2nd International Workshop on Beluga Whale Research & Conservation

ABSTRACTS

DAY 1 | TUESDAY, MARCH 12 *Presenting Author

Keynote Presentations: GLOBAL ADVANCES AND NEEDS FOR BELUGA RESEARCH AND CONSERVATION

9:30-10:00am | **Global Review of the Conservation Status of Monodontid Stocks**

Roderick C. Hobbs[1], Randall R. Reeves[2]*, Jill S. Prewitt[3], Geneviève Desportes[3], Kaitlin Breton-Honeyman[4], Tom Christensen[5], John J. Citta[6], Steven H. Ferguson[7], Kathryn J. Frost[8], Eva Garde[9], Maria Gavrilo[10], Maha Ghazal[11], Dmitri M. Glazov[12], Jean-Francois Gosselin[13], Mike Hammill[13], Rikke G. Hansen[9], Lois Harwood[14], Mads Peter Heide-Joergensen[9], Gerald Inglangasuk[15], Kit M. Kovacs[16], Vera V. Krasnova[17], Daria M. Kuznetsova[12], David S. Lee[18], Véronique Lesage[13], Dennis I. Litovka[19], Eline Lorenzen[20], Lloyd F. Lowry[8], Christian Lydersen[16], Cory J. D. Matthews[7], Ilya G. Meschersky[12], Arnaud Mosnier[13], Gregory O'Corry-Crowe[21], Lianne Postma[7], Lori T. Quakenbush[6], Olga V. Shpak[12], Mikkel Skovrind[20], Robert S. Suydam[22], and Cortney A. Watt[7]

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Abstract

Monodontids, belugas, *Delphinapterus leucas* and narwhals, *Monodon monoceros,* are found in much of the Arctic and in some subarctic areas. They are hunted by indigenous subsistence users, and in the past, some populations were substantially reduced by commercial hunting and culling. More recently, some populations have declined due to uncontrolled subsistence hunting and environmental degradation.

Monodontids are increasingly impacted by human activities in the Arctic including ship and boat traffic, industrial development, ice-breaking, seismic surveys, competition with fisheries, and alteration of habitat due to climate change. Since reviews in the 1990's, new information is available on both species and on changes occurring to their habitat resulting from human activities and climate change. The North Atlantic Marine Mammal Commission (NAMMCO) undertook a review in 2017, which recognized 21 extant beluga stocks, one extirpated beluga stock, and 12 stocks of narwhals. The beluga stocks differed from those recognized in earlier reviews with stocks in the Okhotsk Sea being subdivided due to improved genetic and movement data and some stocks in eastern Russia being combined where limited information did not separate them. The review considered information available on each stock regarding population size, depletion level, current and past removals and trend in abundance to determine status. Levels of information ranged from Cook Inlet and St Lawrence Seaway belugas which have been surveyed numerous times and monitored closely to the belugas of Barents-Kara-Laptev Seas which are described from limited observations of summer aggregations. Concern was expressed where lack of information prevented assessment, removals were not considered sustainable or the population was at risk of decline even without removals occurring. Beluga stocks of greatest concern are small stocks in Ungave Bay (possibly extirpated), Cook Inlet (ca 300), St. Lawrence (ca 900), and Cumberland Sound (ca 1,100), and stocks with uncertainty in Eastern Hudson Bay, and Barents-Kara-Laptev Seas.

Acknowledgements
The authors thank NAMMCO for organizing the GROM workshop. The authors are also grateful to NAMMCO, the Government of Greenland, Shell Global Solution International for providing funding for the event and the attendance of some of the participants, as well the US Marine Mammal Commission for supporting R.R. Reeves.

10:00-10:30am | **White Whales in Svalbard – A Conservation Concern**

Kit M. Kovacs[1]*, Jade Vacquié-Garcia[1], and Christian Lydersen[1]
[1]Norwegian Polar Institute, Fram Centre, N9296 Tromsø, Norway

Abstract
White whales in the Svalbard Archipelago were harvested without restrictions up until the 1960s. At that time, they became protected, and were assumed to be depleted. The species was placed on the Svalbard Red List, in the Data Deficient category, where it remains today. Population monitoring has not been established, but a series of research projects have provided significant amounts of information on habitat use, movement patterns, contaminant levels, diet and genetics for this population. Svalbard's white whales are genetically distinct from West Greenland; insufficient sampling from the Russian parts of the Barents Sea leave relationships to the east a research gap. Svalbard's white whales display a tightly coastal distribution pattern, rarely moving more than 100s of metres from the shorelines (unless pushed offshore by ice) as they move between glacier fronts, which are their principle foraging areas. They spend a lot of time in western Spitsbergen during summer, and shift to the eastern parts of the archipelago as winter approaches. Quite extensive surveys (for whales and polar bears) conducted in the marginal ice zone have never documented white whales either from ship survey lines nor during helicopter transects. Another

noteworthy aspect of their ecology is how quiet this species is in this region. White whales in Svalbard rarely vocalize; only during aggregations where groups come together into large herds for short periods do they perform species-typical levels of vocalizing. Young calves are seen from early spring to late fall, suggesting an extended period of birthing (and mating). Fatty acid analyses of blubber suggest that polar cod (*Boreogadus saida*) are the main prey of white whales in Svalbard. Some elevated contaminant levels are concerning, but declining sea ice extent and seasonal coverage, in addition to melting and retracting tidal glaciers, likely make climate change the primary threat to this population.

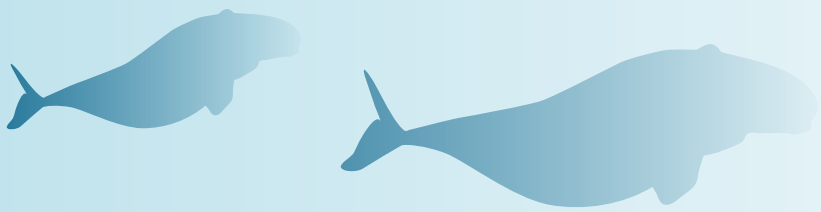
Acknowledgements
This work was financed by the Norwegian Polar Institute, NPIs ICE-centre and the Norwegian Research Council (ICE-whales program).

11:00-11:30am | **Beluga Whale Research in Russia in the Last Decade**

Olga V. Shpak[1]
[1]*Severtsov Institute of Ecology and Evolution, Moscow, 119071, Russia*

Abstract
Beluga whale research in Russia has intensified in the recent 10-15 years. Population structure, abundance and distribution studies were conducted in the White Sea, Okhotsk Sea, Anadyr Gulf (western Bering Sea). Satellite tracking of belugas from these stocks revealed new information on space-use, migratory routes and wintering grounds. Information on beluga distribution in high Arctic seas is received from Marine Mammal Observers. Genetic studies were conducted on samples from different Arctic regions, but mostly from the Russian Far East and the White Sea. Major anthropogenic threats include noise and chemical pollution and livestock transmitted diseases in the estuaries. The effects of noise and Beluga hearing thresholds have been a subject of research for many years, as well as acoustic repertoire. Contamination with chlororganic pollutants was studied in belugas from different regions. Sakhalin-Amur (Okhotsk Sea) belugas were extensively studied in regard to their immune response to human/livestock pathogens. In certain areas, boat tourism presents a threat as disturbance. Salmon fishing net entanglements have been recorded. There are no endangered beluga stocks in Russia, and all are managed as “marine resources”. However, traditional harvest of belugas is minimal, and quotas are seldom requested. Poaching exists, but is rare. Live-captures for display have been a major “resource use” for the past two decades with most whales taken in the western Okhotsk Sea. The experts insist on sustainable use and banning the quotas for the unstudied stocks. A pilot project on the gaps in beluga knowledge in Russia has been recently initiated. It aims at defining the areas of beluga habitat, where little or no dedicated research was conducted. Such regions will be defined as priority research areas, and certain management/conservation actions will be proposed. Beluga research in Russia, although grown in recent years, greatly benefits from international collaboration in different fields.

Acknowledgements
I would like to acknowledge all specialists and organizations which revived the beluga whale research in Russia.



11:30am-12:00pm | **Status of Canadian Beluga Populations: All Those Whales and Yet the Future is Uncertain**

Steven H. Ferguson[1]
[1]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, Manitoba, R3T 2N6, Canada

Abstract
Canadian waters harbour eight beluga populations, or 36% of the 22 recognized globally. The combined abundance of these eight populations accounts for over 70% of the total number of whales. Canadian waters also harbour one of the world's four possibly extirpated beluga populations, and three populations that are at risk of extinction. None of these four Canadian populations show convincing signs of recovery. A modelled estimate of pristine population size can be used to assess the conservation status of each population. The model estimate, which incorporates knowledge of anthropogenic harvest and the scale of temporal depletion, can then be used to define limit reference points for population management. Beluga exhibit two somewhat unique behaviours that may have affected their demographic recovery. Belugas are highly social and highly philopatric. As such, historic harvesting practices that were unselective (e.g. group netting), may have disrupted the social and cultural networks necessary for demographic recovery. This may also explain the apparent "predator pit" demographic pattern observed in these three populations. On a larger scale, a plot of beluga stock abundance results in a self-similarity power law pattern that suggests common social networks akin to human cities.

12:00-12:30pm | **Summary of Stock Structure, Population Status, Harvest and Knowledge of Beluga Whales in Alaska**

Robert S. Suydam[1*], Lori T. Quakenbush[2*], Thomas L. Gray[3], and Kathryn J. Frost[3]
[1]North Slope Borough Department of Wildlife Management, Utqiagvik, Alaska, 99723, USA; [2]Alaska Department of Fish and Game, Fairbanks, Alaska, 99701, USA; [3]Alaska Beluga Whale Committee, Utqiagvik, Alaska, 99723, USA

Abstract
Beluga whales (*Delphinapterus leucas*) are an important subsistence resource for many villages in western and northern Alaska. Thus, information is needed about stock structure, population size and status, harvest levels, and other knowledge to ensure sustainability. The Alaska Beluga Whale Committee (ABWC) co-manages belugas with the U.S. National Marine Fisheries Service (NMFS). There are at least five stocks that use waters off Alaska: Cook Inlet (CI), Bristol Bay (BB), Eastern Bering Sea (EBS), Eastern Chukchi Sea (ECS) and Beaufort Sea (BS). Genetics, movements, distribution, and traditional knowledge have contributed to the knowledge of stock structure. Abundance data are available for all the stocks: CI ~350 and declining; BB~2,500 and stable; EBS~7,000, trend unknown; ECS ~20,000, trend unknown; and BS~40,000, trend unknown. Harvest data are available for all stocks, although the Cook Inlet population is no longer hunted because of its small size. Hunts are sustainable (i.e., less than 2% of population estimates) for BB, ECS, and BS stocks. Additional population data are needed for the Eastern Bering Sea stock to evaluate and ensure sustainability. Distribution and movements of all five stocks have been documented through satellite tagging partnerships between hunters and scientists. Summer distributions are separated, however there is overlap of some stocks during migration. Belugas from four of these

stocks winter in the Bering Sea and also appear to be mostly separated. Belugas in Cook Inlet remain there throughout the year. Climate change and human activity (e.g., shipping, oil and gas exploration and development, commercial fishing) are the greatest threats to belugas in Alaska; however, we need to know more about how belugas are responding to climate change and how to mitigate impacts from industrial activities. The ABWC and its members sponsor, support, and promote continued documentation of traditional/indigenous knowledge and science about beluga whales. Partnerships, in-kind support, co-funding and collaboration among hunters, scientists and managers contribute to the success of the ABWC and documentation of knowledge about belugas.

Session I: BEHAVIOR AND ECOLOGY

1:30-1:50pm | **Why Are Many Beluga Populations so Susceptible to Over-Exploitation and Why Do They Not Recover?**

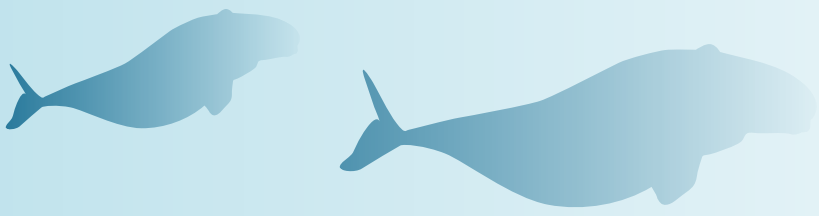
John J. Burns[1]
[1]Living Resources, Inc., Fairbanks, Alaska, 99708, USA

Abstract
In aggregate, multiple separate populations (stocks) of belugas have an almost circumpolar distribution. The late spring/summer distribution of each stock is known to include specific coastal areas such as seaways, fjords, sounds, bays, lagoons, inlets and lower reaches of major river systems. Use and the timing of use is (was) predictable to the point that in many regions hunting and netting have provided a dependable source of food and byproducts to indigenous peoples for millennia. Some commercial hunting was also based in this predictability. Belugas are also subject to other kinds of human-caused mortality, as well as removals by live capture. All of these are additive to losses, sometimes of significant magnitude, from natural causes such as predation, ice-entrapment and some live-stranding events. All things considered, human caused mortality of belugas, even at low levels, on top of "natural" mortality, has had drastic impacts ranging from stock extinctions, to reductions from which some stocks have not recovered or are still declining. This seems especially true for small populations. My contention, is that the intrinsic aspects of beluga behavior, social structure, reproduction and nurture expose some stocks to high risk of significant decline or extinction.

1:50-2:05pm | **Rangewide Population Structure and Hybridization in Beluga**

Mikkel Skovrind[1*] and Eline D. Lorenzen[1]
[1]Natural History Museum of Denmark, University of Copenhagen, Øster Voldgade 5-7, 1350 København K, Denmark

Abstract
To investigate circumpolar patterns of diversity and structuring in belugas, we reviewed all ~3,000 published mtDNA sequences from across their distribution range. Our analyses show that the Western Atlantic is the most diverse region, suggesting a unique demographic history.



All 21 recognized stocks are significantly differentiated from each other, bar three pairwise comparisons. The belugas in the St. Lawrence Estuary are the most distinct - they have the lowest global levels of genetic diversity, and with only two haplotypes present which are not found elsewhere, they are also the most well-differentiated. Belugas in the Barents, Kara and Laptev Seas stock have the highest level of diversity, suggesting this geographically widely-ranging stock may harbor several sub-populations. In the talk we will also present a DNA and stable isotope analysis of a putative beluga/narwhal hybrid skull housed at the Natural history Museum of Denmark. To our knowledge, this is the only known evidence of hybridization between the two species. We show that the specimen is indeed a first-generation hybrid, and reveal that it was a male, with a narwhal mother. Carbon and nitrogen stable isotope analysis of the specimen suggests a unique diet of the hybrid relative to either parental species.

Acknowledgements
Co-authors: Jose Alfredo Samaniego Castruita, Michael V. Westbury, Shyam Gopalakrishnan, Paul Szpak, James Haile, Eve C. Treadaway, Thomas Buur Madsen, Lianne Postma and Mads Peter Heide-Jørgensen.

2:05-2:20pm | **New Biotelemetry Tools for Studying Beluga Foraging Ecology and Characterizing Echolocation Behavior**

Russel D. Andrews[1*], Manuel Castellote[2,3], Caroline E.C. Goertz[4], Roderick C. Hobbs[2], T. Aran Mooney[5] and Lori T. Quakenbush[6]
[1]University of Alaska Fairbanks and the Alaska SeaLife Center, Seward, Alaska, 99664, USA; Present address: Marine Ecology and Telemetry Research, Kingston, Washington, 98346, USA; [2]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA; [3]Joint Institute for the Study of Atmosphere and Ocean, University of Washington, Seattle, Washington, 98195, USA; [4]Alaska SeaLife Center, Seward, Alaska, 99664, USA; [5]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543, USA; [6]Alaska Department of Fish and Game, Fairbanks, Alaska, 99701, USA

Abstract
For beluga whale populations facing threats from environmental change, it is critical to understand habitat use patterns and foraging behavior. However, it is difficult to observe belugas. We therefore sought to improve the available biotelemetry methods. The state-of-the-art method for attaching satellite tags involves capturing a beluga, moving it into shallow water, and holding it to attach the tag, but this is not always feasible. Therefore, seventeen whales, captured for the Bristol Bay Beluga Health Assessment project, were outfitted with LIMPET satellite tags while restrained to determine whether these tags, which can be remotely deployed, were a feasible alternative for tracking belugas. Although designed for whales with dorsal fins, LIMPETs transmitted for 37-114 days on belugas. Additionally, two LIMPETs were deployed remotely from a boat onto free-swimming belugas, and these tags remained attached for 30 and 84 days. We recommend LIMPET tags when tracking durations of a few weeks are valuable but capture is not feasible, or for situations that require rapid deployment of tags, such as when belugas are live-stranded so that the fate of refloated belugas can be monitored. When belugas can be temporarily restrained for instrumentation, satellite-linked stomach temperature tags are valuable for monitoring the timing and approximate magnitude of prey ingestion, but previously the short retention time of stomach temperature

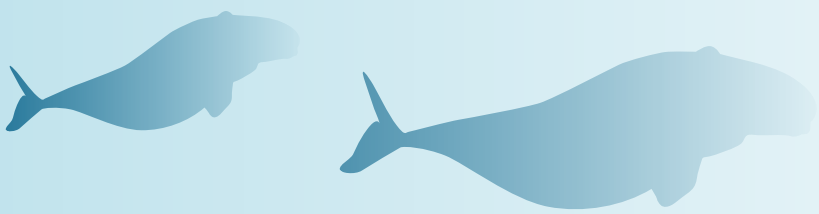
pills (STP) limited their usefulness. We modified our previous design and in 2016 instrumented five belugas with STPs that were retained for 47-120 days (mean: 85 d). By instrumenting belugas with STPs and acoustic-recording tags, we confirmed that successful prey ingestion was always preceded by echolocation click trains ending in very short (< 9.86 ms) inter-click intervals (buzzes). This quantification of feeding buzz characteristics can now be applied to data from moored acoustic-loggers to identify beluga foraging areas, as was done recently in Cook Inlet.

Acknowledgements
This work was carried out under permit #14245. Funding for this project was provided by North Pacific Research Board, Alaska SeaLife Center, NOAA Alaska Fisheries Science Center, NOAA Fisheries Office of Science and Technology's Ocean Acoustics Program, Alaska Department of Fish and Game, and the Georgia Aquarium. Special thanks to all the participants of the Bristol Bay Beluga Health Assessment Project.

