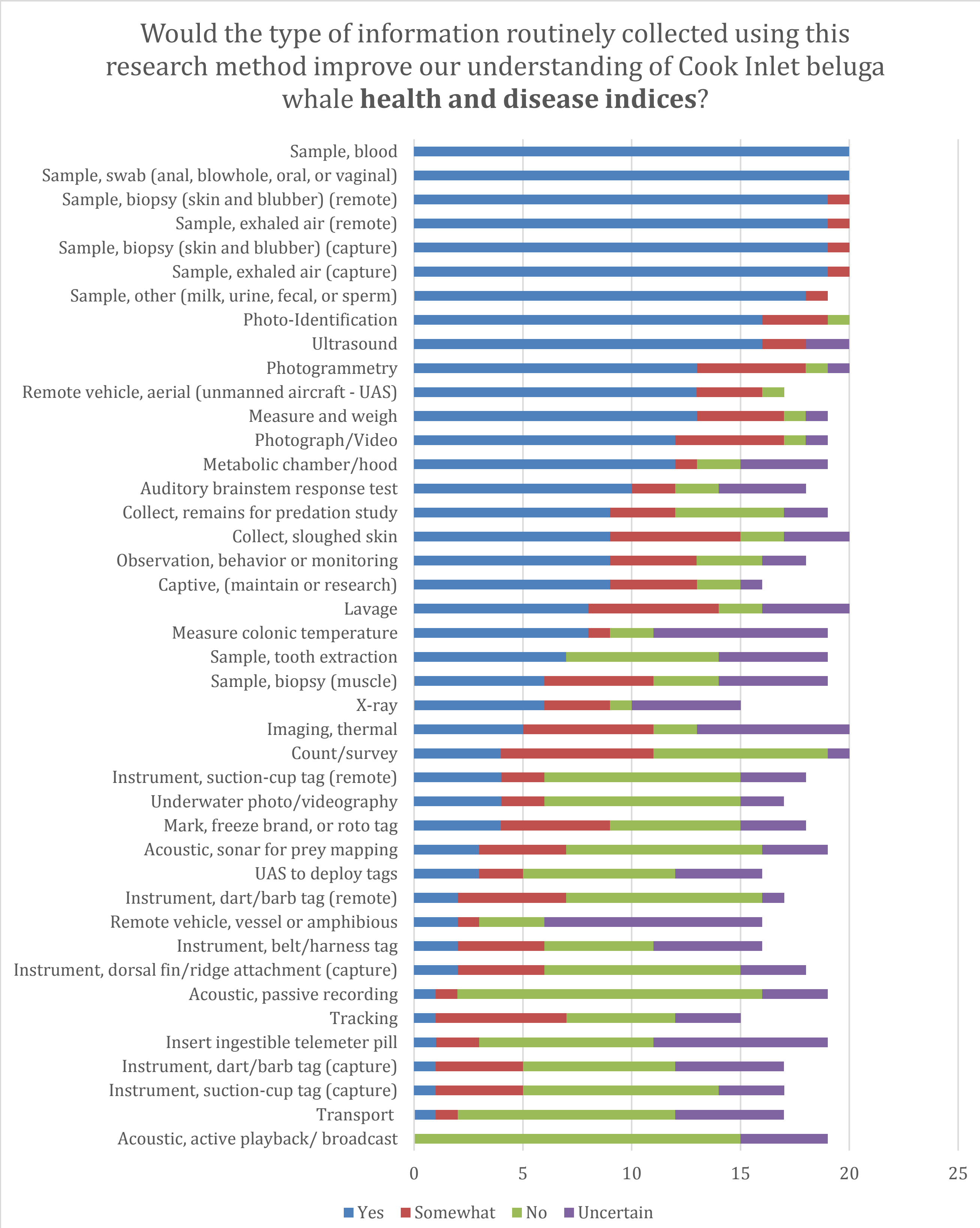
Participant	Affiliation
Russ Andrews, Ph.D.	Marine Ecology and Telemetry Research
Greg Balogh	NMFS Alaska Region
Kathy Burek, D.V.M., D.A.C.V.P.†	Alaska Veterinary Pathology Services
Deborah Fauquier, D.V.M., Ph.D.	NMFS Office of Protected Resources
Chris Garner	DOD Joint Base Elmendorf-Richardson
Verena Gill	NMFS Alaska Region
Carrie Goertz, D.V.M.	Alaska SeaLife Center
Frances Gulland, Vet MB, Ph.D.*	The Marine Mammal Center
Amy Hapeman	NMFS Office of Protected Resources
Mandy Keogh, Ph.D.	Alaska Department of Fish and Game
Barbara Mahoney	NMFS Alaska Region
Tamara McGuire, Ph.D.	Cook Inlet Beluga Whale Photo-ID Project
Mandy Migura*	NMFS Alaska Region
Lori Polasek, Ph.D.	Alaska Department of Fish and Game
Lori Quakenbush	Alaska Department of Fish and Game
Tracy Romano, Ph.D.	Mystic Aquarium
Teri Rowles, D.V.M., Ph.D.*†	NMFS Office of Protected Resources
Kim Shelden	NMFS Alaska Fisheries Science Center, Marine Mammal Lab
Amy Sloan*	NMFS Office of Protected Resources
Robert Suydam, Ph.D.*	North Slope Borough
Peter Thomas, Ph.D.	Marine Mammal Commission
Paul Wade, Ph.D.*	NMFS Alaska Fisheries Science Center, Marine Mammal Lab
Alex Zerbini, Ph.D.	NMFS Alaska Fisheries Science Center, Marine Mammal Lab / Cascadia Research Collective

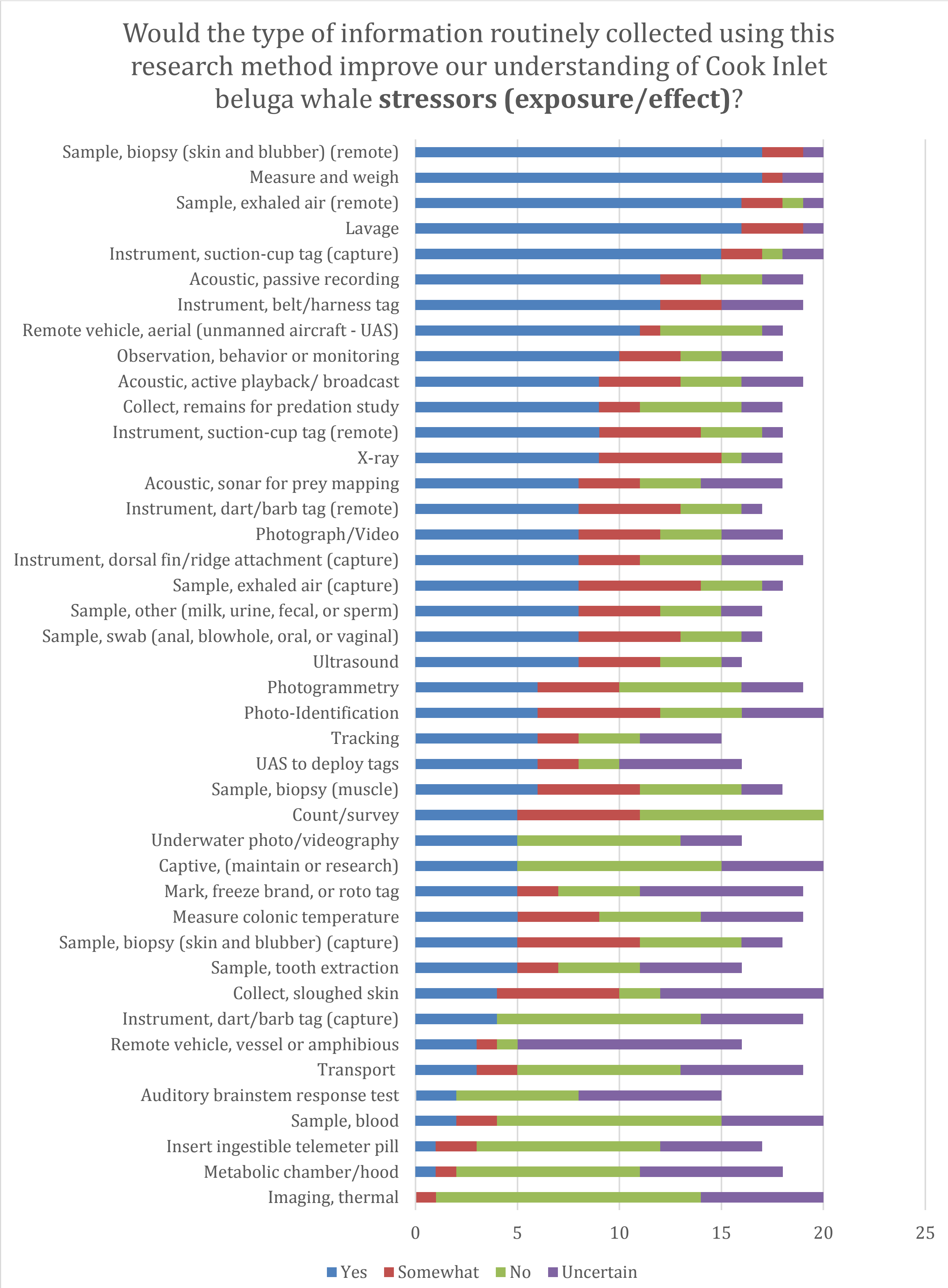
Facilitators: Bennett Brooks and Tushar Kansal, Consent Building Institute

Logistical Support: Kate Al-Sheikhly, Pacific States Marine Fisheries Commission]

Appendix C – Pre-workshop Survey Results



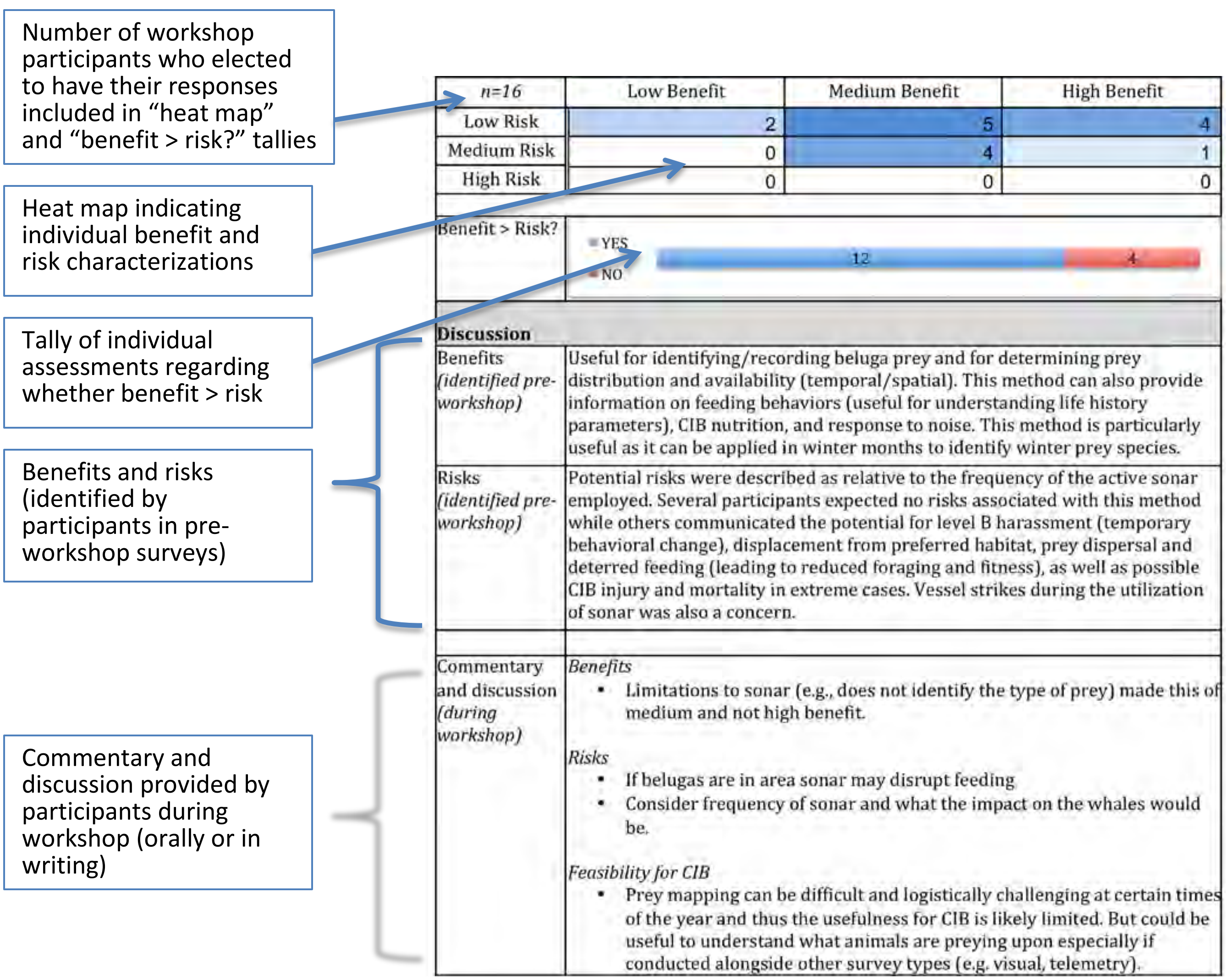

Would the type of information routinely collected using this research method improve our understanding of Cook Inlet beluga whale **health and disease indices**?
Sample, blood
Sample, swab (anal, blowhole, oral, or vaginal)
Sample, biopsy (skin and blubber) (remote)
Sample, exhaled air (remote)
Sample, biopsy (skin and blubber) (capture)
Sample, exhaled air (capture)
Sample, other (milk, urine, fecal, or sperm)
Photo-Identification
Ultrasound
Photogrammetry
Remote vehicle, aerial (unmanned aircraft - UAS)
Measure and weigh
Photograph/Video
Metabolic chamber/hood
Auditory brainstem response test
Collect, remains for predation study
Collect, sloughed skin
Observation, behavior or monitoring
Captive, (maintain or research)
Lavage
Measure colonic temperature
Sample, tooth extraction
Sample, biopsy (muscle)
X-ray
Imaging, thermal
Count/survey
Instrument, suction-cup tag (remote)
Underwater photo/videography
Mark, freeze brand, or roto tag
Acoustic, sonar for prey mapping
UAS to deploy tags
Instrument, dart/barb tag (remote)
Remote vehicle, vessel or amphibious
Instrument, belt/harness tag
Instrument, dorsal fin/ridge attachment (capture)
Acoustic, passive recording
Tracking
Insert ingestible telemeter pill
Instrument, dart/barb tag (capture)
Instrument, suction-cup tag (capture)
Transport
Acoustic, active playback/ broadcast
0
5
10
15
20
25
Yes
Somewhat
No
Uncertain


Would the type of information routinely collected using this research method improve our understanding of Cook Inlet beluga whale stressors (exposure/effect)?
Sample, biopsy (skin and blubber) (remote)
Measure and weigh
Sample, exhaled air (remote)
Lavage
Instrument, suction-cup tag (capture)
Acoustic, passive recording
Instrument, belt/harness tag
Remote vehicle, aerial (unmanned aircraft - UAS)
Observation, behavior or monitoring
Acoustic, active playback/ broadcast
Collect, remains for predation study
Instrument, suction-cup tag (remote)
X-ray
Acoustic, sonar for prey mapping
Instrument, dart/barb tag (remote)
Photograph/Video
Instrument, dorsal fin/ridge attachment (capture)
Sample, exhaled air (capture)
Sample, other (milk, urine, fecal, or sperm)
Sample, swab (anal, blowhole, oral, or vaginal)
Ultrasound
Photogrammetry
Photo-Identification
Tracking
UAS to deploy tags
Sample, biopsy (muscle)
Count/survey
Underwater photo/videography
Captive, (maintain or research)
Mark, freeze brand, or roto tag
Measure colonic temperature
Sample, biopsy (skin and blubber) (capture)
Sample, tooth extraction
Collect, sloughed skin
Instrument, dart/barb tag (capture)
Remote vehicle, vessel or amphibious
Transport
Auditory brainstem response test
Sample, blood
Insert ingestible telemeter pill
Metabolic chamber/hood
Imaging, thermal
0
5
10
15
20
25
Yes
Somewhat
No
Uncertain

Appendix D – Individual Research Method Assessments

Towards the end of day 2 of the workshop, each participant was asked to complete an in-workshop survey summarizing their individual assessment of the 47 research methods covered by the workshop. The information below aggregates these individual responses to provide an in-depth look at feedback on each research method.

Each research method contains a "heat map" that indicates how workshop participants individually characterized the benefit and risk levels associated with each research method ("high," "medium," or "low") as well as a bar chart indicating how many respondents indicated whether the benefit of using the research method outweighs the risk. Additionally, a list of benefits and risks for each research method that workshop participants identified in pre-workshop surveys is provided, along with key discussion points and written commentary about each research method provided during the course of the workshop itself.



n=16	Low Benefit	Medium Benefit	High Benefit
Low Risk	2	5	4
Medium Risk	0	4	1
High Risk	0	0	0

Benefit > Risk? YES 12, NO 4

Discussion	
Benefits *(identified pre-workshop)*	Useful for identifying/recording beluga prey and for determining prey distribution and availability (temporal/spatial). This method can also provide information on feeding behaviors (useful for understanding life history parameters), CIB nutrition, and response to noise. This method is particularly useful as it can be applied in winter months to identify winter prey species.
Risks *(identified pre-workshop)*	Potential risks were described as relative to the frequency of the active sonar employed. Several participants expected no risks associated with this method while others communicated the potential for level B harassment (temporary behavioral change), displacement from preferred habitat, prey dispersal and deterred feeding (leading to reduced foraging and fitness), as well as possible CIB injury and mortality in extreme cases. Vessel strikes during the utilization of sonar was also a concern.
Commentary and discussion *(during workshop)*	*Benefits* • Limitations to sonar (e.g., does not identify the type of prey) made this of medium and not high benefit. *Risks* • If belugas are in area sonar may disrupt feeding • Consider frequency of sonar and what the impact on the whales would be. *Feasibility for CIB* • Prey mapping can be difficult and logistically challenging at certain times of the year and thus the usefulness for CIB is likely limited. But could be useful to understand what animals are preying upon especially if conducted alongside other survey types (e.g. visual, telemetry).

Research Methods

Acoustic, Active Playback/Broadcast (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	9	2	0
Medium Risk	4	3	1
High Risk	0	1	0

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Facilitates the observation of behavioral responses to soundscapes, including sensitivity to anthropogenic noise (e.g., industrial). This method can be applied to infer the meaning of beluga sounds and to devise effective hazing measures (e.g., deterring transit into an oil spill). This method can also inform the development of acoustic guidelines for assessing the effects of anthropogenic sound on behavior, to inform behavioral response assessments of MMPA and ESA analyses, and to inform regulations on and reduce the impacts of human activities (e.g., construction, oil and gas development, etc.) on CIBs.
Risks *(identified pre-workshop)*	Depends on playback message and volume. Many participants felt this method would pose few, if any risks for CIBs. Some suggested playback could lead to elevated stress, level A harassment (PTS or TTS), and level B harassment (disrupting behavioral patterns). The more serious risks described included: hearing loss, potential stranding (e.g., calf-cow pairs), flight response, and interference with life history functions.
Commentary and discussion *(during workshop)*	*Benefits* • Could be explored as a means of evaluating CIB hearing and response to noise, response to stressors/predators *Risks* • Could cause stranding *Less invasive options* • Performing studies/observations of belugas during pile driving at the Port of Anchorage, drilling operations at the oil rigs, seismic activity during blasting, etc. *Feasibility for CIB* • Some participants suggested that acoustic, active playback/broadcast would likely only be of significant value if done with tagged whales.

	Given the logistical challenges of belugas that move around a lot due to tides and highly mobile prey, it might be more efficient to utilize tagged whales in an opportunistic encounter design rather than controlled exposures.

Acoustic, Passive Recording (remote method)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	19
Medium Risk	0	0	0
High Risk	0	0	0

Benefit > Risk?

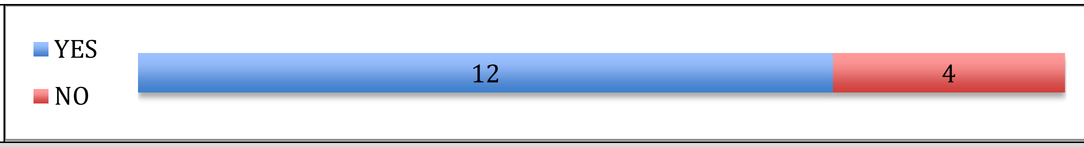
Discussion	
Benefits *(identified pre-workshop)*	A powerful tool and non-invasive method for identifying the temporal and spatial distribution of CIBs (if they are eliciting sounds). This method can be used to monitor and document long-term movement patterns, habitat use, feeding (e.g., terminal buzzes or possibly feeding rates if placed strategically), social behaviors, responses to acoustic stressors, and for determining areas of biological importance. This method also enables the examination of ambient sounds, the determination of acoustic baselines, and the identification of acoustic stressors (e.g., anthropogenic noise), which can be utilized to inform the regulation of human activities. If specific vocalizations can be linked to specific behaviors and/or age classifications, it may provide additional information on life history and stress. Furthermore, if vocalization characteristics can be linked to hearing ability/deficits, recordings could provide useful information about hearing.
Risks *(identified pre-workshop)*	The majority of participants identified no risks associated with the operation of the acoustic instrument itself. Several participants highlighted possible harassment, displacement, and temporary behavioral change associated with device installation and retrieval. Others suggested the possibility of entanglement in lines if the device were equipped with a cable(s).
Commentary and discussion *(during workshop)*	*Benefits* • Provides a window into overall distribution in Cook Inlet at all seasons of the year • Opportunity to detect the presence and level of ambient and anthropogenic sound at the locations where whales are detected and the ability to evaluate movements and vocalizations relative to such sounds • Possibility of evaluating movements in specific areas of concern relative to possible anthropogenic disturbance, such as activities at the Port of Anchorage or near oil platforms • Can provide distribution as well as feeding data

	Risks • Very minimal *Primary rationale* • Passive acoustics can be useful to answer a number of research questions. The method is relatively non-invasive and potentially very useful. It can be expensive and time-consuming depending on the purpose of the research. *Feasibility for CIB* • More PAM at Knik Arm and going into Turnagain Arm, both sides, sounds like a successful way to identify beluga use, behavior, communications, and effects. • PAM in other locations of Cook Inlet is also informative, especially in the winter, when visibility is less. • Recordings in orca habitat could document beluga predation. *Other considerations* • PAM's limitations are often under-appreciated - e.g., hard to turn into numbers of individuals, and range is very limited • Shouldn't over rely on this method as it will miss occurrences of 'silent whales'

Acoustic, Sonar for Prey Mapping (remote method)

n=16	Low Benefit	Medium Benefit	High Benefit
Low Risk	2	5	4
Medium Risk	0	4	1
High Risk	0	0	0

Benefit > Risk?



Discussion	
Benefits *(identified pre-workshop)*	Useful for identifying/recording beluga prey and for determining prey distribution and availability (temporal/spatial). This method can also provide information on feeding behaviors (useful for understanding life history parameters), CIB nutrition, and response to noise. This method is particularly useful as it can be applied in winter months to identify winter prey species.
Risks *(identified pre-workshop)*	Potential risks were described as relative to the frequency of the active sonar employed. Several participants expected no risks associated with this method while others communicated the potential for level B harassment (temporary behavioral change), displacement from preferred habitat, prey dispersal and deterred feeding (leading to reduced foraging and fitness), as well as possible CIB injury and mortality in extreme cases. Vessel strikes during the utilization of sonar was also a concern.
Commentary and discussion *(during workshop)*	*Benefits* • Limitations to sonar (e.g., does not identify the type of prey) made this of medium and not high benefit. *Risks* • If belugas are in area sonar may disrupt feeding • Consider frequency of sonar and what the impact on the whales would be. *Feasibility for CIB* • Prey mapping can be difficult and logistically challenging at certain times of the year and thus the usefulness for CIB is likely limited. But could be useful to understand what animals are preying upon especially if conducted alongside other survey types (e.g. visual, telemetry).

Collect, Remains for Predation Study (remote method)

n=19	Low Benefit	Medium Benefit	High Benefit
Low Risk	4	6	7
Medium Risk	2	0	0
High Risk	0	0	0

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Useful for identifying beluga prey species and possibly for determining exposure pathways. Others highlighted this method as useful for quantifying and gathering data on the effects of killer whale predation on CIBs. Access to CIB remains and/or carcasses allows for veterinarian examination and provides an opportunity to collect biological samples, body measurements, age estimates, gender identification, as well as information on reproductive history, contaminants, and disease exposure. Sample quality diminishes with decomposition.
Risks *(identified pre-workshop)*	Depends on how the remains are collected. Most participants identified no risks associated with this method, others identified minimal risk to individual animals (e.g., disturbance, momentary disruption of feeding, vessel strikes) associated with the mode of collection (e.g., helicopter, boat).
Note re: pre-workshop survey input	Participants expressed considerable confusion regarding this category and were uncertain as to whether this pertained to the collection of prey, belugas, or other samples altogether (e.g., fecal collection).
Commentary and discussion *(during workshop)*	*Benefits* • Potentially helpful to understand whether predation (of belugas) is preventing the CIB population from recovering. *Risks* • Collecting remains of CIB's prey is essentially a no-risk operation • Risks may be associated with trying to get close to whales see if there are bits of prey remaining (i.e. close approach risks) *Feasibility for CIB* • Unlikely to be feasible in Cook Inlet due to strong tides, etc. • Some respondents stated that, because belugas swallow food whole, it is unlikely that there would even be bits of prey to collect

	Editor's note: Survey responses indicated considerable confusion among respondents about whether this research method pertains to CIB' feeding behavior or whether it pertains to killer whale (and other predator) behavior to understand effect of predation on CIBs

Collect, sloughed skin (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	5	3	8
Medium Risk	2	1	1
High Risk	0	0	0

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Participants provided conflicting descriptions of this method. Three participants did not feel sloughed skin was suitable for conducting genetic studies as the superficial skin from molt does not yield usable genetic material. Others felt this method could provide the genetic material necessary for conducting a suite of analyses related to species ID, individual ID, skin microbiome, sexing, aging, stress hormones, stable isotopes, health, kinship, demographics, epigenetics, and emerging pathogen detection. If sloughed skin can be tied to an individual, the benefits of the method are similar to skin biopsies. One participant asserted that analyses require the collection of fresh skin.
Risks *(identified pre-workshop)*	Depends on how samples are collected. Most participants identified no risks associated with this method, others identified risks ranging from disturbance, disruption of feeding, acute stress response, habitat displacement, and vessel-strike, depending on the collection platform.
Commentary and discussion *(during workshop)*	*Benefits* • If sloughed skin could be found, it would be useful for genetic mark-recapture, and analysis for data on health *Risks* • Fairly low risk, with the source of risk being collision due to close approaches to get skin before it disappears or is eaten. • To even obtain this sample you would need to be very close to animals so there is a risk of disturbance and boat strike. *Feasibility for CIB* • Not a practical approach because skin not detected in the environment

Count/survey (remote method)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	18
Medium Risk	0	0	1
High Risk	0	0	0

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Essential for monitoring population decline/recovery and for illustrating trends in demographics, distribution, abundance, age class, and reproduction. This method is also useful for assessing population structure and body condition. Frequent surveys would provide a comprehensive understanding of CIB habitat use which could be utilized for steering development towards less important areas.
Risks *(identified pre-workshop)*	Risks depend on survey platform (e.g., aircraft or vessel) and the distance maintained from animals. Many participants felt the risks associated with this method were negligible. Some highlighted the possibility of take under the ESA and MMPA, including the temporary alteration of behavior, acute stress response, disturbance, harassment, or ship strike associated with a vessel-based approach. One individual felt a vessel-based approach posed greater risk to CIBs.
Commentary and discussion *(during workshop)*	*Benefits* • Abundance surveys, whether by plane or UAS (calibrated to be compared with past plane surveys) is the best way to document beluga abundance, distribution, behavior, white and dark belugas, and trends. • Collecting life history parameters • Long-term monitoring • One participant countered the prevailing viewpoint and suggested that counting belugas doesn't help recover belugas and has little chance of providing data on why they are not recovering. The data does help understand distribution and possible stressors. *Risks* • Some risk with disturbance and a low potential of boat strike *Less invasive options*

	• If enough whales are identifiable from photos, then a properly funded and executed photo ID study would likely eliminate the need for manned aerial surveys. *Other considerations* • Very high priority, according to many workshop participants • Should be conducted from multiple platforms including manned aerial, unmanned autonomous vehicles, and vessels. • One participant suggested that NMFS should fly at least every other year, with every year not being necessary as shown by the beluga abundances in the biannual surveys.

Imaging, Thermal (remote method)

n=15	Low Benefit	Medium Benefit	High Benefit
Low Risk	7	5	1
Medium Risk	2	0	0
High Risk	0	0	0

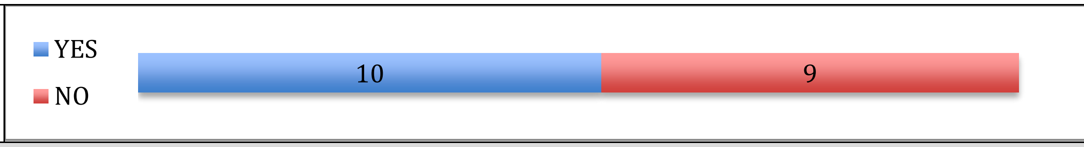
Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Can be applied during surveys/counts to enhance information on abundance, distribution, and habitat use by enabling animal detections during winter or poor weather conditions. Using capture and close-range methods, thermal imaging can provide information on animal health, body condition, thermal stress, blunt force trauma, wound healing, and metabolism (though the latter was considered a stretch). This method can also be utilized to assess wounds or lesions in live-stranded animals; precisely-timed photos of open blowholes may be used to generate an estimated body temperature which could provide information on health and pregnancy.
Risks *(identified pre-workshop)*	Many participants felt the risks associated with this method were negligible and dependent on the data collection platform (e.g., aircraft or vessel); some highlighted the possibility of take under the ESA and MMPA, including temporary alteration of behavior, acute stress response, disturbance, harassment, or ship strike.
Commentary and discussion *(during workshop)*	*Benefits* • Primary benefit of this method in surveying belugas in icy conditions • Thermal imaging could be used at night in place of visual observations from shore, particularly when monitoring for mitigation of industrial activities at night *Risks* • The risks would be the same as for any imaging modality and depends more on how the image is obtained (plane, drone, boat, land based…). *Feasibility for CIB* • This might be useful in the winter to help discern whales from ice but in general thermal imaging may not be as effective for belugas as it is for larger whales with larger blows.

	• Thermal imaging may not provide a good count of belugas because belugas do not surface high enough in the water and breathe high enough to register the temperature differences. May be different in the winter (i.e. cold waters and warm breaths).

Instrument, Dart/Barb Tag (remote method)

n=19	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	0
Medium Risk	0	6	4
High Risk	2	4	3

Benefit > Risk?	

Discussion	
Benefits *(identified pre-workshop)*	Precise and less invasive than other implants; benefits are specific to the tag type implanted. This method provides fine-scale, longer-term data (weeks to months) on movement, distribution, habitat use, subsurface behavior, dive patterns, water temperature, and heart rate. Useful for assessing seasonal variations in habitat utilization, spatial and temporal overlap with human stressors, and for identifying areas of biological importance (e.g., feeding areas). This method can improve input parameters for population modeling.
Risks *(identified pre-workshop)*	Dependent on tag type and deployment. Possible risks include: disturbance or ship strike while approaching the animal, short-term behavioral change (e.g., vessel avoidance), inflammation and infection of the tag site, injury, and death. Most studies show that with robust technology (e.g., low probability of breakage/minimal remnants inside the whale), effect in demographic parameters is low.
Commentary and discussion *(during workshop)*	*Benefits* • Detailed understanding of movement and space-use patterns, including subsurface behavior. • Useful to assess seasonal variation in habitat utilization and potential spatial and temporal overlap with human stressors. • There are instruments that could provide information on vital rates or dive times and thus inform survey models and life-history parameters. • One participant stated that the short-term nature of this collection method is not valuable for CIB. *Risks* • All tags have risk associated with puncture and the possibility of introducing pathogens. • While some workshop participants suggested that dart/barb tags may pose lower risk than spider tags due to their penetrating the body more

	superficially, other participants stated that it is unknown whether one tag type has more or less risk than another. • Many participants suggested that there is inadequate information regarding risks to say that benefits outweigh risks and suggested that an assessment from a surrogate population should be performed. • Remote delivery may still have risks associated with vehicle activity. *Less invasive options* • Can obtain distribution data with other methodologies *Feasibility for CIB* • CIB will likely be difficult targets, so sample size may be quite limited if approaches are limited to the slow and easy style. *Other considerations* • Duration of remotely deployed dart tags is generally 2 months or less. Given fieldwork weather constraints, tags are only likely to be deployed in summer. More information on gross movements in summer is not of extremely high priority. A GPS tag would increase the benefits, though those are heavier to shoot and mostly untested. Dive data would be useful for improving precision and bias of abundance survey availability correction. However, L-95 mortality raises concern about potential impact of dart tags. • In cases of live-stranding of apparently healthy whales, the use of barbed tags should be considered in order to take advantage of hands-on contact with the animal to get short-term data on survival and movements post-stranding.

Instrument, Suction Cup Tag (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	3	4
Medium Risk	2	5	4
High Risk	1	0	0

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Dependent on tag type (e.g., acoustic or satellite). This tag is precise, non-penetrating, and provides short-term data (several hours to days) on fine-scale movements, habitat use, feeding behavior, acoustic behavior (e.g., vocalizations), foraging behavior, dive patterns (e.g., surfacing intervals and depth), water temperature, TDR, and received sound levels. Useful for assessing seasonal variations in habitat utilization, spatial and temporal overlap with human stressors, and for identifying areas of biological importance (e.g., feeding areas). This method may help link individual acoustics to foraging and may provide information on behavior and movement relative to stressors.
Risks *(identified pre-workshop)*	Dependent on tag deployment (e.g., pole, air rifle, from shore, or vessel). Utilizing a close approach for remote tag application could result in take under ESA and MMPA (e.g., disturbance, ship strike, and mortality). Most participants felt impact to the animal would be temporary and void of significant long-term effects, though one participant highlighted the risk of calf-cow separation during the tagging process. Suction-cup tags are relatively large and may cause increased drag, inflammation, or injury to the skin with potential impacts on foraging, energy budgets, and reproduction.
Commentary and discussion *(during workshop)*	*Benefits* • Can provide detailed understanding of underwater behavior, including information on acoustics and potentially feeding. • Useful to collect detailed short-term data (e.g. dive behavior, acoustic behavior), but not likely to provide longer-term data (longer than a few hours). • D-tag could provide invaluable information about diving, foraging behavior, vocalizations, and noise level received by whale. • Only less invasive way to adequately obtain dive profiles for CIBs. *Risks* • Risk due to close approaches.

	• Remote deployment with gun or pole is difficult, so it may be hard to accomplish, but even a few tag deployments would likely be informative. • Risk is low without chase (i.e., slow motoring or drifting). With chase, risk would be medium due to possibility of causing stranding. • Overall, suction cup tags are not very risky. *Less invasive options* • If the remote suction cup tag is placed on the whale from a new device and/or attached by a pole on a stationary surface (shore or boat), then it may provide short-term information without the intensive chase. *Feasibility for CIB* • One participant cautioned that remote deployment of suction cup tags is not possible today or that the tags will not stay on long enough to provide useful information. *Other considerations* • If the deployment can be done using non-chase drift method, this has promise to yield important data from D-tags and could be combined with photo ID and biopsy studies

Observation, Behavior or Monitoring (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	6	14
Medium Risk	0	0	0
High Risk	0	0	0

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Depends on context but offers non-invasive method for assessing individual and group distribution, behavior (e.g., social, feeding, and movement), health (e.g., body condition and advanced illness), reproductive status (e.g., rough age classification and estimation of calf status), and response to stressors. This method provides baseline behavioral data critical for the assessment of actual disturbance during a dose/response study or the analysis of potential disturbance of a proposed action. Information about acute stressors would only be gained if the acute stress were to occur during the observational period. This method has the potential to increase understanding of CIB population across the core research needs discussed during this workshop.
Risks *(identified pre-workshop)*	Many participants felt this method posed no risks if conducted from a sufficient distance. Participants highlighted potential risks as dependent on the mode of data collection (e.g., land, aircraft, and vessel); some highlighted the possibility of take under the ESA and MMPA (e.g., the temporary alteration of behavior, acute stress response, disturbance, harassment, or ship strike).
Commentary and discussion *(during workshop)*	*Benefits* • Baseline information on movements, behavior, and social interactions is important for life history documentation, including feeding places, times and durations and mother-young presence and behavior. Such observations feed into design of surveys and facilitate photo ID efforts. • Aids in understanding "normal behavior" so as to better identify and assess disturbance (behavioral). • Understand numbers and composition. • Can be paired with photo ID to assess health. • Monitoring responses to stressors. *Risks* • Low-risk (assuming the method of monitoring is low risk in that it is land-based, from a boat from a distance that is not harassing, or other

	non-aggressive/non-stressful means). *Feasibility for CIB* • This could be matched with the photo ID or UAS boating activities, or from shore (Turnagain and Knik Arms). • This method is being done by JBER and provides great documentation on beluga feeding, socialization, and behaviors as best as can be observed above the water.

Photo ID (remote method)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	18
Medium Risk	0	0	3
High Risk	0	0	0

Benefit > Risk?

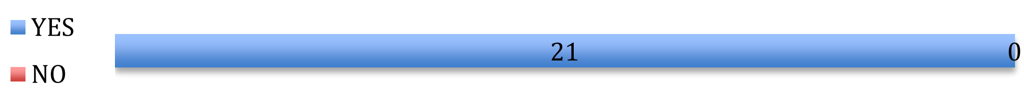
Discussion

Benefits *(identified pre-workshop)*	Non-invasive method of mark-recapture, provides information over long time-scales (years). This method can be used to estimate population parameters (e.g., abundance, survival, and reproductive status/rates), monitor body condition, and evaluate incidence of diseases (e.g., on skin). It also provides data on population abundance/trends, site fidelity, trauma rates, and causes of mortality/movements in response to stressors. However, it can be difficult to define disease from photos and information on acute stressors is only gained if the stress is concurrent with the observational period.
Risks *(identified pre-workshop)*	Largely benign method with limited risk of acute stress response and temporary alteration of behavior. Risks are dependent on the sampling platform (e.g., vessel or land) and on the proximity to the animal(s) being monitored. A vessel-based approach could result in take under ESA and MMPA, (e.g., harassment and ship strike).
Commentary and discussion *(during workshop)*	*Benefits* • Abundance estimation surveys • Most fundamental element of mark-recapture efforts required to monitor and document life-history parameters • Estimate population parameters such as survival and reproductive rates • Essential data on vital rates, distribution of age/sex classes, movements, etc. • Calving intervals and calving timing; condition of the whales by months (skinny, less skinny), distribution, group composition by identified whales and by color (age), counts of groups, etc. • Probably the most important method to assess why CIB is not recovering. *Risks* • Overall very low risk • Risk is low if using field personnel experienced with Cook Inlet and CIBs;

	risk increases if conducting boat based research with inexperienced team. *Other considerations* • Participants made a number of programmatic suggestions, including increased funding from NMFS for more reports and collaborative studies with photo ID, making photo ID information available to the public and to agencies (e.g. by hosting a website to download pictures from research projects to share), funding to sort "non-Tamara" pictures for matching with other photos. • Need to expand data analyses to include fecundity and other analyses brought up in workshop. • Photo ID can be done by people or by UAS. Expansion of UAS photo ID should be investigated to better capture boat shy belugas.

Photogrammetry (remote method)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	18
Medium Risk	0	0	1
High Risk	0	0	0

Benefit > Risk?	
Discussion	
Benefits *(identified pre-workshop)*	Provides insight into the relative body condition of individual whales over time, information on health parameters, reproductive status, birth and survival rates, calf status, demographics, group composition, scarring, injuries, and ontogenetic development. Provides a non-invasive method for mark recapture; serial photos over time improve the quality of the information gathered. Information on acute stressors is only gained if the stress is concurrent with the observational period.
Risks *(identified pre-workshop)*	Largely benign research method with limited risk of acute stress response and temporary alteration of behavior. Risks are dependent on the sampling platform (e.g., UAS, vessel, or land) and the distance maintained from the animals. Drone or vessel-based photo ID could result in take under the ESA and MMPA (e.g., harassment or ship strike).
Commentary and discussion *(during workshop)*	*Benefits* • Documenting age classes in the population, changes in condition of individual animals over time, help identify animals in poor condition, the relative condition of animals, vital information on age structure of population, and calf production on an annual basis. • Has potential for documenting nutritional status, reproductive status *Less invasive options* • With further technological development, UAS-based photogrammetry may someday provide body condition data as well. *Feasibility for CIB* • One participant cautioned that photogrammetry may be difficult because of the turbid water of Cook Inlet

Photograph/Video (remote method)

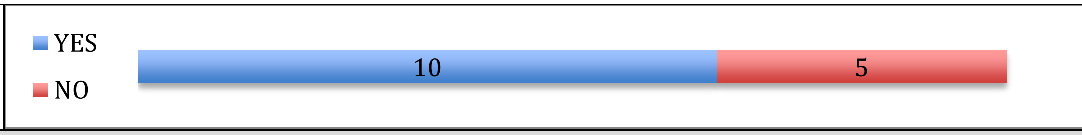
n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	2	6	12
Medium Risk	0	0	1
High Risk	0	0	0
Benefit > Risk?			
Discussion			
Benefits *(identified pre-workshop)*	Non-invasive method(s) (e.g., photogrammetry, photo ID, etc.) for enhancing an understanding of the CIB population over a long temporal scale (years) and across the three core research needs emphasized in this workshop. This method is useful for assessing individual and group distribution (e.g., group composition/size), population demographics, behavior, health parameters (e.g., body condition and injury), and reproductive status. A single point in time photo could provide a very rough age classification and perhaps calf status; serial photos over several years would improve the quality of information collected. Diseases with cutaneous signs could be assessed to estimate rates of trauma. Information about acute stressors would only be gained if the acute stress was concurrent with the observational period.		
Risks *(identified pre-workshop)*	Largely benign research method(s) with limited risk of acute stress response. Risks are dependent on the platform of photo ID or sampling unit (e.g., UAS, vessel, or land) and the distance maintained from the animals. Drone or vessel-based photo ID could result in take under the ESA and MMPA (e.g., harassment, temporary alteration of behavior, or ship strike).		
Commentary and discussion *(during workshop)*	*Benefits* • Photo ID and video provides the opportunity to analyze images from a variety of platforms in the quiet of the lab. These are essential to photo ID and also help in analysis of body condition and skin diseases or other abnormalities, scarring from tags or natural causes, and associations and relative sizes of animals. Videos may record behavior relative to sources of disturbance or stress or social interactions, as well as responses to research methods such as drones. • Helpful to document movements, behaviors, group size and compositions • In contrast to the above, some participants cautioned that photo/video data are not particularly useful in that they are similar to shore-based observations although it would be harder to do monitoring/mitigation		

	through video. Without photo ID information, photos or videos themselves are not critical data. *Risk:* • Little- to no-risk, other than that associated with approach *Other considerations* • Should be paired with other methods or studies, especially other camera- or image-based methods.

Remote Vehicle, Vessel, or Amphibious (remote method)

n=15	Low Benefit	Medium Benefit	High Benefit
Low Risk	5	3	4
Medium Risk	1	2	0
High Risk	0	0	0

Benefit > Risk?



Discussion

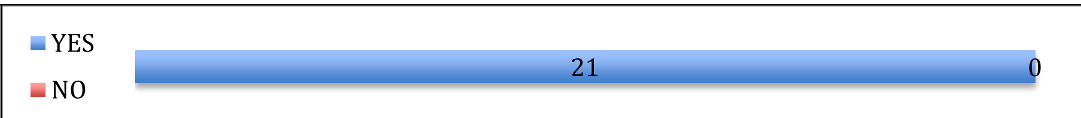
Benefits *(identified pre-workshop)*	Depends on the context and on the quality of the data collected. This method provides a non-invasive way to assess population structure, behavior (e.g., social), and animal health (e.g., body condition, and injury). It may be useful for sampling the environment used by CIBs; such information could be correlated with vessel/aerial surveys and with tagging efforts. This method could also facilitate the wide distribution of acoustic recorders as opposed to the use of place-based moorings.
Risks *(identified pre-workshop)*	Some of the potential risks described by participants included acute stress response, disturbance, temporary alteration of behavior, vessel-strike, and displacement from key habitat. However, eight participants were unsure as to what this category was referring to and requested clarification.
Commentary and discussion *(during workshop)*	*Benefits* • May be useful to sample the environment used by the whales as such information can be correlated with vessel or aerial surveys and also with telemetry data. • Potentially useful with photogrammetry, biopsy, photo ID or to track other research methods or animal response to research or potential disturbance. *Feasibility for CIB* • Passively powered vehicles cannot operate well in Cook Inlet tidal environment due to currents. Powered vehicles pose some risks to CIBs. • Unsure what would be obtained from such vehicles that couldn't be obtained in a less risky way. • One participant suggested that a glider (underwater glider) with acoustic recording capability could be a useful way to do an acoustic survey for belugas in the lower- and middle-inlet in winter, if it would be practical to deploy a glider there. A glider could cover far more ground than fixed moorings for a fraction of the cost. However, gliders need to

	surface once a day or so to communicate, so working in an area with ice could be problematic, but if that issue could be resolved, a glider could be useful.

Remote Vehicle, Aerial (Unmanned Aircraft - UAS) (remote method)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	17
Medium Risk	0	1	1
High Risk	0	0	0

Benefit > Risk?



Discussion

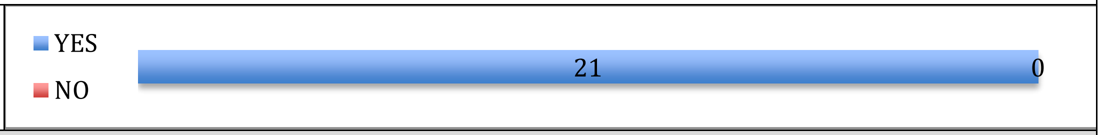
Benefits *(identified pre-workshop)*	Non-invasive method with utility in a range of applications including remote tag deployment, photo ID, photogrammetry, exhaled air capture (possibly), stranding response/monitoring, and population monitoring. The benefits of this method depend on the application and on the proximity to the animal. If utilized for photo ID/videography, this method can provide visual data on animal health (e.g., body condition and injury), abundance, survival, aging, reproduction, calf interval, behavior, site fidelity, and demography. Close-range images could provide information on family group and young with adults. This method was considered effective for enhancing an understanding of CIBs across the three core needs discussed in this workshop.
Risks *(identified pre-workshop)*	Participant responses to this question were considerably mixed. Some participants felt this method posed no risks to CIBs. Risks were described as depending on altitude and on the proximity to the individual or group under observation. Others suggested that this method could result in take as defined under the ESA and MMPA, including temporary behavioral change, acute stress response, disturbance, displacement, harassment, ship strike (if deploying UAS from a vessel), collision between the animal and UAS (if catastrophic failure), injury, or mortality.
Note re: pre-workshop survey input	Please see also entries for photo ID and photogrammetry to understand the benefits and risks associated with UAS use
Commentary and discussion *(during workshop)*	*Benefits* • Potential for counting animals in an area; identifying relative sizes, ages, and condition (photogrammetry); documenting social behavior; and (further in the future) conducting biopsies and blow analyses. • The ability to image a whale for a prolonged time (i.e. hovering) from altitude provides a unique perspective that cannot be realized with other methods. • UAS can be used where boats cannot go, like Turnagain Arm, low water

	in Susitna and Knik, and the other side of a sand bar where belugas are congregated. • Has limited application if the method can't be used beyond visual range. *Risks* • Minimal • Risk depends on altitude being flown and experience of UAV operator. *Feasibility for CIB* • One participant cautioned that fixed wing UAS work are not practical at this point in Cook Inlet as the airspace is too complicated and busy for a UAS to replace a manned aircraft for abundance surveys (and other uses are not clear as yet). *Other considerations* • One participant suggested that more UAS videos and pictures, with a contract to map sightings and behaviors and analyze the pictures and video, should be a high priority.

Sample, Biopsy (Skin and Blubber) (remote method)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	8
Medium Risk	0	0	13
High Risk	0	0	0

Benefit > Risk?



Discussion

Benefits *(identified pre-workshop)*

Provides a wealth of knowledge with a range of applications including molecular genetic analyses (e.g., expression and genetic ID), toxicological analyses (e.g., contaminant loads), epigenetic aging, and animal health (e.g., skin biomes, reproductive/stress hormones, fatty acids, stable isotopes, disease, and immune parameters). This method can also contribute to an understanding of the population structure, kinship, diet/trophic relationships, sexual maturity, pregnancy, and may help generate improved inputs for population models.

Risks *(identified pre-workshop)*

Dependent on biopsy platform (e.g., shore, vessel, or UAS). Most participants felt the risks for remote sampling were short-term (e.g., temporary alteration of behavior) however, infection of the biopsy site and mortality were also listed as possible risks if the equipment was not properly sterilized. Others highlighted possible take under the ESA and MMPA (e.g., disturbance, increased stress, injury, and mortality) resulting from the chase and approach.

Commentary and discussion *(during workshop)*

Benefits

- Collect health, reproductive and other biological samples from undisturbed whales. This information would be helpful for evaluating possible obstacles to recovery.
- Genetic assessment of population abundance and sex-ratios in the population.
- Genetics, aging, stable isotopes, fatty acids and hormone studies.
- Can be used to assess population structure, kinship, for abundance estimation, for monitoring of trends in abundance, diet/trophic relationships, stress hormones and pregnancy.

Risks

- Risk due to infection or collision is generally low, but relative to all methods, falls in the middle range of risks.
- Any puncture has the possibility of introducing pathogens.
- If drifting among animals and no intense chasing of the CIB, then low

	risk (unlikely to hit whale with the boats or propellers; not likely to stress whales with intense chase; not likely to harass whales that will make other studies (photo ID by boat) difficult to get close to whales; not likely to hit the whale in unintended area (near face or blowhole); not likely to strand whales by chasing them in shallows with outgoing tide. • If biopsy requires an intense chase, then risk is higher

Sample, Exhaled Air (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	5	9
Medium Risk	1	0	3
High Risk	0	0	2

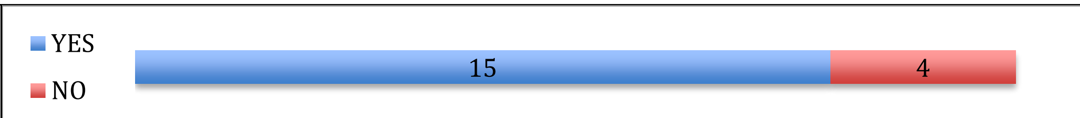
Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Non-invasive method for assessing animal health, metabolic status, and genetics. This method is useful for assessing reproductive and stress hormones, fatty acid, stable isotopes, RNA expression, response to stressors, infectious agents, disease screening, commensal flora, contaminants, biogenic volatile organic compounds, and for conducting longitudinal microbiome studies.
Risks *(identified pre-workshop)*	Limited risk was associated with the procedure of capturing exhaled air; greater risk was associated with the sampling platform. Sampling via vessel or UAS could result in take under the ESA and MMPA, such as disturbance (e.g., increased stress, temporary behavioral change), injury (e.g., ship strike), and mortality.
Commentary and discussion *(during workshop)*	*Benefits* • Blow can provide info on pregnancy status and genetics. • Useful for characterization of and longitudinal studies of microbiome and to assess health (metabolic, stress, and reproductive hormones, immune components, gene expression). *Risks* • Obtaining a breath sample without capture still has risks associated with any chase, follow, and vehicle activity. *Feasibility for CIB* • Challenges include the lack of strong blows by belugas, the need to get multiple blows from the same animal, and the closeness to get the blow • Remote collection of blow may not feasible for free swimming CIBs • Remote collection of blow (e.g. via UAS) may be feasible for live-strandings or collection of blow hands-on in stranding situations where blood collection is not feasible or is challenging • The possibility of pole-based or UAV collection should be explored in order to collect information that is comparable to blood collection for at

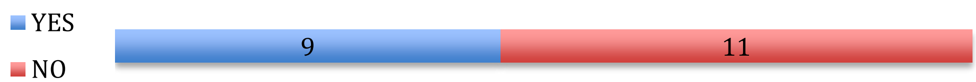
	least some factors. Remote collection of blow could be a very important substitute for capture and blood sampling.

Tracking (remote method)

n=19	Low Benefit	Medium Benefit	High Benefit
Low Risk	2	6	3
Medium Risk	0	4	2
High Risk	1	0	1
Benefit > Risk?			
Discussion			
Benefits *(identified pre-workshop)*	High degree of uncertainty associated with this category as described below. Some participants highlighted that tracking could provide real-time information on spatio-temporal distribution, movement, habitat use, disturbance, feeding behavior, and response to stressors.		
Risks *(identified pre-workshop)*	Some participants felt that tracking incurred no risks given its remote nature, others felt that the potential risks included disturbance, harassment, injury, infection (e.g., of tag-site), and possible mortality depending on the context (e.g., tag-type/attachment).		
Commentary and discussion *(during workshop)*	*Benefits* • Focal follows, acoustic tracking of groups as they move through areas and short-term tracking using UAVs • Info on behavior that may be helpful for assessing stressors and habitat use. • Could also be useful when paired with other methods or for getting fine scale habitat use or changes with exposure to potential stressors. *Risks* • High risk of disturbance for too little data • Effects of intrusive tags on whale health/survival		

UAS to Deploy Tags (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	0
Medium Risk	2	6	6
High Risk	0	5	1

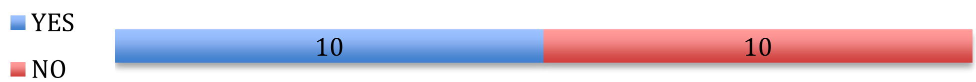
Benefit > Risk?	

Discussion

Benefits *(identified pre-workshop)*	Tagging provides data on distribution, movement, dive behavior, habitat use, feeding areas, and disturbance. An unmanned aerial vehicle could be used to attach suction-cup tags or limpet tags (potentially) to an animal. Tagging via UAS could minimize the risk of vessel-strike, remove the need for capture, possibly decrease stress to the animal, and enhance tagging precision (compared with some other methods).
Risks *(identified pre-workshop)*	The tagging risks were described as being dependent on the tag-type (e.g., penetrating versus non-penetrating). Impacts of penetrating tags could include prolonged wound healing, injury, infection of the tag-site, increased disease exposure, and possible mortality associated with infection. Risks associated with the approach and tagging via UAS included: increased stress, behavioral disturbance, and collision. One participant described deployment via UAS as less-controlled compared with air/rifle gun deployment.
Note re: pre-workshop survey input	One participant asserted that having a highly skilled pilot is necessary for avoiding injury (or mortality) from UAS. Another felt this methodology should be developed on a surrogate population prior to use with CIBs. A third felt this method could be useful but that additional development was necessary prior to employing consistent UAS tagging. Several individuals did not feel equipped to reflect on this methodology.
Commentary and discussion *(during workshop)*	*Benefits* • Not currently possible but has potential to decrease capture stress. *Risks* • This is preferable to live capture of belugas, but at this point the technology is not available and could be risky to test. • Risk from tagging could be higher than capture deployment because of less control over attachment. *Feasibility for CIB* • Using UAS to deploy tags does not seem feasible or likely at this time.

	• Belugas surface so fast that it would be hard (but with talented operator, not impossible) to tag a whale with a UAS. After the SR Killer Whales, would need lots of darts/barbs should the tag hit the water first. This is not like large whale, where the dorsal rolls for multiple seconds. Beluga breaths are usually instantaneous.

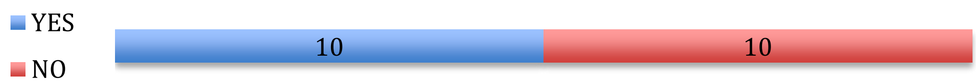
Underwater Photo/Videography (remote method)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	13	2	3
Medium Risk	1	1	0
High Risk	0	0	0
Benefit > Risk?			