2:20-2:35pm | **Hunter Tagging of Belugas (*Delphinapterus leucas*) in the Eastern Bering Sea**

Thomas L. Gray[1*], Kathryn J. Frost[1], John J. Citta[2], Lori T. Quakenbush[2], and Robert S. Suydam[3]
[1]Alaska Beluga Whale Committee, Utqiaġvik, Alaska, 99723, USA; [2]Alaska Department of Fish and Game, Fairbanks, Alaska, 99701, USA; [3]North Slope Borough Department of Wildlife Management, Utqiaġvik, Alaska, 99723, USA

Abstract
Little is known about the distribution, migration, and habitat use of the Eastern Bering Sea (EBS) stock of belugas outside summer when they are present in Norton Sound and offshore of the Yukon delta. Prior attempts to tag belugas in this region were unsuccessful due to the unpredictable presence of belugas, weather, limited time of scientists for tagging, and the high cost of such programs. To overcome these limitations, the Alaska Beluga Whale Committee (ABWC) trained beluga hunters from this region to tag belugas. In 2011, three EBS hunters received hands-on training in Bristol Bay and were added to the Alaska Department of Fish and Game's beluga research permit as hunter-taggers. To date, satellite tags have been attached to six belugas in northern Norton Sound and one in the Yukon delta. Four tags transmitted for a week or less; the remaining three, all deployed near Nome, transmitted 271-419 days. Two belugas tagged in autumn 2012 remained in Norton Sound in October and early November. As sea ice cover advanced they moved out of the Sound and southward, but remained in the EBS. Both returned to Norton Sound by mid-June 2013. Another beluga tagged near Nome in November 2016 spent November 2016-April 2017 in western Norton Sound and adjacent waters of the EBS. In May-June it moved into Norton Sound and to the mouth of the Yukon River where it remained through October then moved again to western Norton Sound. Based on these movements, winter and spring ranges of EBS belugas are between the ranges of Bristol Bay and Beaufort Sea beluga stocks. Belugas tagged by ABWC hunter-taggers are the only EBS belugas ever tagged. They provided the only tagging data on the movements, migration, and overwintering areas of EBS belugas. We conclude that local hunter-tagger teams are an effective way to tag belugas.



Acknowledgements
This work was carried out under permits #14610 and #18890 and ADFG's IACUCs. Funding for this project was provided by the Alaska Beluga Whale Committee from NOAA through its Alaska Native Organization Co-Management Funding Program.

3:00-3:15pm | **Inuvialuit Settlement Region Beluga Tagging Program: A Community and Co-Management Driven Success Story**

Vernon B. Amos[1]*, John Noksana Jr.[2]*, Lisa Loseto[3]*, Gerald Inglangasuk[2], Jennifer Lam[4], Emily Way-Nee[4], and Shannon A. MacPhee[3]
[1]Inuvialuit Game Council, Inuvik, Northwest Territories, X0E 0T0, Canada; [2]Fisheries Joint Management Committee, Inuvik, Northwest Territories, X0E 0T0, Canada; [3]Fisheries and Oceans Canada, Winnipeg, Manitoba, R3T 2N6, Canada; [4]Joint Secretariat- Inuvialuit Settlement Region, Inuvik, Northwest Territories, X0E 0T0, Canada

Abstract
The Inuvialuit Final Agreement has provided a robust and adaptive co-management framework for wildlife management and research for over 30 years and a vehicle for ongoing participation for communities and Inuvialuit boards in order to meaningfully engage in research in the Inuvialuit Settlement Region (ISR). This presentation will look at how community and Inuvialuit boards participated in the co-design and implementation of the current Beaufort Sea Beluga Tagging project. This research project is an example of how community involvement is pivotal in ensuring the success of a project, especially around a highly valued and respected resource like beluga whales. This presentation will review the range of strategies used by the co-management system for Inuvialuit to provide direction and their traditional knowledge in a respectful and culturally empowered manner. It will look at the nature of involvement on the community and co-management board level in co-designing the project in general and in specific components like the animal care protocols and design of the tagging tools. The project also provided opportunities for Inuvialuit to be involved in the decision-making, as well as the implementation of the research project itself. This presentation will review the various communication tools used to provide the Inuvialuit a platform for sharing ideas, concerns and questions to address the sensitivities Inuvialuit have around tagging and handling of beluga whales. It will also look at the communication strategies utilized within the co-management process that ensure alignment of priorities and objectives around this project. The presentation will end with a look at some of the challenges and lessons learned through this process, as well as some of the possible next steps to continue the involvement of Inuvialuit in this project and in the interpretation of the data.

Acknowledgements
Funding for this project was provided by Fisheries and Oceans Canada – National Conservation Plan (NCP), Specific Ecosystem-based Research and Advice (SPERA), Centre of Expertise on Marine Mammals (CEMAM), Oceans Program; CIRNAC- Beaufort Regional Strategic Environmental Assessment (BRSEA); Fisheries Joint Management Committee – Funds for Tarium Niryutait Marine Protected Area, Anguniaqvia niqiqyuam Marine Protected Area, core funds.

3:15-3:30pm | **Improving Our Understanding of Cook Inlet Beluga Disturbance by Anthropogenic Noise**

Manuel Castellote[1*], Mandy Keogh[2], Brian Taras[2], T. Aran Mooney[3], Arial Brewer[1], Justin Jenniges[2], and Chris Garner[4]

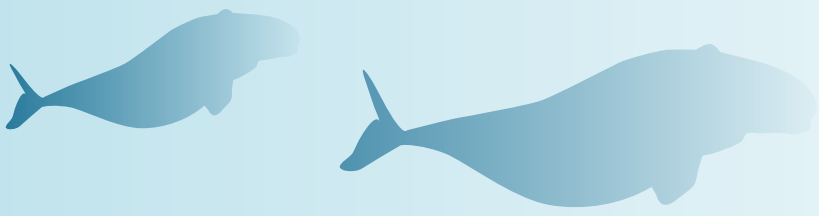
[1]Joint Institute for the Study of the Atmosphere and Ocean, University of Washington and Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA; [2]Alaska Department of Fish and Game, Juneau, Alaska, 99811, USA; [3]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543, USA; [4]US Air Force, Joint Base Elmendorf-Richardson, Alaska, 99506, USA

Abstract

Following a dramatic decline, the Cook Inlet beluga (CIB) population was listed as endangered in 2008. A decade later, this population has shown no sign of recovery, and the causes of this lack of recovery remain unclear. One major threat to the population is anthropogenic noise. NOAA Fisheries regulates noise exposure under both the Marine Mammal Protection Act and the Endangered Species Act. However, noise impact mitigation is limited to close-range effects defined by specific acoustic exposure thresholds of 230 dBpeak/SELcum 185 dB for impulsive noise and SELcum 198 dB for non-impulsive noise. CIB critical habitat is concentrated near Anchorage, which is the largest urban area in Alaska and home to the majority of Alaska's human population. CIB are exposed to a wide variety of potential noise stressors including fishing, mining, dredging, military operations, oil and gas development, air and water transportation, and residential and industrial shore development. Many of these activities are intensified during the beluga main foraging season when ice is absent (May-October). An experimental study at Mystic Aquarium that exposed a trained beluga to recordings of typical Cook Inlet anthropogenic noise (pile driving and vessel noise) at levels well below the regulatory acoustic exposure thresholds indicated significant masking in beluga hearing sensitivity, exceeding 20 dB from baseline hearing. This level of masking has the potential to compromise vital functions such as foraging. Previous acoustic monitoring data shows these noise levels regularly occur in CIB critical habitat. In 2017, a research project was initiated to examine the relationship between beluga presence and exposure to anthropogenic noise, aiming to investigate levels of disturbance and spatial displacement in foraging grounds. This presentation will summarize our current understanding of the temporal and spatial overlap between anthropogenic noise and beluga foraging behavior, and our initial results on displacement from foraging grounds.

Acknowledgements

This work was carried out under permits #14245 and #20465 and IACUC permit # A-NW2013. Funding for this project was provided by NMFS Ocean Acoustics Program, NMFS Recovery Grants to States, and Department of Defense.



3:30-3:45pm | **Time Will Tell: Application of a Long-Term Photo-ID Dataset for Research and Conservation of a Long-Lived Endangered Population, Cook Inlet Beluga**

Tamara L. McGuire[1*], Amber D. Stephens[1], and John R. McClung[1]
[1]The Cook Inlet Beluga Whale Photo-ID Project, Anchorage, Alaska, 99515, USA

Abstract
More information is needed to understand and reverse the lack of recovery of Alaska's endangered Cook Inlet beluga whale (CIBW) population. In order to understand the population characteristics and life histories of this endangered population, the CIBW Photo-ID Project has collected 14 years of photo-identification (photo-id) data and compiled sighting histories for 431 identified whales. While using photo-id to understand population dynamics is like trying to make a movie with a series of snapshots, given time, such longitudinal studies of long-lived species like belugas allow us to capture data that only emerge slowly over years. Here we present a synthesis of information collected on distribution patterns, habitat use, exposure to human activities, group composition, and group behavior of CIBWs which has, in turn, allowed us to identify distinct areas where belugas are found seasonally and "hotspots" of special biological significance (e.g., feeding and calving) that warrant concerted protection. In addition, certain data, such as age of first reproduction, calving interval, calving rate, wound healing, association patterns, sex ratios of groups, and survival after events such as live stranding, remote biopsy, and capture for satellite tagging are only beginning to emerge after a decade of data collection. Integrating long-term photo-id data with data obtained from other means, such as biopsy, drone imagery, necropsy, and tagging, can provide important historical context. We describe how the integration of a continued long-term, Inlet-wide dataset from the CIBW Photo-ID Project with data from other sources into population models that account for sampling constraints and biases will allow scientists to better assess CIBW population dynamics and population viability. This method will be the most powerful approach to help understand the continued lack of recovery of the CIBW population and provide critical information for the management of this endangered beluga population.

Acknowledgements
This work was carried out under permits #481-1759, 14210, and 18016. Funding for this project was provided by the National Fish and Wildlife Foundation, NOAA Fisheries, the North Pacific Research Board, the Alaska Department of Fish and Game, the Department of Defense, the Kenai Peninsula Borough, and the Knik Tribe.

3:45-4:00pm | **Reproductive Status of Female Belugas in the Endangered Cook Inlet Population**

Kim E.W. Shelden[1*], John J. Burns[2], Kathleen A. Burek-Huntington[3], Tamara L. McGuire[4], Daniel J. Vos[5], and Barbara A. Mahoney[6]
[1]Marine Mammal Laboratory, NOAA, Seattle, Washington, 98115, USA; [2]Living Resources, Inc., Fairbanks, Alaska, 99708, USA; [3]Alaska Veterinary Pathology Service, Eagle River, Alaska, 99577, USA; [4]Cook Inlet Beluga Whale Photo-ID Project, Anchorage, Alaska, 99502, USA; [5]Anchorage, Alaska, 99508, USA; [6]NOAA Fisheries Alaska Region, Anchorage, Alaska, 99513, USA

Abstract
Belugas of Cook Inlet are a genetically unique and critically endangered population for which adequate life history data are lacking. We determined reproductive seasonality and status by examining female reproductive tracts. Our sample of 51 females necropsied between March and November (1995-2014) included hunted (pre-2006), live-stranded (that later died), and beachcast whales. Sexually mature females (n=20) ranged from age-14 to 41 GLGs, immature whales were >age-3 (n=7), reproductive status could not be determined for the remainder. Of mature females, 6 were non-gravid, 10 were pregnant, and 4 were recently post-partum. Ovary weights and/or internal ovarian structures of 14 paired and 4 single ovaries were recorded. Corpora counts between paired ovaries did not indicate left-ovary dominance. Support of a single fetus sometimes involves more than one corpora luteum. We found no evidence of reproductive senility; the oldest whale at age-41 was pregnant. Reproductive tracts from younger (<14 GLGs) and older (>41 GLGs) females are not present in the current dataset and will be necessary to determine age of first reproduction and onset of menopause. For example, a female appeared to be post-partum at age-47. The uterus was enlarged, measuring 50 cm by 45 cm, but the ovaries were not collected so reproductive status was not confirmed. Photo-ID matches (2005-2014) provided additional insights and suggested age at first birth (~10-13) is similar to other beluga populations. Of the 10 pregnant whales, 2 had early-stage fetuses (<50 cm), 2 mid-stage (<70 cm), and 6 late-stage (>90 cm). Stranded calves-of-the-year first occurred in July, corroborated by photo-ID documentation of neonates July-October. We applied the fetal growth formula per Robeck et al. (2015) to the length data for fetuses, neonates, and calves. Our findings suggest reproductive seasonality with conception (65%) and birth (57%) dates primarily during the periods March-June and July-October, respectively, though conceptions also occurred from December-February.

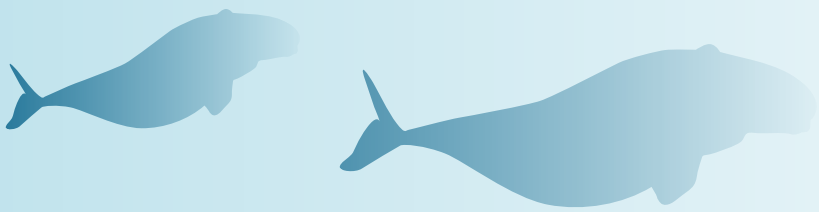
Acknowledgements
This work was carried out under permit #932-1905-00/MA-009526 for samples and #481-1759, #14210 and #18016 for photo-ID. Funding for this project was provided by a Prescott Grant. Thanks to A. Stephens and C. Kaplan for providing the matches of the two photo-identified necropsied whales.

Traditional Ecological Knowledge – Panel I: ARCTIC COMMUNITIES AND BELUGA WHALES

4:15-4:30pm | **Traditional Ecological Knowledge of Beluga: Trends in Research and the Literature**

Kaitlin Breton-Honeyman[1]
[1]Nunavik Marine Region Wildlife Board, Inukjuak, Quebec, J0M 1M0, Canada

Abstract
Beluga occupy a central role in the Arctic ecosystem and are an essential part of Inuit identity and food sovereignty. Throughout the Arctic, Inuit have interacted with beluga for centuries and through this relationship have developed a rich knowledge system. That knowledge provides invaluable insights to many fields, including biology and stewardship. Inuit have been generously sharing their knowledge of beluga with researchers for decades. Initially many of the contributions they made to research projects (often as field guides) went un(der)acknowledged or were considered anecdotal. However, some researchers recognized the importance of the knowledge of hunters, and studies as early as the 70s focused



on gathering Inuit knowledge (e.g. Read and Stephansson 1976). There was a rise in the documentation of traditional ecological knowledge (TEK) of beluga in the 1990s and into 2000s, and an associated increase in references to these studies and other knowledge that came from Indigenous hunters and elders. Following this initial rise in TEK documentation the rate of publication has remained stable, although study design, methods, and engagement with communities has continued to evolve over time. Presently, Inuit, through several national and international reports, are calling for a transformation of research practices. Inuit are demanding to be involved in every stage of the research process and for a fundamental shift in power, particularly in regard to decision making, recognizing that this is required in order to move towards self-determination in research. While TEK studies will continue to play an important role in the field, research projects which are taking place in Indigenous territories are evolving towards more participatory and reciprocal approaches (e.g. knowledge co-production and community driven research) as best practices for Arctic research generally.

Acknowledgements
This basis for this work was conducted as part of a dissertation that was generously supported by the W. Garfield Weston Foundation, the Natural Sciences and Engineering Research Council of Canada, and the Canadian Scholarship Trust Foundation, International Polar Year, the Northern Scientific Training Program, Department of Fisheries and Oceans, and Trent University.

DAY 2 | WEDNESDAY, MARCH 13

Session II: AQUARIUM ANIMAL HUSBANDRY, SCIENCE AND EDUCATION

9:00-9:30am | **The Role of Aquaria in Beluga Research and Conservation**

Tracy A. Romano[1*], Laura A. Thompson[1], Ebru Unal[1] and Maureen Driscoll[1]
[1]Mystic Aquarium, Mystic, Connecticut, 06355, USA

Abstract
Aquaria that maintain belugas under professional care contribute to increasing our general knowledge of belugas, beluga research efforts, expertise in animal care and husbandry, and provide a venue to engage and educate the public about threats and beluga conservation. Mystic Aquarium is dedicated to research that will help to inform health, recovery and management of beluga populations with emphasis on endangered populations such as Cook Inlet belugas. The aquarium setting offers the ability to study belugas under controlled conditions with known diets, health histories, environmental parameters, etc. Aquarium belugas are trained to provide biological samples and participate in informative experimental paradigms. Mystic Aquarium scientists also study belugas in the field and aquarium studies paired with field studies offer unique opportunities for advancing knowledge of belugas. Research studies in aquaria also contribute to recovery and management of endangered belugas such as those in Cook Inlet. Examples of Mystic Aquarium research studies include, but aren't limited to: 1) the neuroimmunological response to environmental and anthropogenic stressors 2) the development of novel non-invasive techniques to assess health in free-ranging, stranded and endangered belugas 3) the hearing and physiological response

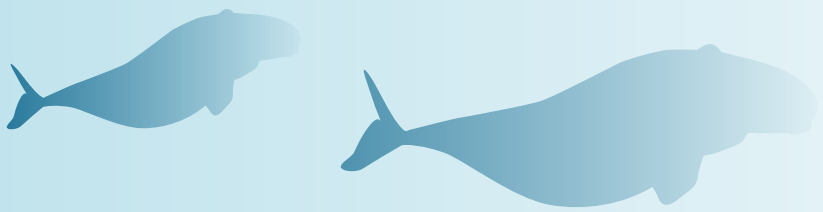
to anthropogenic sound 4) morphometrics to inform photogrammetry studies 5) diving physiology 6) microbiome 7) behavior and reproduction and 8) testing of prototype telemetry devices and cameras before deployment on wild whales. Moreover, given expertise in animal care and handling, Mystic and other aquaria husbandry personnel contribute to live capture release health assessments of wild belugas and rehabilitation of stranded whales as well as outreach. Mystic Aquarium engages and inspires 800,000 visitors per year through our beluga habitat, interactive programs and special educational programs. It is essential for aquarium scientists to collaborate with wildlife biologists and managers in order to utilize our collective expertise and resources. Through this type of collaborative research we can further our understanding of beluga biology and make strides in population recovery and conservation.

Acknowledgements
We are grateful to Mystic Aquarium's animal care and husbandry teams for support of our beluga research efforts. We also thank all of our collaborators who share their expertise and resources to help make this research possible. We are grateful to the Office of Naval Research and the National Science Foundation for funding support.

9:30-9:45am | **Beluga (*Delphinapterus leucas*) Calf Vocal Development in the First Year of Life**

Audra Ames[1,2*], Jason Wood[3], and Valeria Vergara[4]
[1]Fundaciòn Oceanogràfic, Valencia, Valencia, 46013, Spain; [2]The University of Southern Mississippi, Hattiesburg, Mississippi, 39406, USA; [3]Sea Mammal Research Unit (SMRU) Consulting, Vancouver, British Columbia, V6J 1R1, Canada; [4]Ocean Wise Conservation Association, Vancouver, British Columbia, V6G 3E2, Canada

Abstract
We investigated a male beluga calf's vocal development as part of a larger effort to understand beluga mother-calf communication and the impacts of noise on neonate calls. Using a calibrated digital hydrophone with a sampling rate of 256 kHz, we recorded sounds throughout the calf's first year of life, employing concurrent bubble-stream emission or animal separations as a method of identifying calf calls. From his first day of life, the calf produced broadband pulse trains with upper frequency limits reaching ≥ 128 kHz; higher than findings reported by previous studies limited by lower sampling rates. The calf produced pulsed trains more prominently than other call types over the course of his first year. Mixed calls began to appear in month one but were rare. Tonal call production began in month four. We used broadband received levels of the calf's pulsed calls from the first month, produced at known distances from the hydrophone and integrated from 500 Hz to 100 kHz, to calculate apparent source levels, using cylindrical spreading to approximate transmission loss. Source level increased significantly over the first month of life but remained lower than those of adult belugas. Over the calf's first six months of life, pulse repetition rate increased significantly, but did not continue increasing throughout the year. Call duration increased significantly in the first year, as did minimum frequency, peak frequency, and center, first and third quartile frequencies. The coefficients of variation for the acoustic energy parameters decreased from the first six months of life to the last six months, indicating a reduction of variability in energy distribution of the calls. Changes in beluga calf call source level and acoustic energy distribution have important implications for a calf's ability to compensate for noise, especially during the first weeks of life.



9:45-10:00am | **A Review of Recent Studies on Aquarium-Housed Belugas, with Implications for Wild Populations**

Michael Noonan[1]
[1]Canisius College, Buffalo, New York, 14208, USA

Abstract
The results of a series of studies carried out at Marineland of Canada have informed important topics pertaining to beluga whale behavioral biology. These include variations in respiration rates that suggest annual cycles in energetic demands, and shifts in social affiliations and sexual behavior that also vary with season. Close observations of breeding events have revealed important details about both sexual and peri-natal behaviors, including those pertaining to the timing and sequencing of specific components. Likewise, the circumstances under which allomothering does and does not occur have begun to emerge. Finally, experimental investigations of social learning have revealed both age and sex differences in the ways in which new behaviors spread through a population, elucidating in part the means by which cultural differences are established in different areas. The potential implications of all of these findings to wild populations will be offered for discussion.

10:00-10:15am | **What Do We Know About the Behavior of Belugas from Studies in Managed Care?**

Deirdre B. Yeater[1*], Heather M. Hill[2] and Michael Noonan[3]
[1]Sacred Heart University, Psychology Department, Fairfield, Connecticut, 06825, USA; [2]St. Mary's University, Psychology Department, San Antonio, Texas, 78228, USA; [3]Canisius College, Animal Behavior Ecology and Conservation & Biology Department, Buffalo, New York, 14208, USA

Abstract
We have documented a number of similarities in behavior of diverse populations of belugas under human care, many of which have been validated by research on wild belugas. Data collected across multiple facilities corroborates the same-sex affiliations, as seen in wild group compositions, especially confirming the strong propensity for male-male social interactions. Socio-sexual behaviors appear to be an important part of the behavioral repertoire that emerges innately but requires practice. Research on behavioral milestones in calves is consistent with the literature from wild populations, such as; swim positions with mother, separations/reunions with mother, general social interactions, and play. Characteristics of beluga maternal care including nursing behaviors and individual differences in maternal style have been reported from both captive and wild settings. In addition to behavior, studies in managed care have provided information on beluga calf vocal development and individual calls. In conclusion, research on belugas in managed care is informative to researchers studying wild populations and may have possible conservation implications due to the universal nature of these observations.

10:15-10:30am | **Minimally Invasive Physiological Correlates of Intersexual Behavior in Belugas**

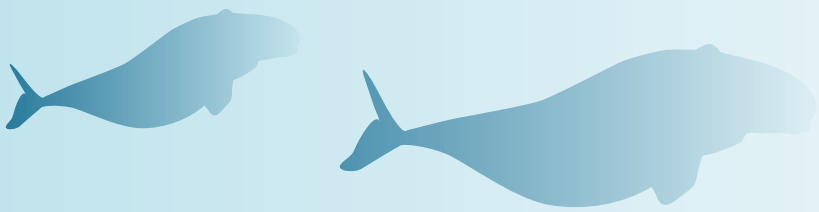
Justin T. Richard[1*], Rachael Desfosses[1], Tracy A. Romano[2] and Becky L. Sartini[1]
[1]University of Rhode Island, Kingston, Rhode Island, 02881, USA; [2]Mystic Aquarium, Mystic, Connecticut, 06355, USA

Abstract
Simultaneous study of reproductive physiology and behavior can yield valuable information about mating strategies, yet these studies are rare in cetaceans due to logistical constraints. A group of 3 belugas (2 males and 1 female) in human care were monitored for one year to determine how behavior varied with reproductive state. Progesterone measurements in weekly blow (exhale) samples were used to detect 3 estrous cycles. Testosterone measurements in blow samples and testes size measurements via ultrasound demonstrated male reproductive seasonality. Four hours of behavioral observations were conducted per week to determine the weekly coefficient of association (COA) for male-female pairs (reported as mean ± SD) and the frequency of specific behaviors. Intersexual associations were seasonal and corresponded with the known breeding season in belugas (March through May: 0.18 ± 0.19; all other months: 0.04 ± 0.06), as well as the known sexual segregation of wild belugas during the summer and fall. The "genital present" was considered an important courtship display performed by males toward the female, with 88% (245/278) of observations occurring during estrous cycles. During the genital present, the female displayed variable responses (such as changing speed or orientation) that varied between males. All 3 estrous cycles, the 5 highest weekly intersexual COA observations, and 94% of the genital presents occurred while male testosterone was declining. The apparent reduced association between measures of male reproductive physiology and courtship behavior suggests that signaling from the female indicating receptivity played a more important role in eliciting courtship behavior from the males than internal physiological cues. Additionally, female belugas may be able to employ pre-copulatory mate choice by responding variably to courtship displays. As paired physiological and behavioral observations of individual wild belugas throughout the year are not feasible, these observations provide an important complement to the study of wild belugas.

Acknowledgements
Funding for this project was provided by the National Science Foundation's Graduate Research Fellowship Program, the Marine Mammal Commission, and the Sea Research Foundation. Special thanks to the beluga trainers at Mystic Aquarium and the undergraduate research assistants who contributed to the project, especially Crysania Brady and Renee Bakker.

11:00-11:15am | **Dive Adaptation of the Beluga (*Delphinapterus leucas*) Immune System and Implications for Altered Dive Behaviors**

Laura A. Thompson[1*] and Tracy A. Romano[1]
[1]Mystic Aquarium, Mystic, Connecticut, 06355, USA



Abstract
The importance of diving for belugas is well rooted in the need to travel under ice, escape from predators and forage. As natural dive patterns of cetaceans are being altered by anthropogenic stressors such as noise, decreased arctic sea ice also leaves belugas at risk from increasing human presence and shifting prey distribution resulting in longer and deeper foraging dives. The consequences of such changes in behavior on health, via activity of immune responses are unknown for belugas, but may have implications leading to increased occurrences of infection or injuries resembling decompression sickness. This project used serum samples from aquarium and wild belugas to investigate inflammatory activity, by measuring the immune activation complement product C5a, in belugas in response to challenges associated with diving such as pressure, physical activity and breath-hold, and potential occurrence of nitrogen bubbles. Aquarium belugas (n=7) had significantly higher C5a as compared with Bristol Bay whales (n=9; Mann Whitney U-test, p=0.016), but displayed no significant changes in C5a following in vitro exposures to either increased pressure (n=3) or nitrogen bubble exposures (n=7). Bristol Bay belugas displayed larger changes in C5a in response to nitrogen bubbles with a significant increase detected at the highest flow rate of 1 ml/min (GLM, p=0.019). Serum C5a was higher following both dive behaviors (n=1) as compared with monthly baseline values, with the largest difference observed following stationary dives. The response of C5a to nitrogen bubbles was also notably increased following both dive behaviors. The data suggests that beluga inflammatory responses may be adapted to challenges associated with diving, but are still impacted by stress physiology, breath hold and activity level during a dive. These results highlight the need for further investigation in order to understand the effects of altered dive behavior due to anthropogenic stressors on the health of belugas.

Acknowledgements
The authors would like to thank the Arctic Coast husbandry staff and Animal Care teams at Mystic aquarium for support of training and sampling efforts. This work was carried out under Mystic Aquarium IACUC protocol #15004. Funding for this work was provided by the Office of Naval Research (ONR) award #N000141512203.

11:15-11:30am | **Stranded Beluga Calf Response and Care, Two Case Reports**

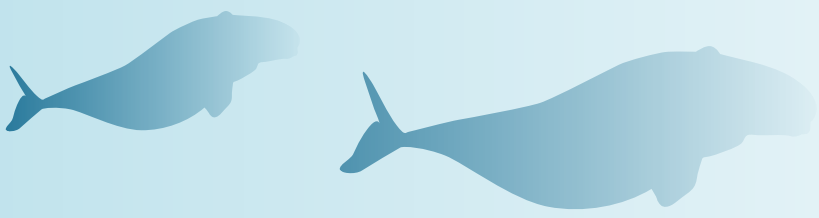
Caroline E.C. Goertz[1*], Kathy Woodie[1], Lisa Hartman[1], Eric Gaglione[2], Dennis Christen[2], Allison D. Tuttle[3], Tracy A. Romano[3], Tim Binder[4], Todd Schmitt[5], Eric Otjen[5], Steve Osborn[6], Manuel Castellote[7,8], T. Aran Mooney[9], Kathy Burek-Huntington[10], Brett Long[1], Deborah Fauquier[11], Barbara A. Mahoney[12], and Teri Rowles[11]
[1]Alaska SeaLife Center, Seward, Alaska, 99664, USA; [2]Georgia Aquarium, Atlanta, Georgia, 30313, USA; [3]Mystic Aquarium, Mystic, Connecticut, 06355, USA; [4]John G. Shedd Aquarium, Chicago, Illinois, 60605, USA; [5]SeaWorld San Diego, San Diego, California, 92109, USA; [6]SeaWorld San Antonio, San Antonio, Texas, 78251, USA; [7]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA; [8]Joint Institute for the Study of Atmosphere and Ocean, University of Washington, Seattle, Washington, 98195, USA; [9]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543, USA; [10]Alaska Veterinary Pathology Service, Eagle River, Alaska, 99577, USA; [11]Marine Mammal Health and Stranding Response Program, Office of Protected Resources, NOAA/National Marine Fisheries Service, Silver Spring, Maryland, 20910, USA; [12]NOAA Fisheries Alaska Region, Anchorage, Alaska, 99513, USA

Abstract
Given the remote, rugged areas belugas typically inhabit, opportunities to rescue live stranded belugas are rare. Additionally, given the relatively low overall success rate of rehabilitating cetaceans, there may be a reluctance to make the attempt. The Alaska SeaLife Center has cared for two stranded beluga calves with two different outcomes. In 2012, a neonatal male beluga calf was found stranded by beach walkers following intense storms in Bristol Bay. In 2017, a young male beluga calf was found opportunistically during a helicopter flight in Cook Inlet. Both calves were transported to the Alaska SeaLife Center for rehabilitation and were initially tube fed fluids combined with an increasing concentration of artificial formula every few hours. Diagnostic, treatment, nutrition, and supportive care plans were developed based on lessons learned from the care of other species of stranded cetaceans and care of neonatal belugas at zoological facilities. Diagnostics included complete blood counts, serum chemistries, microbial cultures of several sites, hearing tests, and morphometric measurements to monitor systemic health. Intensive treatment included in-pool support, antimicrobials, gastrointestinal support, and close monitoring of respirations, urination, defecation, and behavior. In 2012, after three weeks of support, the Bristol Bay calf succumbed to complications connected to the original stranding circumstances namely prematurity, lack of passive transfer, and sepsis. In 2017, after seven weeks the Cook Inlet calf was considered recovered from problems present at admit and taken off all medications. Because of his inability to survive on his own due to his young age and the risk of reoccurrence of pneumothorax, he was declared non-releasable and placed in a zoological facility with other beluga whales for long-term care. Factors leading to successful critical care provide a reference for future cases, which are especially important in the event of strandings of animals from endangered populations.

Acknowledgements
This work was carried out under MMHSRP MMPA/ESA #18786-02. Funding for this project was provided by the NOAA's John H. Prescott Marine Mammal Rescue Assistance Grant Program, the SeaWorld & Busch Gardens Conservation Fund, individual and corporate contributions to the Alaska SeaLife Center, and in-kind support by the home institutions of co-authors.

The co-authors would like to thank all members of the calves' care team, including:

- Georgia Aquarium's Kristen Hannigan, Liz D'Ambra, George Biedenbach, Mel Paynter, Jen O'Dell, Lindsey Ronis, Kelsey Ford, Christina Spilker, and Elizabeth Stadtler
- Shedd Aquarium's Steve Aibel, Tim Ward, Lana Vanagasem, Jessica Whiton, Maura Redding, Susan Allen, Sheri Hendricks, Rochelle Pepper, Jen Barker, Andrea Oakes, and Lisa Takaki
- Mystic Aquarium's Carey Richard, Nicole O'Donnell, Kathryn Justice, Ray Molnar, Chrissy Barth, Jesse Ciletti, and Laurie Macha
- SeaWorld's Scott McCoy, Brant Gabriel, Mitzi Synnott, Katie Kolodziej, and Bill Winhall
- Texas Marine Mammal Stranding Network's Heidi Whitehead,
- Vancouver Aquarium's Brian Sheehan
- Joint Base Elmendorf Richardson's Chris Gardner
- Alaska SeaLife Center's entire staff



11:30-11:45am | **Learning Opportunities with Collection and Stranded Belugas**

Katie H. Kolodziej[1*], Steve Osborn[1], Jennifer Cailleri[1], Heather M. Hill[2], and Caroline E.C. Goertz[3]
[1]SeaWorld San Antonio, San Antonio, Texas, 78251, USA; [2]St. Mary's University, San Antonio, Texas, 78228, USA; [3]Alaska SeaLife Center, Seward, Alaska, 99664, USA

Abstract
Managed populations of belugas provide value in public education as well as opportunities to learn from this species in zoological facilities. Over the past 15 years, a breeding collection of belugas representing all age classes has supported long-term observational and opportunistic research that has been effectively integrated into animal care. Routine observations and health monitoring produce physiological, morphometric, developmental, and behavioral information, improving our ability to care for these individuals but also provides insight into the condition of wild animals. The animal care team and researchers work closely together in order to maximize learning opportunities within routine care of this collection. They collaborate on study design and data collection with direct communications about behavior, health status, data quality, and progress of analysis. SeaWorld San Antonio is committed to continuing studies to better understand beluga health and physiology in addition to those related to long-term study in the fields of communication, social development, and cognition. Last year a non-releasable stranded calf from the endangered Cook Inlet population was placed at SeaWorld San Antonio with nine other beluga and five Pacific White-sided dolphins, adding new opportunities for observations and collaborations. Careful monitoring of his behavior, including obstacles and achievements, as well as the continued documentation of his growth and development started during his rehabilitation has highlighted differences with other individuals, while providing new insights into beluga behavior. Factors leading to his successful integration provide a reference for managing future cases, which are especially important in the event of strandings of animals from endangered populations.

Acknowledgements
This work was carried out under permit #18786-03.

11:45am-12:00pm | **Educational Show Program of Beluga (*Delphinapterus leucas*) at Kamogawa Sea World**

Hiroshi Katsumata[1]
[1]Kamogawa Sea World, Kaogawa, Chiba, 296-0041, Japan

Abstract
Kamogawa Sea World has been keeping belugas since 1976. In the educational show program, the auditory capability of cetacean, especially echolocation, communication and cognitive abilities are presented to the guests. Through the sound analysis devices, the audience can see the supersonic sound live on the screen when belugas use echolocation. The vocal communication between belugas is actually presented by using eyecups and visual discriminative stimuli (SDs). One beluga recognizes the SD and transmits the information to the other blindfolded beluga. Sounds emitted by the beluga who recognized

the SDs of different behaviors are clearly different. One beluga has also been involved with the cognition research project on dolphins for 20 years. In 2014, the study on the vocal imitation of human speech by a beluga, conducted under this project was scientifically verified as the first in the world.

Acknowledgements
The record regarding vocal imitation is based on the work by Dr. Murayama of Tokai University, Japan.

Traditional Ecological Knowledge – Panel II: USING TRADITIONAL KNOWLEDGE IN MANAGEMENT AND CONSERVATION

Poster Session- Poster abstracts follow Day 3

DAY 3 | THURSDAY, MARCH 14

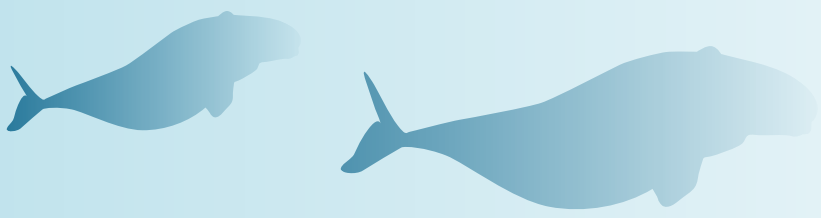
Session IV: CONSERVATION AND MANAGEMENT

8:45-9:10am | ***21st Century Conservation Challenges***

Issues Related to the Stewardship of Beluga Subpopulations World-Wide

Douglas P. DeMaster[1]
[1]University of Alaska, College of Fisheries and Ocean Sciences, Juneau, Alaska, 99801, USA

Abstract
The beluga whale is an Arctic and sub-Arctic species that is susceptible to a number of anthropogenic impacts. Those impacts include: 1) subsistence hunting, 2) pollution, including oil spills, 3) live-capture fisheries, 4) poaching or other unauthorized takes, 5) competition with commercial fisheries, 6) habitat loss or degradation, including climate change, 7) bycatch in commercial fishing, and 8) introduction of disease agents (e.g., pathogens, parasites, harmful-algal blooms). While they are widely distributed, belugas show considerable fidelity to the areas they use and are considered to comprise about 21 subpopulations. Independently or cumulatively, anthropogenic impacts combined with natural events (e.g., predation, mass strandings) dictate whether a given population will persist or not. In recent history, only one population of beluga whale is known to have been extirpated. Laidre et al. recommended the following conservation measures to prevent extirpation due to anthropogenic forcing: 1) improve co-management by local, federal and international partners; 2) recognize spatial and temporal variability in subpopulation responses to climate change; 3) implement monitoring programs with clear goals; 4) mitigate cumulative impacts of human activity; and 5) recognize limits of current protected species legislation. Key to the successful implementation of the above is integration of management related activities by local, regional and international partners and monitoring of population levels, animal health, and anthropogenic removals. Currently many populations and subpopulations have limited information regarding abundance or human removals, which hampers stewardship. In addition, funding limitations are a reason for a lack of mitigation



or management actions in many regions. Efforts to develop cost-effective monitoring programs for all populations are urgently needed. One specific management need is to develop guidance regarding what should be considered minimally adequate precision in and frequency of abundance surveys.