Discussion	
Benefits *(identified pre-workshop)*	While this was described as a non-invasive method for examining CIB behavior (e.g., social and feeding), prey selection, health (e.g., body condition), and for identification (e.g., of individuals and nursing females), many participants felt this method provided minimal utility given the turbid conditions in Cook Inlet. One participant stated that this method could possibly be utilized in Ship Creek or lower Cook Inlet.
Risks *(identified pre-workshop)*	Depends on the mode of application. Participants felt this method results in take under the ESA and MMPA, such as temporary disturbance, harassment, injury, and mortality, resulting from close approach and/or during camera installation and retrieval. The risks would be minimal if cameras were left onsite (similar to PAM).
Commentary and discussion *(during workshop)*	*Feasibility for CIB* • Water too turbid and currents too dangerous

Capture (Remote or capture)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	0
Medium Risk	1	0	6
High Risk	1	4	8

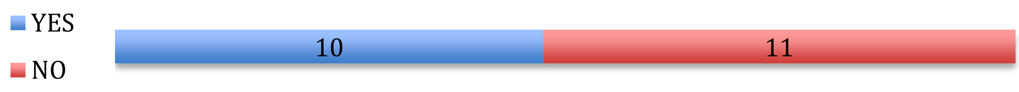
Benefit > Risk?	
Discussion	
Benefits *(identified pre-workshop)*	Participants described capture as allowing for hands-on assessments that cannot be remotely conducted. Participants highlighted capture as enabling critical biological sampling efforts, including the collection of blood and tissue samples, measurements (e.g., length and weight), and sex identification. Capture was also described as providing an opportunity for secure tag attachment. Participants provided far less commentary on the benefits of capture as compared with the other methods reviewed in the pre-workshop survey.
Risks *(identified pre-workshop)*	Included harassment during chase events, as well as acute stress, injury, and mortality resulting from possible collision and/or capture. Participants were also concerned about the impacts of group separation (e.g., mom and calf pairs). Less commentary was provided on the risks associated with capture as compared with other methods. Additionally, consensus on the risks of capture was more apparent.
Commentary and discussion *(during workshop)*	*Benefits* • Important to address a number of research questions and a number of research techniques can be applied in a captured individual. • Allows for many samples and other information to be collected. E.g. applying a long-term tag would also provide movements, residence time, habitat use, movements relative to disturbance, salmon runs, tide cycles by sex if both sexes are tagged. *Risks* • Involves risks of boat activity, prolonged net entanglement, acute stress of chase and capture, potential long term effects. • Risk of mortality of whales from chase and capture • Risk of substantial disruption to the population (with unknown consequences) if capture sample sizes are high. • The risk of capture can be reduced by having the right people with the

	right experience. *Less invasive options* • Photo ID, surveys, and a substantial passive acoustic recorder effort can provide nearly the same type of information, and more, than tagging, with essentially zero risk. • Data that can be acquired from stranded whales can substitute for blood, swab, and blow sampling health assessment work • Vessel surveys and biopsy using drift method, aerial surveys/UAS, stranding response *Other considerations* • Need for additional follow up of captured and tagged BBB and CIB to better understand long term impacts of capture • One participant suggested that, if it is determined that dart tags are safe (in light of L-95 incident), the use of a small number of captures (~5) to deploy GPS dive LIMPET tags and do health assessment work may be acceptable.

Chase (remote or capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	1	0
Medium Risk	4	3	5
High Risk	4	2	2

Benefit > Risk?



<table>
<tr><th colspan="2">Discussion</th></tr>
<tr><td>Benefits (identified pre-workshop)</td><td>This method allows for capture, which provides an opportunity for hands-on assessment that cannot otherwise be conducted (e.g., biological sampling, obtaining biopsies, and tagging).</td></tr>
<tr><td>Risks (identified pre-workshop)</td><td>Described as possibly eliciting strong behavioral responses, stress, harassment, injury, ship strike, stranding, mortality, separation of groups, and separation of calf-cow pairs.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Commentary and discussion (during workshop)</td><td>Benefits

Allows for conducting other research methods that require close proximity to the animal (e.g. biopsy, dart tag, suction cup tag, etc.)

Risks

Risky to the belugas (possibility of collision, behavioral disruption, stress),
Chase is counterproductive because belugas do not respond well to it and it makes it harder to obtain photos or biopsy samples.
May have a greater risk for females or based on the time of the year the research is being done.
To reduce the risk, may require limitations such as length of chase, avoiding groups or individuals with young calves, avoiding birthing seasons or late gestation.

Less invasive options

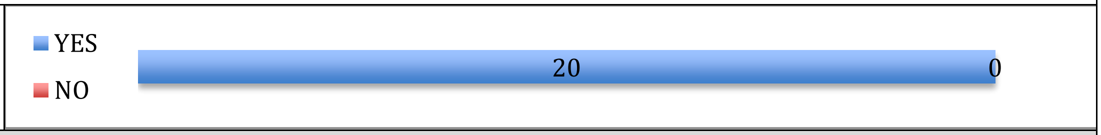
Stealthy biopsy, controlled conditions of capture situation
PAM, photo ID, vessel surveys and biopsy using drift method, aerial surveys/UAS, stranding response
Brief chase may be useful for capture although often the speed is more like accompanying than chasing. Brief chase may also be useful for biopsy although herding to shallow water can be done without a chase. Often chasing results in belugas diving and disappearing while moving
</td></tr>
</table>

	slowly and guiding them where you want them to go is more effective. *Other considerations* • Chase could be relatively mild, or could be aggressive and substantially disruptive, with the risk of stranding whales and therefore risking mortality. In cases of limited chase (such as for suction cup tagging), the benefit may outweigh the risk, whereas there are other types of chase, such as high speed chase to purposefully strand whales in shallow water (e.g., for pole-based biopsy) where the benefit may not outweigh the risk.

Non-Chase Close Approach (remote or capture)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	3	9
Medium Risk	0	2	6
High Risk	0	0	0

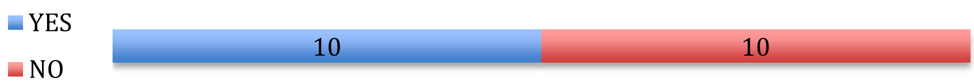
Benefit > Risk?



Discussion	
Benefits *(identified pre-workshop)*	Benefits would depend on the activity or sample being collected. This was described as the least intrusive method for getting close to a whale and for collecting samples remotely. This method enables photo ID, photogrammetry, remote biopsy, UAS use, and the application of suction-cup tags (possibly).
Risks *(identified pre-workshop)*	Included temporary disturbance, acute stress response, displacement, harassment, auditory stress, injury, ship strike, mortality, and the separation of groups or pairs.
Commentary and discussion *(during workshop)*	*Benefits* • Necessary for remote biopsy, suction cup tagging, some photos *Risks* • This method removes much of the concerns [associated with chase] with cow-calf separations and potential for stranding. • Done correctly, this can be a low risk method. But motivated researchers could push the safety envelope at times. • Any close approach, even without chasing, has the risk of harassment, collision, injury, and death.

Restraint (remote or capture)

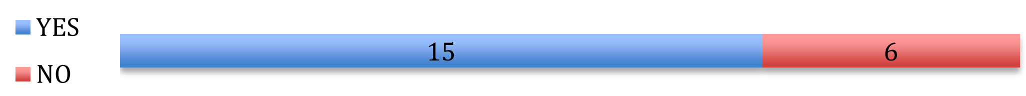
n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	1	1
Medium Risk	1	2	6
High Risk	2	2	5

Benefit > Risk?	
Discussion	
Benefits *(identified pre-workshop)*	Necessary for some critical methods that cannot be conducted remotely (e.g., blood and tissue sampling and secure tag attachment).
Risks *(identified pre-workshop)*	Restraint could result in behavioral responses (e.g., acute stress), reduced fitness, harassment, injury, mortality, and the separation of groups or pairs.
Commentary and discussion *(during workshop)*	*Benefits* • Needed for multiple methods • A captured animal must be restrained for its own safety while conducting the assessment for which it is captured *Risks* • Stress to CIB and possibility of death • The risks of restraint will depend on the individual animal (some need more restraint than others), the location (hard grounded or floating in a sling), the restraint method (nets, hoops, weight of bodies) and the exact procedure being done while under restraint. *Less invasive options* • Depending on purpose of capture and restraint, less invasive options could include PAM, photo ID, vessel surveys and biopsy using drift method, aerial surveys/UAS, stranding response *Other considerations* • Need for additional follow up of captured and tagged BBB and CIB to better understand long term impacts

Auditory Brainstem Response Test (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	7	8
Medium Risk	1	0	1
High Risk	1	2	0

Benefit > Risk?



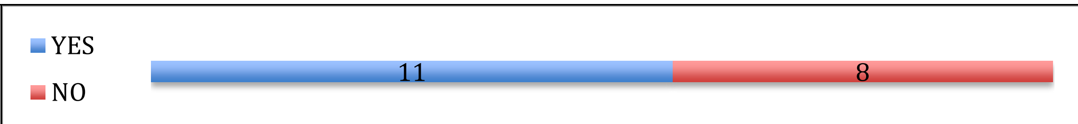
Discussion

Benefits *(identified pre-workshop)*	Participants described this method as an audiogram or hearing loss test. This test quantifies the hearing range of an animal and can help researchers develop an understanding of hearing sensitivity relative to the ambient environment, possible hearing loss, brain function, and stimuli response. The data generated from this method could help inform the regulation of human activities and could be compared with audiogram data on Bristol Bay belugas.
Risks *(identified pre-workshop)*	The greatest risks were associated with the capture and restraint necessary to utilize this method. These risks included take under the ESA and MMPA (e.g., increased stress, injury, and mortality). Many participants felt the test itself would pose minor risks to an individual; one participant felt it could result in hearing injury and other risks in the event that anesthesia were used.
Commentary and discussion *(during workshop)*	*Benefits* • Understanding hearing loss and baseline hearing is important to evaluate the impacts of noise in the environment because hearing is essential to many CIB activities such as feeding, avoiding threats (predators, traffic, risk of live stranding), and social activities. *Risks* • Discounting risk of capture, additional risk is low. *Less invasive alternatives* • Perform ABR on captives and BBB or live stranded CIB. *Other considerations* • The information may not be the highest priority so ABR is unlikely to be the driver for chase and capture and may be lower on the list of sampling and eliminated if time is limited or concerns exist about animal or human safety.

Captive, (Maintain or Research) (require capture)

n=19	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	3	7
Medium Risk	1	0	1
High Risk	3	3	0

Benefit > Risk?



Discussion

Benefits *(identified pre-workshop)*

Wide-range of possible applications, utility, and benefits were associated with captive research. This method enables captive breeding and sampling over long time-scales, including the collection of data on animal health, reproduction, and physiology. Results can be extrapolated to answer questions about the CIB population. Permanent captives can be used as surrogates for testing new technologies and developing/verifying sample analyses, gaining insight into life history parameters, ground-truthing field results, and for studying stress.

Risks *(identified pre-workshop)*

The majority of risks outlined by participants included those associated with the initial chase, capture, restraint, and the possible use of anesthesia (e.g., injury and mortality). Additional risks during captivity include chronic stress and difficulty adapting to captivity (e.g., loss of freedom). Others highlighted general risks associated with removing an animal from a wild population (e.g., "jeopardy" under the ESA).

Commentary and discussion *(during workshop)*

Benefits

- Collecting data, samples and testing out new methods from captive stranded or captive display animals can prove useful as surrogates for free-ranging individuals

Risks

- Captive animals are effectively removed from the population. Risk to population associated with reintroduction is high

Other considerations

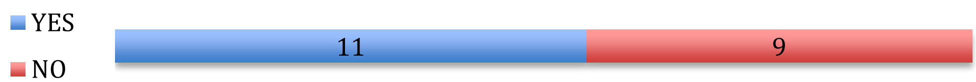
- Some participants cautioned that the priority should be understanding CIBs in the context of their environment and that removing them from their environment will not aid in understanding lack of recovery.
- Participants also cautioned that taking healthy wild CIB into captivity at this time is not warranted, however belugas that are orphaned or compromised could be held. Belugas currently in captivity provide

	valuable information and research opportunities. *Editor's note: Survey responses indicated considerable confusion among respondents about whether this research method pertains to study of already-captive beluga whales or pertains to capturing CIBs and then placing them into captivity.*

Insert Ingestible Telemeter Pill (require capture)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	1	2
Medium Risk	5	4	2
High Risk	1	4	1

Benefit > Risk?



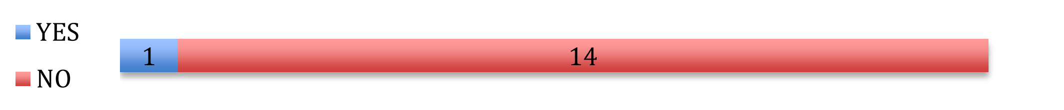
Discussion	
Benefits *(identified pre-workshop)*	Primarily utilized to identify foraging events and study feeding (e.g., digestion time and interval). Useful for collecting physiological data and information on animal distribution, habitat use, prey type (possibly), and feeding disturbance. Can be accompanied by TDRs or tags to confirm feeding events.
Risks *(identified pre-workshop)*	Risk associated with initial chase, capture, and restraint leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Inserting the telemeter pill requires inserting a tube down the animal's throat which can cause discomfort, stress, internal injury, GI obstruction/complications, and possible mortality. Modifications have been made to prevent regurgitation of the pill, the effects of which are unknown; one whale found dead several months later still had the modified pill in its stomach.
Commentary and discussion *(during workshop)*	*Benefits* • Determine when CIBs are feeding so when coupled with another method, like DTAG, can be an important tool to help interpret data from other sources like surface behavioral observations and PAM • This technique provides valuable feeding information regarding where and how often belugas feed successfully. Although this technique has provided a likely link between the terminal buzz and feeding it may be necessary to know how often a terminal buzz results in prey ingestion. *Risks* • Stress to the animal of forcing its mouth open and tubing it to place the pill/a foreign body in its stomach. • One participant noted that, of all the activities that his/her conducted in Bristol Bay, passing a stomach tube to either collect a gastric sample or to insert a telemetry pill was of the most difficult and required the most restraint. *Less invasive options*

	• Acoustic data that can be collected • Past work done in Bristol Bay • This could be explored with live-stranded individuals *Other considerations* • One participant suggested that absent information suggesting a clear signal of nutritional deficiency for a significant portion of the population, that he/she cannot see the benefit of this procedure for CIBs.

Instrument, Belt/Harness Tag (require capture)

n=15	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	0
Medium Risk	1	1	1
High Risk	6	3	3

Benefit > Risk?



Discussion	
Benefits *(identified pre-workshop)*	Depend on tag type; this tag is non-penetrating. This method can provide long-term tracking data (up to a year or more) on distribution, movement (e.g., general and in response to stressors), habitat use, dive behavior (e.g., surfacing intervals), water temperature, and heart rate. Can help identify areas of biological importance (e.g., feeding areas) and can improve input parameters for population modeling.
Risks *(identified pre-workshop)*	Considerable risks were associated with the initial chase, capture, restraint, and possible anesthesia use accompanying this method, all leading to take under the ESA and MMPA (e.g., harassment, stress, injury, and mortality). Risks associated with the tag itself included behavioral impacts, injury (from harness constriction), reduced fitness, increased energetic costs, and possible mortality. One participant felt this was not an acceptable method to employ.
Commentary and discussion *(during workshop)*	*Risks* • Risk of rub and long-term damage from abrasion • Could increase drag and energetic costs of swimming, would need to have a way of detaching or ensuring it doesn't stay on the animal. • This would be a less invasive way to attach a tag and have been considered in the past for belugas but due to the risk of getting caught on things, chafing, and difficulty of adjusting to seasonal changes in girth has not been considered viable. If new material or testing in aquaria could show promise, it should be reconsidered. *Less invasive options* • Other tagging methods

Instrument, Dart/Barb Tag (also remote) (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	2
Medium Risk	1	7	3
High Risk	1	4	3

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Precise and less invasive than other implants; benefits are specific to the tag type implanted. This method provides fine-scale, longer-term data (weeks to months) on movement, distribution, habitat use, subsurface behavior, dive patterns, water temperature, and heart rate. Useful for assessing seasonal variations in habitat utilization, spatial and temporal overlap with human stressors, and to identify feeding areas/areas of biological importance. Can also improve input parameters for population modeling.
Risks *(identified pre-workshop)*	Dependent on tag type and deployment. Possible risks of the tagging procedure include: disturbance or ship strike while approaching the whale, short-term behavioral change (e.g., vessel avoidance), inflammation and infection of the tag site, injury, and death. Most studies show that with robust technology (e.g., low probability of breakage/minimal remnants inside the whale), effects in demographic parameters is low. Participants identified short-term and long-term risks associated with capture and restraint including elevated stress, disturbance, injury, and possible mortality.

Commentary and discussion *(during workshop)*

Benefits

- Detail understanding of movement and space-use patterns, including subsurface behavior. Useful to assess seasonal variation in habitat utilization and potential spatial and temporal overlap with human stressors.
- Determine if a live stranded beluga refloats and survives over the next few weeks
- Assuming animal in hand, this allows for more precise placement of the tag on the whale
- Less invasive than dorsal ridge/spider tags
- Not useful for longer-term information as described for dorsal ridge tags

Risks

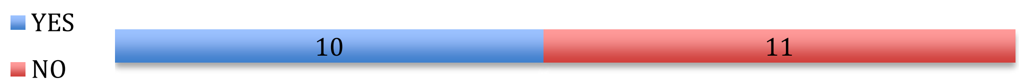
- All tags have risk associated with them, any puncture has the possibility

	of introducing pathogens. • The risk related to capture is the same as with dorsal ridge tags and the risk of infection may be similar to dorsal ridge tags. • Inadequate information regarding risks to say that benefits outweigh risks. Need an assessment from surrogate population first. *Less invasive options* • Can obtain distribution data with other methodologies *Other considerations* • One participant suggested that the short-term nature of this collection method is not valuable for CIB

Instrument, Dorsal Fin/Ridge Attachment (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	0
Medium Risk	1	1	7
High Risk	1	3	8

Benefit > Risk?



Discussion

Benefits *(identified pre-workshop)*	Dependent on tag-type. This method provides real-time information on individual fine-scale movements, dive behavior (e.g., surfacing intervals), and habitat use over months (2-13+). This could assist with identifying areas of biological importance (e.g., feeding areas), feeding rates (if the tag includes audio recording), and movements relative to stressors. The data generated could improve input parameters for population models.
Risks *(identified pre-workshop)*	The greatest risks were associated with the chase, capture, and restraint (e.g., increased stress, injury, and possible mortality). The majority of participants felt that the tagging process itself poses minor risks to an individual (e.g., possible site infection and hematoma), several others highlighted that compromised health from infection could result in mortality.

Commentary and discussion *(during workshop)*

Benefits

- Provide information about movements, residence time, habitat use, response to disturbance, differences in habitat use by age and sex classes, possible stressors/risks, longer-term telemetry data
- Fine scale movement data, which is particularly useful for non-summer months
- In combination with passive acoustics and photo ID could greatly expand understanding of CIB to promote recovery

Risks

- Long term effects of tagging/ scarring
- Higher risk than dart tags; much more invasive as multiple pins going all the way through the body; potential for more damage to the body than dart tags and more opportunities for infection

Less invasive options

- Passive acoustic recording
- Non-invasive approaches provide the potential to answer many

	questions answered by tagging *Other considerations* • Many workshop participants raised questions about the risks associated with dorsal fin/ridge tagging and about whether the benefit to the population as a whole from information gathered from tagging outweighs the risk to the animals that are tagged. Workshop participants noted that, while practices around tagging (and particularly around sterilizing equipment so as not to expose animals to contaminants) have improved during the past twenty years, the level of risk posed to animals from dorsal fin/ridge tags still needs further investigation. While some participants attested to the general safety of dorsal fin/ridge tagging, others strongly called for follow-up monitoring of tagged animals to determine what sub-lethal and lethal effects might emerge.

Instrument, Suction-Cup Tag (also remote) (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	4	3	10
Medium Risk	0	3	0
High Risk	1	0	0

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Dependent on tag type (e.g., acoustic or satellite). This tag is precise, non-penetrating, and provides short-term data (several hours to days) on fine-scale movements, habitat use, feeding behavior, acoustic behavior (e.g., vocalizations), foraging behavior, dive patterns (e.g., surfacing intervals and depth), water temperature, TDR, and received sound levels. This method may link individual acoustics to foraging and may provide information on behavior and movement relative to stressors.
Risks *(identified pre-workshop)*	Employing chase, capture, and restraint during the tagging effort would result in take under the ESA and MMPA (e.g., harassment, stress, injury, and mortality). Most participants felt that the tag application alone would only result in minimal or temporary impacts to the animal. Suction-cup tags are relatively large and may increase drag or cause inflammation or injury to the skin with potential impacts on foraging, energy budgets, and reproduction.
Commentary and discussion *(during workshop)*	*Benefits* • Provide short term data on acoustic and dive behavior. • Some participants raised questions about how helpful the information collected from these tags is for population recovery. *Risks* • Minimal (to animal that is already captured) *Other considerations* • If CIB are also tagged with a dorsal ridge tag a suction cup tag can collect detailed short-term data on acoustic and dive behavior. • Not a substitute for other tags.

Lavage (require capture)

n=16	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	1	0
Medium Risk	5	1	2
High Risk	4	3	0

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Study of stomach contents (if not regurgitated during the chase). This method facilitates data collection on diet (e.g., prey identification) and animal health (e.g., parasite prevalence, gastric flora, stomach bacteria, caloric intake, nutrition, disease, and domoic acid/saxitoxin exposure).
Risks *(identified pre-workshop)*	Invasive method requiring capture and the insertion of a tube down the animal's throat. Participants identified risks associated with the initial chase, capture, and restraint, including take under the ESA and MMPA (e.g., harassment, stress, injury, and mortality). Risks posed by the lavage included temporary discomfort, acute stress response, injury (perforation of the esophagus), inhalation pneumonia, and mortality.
Commentary and discussion *(during workshop)*	*Benefits* • Provides diet data for live-stranded or captured animals *Risks* • Stress to the animal of forcing its mouth open and tubing it • Risk of aspiration pneumonia[5] • Increased handling time *Less invasive options* • Other feeding studies and stomach content analysis *Other considerations* • Some participants suggested that absent information suggesting a clear signal of nutritional deficiency for a significant portion of the population

[5] Reviewing a draft of this report, one workshop participant suggested that the likelihood of aspiration pneumonia would be very low for CIBs and other cetaceans.

	and a clear research need, that they cannot see the benefit of this procedure for CIBs. • One participant suggested that he/she believes that individuals conducting lavage are highly skilled. This participant added that the info would be very helpful and hard to collect otherwise.

Mark, Freeze Brand, or Roto Tag (require capture)

n=18	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	3
Medium Risk	5	3	3
High Risk	2	1	1

Benefit > Risk?

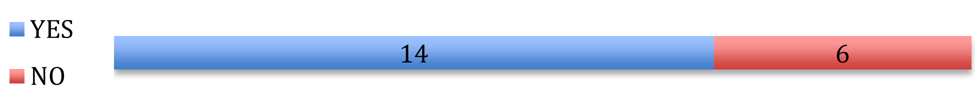
Discussion	
Benefits *(identified pre-workshop)*	This method requires capture and enables the unambiguous identification of individuals to facilitate mark recapture. This ability provides insight into a huge range of parameters including reproductive status, calf interval, abundance, population trends, health status, survival rates, potential causes of mortality, behavior, habitat use, site fidelity, and movement. The benefits of this method are ultimately similar to those associated with photo ID.
Risks *(identified pre-workshop)*	Participants identified considerable risks associated with the initial chase, capture, and restraint leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Risks associated with the actual procedure include increased stress, inflammation, temporary pain, infection of the tag-site, immune reaction, reduced fitness, injury, and mortality.
Commentary and discussion *(during workshop)*	*Benefits* • Facilitates following individuals with photo ID resights of live animals and also with strandings *Risks* • Risks associated with marking/branding/etc. (e.g. stress, inflammation, temporary pain, infection of the tag-site, immune reaction, etc.) *Less invasive options* • Individual markings / natural marks • Use of temporary markers (such as paint sticks) may provide a mark of sufficient duration in order to track individuals.

	Other considerations • One participant recommended genetic (DNA) markers for genetic mark-recapture, kinship, etc. • For already-captured animals, marking can aid later photo ID resights of live animals and also with strandings

Measure and Weigh (require capture)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	6	5
Medium Risk	2	1	2
High Risk	0	1	3

Benefit > Risk?



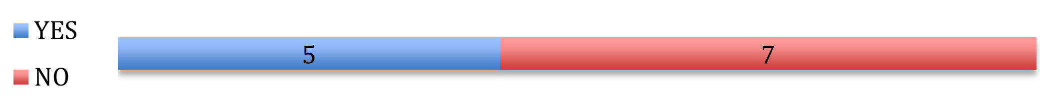
Discussion

Benefits *(identified pre-workshop)*	Provides information on demographics, age, body condition, animal health, and size at first calf. This data could be useful for assessing health if compared with data on captive belugas and other wild populations.
Risks *(identified pre-workshop)*	Participants identified considerable risks associated with the required chase, capture, and restraint leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Several felt that this method posed no risks outside of capture, some identified possible stress, shock, and myopathy associated with restraint while measurements are taken.
Commentary and discussion *(during workshop)*	*Benefits* • Measurements are useful for surrogate of age, for differences between sexes, for growth rate, and possibly for retrospectives on age at first reproduction. *Risks* • Length - zero risk • Weight - high risk to the whale and the people. Would need a large boat with large sling and weight capacity as belugas can weigh >3000 pounds *Less invasive options* • Such information can be garnered from live-stranded and dead animals • Photogrammetry

	Feasibility for CIB • Length: feasible • Weight: very difficult *Other considerations* • If an animal is already captured, it should be measured/weighed, although these things alone are not reasons to capture.

Measure Colonic Temperature (require capture)

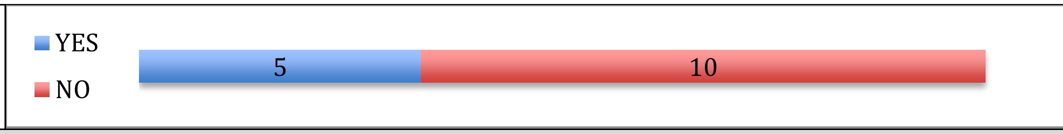
n=12	Low Benefit	Medium Benefit	High Benefit
Low Risk	4	2	0
Medium Risk	5	0	0
High Risk	1	0	0

Benefit > Risk?	
Discussion	
Benefits *(identified pre-workshop)*	Several participants communicated that this method could provide some information on health parameters and very basic life history information.
Risks *(identified pre-workshop)*	Participants identified considerable risks associated with the initial chase, capture, and restraint required for this method, leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Several felt that this method posed no risks outside of capture, though some participants suggested that short-term stress elevation, discomfort, perforation of the colon, and myopathy associated with restraint were possible risks.
Commentary and discussion *(during workshop)*	*Benefits* • Useful to measure an animal's health during capture • Not useful as a research directive Less invasive alternatives / Other considerations • One participant noted: "Getting fecal samples is relatively difficult since it requires raising a tail or rolling onto the side. Our success in accessing an animals belly in Bristol Bay depended on the animal's size, its demeanor, the substrate (firm pack vs soft mud), and everyone's general energy level. However, I never bothered with a temp because that would have required a prolonged period of time and I didn't think that it had any value added, we could track the animal's general temp through behavior and the temp of flips and flukes."

Metabolic Chamber/Hood (require capture)

n=15	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	2	2
Medium Risk	2	1	3
High Risk	3	1	0

Benefit > Risk?



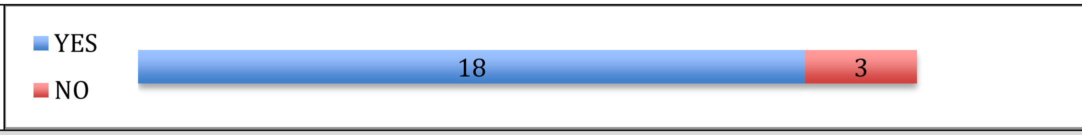
Discussion

Benefits *(identified pre-workshop)*	Provides information on health parameters. This method can generate data on metabolic rates, energetic requirements, hormone levels, and O_2/CO_2 levels. It can also determine how much prey a beluga needs to consume or help identify if prey availability is limiting survival.
Risks *(identified pre-workshop)*	Participants identified considerable risks associated with the initial chase, capture, and restraint required for this method, leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Some identified disturbance and short-term stress elevation as risks associated with this procedure.
Commentary and discussion *(during workshop)*	*Benefits* • Would be useful for developing energetics models for CIB • Not sure of the benefit during capture if the CIB is not in the water and active. It might be useful to know the differences by sex and age and reproductive status even if they are not in the water and swimming. Little is currently known about beluga energetics and caloric needs. *Risks* • Capture and increased holding time for procedure *Less invasive options* • Understanding a beluga's energetic needs at different life stages could be answered with beluga in aquaria *Feasibility for CIB* • Unknown behaviorally how a free-ranging beluga would respond to a metabolic chamber • Better to test this method in the captive display community or another population to see how belugas respond.

Sample, Blood (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	1	13
Medium Risk	0	0	6
High Risk	1	0	0

Benefit > Risk?



Discussion

Benefits *(identified pre-workshop)*	This method provides data on a suite of physiological and health parameters, genetic activity and identification, exposure to diseases, toxins, and contaminants, immune parameters, fatty acids, stable isotopes, reproduction and hormone levels. This method was regarded as useful for determining factors limiting recovery. Multiple participants felt that a comparison with the Bristol Bay population would be informative. One participants stated: *A gold standard with too many benefits to list.*
Risks *(identified pre-workshop)*	Greatest risks were associated with the chase, capture, and restraint required for this method, specifically regarding elevated stress, injury, mortality, and other take under the ESA or MMPA. The majority of participants felt that the procedure itself only poses minor risks (e.g., possible site infection and hematoma) and acute stress response.
Commentary and discussion *(during workshop)*	*Benefits* • Provides data on a suite of physiological and health parameters, genetic activity and identification, exposure to diseases, toxins, and contaminants, immune parameters, fatty acids, stable isotopes, reproduction and hormone levels *Risks* • Minimal (other than capture) *Less invasive options* • Blood samples taken from live-stranded and freshly dead animals *Other considerations* • If an animal is already captured, blood sample should be taken, although blood sample alone should not be basis for capture • Unlikely to get enough samples from population to be meaningful for some studies

Sample, Biopsy (Muscle) (require capture)

n=16	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	1	0
Medium Risk	4	1	2
High Risk	6	2	0

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Provides information on a suite of health parameters (e.g., body condition, hormones, disease, fatty acids, stable isotopes, O_2/CO_2 blood concentrations, and lactic acid), as well as data on genetics, metabolic conditions, diet, reproductive status, contaminant exposure, and dive capability/physiology (potentially). This method may help determine the factors limiting CIB recovery.
Risks *(identified pre-workshop)*	This method requires capture, therefore participants identified considerable risks associated with the initial chase, capture, and restraint leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Some participants identified acute stress response, pain, extensive external/internal injury, site inflammation, infection, disease, immune response, reduced wound healing, and mortality as risks associated with the biopsy procedure.
Commentary and discussion *(during workshop)*	*Benefits* • [See list of benefits identified pre-workshop *(listed above)*] *Risks* • Potential to introduce infection near fascia • Riskier than just skin and blubber biopsy and unclear what is gained by examining the muscle tissue that is directly relevant for recovery *Less invasive options* • Blood draw • Skin/blubber biopsy

Sample, Biopsy (Skin and Blubber) (also remote) (require capture)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	0	9
Medium Risk	1	1	8
High Risk	0	0	0

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Provides a wealth of knowledge with a range of applications including molecular genetic analyses (e.g., expression and genetic ID), toxicological analyses (e.g., contaminant loads), epigenetic aging, fatty acids, stable isotopes, and animal health (e.g., skin biomes, reproductive/stress hormones, disease, and immune parameters). This method can also contribute to an understanding of the population structure, kinship, diet/trophic relationships, sexual maturity, pregnancy, and may help generate improved inputs for population models.
Risks *(identified pre-workshop)*	Participants described greater risks associated with the chase, capture, and restraint rather than with the sampling procedure itself, including take under the ESA and MMPA (e.g., disturbance, increased stress, injury, and mortality). The risks associated with the biopsy procedure alone include infection and mortality in the event that the sampling equipment is improperly sterilized.

Commentary and discussion *(during workshop)*	*Benefits*
	• Collect health, reproductive and other biological samples. This information would be helpful for evaluating possible obstacles to recovery.
	• Genetic assessment of population abundance and sex-ratios in the population.
	• Genetics, aging, stable isotopes, fatty acids and hormone studies.
	• Can be used to assess population structure, kinship, for abundance estimation, for monitoring of trends in abundance, diet/trophic relationships, stress hormones and pregnancy.
	
	Risks
	• Participants expressed conflicting opinions about whether post-capture biopsy involves greater or lesser risk than remote biopsy:
	  o Greater risk involved than with remote biopsy due to capture; capture for biopsy not justified when can get remotely.
	  o Less risk than remote biopsy collection due to the ability to

	precisely target the biopsy location and the sterilization of the animal's body that can be done prior to/after the collection • The risk of biopsy would increase with the depth of biopsy so biopsy of superficial blubber is less risky than a full blubber-depth biopsy (which is harder to do and risks also getting muscle)

Sample, Exhaled Air (also remote) (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	16
Medium Risk	2	0	1
High Risk	0	0	0

Benefit > Risk?

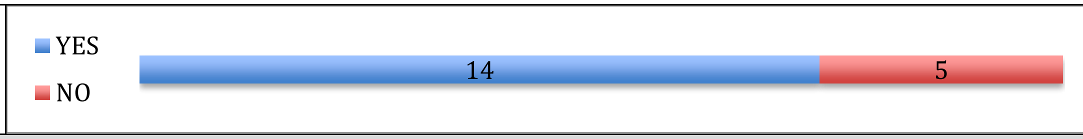
Discussion

Benefits *(identified pre-workshop)*	Non-invasive method for assessing animal health, metabolic status, and genetics. This method is useful for assessing reproductive and stress hormones, fatty acids, stable isotopes, response to stressors, infectious agents, disease screening, commensal flora, contaminants, biogenic volatile organic compounds, and for conducting longitudinal microbiome studies.
Risks *(identified pre-workshop)*	Participants identified few risks associated with exhaled air capture, with the exception of increased stress resulting from close proximity to the animal's blowhole. Participants described the greatest risks of this method as stemming from chase, capture, and restraint, which would result in take under the ESA and MMPA, such as disturbance (e.g., increased stress, temporary behavioral change), injury (e.g., ship strike), and mortality.
Commentary and discussion *(during workshop)*	*Benefits* • Blow can provide info on pregnancy status and genetics. • Useful for characterization of and longitudinal studies of microbiome and to assess health (metabolic, stress, and reproductive hormones, immune components, gene expression). • Collecting such samples from a restrained individual is more efficient and provides opportunity for sequential sampling *Risks* • Minimal additional risk to an animal that is already captured.

Sample, Swab (Anal, Blowhole, Oral, or Vaginal) (require capture)

n=19	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	11
Medium Risk	1	2	2
High Risk	1	0	0

Benefit > Risk?



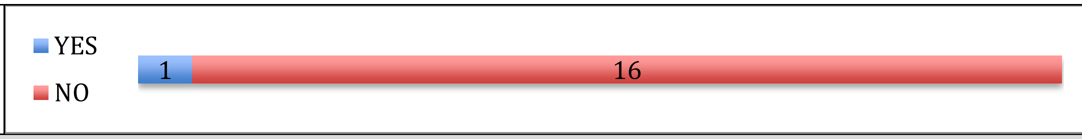
Discussion	
Benefits *(identified pre-workshop)*	Provides data on a suite of health parameters (e.g., body condition, stress levels, hormones, fatty acids, stable isotopes, immune parameters, skin microbiome, contaminants, HABs, pathogens, prevalence of microorganisms, commensal/pathogenic flora, and disease), genetic/sex identification, and reproductive status. This method was regarded as useful for determining factors limiting recovery. Multiple participants felt that comparison with the Bristol Bay population would be informative.
Risks *(identified pre-workshop)*	The greatest risks were associated with the initial chase, capture, and restraint required by this method, leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Possible sampling risks include stress (from added restraint time and close proximity to the animal), temporary alteration of behavior, discomfort, injury, infection, disease, and mortality. One participant cautioned that pathogens could be introduced at the sampling site if the equipment was not property sterilized.
Commentary and discussion *(during workshop)*	*Benefits* • Important for health assessments • Important to understand normal and unusual bacterial and fungal flora and fauna *Risks* • Minimally invasive *Feasibility for CIB* • One participant noted: “Accessing the 'bottom' of a whale can be difficult. Getting rectal or vaginal swabs is relatively difficult since it requires raising a tail or rolling onto the side. Our success in accessing an animal’s belly in Bristol Bay depended on the animals size, its demeanor, the substrate (firm pack vs soft mud), and everyone's general energy level.”

	Other considerations • Not itself a reason for capture, but if capture done, these samples should be collected.

Sample, Tooth Extraction (require capture)

n=17	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	0
Medium Risk	0	0	1
High Risk	9	5	2

Benefit > Risk?



Discussion

Benefits *(identified pre-workshop)*

Provides a method for definitive aging, as well as information on population parameters, genetics, long-term diet, fatty acids, stable isotopes, age at first reproduction (potentially), and animal health (e.g., hormone levels, contaminant exposure, and disease). This method was regarded as useful for determining factors limiting recovery.

Risks *(identified pre-workshop)*

Considerable risks were associated with the initial chase, capture, and restraint required by this method, leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Considerable risks were also associated with the extraction procedure including elevated stress, pain, injury, trauma to the jaw, infection, and mortality. One participant cautioned that extraction and an open wound would create an entryway for disease and infection possibly leading to compromised immunity and reduced foraging ability.

Commentary and discussion *(during workshop)*

Benefits

- Information from a tooth (e.g., age and isotopic history)

Risks

- Beluga teeth are deep rooted and extraction would require a tremendous effort, would be painful, very stressful, and healing would likely take some time and the chances of infection would be high in a deep socket wound.
- Length of time being held in captivity

Less invasive options

- Tooth extraction from dead strandings
- Soft tissue samples for other types of analysis (e.g. stable isotopes)
- Radiographic methods for aging (these are in development for Tursiops and could be ground-truthed using the captive display beluga community)

Sample, Other (Milk, Urine, Fecal, or Sperm) (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	2	5
Medium Risk	2	6	4
High Risk	0	0	2

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Depends on sample type; though all of the samples in question provide information on animal health and physiology, similar to blood sampling. Broadly, participants described these samples as generating information on age, long-term stress hormones, milk composition, sperm count (sperm), disease, contaminant loads, reproductive status, renal function, prey DNA (feces), contaminants, and fatty acids/stable isotopes (milk). This method can enable pathogen testing (e.g., for algal toxins, virus, and bacteria) and molecular genetic analyses (from some samples). This method was regarded as useful for determining factors limiting recovery.
Risks *(identified pre-workshop)*	Considerable risks were associated with the initial chase, capture, and restraint (if required for this method) leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). One participant highlighted the risk of separating calf/cow pairs. Participants described lesser risks associated with sampling methods (e.g., temporary discomfort, elevated stress, and minor injury). However, sampling methods and risk vary across sample type, some have the potential to result in a wound which could lead to infection and possible mortality.
Commentary and discussion *(during workshop)*	*Benefits* • Milk and urine samples could be valuable to monitor for domoic acid and saxitoxin. • Feces sampling provides information about parasites • Value of sperm collection unclear *Feasibility for CIB* • Milk samples are not hard to get. • Feces samples are not easily attainable. • One participant noted: "Accessing the 'bottom' of a whale is relatively difficult since it requires raising a tail or rolling onto the side. Our success in accessing an animals belly in Bristol Bay depended on the

	animals size, its demeanor, the substrate (firm pack vs soft mud), and everyone's general energy level.” • Some of these samples would require sterile technique, which would be impossible on the beach or in a sling. A clean platform would be required. *Other considerations* • Should not be reason for capture, but should be collected if capture already occurring and does not notably increase capture time and is collected non-invasively.

Transport (require capture)

n=20	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	0	0
Medium Risk	1	0	1
High Risk	13	3	1

Benefit > Risk?

Discussion	
Benefits *(identified pre-workshop)*	Transport facilitates the relocation of an animal to a safer place (e.g., non-oiled, absent of predators, or deeper water), a location that is easier to work in (e.g., provide better care or enhance assessments), for captive breeding, or for the purposes of rescue and rehabilitation. The transport process also provides an opportunity to measure stress in response to transport. Multiple participants felt there were no benefits associated with this method.
Risks *(identified pre-workshop)*	Considerable risks were associated with the initial chase, capture, and restraint necessary for transport which participants suggested result in take under the ESA and MMPA (e.g., harassment, injury, and mortality). The transport process itself may put pressure on internal organs and may lead to overheating, elevated stress, reduced fitness, and possible mortality.
Commentary and discussion *(during workshop)*	*Benefits* • Transport of a live stranded animal to rescue it by transporting it to another location if it was almost certain to die otherwise. *Risks* • Stress response high. *Rationale* • The only time the benefit would outweigh the risk is if a live stranded animal could be rescued by transporting it to another location and it was almost certain to die otherwise.

Ultrasound (require capture)

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	1	3	14
Medium Risk	0	1	1
High Risk	0	1	0

Benefit > Risk?

Discussion

<table>
<tr><td>Benefits
(identified pre-workshop)</td><td>Facilitates a number of health and reproductive assessments to examine various organ systems, sexual maturity, pregnancy, body condition, blubber thickness, and disease. This method may help determine the stage at which population growth is limiting recovery.</td></tr>
<tr><td>Risks
(identified pre-workshop)</td><td>Considerable risks were associated with the initial chase, capture, and restraint required by this method, leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Participants described only minor risks associated with sampling methods (e.g., temporary discomfort and elevated stress).</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Commentary and discussion
(during workshop)</td><td>Benefits
Non-invasive way to determine blubber depth/pregnancy
Ultrasound for blubber depth at multiple locations can provide blubber stores. These values can be compared by sex, age, season, and population.
Less invasive alternatives
Conduct ultrasound on live-stranded belugas
Other considerations
Not itself a reason for capture, but if capture occurs, this should be collected</td></tr>
</table>

X-ray (require capture)

n=14	Low Benefit	Medium Benefit	High Benefit
Low Risk	5	0	2
Medium Risk	1	3	0
High Risk	3	0	0

Benefit > Risk?

Discussion

Benefits *(identified pre-workshop)*	Enables various health assessments, diagnostics, and monitoring for signs of deformities, fractures, trauma, foreign objects (e.g., metal), disease, and pregnancy (potentially). Provides information on body condition, bone position, bone growth, ossification, and interactions with humans (e.g., from fishing gear). Can possibly be used for aging with high resolution images.
Risks *(identified pre-workshop)*	Considerable risks were associated with the initial chase, capture, and restraint required by this method, leading to take under the ESA and MMPA (e.g., harassment, injury, and mortality). Participants described only minor risks associated with sampling methods (e.g., temporary discomfort and elevated stress). Some participants felt that this method posed no risks outside of capture. However, this method was described as requiring longer hold times.
Commentary and discussion *(during workshop)*	*Benefits* • Benefits unclear. *Risks* • Expanded time holding captured animals. • Low-level risk from radiation. *Feasibility for CIB* • Likely impractical in Cook Inlet.

Strandings

n=21	Low Benefit	Medium Benefit	High Benefit
Low Risk	0	0	19
Medium Risk	0	0	2
High Risk	0	0	0

Benefit > Risk?	
Discussion	
Benefits *(identified pre-workshop)*	*Note: this method was not included in the pre-workshop survey.*
Risks *(identified pre-workshop)*	*Note: this method was not included in the pre-workshop survey.*
Commentary and discussion *(during workshop)*	*Benefits* • Valuable information could be collected about cause of death, health and life history. • Valuable information can be collected on dead strandings including teeth, genetics, measurements, et cetera. • Stranding data should be collected before determining data needs from live animals. *Risks* • Medium risk in live strandings; no risk in dead strandings. *Less invasive options* • Analysis of existing (archived) data from stranded animals. *Other considerations* • Stranding data should be fully analyzed and summarized. Sample analysis would be useful to help guide future research/ methods or rank potential risks. • One participant suggested that NMFS should respond to ALL strandings, live or dead. No matter the condition (old or fresh). There should be a program for dedicated systematic carcass surveys.

Presentation 1

Cook Inlet beluga whale population characteristics, and summary of recent research

Paul Wade, Ph.D., NMFS Alaska Fisheries Science Center, Marine Mammal Lab

NOAA
FISHERIES

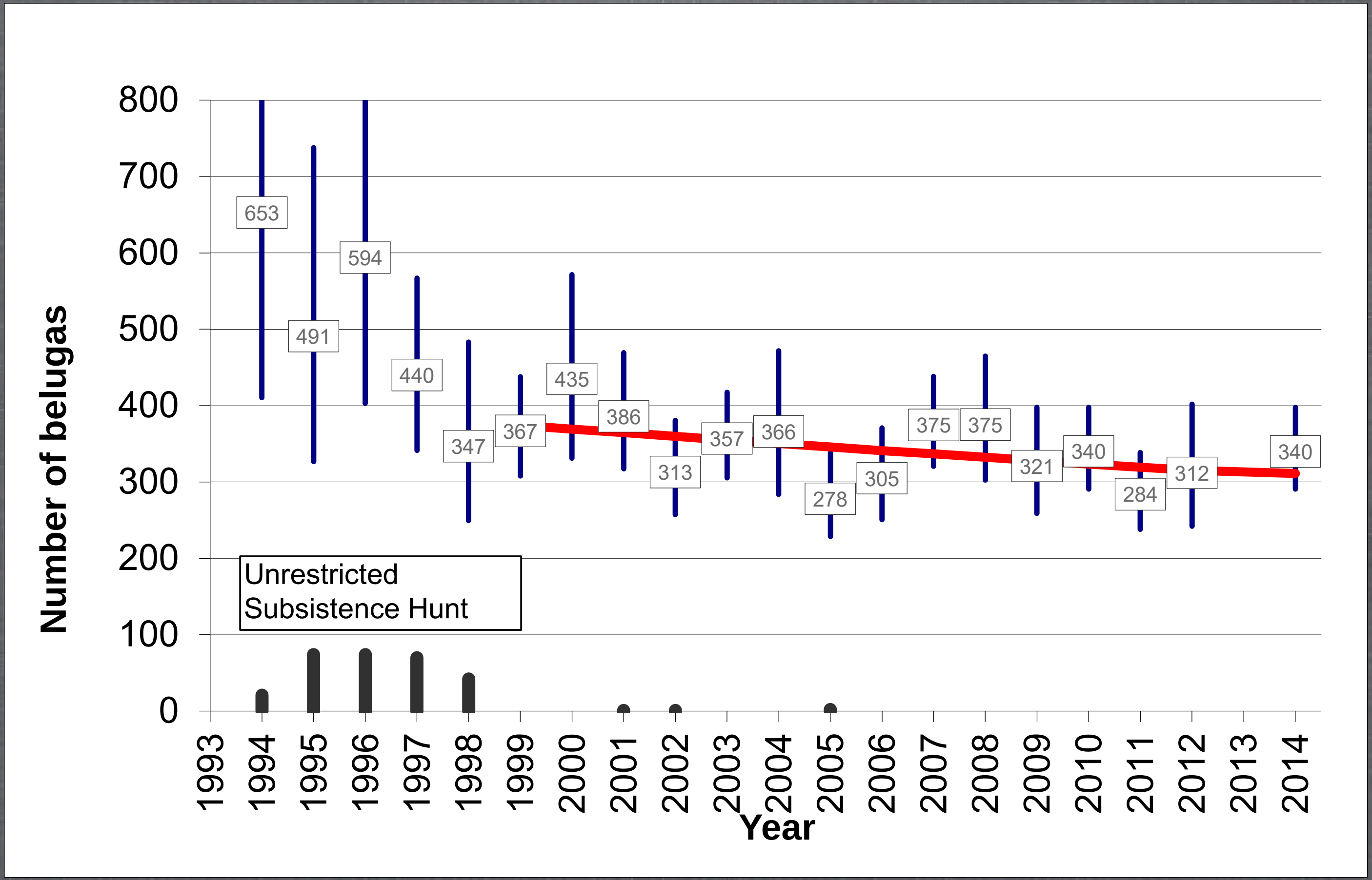
Cook Inlet beluga whale population characteristics, and summary of recent research

Paul R. Wade
Marine Mammal Laboratory
Alaska Fisheries Science Center
NOAA Fisheries
Seattle, WA

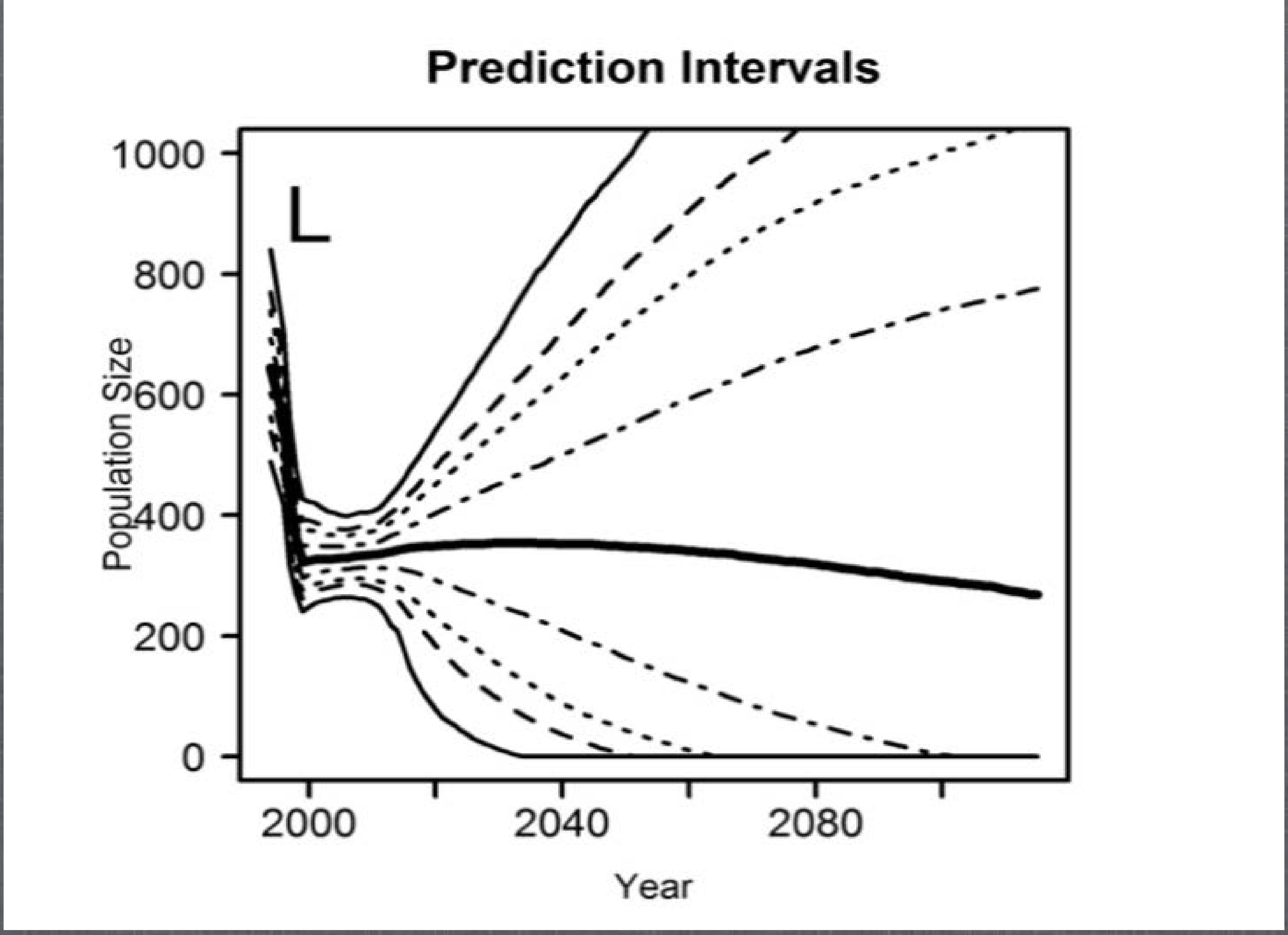
Aerial surveys for abundance and distribution

Cook Inlet Beluga Abundance, Trend and Subsistence Hunt

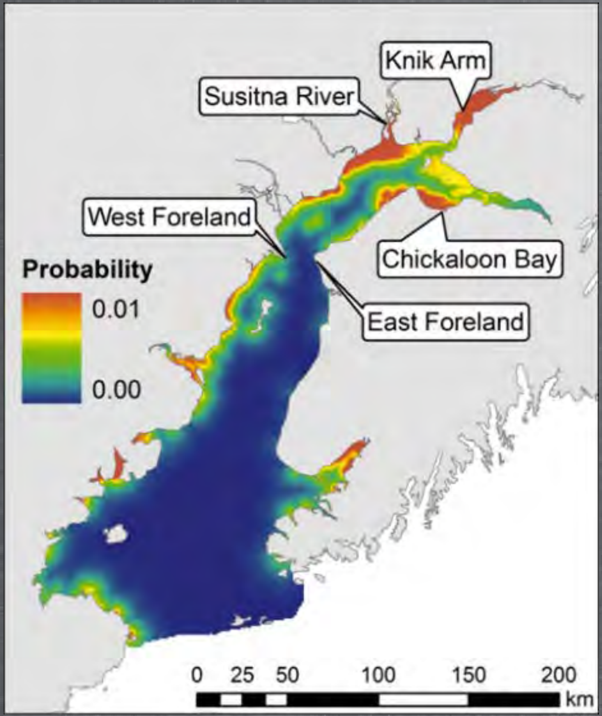
- *Prior to 1999 subsistance hunts of belugas were unrestricted in Cook Inlet.*
- *In the mid 1990's the subsistence hunt exceeded 70/year and can explain the decline during that period (>283 whales killed, estimated decline of ~240).*
- *Decline from ~1300 in 1979 to ~650 in 1994 could be explained by a hunt of ~60/year*
- *Since 1999 the population has shown no signs of increasing, and has perhaps continued to decline (more slowly). The cause of the lack of recovery is unknown.*

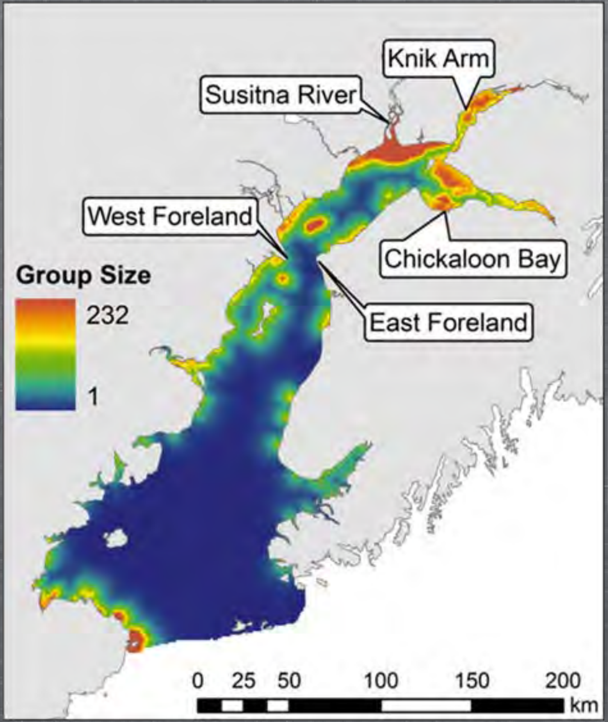


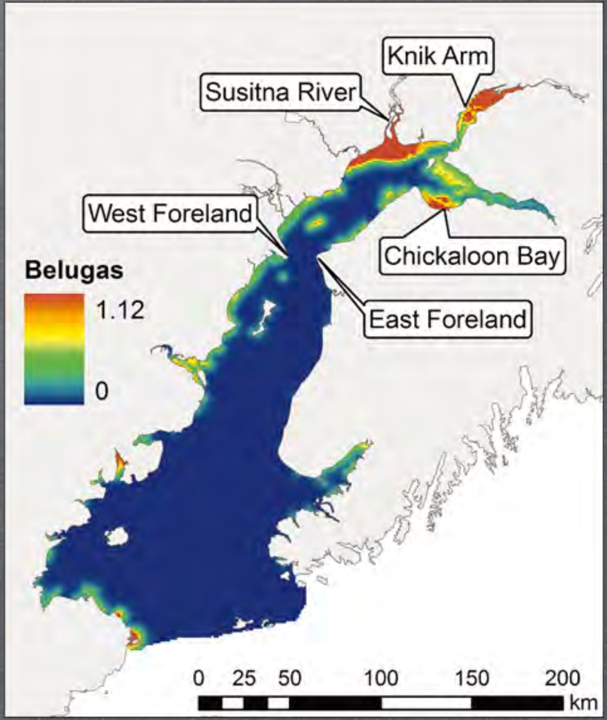
Population modeling
Population Viability Analysis
(Hobbs et al. 2015)