9:10-9:30am | ***Threats on Cook Inlet Beluga and Recovery***

The Development of the Recovery Team's Draft Recovery Plan for Cook Inlet Whales: Where Theory Met Practice

Tamara L. McGuire[1]
[1]*The Cook Inlet Beluga Whale Photo-Id Project, Aqua Wildlife Research, Anchorage, Alaska, 99515, USA*

Abstract
The Cook Inlet Beluga Whale Recovery Team was a group of over 30 volunteer team members, organized into a Science Panel and a Stakeholder Panel, who worked for three years to create a draft Recovery Plan for the endangered Cook Inlet beluga whale population. This presentation is the Team Leader's recollection and perspective of the process, a summary of the resulting draft, and an overview of how it differs from the version finalized and implemented by the National Marine Fisheries Service. Emphasis is given to the Science Panel's assessment of threats and the development of recovery criteria.

9:30-9:50am | ***Threats on St. Lawrence Estuary Beluga***

Aggravating Effects of Climate Variability on a Small Arctic Population at the Southern Limit of its Species' Distribution and Exposed to Multiple Human Stressors: The St. Lawrence Estuary Beluga

Véronique Lesage[1]
[1]*Fisheries and Oceans Canada, Mont-Joli, Quebec, G5H 3Z4, Canada*

Abstract
Up until recently, the St. Lawrence Estuary (SLE) beluga was considered a *Threatened* population, with an estimated population size of around 1,100 individuals. However, an abnormally high number of newborn beluga reported dead in 2012 triggered an in-depth review of the population status. This review indicated that the population was stable or increasing at a slow rate (0.13% per year) until the early 2000s, but began declining thereafter at a rate of approximately 1% per year. This decline was accompanied by high interannual variability in calf survival and pregnancy rate, and since 2010, by peripartum complications among dead adult females (a new phenomenon in SLE beluga). These recent and major changes in population dynamics and trends coincided with negative anomalies of several environmental conditions within an already-deteriorated ecosystem for beluga. These included further reductions in prey availability relative to long-term averages for the Gulf of St. Lawrence, a warming climate, chronic exposure to shipping traffic, disturbance from increasing whale-watching activities in parts of the beluga Critical Habitat, high levels of a larger number of contaminants (e.g., PCBs, DDTs, PBDEs), and episodic harmful algal blooms. From this, we conclude that collectively, recovery measures implemented to date have been insufficient to reduce threats and promote recovery of this now *Endangered* population. A recent

population viability analysis for SLE beluga indicated that simultaneous, forceful actions are required to mitigate the effects of noise, contaminants and reduced prey availability. Failing this, the SLE beluga may not have the necessary resilience to cope with the effects of a warming climate.

Acknowledgements
This presentation reports on the findings of multiple research scientists that have come together, and presented their time series to understand trends and stressors acting on the St. Lawrence Estuary beluga population. Contributors include from Fisheries and Oceans Canada: Hugo Bourdages, Catherine Couillard, Thomas Doniol-Valcroze, Peter Galbraith, Jean-François Gosselin, François Grégoire, Mike Hammill, Michel Lebeuf, Caroline Lehoux, Véronique Lesage, Ian McQuinn, Lena Measures, Sonia Michaud, Arnaud Mosnier, Stéphane Plourde, Meriem Raach, Michael Scarratt, Michel Starr. Contributors also include Pierre Béland (Institut National d'Écotoxicologie du Saint-Laurent), Clément Chion (University of Quebec in Outaouais), Stéphane Lair and Daniel Martineau (University of Montreal), Nadia Ménard and Samuel Turgeon (Saguenay St. Lawrence Marine Park), Robert Michaud (Group of Research and Education on Marine Mammals). Rob Williams and Erin Ashe (Ocean Initiatives), Bob Lacy (Chicago Zoological Society), Ailsa Hall (University of St. Andrews) were the lead authors on the population viability analysis.

9:50-10:10am | ***Science-Based Conservation***

Science in Beluga Whale Conservation: The State of the Art!

Greg O'Corry-Crowe[1*] and Robert Suydam[2]
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Abstract
If society sets conservation objectives, science's role can be seen as informing policy to achieve those objectives. However, what we value about the natural world and feel is worth conserving is constantly evolving, and this is directly influenced by advances in scientific research. The conservation of beluga whales and their habitats is no exception. Conservation objectives over the past several decades have focused on identifying management units or stocks of beluga whales, the monitoring of abundances and trends, the identification and elimination of threats and assessments of whether certain stocks need additional protection in order to halt observed declines and promote recovery. Over this time, there have been substantial advances in research on beluga whale biology, ecology and threats to survival. Such advances have been driven primarily by technological breakthroughs in fields like molecular biology, acoustic monitoring and satellite telemetry and are aided by the sharing of ideas and results; most of which is dependent on financing these efforts. Several recent advances in beluga whale science, including improved understanding of movements, habitat preferences, social structure and population trends, are telling us that some current policies may be inadequate to achieve conservation objectives and inadequate to tackle emerging conservation issues, including impacts of climate change, preventing extinction and helping depleted stocks recover. We argue that current measure-and-monitor science is not sufficient to meet the conservation demands of beluga whales in the 21st century. Furthermore, beluga whale research is

not keeping pace with advances in some scientific fields, including genomics and resilience science, while policy is lagging behind current thinking regarding natural resource management. Ultimately, we are in danger of unlearning the value of the co-management approach that emerged between western science and Native knowledge in the 1990s, where greater inclusion of differing views and perspectives leads to more effective conservation action.

Acknowledgements
Our work over the years has been made possible by the generous support of Native communities across the Arctic and subarctic, and has been funded by Federal co-management funding from the Alaska Beluga Whale Committee. Additional support has come from the North Slope Borough Department of Wildlife Management, Harbor Branch Oceanographic Institute, the Alaska Department of Fish and Game, and the National Fish and Wildlife Foundation.

10:45-11:00am | **Collaborative Interdisciplinary Studies to Understand Beluga Whale Health, Physiology, and Life History in Bristol Bay, Alaska**

Caroline E.C. Goertz[1*], Kathy Burek-Huntington[2], Russel D. Andrews[1,3], Lori T. Quakenbush[4], Tracy A. Romano[5], Manuel Castellote[6,7], T. Aran Mooney[8], Leslie A. Cornick[9], Stephanie Norman[10,11], Amanda Moors[12], Eric Gaglione[13], Dennis Christen[13], Tim Binder[14], Brett Long[1],and Roderick C. Hobbs[6]
[1]Alaska SeaLife Center, Seward, Alaska, 99664, USA; [2]Alaska Veterinary Pathology Service, Eagle River, Alaska, 99577, USA; [3]School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, Alaska, 99701, USA; [4]Alaska Department of Fish and Game, Fairbanks, Alaska, 99701, USA; [5]Mystic Aquarium, Mystic, Connecticut, 06355, USA; [6]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA; [7]Joint Institute for the Study of Atmosphere and Ocean, University of Washington, Seattle, Washington, 98195, USA; [8]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543, USA; [9]Eastern Washington University, Cheney, Washington, 99004, USA; [10]Marine-Med, Bothell, Washington, 98021, USA; [11]World Vets/EcoMarine Institute, Gig Harbor, Washington, 98332, USA; [12]National Institute of Standards & Technology, Charleston, South Carolina, 29412, USA; [13]Georgia Aquarium, Atlanta, Georgia, 30313, USA; [14]John G. Shedd Aquarium, Chicago, Illinois, 60605, USA

Abstract
Beluga whales (*Delphinapterus leucas*) are a species of great interest because of their role as a sentinel species, importance to subsistence, vulnerability to climate change, and for helping us to understand threats to at-risk populations. Studying beluga whales can be challenging because the remote and harsh environment in which they live requires extensive and expensive logistical support. Given these challenges, researchers from different disciplines and institutions collaborated on studies of wild belugas in Bristol Bay. This approach also allows for a more intensive interpretation of results not possible with independent studies. In six field seasons in Bristol Bay, we captured and released 56 beluga whales from which we collected blood, feces, gastric contents, skin, blubber, blowhole swabs, breath exhalations, as well as morphological, auditory, and ultrasound measurements. Satellite-linked transmitters were attached to track the whales upon release to monitor their movements and habitat use over time. Total handling time, from net entanglement to release, averaged 88 minutes (range 49-125 minutes). Information gained to date has advanced our understanding of beluga whale health, physiology, disease

exposure, immunology, body condition, hearing sensitivity, potential noise impacts, acoustic habitat, foraging behavior, and habitat use. Additionally, this project facilitated training of hunters to tag belugas in other remote regions and contributed to graduate student studies. This project also validated sampling techniques for use when capture is not feasible, such as remotely deployed tags, darting biopsies, and exhalation collection. Future research will include comparative studies to better understand why Bristol Bay supports a healthy, growing beluga population while Cook Inlet, a similar estuarine habitat, does not.

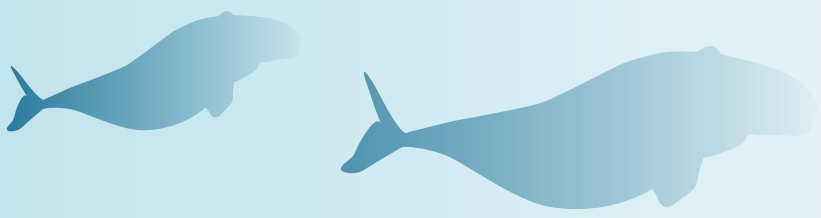
Acknowledgements
This work was carried out under the following authorizations: NMFS Scientific Research Permits (782-1719; 932-1489; and 14245), ADF&G IACUC (06-16), NOAA/MML IACUC (AFSC/NWFC 2012-1), and the Bristol Bay Marine Mammal Council. Funding for this project was provided by NOAA, Georgia Aquarium, Shedd Aquarium, and in-kind support for participants by their home institution.

The authors would like to acknowledge and thank the members of the research and capture crews. Special thanks go to Helen Aderman, Bristol Bay Native Association, for helping to coordinate boat captains and other local participants including Ben Tinker, Richard Hiratsuka, Albie Roehl, William and Daniel Savo, Danny Togiak, William Norbert and their respective first mates. We appreciate the substantial assistance in animal handling and sample and data collection by Natalie Rouse, Renae Sattler, George Biedenbach, William Hurley III, Tracey Spoon, Mandy Keogh, Laura Thompson, Justin Richards, Lisa Naples, Jennifer Trevillian, Jen Godfrey, and Lindsey Saxon Kendall. Also, we greatly appreciate the guidance, suggestions, and support of T. Rowles (NOAA).

11:00-11:15am | **A Holistic Approach to Examining Factors Limiting the Health and Recovery of Beluga Whales (*Delphinapterus leucas*) in Cook Inlet, AK**

Kim Parsons* [1], Gina Ylitalo[2], Nicholas Kellar[3], Amy Apprill[4], Tracy A. Romano[5], Scott Baker[6], Kelly Robertson[3], Tamara L. McGuire[7], Robert Michaud[8], Teri Rowles[9], and Paul R. Wade[1]
[1]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, Seattle, Washington, 98112, USA; [2]Northwest Fisheries Science Center, NOAA, Seattle, Washington, 98112, USA; [3]Southwest Fisheries Science Center, NOAA, La Jolla, California, 92037, USA; [4]Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02540, USA; [5]Mystic Aquarium, Mystic, Connecticut, 06355, USA; [6]Hatfield Marine Science Ctr, Newport, Oregon, 97365, USA; [7]Anchorage, Alaska, 99518, USA; [8]Group for Research and Education on Marine Mammals, Tadoussac, Quebec, G0T 2A0 Canada; [9]MMHSRP, NOAA, Silver Spring, Maryland, 20910, USA

Abstract
The beluga whales (*Delphinapterus leucas*) of Cook Inlet Basin are an iconic marine species of significance to both the regional marine ecosystem and the Alaska Native community. This population declined from an estimated 1,293 individuals in 1979 to a population of less than 400, in a few decades. Data from systematic aerial surveys suggest that despite a dramatic reduction in subsistence hunts, the Cook Inlet beluga population fails to exhibit significant population growth. The most recent estimate from 2016 aerial surveys indicates a population size of 328 whales (CV = 0.083, CI = [279, 386]). Despite protection over the last decade under the U.S. Endangered Species Act, evidence of population growth is lacking and significant scientific resources are being dedicated to understanding the factors



limiting the conservation and recovery of Cook Inlet belugas. Annual remote tissue biopsy sampling efforts commenced in 2016, generating 36 skin/blubber biopsies to date. In addition to archived skin samples, these tissue biopsies are being used in interdisciplinary, collaborative studies to examine potential factors limiting population survival and fecundity. Molecular genetics and genomic approaches include characterization of epidermal microbiota, whole genome sequencing, nuclear genotyping and mitochondrial sequencing to characterize patterns of kinship and relatedness. Sex-based patterns of testosterone, cortisol and progesterone in blubber are being used to estimate pregnancy rates and sexual maturity. Transcriptomics and expression of health-related genes will be examined with respect to persistent organic pollutants and emerging contaminants in blubber biopsies. Stable isotopes (13C and 15N) from skin biopsies will provide insight into prey preferences and patterns of age-related epigenetic methylation will be characterized to estimate both chronological and ordinal ages of biopsy-sampled whales. This holistic approach to generating individual-based data represents a critical step towards a better understanding of the factors limiting the recovery of this endangered population.

Acknowledgements
Field work and sample collection was carried out collected by the NOAA Marine Mammal Lab under NMFS ESA/MMPA Permit #20465. Funding for this project was provided by NOAA Fisheries, AFSC, MML.

11:15-11:30am | **Photogrammetry of Cook Inlet Beluga Whales Using an Unmanned Aircraft System**

Paul R. Wade[1*], Hollis M. Europe[2], Jacob C. Barboro[2], Janice M. Waite[1], Christy Sims[1], Justin Jenniges[3], Tom Gage[4], and John W. Durban[2]
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Abstract
The Cook Inlet beluga whale is a genetically distinct, geographically separate population that declined rapidly in the 1990s, and has continued to experience a slower decline since, resulting in it being classified as endangered. Although the abundance and trend of the Cook Inlet beluga population is known, little is known about vital rates that could shed light on causes of the lack of recovery. In 2017, we initiated a project using an unmanned aircraft system (a hexacopter) launched from a small boat to take high-resolution aerial photographs of beluga whales in Cook Inlet. Measurements of the number of pixels on each image can be converted to an absolute distance using the measured altitude of the aircraft (using a laser altimeter), the focal length of the lens, and the pixel size of the camera sensor. The primary objective of the project is to identify newborn calves from their length in order to estimate an annual index of calf production in order to determine whether this population exhibits a reproductive rate typical of that expected for a healthy beluga population. The opaque waters of Cook Inlet prevent measurement of total body length, so we are instead measuring relative body length (the distance from the blowhole to the dorsal ridge), which can be scaled up to total body length by using paired-measurement datasets. In the first field season, we conducted 67 flights (11 hours of flight time) over 11 encounters with beluga whales,

resulting in a total of 1077 usable photographs of beluga whales, 661 of which can be used to measure the blowhole to dorsal ridge length. Preliminary measurements indicate newborn calves (54.7-63.5cm) can be clearly distinguished from presumed (from blue-gray color) one-year old calves (71.5-82.1cm), indicating photogrammetry can be used to identify young-of-the-year and estimate annual calf production.

Acknowledgements
This work was carried out under NMFS ESA/MMPL Permit #20465. Funding for this project was provided by NOAA Fisheries.

11:30-11:45am | **First Abundance Estimate of the Svalbard White Whale Population, *Delphinapterus leucas*, Norway**

Jade Vacquié-Garcia[1*], Christian Lydersen[1], Tiago A. Marques[2,3], Magnus Andersen[1], and Kit M. Kovacs[1]
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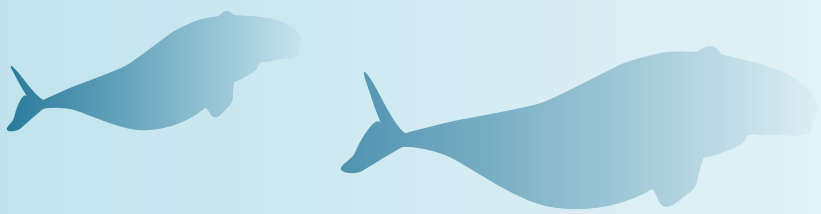
Abstract
The Svalbard Archipelago in the Norwegian High Arctic is experiencing rapid declines in the seasonal duration and extent of sea-ice cover and local tidal glaciers are melting and retracting onto land. These changes represent a serious threat to all of the resident ice-associated species, including white whales (*Delphinapterus leucas*). However, no assessments of abundance exist for white whales in this region, so neither the population size, nor the population trend, are known. Thus, an aerial survey was conducted during summer 2018 to provide the first abundance estimate for the Svalbard white whale population. A combination of strip and distance sampling line transects were flown, covering (i) the coastline of all major islands in Svalbard (ii) the fjords and (iii) transects out from the coast into the open ocean. A total of 265 individuals in 22 groups of white whales were detected along the 4993 km of coastline transects. Two observations (9 individuals) occurred along the 1481 km of transects conducted in the fjords. No white whales were observed along the 535 km of open ocean transects. After correcting for surface availability (based on four different turbidity factors), calculated using available tracking and diving data obtained from the same population in the summer season, a preliminary estimate for the Svalbard white whale population is 539 [421-747] individuals. This estimate is surprisingly low considering that this species is the most frequently observed Arctic cetacean in the area, but it does confirm suspicions based on challenges encountered in finding animals when operating tagging programs. This first abundance estimate for the population is important in the context of the rapid environmental change that is taking place in the region, providing an important baseline for comparison with future abundance estimates. It also represents an essential step in the local conservation and management of this species.

Acknowledgements
This study was supported financially by the Norwegian Polar Institute, the Norwegian Research Council (ICE-WHALES, TIGRIF and GLAERE programs), the Norwegian Polar Institute's ICE Research Centre and the Fram Centre's Fjord and Coast Flagship. We thank Samuel Martinez Llobet for help in the field.



11:45am-12:00pm | **Sonic Seas: Hearing Abilities of Bristol Bay and Cook Inlet Belugas**

T. Aran Mooney*[1], Manuel Castellote[2], Ian Jones[1], Roderick C. Hobbs[2], Lori T. Quakenbush[3], Eric Gaglione[4], Chris Garner[5], Teri Rowles[6], Deborah Fauquier[6], and Carrie E.C. Goertz[7]
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Abstract
Hearing is crucial for beluga behaviors including communication, foraging, and navigation. In many habitats, noise levels are increasing, largely due to human activities. Measuring beluga hearing abilities provides a critical baseline to estimate noise impacts on vital behaviors and beluga biology. In three expeditions since 2012 we measured hearing in 26 wild Bristol Bay belugas, providing a unique understanding of hearing sensitivities and subsequent variation in a healthy wild population. In the fall of 2017, a beluga calf from the endangered Cook Inlet beluga population stranded and we measured its hearing in October and December. These data provide the first empirical hearing data hearing for a Cook Inlet beluga allowing for estimations of sound-sensitivity in this population, and comparisons to the well-studied Bristol Bay population. Both data sets show generally sensitive hearing (<60 dB) with most animals hearing high frequencies (up to 120-150 kHz) with hearing thresholds near or at the current ambient noise levels. Increases in ambient noise due to anthropogenic activities are likely to influence hearing abilities of beluga whales. In addition, measuring the hearing in the calf over time will provide additional information on age related hearing changes. Hearing assessments of both populations, and ambient noise data collected in Bristol Bay, provide important baseline knowledge to better address environmental concerns related to the lack of recovery for the endangered Cook Inlet beluga population, and general increase of underwater noise in the Arctic.

Acknowledgements
Project funding and field support provided by multiple intuitions including Georgia Aquarium, the Marine Mammal Laboratory of the Alaska Fisheries Science Center (MML/AFSC), and the WHOI (Arctic Research Initiative and Marine Mammal Center). Field work was also supported by National Marine Fisheries Service Alaska Regional Office (NMFS AKR), the WHOI Ocean Life Institute, U.S. Fish and Wildlife Service, Bristol Bay Native Association and their Marine Mammal Council, Alaska SeaLife Center, Shedd Aquarium and Mystic Aquarium. Audiogram analyses were initially funded by the Office of Naval Research. Special thanks go to Bristol Bay Native Association for helping to coordinate boat captains and other local participants. NMFS marine mammal stranding network supported travel for the CI beluga work. Fieldwork was conducted under NMFS permit no. 14245 and in accordance with approval from the NMML/AFSC IACUC protocols (ID number: AFSC-NWFSC2012-1) and WHOI IACUC protocols (ID number: BI166330). Cook Inlet work was conducted under permission from the NMFS Marine Mammal Stranding Network and the Office of Protected Resources.

12:00-12:15pm | **Mom, Can You Hear Me? Impacts of Underwater Noise on Mother-Calf Contact Calls in Endangered Belugas (*Delphinapterus leucas*)**

Valeria Vergara[1*], Jason Wood[2], Audra Ames[3], Marie-Ana Mikus[4], Véronique Lesage[5], and Robert Michaud[6]

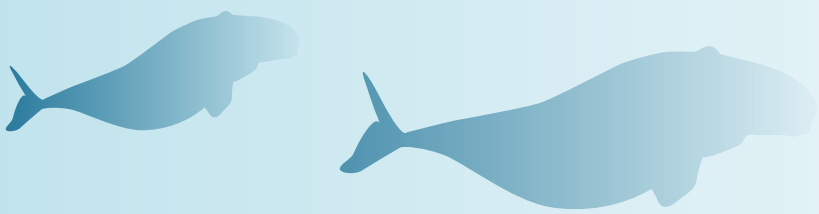
[1]Ocean Wise Conservation Association, Vancouver, British Columbia, V6G 3E2, Canada; [2]Sea Mammal Research Unit (SMRU) Consulting, Vancouver, British Columbia, V6J 1R1, Canada; [3]Fundaciòn Oceanogràfic, Valencia, 46013, Spain; [4]Ocean Wise Conservation Association, Vancouver, British Columbia, V6G 3E2, Canada; [5]Maurice-Lamontagne Institute, Fisheries and Oceans Canada, Mont –Joli, Quebec, G5H 3Z4, Canada; [6]Group for Research and Education on Marine Mammals, Tadoussac, Quebec, G0T 2A0, Cananda

Abstract

Noise and other anthropogenic disturbance from recreational and commercial vessel traffic were identified to be among the main threats to the recovery of the endangered St Lawrence Estuary (SLE) beluga population. The consequences of acoustic masking could be particularly adverse in the case of critical vocalizations that maintain contact between mothers and their dependent but mobile calves. Here, we modeled communication range of adult and newborn beluga broadband contact-calls under quiet and noisy conditions in Baie *Sainte-Marguerite*, an important summering area for this population. To do so, we used measurements of ambient noise obtained with a calibrated hydrophone in the presence and absence of boats (verified visually from an observation tower), a composite beluga audiogram based on thresholds pooled from all individuals tested with AEP and behavioral methods and apparent source levels of adult and neonate contact-calls. Source levels were estimated from received levels of contact-calls recorded from two wild populations (SLE and Eastern High Arctic) and from Oceanogràfic aquarium (two adults and a neonate) at known distances from a calibrated hydrophone, with propagation loss equations suited to each location and from contact-calls recorded from five individuals carrying temporary Dtags (SLE). The modeled median distance at which the signal excess reached zero in all 1/12 octave bands analyzed (487 to 97162Hz center frequencies), considered the maximum communication range, was considerably reduced in noisy conditions, particularly for neonates, given that their calls had substantially lower source levels and peak frequencies than adult contact-calls. Thus, a neonate's call would suffer a 56% reduction in range at a median distance of 190m in noisy conditions. The estimates in our study are the first approximations of source levels and active space of beluga calls with a known function and show that masking of these calls by noise may be particularly problematic for the underdeveloped contact-calls of neonates.

Acknowledgements

This work was carried out under permits # SAGMP-2018-28703 and QUE-MM02-2017. Funding for this project was provided by the AZA Conservation Grants Fund, the Sea World Busch Gardens Conservation Grant, Earth Rangers, the Kenneth M. Molson Foundation and the Fondation de la Faune du Québec.



12:15-12:30pm | **Causes of Mortality in St. Lawrence Estuary Beluga Whales (*Delphinapterus leucas*): Changes in Occurrences Over the Last 35 Years**

Stéphane Lair[1*], Robert Michaud[2], Véronique Lesage[3], Pierre Béland[4] and Nadia Ménard[5]
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Abstract
Mortalities of St. Lawrence Estuary beluga (Quebec, Canada) have been monitored without interruption for 35 years. Cancer and infectious diseases have been identified as the cause of death in respectively 16% and 43% of the beluga for which a cause of death was determined (n=190). Exposure to carcinogenic contaminants such as PAHs, and to immunomodulating compounds such as PCBs have been proposed as risk factors for the development of cancers and infectious diseases, respectively. Over the years, we have observed a marked decrease in the occurrence of cancer, which correlates with the decrease in PAH levels in the sediments of beluga habitat. In adult beluga (≥30 years), the percentage of beluga that died with a cancer decreased from 27% for 1983–2010 to 5% for 2011–2017. This observation strongly supports a causal relationship between the development of cancer and exposures to industrial contaminants. A slight decrease in the occurrence of infectious diseases has also been observed in adults, which somewhat coincides with the decrease in the levels of contamination by PCBs. Mortality in calves were only occasionally documented from 1983 to 2007 (0–3 dead calves seen annually). Since 2008, the numbers of carcasses of calves reported annually have dramatically increased (1–16 dead calves seen annually). So far, *post-mortem* examinations have not identified causes for these mortalities. A concurrent increase in *peri-partum* mortalities of adult females was also observed. This suggests that the increase in calf mortality is associated with an increase in the occurrence of calf/mother separations/abandonments subsequent to parturition complications. Hypotheses proposed to explain this increase include exposure to endocrine disrupting xenobiotics, such as PBDEs, nutritional stress due to global modifications of the ecosystem and increase in disturbances from boat traffic. The lower calf survival currently observed could obviously threaten the long-term sustainability of this population.

Session IV Continued: Conservation and Management

2:00-2:20pm | ***Management and Regulation for Cook Inlet Beluga***

Conservation and Management of the Endangered Cook Inlet Beluga Whale Population in Alaska

Verena A. Gill[1]
[1]NOAA Fisheries, Alaska Region, Anchorage, Alaska, 99513, USA

Abstract
In Alaska there are five stocks of beluga whales, but only one is listed under the Endangered Species Act (ESA); the Cook Inlet (CIBW) population was listed as endangered in 2008. The population has declined by nearly 75% since 1979—from about 1,300 whales to around 330. In December 2016, the NOAA Fisheries Alaska Region released a Recovery Plan for CIBW, and in 2018 a Recovery Implementation Task Force was created under a partnership with the State of Alaska Department of Fish and Game to provide guidance and recommendations for implementing recovery. The Task Force includes three committees - Research, Habitat and Threats Management and Outreach. The focus is on short-term actions that can be completed in the next 2-5 years. Prior to the establishment of the CIBW Task Force, NOAA and partners had already begun to implement 33 of the 64 recovery actions from the recovery plan. Recently implemented recovery actions include: 1) the "Belugas Count! Event"; 2) a study to determine the energetic requirements and metabolic needs of CIBW; 3) CIBW winter distribution surveys and 4) examination of contaminants of emerging concern in CIBW prey. NOAA also implements conservation actions through ESA Section 7, consultation to mitigate impacts of human activities on CIBW (e.g., oil and gas exploration and development, port expansions and research). These mitigations include project modifications that reduce noise and spatio-temporal overlaps with belugas, shutdown zones and vessel and aircraft distance and altitude restrictions. Other CIBW conservation efforts by NOAA Alaska include increased outreach efforts to minimize anthropogenic effects on CIBW, to increase reporting of live and dead belugas and to shift societal attitudes towards conservation of this "urban" whale population.

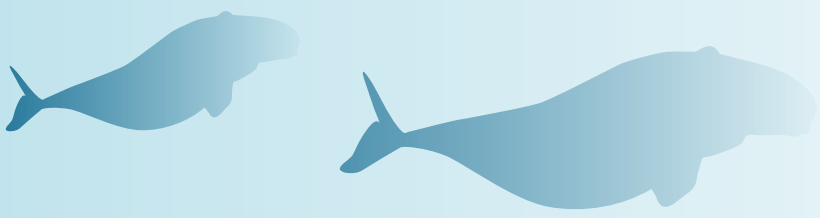
Acknowledgements
Thank you to the defacto Cook Inlet beluga team made up of federal, state, NGO biologists and citizen scientists who work together to contribute to our understanding of the factors impacting the beluga population in Cook Inlet.

2:20-2:40pm | ***Management and Regulation for St. Lawrence Beluga***

Protection and Conservation Efforts for the Recovery of St. Lawrence Beluga

Nicole Bouchard[1]
[1]Fisheries and Oceans Canada, Mont-Joli,, Quebec, G5H 3Z4, Canada

Abstract
The regulatory framework in force in Canada provides various complementary tools for protecting St. Lawrence beluga and their habitat. The Species at Risk Act has provisions prohibiting the killing and harming of endangered species, and requires that their critical habitat be identified based on the best available information, and protected. Critical habitat is always defined as a geographic area, and is accompanied by a biophysical description that includes biological functions and attributes. In some species such as St. Lawrence beluga, maintaining a suitable acoustic environment is part of the critical habitat features that need to be preserved. In addition to the Species at Risk Act, beluga also benefit from the protection of other regulatory instruments such as the Fisheries Act and Marine Mammal Regulations.



The St. Lawrence beluga population was severely depleted by commercial hunting and is now threatened by contamination, availability of prey, disturbance and underwater noise. Actions have been proposed and undertaken to counter these threats. Meanwhile, a vast number of research initiatives have been supported over the past decades to advance our understanding of the threats and monitor the population. Science has been crucial to inform and prioritize measures that were implemented such as reducing water pollution and enforcing a minimum approach distance. For example, the current Ocean Protection Plan constitutes a major initiative to improve our understanding of the impact of noise on St. Lawrence belugas and examine the most effective scenarios for mitigating this threat. Despite all the efforts and the existence of powerful legislative tools, the implementation of effective mitigation measures to favor the recovery of the beluga population is faced with several challenges. This is especially true in the current context where knowledge gaps are many, thresholds for significant biological cumulative impacts are often undetermined, and where global threats such as contamination or climate change are international issues.

2:40-2:55pm | **Co-Management as a Means of Addressing Science Needs for Belugas (*Delphinapterus leucas*) in Western Alaska**

Kathryn J. Frost[1*], Lloyd F. Lowry[1], Robert S. Suydam[2], Lori T. Quakenbush[3], John J. Citta[3], Greg O'Corry-Crowe[4], Willie Goodwin[1], and Thomas L. Gray[1]
[1]*Alaska Beluga Whale Committee, Utqiagvik, Alaska, 99723, USA;* [2]*North Slope Borough Department of Wildlife Management, Utqiagvik, Alaska, 99723, USA;* [3]*Alaska Department of Fish and Game, Fairbanks, Alaska, 99709, USA;* [4]*Harbor Branch Oceanographic Institute, Florida Atlantic University, Fort Pierce, Florida, 34946, USA*

Abstract
The Alaska Beluga Whale Committee (ABWC) was formed in 1988 to conserve beluga whales and manage beluga subsistence hunting in western and northern Alaska in cooperation with the National Marine Fisheries Service (NMFS). When the ABWC was formed, there was no consistently funded research or management program for belugas in Alaska. The ABWC brought together representatives from beluga hunting communities in Alaska; federal, state, tribal, and local governments; and beluga researchers to develop and implement a program to provide the data needed for sound beluga management. Goals of that program were to identify management stocks in western Alaska, estimate abundance and trends of those stocks, and monitor the subsistence harvest by Alaska Natives for each stock. With funding from NMFS and other cooperators, the ABWC has conducted 23 multi-day aerial surveys of belugas in three areas, Bristol Bay, eastern Bering Sea, and the eastern Chukchi Sea since 1990. Since 1996, the ABWC has conducted or collaborated in beluga tracking studies, including the training of hunters to attach transmitters, in Bristol Bay, the eastern Bering Sea, and the eastern Chukchi Sea. In 1989, the ABWC initiated a pioneering genetics study of beluga stock identity and by 2017 had facilitated the collection of more than 2,000 beluga skin samples. It supported a genetics-based mark-recapture study to estimate beluga abundance in Bristol Bay and to validate aerial survey estimates, in addition to studies of diet and passive acoustics. The ABWC has held 5 science workshops to present in-depth but plain English information to delegates from beluga-hunting communities. Since 1988, ABWC collaborators have authored more than 40 publications on Alaskan belugas. The ABWC is not only cost-effective but produces results that are scientifically valid AND locally accepted. The ABWC stands as a model of what can be achieved when Native hunters, scientists, and managing agencies work together.

Acknowledgements
Co-management activities and supporting research have been funded by the Alaska Beluga Whale Committee through grants from the National Oceanic and Atmospheric Administration Alaska Native Organization Co-Management Funding Program. Additional support has been provided by the North Slope Borough Department of Wildlife Management, the Alaska Department of Fish and Game, the National Marine Fisheries Service (NMFS) Marine Mammal Laboratory, the NMFS Alaska Region, Bureau of Ocean Energy Management, National Fish and Wildlife Foundation, Office of Naval Research, the Bureau of Indian Affairs, and others.

2:55-3:10pm | **Co-Management of Marine Mammals in Northern Canada: Is There a Place for the Precautionary Approach?**

Arnaud Mosnier[1], Mike O. Hammill[1*], Garry B. Stenson[2], Thomas Doniol-Valcroze[3], and Jean-François Gosselin[1]
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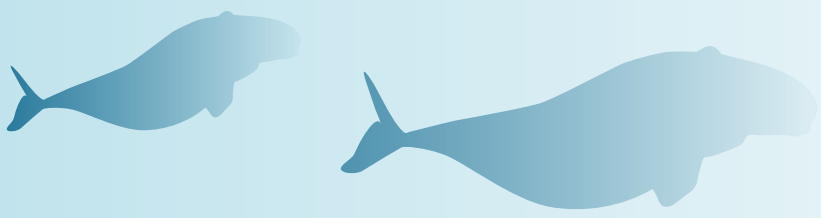
Abstract
The signing of land claims agreements with Canada's Inuit essentially transferred wildlife management responsibilities to co-management boards and restricted the powers of the responsible minister to overturn Board decisions. This has resulted in an apparent management paradox, since on one hand the Government's ability to limit harvesting has been constrained, while on the other hand, Canada has international responsibilities to ensure that its management framework respects the Precautionary Approach (PA). The rights of hunters to harvest are often highlighted in discussions with stakeholders, but the land claims agreements also call for the development of management systems that respect the principles of conservation and ensure sustainability of the resource. The latter suggests that a PA framework would be consistent with the concepts and principles of recent land claims agreements implemented in Canada. A subsistence harvest PA may resemble frameworks used in commercial fisheries, but would differ in aspects such as level of risk tolerance and time to recovery to increase the acceptability of such approach. Ultimately, a successful framework will depend on meaningful collaboration between hunters, scientists and co-management partners.

3:10-3:25pm | **Management Planning for Belugas (*Delphinapterus leucas*) in Kotzebue Sound and the Eastern Bering Sea**

Kathryn J. Frost[1*], Thomas L. Gray[1], Willie Goodwin[1], Ernie Barger[1], and Robert S. Suydam[2] [1]*Alaska Beluga Whale Committee, Utqiagvik, Alaska, 99723, USA; [2]North Slope Borough Department of Wildlife Management, Utqiagvik, Alaska, 99723, USA*

Abstract
The Alaska Beluga Whale Committee (ABWC) co-manages the subsistence harvest of belugas in Alaska through an agreement with the National Marine Fisheries Service stating that the ABWC and its



Management Regions will "Establish a reasonable harvest level based on the number of animals and cultural and subsistence needs." However, this agreement provides no specifics about how management goals might be accomplished, particularly if the harvest is near or above the sustainable level. Belugas have declined substantially in Kotzebue Sound since 1983, likely initially due to unsustainable subsistence harvesting. There are no reliable pre-decline abundance estimates and current abundance is so low that conventional abundance surveys are impractical. Genetics information suggests Kotzebue Sound belugas once constituted a separate stock, but current stock identity is unclear. Despite this uncertainly, beluga hunters in Kotzebue Sound want to find a way to "bring belugas back." In 2016, the Native Village of Buckland applied for and received grant funding to explore ways to restore Kotzebue Sound belugas to their former abundance. The result is a Kotzebue Sound Beluga Plan. The challenge now is to develop consensus that the Plan is reasonable, the situation is not hopeless, and the sacrifices necessary to bring belugas back are worthwhile. Belugas from the Eastern Bering Sea (EBS) stock, unlike Kotzebue Sound, are abundant. However, recent abundance estimates together with harvest information suggest the average annual harvest may be approaching sustainable limits. It is timely for hunters to discuss the sustainability of harvests. This discussion is complicated because two socially distinct regions and >20 communities harvest from this stock. Without facilitation by the ABWC, it is unlikely that communities will address this issue or that the two regions will interact about a beluga plan. Through proactive discussions, education, and planning the ABWC hopes to ensure the EBS beluga harvest remains sustainable.