Habitat Modeling: Preferred Summer Habitat
Goetz et al. 2007, 2012

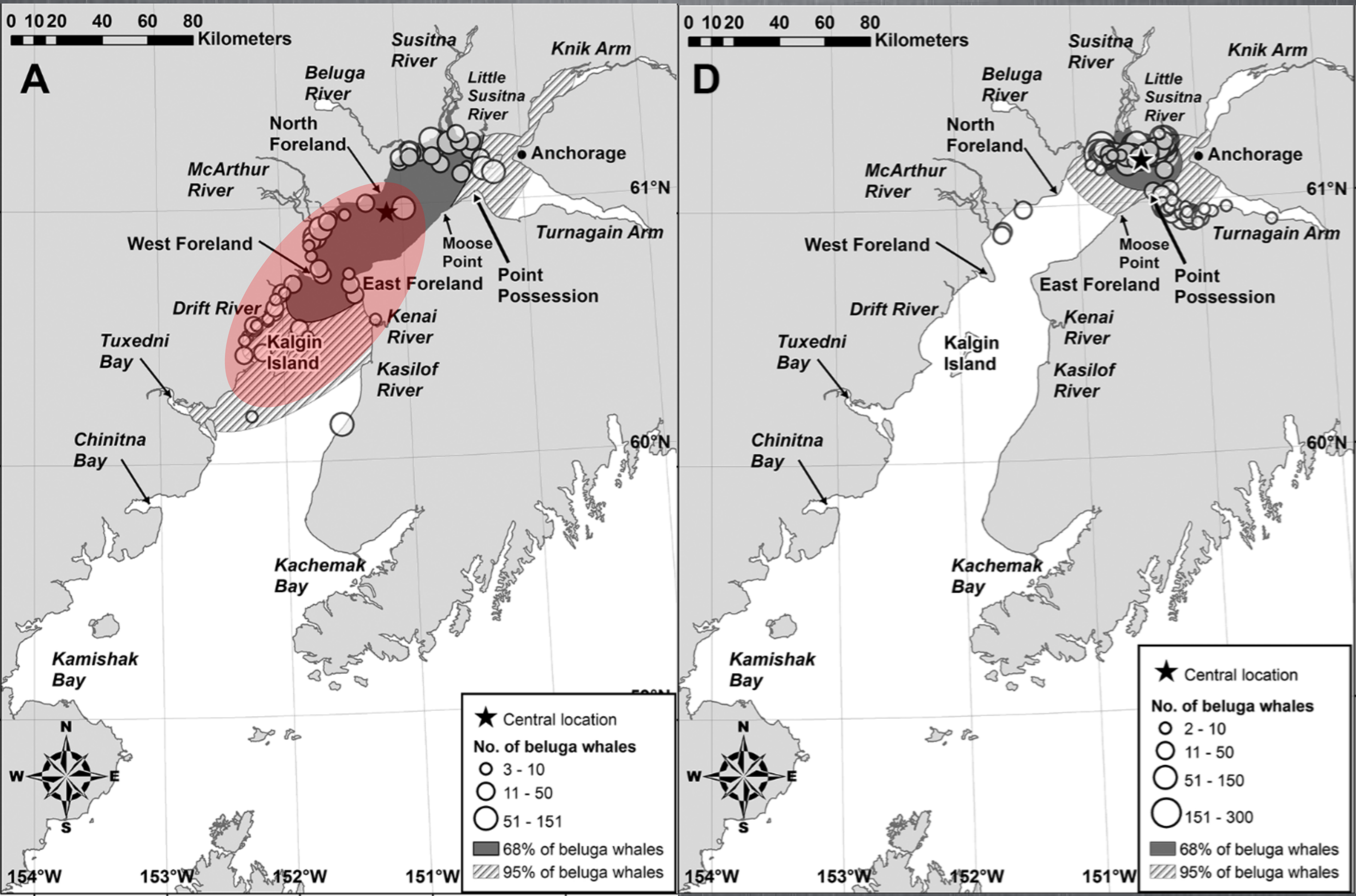


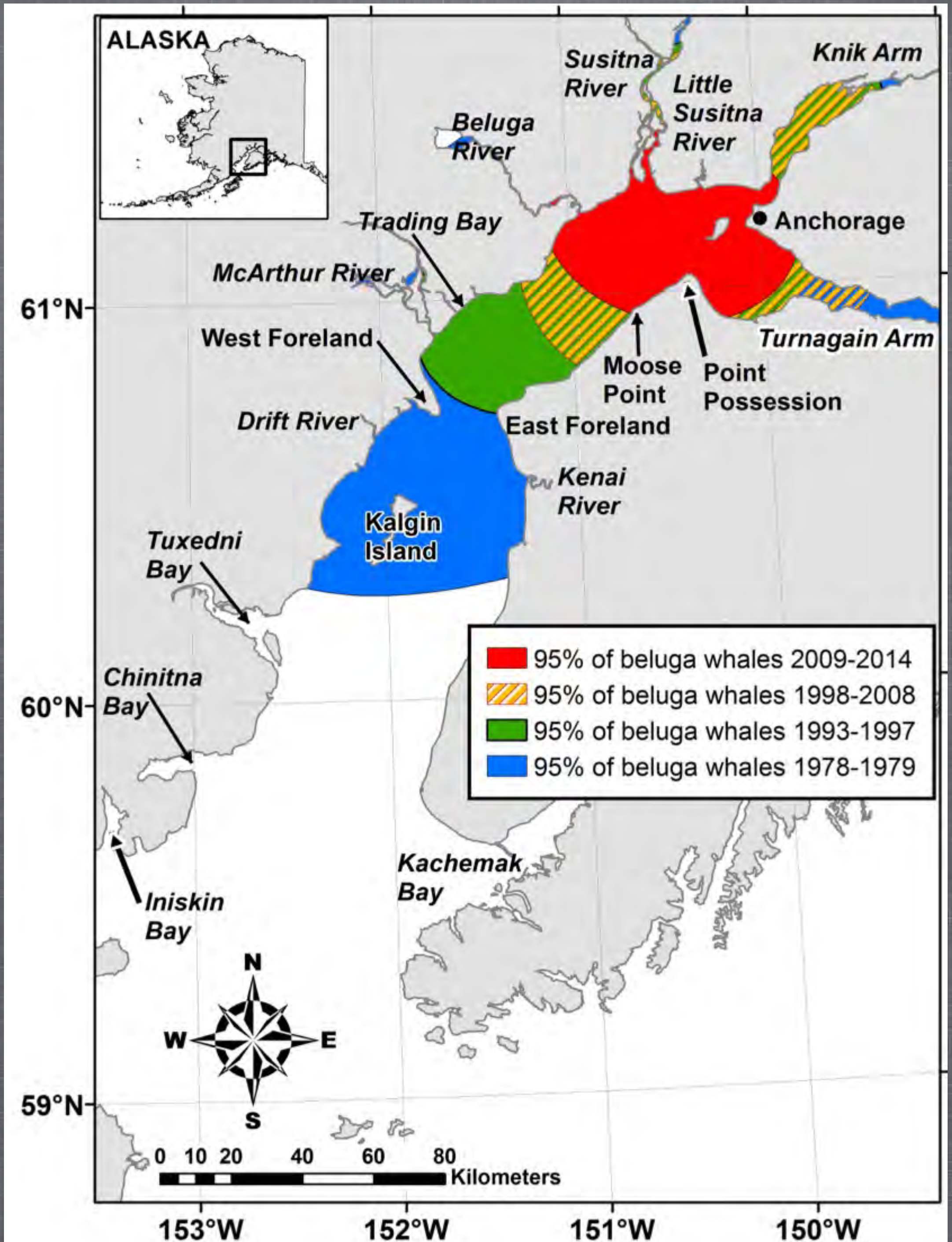




1978-79

2009-14




ALASKA
Susitna River
Knik Arm
Little Susitna River
Beluga River
Trading Bay
Anchorage
McArthur River
61°N
West Foreland
Turnagain Arm
Moose Point
Point Possession
Drift River
East Foreland
Kenai River
Kalgin Island
Tuxedni Bay
95% of beluga whales 2009-2014
95% of beluga whales 1998-2008
95% of beluga whales 1993-1997
95% of beluga whales 1978-1979
Chinitna Bay
60°N
Kachemak Bay
Iniskin Bay
N
W
E
S
59°N
0 10 20 40 60 80
Kilometers
153°W
152°W
151°W
150°W

Seasonal Distribution and Foraging Behavior of Cook Inlet Belugas Based on Acoustic Monitoring

Manuel Castellote, Robert J. Small, Jeffrey Mondragon, Justin Jenniges, and John Skinner

2016

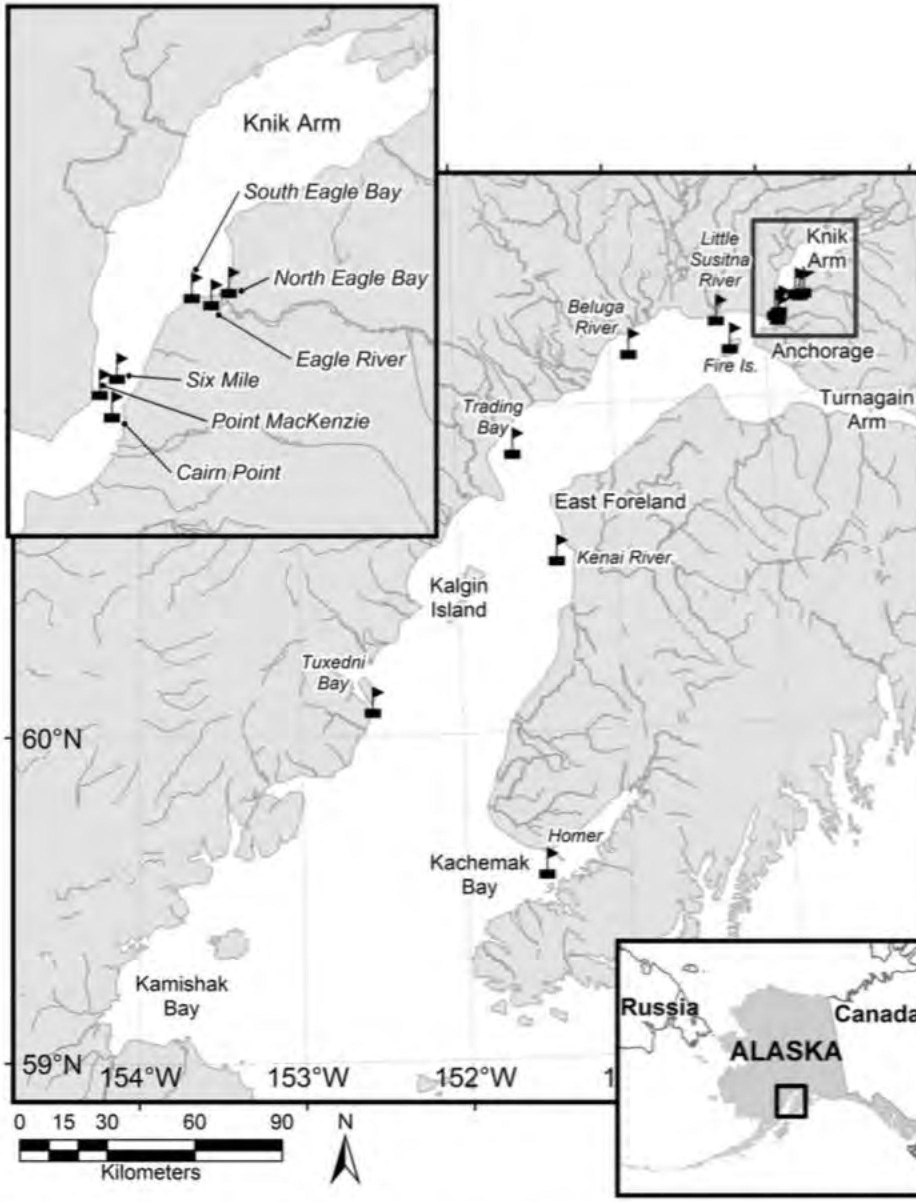


Figure 1. Locations where acoustic moorings were deployed to monitor for beluga whales from July 2008 to May 2013, in Cook Inlet, Alaska. The Knik Arm insert shows the six overwinter deployment sites for that area.

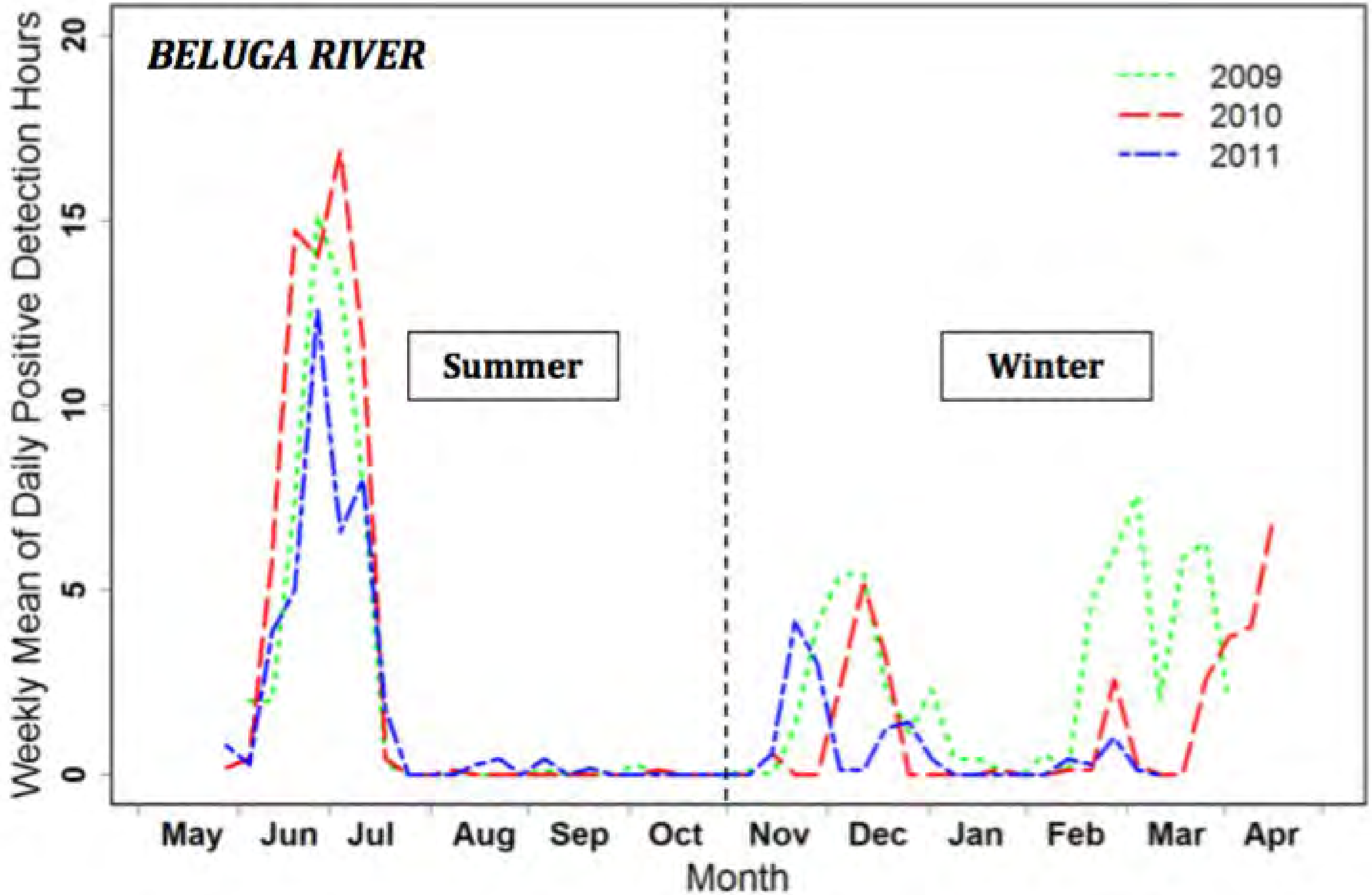
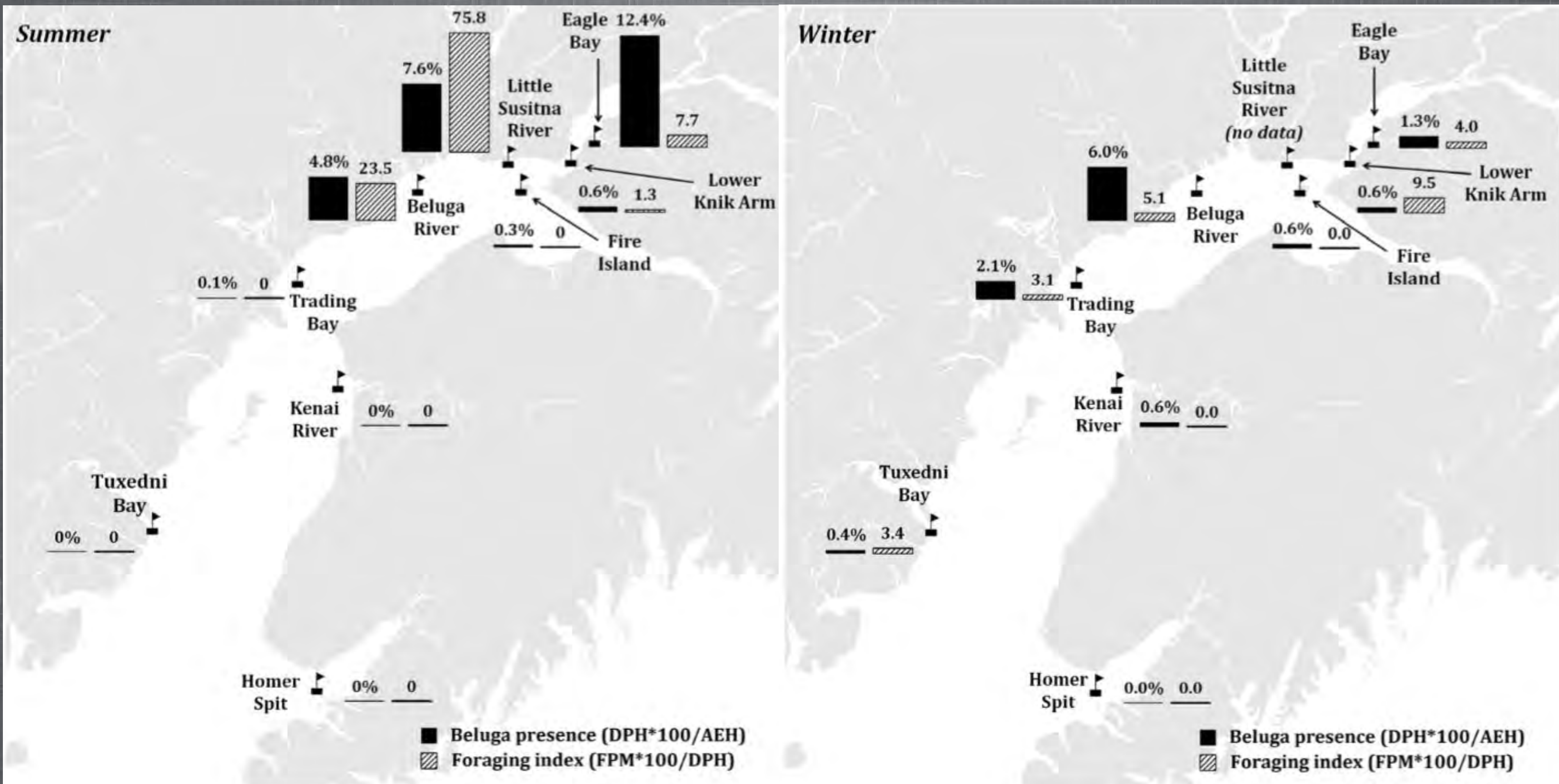


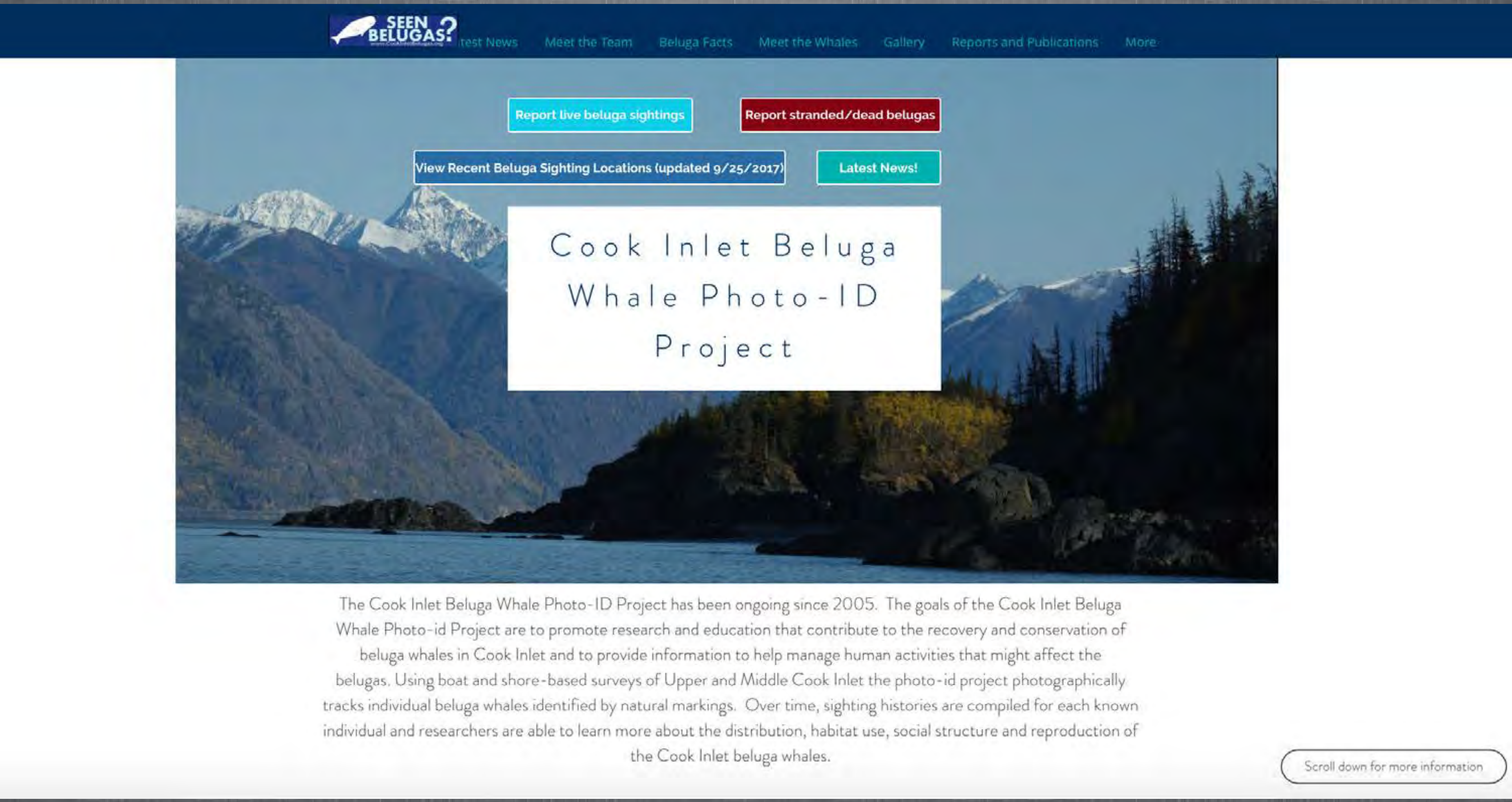
Figure 3E. Weekly mean of daily beluga detection positive hours (DPH) by month at Beluga River, Cook Inlet, Alaska, 2009-2011.



Summer
75.8
Eagle Bay
12.4%
7.6%
Little Susitna River
7.7
4.8%
23.5
Beluga River
0.6%
1.3
Lower Knik Arm
0.3%
0
Fire Island
0.1%
0
Trading Bay
Kenai River
0%
0
Tuxedni Bay
0%
0
Homer Spit
0%
0
Beluga presence (DPH*100/AEH)
Foraging index (FPM*100/DPH)
Winter
Eagle Bay
Little Susitna River (no data)
1.3%
4.0
6.0%
5.1
Beluga River
Lower Knik Arm
0.6%
9.5
0.6%
0.0
Fire Island
2.1%
3.1
Trading Bay
Kenai River
0.6%
0.0
Tuxedni Bay
0.4%
3.4
Homer Spit
0.0%
0.0
Beluga presence (DPH*100/AEH)
Foraging index (FPM*100/DPH)

Cook Inlet Beluga Whale Photo-ID Project run by Dr. Tamara McGuire. 2005-2016

Funded by AK Region since 2015



The Susitna River Delta as a calving ground: Evidence from observation of a Cook Inlet beluga birth and the 2005-2015 seasonal and geographic patterns of neonate occurrence in Upper Cook Inlet.

Tamara McGuire[1], Amber Stephens[1], Brad Goetz [1,2]

1. LGL Alaska Research Associates, Inc.
   2000 West International Airport Road, St C1
   Anchorage, Alaska, USA 99502 tmcguire@lgl.com, astephens@lgl.com
2. Kincaid Elementary School, Anchorage, Alaska.

Background

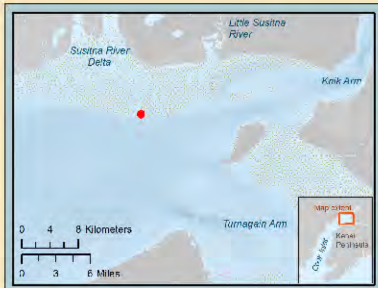
The scientific literature has not identified if distinct calving grounds and calving seasons exist for endangered Cook Inlet beluga whales (CIBW), as they do with other beluga populations. Specific calving grounds or seasonal calving periods for CIBW have not been designated because births in the wild have not been previously documented.

Methods

Cook Inlet Beluga Whale Photo-Identification Project

- Upper Cook Inlet 2005-2015
- Kenai River Delta 2011-2013
- ~250 boat- and land-based photo-id surveys
- Conducted under NMFS permit #18016
- Ice-free season.
- Note group size, location, behavior, and color/ age-class

Neonates (newborns, hours to days old) are distinguished from calves by their smaller size, darker color, sunken head, fetal folds, and uncoordinated "corky" surfacing/swimming behavior.



Birth Observed

We observed a CIBW birth on July 20, 2015 in the Susitna River Delta, Upper Cook Inlet Alaska.

- The birth took place during low tide, in shallow waters (~1.3m) along the exposed mudflats, 5-10 m from shore. This was a cove-like area where the current was reduced relative to nearby areas.
- The birth occurred in a larger group of 313 whales, with at least three other neonates seen in the group.
- Little of the birth event was visible at the surface and the turbid waters did not permit us to see underwater.
- An adult beluga was noted to be a few meters away from the main group. The group was traveling along the exposed edge of the mudflats, but the lone beluga was floating log-like at the surface. It was eventually joined by other belugas, and a neonate with deep fetal folds surfaced explosively from alongside the lone beluga.
- During the 37-minute observation period, the neonate was often seen listing to one side at the surface and appeared motionless, but then was pushed upright by other belugas. At times it would disappear from view, but then later was seen being pushed forcefully to the surface by a small group of attending whales.
- When last seen, the neonate appeared to be breathing and swimming on its own, but remained surrounded by a small group of belugas.

Seasonal Patterns

Neonates were seen over a 5-12 week period every field season, usually beginning in mid-July.

Year	Field season	First neonate sighting	Last neonate sighting	# weeks from first to last neonate sightings of season	Location of first neonate sighting of season
2005*	April 14-Oct 21	July 6	n/a	n/a	Susitna River Delta
2006*	May 12-Oct 5	n/a	n/a	n/a	n/a
2007*	June 28-Oct 27	July 27	n/a	n/a	Susitna River Delta
2008	May 21-Oct 28	July 24	Sep 30	9	Susitna River Delta
2009	June 19-Oct 24	Aug 1	Oct 15	9	Susitna River Delta
2010	May 9-Oct 15	July 16	Oct 8	12	Susitna River Delta
2011	April 16-Oct 22	July 27	Sep 27	9	Susitna River Delta
2012	May 2-Oct 21	July 20	Oct 4	11	Susitna River Delta
2013	April 20-Sep 21	July 31	Sep 3	5	Susitna River Delta
2014	July 8-Oct 3	July 21	Oct 3	10.5**	Susitna River Delta
2015	May 28-Oct 1	July 19	Oct 1	10.5**	Susitna River Delta

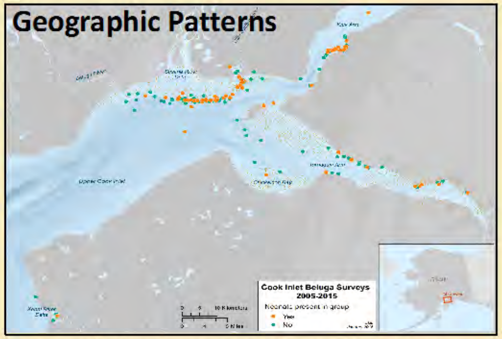
*neonates were not differentiated from calves during the 2005-2007 surveys, but neonates were noted if visible in photos

** last day of field season

In all instances, the first neonates of the field season were seen in the waters of the Susitna River Delta (defined as between the Beluga River and Little Susitna River).

As each field season progressed, neonates were seen in all other survey areas where belugas were encountered (Susitna River Delta, Knik Arm, Turnagain Arm, Chickaloon Bay, and the Kenai River).

Geographic Patterns



Locations of beluga groups seen with and without neonates, 2005-2015. Groups with belugas of unknown age-class (due to poor sighting conditions) are not shown.

Conclusion

Keeping in mind the bounds of the study area and study period, these results provide evidence to support the designation of the Susitna River Delta as CIBW calving grounds, the nearshore areas of Upper Cook Inlet as nursery grounds, and mid-July through mid-October as the peak calving period in Upper Cook Inlet.

Thanks to Ken Matthews and Lauren Bisson of LGL for GIS support.

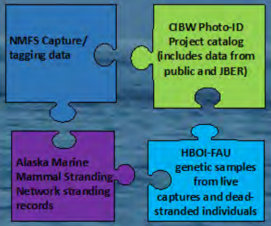
Adding pieces to the puzzle: Consolidating datasets from photo-id, stranding, and genetic studies extends what can be learned from satellite-tagging of endangered Cook Inlet beluga whales

Tamara McGuire[1], Amber Stephens[1], Kim Shelden[2], Mandy Migura[3], Christopher Garner[4], Carrie Goertz[5], Kathy Burek Huntington[6], Greg O'Corry-Crowe[7], Tatiana Ferrer[7]

tmcguire@lgl.com
[1] LGL Alaska Research Associates, Inc., Anchorage, AK
[2] NOAA Alaska Fisheries Science Center, Seattle, WA
[3] NOAA Fisheries Alaska Region, Anchorage, AK
[4] Joint Base Elmendorf and Richardson, Anchorage, AK
[5] Alaska SeaLife Center, Seward, AK
[6] Alaska Veterinary Pathology Services, Eagle River, AK
[7] Florida Atlantic University, Fort Pierce, FL

Background

Between 1999 and 2002, the National Marine Fisheries Service (NMFS) captured 20 Cook Inlet beluga whales (CIBWs, *Delphinapterus leucas*) and instrumented 18 (8 males, 10 females) of them with satellite tags. Years later, the CIBW Photo-ID Project discovered several photo-identified CIBWs had scar patterns consistent with satellite-tag attachment methods and realized that photographic resighting of these individuals could provide post-tagging information about survival, reproduction, and movement/residency for decades beyond the original satellite tag life (1-295 days). Four datasets (below) were reviewed and combined to assemble life histories of the satellite-tagged CIBWs. These datasets spanned 1999-2015.



#Puzzle pieces throughout poster correspond to color of data sets above and depict origin of data.

Results

- 15 of the 20 captured CIBWs were later identified as individuals within the CIBW Photo-id catalog (14 with tag scars, 1 captured but not tagged). Ten were photographed as recently as 2015, representing 50% of the 20 CIBWs originally captured.
- Three satellite-tagged whales have been confirmed dead since 2002; match confirmation was provided by a flipper-band, and by genetic fingerprinting of two whales recovered dead. Photo-id records also suggest that a fourth whale may have died after 2007.
- Seven individual whales in the photo-id catalog could be photographically matched to their original capture photos. Genetic samples taken during tagging confirmed that three of these were males and four were females. Seven others are suspected to be females based on close accompaniment by calves in photographs.
- Five of the 14 cataloged satellite-tagged whales had signs of tag-site infection in photos, eight had signs of deformity above the tag site, and two displayed damage to the pectoral fins from flipper bands applied during tagging.
- All of the 15 captured/satellite-tagged whales in the photo-id catalog were resighted in Upper Cook Inlet's Susitna River Delta, and most were also resighted in Knik Arm and Turnagain Arm, displaying distribution and movement patterns consistent with those obtained from the transmitting tags.

Conclusion

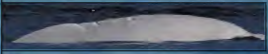
Combining these four datasets broadens what can be learned about these individuals and the population, extending the temporal range of the satellite tags, and adding biological data to the photo-id catalog.

EXAMPLES OF MATCH BETWEEN PHOTOS OF INDIVIDUAL BELUGAS DURING TAGGING AND PHOTO-ID CATALOG#:

Capture/Tagging Data	
NMFS CIBW ID Number	CI-01-06
Date captured/tagged	15 August 2001
Capture location	Knik Arm
Sex (visual/genetics at capture)	female
Color recorded at capture	white
Length at capture (cm)	401
Photo-ID Resight Data	
Photo-ID number and name	R103/L493 "Strapped"
Years resighted	All years 2005-2015
Number of years resighted	11
Maximum number of resightings per year (and year)	12 in 2008
Span of records (photo-id and/or tagging)	2001-2015
Presumed mother (seen with calves?)	yes
Locations sighted	Susitna River Delta, Knik Arm, Turnagain Arm
Tag-site condition (infections, margins)	Tag scars and biopsy scars conspicuous but clean margins and no signs of infections
Other (e.g., abnormal body condition, disease, trauma)	New scar in 2015- right side- possible tooth rake marks
Flipper bands?	Not used in 2001 tagging


Dual-side photo of female whale CI-01-06 captured and tagged on August 15, 2001. Photo courtesy of NMFS[b].

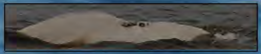

Left-side photo of whale R103/L493 "Strapped" in 2006. This photo shows five pin scars plus one biopsy scar. Photo courtesy of CIBW Photo-ID Project[a].


Right-side photo of R103/L493 "Strapped" in 2015. Photo courtesy of CIBW Photo-ID Project[a].

Capture/Tagging Data	
NMFS CIBW ID Number	CI-02-05
Date captured/tagged	2 August 2002
Capture location	Knik Arm
Sex (visual/genetics at capture)	male
Color recorded at capture	white/gray
Length at capture (cm)	386
Photo-ID Resight Data	
Photo-ID number and name	L2303/R17366 "Sash"
Years resighted	all years 2006-2015
Number of years of resightings	10
Maximum number of resightings per year (and year)	4 (2007, 2011, 2014)
Span of records (photo-id and/or tagging)	2002-2015
Presumed mother (seen with calves?)	no
Locations sighted	Susitna River Delta, Knik Arm, Turnagain Arm
Tag-site condition (infections, margins)	Infection of tag scar first noted 2006, deteriorated each year
Other (e.g., abnormal body condition, disease, trauma)	Concavity of dorsal area around tagging site, first noted 2006
Flipper bands?	Yes, damage to flipper in resight photos
Information on death?	Dead 12 June 2015, Tyonek
Match confirmed by genetics?	yes
Other	Necropsy report available from NMFS upon request


Left-side photo of CI-02-05 captured and tagged on August 2, 2002. Photo courtesy of NMFS[b].


Left-side necropsy photo of L2303/R17366 "Sash" on June 12, 2015. Note left pectoral fin damage and concave tag site. Photo courtesy of Kathy Burek Huntington[c].


Right-side photo of L2303/R17366 "Sash" in 2014. Photo courtesy of CIBW Photo-ID Project[a].

Capture/Tagging Data	
NMFS CIBW ID Number	CI-01-01
Date captured/tagged	10 August 2001
Capture location	Little Susitna River
Sex (visual/genetics at capture)	female
Color recorded at capture	gray
Length at capture (cm)	257
Photo-ID Resight Data	
Photo-ID number and name	R243/L7861 "Scrappy"
Years resighted	2005, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015
Number of years resighted	10
Maximum number of resightings per year (and year)	4 in 2010
Span of records (photo-id and/or tagging)	2001-2015
Presumed mother (seen with calves?)	no
Locations sighted	Susitna River Delta, Knik Arm, Turnagain Arm
Tag-site condition (infections, margins)	Appeared to be healing well in 2005, some infection visible 2011-2015
Other (e.g., abnormal body condition, disease, trauma)	skin infection at time of tagging and throughout sighting history
Flipper bands?	Not used in 2001 tagging


Left-side photo of CI-01-01 captured and tagged on August 10, 2001. Photo courtesy of NMFS[b].


Left-side photo of R243/L7861 "Scrappy" in 2011. Possible infection of left tag scars. Photo courtesy of CIBW Photo-ID Project[a].


Right-side photo of R243/L7861 "Scrappy" in 2005. Photo courtesy of CIBW Photo-ID Project[a].

Capture/Tagging Data	
NMFS CIBW ID Number	CI-02-08
Date captured/tagged	4 August 2002
Capture location	Knik Arm
Sex (visual/genetics at capture)	male
Color recorded at capture	white/gray
Length at capture (cm)	376
Photo-ID Resight Data	
Photo-ID number	L2579/R115 "Sashtoo"
Years resighted	2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014
Number of years resighted	9
Maximum number of resightings per year (and year)	14 in 2011
Span of records (photo-id and/or tagging)	2002-2014
Presumed mother (seen with calves?)	no
Locations sighted	Susitna River Delta, Knik Arm, Turnagain Arm
Tag-site condition (infections, margins)	Tag scars conspicuous but clean margins and no signs of infections
Other (e.g., abnormal body condition, disease, trauma)	neck abrasions
Flipper bands?	Flipper-band damage seen on dead whale
Information on death?	Dead 26 May 2014 Kincaid Park, Turnagain Arm, Anchorage
Match confirmed by genetics?	yes
Other	Necropsy report available from NMFS upon request


Dual-side photo of CI-02-08 captured and tagged on August 4, 2002. Photo courtesy of NMFS[b].


Left-side photo of dead L2579/R115 "Sashtoo" on May 27, 2014. Note damaged left pectoral fin. Photo courtesy of Bill Streever.


Left-side photo of L2579/R115 "Sashtoo" side swimming in 2007. Note flipper band embedded in left pectoral fin. Photo courtesy of Chris Garner, JBER.

EXAMPLES OF CONFIRMED SATELLITE-TAGGED INDIVIDUALS IN THE PHOTO-ID CATALOG UNMATCHED TO INDIVIDUALS DURING TAGGING#:

Capture/Tagging Data	
NMFS CIBW ID Number	Unable to match
Photo-ID Resight Data	
Photo-ID number and name	R549/L1936 "Tagger"
Years resighted	2005, 2006, 2009, 2011, 2014, 2015
Number of years resighted	6
Maximum number of resightings per year (and year)	5 in 2006
Span of records (photo-id and/or tagging)	2005-2015
Presumed mother (seen with calves?)	yes
Locations sighted	Susitna River Delta, Knik Arm, Turnagain Arm
Tag-site condition (infections, margins)	Tag scars conspicuous but healed
Other (e.g., abnormal body condition, disease, trauma)	Slightly concave along dorsal crest between tag scars


Right-side photo of R549/L1936 "Tagger" in 2014. Photo courtesy of CIBW Photo-ID Project[a].


Left-side photo of R549/L1936 "Tagger" in 2006 with an accompanying calf. Photo courtesy of CIBW Photo-ID Project[a].

Capture/Tagging Data	
NMFS CIBW ID Number	Unable to match
Photo-ID Resight Data	
Photo-ID number and name	L480 "Dimples-L"/R49 "Dimples-R"
Years resighted	2005, 2006, 2008, 2010, 2011, 2012, 2014, 2015
Number of years resighted	8
Maximum number of resightings per year (and year)	10 in 2011
Span of records (photo-id and/or tagging)	2005-2015
Presumed mother (seen with calves?)	yes
Locations sighted	Susitna River Delta, Knik Arm, Turnagain Arm
Tag-site condition (infections, margins)	Only one tag scar visible, and appears to heal cleanly then close
Other (body condition, infections, trauma)	site around tag scar concave, some concavity of dorsal crest over tag site


Left-side photo of L480 "Dimples-L"/R49 "Dimples-R" in 2005. Photo courtesy of CIBW Photo-ID Project[a].


Left-side photo of L480 "Dimples-L"/R49 "Dimples-R" in 2015. Photo courtesy of CIBW Photo-ID Project[a].

MATCH BETWEEN PHOTOS OF INDIVIDUAL BELUGA AT CAPTURE AND PHOTO-ID CATALOG (WHALE CAPTURED, NOT TAGGED)#:


Left-side photo of untagged female whale captured on May 31, 1999. Photo courtesy of NMFS[b].

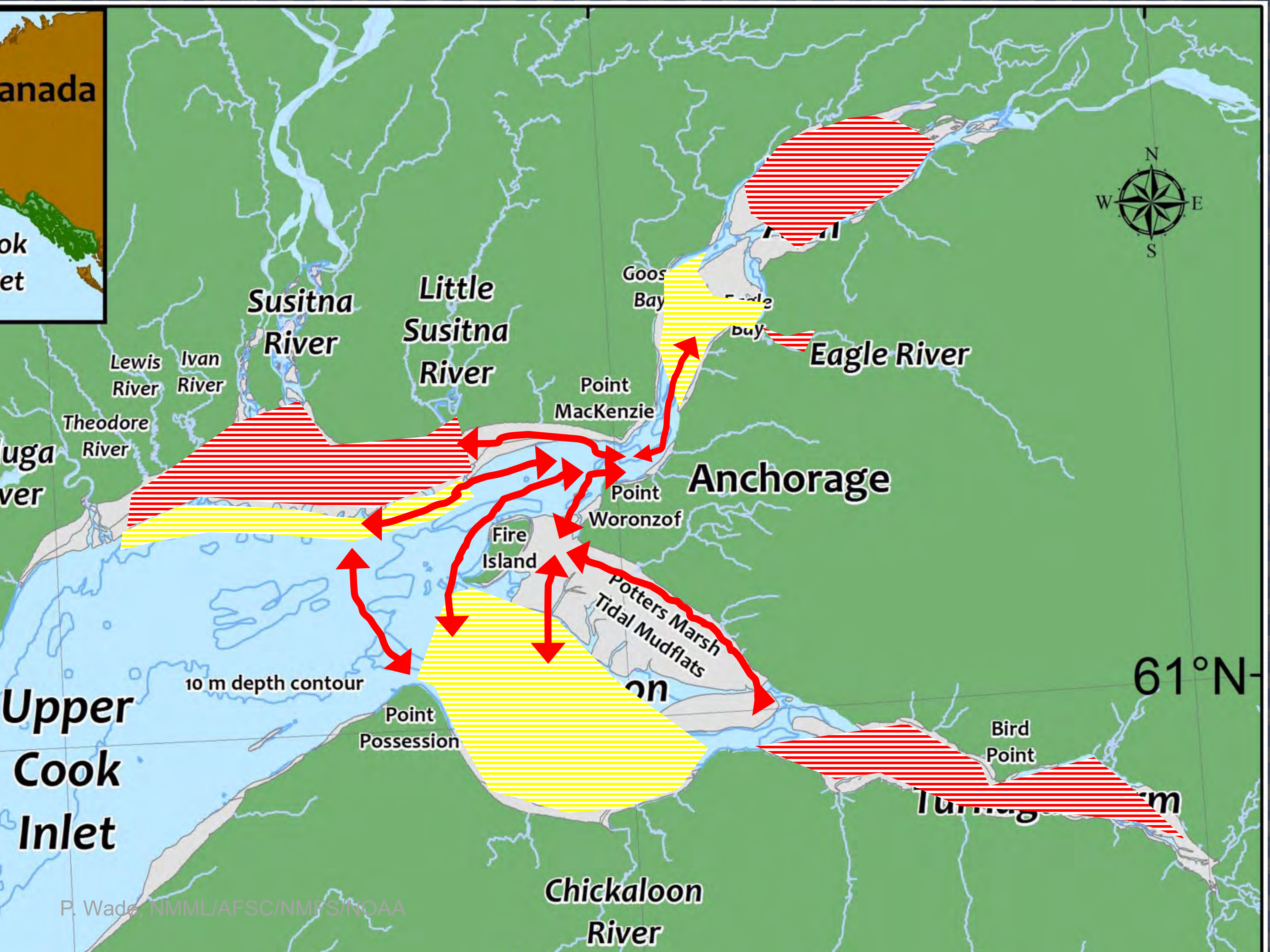

Left-side photo of whale L2191 in 2007. Photo courtesy of CIBW Photo-ID Project[a].

Capture/Tagging Data	
NMFS CIBW ID Number	None Described in Ferrero et al. 2000
Date captured/tagged	31 May 1999
Capture location	2 km up the Little Susitna River
Sex (visual/genetics at capture)	female
Color recorded at capture	gray
Length at capture (cm)	230
Photo-ID Resight Data	
Photo-ID number	L2191*
Years resighted	2007
Number of years resighted	1
Maximum number of resightings per year (and year)	1 in 2007
Span of records (photo-id and/or tagging)	1999-2007
Presumed mother (seen with calves?)	no
Locations sighted	Susitna River Delta
Tag-site condition (infections, margins)	Not tagged
Other (e.g., abnormal body condition, disease, trauma)	large white patches- skin infection?
Flipper bands?	No record of use during tagging/flippers not seen in tagging or photo-id photos

*not an individual in the catalog- classified as "temporary folder" because only seen one day and profile does not meet criteria to be considered an individual in the catalog.

[a]CIBW Photo-ID photos taken with NMFS MMPA/ESA research permits # 14210 and #18016. [b]NMFS satellite-tag capture photos taken under permits # 957 and 782-1438 (Amendment 3). [c]Stranding photos taken under permit #932-1905/MA-009526 and supported by Prescott Grant NA12NMF4390162


7


anada
ok
et
Susitna
River
Little
Susitna
River
Lewis
River
Ivan
River
Theodore
River
uga
ver
Goos
Bay
Bay
Eagle River
Point
MacKenzie
Anchorage
Point
Woronzof
Fire
Island
Potters Marsh
Tidal Mudflats
10 m depth contour
Upper
Cook
Inlet
Point
Possession
on
61°N
Bird
Point
m
Chickaloon
River
N
S
W
E
P. Wade, NMML/AFSC/NMFS/NOAA

What is the cause of the lack of recovery?

- **Lingering consequences of over-hunting?**
- **Decline is prey populations?**
- **Disturbance from anthropogenic noise?**
  - **Preventing access to important foraging, mating or calving habitat?**
- **Decline in reproduction from emerging contaminants?**
- **Direct human-caused mortality (boat strikes, bycatch, poaching)?**

Vol. 32: 43–57, 2017
doi: 10.3354/esr00786

ENDANGERED SPECIES RESEARCH
Endang Species Res

Published February 7

Contribution to the Theme Section '21st century paradigms for measuring and managing the effects of anthropogenic ocean noise'

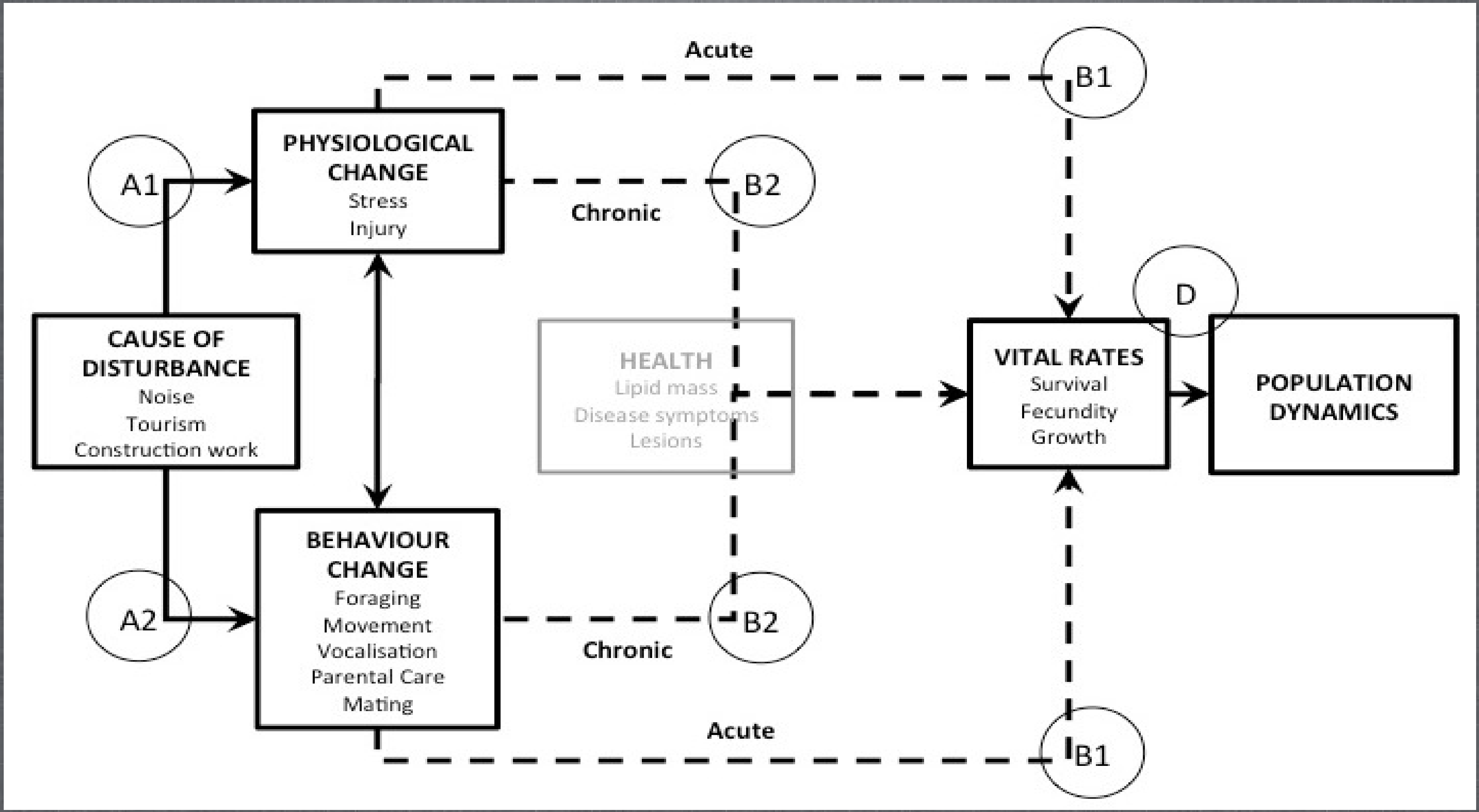
Potential for spatial displacement of Cook Inlet beluga whales by anthropogenic noise in critical habitat

Robert J. Small[1,*], Brian Brost[2], Mevin Hooten[3,2,4], Manuel Castellote[5,6], Jeffrey Mondragon[1]

[1]Alaska Department of Fish and Game, 1255 West 8th Street, Juneau, AK 99801, USA
[2]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 1484 Campus Delivery, Fort Collins, CO 80523, USA
[3]U.S. Geological Survey, Colorado Cooperative Fish and Wildlife Research Unit, 1484 Campus Delivery, Fort Collins, CO 80523, USA
[4]Department of Statistics, Colorado State University, 1484 Campus Delivery, Fort Collins, CO 80523, USA
[5]Joint Institute for the Study of the Atmosphere and Ocean (JISAO), University of Washington, 3737 Brooklyn Avenue NE, Seattle, WA 98105, USA
[6]Alaska Fisheries Science Center, Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA

ABSTRACT: The population of beluga whales in Cook Inlet, Alaska, USA, declined by nearly half in the mid-1990s, primarily from an unsustainable harvest, and was listed as endangered in 2008. In 2014, abundance was ~340 whales, and the population trend during 1999–2014 was −1.3% yr^{-1}.