Acknowledgements
Funding for these management planning efforts has been funded by the Alaska Beluga Whale Committee through grants from the National Oceanic and Atmospheric Administration Alaska Native Organization Co-Management Funding Program and by the US Department of the Interior Tribal Wildlife Grants Program. Additional support has been provided by the Native Village of Buckland, the NANA Regional Corporation, Maniilaq Association, and the North Slope Borough Department of Wildlife Management.

3:25-3:40pm | **Beluga Management and Monitoring in the Inuvialuit Settlement Region**

John Noksana Jr.[1*], Gerald Inglangasuk[2*], Lisa Loseto[2], Shannon MacPhee[2], Jasmine Brewster[3], Kayla Hansen-Craik[4], and Emily Way-Nee[4]
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Abstract
The beluga monitoring program in the Inuvialuit Settlement Region (ISR) is co-managed by the Fisheries Joint Management Committee (FJMC), Fisheries and Oceans Canada, and various Inuit communities in the Western Canadian Arctic. Each summer, harvesters and their families travel to traditional whaling camps or other sites along the Canadian Beaufort Sea coast to conduct hunting of belugas. The majority of beluga harvesting in the ISR occurs in July when the whales aggregate in the shallow areas of the Mackenzie River Estuary. However, beluga are also harvested near the communities of Paulatuk, Sachs Harbour and Ulukhaktok during the summer.

The Beaufort Sea beluga stock is managed through the FJMC Beaufort Sea Beluga Management Plan, which was established in 1991. The first formal beluga harvest-monitoring program for the region began in 1973, and since then, data has been collected annually from the harvesters on the size and timing of the whale harvest, and the number of whales struck, landed and lost. The program has been developed over many years, and it is now the longest and largest monitoring database of beluga whale harvest information in Canada. The main goal of the beluga harvest-monitoring program is to detect changes in the harvest and health of the beluga over time. Local people are hired from the communities to be monitors; these people collect various measurements and tissue samples from the harvested whales, which are sent for analysis of age, sex, genetics, contaminants, etc. In addition to the monitoring program, the harvester reward program encourages harvesters to measure and sample their own whale when a monitor is not available. The FJMC beluga monitoring program is one example of co-management in the ISR that highlights how co-management efforts can be built upon a harvest-monitoring program and expanded into standardized and adaptive ecosystem-based management systems involving multiple stakeholders.

Acknowledgements
Funding for this program was provided by the Fisheries Joint Management Committee, Fisheries and Oceans Canada, and the Northern Contaminants Program.

Posters: HEALTH AND PHYSIOLOGY

Poster #1: Pathology and Epidemiology of Cutaneous Anomalies in Beluga Whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Quebec, Canada

Rozenn Le Net[1], Sylvain Larrat[2], Stéphane Lair[1*], and Robert Michaud[3]
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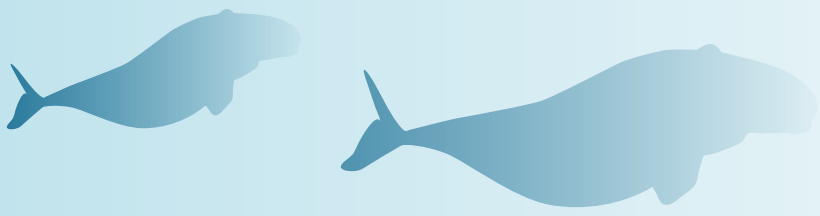
Abstract
Skin lesions have been documented in most cetacean species, including St. Lawrence beluga whales (*Delphinapterus leucas)*. The nature, cause and significance of these skin anomalies are, however, poorly understood. A total of 26,020 photographs representing 5,388 individual sightings, collected from 2003 to 2014 as part of a photo-identification program, were examined for the presence of cutaneous anomalies. Eighteen different macroscopic skin conditions were defined. In grey and white belugas, rake marks (grey: 77.2%, 95% IC: [74.9-79.5]; white: 69.5%, [68.0-71.0]), single linear scars (SLS) (grey: 55.0%, [52.3-57.8]; white: 55.1% ,[53.5-56.7]) and nummular depressions (grey: 39.9% [37.2-42.6]; white: 34.9% [33.4-36.4]) were the three most common skin conditions observed, whereas skin lacerations were the most common in newborns (21.9% [17.0-26.8]), followed by SLS (19.2% [14.5-23.9]) and ulcers (17.1% [12.6-21.6]). Associations between the different skin anomalies were tested using chi-square tests and application of Bonferroni correction. Rake marks, single lacerations and SLS (P<0.017), as well as yellow



patches, nummular depressions and “map” lesions (P<0.0083), were significantly associated. Logistic regression modelling revealed significant correlations between independent variables (age category, month and year) and some skin anomalies. In addition to this work based on photographs, cutaneous lesions from 113 stranded belugas were characterized macroscopically and microscopically. Seven presentations were characterized by histopathology. Foreign bodies and a gamma-herpesvirus were detected in a limited number of these lesions, whereas the etiology of most of these lesions remains unclear. This is the first study that investigated skin conditions in belugas in the St. Lawrence Estuary.

Acknowledgements
Funding for this project was provided by the *Fonds du Centenaire.*

Poster #2: Concentration of Omega-3 Fatty Acid Levels in the RBCs of Wild Alaskan Belugas (*Delphinapterus leucas*) with Unknown Dietary Habits and Managed Belugas Fed a Herring (*Clupea harengus*) and Capelin (*Mallotus villosus*)

Todd L. Schmitt[1*], Caroline E.C. Goertz[2], Roderick C. Hobbs[3], and William S. Harris[4]
[1]SeaWorld, San Diego, California, 92109, USA; [2]Alaska SeaLife Center, Seward, Alaska, 99664, USA; [3]Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA; [4]Sanford School of Medicine, University of South Dakota and Omega Quant Analytics, LLC, Sioux Falls, South Dakota, 57106, USA

Abstract
Essential omega 3 (n-3) and omega 6 (n-6) long chain polyunsaturated fatty acids (PUFAs) are found in plants, nuts, vegetable oils, fish and various marine invertebrates. In animals and humans dietary PUFAs have protective effects against inflammatory conditions, neurocognitive disorders, and cardiovascular disease. Historically, fatty acids have been analyzed in the blubber of wild marine mammals to aid determination of trophic feeding levels in order to approximate prey type and feeding strategy. This study compared the n-3 and n-6 PUFA levels found in RBC membranes from wild Alaskan belugas with unknown dietary habits with managed belugas fed a controlled diet of herring (*Clupea harengus*) and capelin (*Mallotus villosus*). Dietary fatty acid signatures varied between wild and managed belugas with 20- and 22-carbon monounsaturated fatty acids, which are characteristic of herring and capelin, linked to a copepod based food web, and were higher in managed animals, while 20:4n-6 (arachidonic acid; AA) was higher wild belugas. High levels of AA have been observed in epibenthic invertebrates which suggest a pelagic link to the food web. 20:5n-3 (eicosapentaenoic acid, EPA) was lower in wild belugas, whereas the other marine n-3 PUFA, 22:6n-3 (docosahexaenoic acid, DHA) was similar between groups. The Omega-3 index (RBC EPA+DHA, risk factor for cardiovascular disease in humans) was lower in wild belugas compared to managed belugas. Although blubber fatty acid patterns were not determined in this study, the use of RBC fatty acid patterns may be a more useful tool for exploring dietary differences between wild and managed belugas and may therefore help in evaluating prey item diversity between beluga populations and PUFA-related health indices.

Acknowledgements
The research conducted on wild belugas was authorized under NOAA permit # 14245-04.

Poster #3: Protozoal Agents Infecting Tissues from Hunter Harvested Beluga (*Delphinapterus Leucas*) in the Cook Inlet and Western Arctic

Michael E. Grigg[1*], Stephen Raverty[2], Jered M. Wendte[1], Katherine H. Haman[1], Amy R. Sweeny[1], Ole Nielson[3], Lisa Losetto[3], and Kathy B. Huntington[4]

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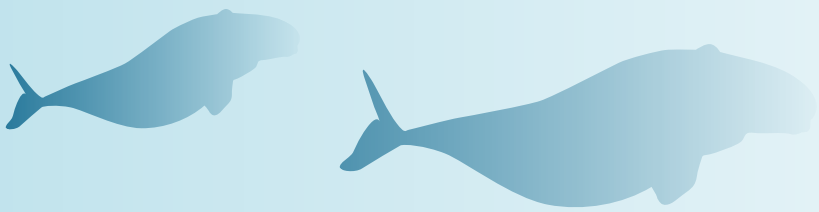
Abstract

The true extent to which protozoan parasites infect Arctic populations of hunter harvested beluga is unknown. These marine mammals are a source of nutrition for many first nation peoples in the Western Canadian Arctic and Alaska, highlighting the importance of determining whether zoonotic protozoan parasites infect these populations. Healthy, hunter-harvested beluga (54 individuals) sampled between 2008-2015 were assessed for protozoal infection using PCR-DNA sequencing directly from host tissues. The genetic analyses identified two protozoal agents, a new *Sarcocystis* species we refer to as *Sarcocystis monodontidis*, was detected in the majority of animals sampled (32/54; 59%) as well as *Toxoplasma gondii,* a prevalent zoonoses, that infected 6/54 (11%) whales. Whales infected with *S. monodontidis* possessed light to heavy infections with individual sarcocysts noted within striated muscles of the tongue, esophagus, and diaphragm, as well as skeletal muscle fibers throughout the torso. No inflammation was associated with intact cysts. *Toxoplasma* parasites were detected in the heart and diaphragm of infected whales and immunohistochemical staining confirmed the presence of *Toxoplasma* cysts in the heart of one whale, establishing the presence of transmissible forms of the parasite in Arctic beluga. Multilocus genotyping of the *T. gondii* infected whales identified two, not previously characterized, recombinant strains. This is the first study to genetically characterize chronic *T. gondii* infections in healthy, free-ranging beluga with no associated histopathology of active toxoplasmosis. These whales are wide ranging and a source of parasite exposure could not be identified. However, detection of novel, recombinant strains of *T. gondii* infecting beluga may indicate that the definitive felid host is expanding this parasite in the Arctic, since beluga are not carnivorous, and were likely infected through ingestion of *T. gondii* oocysts, products of the parasite's sexual cycle.

Acknowledgements

This work was carried out under Permit No.'s 18786 and MA-009526. This work was supported in part by the National Institutes of Allergy and Infectious Diseases. The authors would like to thank Dr. N. Sundar of the NIH for initial sample preparation and processing, Inuvialuit Game Council, regional hunters who generously shared tissues from their harvest and staff at DFO for field support and transport.



Poster #4: Molecular Biomarkers as Potential Indicators of Health in Wild Belugas (*Delphinapterus leucas*)

Ebru Unal[1*], Caroline E.C. Goertz[2], Roderick C. Hobbs[3], Robert S. Suydam[4], and Tracy A. Romano[1]
[1]Mystic Aquarium, Mystic, Connecticut, 06355, USA; [2]Alaska Sea Life Center, Seward, Alaska 99664, USA; [3]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA; [4]North Slope Borough Department of Wildlife Management, Utqiagvik, Alaska, 99723, USA

Abstract
The health implications of increasing exposure of marine mammals to environmental and anthropogenic stressors have been of major concern, warranting a better understanding of underlying physiology. This study screened gene expression profiles of ten stress and immune-related biomarkers using real-time polymerase chain reaction in both wild and aquarium belugas, reporting their reference ranges. Blood (n=106) and skin (n=93) samples were collected from three different populations of wild belugas in Alaska: 1) following live capture-release health assessments during 2008, 2012-2014, 2016 in Bristol Bay, 2) following subsistence hunts during 2012-2014, 2016, 2017 in Eastern Chukchi Sea, and 3) during rehabilitation of one beluga calf between Oct 2017-March 2018 in Cook Inlet. Blood samples were also collected from five aquarium belugas in Mystic, Connecticut under behavioral control. Live-captured released whales showed significant ($p<0.05$) down-regulation of interferon-gamma (IFNγ) in the blood pre- versus post-examination along with increasing serum cortisol levels, indicative of a physiological response to capture and restraint. Wild belugas also displayed higher levels of inflammatory IFNγ and stress response marker glucocorticoid receptor (Nr3c1) when compared to aquarium whales. The Cook Inlet beluga showed significantly lower ($p<0.001$) transforming growth-factor-beta (TGFβ) and significantly higher Nr3c1 transcription ($p<0.05$) than both Bristol Bay and Aquarium whales. When compared to blood, skin samples displayed higher differentiation among the two wild populations (Bristol Bay and Eastern Chukhi Sea) based on t-tests, Principle Component Analysis, and General Linear Model analysis including significant (multiple test corrected $p<0.05$) seasonal and/or spatial effects. Interleukins IL10 and IL12, TGFβ, Nr3c1, toll-like receptor-4 (TLR4), and aryl hydrocarbon receptor (AHR) were the most informative biomarkers in skin reflecting gene expression changes between populations. Overall, biomarkers listed in this study were suggested as promising indicators of health status in belugas, and confirmed usefulness of skin as a minimally-invasive matrix to capture population-level differences in free-ranging cetaceans.

Acknowledgements
This study was funded by Office of Naval Research (ONR Award no: N00014-14-1-0411). The authors thank the North Slope Borough Department of Wildlife Management, Utqiagvik, AK, the Point Lay field team and the community of Point Lay, AK. The authors also thank the Bristol Bay field team along with the Bristol Bay Marine Mammal Council and Bristol Bay Native Association. The authors are thankful to the Alaska Sea Life Center for providing samples from the Cook Inlet beluga calf. The Alaska Beluga Whale Committee encouraged health studies on belugas. In addition, the authors acknowledge the Mystic Aquarium animal care team, the Arctic Coast husbandry team and research staff for their collaboration and assistance in sampling aquarium whales.

Poster #5: Through the Looking Glass: Using Epidermal Microbiomes to Peer into Beluga Health

Amy M. Van Cise[1*], Paul R. Wade[2], Caroline E.C. Goertz[3], Kathy Burek-Huntington[4], Kim Parsons[5], Roderick C. Hobbs[2], and Amy Apprill[1]

[1]Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02540, USA; [2]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, Seattle, Washington, 98115, USA; [3]Alaska SeaLife Center, Seward, Alaska, 99664, USA; [4]Alaska Veterinary Pathology Service, Eagle River, Alaska, 99577, USA; [5]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, Washington, 98115, USA

Abstract

The Cook Inlet, Alaska population of beluga whales suffered a 47% reduction in abundance between 1994 and 1998, and show no signs of recovery in the 12 years since the 2006 moratorium on hunting in the region. We examine the epidermal microbiome from individuals in the Cook Inlet population, and compare with healthy and diseased individuals in nearby Bristol Bay, to determine whether individual health status is related to depressed population growth in the region. Skin diseases have been linked to poor health condition in several cetacean species, and changes in epidermal microbiomes have been linked to skin disease in some mammalian species. Ninety samples were collected either from stranded individuals or via biopsy dart between 2008 and 2018 in Bristol Bay and Cook Inlet. Whole DNA was extracted from epidermal tissue, and a portion of the small subunit ribosomal RNA gene was targeted and amplified by PCR using primers that target bacteria and archaea. PCR product was screened for size using gel electrophoresis before sequencing at the University of Georgia. The resulting sequences were aligned to the SSU rRNA gene and trimmed at similar locations, then classified into operational taxonomic units (OTUs) for analyses of phylogeny and biodiversity. Using PERMANOVA, we test the hypotheses that geographic area, individual health, sex, age class, and sample type affect epidermal microbiome composition. We further examine differences between healthy and unhealthy individuals in Bristol Bay by computing distance metrics between the two groups based on Bray-Curtis similarity and Kullback-Liebler divergence. Using the same method, we determine whether the epidermal microbiome of Cook Inlet beluga whales is more similar to healthy or unhealthy whales in Bristol Bay. Results of these analyses provide insight into the health status of the Cook Inlet beluga population, and may help determine a strategy for their conservation.

Acknowledgements

Samples were collected by the NOAA Marine Mammal Lab under NMFS ESA/MMPA Permit #20465 and by MMHSRP under NMFS Marine Mammal Research Permit No. 782-1719. Funding for genetic lab work and data analysis was provided by Woods Hole Oceanographic Institution.

Poster #6: Use of Endocrine Analyses in Health Assessments of Beluga Whales

Shannon Atkinson[1*], Daniel J. Vos[2], Kendall Mashburn[1], and Tracy A. Romano[3]

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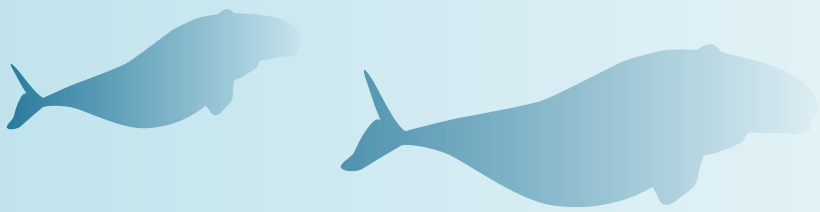

Abstract
Cook Inlet beluga whales (CIB) are a genetically distinct population, listed as endangered in 2008 after experiencing large declines in abundance, however during the 18 years following the moratorium on the suspected cause of subsistence hunting, the populations have failed to show signs of recovery. Collection of longitudinal samples from animals in managed care settings provides an opportunity to profile reproductive and metabolic hormones from healthy animals that reside in a stable environment. To determine the efficacy of hormonal assays in health assessment protocols, reproductive and metabolic hormones were measured in samples collected from January to May from beluga whales at Mystic Aquarium and compared to samples collected from 11 free-ranging belugas (6 CIB and 5 from Bristol Bay). Profiles of estrogen and progesterone from the Mystic Aquarium beluga whales were typical of non-pregnant females and included apparent ovulations that occurred in May. Concentrations of progesterone were 7-fold higher in CIB, and likely represented concentrations indicative of pregnancy. Seasonal production of testosterone in a single male beluga at Mystic Aquarium had a parallel progesterone profile that was an order of magnitude lower in concentration. The seasonal increase in testosterone was coincident with a 60-75% reduction in total estrogen concentrations, and likely reflected a seasonal suppression of aromatase enzyme activity. Metabolic hormones, thyronine (TT4) and triiodothyronine (TT3) were similar between the Aquarium and wild whales. Cortisol was elevated in the CIB and Bristol Bay whales, which likely reflected the chase, capture, and tagging of the whales, and possibly other stressors in their environment. We conclude that the analysis of reproductive and metabolic hormones provides useful diagnostic information on the physiology of beluga whales, including the detection of pregnancy and assessment of metabolic state. We recommend that endocrine assessments should be incorporated as part of health evaluations.

Acknowledgements
We thank the National Marine Fisheries Service for permitting and logistical support of the field efforts.

Poster #7: Advancing the Use of Thyroid Hormone Measures in Health Assessments of Aquarium-Maintained and Free-Ranging Beluga Whales (*Delphinapterus leucas*)

Jennifer E. Flower[1*], Laura A. Thompson[1*], Maureen V. Driscoll[1], Matthew C. Allender[2], Richard P. Giovanelli[3], Sandra D. Summers[3], Tracy R. Spoon[1], Judy A. St. Leger[4], Caroline E. C. Goertz[5], J. Lawrence Dunn[1], Tracy A. Romano[1], Roderick C. Hobbs[6], and Allison D. Tuttle[1].
[1]Mystic Aquarium, Mystic, Connecticut, 06355, USA; [2]Department of Comparative Biosciences, College of Veterinary Medicine, University of Illinois, Urbana, Illinois, 61802, USA; [3]Pfizer Research and Development, Groton, Connecticut, 06340, USA; [4]SeaWorld Parks and Entertainment, San Diego, California, 92109, USA; [5]Alaska SeaLife Center, Seward, Alaska, 99664, USA; [6]Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, Washington, 98115, USA

Abstract
Thyroid hormones play a fundamental role in protein formation, temperature regulation, growth, and metabolism. Previously, since no baseline values for thyroid hormones in beluga whales (*Delphinapterus leucas*) existed, assessment of thyroid hormone concentrations were underutilized in clinical and research

settings. The purpose of this study was to 1) document concentrations of total thyroxine (tT4) and total triiodothyronine (tT3) in aquarium-maintained and free-ranging belugas, 2) determine the influence of age, sex, and season on thyroid hormone concentrations and 3) validate detection of thyroid hormones in blow. Archived serum samples were collected from healthy aquarium-maintained (n=43) and free-ranging (n=39) belugas, and serum tT4 and tT3 were measured using chemiluminescence immunoassay. Mean tT4 and tT3 concentrations in aquarium-maintained belugas were 5.67±1.43 µg/dl and 70.72±2.37 ng/dl, respectively. Sex comparisons showed that aquarium-maintained males had significantly greater tT4 and tT3 (9.70±4.48 µg/dl and 92.65±30.55 ng/dl, respectively) than females (7.18±2.82 µg/dl and 77.95±20.37 ng/dl) (P=0.004 and P=0.013). Age comparisons showed that aquarium-maintained beluga aged 1-5 yr had the highest tT4 and tT3 (8.17±0.17 µg/dl and 105.46±1.98 ng/dl, respectively) (P=0.002 and P<0.001). Total thyroxine differed significantly between seasons, with lowest concentrations in winter (4.59±1.09 µg/dl) compared with spring (P=0.009), summer (P<0.0001), and fall (P<0.0001). Free ranging beluga had significantly higher concentrations of both tT4 and tT3 (11.71±3.36 µg/dl and 103.38±26.45 ng/dl, respectively) compared to aquarium-maintained whales (P<0.0001 and P<0.001). Clinicians should consider biologic and environmental influences (age, sex, and season) for a more accurate interpretation of thyroid hormone concentrations in belugas. Where blood sampling is not feasible, current efforts to validate thyroid measures in blow are being investigated in the Mystic Aquarium research laboratory and may provide a valuable alternative for gathering physiological information. The findings of this study provide a baseline for thyroid health monitoring and comprehensive health assessments in both aquarium-maintained and free-ranging beluga whales.

Acknowledgments
The authors acknowledge National Oceanic and Atmospheric Administration permits 782-1719-07 and 932-1489-10, and the Alaska Department of Fish & Game Animal Care and Use Committee (06-16). The authors thank the Office of Naval Research for funding the blow portion of this research (ONR award #N00014-18-1-2779). This study constitutes Mystic Aquarium IACUC#10009 and Sea Research Foundation scientific contribution #217.

Poster #8: Saliva as an Alternative Matrix to Measure Cortisol in Aquarium Belugas (*Delphinapterus leucas*)

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Mystic Aquarium, Mystic, Connecticut, 06355, USA

Abstract
Non-invasive sampling methods are frequently used to monitor glucocorticoids (i.e. cortisol) in zoos and aquariums and can be used to evaluate fitness and stressor load as well as used for research purposes. Saliva is an alternative sample matrix that can provide valuable information regarding cortisol levels of marine mammals under human care. The goal of this study was to validate a commercially available enzyme immunoassay (EIA) for measuring cortisol in saliva samples collected from beluga whales (*Delphinapterus leucas*). Saliva was collected with SalivaBio infant oral swabs and hormones were

extracted using an ethyl acetate extraction protocol. Laboratory validations (parallelism, accuracy, and inter-, intra-assay validation were carried out using the Cayman Chemical cortisol EIA kit (detection limit 35 pg ml^{-1}) with beluga salivary cortisol. Biological validation was carried out using samples collected from aquarium belugas during a known stressor (i.e. out of water examinations). Cortisol levels in aquarium belugas (n=3) increased between baseline (before exam) levels and samples taken at 30 minutes out of water, which reflected previously published cortisol trends in blow. Although further investigation is needed, this study suggests that saliva sampling is a good candidate for non-invasive monitoring of hormones such as cortisol in aquarium belugas for research and health monitoring.

Acknowledgments
This work was supported by a grant from the Office of Naval Research (ONR N00014-11-1-0437). Sampling support for this project was provided by Mystic Aquarium and the beluga whale husbandry team.

Poster #9: Further Investigation of Blow or Exhaled Breath Condensate as a Non-Invasive Tool to Monitor the Physiological Response to Stressors in Cetaceans

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Abstract
The Arctic is "ground zero" for climate change. Arctic marine mammals such as the beluga whale (*Delphinapterus leucas*) are at risk due to potential shifts in prey and threats such as oil spills and increased shipping. Belugas are important to study because they are apex predators and sentinels of the health of the oceans. Using non-invasive methods like blow, or exhaled breath to assess health, offers an alternative method to collecting blood, the 'gold standard' which requires capture and restraint. Exhaled breath can reveal health information on reproductive status, stress physiology (i.e. cortisol) and metabolism (i.e. thyroid hormones) in wild and aquarium belugas. Further validation of this technique is required (e.g. to standardize starting material). The overall purpose of this study is to standardize multiple approaches to collecting and validating blow. The specific objectives are to 1) determine how volume and cortisol vary with number of exhales and 2) if sex can be determined by utilizing DNA, in the same blow sample as the hormone measurements. Two belugas (one male and one female) under professional care at Mystic Aquarium were trained to exhale into a petri dish containing a nitex membrane. Blow samples were collected over three sessions with varying number of exhales (e.g. 1, 2, 4 exhales). Volume and DNA in the blow was measured, then analyzed for cortisol by enzyme immunoassay (EIA) or used in Polymerase Chain Reaction (PCR) to amplify zinc-finger (*Zfx* and *Zfy*), sex related genes. The results show higher exhales yield more supernatant ($P<0.05$); however, cortisol levels were consistent and independent of exhale numbers and blow volume. Sex was able to be determined by utilizing DNA from the same blow sample as the hormone measurements. Blow sampling demonstrates to be a promising technique to monitor health in beluga whales.

Poster #10: Cortisol as a Measure of Stress Response in Belugas (*Delphinapterus leucas*)

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Abstract
Cortisol has been extensively used as stress indicator in many species. In this study blood samples were collected in 2 adult captive belugas under normal housing conditions, after staying at a low level of water, after moving between pools, and after exposure to acoustic noise. Cortisol was measured in a total of 120 samples. The baseline level of cortisol in belugas under normal conditions ranged between 31 and 91 ng/ml and averaged 43±3 ng/ml in beluga 1 and 50±3 ng/ ml in beluga 2. Staying at a low level of seawater (5-10 cm for 50-90 min, 3 experiments) increased cortisol concentration by 1.6-2.9 fold and moving belugas between pools increased by 1.9-4.9 fold (4 experiments). One beluga was exposed to seismic and shipping noise with peak intensity of 145, 150, 155 and 160 dB and duration of 10, 60 and 180 min. Cortisol was evaluated after series of daily exposures (a total of 47 grouped in 8 series, 3-7 exposures/series, 1-3 exposures/day). The post-exposure level of cortisol in beluga 1 ranged between 65 and 157% of the pre-exposure levels (40-63 ng/ml) and averaged 105±10%. We found no correlation between noise parameters (intensity and duration) and post-exposure cortisol concentration. Behavioral and electrophysiological (ABR) hearing thresholds were measured over the course of the study. They ranged within the pre-exposure levels. In conclusion, moving belugas to a novel pool and keeping them out of water caused an increase of blood cortisol, indicating an acute stress response. However, repeated exposure to the shipping and seismic noise with a peak intensity up to 160 dB and duration up to 3 hours did not feature acute or chronic stress reaction in the studied beluga based on the plasma cortisol values.

Acknowledgements
The capture permits were issued by the Russian Federation Federal Agency for Fishery. Research was supported by Russian Foundation for Basic Research and Utrish Dolphinarium Ltd. (grant #16-04-01306).

Poster #11: Fecal Glucocorticoid Metabolites - A Noninvasive Tool to Monitor Health in Beluga Whales

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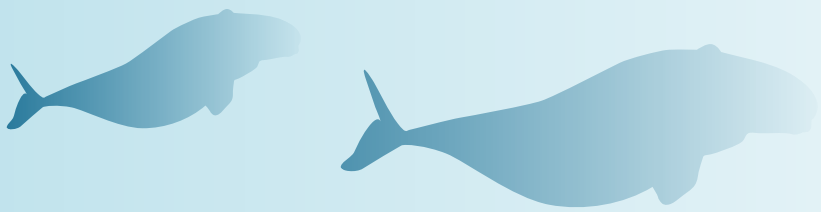
Abstract
Fecal glucocorticoid metabolites (FGM) are a valuable source of endocrine information and provide an alternative noninvasive method to monitor hormone levels in wildlife populations. In this study, we validated a commercially available corticosterone enzyme immunoassay (EIA) for measuring FGM in beluga whale feces by passing tests for parallelism, accuracy, and inter- and intra-assay variability. We also carried out a biological validation with aquarium belugas to show that FGM levels follow a



similar trend as real-time cortisol levels measured in blood and respiratory blow samples taken during an external challenge. Samples collected from aquarium belugas over several years show that FGM increase with age, and that females demonstrate elevated FGM during the beginning of the reproductive season. Samples collected from subsistence hunted belugas show that pregnant females have significantly higher FGM levels than male belugas, demonstrating that this method is capable of measuring physiologically meaningful changes. This method was tested by monitoring FGM levels in a rescued beluga calf belonging to the endangered Cook Inlet population at the Alaska Sea Life Center (Seward, Alaska) in 2017 during rehabilitation.

Acknowledgements
We thank the Mystic Aquarium Arctic Coast team for their effort in collecting fecal samples from our belugas, Brandy Hebert for her assistance in the laboratory, the Community of Point Lay, AK and Dr. Robert Suydam, North Slope Borough Department of Wildlife Management, AK, for support and assistance in coordination of sample collection under permit #17350, and Katie Graham and the New England Aquarium for the use of their equipment. Tyonek fecal samples were collected at Alaska SeaLife Center under MMHSRP MMPA/ESA #18786-03.

Poster #12: Behavioral Training for Preventative Health Care and Research Sampling in Beluga Whales (*Delphinapterus leucas*) at Mystic Aquarium

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Abstract
The training of marine mammals for participation in medical behaviors is an important component of the care and management of animals in zoological institutions. Mystic Aquarium is devoted to extensive training of beluga whales for veterinary diagnostics and procedures, as well as participation in approved research projects, including the development of novel sampling techniques. Behavioral endoscopy performed in shallow water has provided veterinary staff with the opportunity to assess the health of the esophageal and gastric mucosa and has allowed for collection of gastric biopsies for histopathologic evaluation without restraint. Voluntary nebulization training has expanded the ability to administer medications directly into the respiratory tract in belugas with a cetacean nebulizer unit, enhancing the treatment of respiratory conditions without requiring restraint. Voluntary in-water ultrasounds have allowed veterinary staff to perform full body health assessments focused on the thorax and abdomen to obtain normal baseline data for each beluga as well as identify and monitor disease processes. In addition to the medical benefits of behavioral training, samples obtained through voluntary behaviors have allowed Mystic Aquarium's researchers to validate non-invasive sampling techniques with saliva, respiratory exhale (blow), and feces by pairing with blood samples, also performed under behavioral control, prior to the integration of these new approaches into health assessment efforts on free-ranging beluga populations. The training of beluga whales for voluntary preventative health care and research sampling requires extensive collaboration between veterinary, husbandry, and research staff.

Poster #13: A Multi-Institutional Photogrammetry Validation Study with Beluga Whales under Human Care

Valeria Vergara[1*], Robert Michaud[2], Michel Moisan[2], Dennis Christen[3], Katherine Lorenz-Flammer[3], Steve Aibel[4], Maris Muzzy[4], Tracy A. Romano[5], Kathryn Justice[5], and Salvador Sanchez[6]
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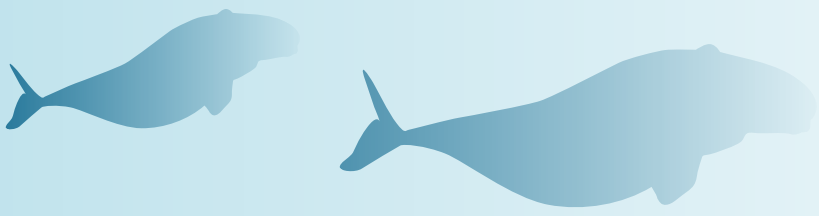
Abstract
Photogrammetry via unmanned aerial vehicles is increasingly used worldwide for wildlife research and monitoring. Photogrammetric assessment of body condition, growth trends, and pregnancy status are amongst the successful uses in cetacean research. For example, an ongoing photogrammetry study of the endangered St. Lawrence Estuary beluga population aims to inform evaluations of individual health and pregnancy rates, and elucidate the effects of nutritional stress due to food shortages. Such studies can benefit from photogrammetry validation data of known individuals under human care. The main objective of this study is to provide periodic vertical photographs from a fixed camera at a known height, paired with morphometric data (measurements and weights) from belugas held at various aquaria to inform photogrammetry studies of wild populations. The measurements include girths at the neck, pectoral fins, origin of dorsal ridge, center of dorsal ridge, urogenital region, and mid peduncle, and length from tip of rostrum to fluke notch, and from blowhole to beginning of dorsal ridge. The study includes, to date, weekly paired photos and measurements from three pregnant females held at Oceanogràfic (2016, 22 weeks of paired data), Georgia (2017, 23 weeks of paired data) and Shedd (initiated in Dec 2018) aquaria. In addition, the study includes the following data sets from non-pregnant animals: 1 male and 2 females from Georgia (monthly photos and morphometrics beginning Nov 2017, and quarterly weights), 4 females and 3 males from Shedd (bi-monthly photos and morphometrics beginning Dec 2018, bi-annual weights), and 1 female and 1 male from Mystic (monthly photos and morphometrics beginning Oct 2018, and bi-annual weights). These data will be integrated into a database of photographs of free-ranging beluga whales from the endangered St. Lawrence Estuary population, to assist in the identification of pregnant whales and the interpretation of body condition for this population.

Acknowledgements
This work was carried out under institutional Animal Care approvals. We are grateful to all the participating institutions for allocating their time, resources and expertise to this project.



Poster #14: Photographic Identification of Beluga Whales in Cunningham Inlet, Aided by Cross-Correlation of Dorsal Ridge Profiles

Thorsten Lisker[1], Gretchen Freund[2], and Megan McDermott[2]
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Abstract
Over the course of six years, we have observed the population of beluga whales that visit Cunningham Inlet during several weeks in summer. We have focused on taking photographs of such animals whose dorsal ridge exhibits uneven structures that can be used for re-identification, such as notches, dips and scars. This dorsal profile is then traced semi-automatically on the computer screen and converted into a table of pixel positions and local slopes, serving as a digitally encoded fingerprint of the animal. For this we are using a software setup that joins available visualization and image enhancement techniques through our own C++ program. In order to identify potential resightings, we compute the cross-correlation product of a given dorsal profile with each of the other profiles in our database, also taking into account that the animal may have been observed under a slightly different angle each time. This yields a ranked list of possible matches, which are then selected by visual inspection. Aided by this method, we find that at least a fraction of the belugas returned to Cunningham Inlet over a time span of several years. Furthermore, we confirm that a number of animals spent at least several days in a row in the inlet, sometimes more than a week.

Poster #15: Medical Aspects of the Translocation to the St. Lawrence Estuary (Quebec, Canada) of a Beluga (*Delphinapterus leucas*) Trapped in a River

Rozenn Le Net[1], Émilie L. Couture[1,2*], Bill Lasby,[3] Tonya Wimmer[4], Martin Haulena[3], Stéphane Lair[1], Janie Giard[5], Robert Michaud[5], Tim Binder[6], Isabelle Elliott[7], and Véronique Lesage[8]
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Abstract
A juvenile male beluga (*Delphinapterus leucas*) trapped in the Nepisiguit River (NB, Canada) was captured and translocated on mid-June 2017 after having spent at least 15 days in freshwater. The animal was thin, moderately dehydrated and showed a decreased response to stimuli. The skin was rough with irregular patches of brown-colored sloughing material. Hypokalemia, marked hyponatremia and metabolic alkalosis were documented and most likely due to the lack of food intake and prolonged fresh water exposure. Elevated BUN and creatinine were consistent with dehydration. Lactated Ringer's solution was administered intravenously during transportation. Within five hours of capture, which included two driving

segments, and a 35-minute flight on a chartered plane, the beluga was released in proximity of a beluga pod in the St. Lawrence Estuary (Qc). The whale was tracked for 19 days post-release using a dorsal crest-implantable satellite transmitter. During that time it traveled over 570 km within its summer range. This individual was resighted 13 months later off range in Ingonish, off Cape Breton (NS). He looked relatively healthy and was with another juvenile beluga. Histopathological examination of the sloughed epidermis showed hydropic degeneration with thickening of the parakeratotic layer that was invaded with oomycetes. Although belugas are frequently observed in riverine water of low salinity, this case shows that prolonged exposure to fresh water and fasting can result in skin disorders, dehydration and significant electrolytic imbalances in this species. Nevertheless, these health issues seemed to have resolved with the return of the animal in saline water.