Population Consequences of Disturbance





Acoustic detection of sucessful prey capture
Castelotte et al. 2016

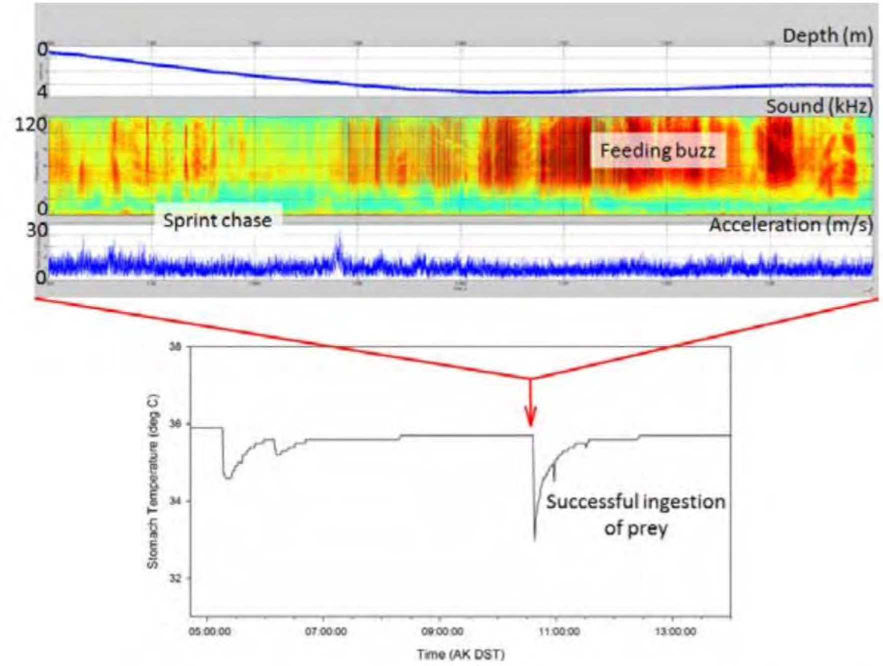
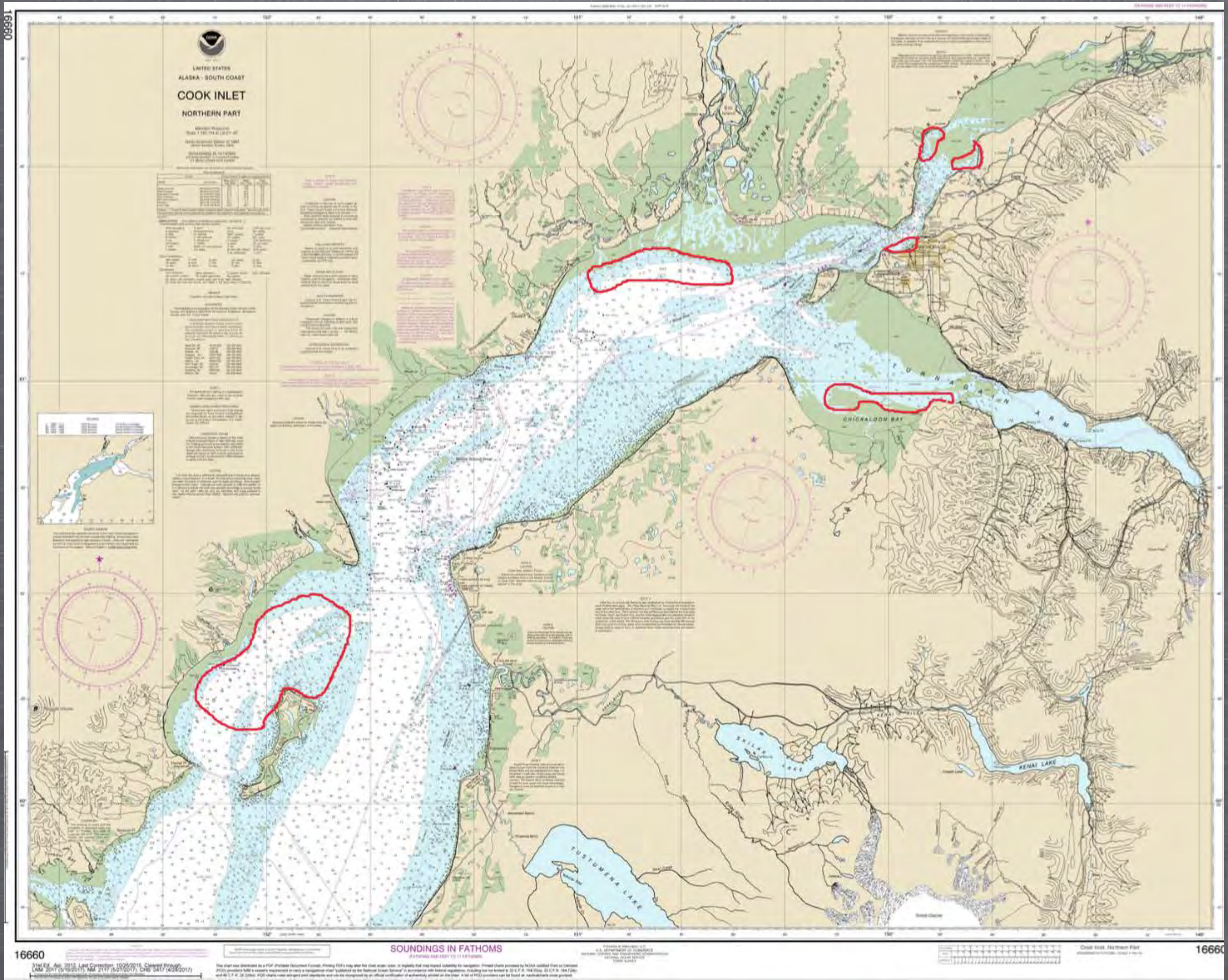
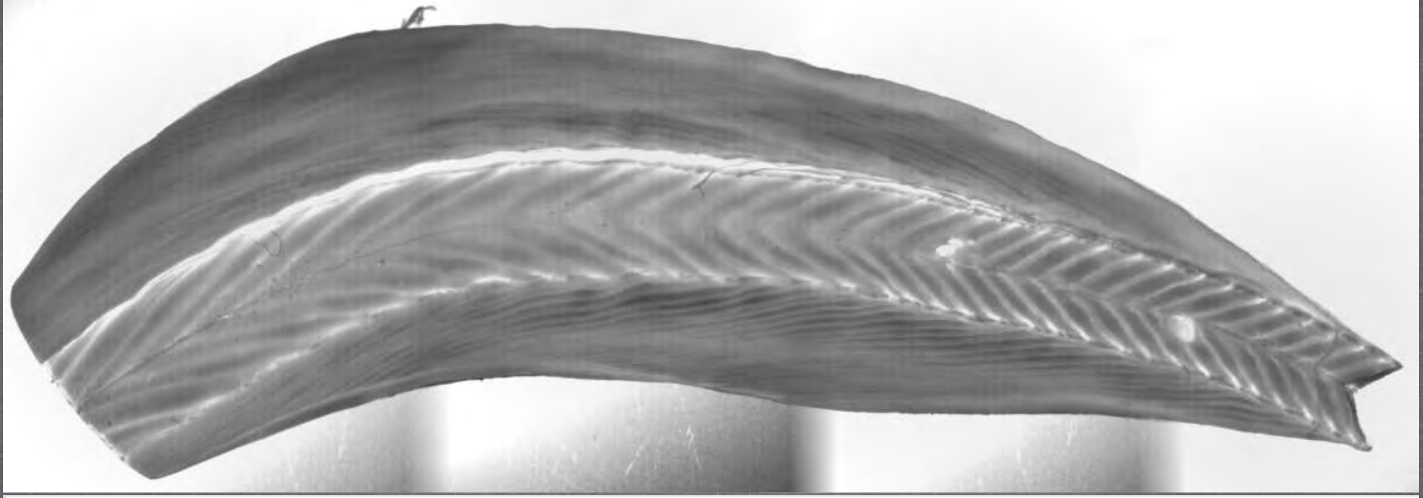
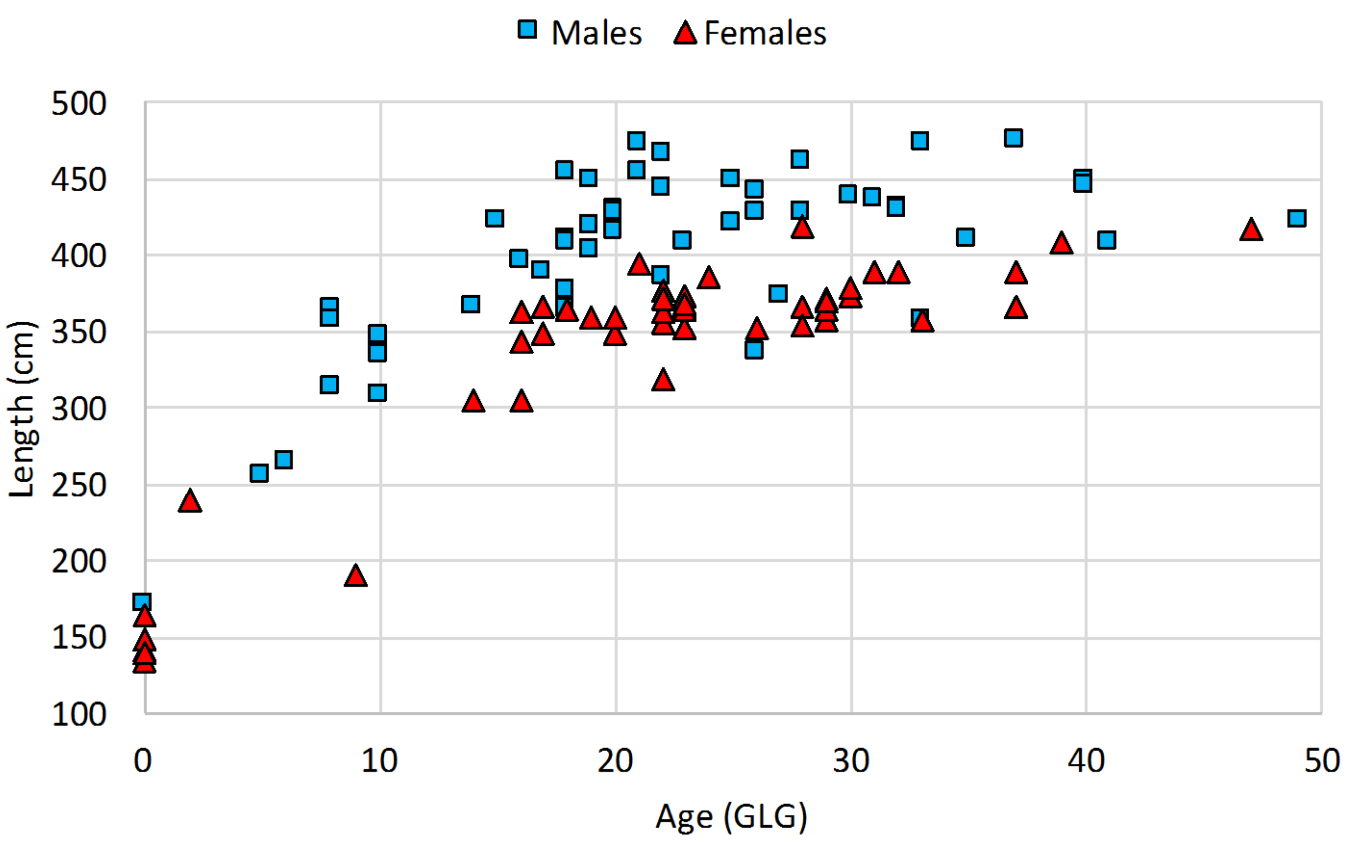


Fig. 2 Data from multi-sensor tags deployed on a Bristol Bay Beluga in May 2016. Concurrent depth, sound, and acceleration data during the 40 seconds at the time of a decrease of stomach temperature indicative of successful prey capture.

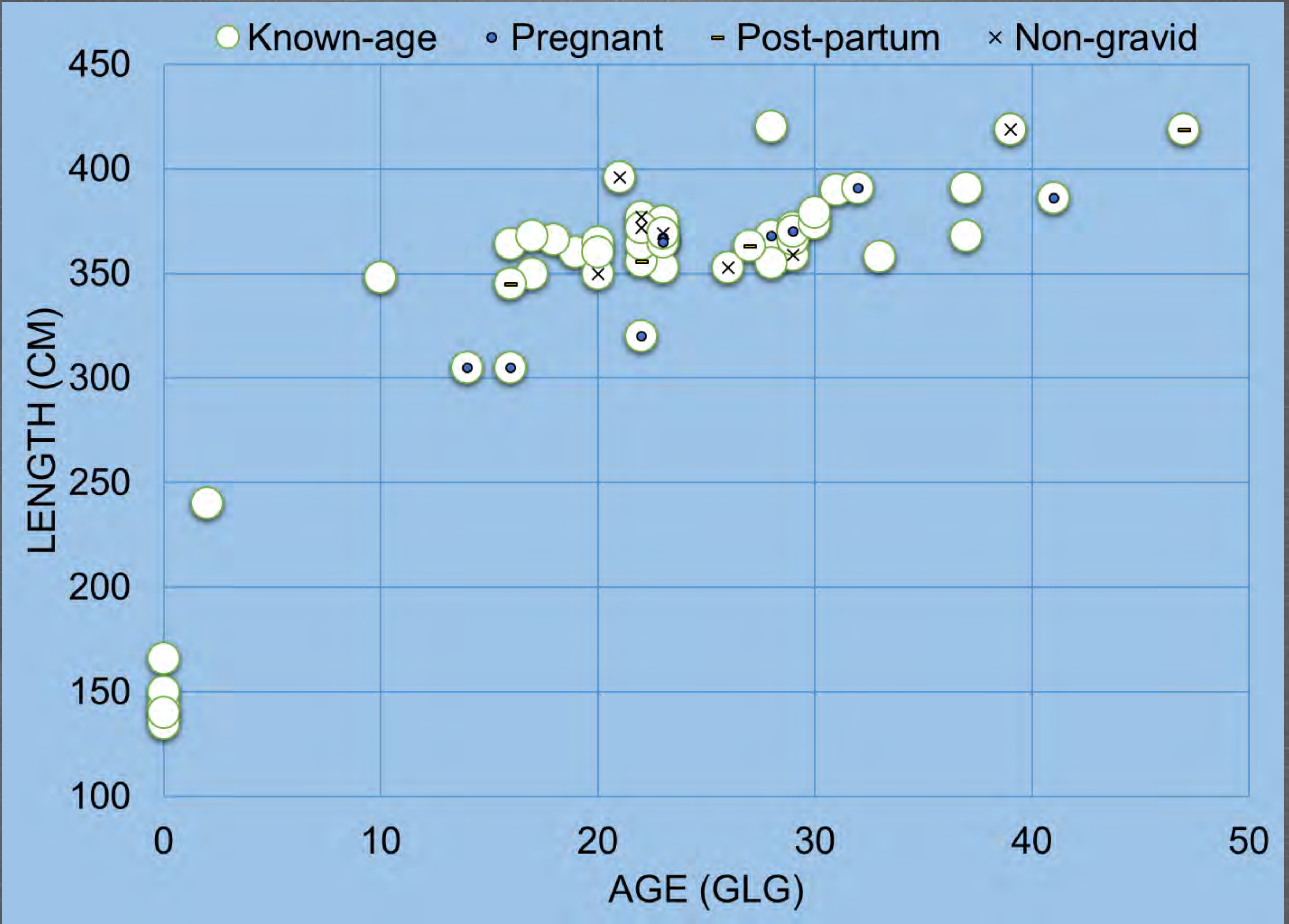
Expanded acoustic research
Deploying ~ 12 Passive Acoustic Recorders
Section 6 ADF&G and AFSC funding







Males
Females
Length (cm)
500
450
400
350
300
250
200
150
100
0
10
20
30
40
50
Age (GLG)



Known-age
Pregnant
Post-partum
Non-gravid
LENGTH (CM)
450
400
350
300
250
200
150
100
0
10
20
30
40
50
AGE (GLG)

Cook Inlet Beluga Whale Diet Using Stable Isotope Analysis

Mark A. Nelson and Lori T. Quakenbush, Alaska Department of Fish and Game, 1300 College Road, Fairbanks, AK 99701, Mark.Nelson@alaska.gov

Introduction

Determining whether changes have occurred in the diet of endangered Cook Inlet beluga whales (*Delphinapterus leucas*) is important for understanding whether diet was a factor in the population decline or is currently a factor in its recovery. Using bone from the skulls of Cook Inlet beluga whales, we determined the $\delta^{15}N$ and $\delta^{13}C$ isotope signatures for 23 belugas collected between 1965 and 2007. We also determined the isotope signatures of prey species found in stranded beluga stomachs, sport caught salmon from Cook Inlet, and from recent literature to determine possible important prey items.

Methods

Cook Inlet belugas

We sampled bone from Cook Inlet beluga skulls in the University of Alaska Fairbanks, Museum of the North collection.

Bone samples were cleaned, treated with hydrochloric acid to isolate the collagen, and then freeze dried.

The dried samples were analyzed using a mass spectrometer for carbon and nitrogen isotope values.

Prey

Samples of fish bones were taken from the stomachs of Cook Inlet belugas, and processed in the same manner as the skulls. Muscle was taken from sport caught salmon, freeze dried, and then analyzed with the mass spectrometer. King, chum, and sockeye values from the North Pacific were found in recent literature.

Results

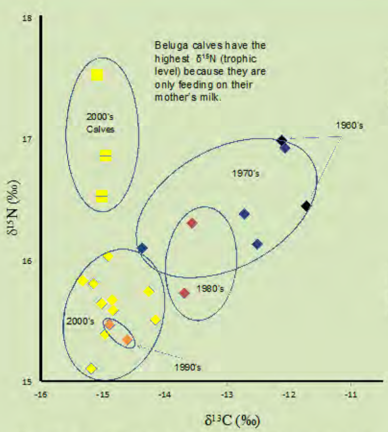


Figure 1. Scatter plot of collagen $\delta^{13}C$ and $\delta^{15}N$ stable isotope ratios for 23 Cook Inlet beluga collected between 1964 and 2007.

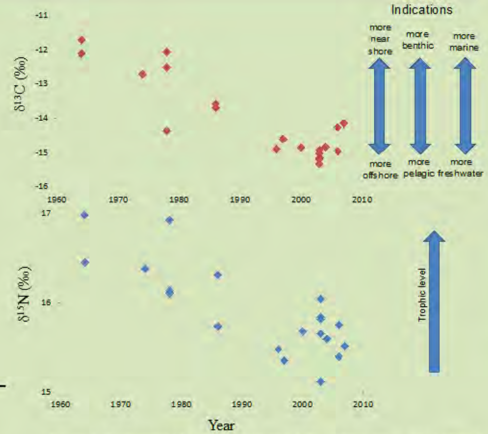


Figure 2. Scatter plot of collagen $\delta^{13}C$ and $\delta^{15}N$ stable isotope ratios plotted against the year they died. Only data from adults are shown in this figure.

The results of 19 adult Cook Inlet beluga skulls show a decrease in $\delta^{13}C$ and $\delta^{15}N$ from the 1960's to present.

Results

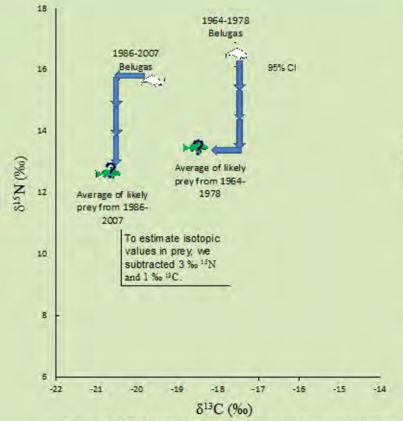


Figure 3. Adult beluga isotope values and extrapolated prey values for two time periods, 1964-1978 and 1986-2007.

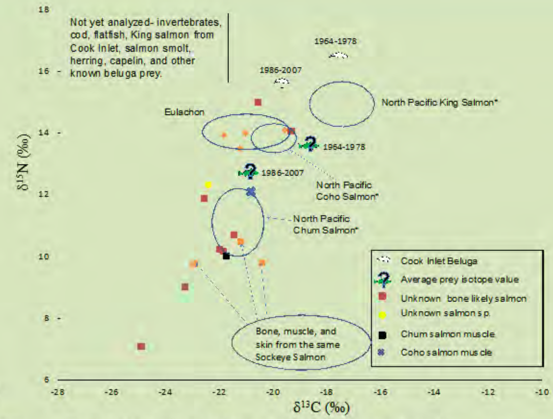


Figure 4. Values of adult belugas, extrapolated prey, and potential prey items in Cook Inlet. * Values for North Pacific salmon from *F.R. Satterfield IV and B.P. Finney. Progress in Oceanography 53 (2002) 231–246*

We determined the isotope signature of potential beluga prey in Fig. 3., then compared that to prey items we found in the stomachs of stranded beluga whales, sport caught salmon from cook inlet, and North Pacific salmon values in recent literature (Fig. 4). Fig. 4 is missing many potential prey items.

Conclusion, Discussion, and Next Step

Has Cook Inlet Beluga Whale Diet changed?

Yes. Based on our sample of 19 skulls, Cook Inlet beluga whales have a different isotope signature in recent years (1986–2007; n=13) then they did in the past (1964–1978; n=6).

What does the change in $\delta^{15}N$ mean?

The change in $\delta^{15}N$ indicates that belugas are feeding lower on the food chain now then in the past. Further studies are needed to determine how their diet has changed.

What does the change in $\delta^{13}C$ mean?

The change in $\delta^{13}C$ indicates a change in the food source. This could be caused by:
1) A switch from prey that feed near shore to prey that feed offshore
2) A switch from eating marine species to eating freshwater species
3) A switch from eating benthic species to eating pelagic species.

Again, further study is necessary to understand how the diet has changed.

What is next?

Next we will analyze more potential prey items from Cook Inlet, then apply prey mixing models to determine what proportion of each potential prey item makes up the diet now and in the past.

Acknowledgments: This project is funded by NOAA Fisheries, Alaska Region. We would like to thank Dr. Link Olson and Brandy Jacobsen at the University of Alaska Museum of the North for providing access to beluga skulls in their collection (UAM #s 86886, 11642, 11643, 16008, 16009, 16014, 16013, 16010, 16006, 91731, 91771, 87332, 48680, 97401, 91769, 94549, 92570, 83805, 87979, 92569, 48678, 91772, 91770, 91732). We would also like to thank Dr. Matthew Wooller, Timothy Howe, and Norma Haubenstock from the Alaska Stable Isotope Facility at the Water and Environmental Research Center, University of Alaska for assistance in processing, analyzing and interpreting the samples. Beluga samples used in this research were collected and archived under various NOAA permits maintained by NMFS, Alaska Region and the University of Alaska Museum of the North from 1973 to present.

2017 CI Beluga Hexacopter Photogrammetry Survey

P. Wade, NMML/AFSC/NMFS/NOAA
NMFS ESA/MMPA Permit #20465


NMFS ESA/MMPA Permit #20465

Biopsy sampling survey

- Funded by AK Region

- 2016 Feasibility study
  - Dr. Tamara McGuire CI Beluga Photo ID
  - Robert Michaud and Michel Moissan (GREMM)
  - 6 samples

- 2017 project (led by MML)
  - Aug 31 – Sept 10
  - Dr. Tamara McGuire CI Beluga Photo ID
  - Robert Michaud and Michel Moissan (GREMM)
  - 12 samples

Biopsy sampling survey

- Hormone analysis for pregnancy and sexual maturity (SWFSC)
- Stable isotopes for prey preferences (NWFSC)
- Contaminants (NWFSC)
  - Emerging pollutants, especially endocrine disruptors
- Skin microbiome analysis (WHOI)
  - Research on baleen whales has shown changes in microbes on skin between healthy and compromised whales
- Genotyping for genetic identification of individuals (AFSC)
  - Development of SNPs
- Epigenetic aging
  - Scott Baker (Hatfield/OSU) and I (NPRB grant)
- Beluga genome project (NIST/contracted)
- Immune response/stress via gene expression?
  - AFSC, Mystic Aquarium

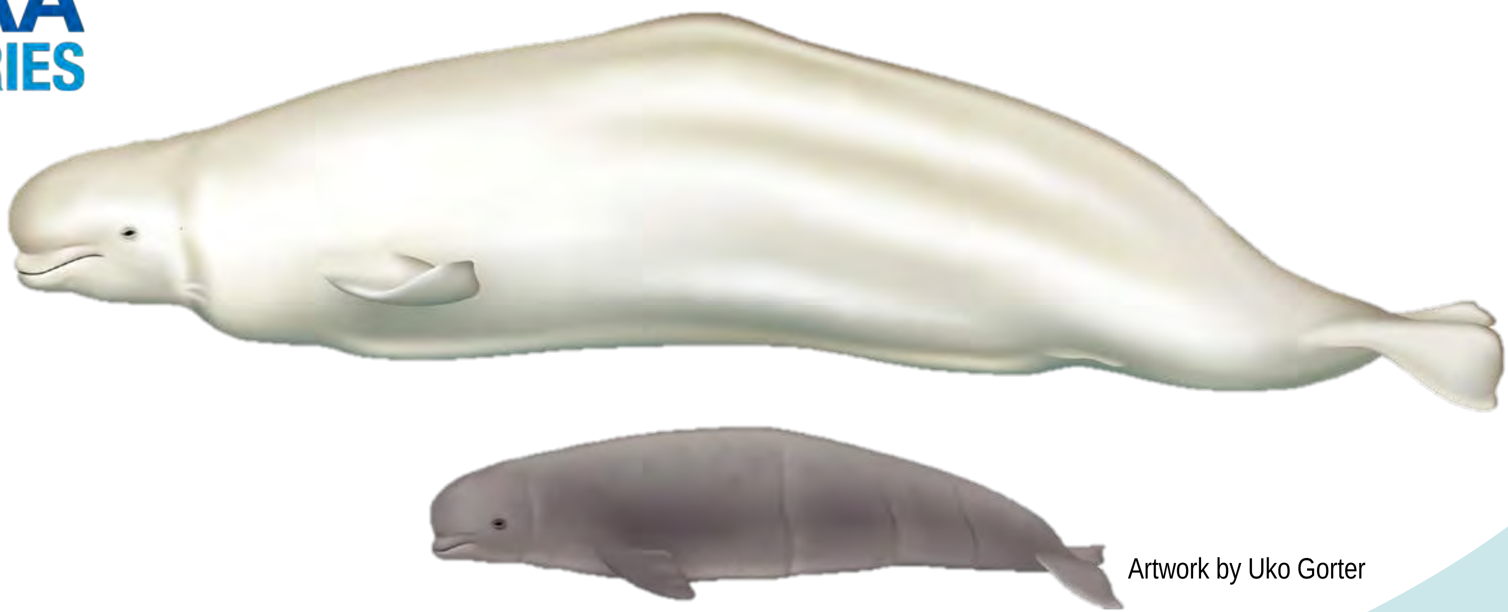

NMFS ESA/MMPA Permit #20465

Presentation 2

Satellite-Tagging and Health Assessments in Cook Inlet, Alaska, 1999 to 2002

Kim Shelden, NMFS Alaska Fisheries Science Center, Marine Mammal Lab

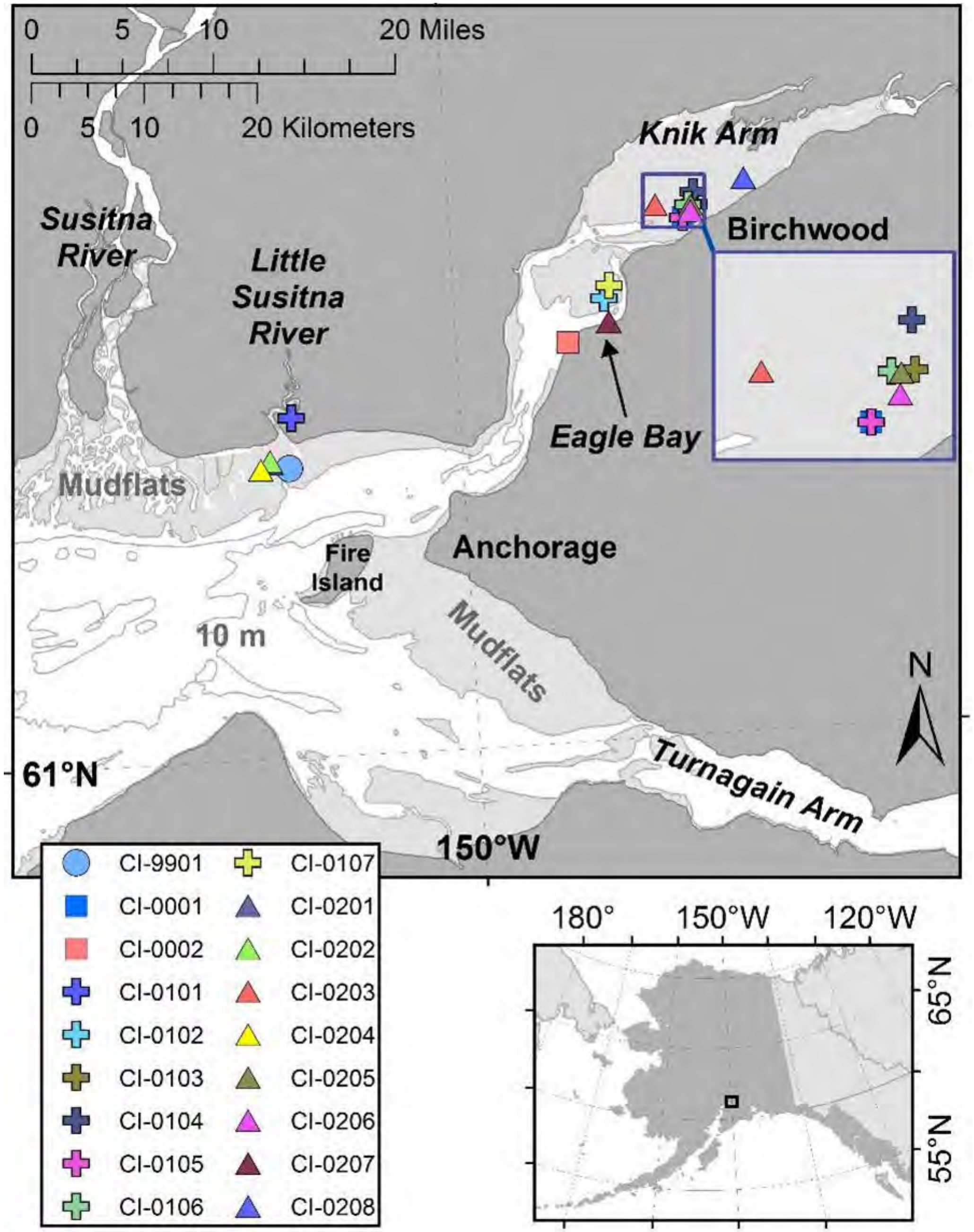
Satellite-Tagging and Health Assessments Cook Inlet, Alaska, 1999 to 2002

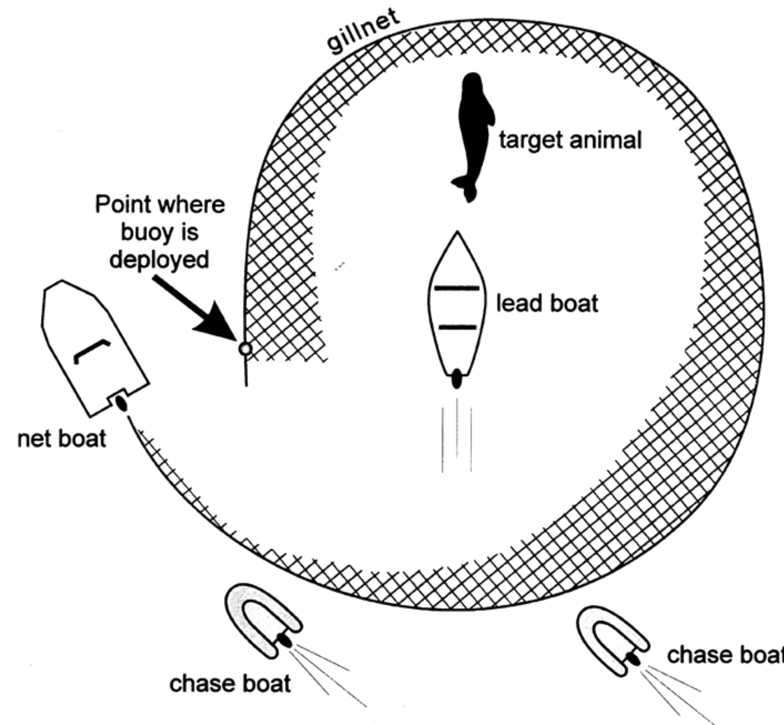


Artwork by Uko Gorter

Kim Shelden, presenter
AFSC, Marine Mammal Laboratory

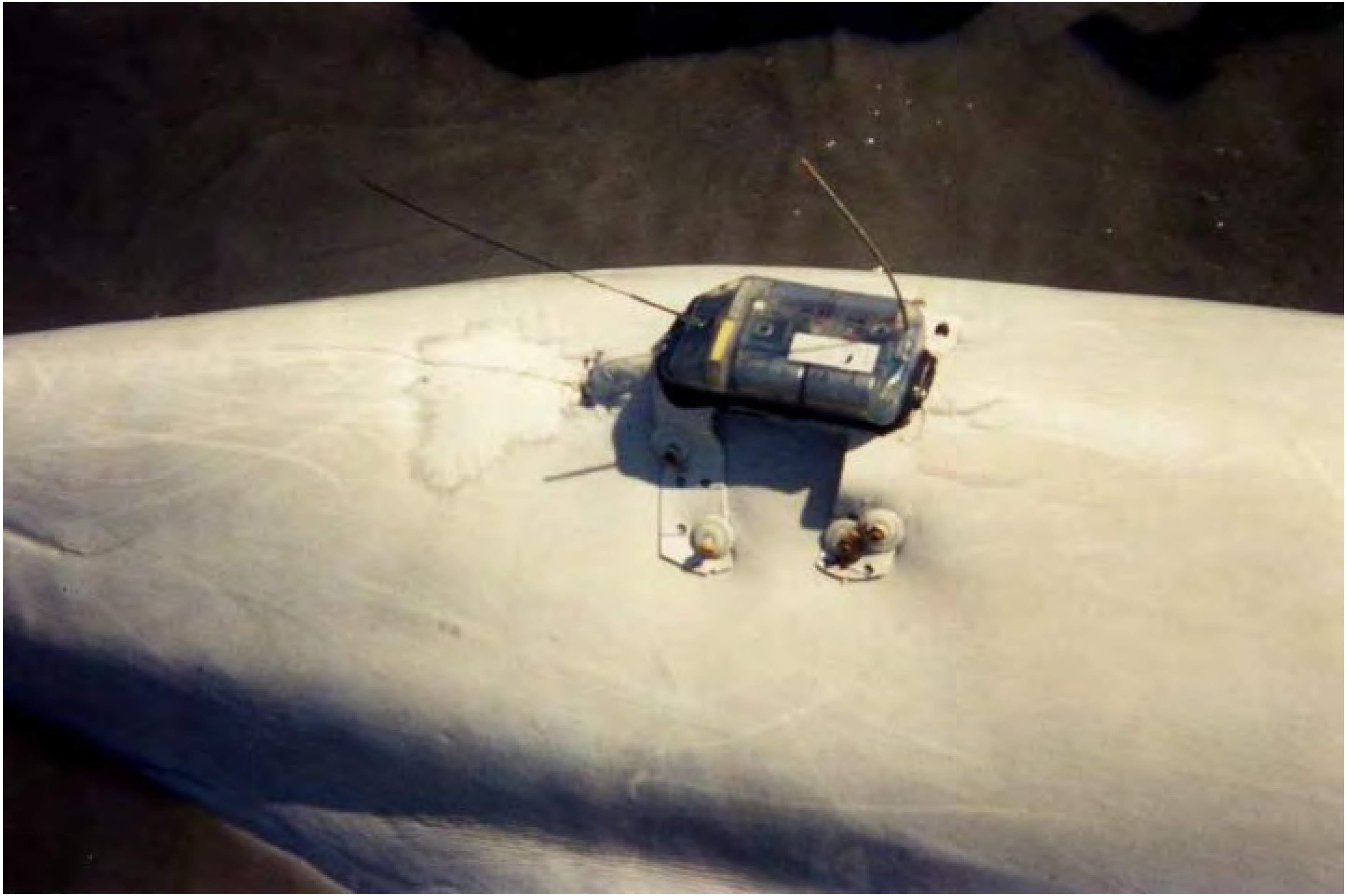
Invasive Techniques Workshop
Capt. Cook Hotel, Anchorage, Alaska
November 29-30, 2017

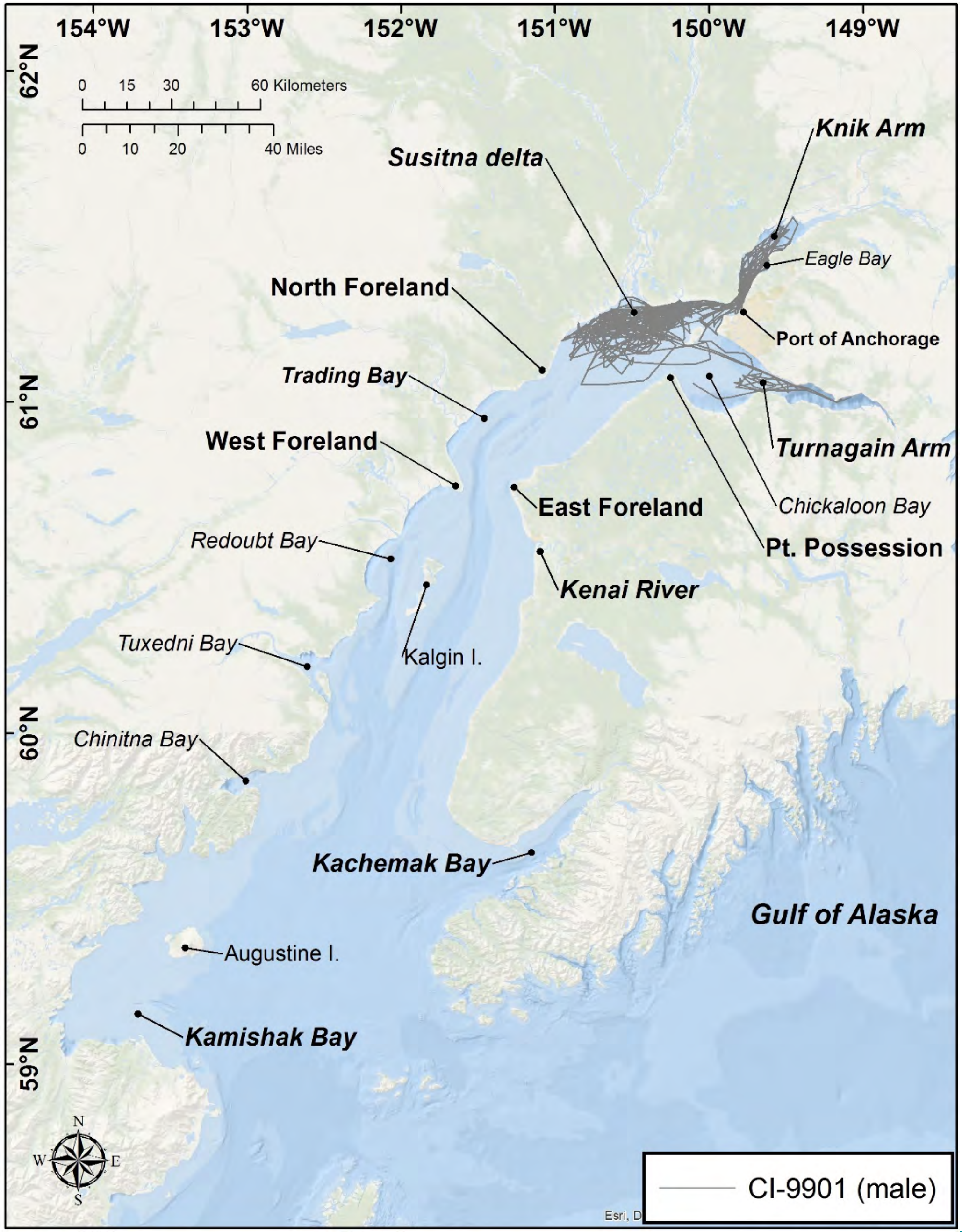




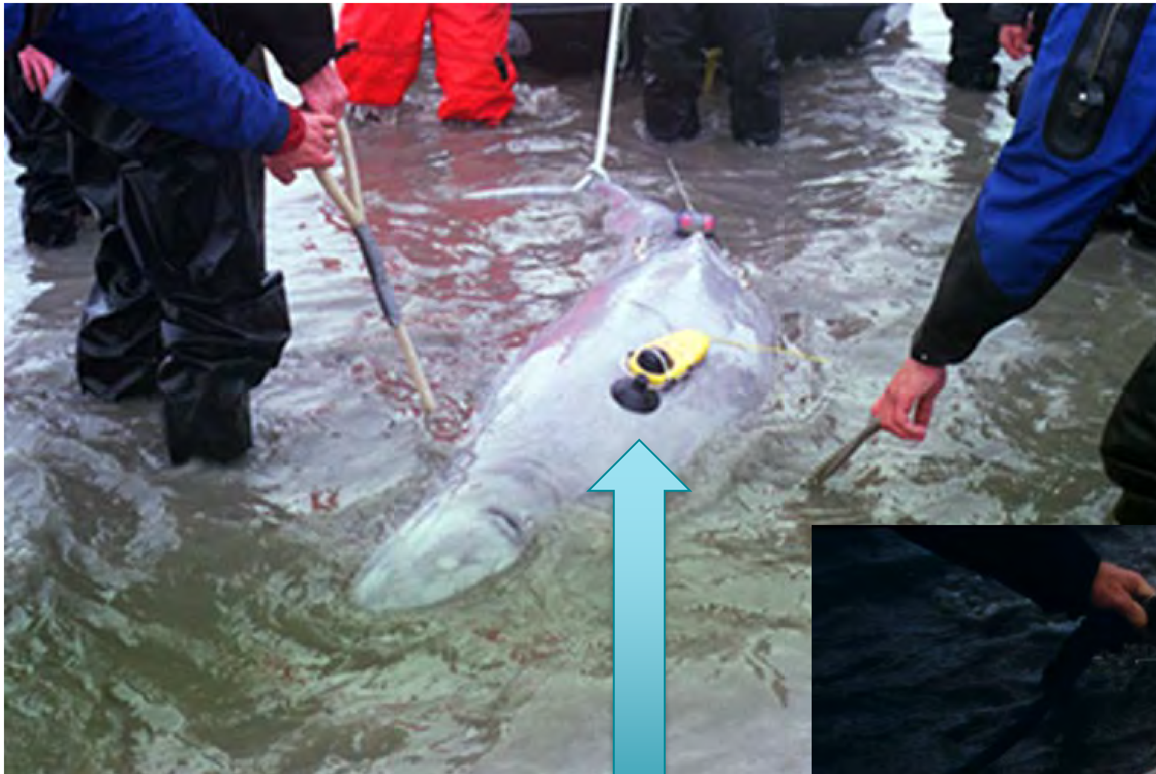
Ferrero et al. 2000. Mar. Fish. Rev. 62(3)

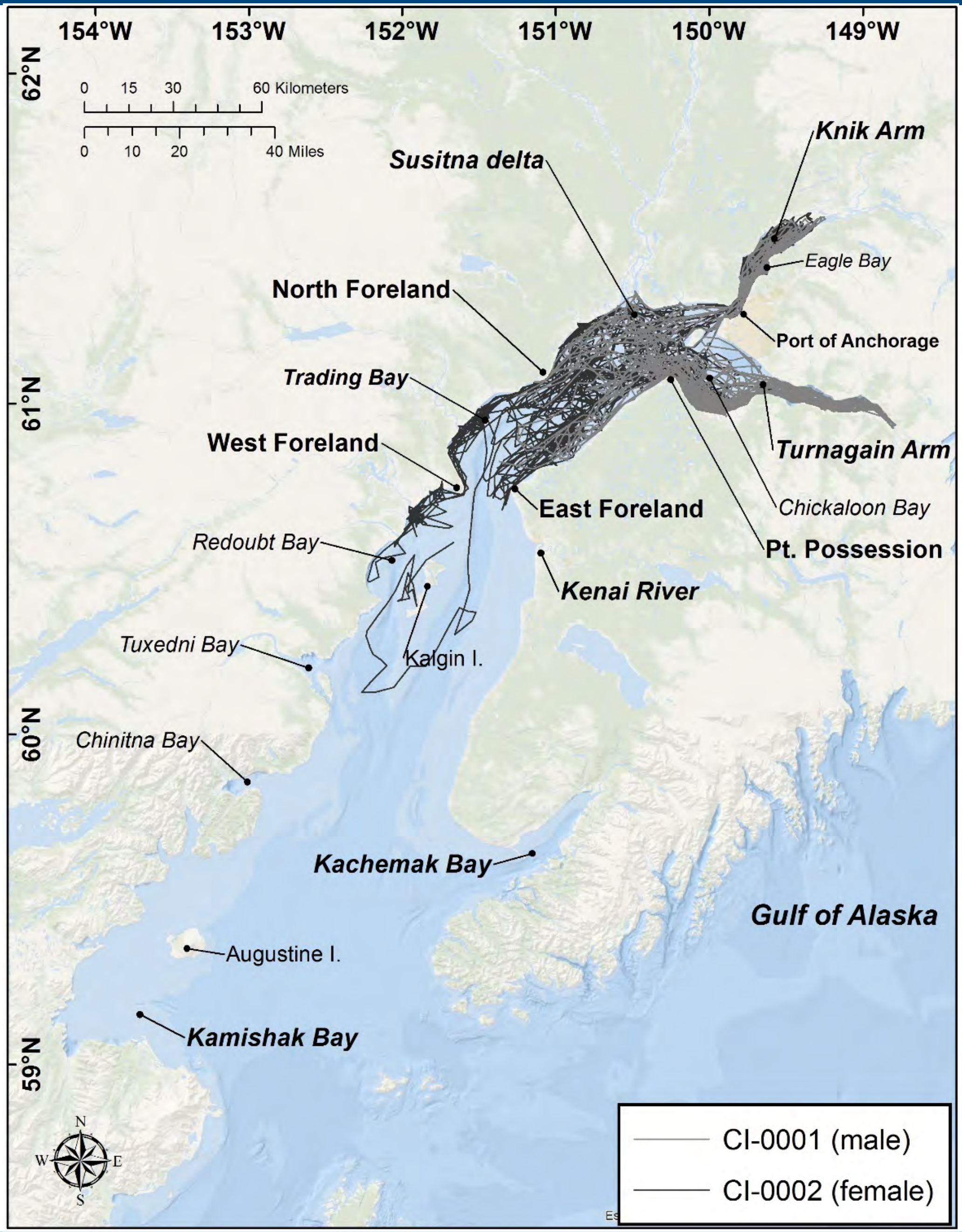
1999



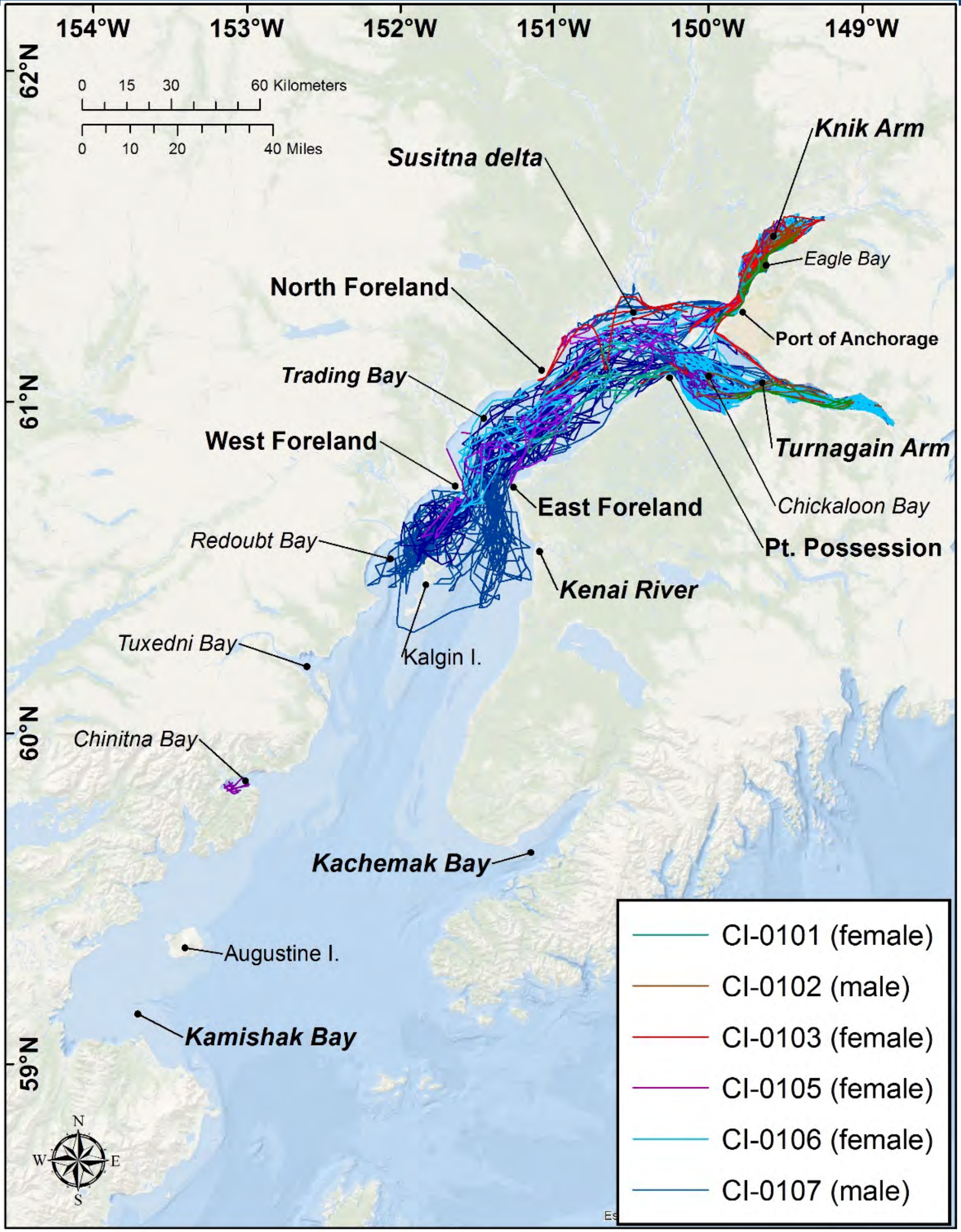

154°W
153°W
152°W
151°W
150°W
149°W
62°N
61°N
60°N
59°N
0 15 30 60 Kilometers
0 10 20 40 Miles
Knik Arm
Susitna delta
Eagle Bay
North Foreland
Port of Anchorage
Trading Bay
West Foreland
East Foreland
Turnagain Arm
Chickaloon Bay
Redoubt Bay
Pt. Possession
Kenai River
Tuxedni Bay
Kalgin I.
Chinitna Bay
Kachemak Bay
Gulf of Alaska
Augustine I.
Kamishak Bay
N
W
E
S
CI-9901 (male)

2000

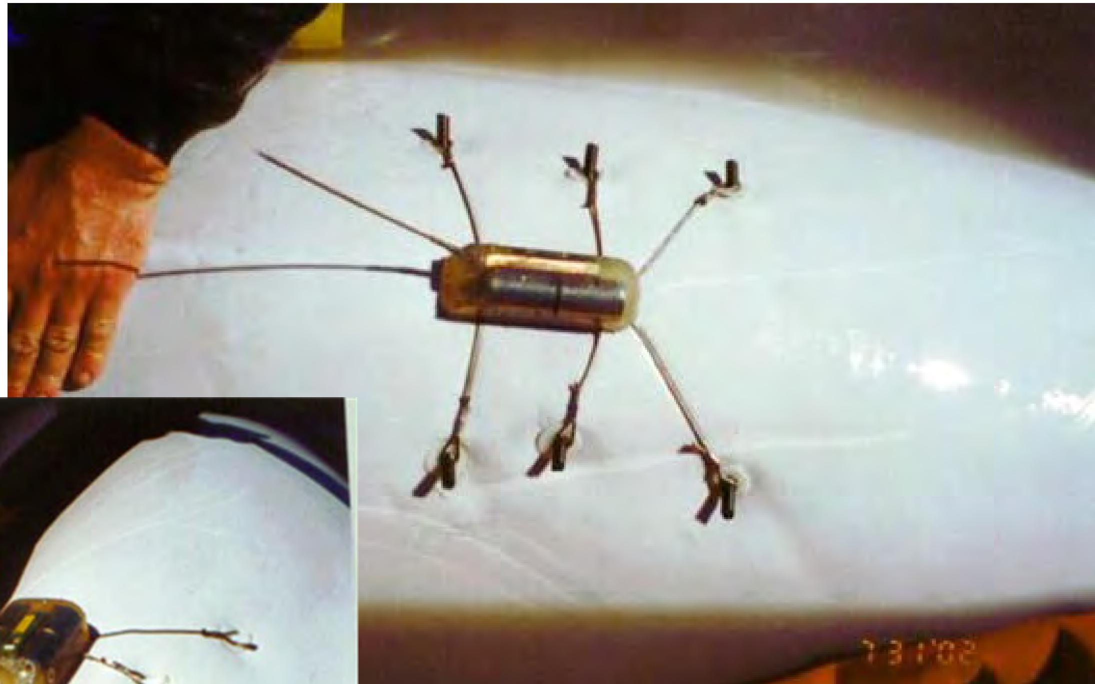


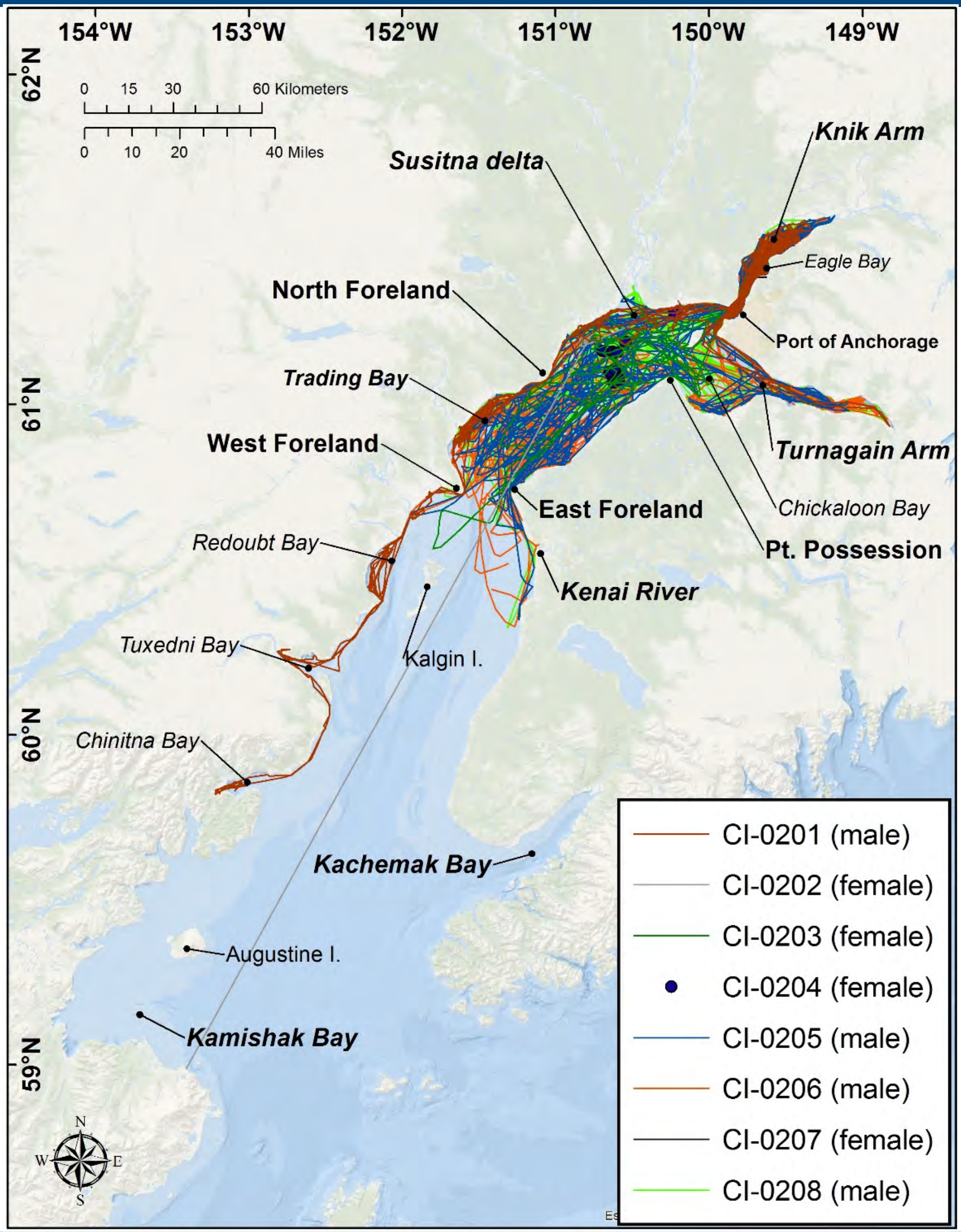

154°W
153°W
152°W
151°W
150°W
149°W
62°N
61°N
60°N
59°N
0 15 30 60 Kilometers
0 10 20 40 Miles
Knik Arm
Susitna delta
Eagle Bay
North Foreland
Port of Anchorage
Trading Bay
West Foreland
Turnagain Arm
East Foreland
Chickaloon Bay
Redoubt Bay
Pt. Possession
Kenai River
Tuxedni Bay
Kalgin I.
Chinitna Bay
Kachemak Bay
Gulf of Alaska
Augustine I.
Kamishak Bay
CI-0001 (male)
CI-0002 (female)

2001


154°W
153°W
152°W
151°W
150°W
149°W
62°N
61°N
60°N
59°N
0 15 30 60 Kilometers
0 10 20 40 Miles
Knik Arm
Susitna delta
Eagle Bay
North Foreland
Port of Anchorage
Trading Bay
West Foreland
Turnagain Arm
East Foreland
Chickaloon Bay
Redoubt Bay
Pt. Possession
Kenai River
Tuxedni Bay
Kalgin I.
Chinitna Bay
Kachemak Bay
Augustine I.
Kamishak Bay
N
W
E
S
CI-0101 (female)
CI-0102 (male)
CI-0103 (female)
CI-0105 (female)
CI-0106 (female)
CI-0107 (male)

2002

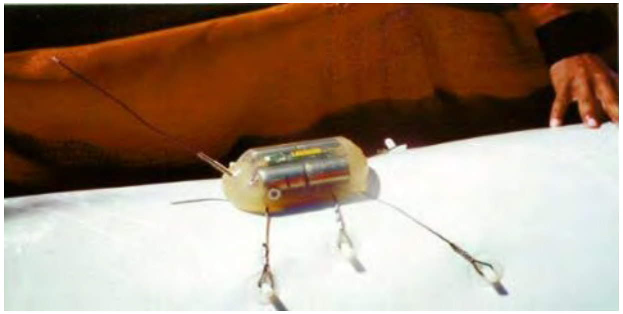


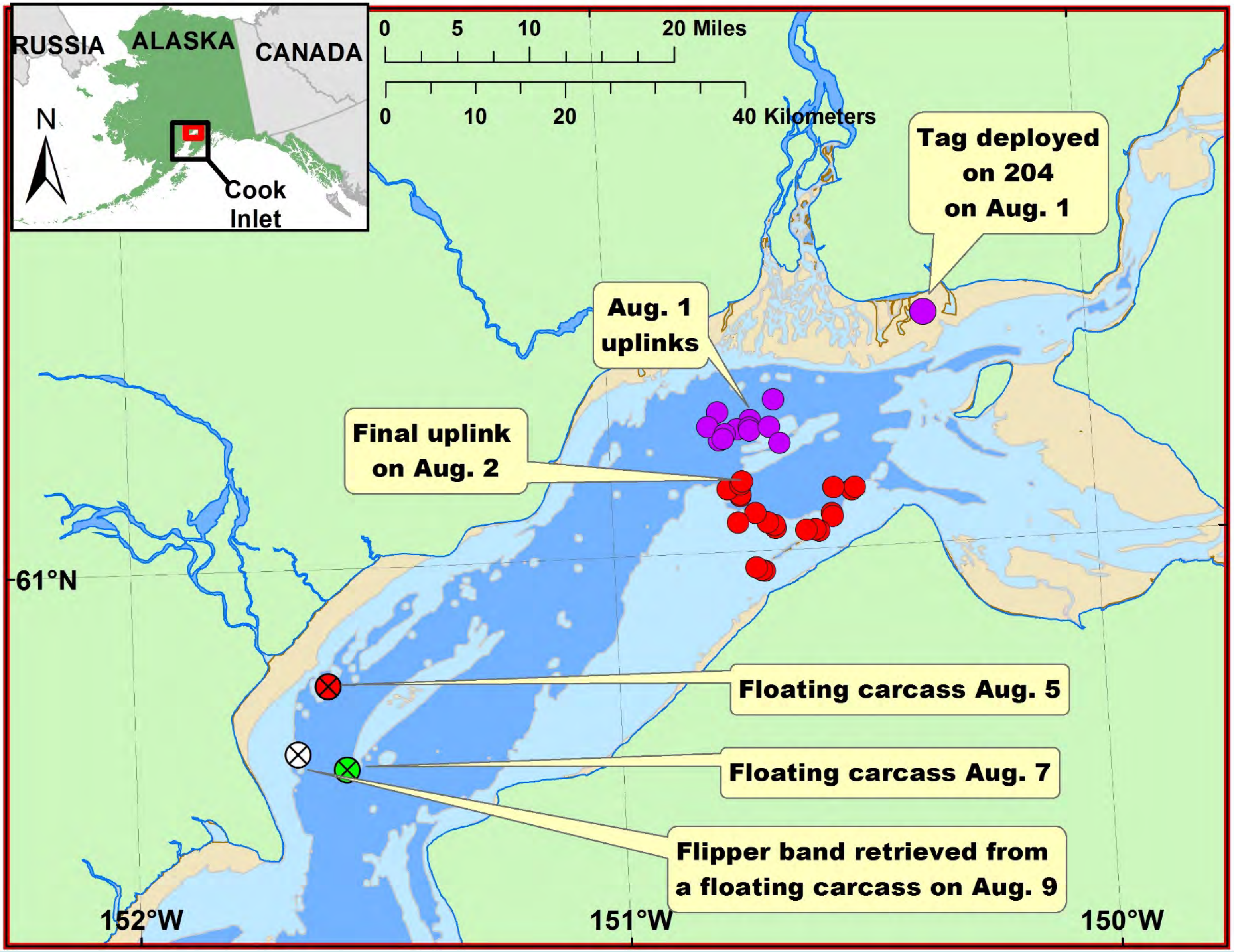

154°W
153°W
152°W
151°W
150°W
149°W
62°N
61°N
60°N
59°N
0 15 30 60 Kilometers
0 10 20 40 Miles
Knik Arm
Susitna delta
Eagle Bay
North Foreland
Port of Anchorage
Trading Bay
West Foreland
Turnagain Arm
East Foreland
Chickaloon Bay
Redoubt Bay
Pt. Possession
Kenai River
Tuxedni Bay
Kalgin I.
Chinitna Bay
Kachemak Bay
Augustine I.
Kamishak Bay
N
S
E
W
CI-0201 (male)
CI-0202 (female)
CI-0203 (female)
CI-0204 (female)
CI-0205 (male)
CI-0206 (male)
CI-0207 (female)
CI-0208 (male)

Successes and Failures

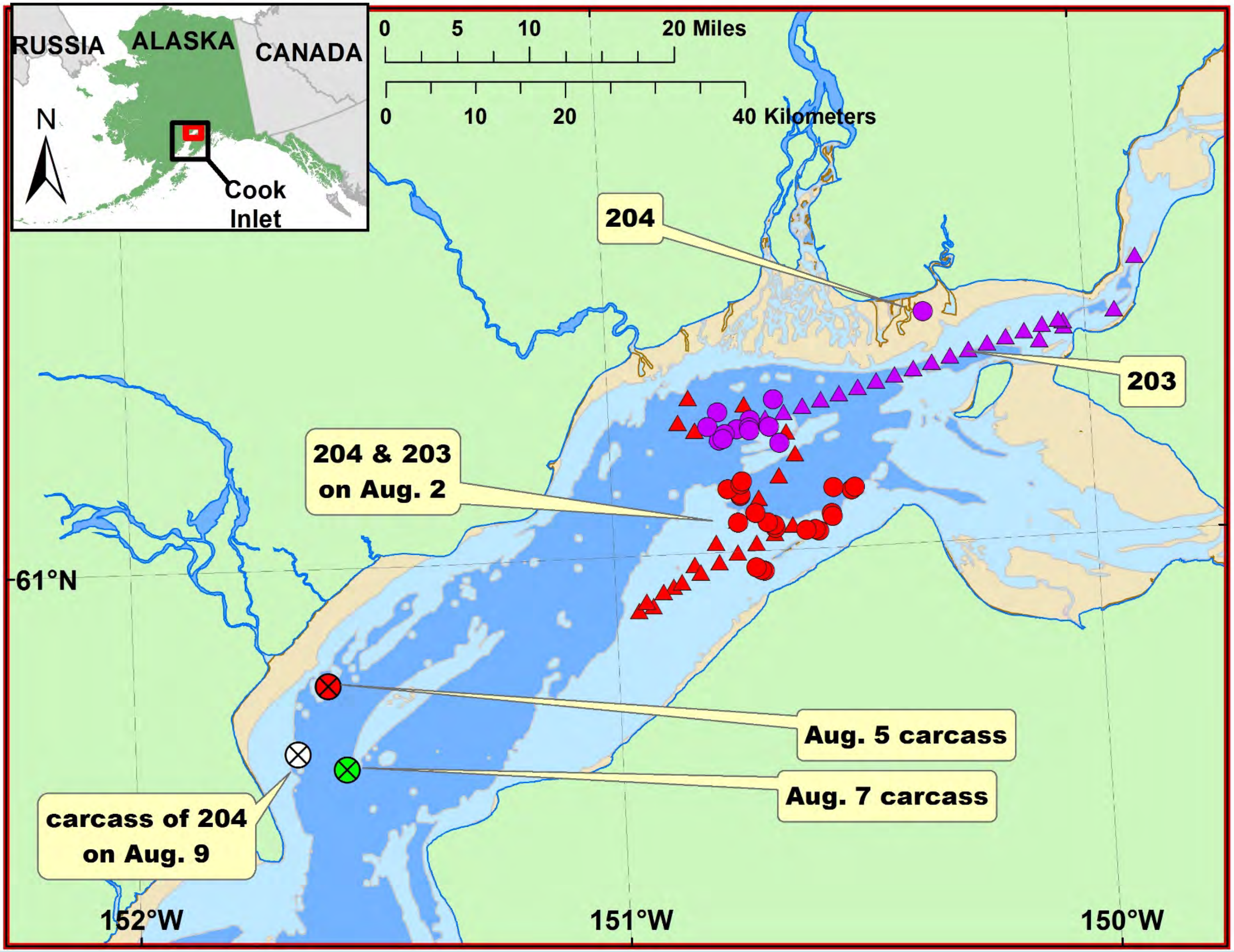
- 13 whales with tags that transmitted over 3 months
  (94 – 293 days, average 149 d)
- 2 whales with tag(s) that did not transmit
  (102* & 104)
- 3 whales with <2 d of normal diving behavior
  (202, 204, & 207)

CI-0204

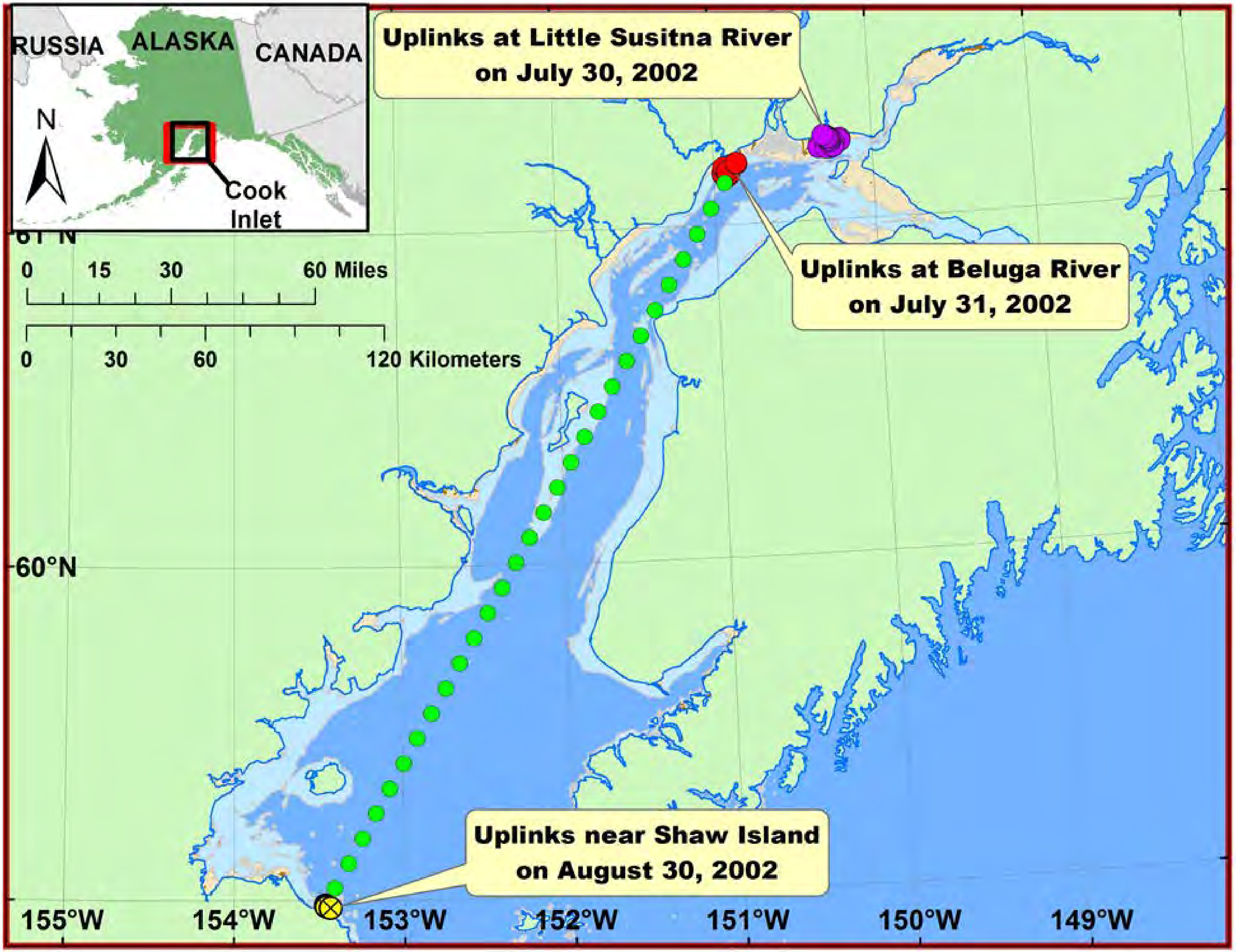


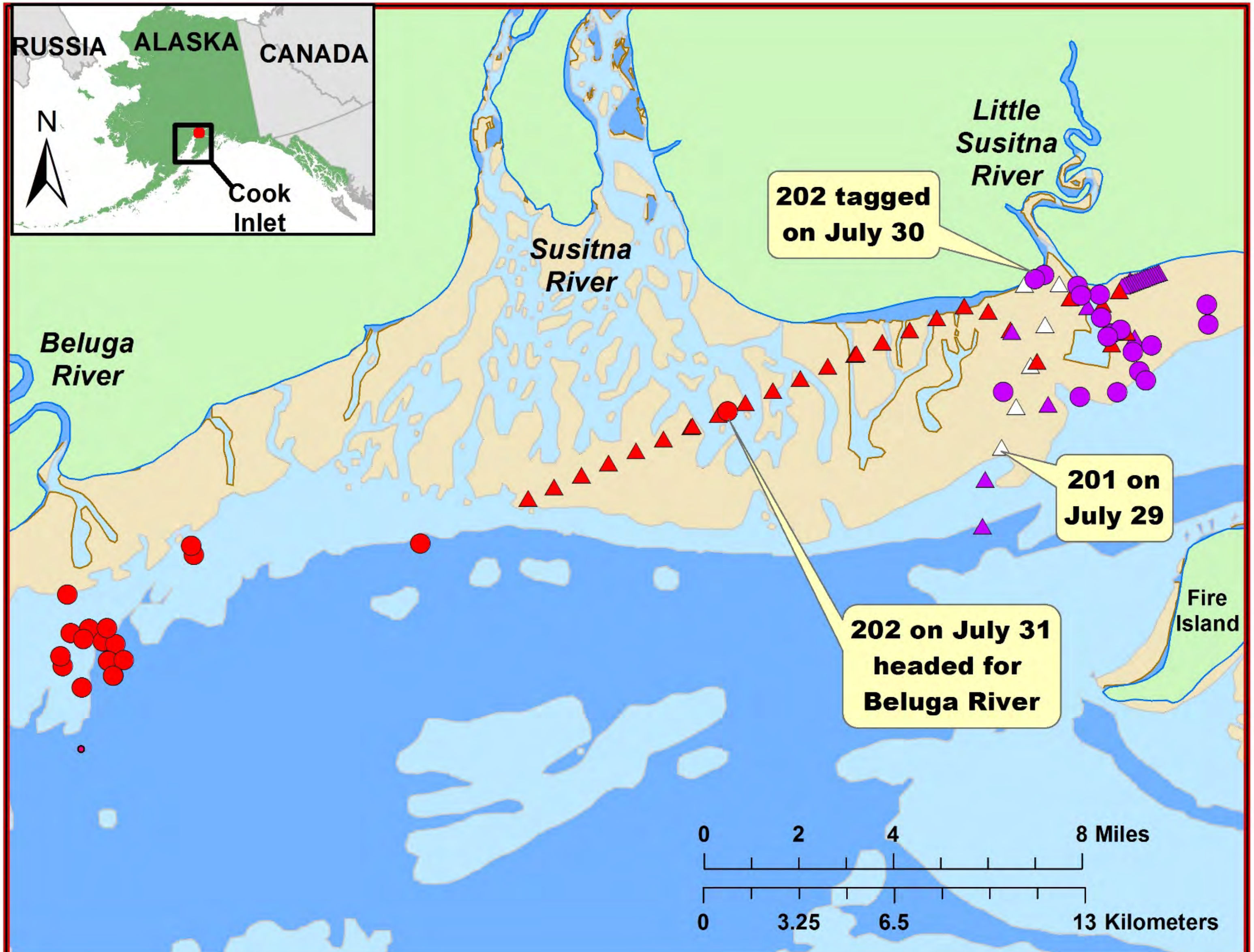


RUSSIA
ALASKA
CANADA
N
Cook Inlet
0 5 10 20 Miles
0 10 20 40 Kilometers
Tag deployed on 204 on Aug. 1
Aug. 1 uplinks
Final uplink on Aug. 2
61°N
Floating carcass Aug. 5
Floating carcass Aug. 7
Flipper band retrieved from a floating carcass on Aug. 9
152°W
151°W
150°W

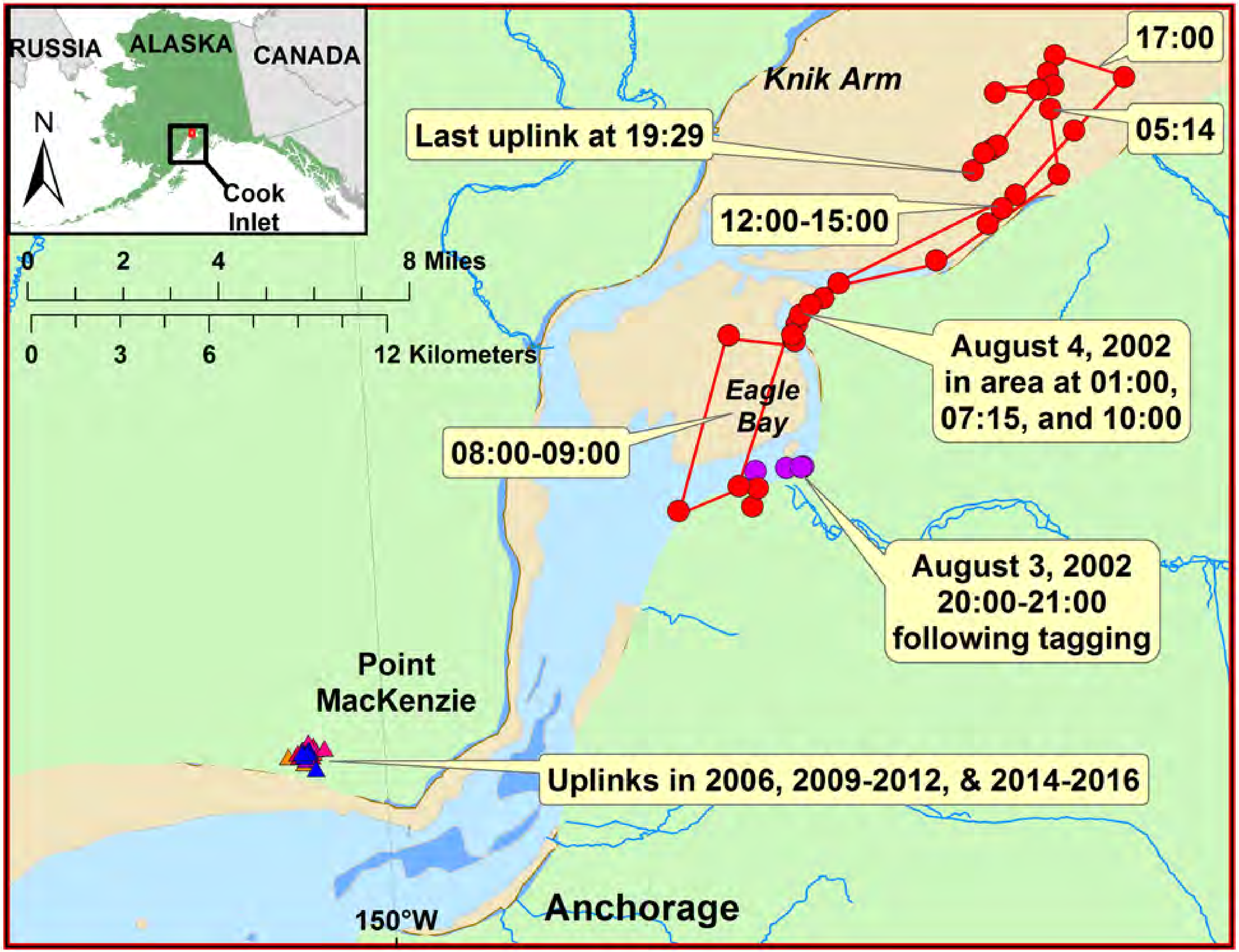

RUSSIA
ALASKA
CANADA
N
Cook
Inlet
0
5
10
20 Miles
0
10
20
40 Kilometers
204
203
204 & 203
on Aug. 2
61°N
Aug. 5 carcass
Aug. 7 carcass
carcass of 204
on Aug. 9
152°W
151°W
150°W

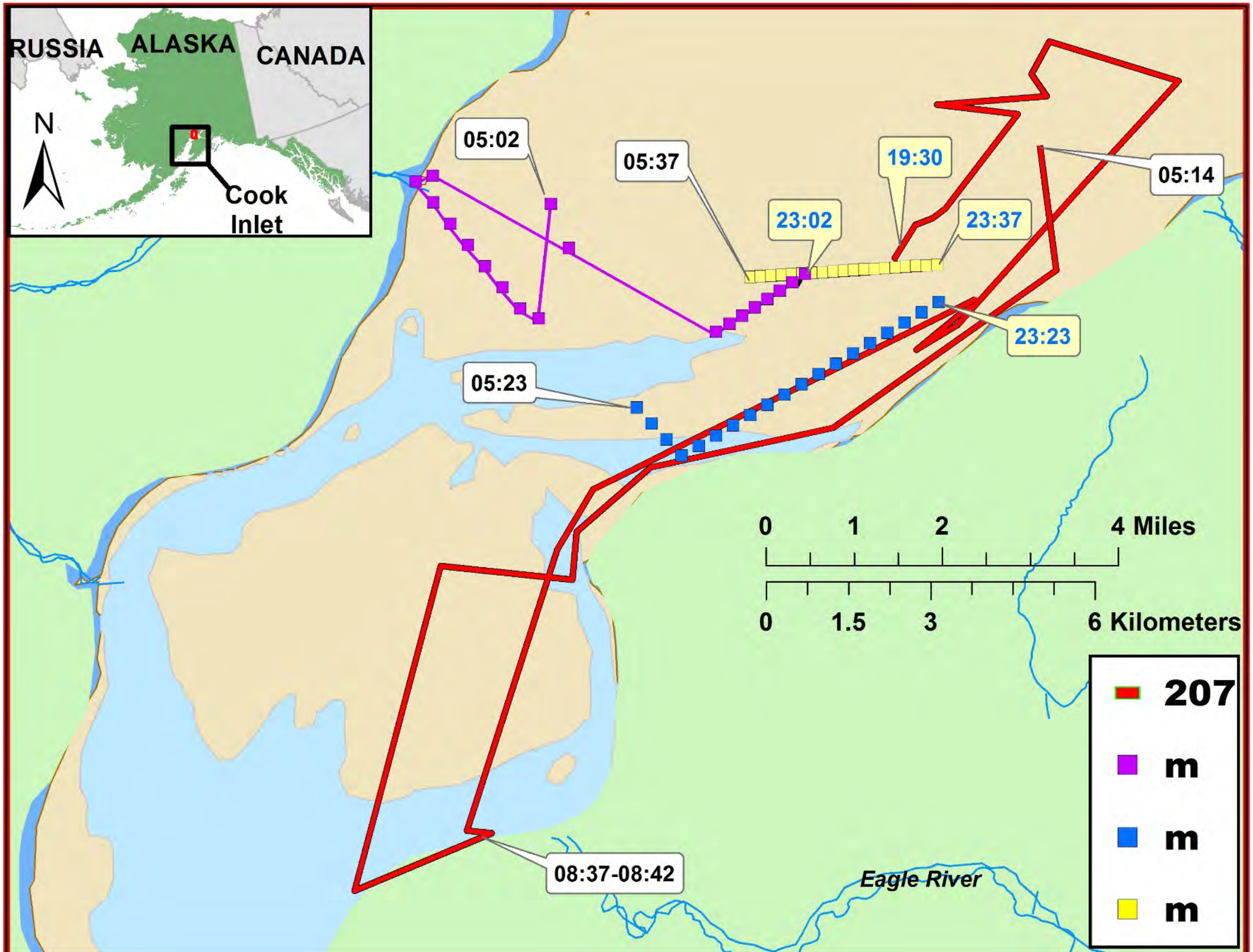
CI-0202


RUSSIA
ALASKA
CANADA
N
Cook Inlet
Uplinks at Little Susitna River on July 30, 2002
Uplinks at Beluga River on July 31, 2002
Uplinks near Shaw Island on August 30, 2002
0 15 30 60 Miles
0 30 60 120 Kilometers
60°N
155°W
154°W
153°W
152°W
151°W
150°W
149°W


RUSSIA
ALASKA
CANADA
N
Cook
Inlet
Susitna
River
Little
Susitna
River
202 tagged
on July 30
Beluga
River
201 on
July 29
202 on July 31
headed for
Beluga River
Fire
Island
0 2 4 8 Miles
0 3.25 6.5 13 Kilometers

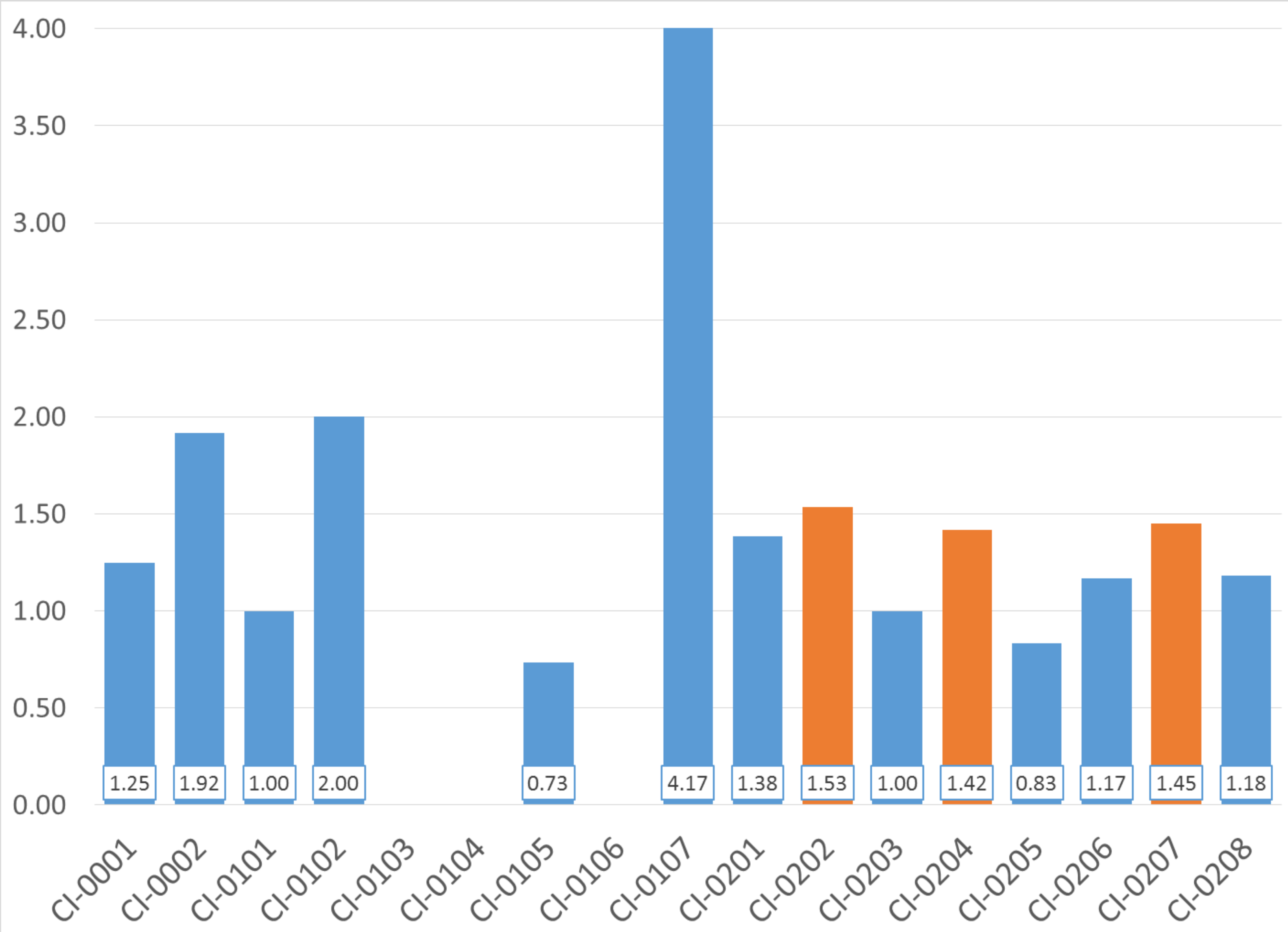
CI-0207

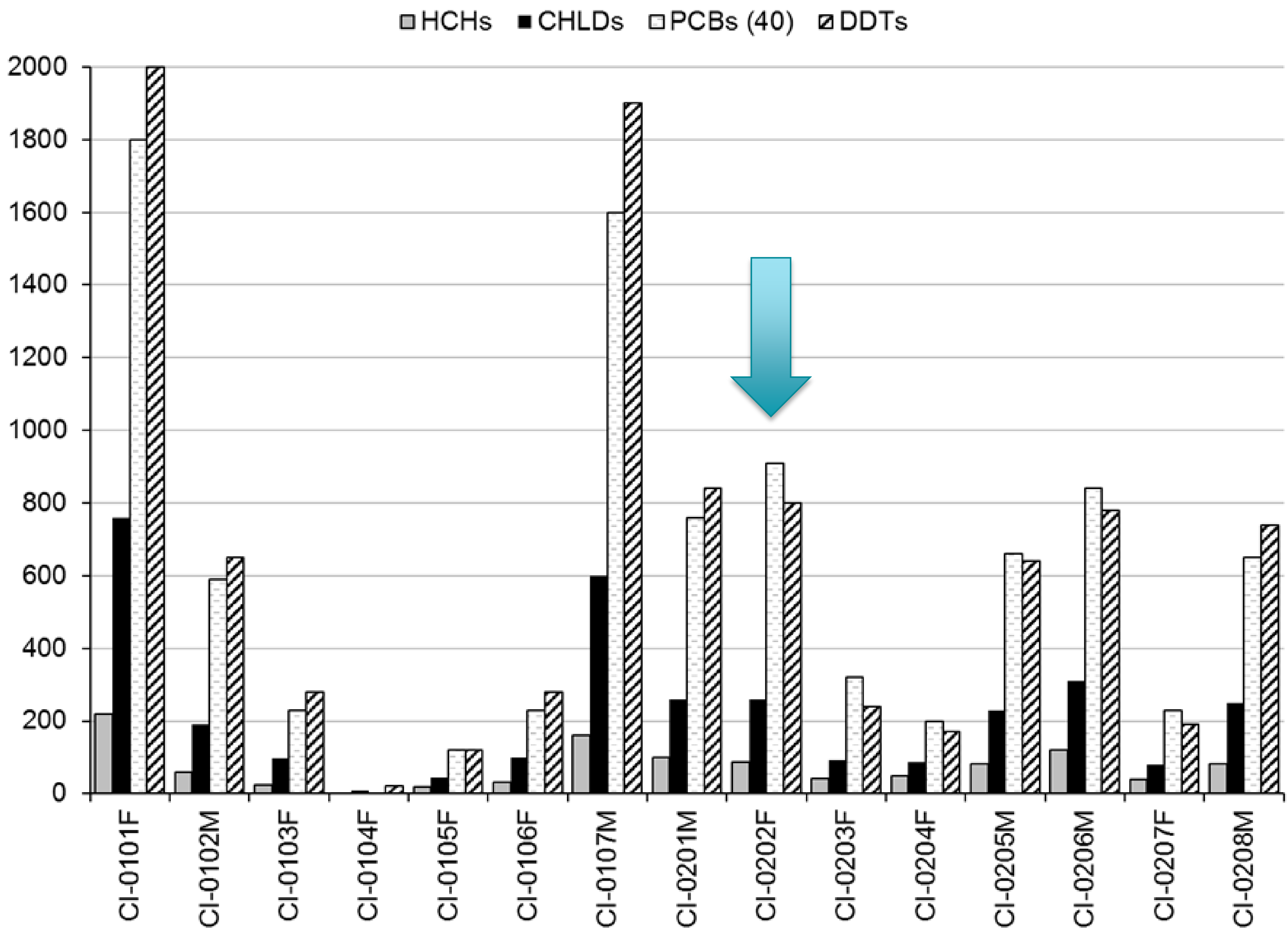

RUSSIA
ALASKA
CANADA
N
Cook Inlet
0
2
4
8 Miles
0
3
6
12 Kilometers
Knik Arm
17:00
05:14
Last uplink at 19:29
12:00-15:00
August 4, 2002 in area at 01:00, 07:15, and 10:00
Eagle Bay
08:00-09:00
August 3, 2002 20:00-21:00 following tagging
Point MacKenzie
Uplinks in 2006, 2009-2012, & 2014-2016
150°W
Anchorage



RUSSIA
ALASKA
CANADA
N
Cook Inlet
05:02
05:37
19:30
23:02
23:37
05:14
23:23
05:23
08:37-08:42
Eagle River
0
1
2
4 Miles
0
1.5
3
6 Kilometers
207
m
m
m

Capture to Release Time




HCHs
CHLDs
PCBs (40)
DDTs
2000
1800
1600
1400
1200
1000
800
600
400
200
0
CI-0101F
CI-0102M
CI-0103F
CI-0104F
CI-0105F
CI-0106F
CI-0107M
CI-0201M
CI-0202F
CI-0203F
CI-0204F
CI-0205M
CI-0206M
CI-0207F
CI-0208M

Acknowledgements

Native Village of Tyonek

NOAA

JBER
Joint Base Elmendorf-Richardson

A. V. P. S.

UNIVERSITY of ALASKA
Many Traditions One Alaska

FAU
FLORIDA ATLANTIC UNIVERSITY

SeaWorld

Background Info. & Tag Animations

- Show if time/interest.

Field ID	Flipper band	Sex	Tag type	Attachment type	Capture, tagging, release time	Total hours	Duration days (analysis days)	Reason for tag failure
RCF-399		F	none					
RCF 400	Both	M	ST16	4-pin strap			109 (103)	Battery
CI-DL-01-00		F	none					
CI-DL-03-00		M	ST16	3-pin cable	17:45, 18:10, 19:00	1.3	115 (112)	Battery
CI-DL-02-00		F	ST16	3-pin cable	12:20, 13:30, 14:15	1.9	127 (126)	Battery
CI-01-01		F	SPOT2	3-pin cable	13:30, 14:30	1.0	122 (6)	Battery (3-day w/ temp)
CI-01-02		M	ST16/	3-pin cable	15:45, 17:45	2.0	0	Never transmitted
			SPOT2	2-pin cable			107 (6)	? (6-day w/ temp),
CI-01-03		F	ST16/	2-pin strap	13:35, ?		130 (22)	Unknown – no status updates
			SPOT2	2-pin cable				Did not transmit until ST16 failed (3-day). Temp collection failed.
CI-01-04		F	ST16/	2-pin strap	12:15, ?		0	Never transmitted though tested
			SPOT2	2-pin cable			0	Never transmitted though tested (6-day w/ temp)
CI-01-05		F	SPOT2	2-pin cable	14:52, 15:36	0.7	141 (15)	Battery (6-day no temp)
CI-01-06		F	ST16/	3-pin cable	?, ?		105 (95)	Unknown – battery power appears adequate
			SPOT2	2-pin cable			105 (-)	Battery (6-day no temp)
CI-01-07		M	ST16/	3-pin cable	12:50, 18:00	4.2	201 (200)	Battery
			SPOT2	2-pin cable	(caught on tide)		107 (-)	No status updates (6-day no temp)
CI2002-01	Right	M	ST16L	3-pin cable	10:00, 10:30, 11:23	1.4	94 (92)	? – battery power appears adequate
CI2002-02	Left	F	ST16L	3-pin cable	09:48*, 10:55, 11:50	1.5	<2	Lower inlet location (possible whale died)
CI2002-03	Left	F	ST16S	3-pin cable	13:35, 13:50, 14:35	1.0	24 (23)	Status updates show erratic voltage readings.
CI2002-04	Right	F	ST16L	3-pin cable	11:35, 12:05, 12:50	1.4	<2	Whale died
CI2002-05	Left	M	ST16S	3-pin cable	13:10, 13:30, 14:00	0.8	241 (216)	Battery
CI2002-06	Right	M	ST16S	3-pin cable	13:40, 14:15, 14:50	1.2	231 (201)	Battery
CI2002-07	Right	F	ST16L	3-pin cable	18:49, 19:40, 20:15	1.5	<2*	Still transmitting (possible whale died)
CI2002-08	Left	M	ST16S	3-pin cable	15:15, 15:40, 16:26	1.2	293 (265)	Battery

1999 animation

2000 animation

2001 animation

2002 animation

Presentation 3

The Cook Inlet Beluga Whale Photo ID Project

Tamara McGuire, Ph.D., LGL Alaska Research Associates

Purpose: Summarize information from the Cook Inlet Beluga Whale (CIBW) Photo-ID Project about wound healing from the following research activities on CIBW:

1. satellite- tagging 1999-2002
2. remote biopsy 2016,2017

The Cook Inlet Beluga Whale Photo-Id Project

SEEN BELUGAS?

www.CookInletBelugas.org

Summary report for all identified CIBW photographed 2005-2015 verified and suspected satellite tagged (sighting records, tag scar condition photos, reproductive info.)

McGuire, Tamara and Amber Stephens. 2016. Summary Report: Status of previously satellite-tagged Cook Inlet beluga whales. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for National Marine Fisheries Service, Alaska Region. 86p.

Download PDF at www.cookinletbelugas.com

With contributions from Chris Garner, Mandy Migura, Barb Mahoney, Kim Shelden, Sally Mizroch, Carrie Goertz, Kathy Burek, and the Alaska Marine Mammal Stranding Network

Examples of identified satellite-tagged CIBW in this presentation:

- 1 example of the cleanest tag scars observed (“Humperdink”)
- 1 example of healed but conspicuous tag scars (“Strapped”)
- 2 examples of dead sat- tagged whales

  “Sash” deteriorating tag scars

  “Sashtoo” clean tag scars
- 1 example of a deteriorating tag scar (“Jabbathehut”)

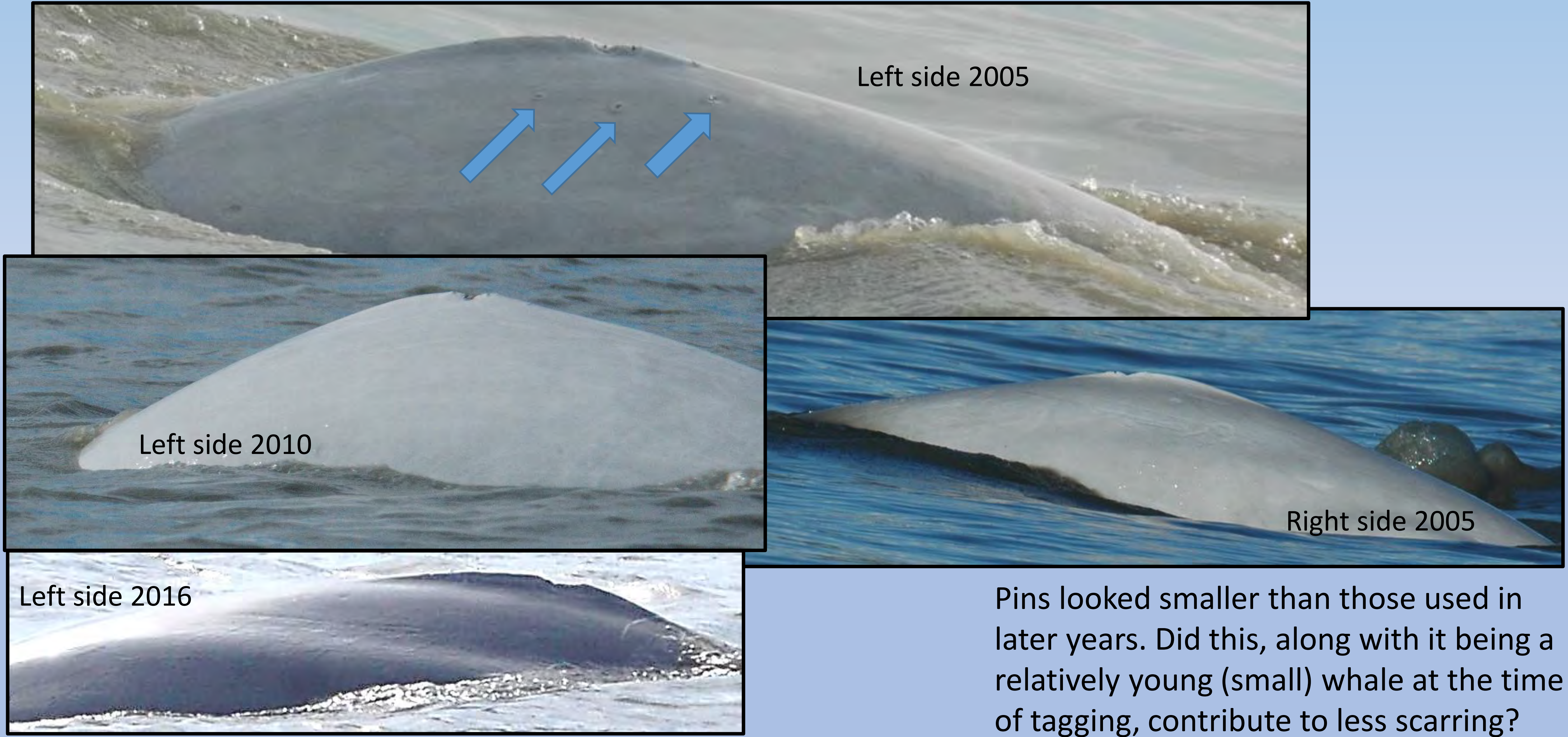
"Humperdink"

NMFS field #/name/sex tagging	CI-00-02 "Paul"a female
Photo-Id Catalog name	L2467/R111 Humperdink
Date tagged	13 Sept 2000
Years resighted by Photo-ID Project	2005-2016 (not 2006)
Comments	Right and left side images in catalog, seen with calves

Left-side photo of tag placement

Tagging photo courtesy of NMFS.

"Humperdink"- cleanest healing tag scars observed

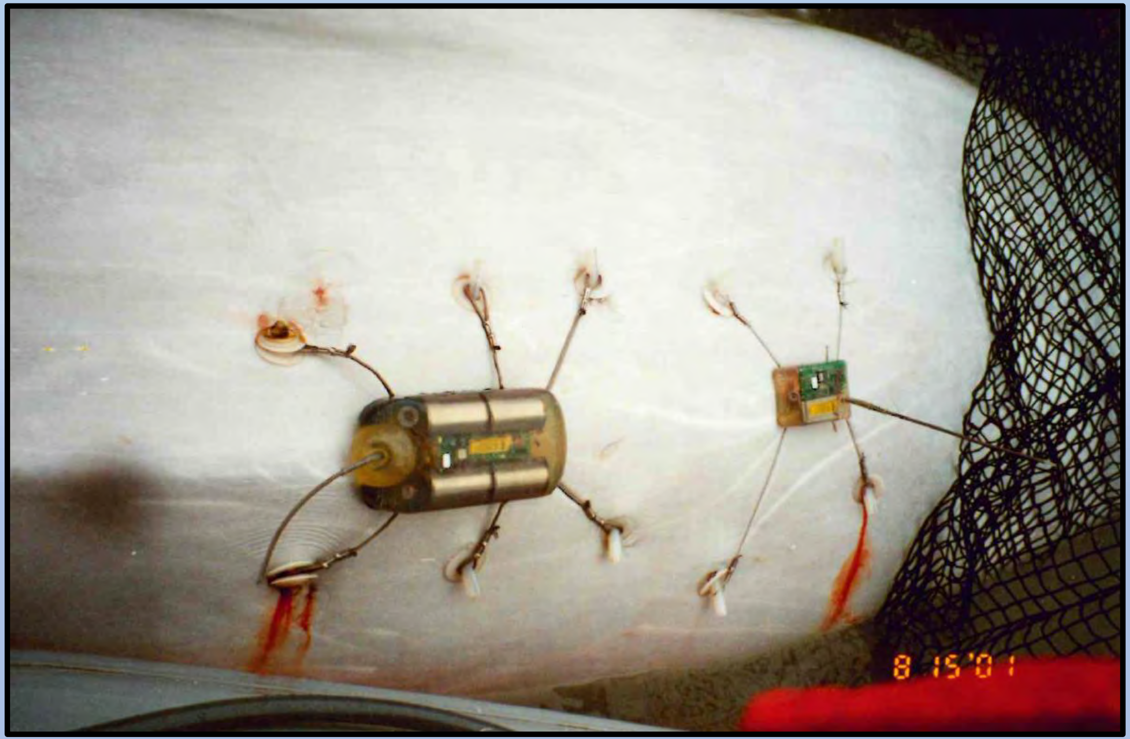


Pins looked smaller than those used in later years. Did this, along with it being a relatively young (small) whale at the time of tagging, contribute to less scarring?

Photo-ID photos taken with NMFS permit 14210 and 18016.

“Strapped”- clean but conspicuous tag scars

NMFS field #/name/sex tagging	CI-01-06 female
Photo-Id Catalog Name	L493/R103 Strapped
Date tagged	15 Aug 2001
Years resighted by Photo-ID Project	Every year 2005-2016
Comments	Seen with calves



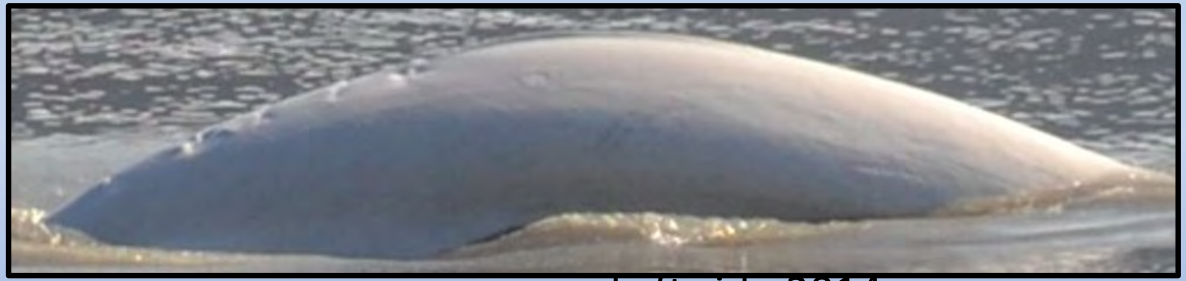
head

Tagging photo courtesy of NMFS.

"Strapped" example of healed but conspicuous tag scars


2016 left and right side (Robert Michaud, GREMM)

Left side 2006 (5 pins plus one assumed biopsy trocar scar)



Left side 2014

Right side 2005

2013 dual- side view

Photo-ID photos taken with NMFS permit 14210 and 18016.

"Sash"- example tag scarring/ signs of tag site deterioration/infection

NMFS field #/name/sex tagging	CI-02-05 male
Photo-Id catalog name	L2303/R17366 "Sash"
Date tagged	2 Aug 2002
Years resighted by Photo-ID Project	every year 2006-2015
Comments	Infection first seen 2007 Dead June 12, 2015

Right-side photo

Flipper band attachment on left pectoral fin

Right-side photo

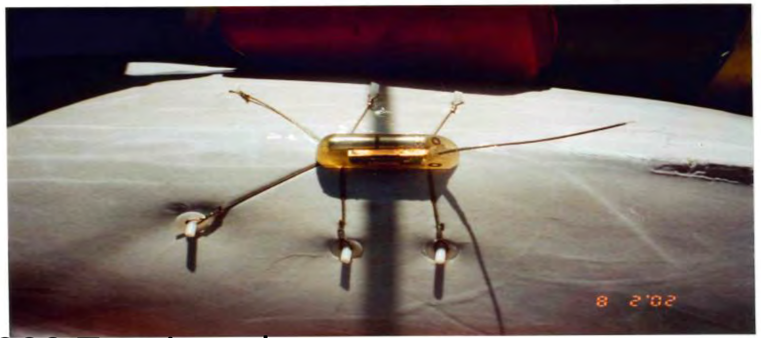
Tagging photos courtesy of NMFS.

“Sash” left

2007 left side , notice the concave profile

2011 left side with visible tag site deterioration

2014 left side with visible tag site deterioration



2002 Tagging photo

June 12, 2015 necropsy photos (above and below) notice left pectoral fin damage.

Photo-ID photos taken with NMFS permit 14210 and 18016. Tagging photo courtesy of NMFS.
Stranding photo courtesy of Alaska Marine Mammal Stranding Network.

“Sash” right

2006-2014 photos. Note increasing tag site deterioration, infection and concave profile


Right side 2006


Right side 2007


Right side 2008
note yellow coloration
around deteriorating tag site

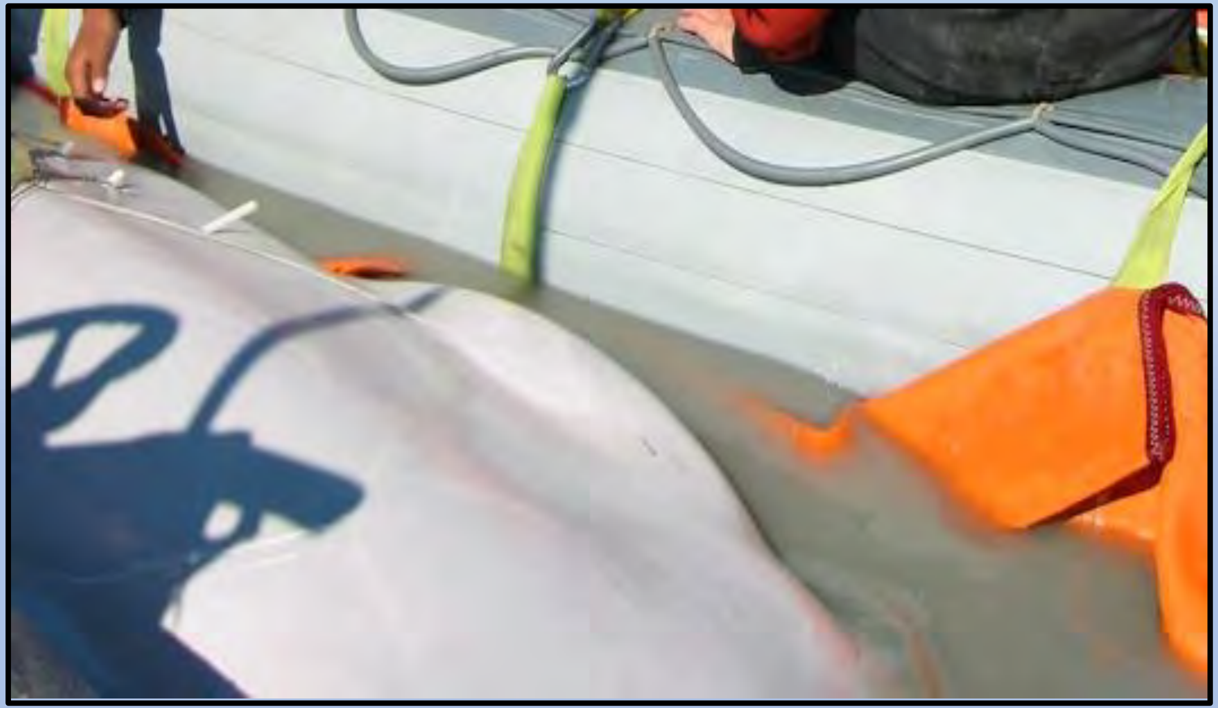

Right side 2013


Right side 2014

Photo-ID photos taken with NMFS permit 14210 and 18016.

"Sashtoo"- example of dead whale with relatively clean but conspicuous tag scars

NMFS field #/name/sex tagging	CI -02- 08 male
Photo-Id catalog name	L2579/R115 Sashtoo
Date tagged	4 Aug 2002
Years resighted by Photo-ID Project	Yearly 2005-2014
Comments	Dead May 2014



head

Tagging photo courtesy of NMFS.

“Sashtoo”- example of dead whale with relatively clean tag scars

May 2, 2014 Left-side photo of dead whale. Take note of damaged left pectoral fin. Photo courtesy of Bill Streever.

“Sashtoo”

Left-side tag scars

photo courtesy of Russ Andrews, Alaska SeaLife Center

“Sashtoo”

Right-side photo

photo courtesy of Russ Andrews, Alaska SeaLife Center

“Sashtoo”

Right-side photo 2006

Note flipper band embedded in damaged left pectoral fin.

2007 left-side photo of whale side swimming.

Photo-ID photos taken with NMFS permit 14210 and 18016.
lower photo courtesy Chris Garner, JBER DOD

“Sashtoo”

2010 left-side photo
Note trocar scar

2008 dual-side photograph

2012 right-side photograph

Photo-ID photos taken with NMFS permit 14210 and 18016.

“Jabbathehut”- example of extreme tag scarring/tag site deterioration

NMFS field #/name/sex tagging	C1- 02-06 male
Photo-Id catalog name	L2204/R17367 Jabbathehut
Date tagged	3 Aug 2002
Years resighted by Photo-ID Project	2005, 2006, 2007
Comments	Not seen after 2007, suspected to have died, based on lack of photo-id resights compared to other individuals in catalog

Tagging photo courtesy of NMFS.

"Jabbathehut"- example of tag scarring/ obvious tag site deterioration

2005 right side

2006 left side

2007 right side
note concave profile and tag site deterioration

2007 left side

2016 and 2017 biopsied CIBW follow up

Paxarm® MK24b 2001 biopsy rifle range (3-30 m/9-98 ft) used blank .22 caliber charges to project an 18-mm (0.7-inch) plastic cylinder carrying the biopsy dart (8 mm diameter by 35 mm length/0.31 by 1.4 inches) at a maximum muzzle velocity of 40 m (131 ft) per second.

Biopsy sampling and close approach for photo-id /biopsy
NOAA Fisheries MMPA/ESA Scientific Research
Permit #14245-04 to the NMFS Marine Mammal Laboratory (MML).

2016 biopsied CIBW follow up

left side of D220 “Smiley”
DL-CIB16-36
female

2007

Aug 20, 2016 (Robert Michaud GREMM)

Sept 9, 2016
(courtesy Marc Webber USFWS/UAA)

Photo-ID photos taken with NMFS permit 14210 and 18016. Biopsy sampling and close approach for photo-id /biopsy
NOAA Fisheries MMPA/ESA Scientific Research
Permit #14245-04 to the NMFS Marine Mammal Laboratory (MML).

Biopsied whale DL-CIB-16 32 male

Aug 15, 2016 (Robert Michaud GREMM)

Aug 18, 2016
(Robert Michaud GREMM)

Sept 9, 2016

Biopsy sampling and close approach for photo-id /biopsy
NOAA Fisheries MMPA/ESA Scientific Research
Permit #14245-04 to the NMFS Marine Mammal Laboratory
(MML).

2017 biopsied CIBW follow up   CIBW R1187/ DL-CIB17-05

2015

Sept 3, 2017 biopsy hit and later in day biopsy miss

7:10 pm UCI (Brenda Rhone, MML)

8:46 pm UCI

Photo-ID photos taken with NMFS permit 14210 and 18016.
Biopsy sampling and close approach for photo-id /biopsy NOAA Fisheries MMPA/ESA Scientific Research Permit #14245-04 to the NMFS Marine Mammal Laboratory (MML).

Summary reports for CIBW biopsy 2016

McGuire, T., R. Michaud, M. Moisan, C. Garner. 2017. Cook Inlet Beluga Whale Biopsy: Field Report for 2016 Feasibility Study. Report prepared by LGL Alaska Research Associates, Inc., GREMM, and JBER for NMFS 67 p. + Appendices.

McGuire, T., A. Stephens, R. Michaud, M. Moisan, C. Garner. 2017. Cook Inlet Beluga Whale Biopsy: Photo-Identification of Biopsied Whales during the 2016 Feasibility Study. Report prepared by LGL Alaska Research Associates, Inc., GREMM, and JBER for NMFS 33 p.

Download PDF at www.cookinletbelugas.com

Presentation 4

Bristol Bay Beluga Health Assessment and Methods Development

Lori Quakenbush, Alaska Department of Fish and Game, and Carrie Goertz, D.V.M., Alaska SeaLife Center

Bristol Bay Beluga Health Assessment and Methods Development- A Collaboration

Lori Quakenbush – Alaska Department of Fish and Game and
Carrie Goertz - Alaska SeaLife Center for
Cook Inlet Beluga Research Methods Workshop
29-30 November 2017

Collaborative Partners

GEORGIA AQUARIUM

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

A. V. P. S.

Alaska SeaLife Center
Seward, Alaska

ALASKA
DEPARTMENT OF FISH AND GAME

ReSEARCH
MYSTIC AQUARIUM

NIST

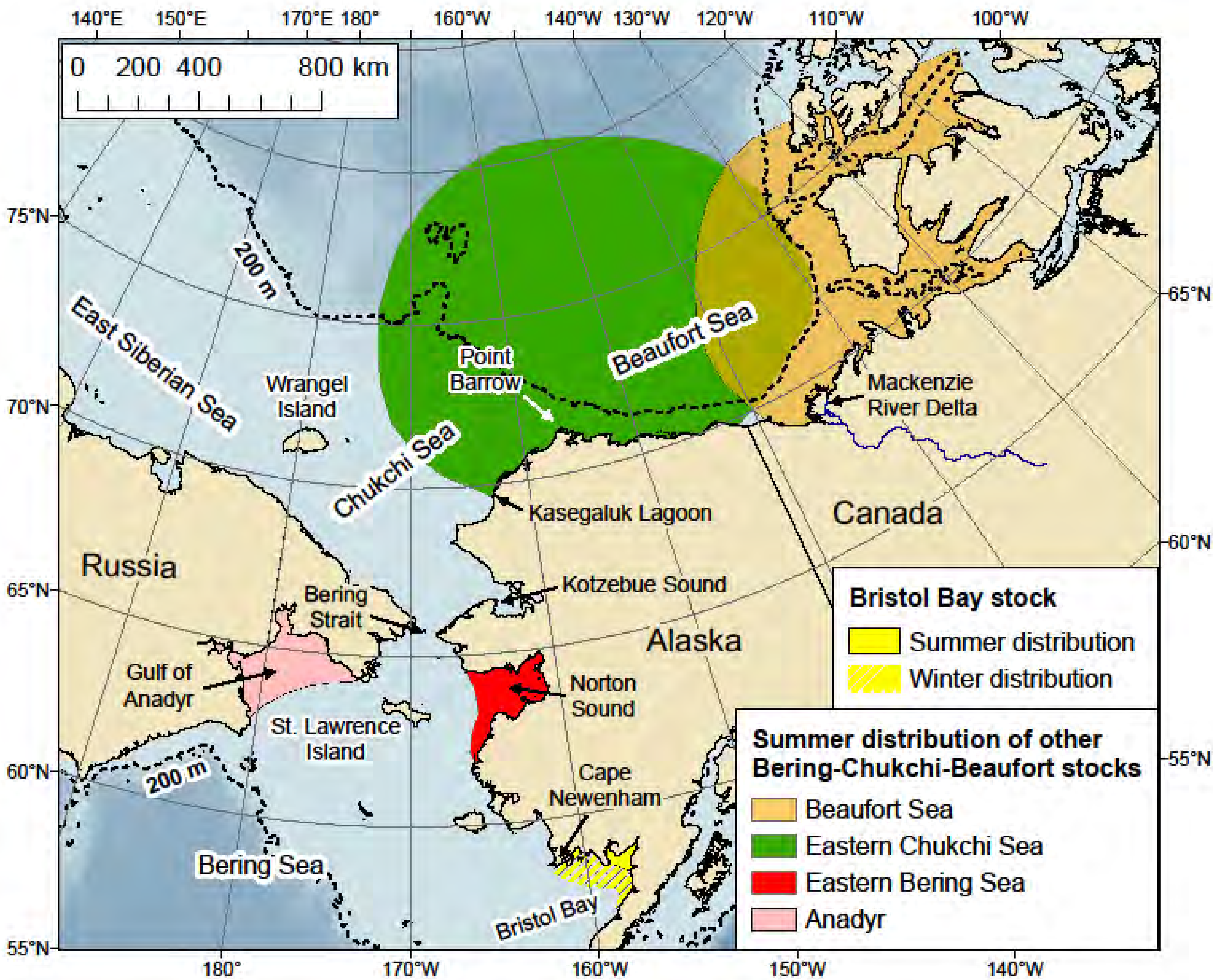
WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

Shedd
AQUARIUM

ALASKA PACIFIC UNIVERSITY

MARINE-MED

UAF
UNIVERSITY OF ALASKA FAIRBANKS



140°E
150°E
170°E 180°
160°W
140°W 130°W
120°W
110°W
100°W
0 200 400 800 km
75°N
70°N
65°N
60°N
55°N
65°N
60°N
55°N
180°
170°W
160°W
150°W
140°W
200 m
East Siberian Sea
Wrangel Island
Point Barrow
Beaufort Sea
Mackenzie River Delta
Chukchi Sea
Kasegaluk Lagoon
Canada
Russia
Bering Strait
Kotzebue Sound
Alaska
Gulf of Anadyr
Norton Sound
St. Lawrence Island
200 m
Cape Newenham
Bering Sea
Bristol Bay
Bristol Bay stock
Summer distribution
Winter distribution
Summer distribution of other Bering-Chukchi-Beaufort stocks
Beaufort Sea
Eastern Chukchi Sea
Eastern Bering Sea
Anadyr

Project History (56 belugas sampled)

- 2008 May & Sep: 10 & 8 whales
  - For habitat use, health assessment was added
- 2012 Sep: 9 whales (novel tags, audiology, breath)
- 2013 Aug: 10 whales (↑ sample size, new tests)
- 2014 Aug: 10 whales (habitat use, vocalizations)
- 2016 May: 9 whales (feeding ecology)
- Authorizations: NMML, BBNA, ADF&G, and NMMHSP
- Funding:
  - MML, Georgia Aquarium, Shedd Aq
  - Other support: ASLC, Mystic Aq, NIST
  - Individual researchers

Objectives

- Obtain samples from healthy Bristol Bay belugas for a baseline and to compare with Cook Inlet.
- Develop methods to collect samples from wild belugas that can be used to evaluate health and other information.

Field Team Roles

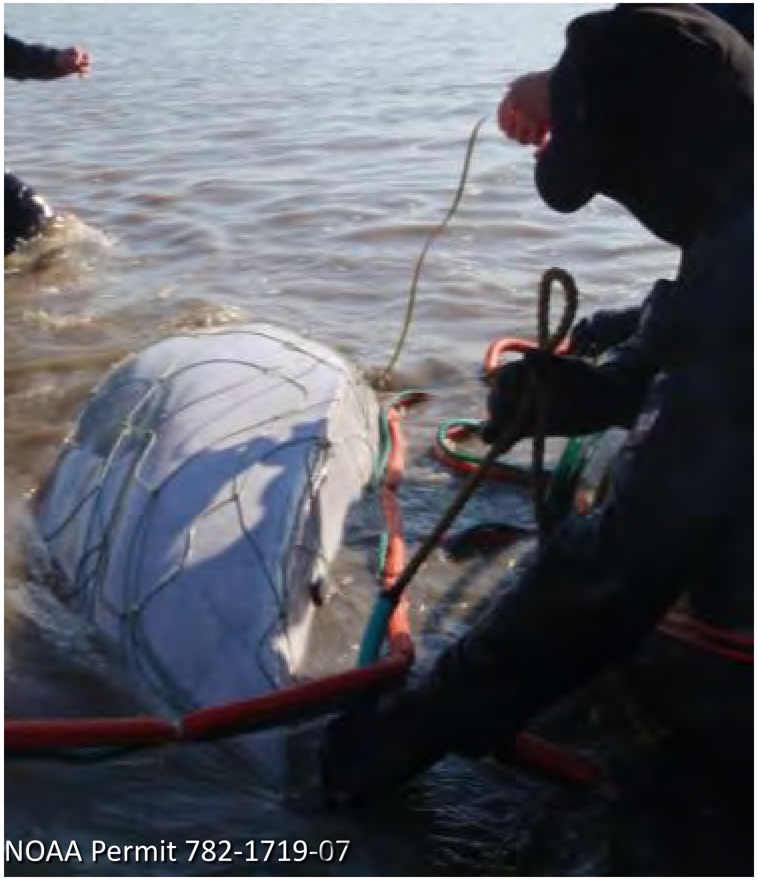
- Science Lead (NMML)
- Boat Organizer and On-water Leader (ADF&G)
  - 3-4 boats, each with a driver and assistant from local area
- Field Veterinarian
- Sample processors and analyzers (3)
- Animal handlers (3-4)
- Additional researchers (3-4)

Lead boat with net

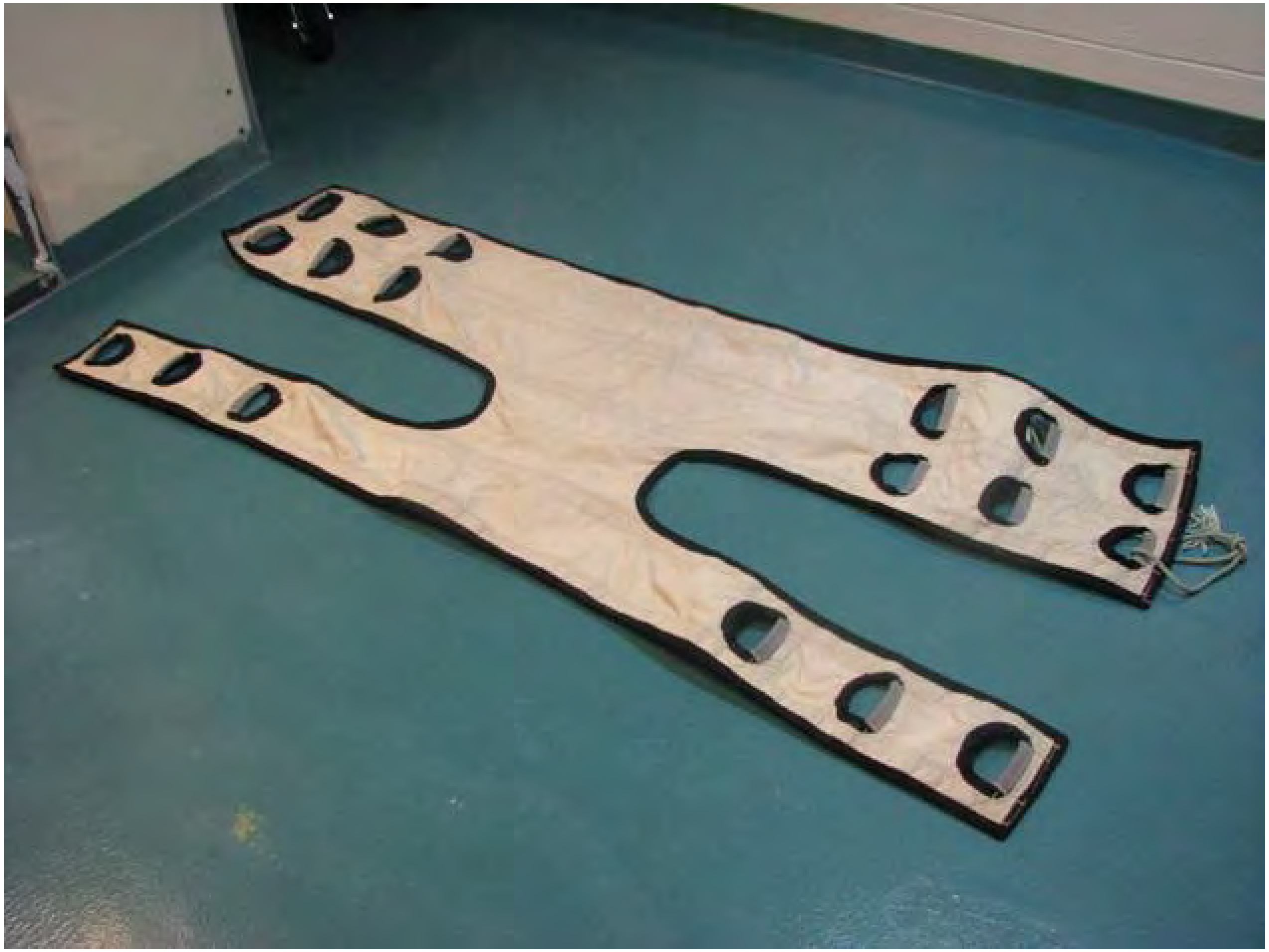

60
YAMAHA
NOAA Permit 782-1719


NOAA Permit 782-1719

Placing a Tail Rope



‘Belly Band’




ALUMAWELD
TOHATSU
YAMAHA
NOAA Permit 782-1719-07

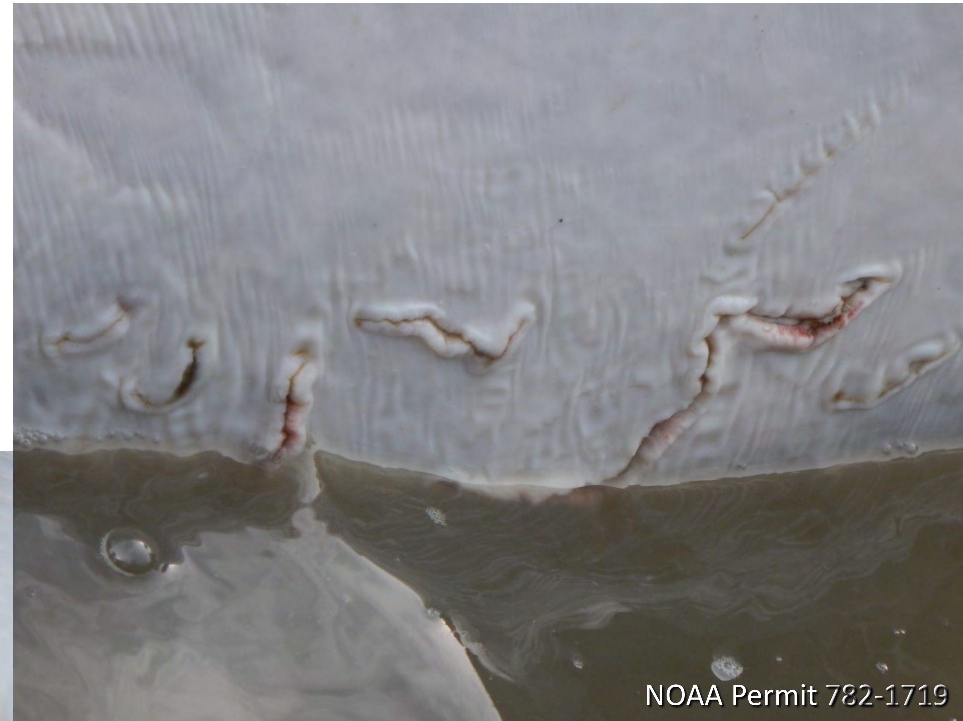
Samples: Blood draw

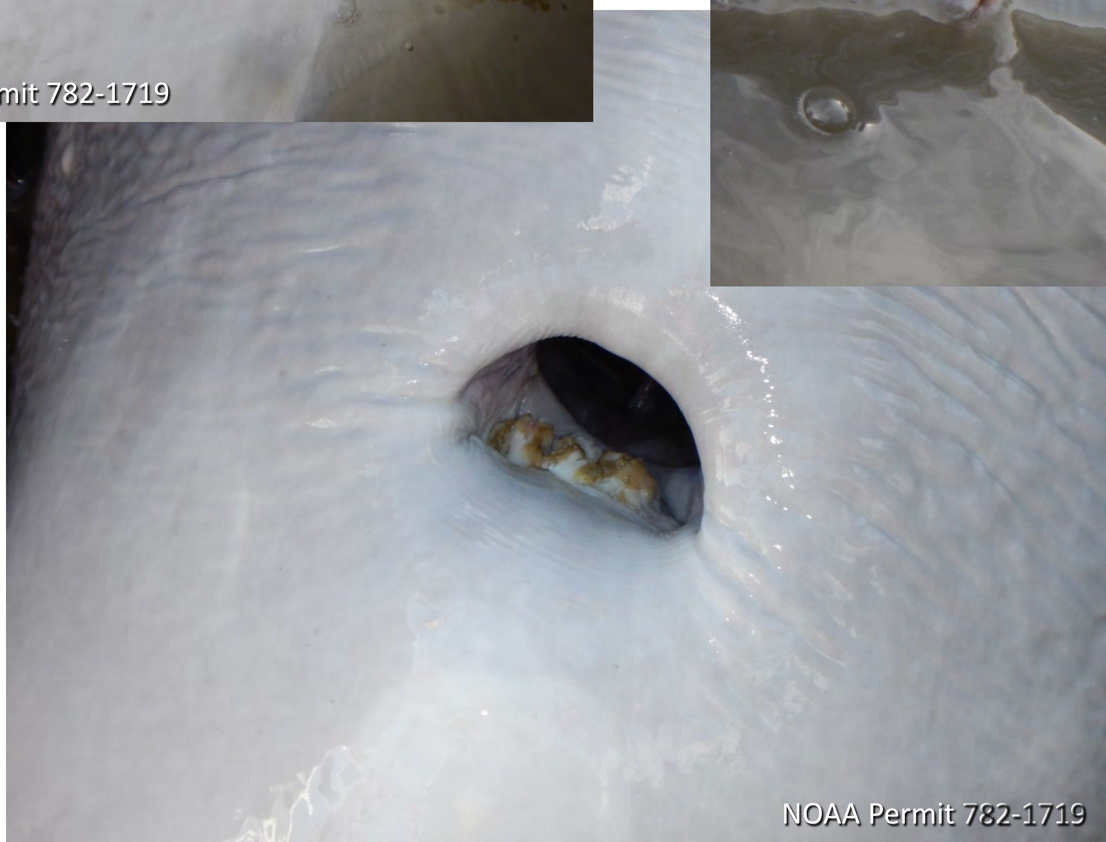
More samples

“Blow” from blowhole

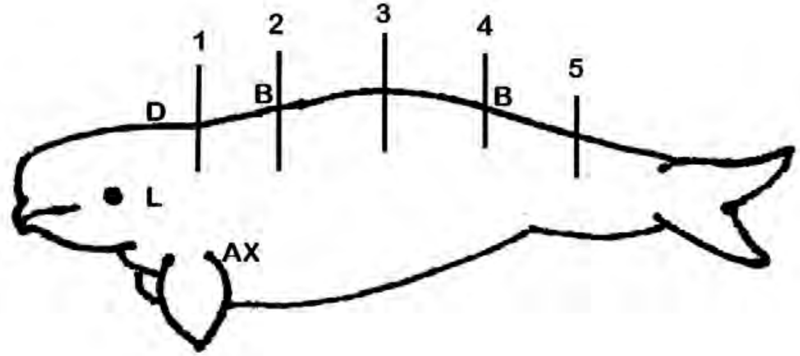
Swabs from blowhole

Photos and biopsy of skin abnormalities





Ultrasound for blubber thickness (can be done during hearing test)



How good is the ultrasound at measuring blubber thickness?

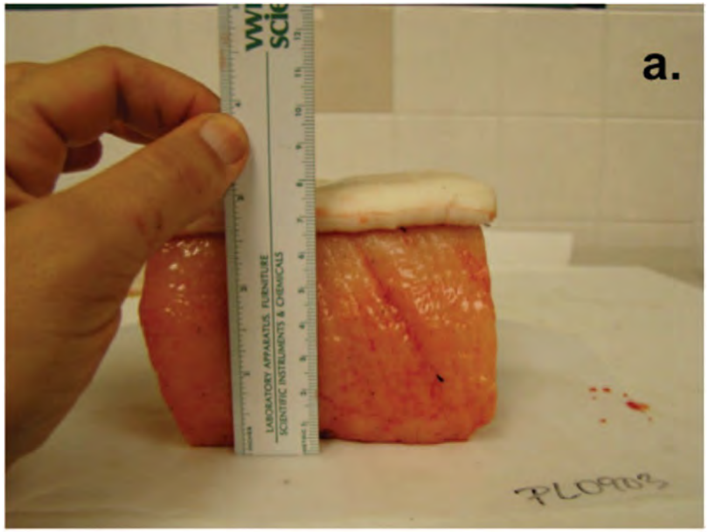
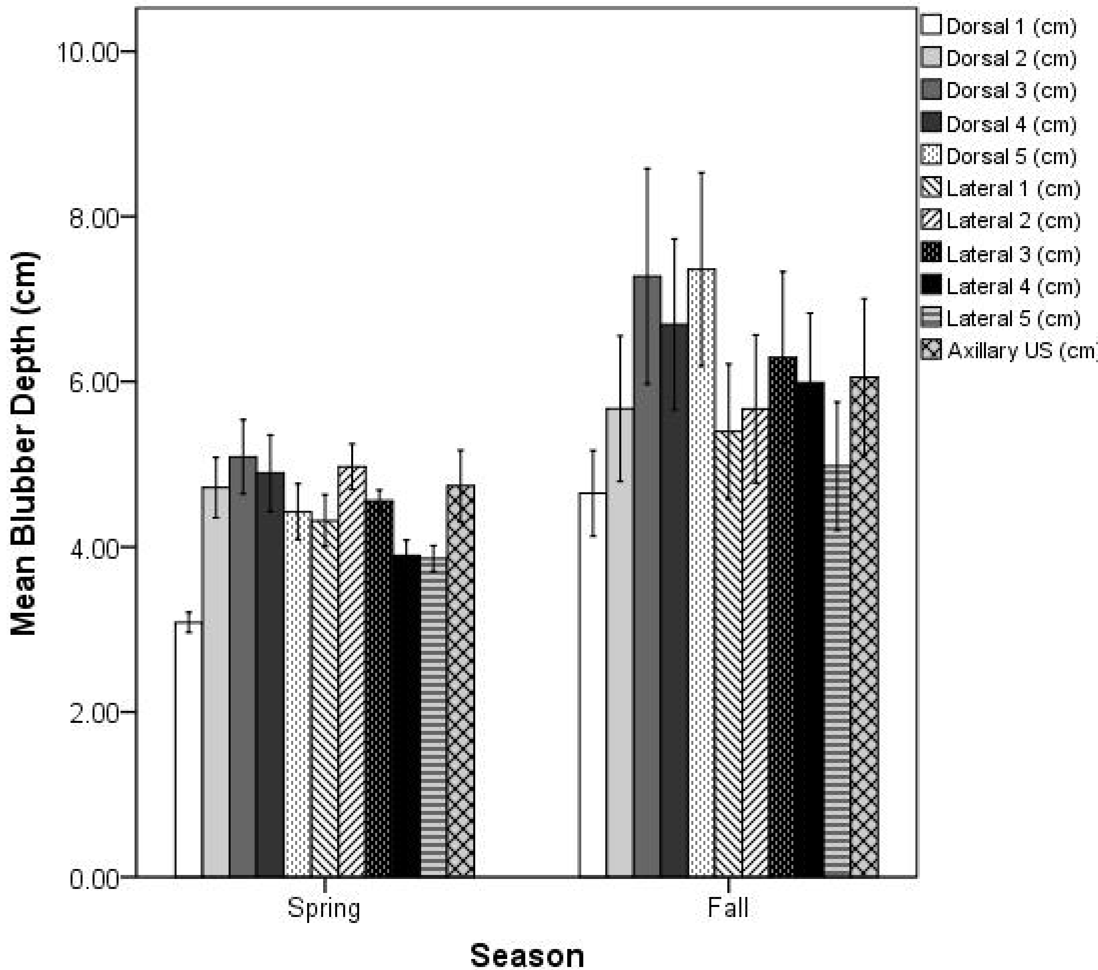


Fig. 3. From Cornick et al. 2016

Cornick et al. 2016. Seasonal and developmental Differences in blubber stores of beluga whales in Bristol Bay, Alaska using high-resolution ultrasound. **Journal of Mammalogy** doi:10.1093/jmammal/gyw074

Ultrasound in Bristol Bay says belugas are fatter in fall



Cornick *et al*. unpublished data

Beluga hearing tests (audiograms)

2012 (n=7), 2014 (n=10), 2016 (n=9)
19 males, 7 females

Castellote et al. 2014. Baseline hearing abilities and variability in wild belugas. J. Experimental Biol. Doi:10.1242/jeb.093252

Mooney et al. In review. Variation in hearing within a wild population of beluga whales. Bioacoustics

Satellite tagging and tag testing

Belugas captured for health assessment are also tagged.

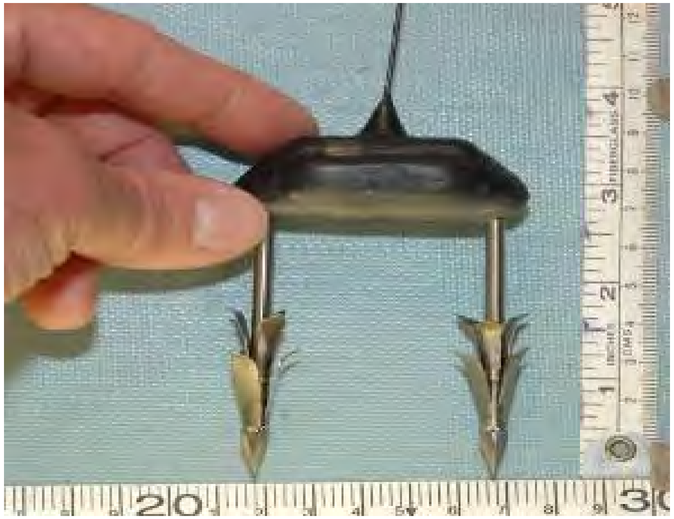
Tags that record sound (temporary suction cup tags)

Satellite tags (LIMPET) that are smaller and may not require the beluga to be captured are being tested.

Satellite (spider tag) and Acoustic (suction cup tag)


NOAA Permit 14245

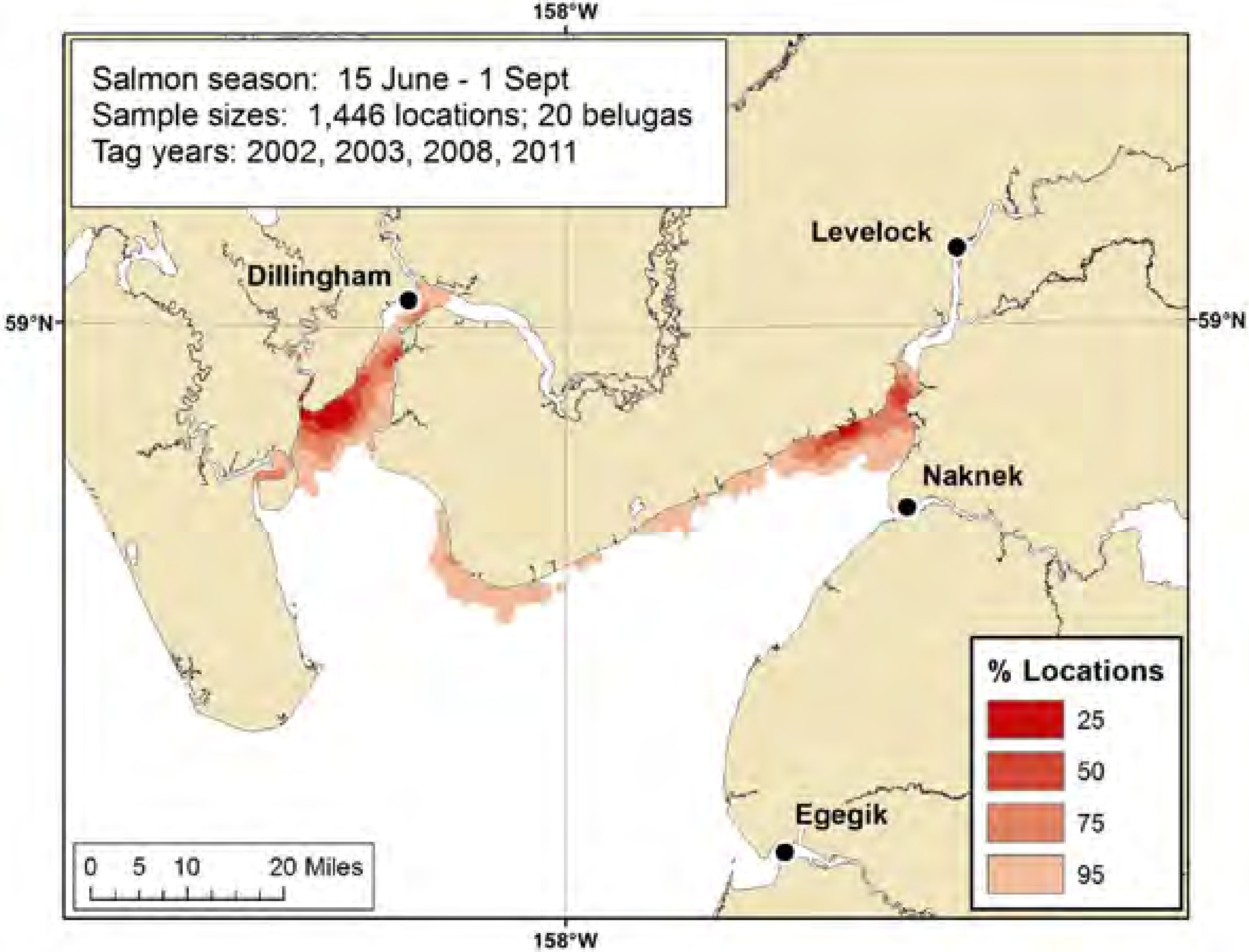
LIMPET tags



Smaller less impact to skin


NOAA Permit 14245


HONDA
90
ALUMAWELD



Citta et al. 2016. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska.
Marine Mammal Science doi:10.1111/mms.12337

BBB Sampling & Analyses

Sampling / Processing

- Blood (~200 mls), pre and post
- Morphometrics
- Rectal swabs +/- feces
- Blowhole swabs
- Exhaled breath condensate
- Blubber depths by U/S
- Skin (normal and lesions)
- Full thickness blubber biopsy
- Gastric samples
- Tagging (Spider, LIMPET)
- Audio Evoked Potential (hearing)

Analyses - Lab

- CBC, Chem, hormone- Cornell
- Functional immunity & neuroendocrine- Mystic
- Micro & Serology- UGA, UCD
- Contaminants- NIST, NWFSC
- Habitat use- NMML & ADFG
- Telemetry- ASLC & NMML
- Genomics- NIST, Mystic
- Audiology- NMML
- Genetics- GOCC


SCUBAPRO
everdry 4
NOAA Permit 14245

Acknowledgements

Myra Olsen (BBNA-MMC)

Helen Aderman (BBNA)

Ben Tinker (Crew Capt.)

Richard Hiratsuka (Boat Capt.)

Joe Hiratsuka (Boat Capt.)

Robin Chythlook (Boat Capt.)

William Savo (Boat Capt.)

Joe Coolidge (Crew)

Bryan Hodgson (Crew)

Thomas Hiratsuka (Crew)

Togiak NWR

ADF&G

Collaborative Partners

GEORGIA AQUARIUM

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

A. V. P. S.

Alaska SeaLife Center
Seward, Alaska

ALASKA
DEPARTMENT OF FISH AND GAME

RESEARCH
MYSTIC AQUARIUM

NIST

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

Shedd
AQUARIUM

ALASKA PACIFIC UNIVERSITY

MARINE-MED

UAF
UNIVERSITY OF ALASKA FAIRBANKS

NOAA Permit 14245


NOAA Permit 14245

Presentation 5

Post Mortem Findings of Tagged Belugas, 3 Cases

Carrie Goertz, D.V.M., Alaska SeaLife Center and Kathy Burek, D.V.M., D.A.C.V.P., Alaska Veterinary Pathology Services

Post Mortem Findings of Tagged Belugas, 3 Cases

Carrie Goertz & Kathy Burek

Plus information from Kim Shelden, Tamara McGuire, & Russ Andrews

Cook Inlet Beluga Research Methods Workshop, Nov 2017

Case 1: AVPS# V14-091

Tagging Details

- Date: 4 Aug 2002
- Location: Knik Arm
- Tag: PTT #25847, 2-battery, 3 rods
- Captured at 15:15, held 71 minutes
- Length: 376 cm
- Transmitted until 25 May 2003

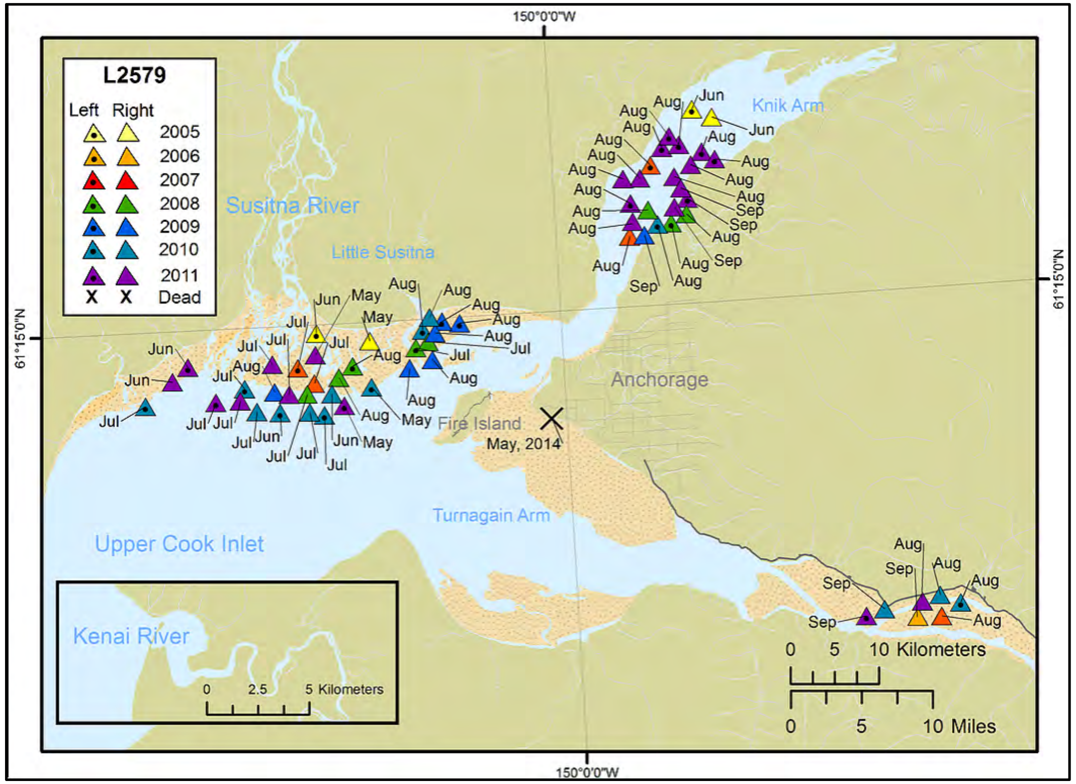
Figure 25.--Whale CI2002-08 (alternate ID CI-0208) outfitted with a two-battery ST16 'spider' tag via nylon rods inserted through the blubber layer of the dorsal ridge (right panel).

LGL Photo-ID Sightings 2005-2014

Cook Inlet Beluga Whale Photo-ID Project photos taken with NMFS permit 14210 and 18016

Figure B28. Right-side photo of L2579/R115 Sashtoo in 2006.

Figure B31. Right-side photo of L2579/R115 Sashtoo in 2012.

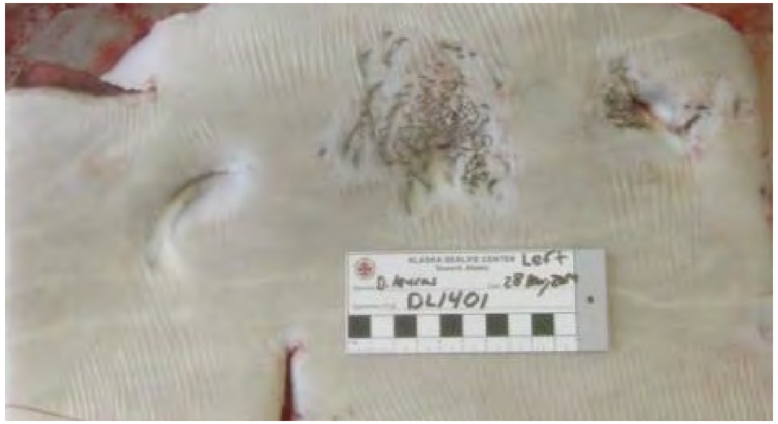


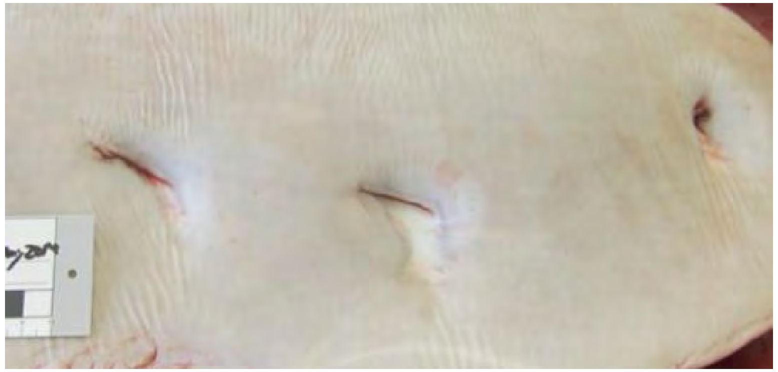
Stranding Details

- Found 8PM 26 May 14 (~11 Y & 10 M post tagging)
- Close to a pregnant female
- Cook Inlet, Kincaid Park (61.14510N, 150.03702 W)
- Presumed to have strand during previous low tide ~noon, -2.6 ft, winds 6-23 mph
- Sampled on 27 & 28 May 14

Integument Findings by Tag

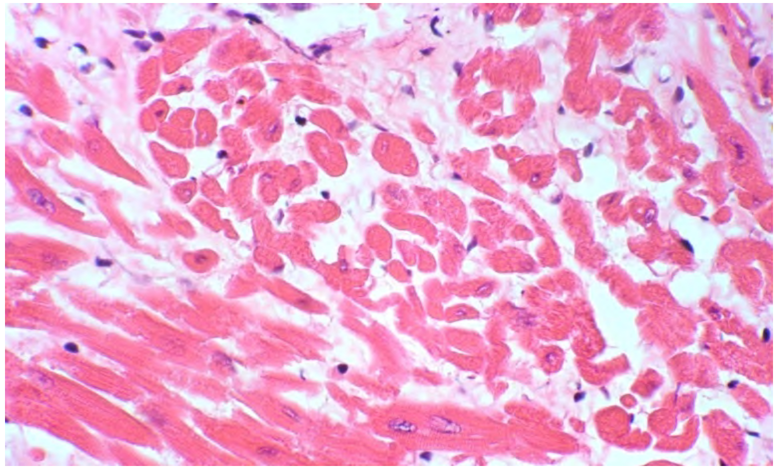
- Very good healing of the through and through perforations
- Intradermal epithelial tracks, mild inflammation
- Mild, chronic, multifocal steatitis (by pins & elsewhere)
- Mild, chronic superficial dermatitis

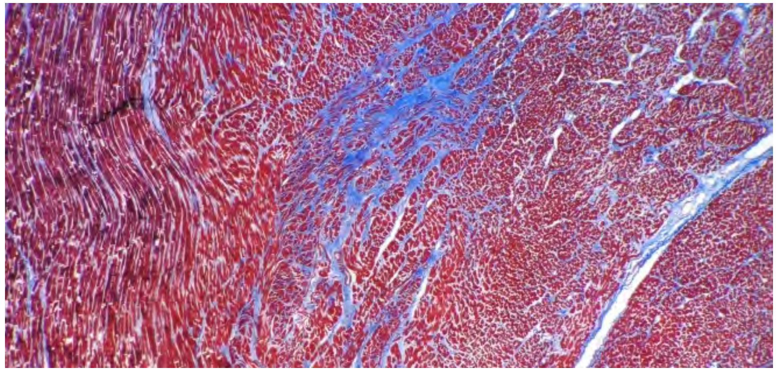




COD & Other Findings

- COD: Massive aspiration of glacial silt, deep into airways
- Contributory
  - CV: cardiomyopathy, myocardial fibrosis, aortic dysplasia, arteriosclerosis
- Miscellaneous, mild, likely incidental findings
  - Encephalitis, cerebellar edema
  - Parasitic pneumonia
  - Chronic hepatic passive congestion (2° to R-sided heart failure)
  - Degenerative myopathy, multifocal, peracute
  - Adrenocortical nodular hyperplasia
  - Lymphoplasmacytic & eosinophilic enteritis
  - Damage to left pectoral fin from flipper band





Conclusion

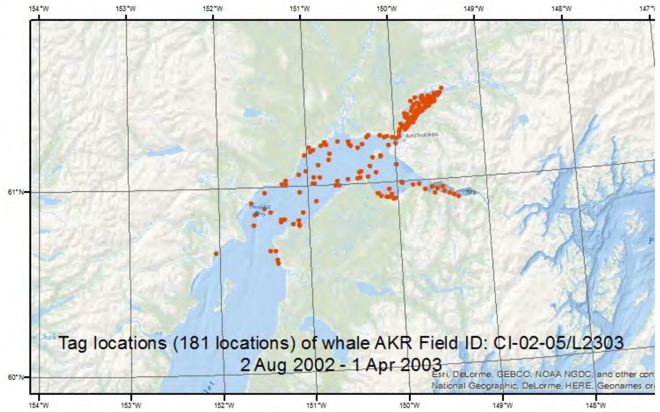
This whale live stranded during a relatively extreme low tide. Subsequently, he aspirated a large amount of mud which blocked his airways. Additionally, he had cardiac changes associated with age in other beluga which may have impaired his ability to handle the cardiovascular stresses of live stranding.

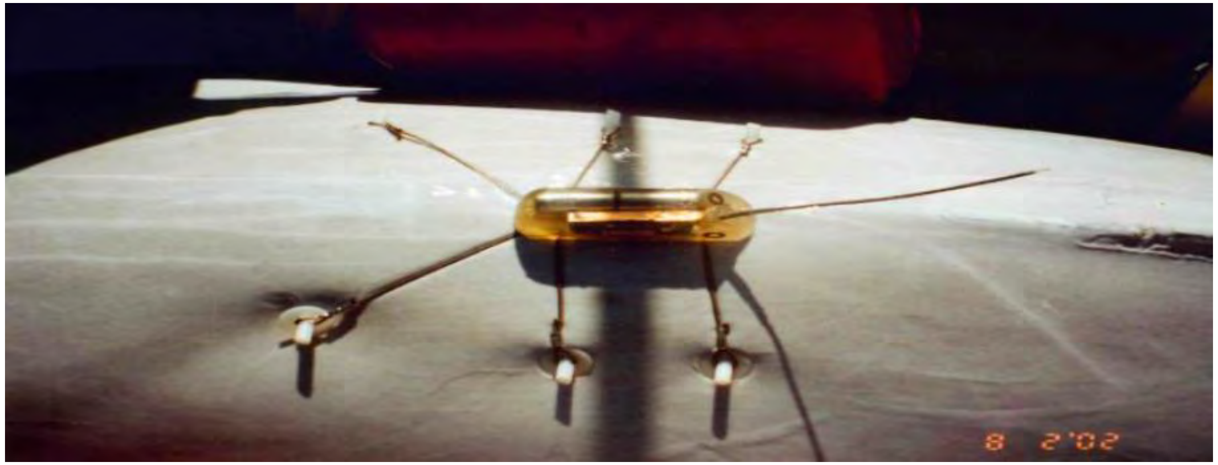
Case 2: AVPS# V15-071

Tagging Details

- Date: 2 Aug 2002
- Location: Knik Arm
- Tag: PTT #13947, 2-battery, 3 rods
- Captured at 13:10, held 30 minutes
- Length: 386 cm
- Tag transmitted until 1 Apr 2003

Figure 6.--Sling system used to immobilize belugas during tagging operations in Cook Inlet, Alaska, in 2001-2002. Satellite-linked time/depth recording tags were attached via three nylon rods inserted through the blubber layer of the dorsal ridge. A two-battery version is shown on whale CI-0205.





Additional History

Cook Inlet Beluga Whale Photo-ID Project photos taken with NMFS permit 14210 and 18016

- Re-sighted by LGL's photo ID project 2006-2015
- Area by scars appeared to start deteriorate in 2007
- Yellow coloration around tag site
- Depressions more noticeable
- Declining body condition

Figure B10. Right-side photo of L2303/R17366 Sash in 2006.

Figure B12. Right-side photo of L2303/R17366 Sash in 2009. Note yellow coloration around deteriorating tag site.

Figure B13. Right-side photo of L2303/R17366 Sash in 2013.

Figure B14. Right-side photo of L2303/R17366 Sash in 2014.

Stranding Details

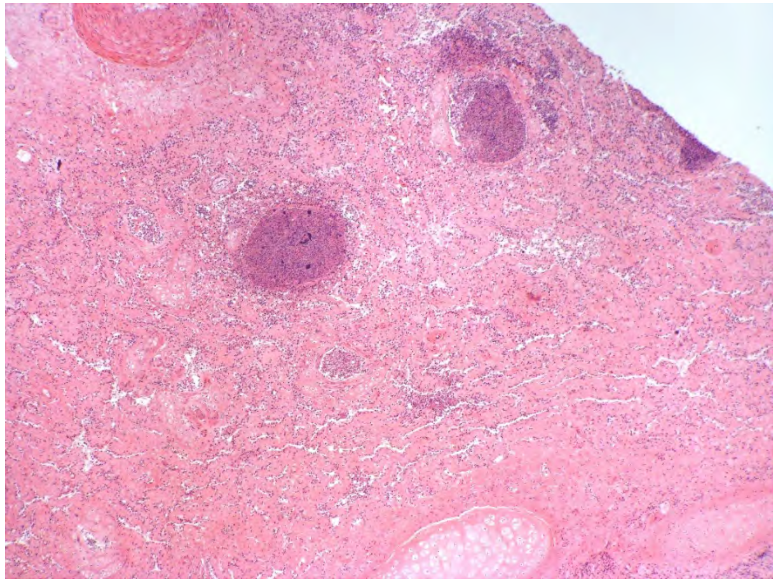
- Found 12 Jun 15 (~12 Y & 10 M post tagging)
- Cook Inlet, western shore, Tyonek (61.0634N, 151.14061666W)
- Necropsied on 13 Jun 15

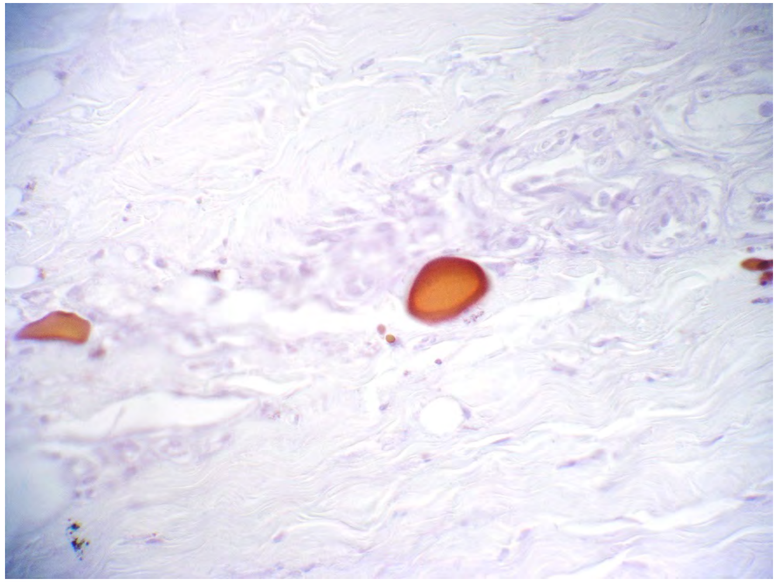
Gross Necropsy Findings

- Chronic injury, dorsal midline, most likely infected transmitter site +/- other trauma
- COD – septicemia due to primary pneumonia with secondary infection of tracts
  - Fibrinosuppurative pleuritis and abscessing pneumonia
  - Myocarditis, suppurative, focal
  - Embolic nephritis, suppurative with abscessation
  - Lymphadenitis, suppurative with abscessation, multifocal pleural cavity
- Acute & chronic defects in flippers & fluke consistent with net injuries and flipper band
- Poor body condition

Histopathology

- COD: chronic severe bacterial bronchopneumonia (S. aureus) with abscessation and pleuritis, 2° to rupture of a lung abscesses → septicemia → seeding of multiple tissues (kidney, LNs, skin lesions)
- Additional Findings
  - Dermatitis, steatitis, arteritis
  - Tonsillitis, sialoadenitis
  - Adrenalitis
  - Thyroid follicular cysts
  - Testicular degeneration
  - Cystitis
  - Degenerative myopathy, multifocal
  - Esophagitis
  - Duodenitis





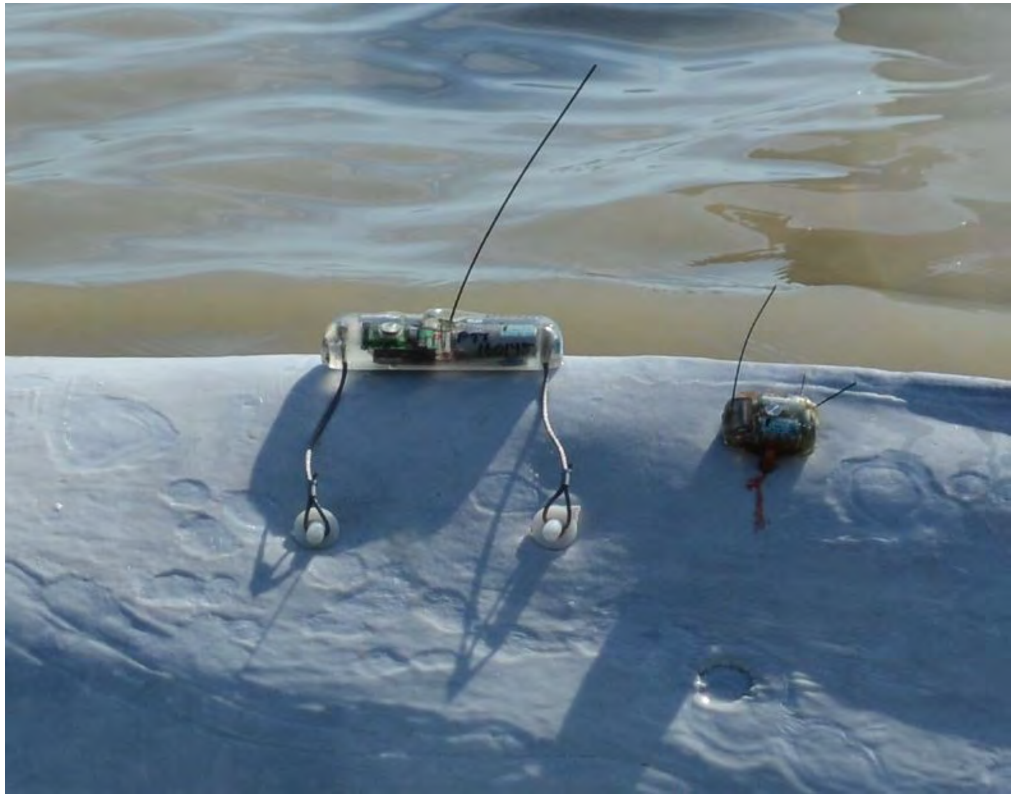
Conclusion

This whale's lung had a chronic infection of *Staph aureus* with multiple abscesses. Rupture of abscesses would have caused sepsis & seeding of additional tissues including kidneys, multiple lymph nodes, and the skin. Old scars would have been especially susceptible to 2nd infection because disrupted capillaries would 'trap' bacteria.

Case 3: AVPS# V16-086

Tagging Details

- Date: 15 May 16
- Location: Bristol Bay
- Tag: 2 pin Argos (#15A0530), plus 2 pin LIMPET
- Captured at 15:42, held 119 minutes
- Length: 384 cm
- Tag transmitted until 16 Sep 16 (after death)



Additional History

Area of positions received on August 19, 25, 28, and 31, and September 1 and 6.

Positions received on September 11.

Only one position estimate received on September 16, an LC1, but this is after time of death.

12Sep2016 12:57 GMT (04:57AKDT), something happens that causes the pressure transducer to dramatically change its baseline

13Sep2016 00:41:30 GMT (12Sep2016 16:41:30): no more changes detected on wet/dry sensor or light level sensor, suggesting animal is no longer moving up and down at all, small stomach temperature drop.

13Sep2016 09:15 GMT (13Sep2016 01:15 AKDT): body temperature finally started to significantly decline without reversal.

Stranding Details

- 13 Sept 16: Estimated date of death
- 18 Sep 16: Found close to Ekuk, Nushagak River
  - Two more dead beluga observed within ~2 miles (ASLC# DL1604 & DL1605)
- 19 Sep 16 (Monday): Tag and surrounding tissue removed
- 23 Sep 16 (Friday): Additional sampling of carcass
  - Significant post mortem analysis

Gross Necropsy: Lacerations (Pre & Post Mortem)

- Lacerations, multiple 5 – 75 cm lacerations with linear ‘sharp’ edges
- Area of presumed hemorrhage along peduncle
- Set net anchors occur up to every 400 ft

Gross Necropsy: Extensive anterior bruising

- Circumferential, most significant by and forward of pectoral flippers
- Blunt trauma pattern consistent with orca attack or boat strike
- Orca had been observed in the area about the time of death

Gross Necropsy: LN

- Abscessed pre-scapular lymph node
- Locally extensive but did not communicate with lungs or tag site
- ~100 cm from tag site
- Both grew *Strep uberis*

Conclusion

The extensive post-mortem changes make it difficult to assign a specific cause of death. The following are possible contributors to death.

- Illness 2nd to *Strep uberis* (found at tag site and in abscess)
- Orca attack (unusual pod sighting, additional beluga carcasses found, bruising consistent with blunt force trauma, change in pressure transducer ‘baseline’)
- Debilitation 2nd to live stranding (laceration due to set net anchors, debris packed in upper airway)
- Anomalous weather including winds and lightning

MMHSRP MMPA/ESA #18786-02

Cases

ID	Tagged	Found deceased	
AKR# CI-2002-08/CI-02-08/CI-0208 LGL# L2579/R115 “Sashtoo” NMFS# 2014033 ASLC# DL1401 AVPS# V14-091	4 Aug 2002	26 May 2014	Male Found close to pregnant female Cook Inlet
AKR# CI-2002-05/CI-02-05/CI-0205 LGL# L2303/R17366 “Sash” NMFS# 2015066 ASLC# DL1501 AVPS# V15-071	2 Aug 2002	12 Jun 2015	Male Cook Inlet
DLBB16-06 NMFS# 2016228 ASLC# DL1603 AVPS# V16-086	15 May 2016	16 Sep 2016	Male Bristol Bay

Ancillary Test Results (AVPS# V14-091)

- Virology: negative on SLAM and BWK cells
- Bacteriology
  - Fecal: *Clostridium perfringens, Clostridium sordelli, Cirobacter sp*
  - Lung: *Citrobacter, Edwardsiella tarda, Enterococcus sp, Morganella sp, Shewanella putrefaciens*
- Molecular
  - Respiratory: NEG for *herpesvirus, influenza, morbillivirus* (UGA & MIT)
  - POS *Streptococcus parauberis, Erysipelothrix spp*
  - NEG *Mycoplasma*
- Parasites
  - Esophagus: *Anisakis simplex*
  - Kidney: *Crassicauda giliakiana*

Ancillary Test Results (AVPS# V15-071)

- Bacteriology
  - Staphylococcus aureus (heart, lung, mediastinal LN, feces, pleura, skin lesions)
  - Feces: Morganella morganii, E. coli, C. tertium,
  - Skin lesion: Photobacterium damsela,
  - Pleura: Aeromonas sp
- Toxicology: negative for PSPT-STX, DA

Histopath & Ancillary Results: AVPS# V16-086

- Satellite tag and limpet tag site inflammation
- Chronic active, moderate, erosive suppurative dermatitis
- Chronic active, necrotizing myositis and steatitis, limpet and satellite tag sites with isolation of multiple organisms including *Streptococcus uberis*
- Abscessed lymph node (with isolation of multiple organisms with primary *Streptococcus uberis)*
- Muscle and fascia – acute hemorrhage
- Degenerative myopathy, acute
- Intrabronchiolar mixed bacteria (bronchopneumonia or terminal aspiration (most likely)

Presentation 6

Early In-Field Experience Perspective

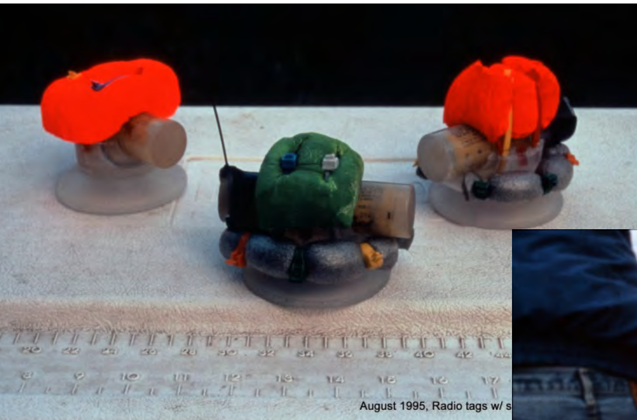
Barbara Mahoney, NMFS Alaska Region

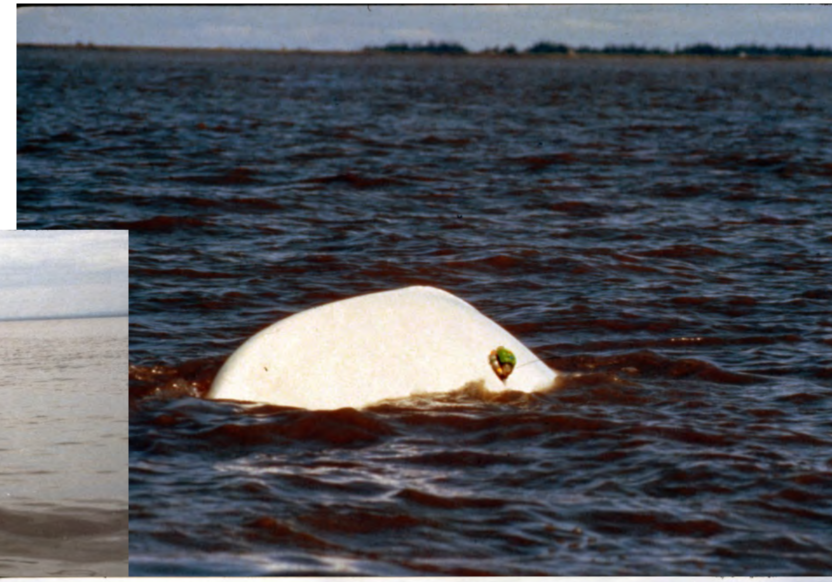
Cook Inlet Beluga Research Methods Workshop

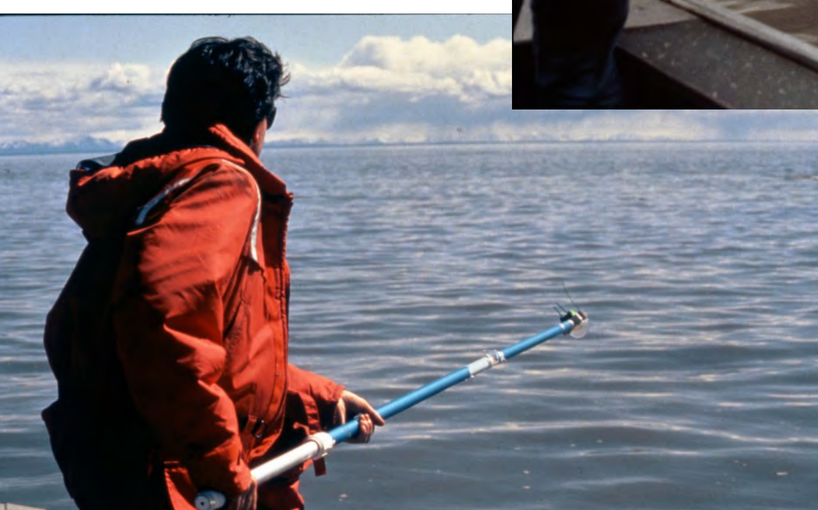
Early In-Field Experience Perspective

Cook Inlet   TIDES

Cook Inlet Beluga Suction Tags
July 1995







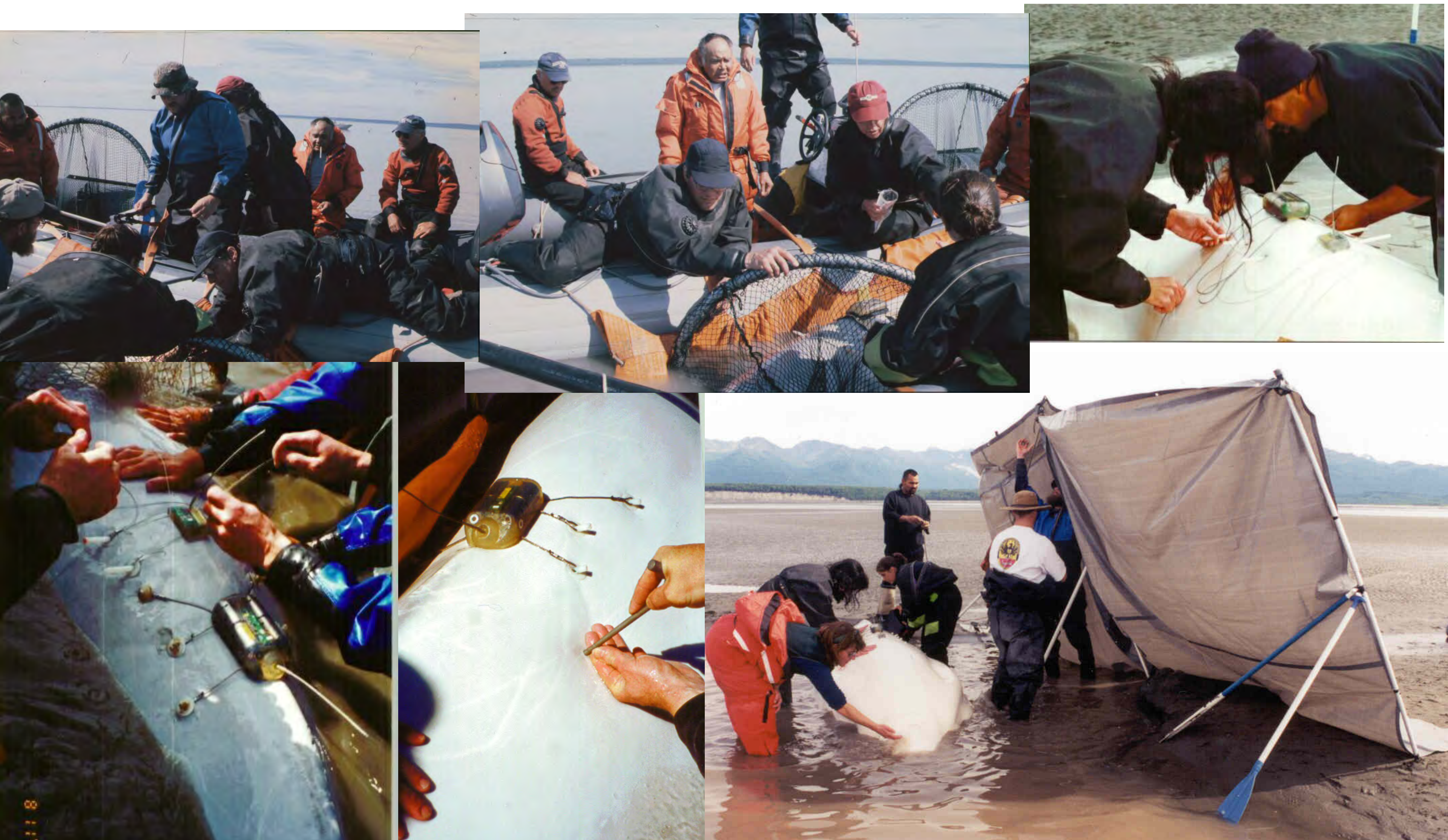
DAY	DATE	TIME	TIDE HT			Meet	boats in water	Retrieve	2nd Retrieve
	10-Aug-01	Sunrise	5:56 AM	Sunset	10:13 PM				
		7:30a	8.3						
Friday		8:00a	11.9	rising		7:00	7:45	15:00	19:30
		4:00p	10.1	falling					
		4:30p	7.9						
		8:00p	11.8	rising					
		10:00p	23.1						
	11-Aug-01	Sunrise	5:59 AM	Sunset	10:10 PM	Meet	boats in water	Retrieve	2nd Retrieve
		7:30a	3.6						
Saturday		8:00a	6.2						
		8:30a	9.3	rising		8:00	8:45	16:00	20:15
		5:00p	10.5	falling					
		5:30p	8.6						
		8:00p	8.4						
		8:30p	11.4	rising					
		10:00p	19.3						
	12-Aug-01	Sunrise	6:01 AM	Sunset	10:07 PM	Meet	boats in water	Retrieve	2nd Retrieve
		5:00a	11.3						
		5:30a	9.5	falling					
Sunday		9:30a	9	rising		8:45	9:45	17:30	21:00
		10:00a	11.7						
		6:00p	11.8						
		6:30p	10	falling					
		10:00p	14.9						
	13-Aug-01	Sunrise	6:04 AM	Sunset	10:04 PM	Meet	boats in water	Retrieve	2nd Retrieve
		6:00a	11.2	falling					
		6:30a	9.5						
Monday		11:00a	10.5	rising		10:00	11:00	19:00	22:00
		8:00p	10.2	falling					
		8:30p	9.2						
		9:00p	9.1						
		10:00p	10.9						
	14-Aug-01	Sunrise	6:07 AM	Sunset	10:01 PM	Meet	boats in water	Retrieve	2nd Retrieve
		7:00a	11.5						
		7:30a	9.7	falling					
Tuesday		8:00a	7.9			6:15	7:15	after 12:30	21:00
		12:00p	8.8						
		12:30p	11.3	rising					
		9:00p	11.2						
		9:30p	9.9	falling					
		10:00p	9.2						

DAY	DATE	TIME	TIDE HT			Meet	boats in water	Retrieve	2nd Retrieve
	29-Jul-02	Sunrise	5:26 AM	Sunset	10:47 AM				
Monday		7:00	10+			7:00	7:30	14:30	20:00
		7:30	14	rising					
		2:30	12	falling					
		7:30	10+						
		8:00	14+	rising					
		Sunset	26	rising					
	30-Jul-02	Sunrise	5:29 AM	Sunset	10:44 AM	Meet	boats in water	Retrieve	2nd Retrieve
Tuesday		8:00a	11+						
		8:30a	15	rising		7:45	8:15	15:00	20:30
		3:00p	13	falling					
		3:30p	11						
		8:00p	10						
		8:30p	13+	rising					
		Sunset	24+	rising					
	31-Jul-02	Sunrise	5:31 AM	Sunset	10:41 AM	Meet	boats in water	Retrieve	2nd Retrieve
Wednesday		9:00	11+			-			-
		9:30	14+	rising		8:30	9:00	16:00	21:00
		16:00	13+	falling					
		16:30	11						
		21:00	12+	rising					
		Sunset	23+	rising					
	1-Aug-02	Sunrise	5;34	Sunset	10:39 AM	Meet	boats in water	Retrieve	2nd Retrieve
Thursday		10:00	11+						
		10:30	14+	rising		9:45	10:15	17:30	22:00
		5:30	12	falling					
		9:30	11+						
		10:00	14+	rising					
		Sunset	16+	rising					
	2-Aug-02	Sunrise	5:36 AM	Sunset	10:36 AM	Meet	boats in water	Retrieve	2nd Retrieve
Friday		11:00	10+						
		11:30	12+	rising		11:00	11:30	19:00	22:30
		19:00	12+	falling					
		19:30	11						
		Sunset	12	rising					
	3-Aug-02	Sunrise	5:39 AM	Sunset	10:33 AM	Meet	boats in water	Retrieve	2nd Retrieve
Saturday		12:30	11+						
		13:00	13+	rising		12:30	13:00	20:30	12:00
		20:30	12+	falling					

Cook Inlet Beluga Satellite Tag
May 1999

Cook Inlet Beluga Satellite Tags
September 2000

Cook Inlet Beluga Satellite Tags
August 2001



Cook Inlet Beluga Satellite Tags
July - August 2002





Bristol Bay Satellite Tags
May 2002 - 2003

Presentation 7

Southern Resident Killer Whale L95 Case Review

Deborah Fauquier, D.V.M., Ph.D., NMFS Office of Protected Resources

L95 Case Review

Deborah Fauquier, NOAA, NMFS, OPR

Acknowledgements

- British Columbia, Ministry of Agriculture and Lands, Animal Health Center
  - Dr Stephen Raverty
- Department of Fisheries and Oceans:
  - Dr John Ford, Paul Cottrell, Lisa Spavin, Lara Sloan and many staff
- NOAA:
  - Dr Brad Hanson, Dr Teri Rowles, Lynne Barre, and many others
- SeaDoc Society:
  - Dr Joseph Gaydos
- Histopathology
  - Dr David Rostein
  - Dr K Colegrove
- Radiology:
  - Dr Sophie Dennison
  - Dr Tori McCleveen
- Molecular studies:
  - Dr Tracy Goldstein, UC Davis
  - Dr Karen Terio, University of Illinois
- Myocology
  - Dr Linda Hoang, BC CDC
- Members of the expert review panel

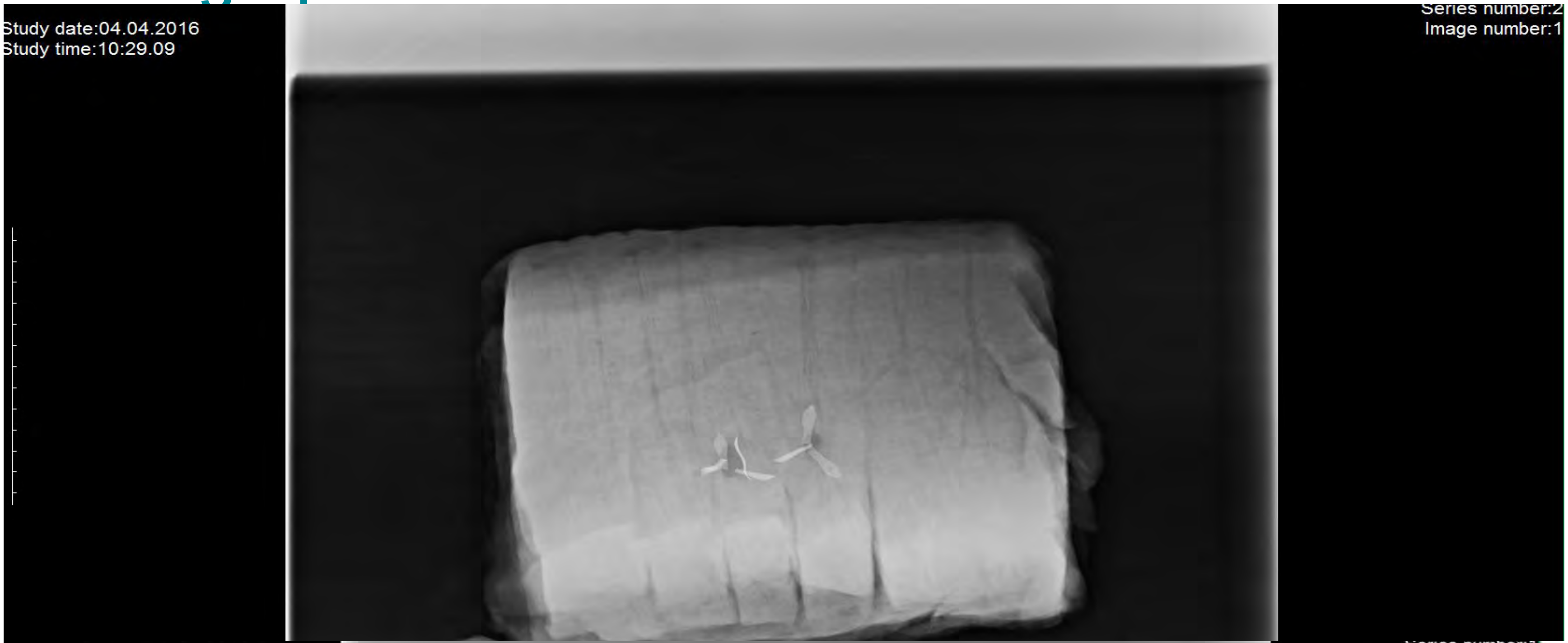
Background

- 20 year old adult male SRKW
- Tagged February 23, 2016 (LIMPET Tag)
  - No apparent abnormalities
  - First attempt missed, tag recovered from the water, disinfected in the field and redeployed
- Re-sighted Feb 25, 2016
  - Thin body condition
- Signal lost Feb 26, 2016
- Re-sighted alive Feb 27, 2016, no pictures of tag placement (signal loss presumed due to premature detachment)

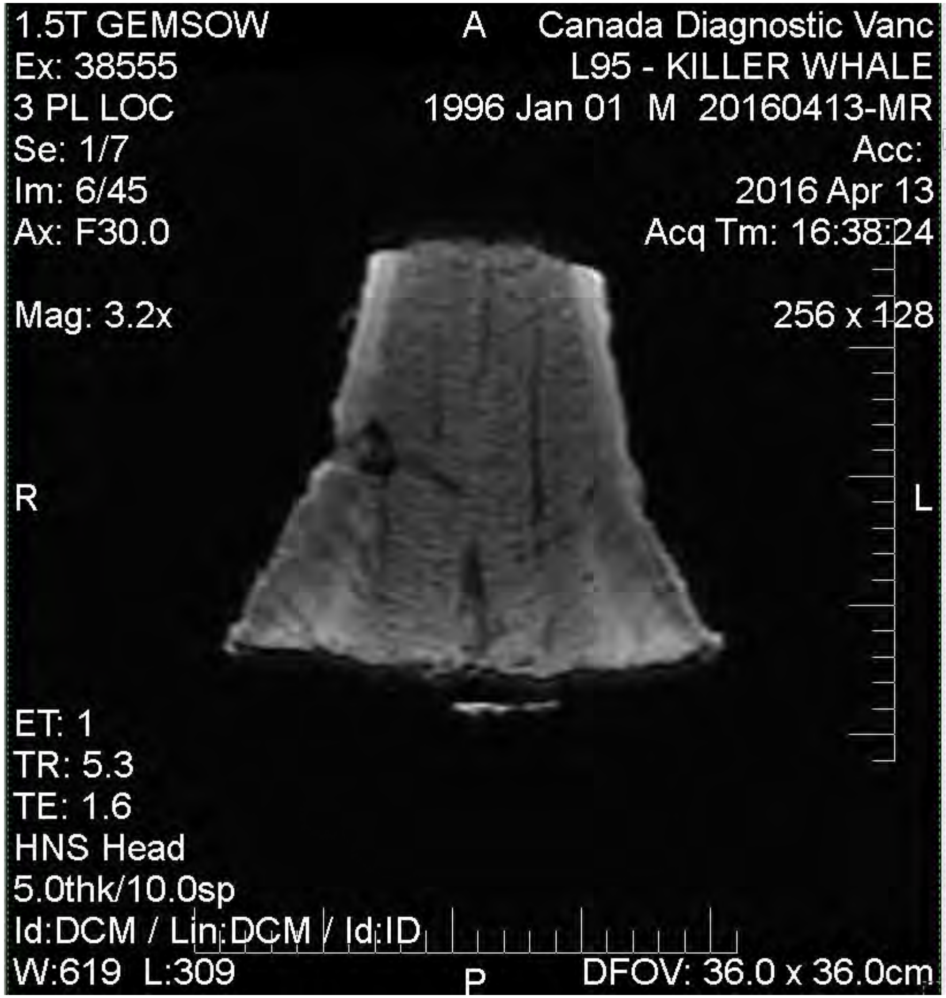
Necropsy L95

Found dead off west coast of Vancouver Island, BC, on March 30, 2016 (37 days post-day of tag deployment)
Necropsy April 1, 2016

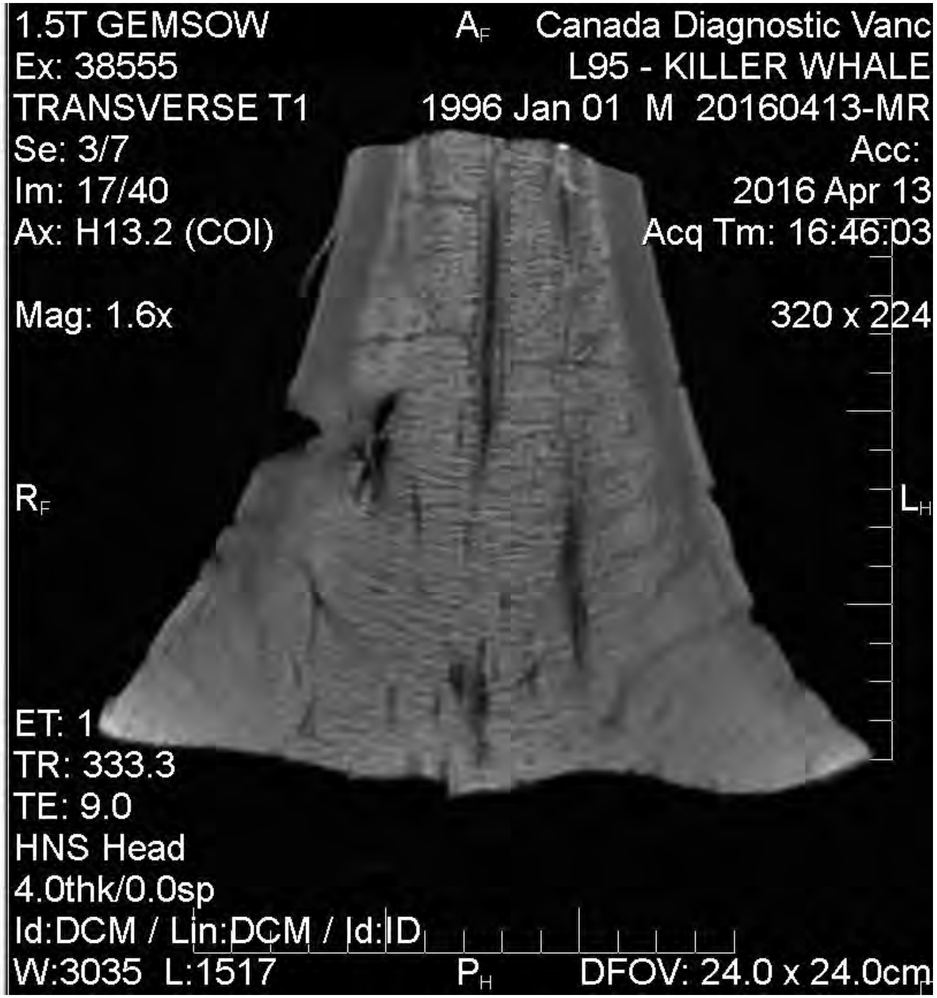
Radiographs



MRI Studies



1.5T GEMSOW
A
Canada Diagnostic Vanc
Ex: 38555
L95 - KILLER WHALE
3 PL LOC
1996 Jan 01 M 20160413-MR
Se: 1/7
Acc:
Im: 6/45
2016 Apr 13
Ax: F30.0
Acq Tm: 16:38:24
Mag: 3.2x
256 x 128
R
L
ET: 1
TR: 5.3
TE: 1.6
HNS Head
5.0thk/10.0sp
Id:DCM / Lin:DCM / Id:ID
W:619 L:309
P
DFOV: 36.0 x 36.0cm



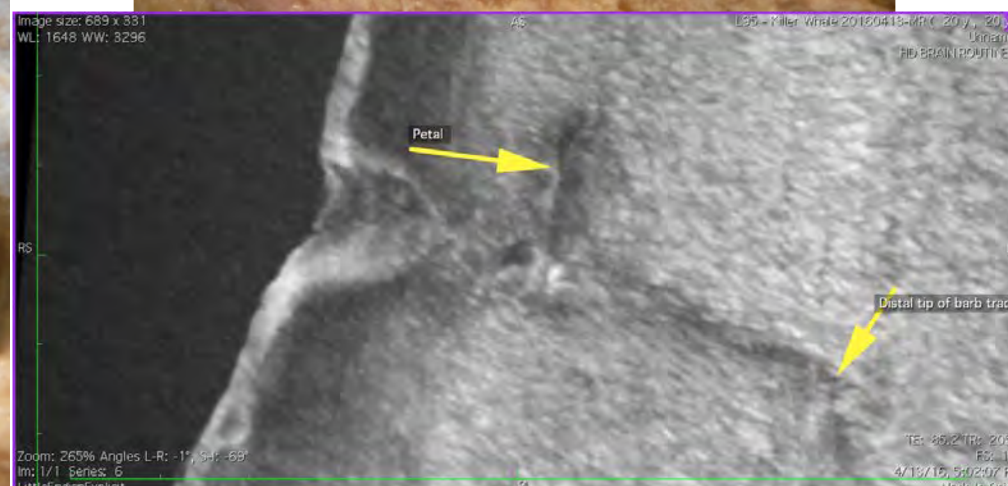
1.5T GEMSOW
A_F
Canada Diagnostic Vanc
Ex: 38555
L95 - KILLER WHALE
TRANSVERSE T1
1996 Jan 01 M 20160413-MR
Se: 3/7
Acc:
Im: 17/40
2016 Apr 13
Ax: H13.2 (COI)
Acq Tm: 16:46:03
Mag: 1.6x
320 x 224
R_F
L_H
ET: 1
TR: 333.3
TE: 9.0
HNS Head
4.0thk/0.0sp
Id:DCM / Lin:DCM / Id:ID
W:3035 L:1517
P_H
DFOV: 24.0 x 24.0cm

MRI Studies


Image size: 689 x 331
WL: 1648 WW: 3296
L95 - Killer Whale 20160413-MR (20 y , 20 y)
Unnamed
HD BRAIN ROUTINE-5
Distal tip of barb tract
Level of petals
Zoom: 265% Angles L-R: 0°, S-I: -70°
Im: 1/1 Series: 6
TE: 85.2 TR: 2050
FS: 1.5
4/13/16, 5:02:07 PM
Image size: 689 x 331
WL: 1648 WW: 3296
L95 - Killer Whale 20160413-MR (20 y , 20 y)
Unnamed
HD BRAIN ROUTINE-5
Length: 6.38 cm
Zoom: 265% Angles L-R: 0°, S-I: -68°
Im: 1/1 Series: 6
LittleEndianExplicit
TE: 85.2 TR: 2050
FS: 1.5
4/13/16, 5:02:07 PM
Made In OsiriX

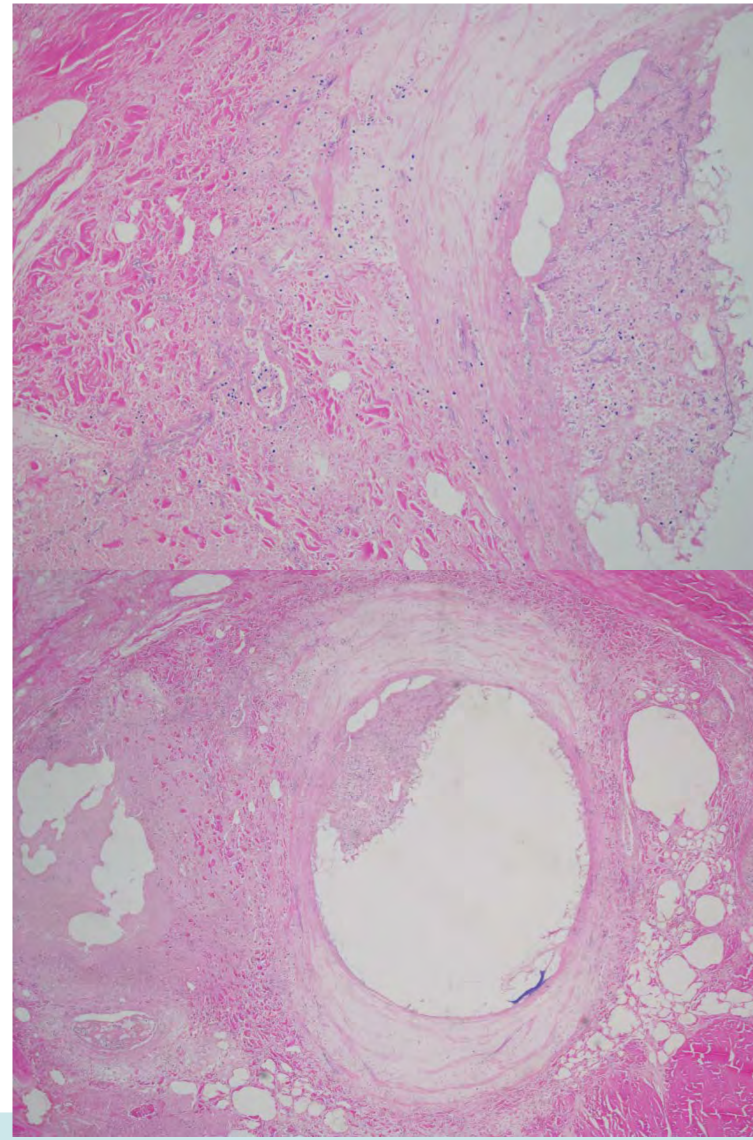
Gross Necropsy Dissection



Retained Petals

Histopathology Findings



- Transmural vasculitis with invasive fungal hyphae morphologically consistent with mucormycosis;
- Similar hyphae are evident within blood vessels and infiltrating adjoining tissue and airways in multiple lung sections (disseminated mucormycosis);
- Splenic enlargement, and acute peritonitis.

Expert Panel Findings

- In summary the expert panel determined that even though the killer whale presented in moderate to advanced decomposition at the time of necropsy there was sufficient evidence as determined by gross dissection, radiographs, MRI and histopathology of the tag site to implicate the tag attachment site as a source of fungal infection to the whale.
- This fungal infection contributed to illness in the whale and most likely contributed to its death. Additional contributors to death included the fungal bronchopneumonia, poor body condition and possible immunosuppression.

Predisposing Factors

- There were several factors in this case that may have predisposed this whale to a fungal infection at the tagging site including:
- incomplete disinfection of the tag after seawater contamination,
- retention of the tag petals which may have allowed for formation of a biofilm or direct pathogen implantation,
- placement of the tag lower on the body and near large bore vessels which increased the chance of fungal dissemination through the blood system,
- poor body condition,
- and possible immunosuppression.

Questions?

Presentation 8

Humpback whale deep implant tagging review

Alex Zerbini, Ph.D., NMFS Alaska Fisheries Science Center, Marine Mammal Lab / Cascadia Research Collective, and Frances Gulland, Vet MB, Ph.D., The Marine Mammal Center

LARGE CETACEAN IMPLANTABLE SATELLITE TAGS: ASSESSING IMPACTS AND IMPROVING DESIGNS THROUGH FOLLOW UP STUDIES WITH GULF OF MAINE HUMPBACK WHALES

Alex Zerbini – Cascadia Research Collective & MML-AFSC-NOAA

Frances Gulland – The Marine Mammal Center

Jooke Robbins – Center for Coastal Studies

- Russ Andrews (Marecotel, UAF)
- Virginia Andrews-Goff (AAD)
- Mark Baumgartner (WHOI)
- John Calambokidis (CRC)
- Phillip Clapham (MML-NOAA)
- Michael Double (AAD)
- Andreas Fahlman (WHOI)
- Nicholas Gales (AAD)
- Terry Hammar (WHOI)
- Melinda Holland (Wildlife Computers)
- Jason Kapit (WHOI)
- Amy Kennedy (MML-NOAA)
- Scott Landry (CCS)
- Andy Leask (Wildlife Computers)
- David Mattila (CCS/IWC)
- Rupak Rajachar (MTU)
- Douglas Sandilands (CCS)
- Greg Schorr (Marecotel)
- Jennifer Tackaberry (CCS)
- Shawn Wilton (Wildlife Computers)

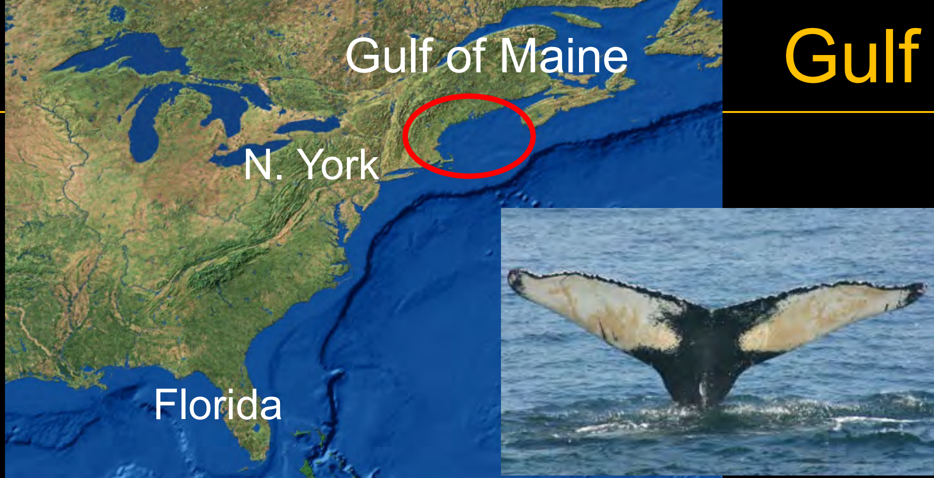
24 collaborators from 10 different organizations

The Gulf of Maine Study Objectives

- Deploy tags and follow tagged whales (Jul-Nov)
- Evaluate large whale tag deployment and tag design
- Characterize the range of responses to tags and tagging:
  - ✓ Behavioral effects
  - ✓ Wound healing
  - ✓ Physical/Physiological effects
  - ✓ Demographic effects
- Gather information on habitat use of GOM humpback whales

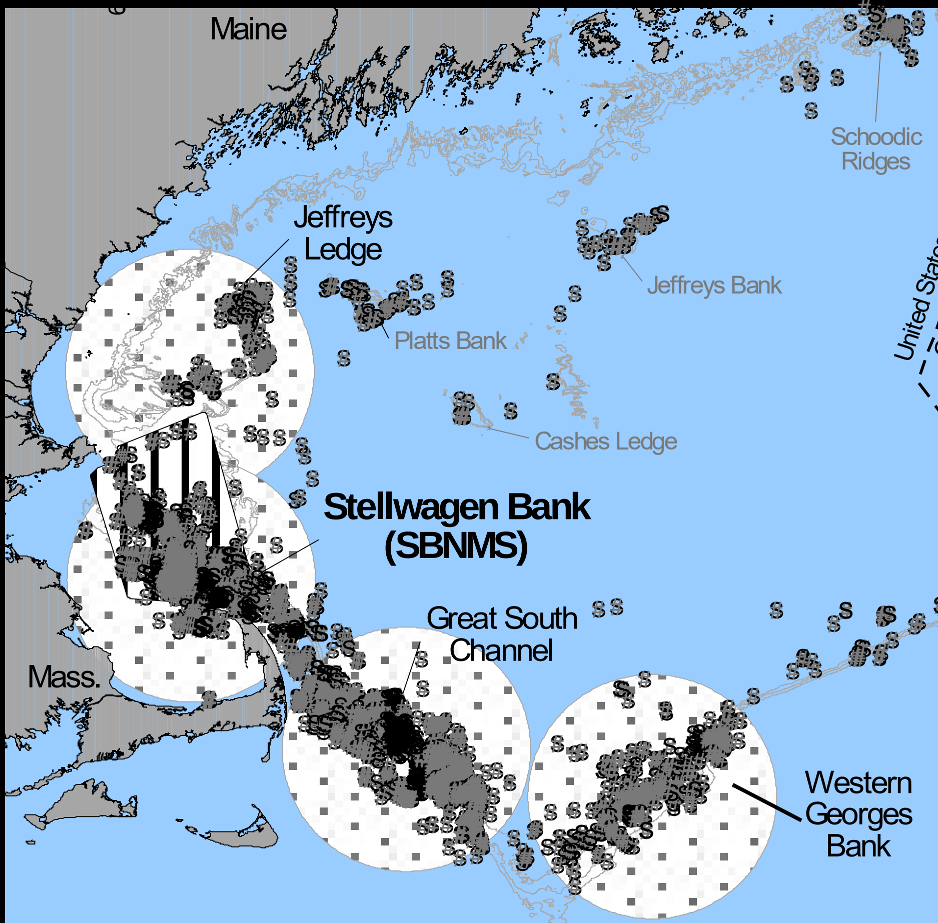
The Gulf of Maine Study Objectives

- Deploy tags and follow tagged whales (Jul-Nov)
- Evaluate large whale tag deployment and tag design
- Characterize the range of responses to tags and tagging:
  - ✓ Behavioral effects
  - ✓ Wound healing
  - ✓ Physical/Physiological effects
  - ✓ Demographic effects
- Gather information on habitat use of GOM humpback whales



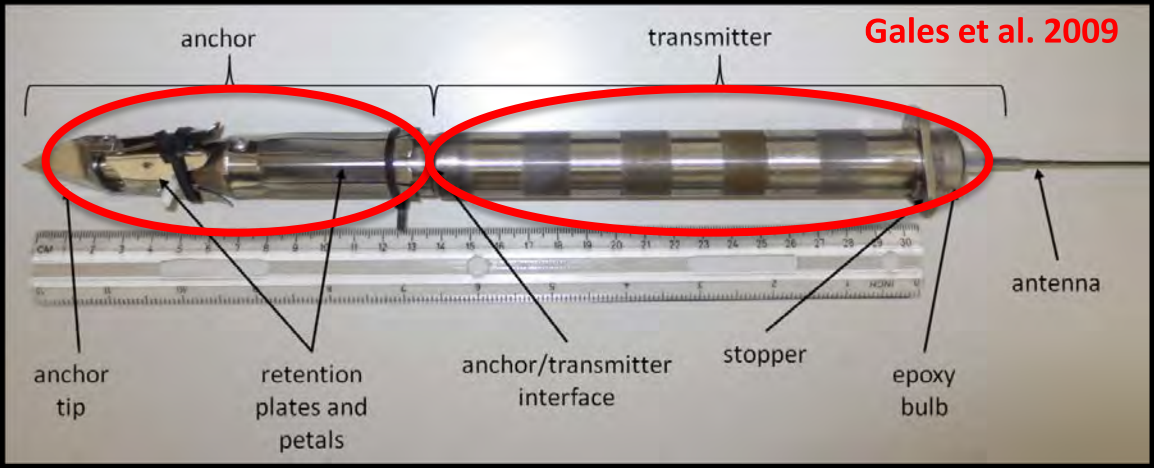
Gulf of Maine Humpback Whales

- Balanced study design: choice of animals
- Individual identification studies since 1970s
- Known sex, age, reproductive history, preferred habitats
- Long and predictable residency (April-December) near Cape Cod
- High rate of annual returns and multiple within-season re-sightings (~95%)
- Data collection from research vessels and collaborating naturalists on whale watching vessels



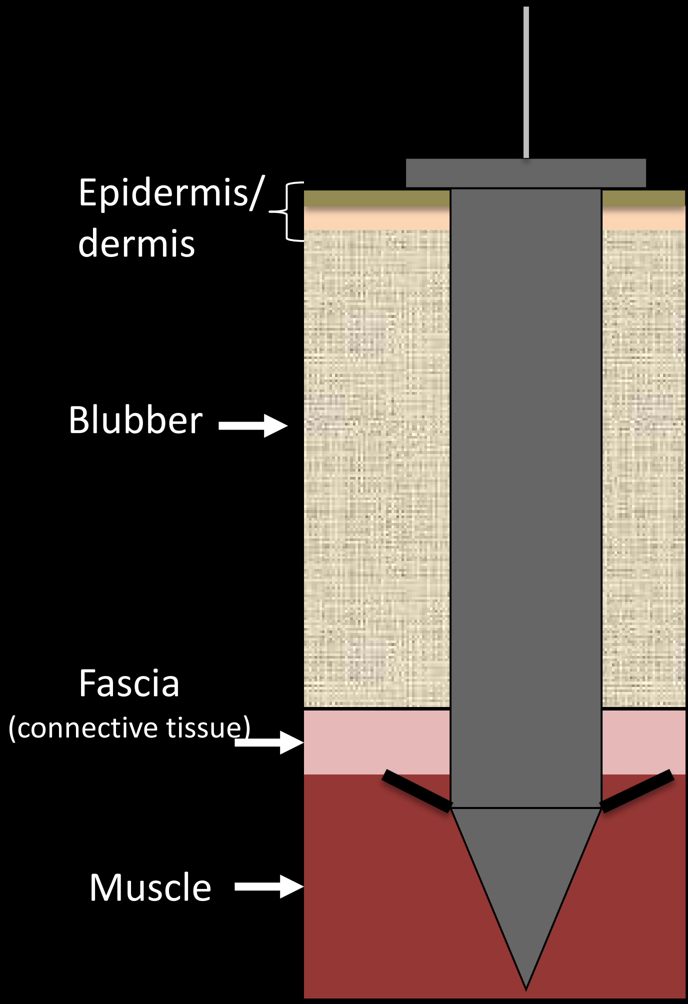
Tag Type

- “Implantable”, Type I (ONR, 2009), Type C (Consolidated)



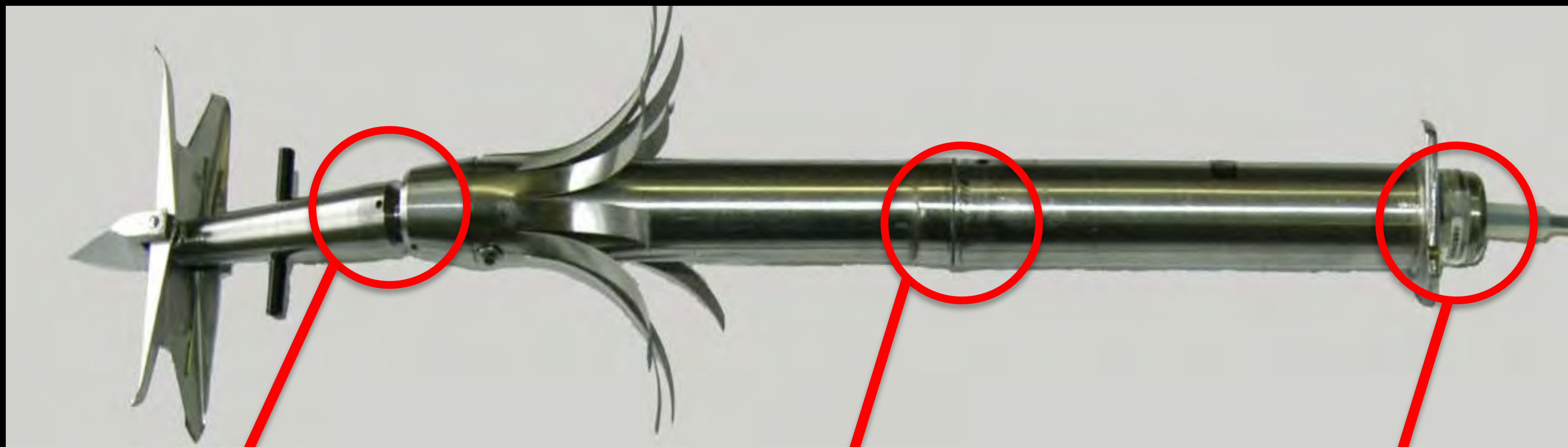
SS surgical quality
L: 22-30 cm, D: 20-24mm

Tag durations: median durations several weeks to months
Maximum durations: nearly 2 years



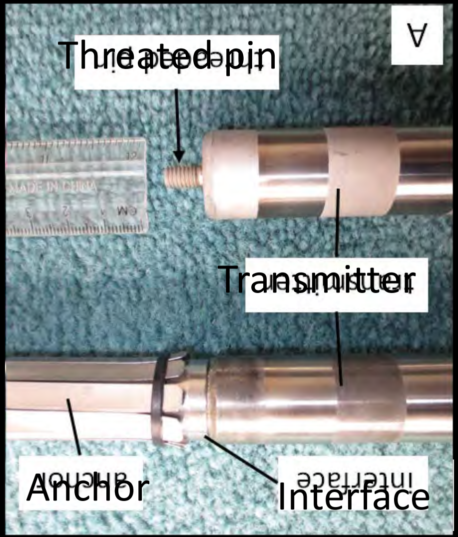
Tag Versions in the Gulf of Maine Study

- Articulated/Interfaced (Flawed)



ANCHOR ARTICULATION

ANCHOR/TRANSMITTER INTERFACE



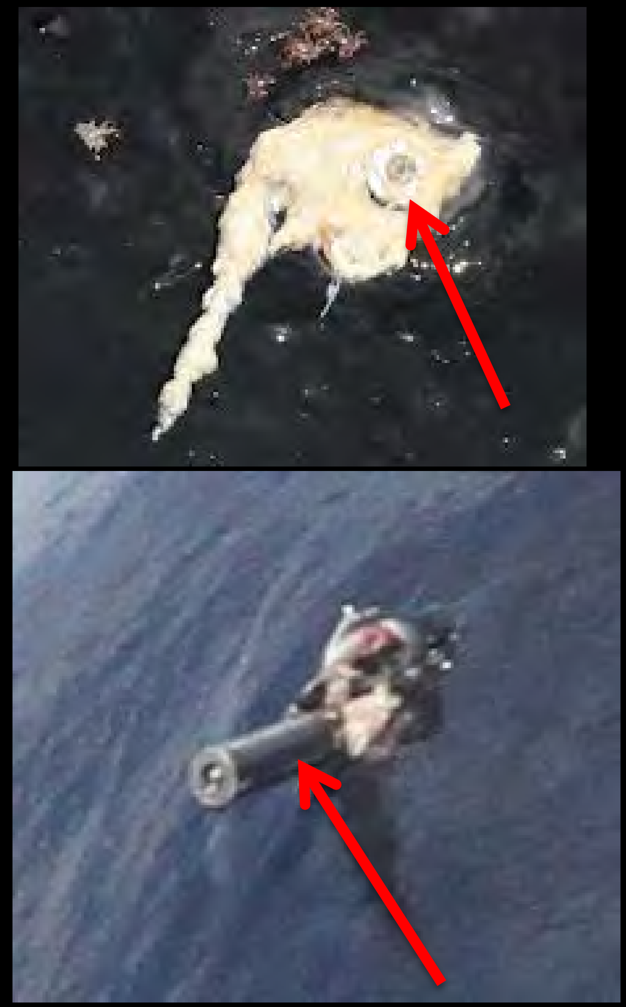
EPOXY BULB

Tag Versions in the Gulf of Maine Study

- Documentation of flawed elements

Anchor Articulation

Anchor/Transmitter Interface

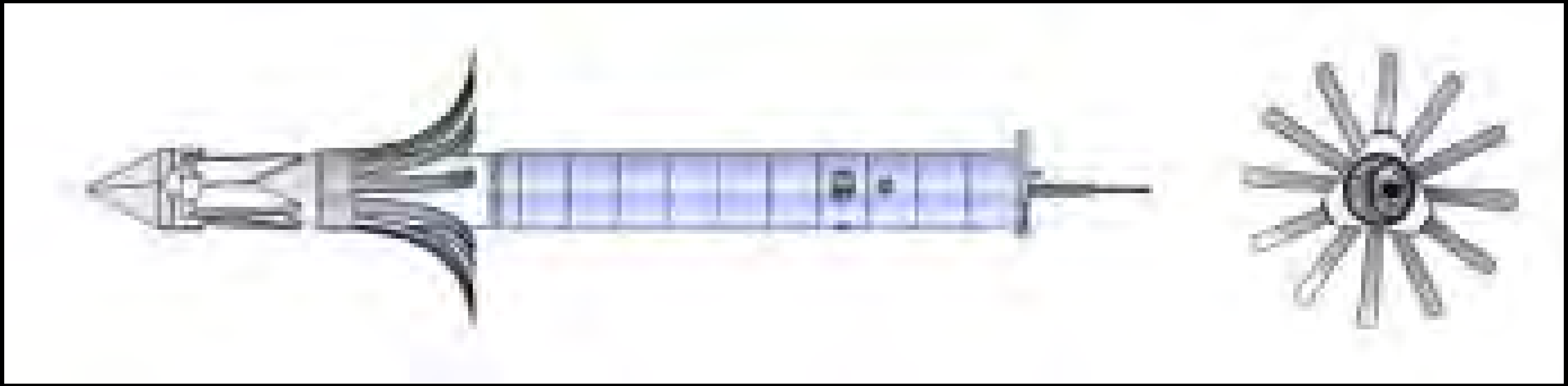


Epoxy bulb

Tag Versions in the Gulf of Maine Study

- Articulated/Interfaced (Flawed)

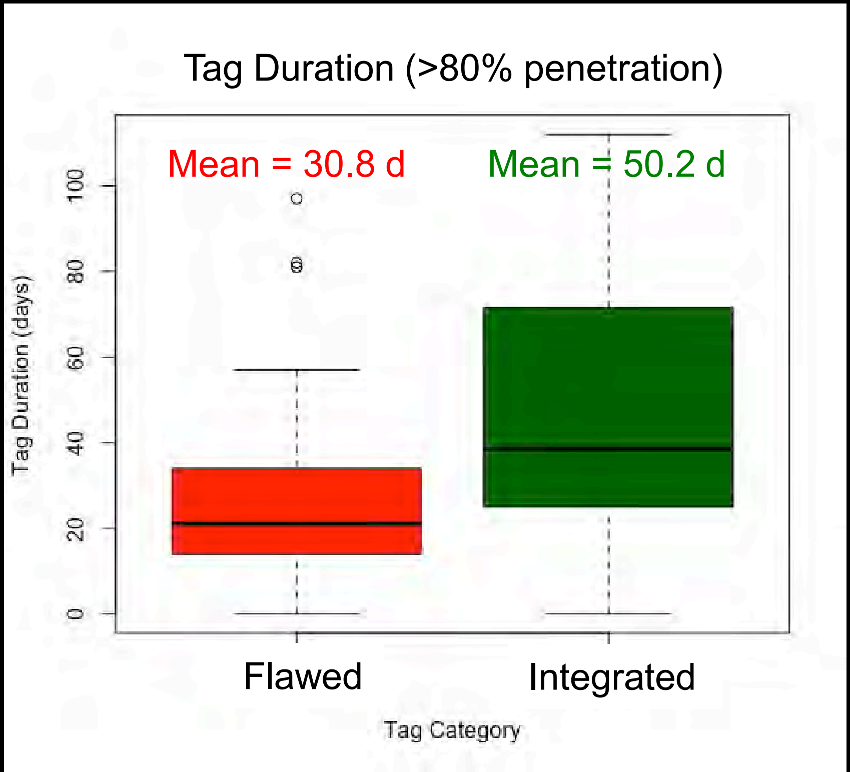
- Fully Integrated (flawed elements eliminated)



Integrated tags: improved performance

GLM – Factors Affecting Tag Duration

Model Parameter	Estimate	SE	*t* value	*p*-value
Intercept	4.306	0.718	5.994	**<0.001**
Tag type (integrated)	**1.466**	**0.617**	**2.375**	**0.021**
Sex (M)	0.997	0.643	1.551	0.127
Vertical placement (Upper)	1.266	0.683	1.853	0.069
% exposed	**-10.701**	**4.055**	**-2.639**	**0.011**



Sample sizes:

- 23 flawed tags
- 20 integrated tags

- Consequences of breakage of flawed elements

Large proportion of persistent lesions (e.g. swelling)

Retention of tag elements for extended periods

Scoring System for Photo Evaluation

Feature	Description	Score
Swelling	Localized, focal, under 30 cms diameter	1
	Regional, focal, over 30 cms diameter	2
	Irregular size and shape, over 30 cms diameter	3
Skin loss	Up to 1 cm diameter greater than size of tag cross section	1
	Up to 3 times tag diameter	2
	Larger than three times tag diameter	3
Exudate	Clear	1
	Blood	2
	Purulent	3
Tissue extrusion	Fresh tissue	1
	Necrotic tissue	2
Pigmentation change	Change in color of skin around tag site	1
Depression/divot	Diameter of tag or less	1
	Up to approx. 3 x tag diameter, shallow	2
	Significantly larger than tag diameter, deep	3
Cyamids in tag site	Within tag site margins	1
	Patch extending beyond tag site margins	2
Total score		

Change in overall qualitative state of tag site since the last photograph

0.5 = Improving
1 = Similar
2 = Worse

this qualifier helped identify times of change, and reexamination of photographs

Presence of tag, tag remnants noted

DATE_SIGHTED	ELAPSED DAYS	Swelling	Skin loss	Exudate	Tissue extrusion	Pigmentation change	Depression	Cyamids	Change	Tag visible notes
7/10/2011	0	0	0	0	0	0	0	0		yes
7/16/2011	6	0	1	0	0	0	0	0	1	no
7/19/2011	9	0	1	0	0	0		0	1	no
7/20/2011	10	0	1	0	0	0	0	0	1	no
7/25/2011	15	1	2	0	1	0	0	0	2	no
8/5/2011	26	2	2	0	2	0	0	0	2	no
8/8/2011	29	2	2		2	0	0	0	1	no
8/11/2011	32	2	2		0	0	1	0	0.5	Two photos on same day show tisue was sloughed this day
8/13/2011	34	2	2		0	0	1	0	1	no
8/17/2011	38	2	2		0	1	2	0	1	
8/18/2011	39	2	2		0	1	2	0	1	no
6/6/2012	332	2	2		0	1	2	0	1	overall body condition has declined
6/7/2012	333	2	2		0	1	2		1	no
6/8/2012	334	2	2		0	1	2		1	no
6/11/2012	337	2	2		0	1	2		1	no
6/12/2012	338	2	2		0	1	2		1	no
7/6/2012	362	2	2		0	1	2		1	no
7/7/2012	363	2	2		0	1	2		1	?
7/9/2012	365	2	2		0	1	2		1	
7/10/2012	366	2	2	3	0	1	2		2	only day exudate detected, looks purulent (white, opaque)
7/20/2012	376	2	2		0	1	2		1	
7/21/2012	377	2	2		0	1	2		1	
7/24/2012	380	2	2		0	1	2		1	
7/30/2012	386	2	1		0	1	2		1	
7/31/2012	387	2	1		0	1	2		1	
8/3/2012	390	2	1		0	1	2		1	
8/4/2012	391	2	x		0	x	x		1	

Effects of Angle


Differential appearance of a divot (above) and swelling (below) when viewed from different angles on the same day


Water Droplets, Light

Scale

Rings Marked on Tag Stem Invaluable

Insertion

Skin edges cut cleanly, usually everted, no hemorrhage, (blood droplets observed, discharges washed away rapidly), tag depth varied

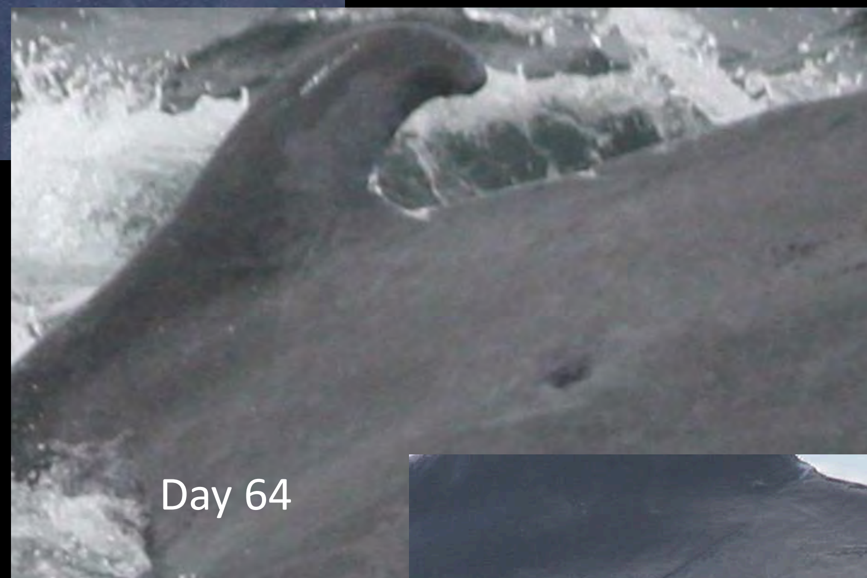
Skin Margins
Adherence to tag varies

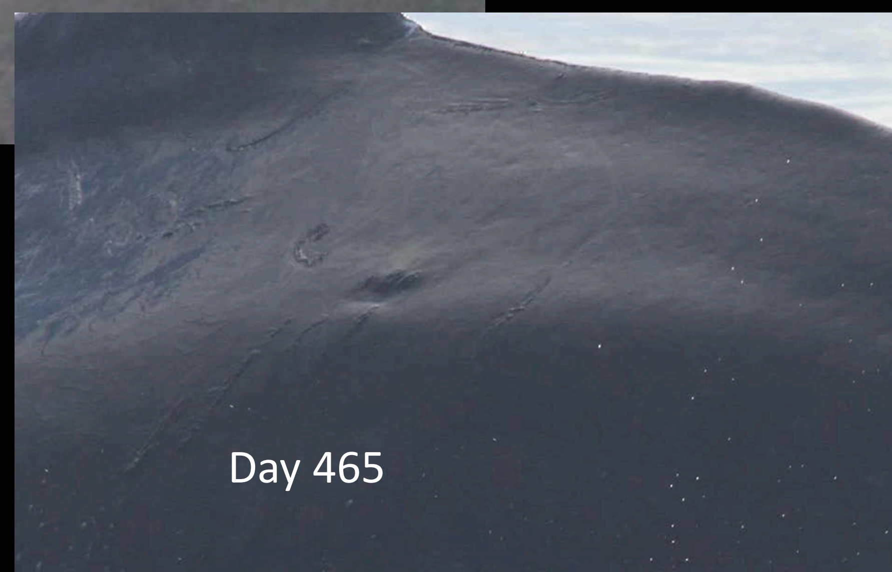
Skin wound margins increased 1-4 weeks post tagging,

1-3 times diameter of tag

Contraction of skin margin, skin depression prior to tag loss

Tag loss, skin healing, divot





Skin discoloration

Change in vasculature ?
Changes in skin slough rate?

Day 3-30, blubber loss, white appearance, rarely with discharge, no indication of purulent material or necrotic blubber

Regiona

Regional swelling

Hematoma?

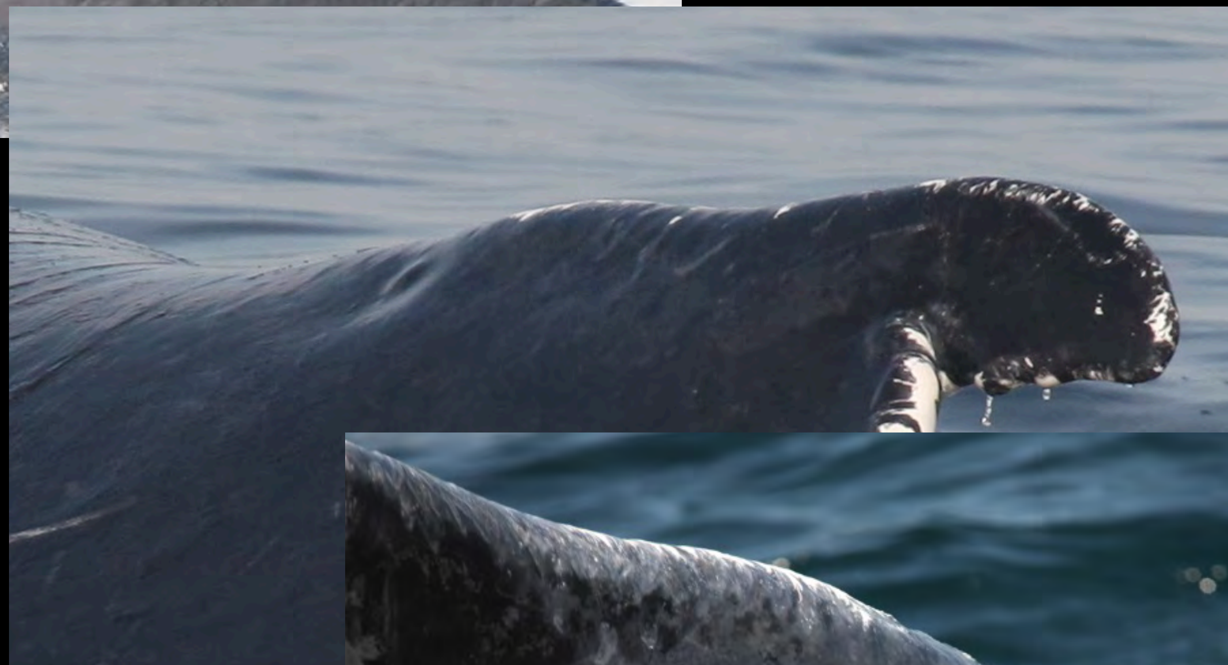
Foreign body reaction?

Abrasion of muscular fascia by tag remnant ?

2011 Tags – Anchor retention

- Swellings within days of insertion
- No hemorrhage, discharge, or progression in size
- 2-5 years later, bleb developed at site or within the swelling, anchor parts lost

Unusual case: Contralateral lesion



Quantitative Evaluation of Factors Affecting Swelling Severity

Proportional Odds Models

Model Parameter	Est.	SE	Wald z	p-value
Days Post Deployment	-1.459	0.303	-4.77	<0.001
Sex (Males)	-1.131	0.558	-2.02	0.042
Tag Type (Integrated)	-1.669	0.664	-2.51	0.012
Vertical Placement (Upper)	-2.714	0.586	-4.63	<0.001
Horizontal Placement (Central aft)	-1.483	0.703	-2.83	0.034
Horizontal Placement (Posterior)	-2.434	2.002	-1.21	0.224

Quantitative Evaluation of Factors Affecting Depression Severity

Proportional Odds Models

Model Parameter	Est.	SE	Wald z	p-value
Days Post Deployment	2.880	0.24 0	11.993	0.000
Sex (Males)	0.457	0.22 1	2.068	0.039
Tag Type (Integrated)	-0.448	0.30 7	-1.482	0.137
Vertical Placement (Upper)	0.774	0.24 1	3.213	0.001
Horizontal Placement (Central aft)	-0.904	0.36 0	-2.508	0.012
Horizontal Placement (Central forward)	-1.049	0.30 9	-3.399	0.001
Horizontal Placement (Posterior)	-0.696	0.86 6	-0.804	0.422

Male survival probability (CJS c-r model)

Apparent survival	Detection probability	Delta AICc	Model Likelihood	# Parameters
FLAWED	-	0.000	1.000	3
-	-	0.456	0.796	2
FLAWED	TAG	1.224	0.542	4
-	TAG	1.608	0.542	3
TAG	-	1.904	0.386	3

Models shown were those within 2 AICc units and therefore equally likely given the data. Parameters constraints considered: TAG=tagged whales differed from controls, FLAW= difference only occurred in 2011-2012 (years of breakage).

Female survival and calving probability (Multistate model)

Survival	Detection	Calving	Delta AICc	Model Likelihood	# Parameters
CALF	CALF	FLAWED	0.000	1.00	7
CALF	-	FLAWED	0.014	0.99	6

Models shown were those within 2 AICc units and therefore equally likely given the data. Parameters constraints considered: TAG=tagged whales different from controls, FLAW= difference only occurred in 2011-2012 (years of breakage), CALF = calving state.

Quantitative Evaluation of Demographic Effects

Calving probability

Conclusions

- Follow-up studies: important to assess tag robustness in field conditions and potential impacts of tagging.
- Use of invasive tags can result in effects to individual whales and to demographic parameters (calving).
- Resolution of tag flaws and use of robust designs significantly improved tag performance and minimized effects of tagging (minimized risk). Highlights the need for using robust and well tested methods.
- Studies are ongoing to assess potential improvements in the probability of calving the year after tagging.
- Further tag evaluation is continuing to assess recent technological improvements in integrated tags.

Acknowledgements

Funding Agencies:

Field assistance and data sharing: Bob Lynch, Lisa Sette (CCS) and Bill McClellan (UNCW). The Gulf of Maine whale watching community, especially: Blue Ocean Society, Boston Harbor Cruises, the Dolphin Fleet, New England Coastal Wildlife Alliance and Whale and Dolphin Conservation.

Research was performed under IACUC approval and NOAA permits 14245, 16325 and 633-1778.

Male survival

Group	Apparent survival	Detection probability
Tagged (n=22)	0.951* SE=0.032	0.962 SE=0.023
Control (n=30)	0.983 SE=0.013	0.952 SE=0.021

Female survival

Group	Apparent survival	Detection probability
No calf	0.999 (SE=<0.001)	0.988 (SE=0.007)
Calf	0.946 (SE=0.040)	0.957 (SE=0.024)

Presentation 9

Tagging Workshop summary and recommendations

Russ Andrews, Ph.D., Marine Ecology and Telemetry Research

CETACEAN TAG DEVELOPMENT, TAG FOLLOW UP and TAGGING BEST PRACTICES WORKSHOP
Silver Spring MD, September 6-8, 2017
Agenda

Day I

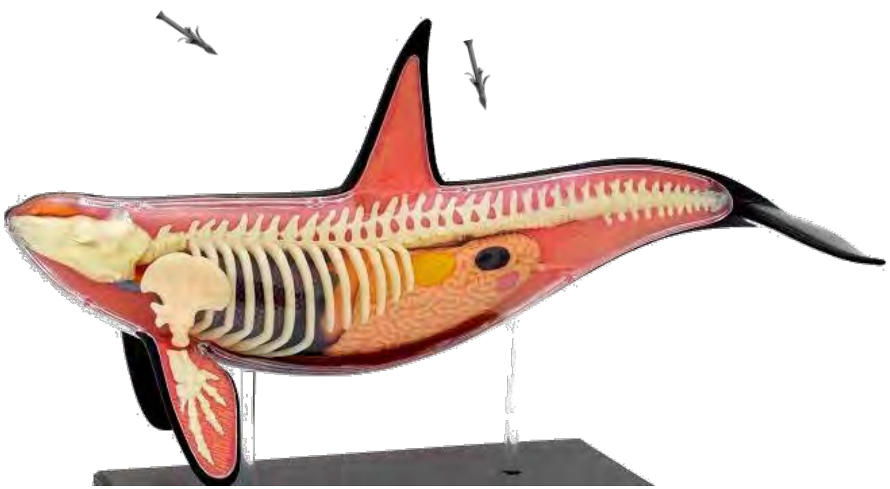
1. Registration (0800 – 0830)
2. Opening Remarks (0830-0915) (IWC, NOAA, ONR)
   a. Terms of Reference
   b. Expected outcomes
   c. Introduction of Chair and Rapporteurs
3. Tag Terminology (0915 – 0925) (Andrews)
4. Short presentations and brief plenary discussions (Day I, 0925-1730 and Day II, 0800-1000)
   a. **Invasive Tags**
      1. Presenters (each presentation should allow for 5 minutes of questions within their respective time allocation)

	Presenter	Time	Type
i.	Kleivane	(0925 – 0940)	Type C
ii.	Double	(0940 – 0955)	Type C
BREAK		**(0955 – 1010)**	Type C
iii.	Zerbini	(1010 – 1030)	Type C
iv.	Gulland	(1030 – 1045)	Type C
v.	Robbins	(1045 – 1100)	Type C
vi.	Mate	(1100 – 1120)	Type C
vii.	Norman/Calambokidis	(1120 – 1140)	Type C
viii.	Heide-Jorgenson	(1140 – 1200)	Type C / Type A
LUNCH		**(1200 – 1300)**	Type C / Type A
ix.	Minamikawa	(1300 -1315)	Type C / Type A
x.	Andrews	(1315 – 1335)	Type A
xi.	Schorr	(1335 – 1350)	Type A
xii.	Raverty	(1350 – 1405)	Type A
xiii.	Baird	(1405 – 1420)	Type A
xiv.	Calambokidis	(1420 – 1435)	Type A
xv.	Moore	(1435 – 1450)	Type A
xvi.	Balmer	(1450 – 1505)	Type B
xvii.	Wells	(1505 – 1525)	Type B
BREAK		**(1525 - 1540)**	
xviii.	Mulcahy	(1540 – 1555)	

   b. **Plenary Discussion** (1555 – 1730)

Tag types

Invasive

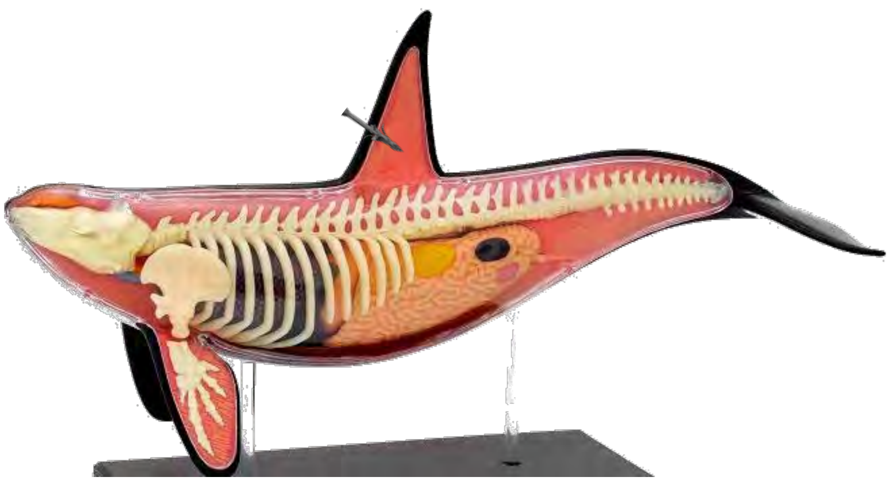


Non-invasive

Tag types

Invasive

Non-invasive

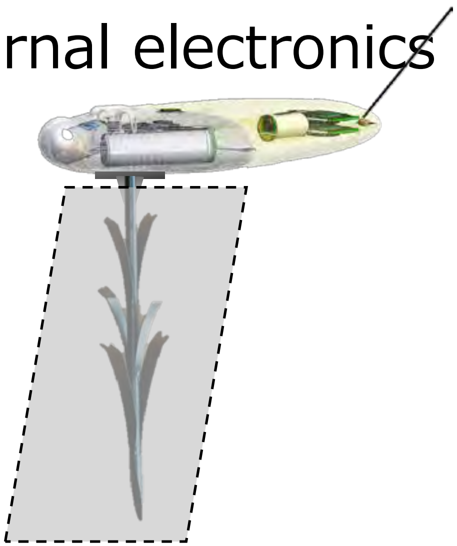


(Penetrating)

(Non-penetrating)

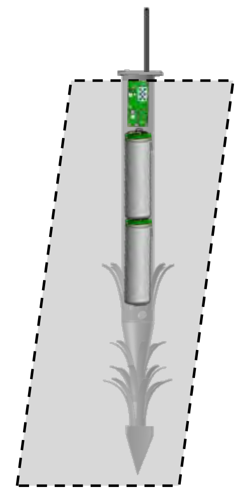
Invasive tag types

- External electronics

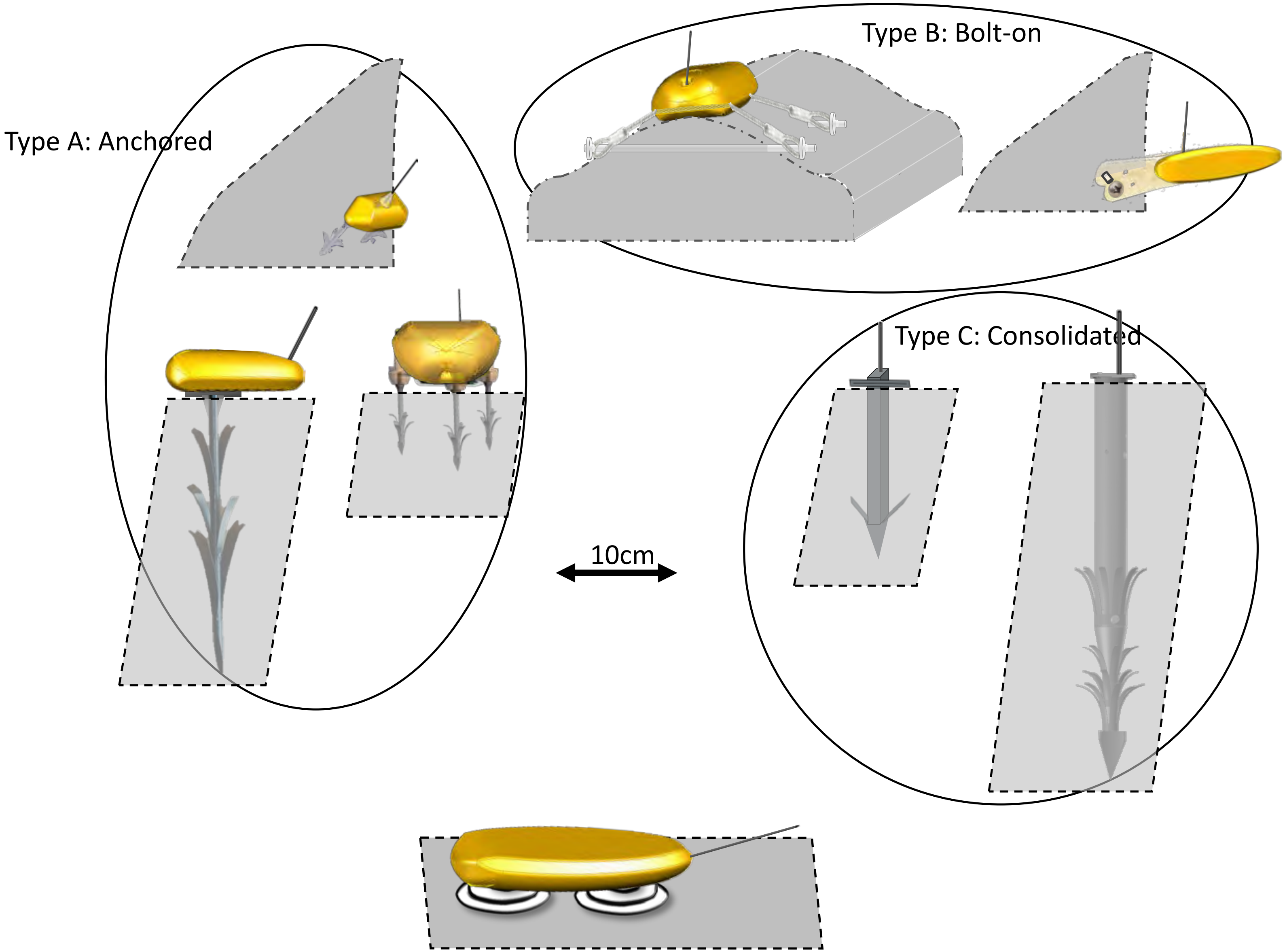


  - Type A: Anchored
  - Type B: Bolt-on

- Internal electronics



  - Type C: Consolidated



Type A: Anchored
Type B: Bolt-on
Type C: Consolidated
10cm

AGENDA for CETACEAN TAG DEVELOPMENT, TAG FOLLOW UP and TAGGING BEST PRACTICES WORKSHOP

Day II (0800-1600)

4. Continuation of presentations and plenary discussion (0800 – 1015)
    a. **Non-Invasive Tags**
        1. Presenters (each presentation should allow for 5 minutes of questions)
            i. Shorter (0800 – 0820)
            ii. Van der Hoop (0820 – 0835)
    b. **Future Advances**
        1. New materials / New approaches from biomedical field
            i. Rajachar (0835 – 0855)
    c. **Plenary Discussion** (0855 – 1015)

5. **BREAK** (1015-1030)
6. 'Cetacean Tagging Best Practices Guidelines' (1030 – 1230)
    a. Outline of process for review, revision, publication of Guidelines
    b. Review of draft of Guidelines content
    c. Initial discussion of Guidelines
7. **LUNCH** (1230 – 1330)
8. Breakout groups (Group 1: Tag users and Follow-up. Group II: Vets) (1330 – 1730).
    Only those workshop participants that are actively deploying or designing tags, involved in follow-up, or are veterinarians are invited to the breakout group. Other attendees that are not tag users/developers or veterinarians may skip the afternoon session and return on Day III at 0900 when summaries of breakout group discussions will be presented.

Cetacean Tagging Best Practice Guidelines

Russel Andrews, Robin Baird, John Calambokidis, Caroline E.C. Goertz, Frances Gulland, Mads Peter Heide-Jorgensen, Sascha Hooker, Mark Johnson, Bruce Mate, Yoko Mitani, Doug Nowacek, Kylie Owen, Ann Pabst, Lori Quakenbush, Stephen Raverty, Jooke Robbins, Greg Schorr, Olga Shpak, Forrest Townsend, Marcela Uhart, Randy Wells, and Alex Zerbini (affiliations at end).

Abstract

1. Introduction

1.1 Approach

2. Key Topics and Recommendations

2.1. Ethical and Legal Considerations of Tagging

2.1.1 Recommendations re ethical and legal considerations of tagging:

2.2. Tag design and deployment

2.2.1 Invasive tags

2.2.2 Non-invasive tags

2.2.3 Choice of tag type

2.2.4 Tag Design

2.2.5 Sterilization

2.2.6 Tag operation

2.2.7 Tag deployment

2.2.8 Identification of tagged individuals

2.2.9 Development of new equipment and methods

2.2.10 Recommendations re tag design and deployment:

2.4 Capture-release and tagging of restrained animals

2.4.1 Rationale for capture-release

2.4.2 Methods for capture-release

2.4.3 Recommendations for capture-release:

2.4.4 Recommendations for restraint and handling:

2.5 Training/qualifications of personnel

2.5.1 Importance of training for remote tagging

2.5.2 Importance of training for capture, handling, tagging, and release

2.5.4 Recommendations for training of taggers:

2.5.5 Recommendations for training of boat drivers:

2.5.4 Recommendations for training in capture, handling, and release methods:

2.6 Selection of candidates for tagging

2.6.1 Conservation status

2.6.2 Timing

2.6.3 Age class

2.6.4 Physiological status and health

2.6.5 Multiple tags

2.6.6 Recommendations re selection of candidates for tagging:

2.7 Assessing effects with effective follow-up studies

2.7.1 Designing an effective follow-up study

2.7.2 Recommendations re assessing effects with effective follow-up studies:

2.8Reporting and data sharing

2.8.1 Recommendations re reporting and data sharing:

3. References

Table 1. Ultimate causes of lack of transmissions from VHF or UHF (satellite-linked) tags. Possible proximate causes of each category of unexpected failure are also provided, along with signs or sequelae that may be observed in previously transmitted messages or in photographs or follow up field observations (some may be obvious, like broken dart shafts, others inferred from visual signs, such as purulent discharge suggesting infection, or even less obvious signs, such as swelling).

Ultimate cause	Proximate cause		Notes re: Signs or consequences
Undetermined	Any of the below		In most cases, transmissions are suddenly lost with no warning messages and no resightings of the tagged animal. The evidence from follow-up studies is that this is rarely because of mortality. Therefore, dedicated follow-up studies can be critical for diagnosing problems and improving tag design and deployment methods.
Tag electronics failure	Battery failure		Unexpectedly low battery voltage or high rate of decreasing voltage
	Antenna breakage		Poor signal strength or visual confirmation of frayed or broken antenna
	Wet-dry sensor fouling or breakage		Unexpectedly high rate of transmissions due to transmission underwater (in most cases, corrosion or biofouling will increase the resistance between the electrodes, mimicking emersion).
	Firmware bug		Unlimited variety of disappointing revelations.
Tag attachment failure (tag loss)	Improper attachment		Retention elements fail to implant at all or to an adequate depth, or tag fails to attach to the desired target anatomic location (due to animal behavior, environmental conditions, operator issues, or other challenges of deploying onto moving animals from unstable platforms).
	Failed attachment	Migration of bolt, pin or rod	In Type B tags, if attachment rod(s) migrate caudally through dorsal fin tissue, drag may increase dramatically, resulting in progressive changes swimming and dive behavior.
	Mechanical breakage	Tag package breakage	Lacking visual confirmation, fractures can result in water intrusion which may manifest in unexpected sensor readings, accelerated battery voltage decline, or just sudden electronics failure.
		Implanted element breakage	Retention of observable parts after tag loss. Migration to the surface may take weeks to years. Type A: visual evidence of retained dart shafts snapped or separated from electronics package; Type B: pierced elements (e.g. bolts/pins/rods) snapped or connections to tag severed. Type C: anchors separated from main tag package.

	Typical foreign body response		Wound margins well delineated and even with adjoining skin, healthy granulation tissue visible at surface; typically results in complete wound healing, although in some species, repigmentation of the tagged area may not occur.
	Secondary infection		Swelling and retraction of the penetrating site margins, dependent swelling, blood or discharge either overlying or draining from the tag site and secondary effects, such as loss of condition and potential behavioral changes.
	Large external force		Wound and surrounding epidermis may appear similar to normal foreign body response; in some cases, retention elements can leave tell-tale scratch marks, or cause unusual wound margins. Recovered tags can also show evidence of being scraped against another animal or some object, including the seafloor.
Mortality	Natural		Possibly unusual movement or other behaviors leading up to time of death; body temperature sensors may reveal abnormally high temperature due to inflammation, infection or an unexplained cause of hyperthermia.
	Tag-related	Puncture of bone or internal organ	Depending on the extent of injury, organ involved and possible secondary microbial invasion, clinical signs may be inapparent on external exam or there may be swelling or depression and discharge from tag site, subcutaneous swelling within the vicinity of the penetrating wound, loss of nutritional condition, difficultly with swimming and other factors. Never reported in tagged cetaceans.
		Introduction of secondary infection	Likely not to be confirmed without carcass recovery and thorough necropsy. Taggers should coordinate with stranding networks regarding the species and site location of tags so they can be assessed during stranding responses. Based on external lesions alone, it is difficult to infer either a localized abscess or granuloma at the tag site, versus widespread or systemic infection. Overall nutritional condition, activity and behavior prior to death may provide clues to the health status of the animal.
		Entanglement	We are unaware of any occurrence in cetaceans, but anecdotes from fish tagging studies have been reported
		Tag-induced predation	Never reported in cetaceans, but uncommonly observed in fish studies. This should be considered if contemplating the attachment of ultrasonic tags to cetaceans that are prey of other cetaceans.

* The causes of loss of transmissions listed above are not mutually exclusive and there may be multiple issues that occur either simultaneously or in succession after tag deployment

Day III (0800 – 1600)

10. Continuation of Breakout group (0800-0900)
11. Summaries by break-out group rapporteurs (0900-930)
12. Plenary discussion of breakout group topics, including feedback on Guidelines (0930 – 1230)
13. LUNCH (1230 – 1330)
14. Continuation of plenary discussion (1330 – 1430)
15. Research recommendations and future directions (1430-1500)
16. Agreement on Guidelines revision (1500– 1545).
17. Concluding remarks and plan for workshop report composition (1545-1600)
18. ADJOURN (1600)

Decision process

In principle:

- Short- and long-term objectives clearly specified
- Weigh up overall benefits against costs (multiple factors incl. status)
  - e.g. risk to individuals/benefits to populations
- Likelihood of success
- Is tagging the most appropriate method?

→

Practicalities:

1. Tag options
2. 'Delivery' options
3. Area and time
4. Sample size (failure rate, etc.)
5. Candidates age- sex- health etc. relate to objectives
6. Tagging protocols to minimize disturbance and maximize chances of success
7. Experienced team
8. Focused follow-up studies on 'effects' to inform future work

→

Phased and iterative approach:

1. Feasibility – existing data or if necessary in other areas
2. Review results
3. New/revised priorities/approach
4. Focused further studies
5. STOP when sufficient

2.2.5 Sterilization and maintenance of sterilization

All implanted parts of a tag must be thoroughly cleaned of chemical contaminants (such as machining oils) and then sterilized before implantation.

Sterilization Options:
Gas sterilization with ethylene oxide (EtO)
Chemical sterilants include hydrogen peroxide, peracetic acid, glutaraldehyde, and hydrogen peroxide/peracetic acid mixtures.

The sterility of the implanted parts of a tag should be maintained until deployment.

If the penetrating elements of the tag become majorly contaminated (e.g. implant parts come into direct contact with nonsterile surfaces tagging attempt that missed the animal, tag falls into the boat,), **they should be re-sterilized prior to use**. In the event of exposure to air only, assuming implantable portions of the tag have remained covered and therefore protected from spray/blow, tags may be re-packaged in a sterile wrapper or container for use during a given day but should be treated with high level disinfection (HLD) that evening prior to use the next day.

Presentation 10

Physiological stress responses in odontocetes

Frances Gulland, Vet MB, Ph.D., The Marine Mammal Center


Overview of Stress in Cetaceans

Stress:

An organism's response to a noxious factor (”stressor”) that aims to restore homeostasis

e.g. Adrenal release of catecholamines in a male monkey fighting for social rank

Allostatic load:

Cumulative impact of repeated stress responses

e.g. Atherosclerosis in male monkeys due to elevated blood pressure in response to increased catecholamines

- Selye 1975 Eustress/Distress; Sapolski Allostasis
- Mild – activate cellular mechanisms
- Moderate/Severe – activate neuroendocrine responses
- Acute (short) – neural
- Chronic (long) - endocrine

Stress Response

- Neural axis (seconds)
  - Direct activation of sympathetic nervous system

    Neuromuscular system
- Neuroendocrine (minutes)
  - Brain (amygdyla, hippocampus)

    Spinal cord, adrenal medulla, catecholamines
- Endocrine (hours, days, weeks)
  - Hypothalamus, pituitary

    ACTH: adrenal cortex: cortisol, aldosterone

    TSH: thyroid: T3/T4

    Growth hormone

    ADH: renin angiotensin,

    Oxytocin
- Cellular (seconds to weeks)
  - Upregulation of oxidative stress pathways
  - Altered telomerase activity

Cumulative Impacts

- Stressors activating common pathways usually synergistic, increasing intensity and/or duration of response
- Stressors activating different pathways usually additive
- Complex feedback mechanisms exist, altering gene expression, hormone production and secretion, neural activity

Effects
Epinephrine/Norepinephrine (Adrenaline/Noradrenaline)

Neural

- Increased heart rate
- Increased blood pressure
- Bronchodilation
- Smooth muscle contraction

  uterus, sphincters
- Changes in blood flow to decreased digestion, urine output
- Gluconeogenesis
- Increased metabolic rate

Neuroendocrine

- Adrenal release of epinephrine, norepinephrine

  all neural effects
- Modulation of immune system

Effects
Endocrine

<u>Cortisol</u>

- Increased gluconeogenesis
  - Protein, fat breakdown
- Immune suppression
- Altered hippocampal activity
- Decreased neural plasticity

<u>Oxytocin</u>

- Uterine contraction
- Milk let down

<u>Aldosterone</u>

- Water, sodium retention
- Increased blood volume

<u>Thyroxine</u>

- Increased metabolic rate
- Control of moult

<u>Growth hormone</u>

Cetaceans & Catecholamines

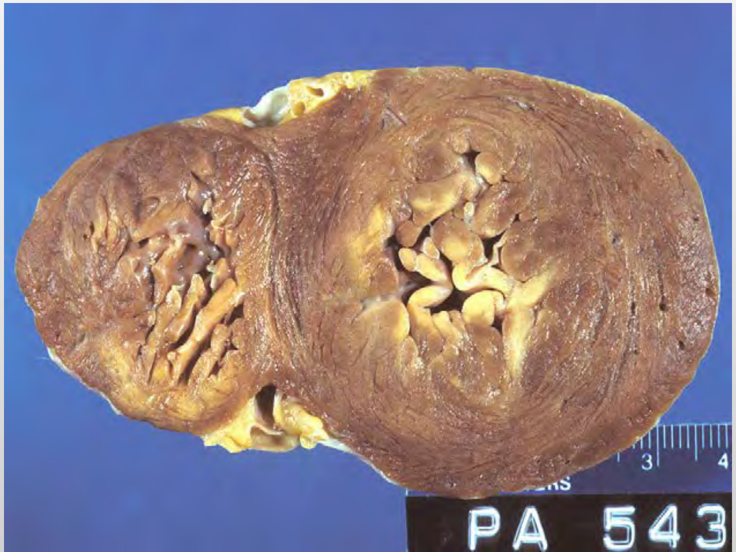
- Increased dopamine levels in *Stenella* post chase in tuna fishery

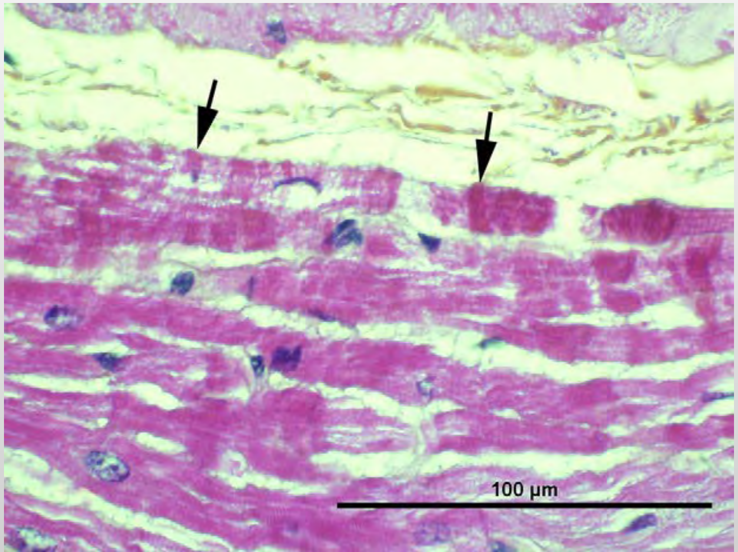
  St Aubin et al 2013
- Increased levels in beluga post capture and transport

  St Aubin and Geraci 1990, Spoon and Romano 2012
- Increased blood levels in beluga exposed to noise

  Thomas et al 1999, Romano et al 2004
- Surge in blood levels suggested as cause of cardiomyopathy observed in dead odontocetes

  Turnbull and Cowan 1998, Cowan and Curry 2008; Herráez et al 2013





Cetaceans and Cortisol

- Chase and capture increases blood levels in *Tursiops, Beluga*
  Thomson & Geraci 1986; St. Aubin and Geraci 1988 & 1992; Orlov et al 1988, Fair et al 2014
- *S*tranding causes four fold increase in blood levels in pilot whales
  Geraci and St Aubin 1987
- Lack of exposure to ship noise lowers fecal cortisol and metabolites in North Atlantic Right Whale feces *Rolland et al 2012*
- Cold exposure increases blood cortisol in *Tursiops* *Houser et al 2011*

Other Hormones

- Thyroid hormone levels in *Tursiops* *Fair et al 2011*
- Cold exposure increases aldosterone in *Tursiops*

  Houser et al 2011
- Seasonal changes in fecal thyroid hormones in Southern Resident Killer Whales

  Ayres et al 2012

Stress in Cetaceans
Unknowns,
Potential Life History Consequences

- Effect on growth
  - Cortisol, thyroid, growth hormones alter lipid metabolism, gluconeogenesis, moult
  - Oxidative stress alters fat metabolism, immunity, telomerase activity
- Effect on reproduction
  - Catecholamines cause uterine contraction, abortion
  - Oxytocin can cause premature parturition, alter milk let-down
- Effect on mortality
  - Catecholamines can cause acute cardiomyopathy
  - Decreased immunity increases susceptibility to infectious disease
  - Toxins interact cumulatively via oxidative stress pathways

Presentation 11

Measures of stress response in odontocetes and its implications

Tracy Romano, Ph.D., Mystic Aquarium

MYSTIC AQUARIUM
RESEARCH

Measures of the Stress Response and its Implications

Cook Inlet Beluga Research Methods Workshop

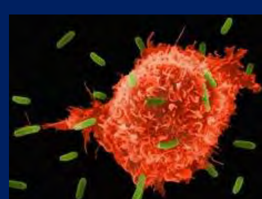
November 29 – 30, 2017

Nutrition Noise Contaminants Environment Toxins

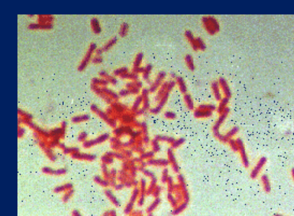
IMMUNE SYSTEM

PATHOGEN EXPOSURE

↓



INFECTION



↓

DISEASE

Aquarium – Controlled Conditions

Live Capture-Release

Subsistence Harvest

Hormones:

- Norepinephrine, Epinephrine, Dopamine
- ACTH, Cortisol, Aldosterone, Thyroid Hormone, Reproductive Hormones

Immune Function:

- Phagocytosis and Respiratory Burst
- Lymphocyte Proliferation
- Lymphocyte Subsets
- CBCs, Serum Chemistries

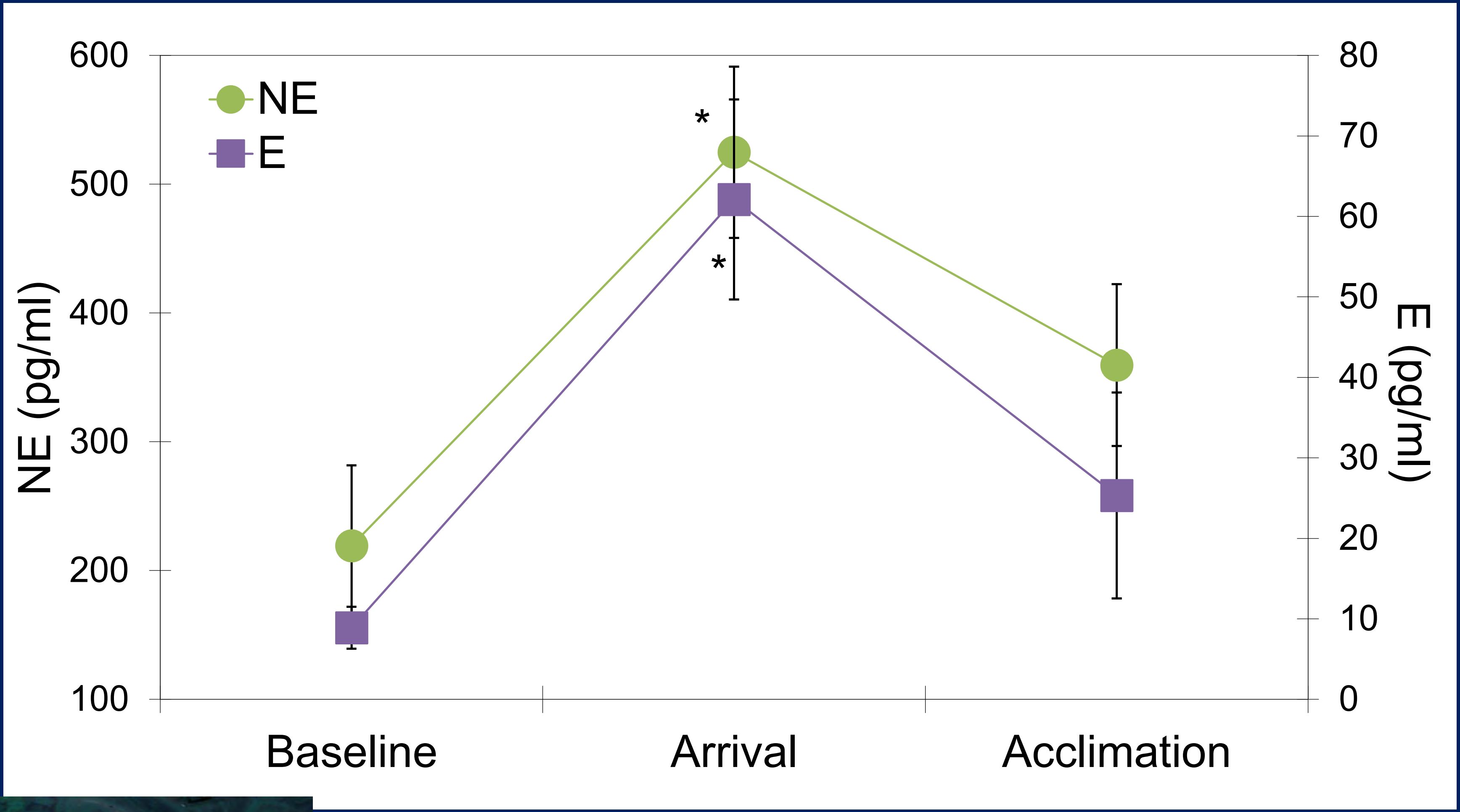
I. Beluga transport and introduction

Subjects:

- **Four transported belugas from Shedd Aquarium**
  - **baseline = 2 wks prior to transport**
  - **arrival = immediately before release**
  - **acclimation = 5-6 mo post-arrival**

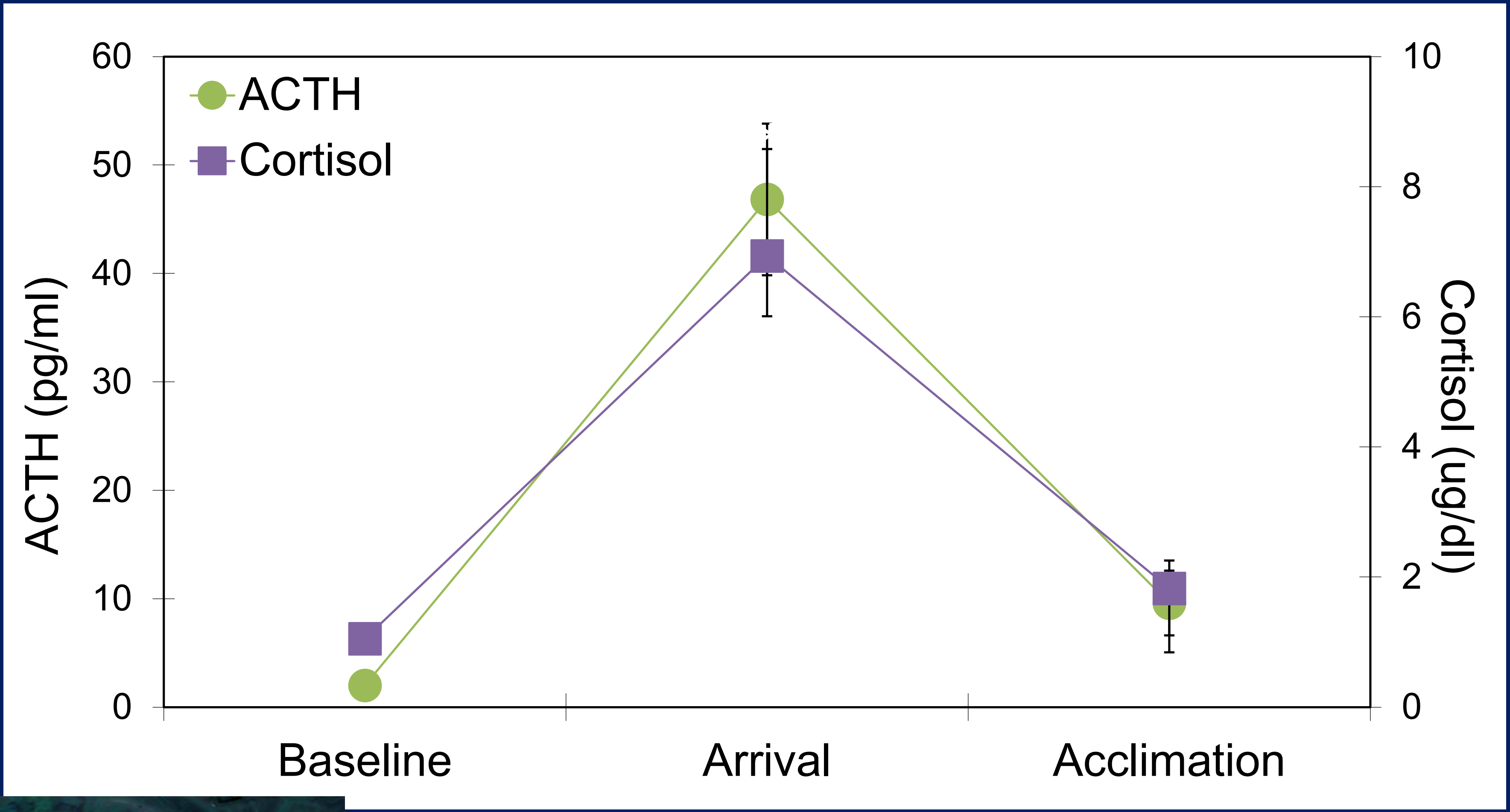
- **Three resident belugas at Mystic Aquarium**
  - **baseline = 2 & 6 wks prior to arrival**
  - **arrival = 5 days post-arrival**
  - **acclimation = 4 & 8 wks post-arrival**

Transported Belugas



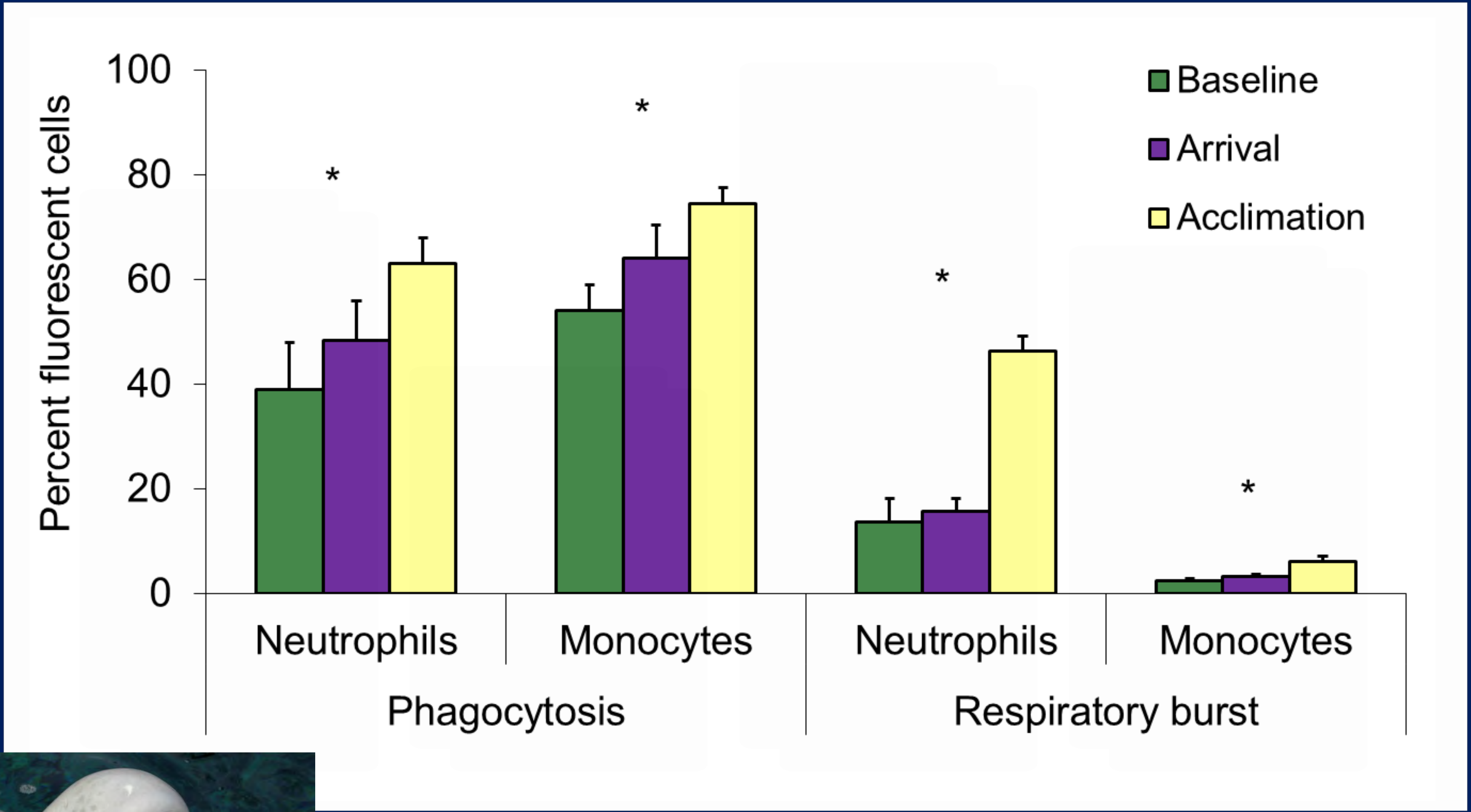
***p<0.05, Non-parametric Friedman two-way ANOVA**

Transported Belugas



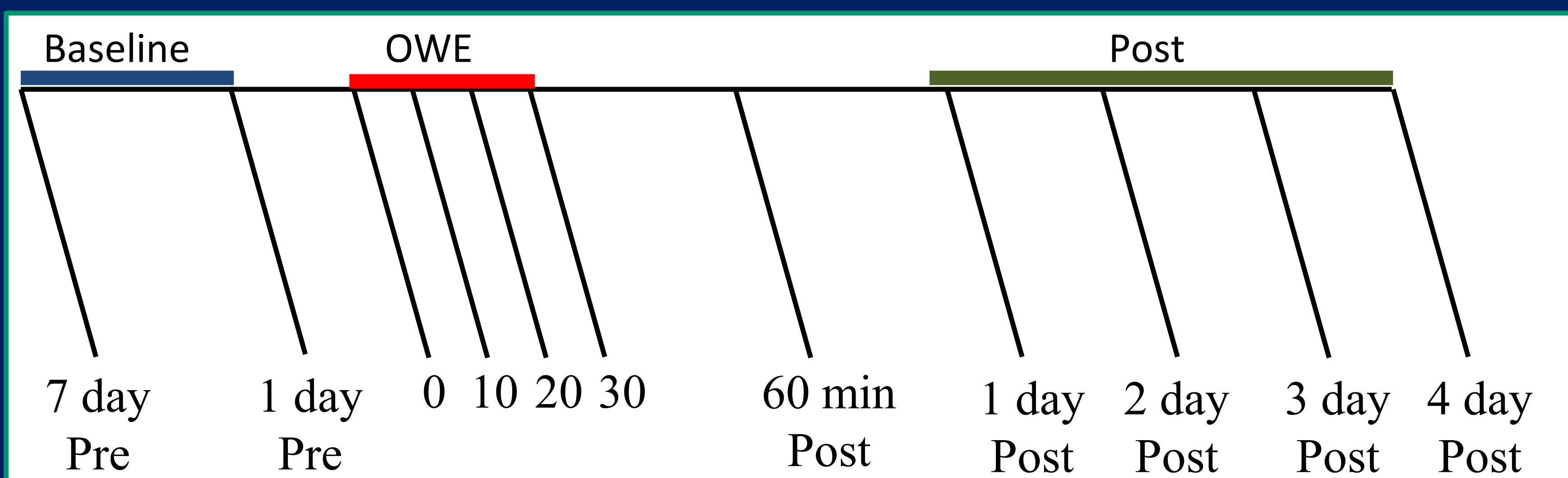
*p<0.05, Non-parametric Friedman two-way ANOVA

Transported Belugas



*p<0.05, Non-parametric Friedman two-way ANOVA

II. Beluga Out of Water Examination (OWE)



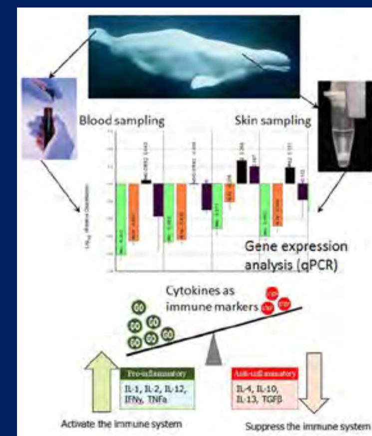
Slide removed – unpublished research findings

Slide removed – unpublished research findings

Slide removed – unpublished research findings

Slide removed – unpublished research findings

Non-invasive Sampling for Health Monitoring in Free Ranging Whales

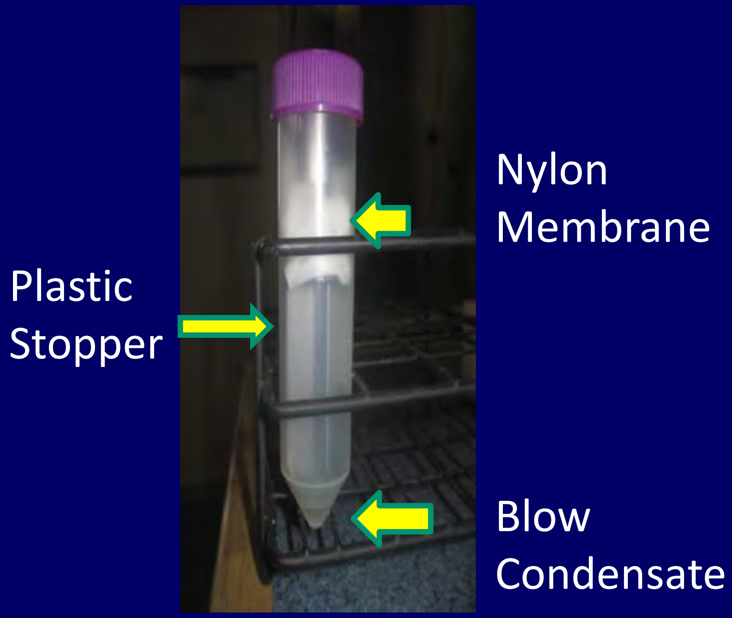


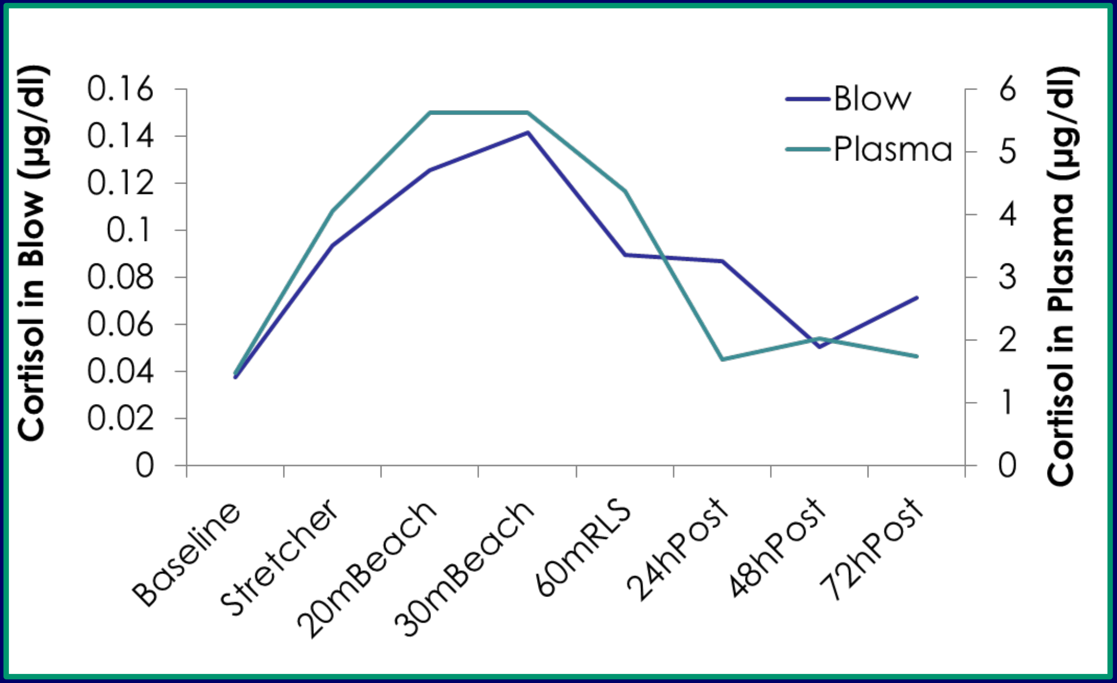
Skin Sampling

Fecal Sampling

Blow Sampling

Non-Invasive Hormone Monitoring in Blow

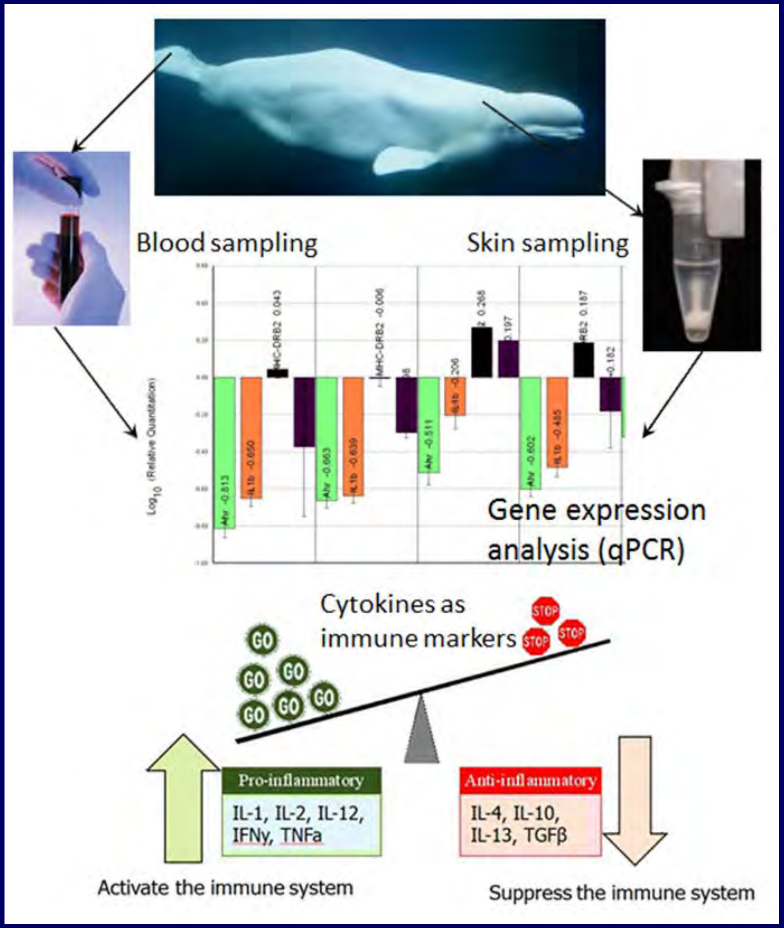


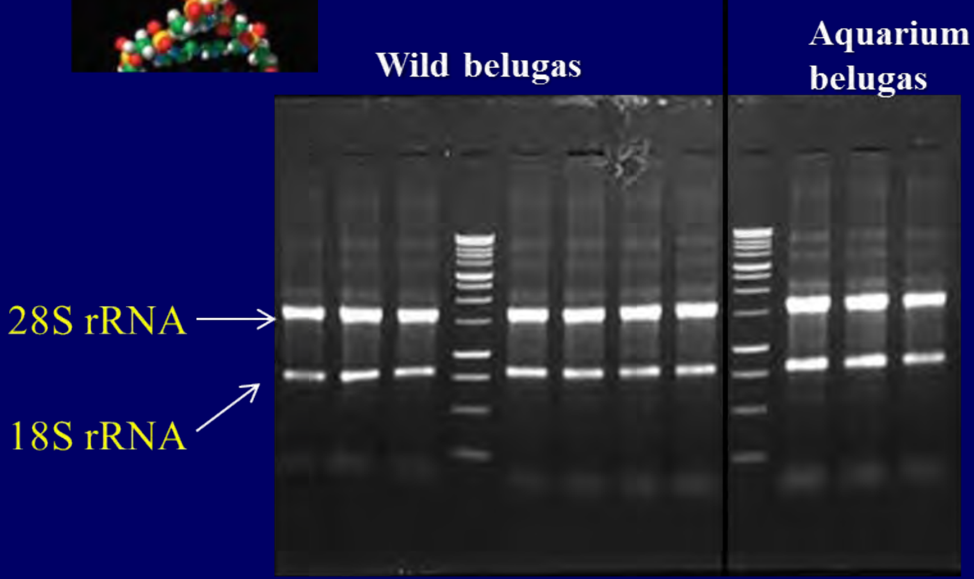


Next Steps

- Dilution Factor e.g. urea, total protein
- Test on Free Swimming Belugas
    - Proof of concept in Aquarium belugas e.g. drones
    - Small boat, kayak
- Prepared in case of Cook Inlet beluga stranding and response

Non-Invasive Gene Expression Monitoring in Blood vs. Skin





Slide removed – unpublished research findings

Slide removed – unpublished research findings

Slide removed – unpublished research findings

Summary
Points to Consider during the Workshop

- Hormone and Immune Function measures on two wild populations and Aquarium whales for comparison
- Individual response to a stressor- duration, intensity, type
- Cumulative effects
- Acute vs. Chronic
- Less invasive tissue matrices show promise

Acknowledgments

- Mystic Aquarium's Research Team: Drs. Laura Thompson, Ebru Unal, Maureen Driscoll, Paul Anderson and Justin Richard
- Office of Naval Research
- Research Permits: 782-1719, 14245, 14610, 17350, 42-1908, 17298
- Dr. Robert Suydam and Department of Wildlife Management, North Slope Borough
- Village of Point Lay, AK
- Point Lay Field Team
- Bristol Bay Native Association and Bristol Bay Marine Mammal Council
- Drs. Carrie Goertz, Rod Hobbs, Lori Quakenbush and Bristol Bay Field Team
- Mystic Aquarium's Arctic Coast and Animal Care Teams