Acknowledgments
This translocation was supported by the Fisheries and Oceans Canada, the *Groupe de recherche et d'éducation sur les mammifères marins (GREMM)*, the Marine Animal Response Society (MARS), the *Réseau québecois d'urgences pour les mammifères marins*, Bathurst Fire Department, Robertville Fire Department, St. Anne Regional Fire Department, Parks Canada, Transport and Infrastructure in Canada, Whale Stewardship Project, *Port de Gros-Cacouna*, *Arrimage Quebec*, Rivière-du-Loup and Bathurst Airports, Chrono Aviation, Police services of Bathurst and Rivière-du-Loup, *Centre de remorques usagées du Québec* and the following zoological institutions: Shedd Aquarium, Vancouver Aquarium, *Aquarium du Québec* and *Zoo de Granby*.

Poster #16: Age and Growth Analyses for the Endangered Beluga Whales in Cook Inlet, Alaska

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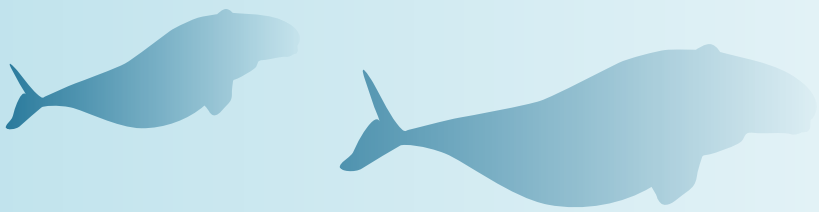
Abstract
Cook Inlet belugas are genetically unique and critically endangered. Demographic data are sparse for these whales. Ages were obtained from teeth collected from 118 whales. Samples ranged from a single tooth to both sets of teeth from the left and right mandibles. Matched teeth between mandibles (42 whales) gave statistically equivalent values but discrepancies increased with age. Of the paired teeth, 77% had ages within 0 to +/- 1 year, and 89% within +/- 2 years. As animals aged, more discrepancies between mandibles became apparent, however, this did not exceed +/- 3 years in anterior teeth until age 28, and in teeth posterior to tooth 5 until age 29. Tooth wear was examined for whales with >3 teeth per mandible (56 left lower mandibles, 54 right lower mandibles), and was found to increase with age but not necessarily anteriorly to posteriorly on the jaw. Teeth posterior to position 5 exhibited the least amount of wear, greatest frequency of neonatal caps, and the highest GLG counts. Growth curves for males (n=53) and females (n=47) were developed for 100 known-length belugas including calves and a full-term fetus. The Gompertz model with sex-specific asymptotic length and common shape parameters was the best fit. Six other models received similar support (Δ AIC$\leq$2); three Gompertz and three von Bertalanffy, all



with sex-specific asymptotic length. Age and length were highly correlated for female and male samples. Sexual dimorphism was exhibited in the data and in the best fit growth curve model, with males in general being longer (438.19 cm (95%CI = 425.23-451.16) at a given age than females (383.49 cm (95%CI = 372.45-394.53)). Age length data from two males tagged with satellite-transmitters in 2002 indicate Cook Inlet whales deposit at most one growth layer group per year.

Acknowledgements
The Anchorage Regional Office of the National Marine Fisheries Service provided funding and logistic support as part of the stranding response plan for Cook Inlet (available at: https://alaskafisheries.noaa.gov/sites/default/files/beluga_stranding_plan2009.pdf). NMFS Research Samples were collected under Permit 932-1905-00/MA-009526 under the Marine Mammal Health and Stranding Response Permit. Funding was also provided through Prescott Grant NA12NMF4390162.

Poster #17: Efforts to Examine and Mitigate the Potential Effects of Motorized Watercraft Use on Cook Inlet Beluga Whale (*Delphinapterus leucas*) Activity in Alaska's Twentymile River During Seasonal Fish Spawning Periods

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Abstract
Critically endangered Cook Inlet beluga whale (*Delphinapterus leucas*) (CIBW) activity in Alaska's Twentymile River has been confirmed by previous research and indicated via anecdotal observations. Heightened human activity on Twentymile during seasonal fish spawning periods may coincide with increased CIBW use and need of access to the river and adjacent critical habitat during this time. Motorized watercraft use, the dominant use type in this location (primarily for the purpose of fishing), may adversely affect beluga whales as a source of noise and potential strikes. This 2017 pilot study initiated efforts to: 1) Document the extent of CIBW use of the Twentymile River; 2) Determine the potential effects motorized watercraft use may have on beluga activity and behavior in this location; and 3) Gauge boater knowledge of CIBW activity on the river. A final objective was engaging the boating community in a participatory manner to inform efforts to and mitigate impacts on belugas. Data was collected via: shore-based observation sessions (n=82) on 78 sampling days (May-October); recreational boater interviews (n = 49); and in collaboration with local commercial river guides (n=3). A total of 121 belugas were observed (including calves) and 160 boats (99% motorized). The highest levels of beluga and boating activity were observed during the salmon run period (August-October). Out of 15 total 'interactions' of belugas with watercraft observed or reported, 5 instances of belugas displaying acute behavioral shifts in apparent response to boats were documented. Forty-one percent (n=20) of boater interview groups displayed a lack of awareness regarding CIBW activity on Twentymile and the potential effects of motorized watercraft use on belugas, indicating a need for increased education to mitigate future impacts. To inform mitigation efforts, boaters were asked to reflect on the issue and provide useful suggestions to more effectively increase awareness and encourage 'beluga friendly' boating practices.

Acknowledgements
This work was carried out with the consent of NOAA Fisheries and the U.S. Forest Service. The project was self-funded.

Poster #18: Results of a New Pilot, Shore-based Beluga Whale Citizen Science Monitoring Program in Alaska's Upper Cook Inlet

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[1]Beluga Whale Alliance, Girdwood, Alaska, 99587, USA

Abstract
In 2018, Beluga Whale Alliance piloted a new shore-based citizen science monitoring program focused on collecting scientific sightings data on critically endangered Cook Inlet beluga whale distribution and behavior, as well as potential threats, along a 40-mile stretch of coastline identified as 'critical' habitat to this population. The project ran from early August through mid-October, 2018, trained and engaged dozens of community members as well as tourists to the region, and assisted in providing sightings and photographic data to support ongoing existing efforts of the Cook Inlet Beluga Whale Photo Identification Project. Sightings data was collected via standardized shore-based monitoring sessions by trained BWA team members and community volunteers, as well as via social media, text message, and phone calls submitted by the public. Dozens (**Note: data still being analyzed*) of groups of belugas were observed ranging from one to over 80 individuals, and exhibited a range of behaviors, including traveling, milling, vocalizing, spyhopping, and even a unique style of 'breaching.'

Acknowledgements
Funding for this project was provided by generous donations by supporters of Beluga Whale Alliance.

Poster #19: Use Your Melon: Engaging Undergraduates in the Process of Science by Exploring Beluga Facial Expressions

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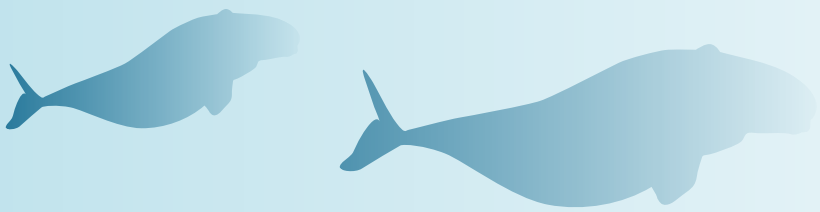
Abstract
In undergraduate STEM education, there is a growing emphasis on explicitly training undergraduates the scientific process skills that enable them to "think like a scientist." These skills are efficiently acquired during mentored research opportunities, but students involved in faculty-led research may not have the opportunity to engage in their own scientific inquiry. Over a two-year period, 10 undergraduate students at the University of Rhode Island have contributed at least one semester to a research project on facial expressions in beluga whales that intentionally provides these opportunities. Over 200 hours of video of the belugas at Mystic Aquarium were previously analyzed for when a beluga changed the "shape" of their melon. After completing a rigorous training protocol with statistical validation of interobserver reliability,



students reanalyze the video to assign hundreds of shapes to a specific ethogram and record any behaviors performed within 10 seconds of the shape. Students are given the freedom to develop their own hypothesis based on these observations. Through individual meetings and pre-recorded tutorials, students are taught the process of refining a hypothesis, manipulating the large data set (currently 2307 shapes), and selecting and creating the appropriate graph(s). Then, they apply these skills to test their own hypothesis and create their own scientific poster to present to faculty and students, with opportunities for feedback throughout this entire process. This project is ideal for involving undergraduates in science because the prerequisite skills required are minimal, enabling students with no previous research experience to contribute and reach the higher order cognitive skills of evaluate, analyze, and create sooner and with less foundational training than lab-based research. Students have made meaningful contributions to the project while preparing themselves to succeed in future research opportunities, highlighting the value of collaborations between aquaria and universities for both research and education purposes.

Acknowledgements
Special thanks to the students involved in this work: Rachael Desfosses, Sam Giaccone, Joseph Golden, Samantha Kaiser, Isabelle Pellegrini, Emily Pepin, Stephanie Peramas, Mallory Pierce, Kaitlyn Quirke, and Lauren Salisbury. This research is made possible through collaboration with Mystic Aquarium.

Poster #20: A Scientific Research Based Educational and Cultural Exchange Program for Alaska Native and Native American Youth Focused on the Arctic, Beluga Whales and Climate Change

Tracy A. Romano[1], Robert S. Suydam[2*], Leslie Pierce[2], Jason Mancini[3], Candyce Testa[4], and Annawon Weeden[4]
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Abstract
Mystic Aquarium (MA), Connecticut, (CT), and the North Slope Borough Department of Wildlife Management (NSB-DWM), Alaska (AK) are partners in an ongoing study to collect and analyze life history and health information from Chukchi Sea belugas to establish current baseline information and provide comparative data for Cook Inlet and other beluga stocks. Based on this research, an educational and cultural exchange program was established for Alaska Native youth and Native American youth near Mystic, CT. The main goal of the program is to stimulate interest and excitement about science, inspire high school students to pursue education and careers in science and ultimately be a resource to their communities for the management and sustainability of marine resources. Additionally, the youth from both locations share their culture and traditions. The program begins in Point Lay, AK when MA and NSB-DWM scientists conduct fieldwork on wild belugas during the summer. The youth assist with live capture, tagging, sampling and release studies of belugas and collection of data and samples from subsistence harvested belugas. Subsequently, the youth travel to Mystic, CT, to participate in hands-on beluga research, analyze samples collected and learn what the samples reveal. In addition, the students participate

in learning activities focused on beluga biology, the local marine environment, other aspects of science and husbandry and various career opportunities. Time is also spent at the Mashantucket Pequot Museum and reservation learning about the history, culture and traditions of this local community. During their visit to the reservation, the students have an opportunity to interact with tribal members and participate in native crafts, dance and sports. Following the program, the students are encouraged to return to MA or work with the NSB as a research intern, participate in other science programs/camps and conferences, go on to college and share their learning experience with other youth and their communities. The desired outcome is engagement and education that leads towards local involvement in the management and sustainability of belugas for generations to come.

Acknowledgements
The authors wish to thank the Mayor's office of the North Slope Borough for funding the program, the staff at Mystic Aquarium and the Mashantucket Museum and Research Center, the Mashantucket Pequot Tribal Council for funding travel support, Rodney Butler (Chairman), the Mashantucket Pequot Tribal Nation and the people of Point Lay, Alaska.

Posters: BEHAVIOR

Poster #21: Quantitative Analysis on Echolocation Clicks of Beluga Whales in Bristol Bay, Alaska

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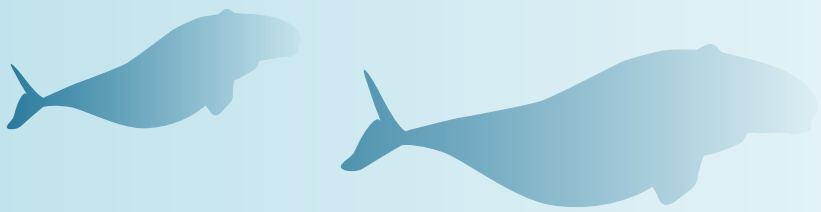
Abstract:
Echolocation is vital for beluga whale (*Delphinapterus leucas*) and on-axis echolocation records are sparse for wild representatives of this taxa and many other odontocetes. Using a high sampling signal acquisition system, echolocation clicks of 13 wild beluga whales were recorded during capture–release events in Bristol Bay, AK, USA in 2014 and 2016. The subsequent analysis showed the bandwidth, duration, peak frequency, and centroid frequency clicks were different across the animals. We then assembled the clicks from all the whales, which resulted in a total number of 1185. The overall mean duration, peak frequency, centroid frequency, $bandwidth_{-3dB}$, $bandwidth_{-10dB}$, and $bandwidth_{rms}$ of the clicks were calculated as 86.6 ± 28.4 μs, 95.7 ± 38.2 kHz, 100.1 ± 23.7 kHz, 14.9 ±7.7 kHz, 47.8 ±25.1 kHz and 30.3 ±8.5 kHz respectively. Clicks were divided into five groups based on source level. Though for each whale, the spectrums had little difference among the groups, the results did show with the increase of source level, duration and $bandwidth_{rms}$ increased while $bandwidth_{-3dB}$, $bandwidth_{-10dB}$, peak frequency and centroid frequency decreased. Results reflected differences in echolocation clicks among individual belugas, which requires analysis on more individuals of the species to better understand the natural echolocation variability of the species. Also, the new perspective, in which the source level was used to group the clicks, might be extended to biosonar studies on other species.



Acknowledgements
We acknowledge the Bristol Bay beluga population heath assessment team coordinated by the Alaska SeaLife Center and Alaska Department of Fish and Game, and project sponsors Georgia Aquarium and Shedd Aquarium. This work was done under NMFS permit #14245 to the MML/AFSC.

Poster #22: Acoustic Analysis as a Methodology for Assessing Stress in Belugas (*Delphinapterus leucas*)

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Abstract
Marine mammals are routinely exposed to a plethora of acute and chronic stressors, both natural and anthropogenic. Effects of these stressors range from short-term changes in behavior to potentially long-term changes in reproductive fitness, foraging effectiveness, and spatial habitat usage. Concentrations of cortisol, a stress hormone, are used as a quantifiable measure of stress in free-ranging animals. Traditionally, cortisol is measured from plasma, which allows for fine-scale analysis of stress levels. However, blood sample collection is highly invasive; confounding effects from the stress of research handling may make it challenging to get accurate baseline cortisol measurements. Analysis of acoustic behavior could provide the opportunity to measure stress non-invasively and at a fine time scale. In this study, acoustic and hormonal data collected during health assessments conducted on the Bristol Bay beluga population will be used to evaluate belugas' vocal behavior as it relates to the stressor of the live capture itself. Acoustic recordings made during each animal's assessment (n=19) will be analyzed, and trends in vocal behavior will be related to cortisol concentrations measured at the beginning and end of each assessment. Acoustic recordings and movement data collected remotely using DTAGs will be used to relate vocal behavior to the expected decrease in stress after release for 8 of the 19 animals. Metrics measured by the DTAG's accelerometer and magnetometer, such as swim speed, fluking energy, and fluking rate, will be used to assess changes in the tagged whale's behavioral patterns immediately post-release. Characteristics and acoustic parameters of calls made throughout the tag deployment will be compared to those made during the health assessment process. This will allow for fine-scale analysis of how vocal behavior differed across stress contexts.

Acknowledgements
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Poster #23: Reproductive Parameters of Female Beluga Whales of the Eastern Canadian Arctic

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Abstract
Monitoring marine mammal populations and their changing habitats is crucial for assessing population viability, potential recovery rates and conservation. Female reproductive parameters for wild beluga whale populations have not been updated for decades, and recent environmental changes provides impetus to update population health assessments. Here we summarize reproductive data collected from female reproductive tracts of three eastern Canadian Arctic beluga populations: High Arctic/Baffin Bay (HA), Western Hudson Bay (HB) and Cumberland Sound (CS) from reproductive samples collected as part of community-based monitoring, 1989 to 2014. Body asymptotic length of CS beluga (352.3 cm) was greater than HB whales (339.5 cm) based on growth curves fitted to 1-51 yrs. Overall mean of uterus body size and vaginal fold count was 0.19±0.1SD and 10.3±2.4SD although mature CS females showed slightly more folds (11.5±2.1) than immature females (10.6±1.7). CS females matured at a later age (9.0 y vs HB=9.8) and at a greater length at sexual maturity (319.5 vs HB=290.0). In HB females with the largest sample size, total corpora counts correlated with ovarian activity and age. The number of corpora (≥10mm) suggests reproductive senescence to establish between the ages 40 and 50 y. Ovarian activity increased for HB beluga between 1992-1998 and 2004-2014 periods. The correlation between proportion of active females and incidence of disease was suggestive. Improved understanding of female reproductive patterns and knowledge of changes in the spatial and temporal timing of reproductive processes in wild belugas is extremely challenging to obtain and yet fundamental if beluga whales are managed based on reproductive health.

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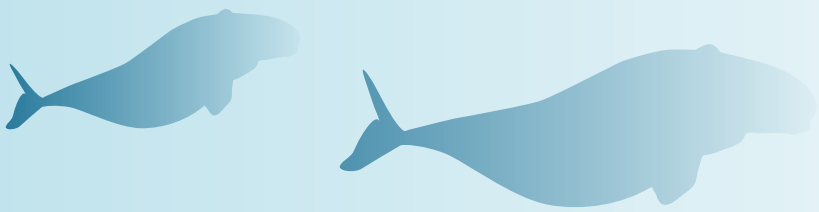

Poster #24: First Thirty Days of Life: Examining Calf Behavioral Development in Beluga Whales (*Delphinapterus leucas*) at One Zoological Facility

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Abstract
Cetacean development is important for general comparative understanding and the implementation of informed husbandry policies. Due to the inaccessibility of many of these species in the wild, researchers can study professionally managed care populations to better understand basic developmental patterns of cetaceans, as well as to improve husbandry policies for facility animals. Eight beluga whale calves were observed for the first 30 days of life to determine the developmental trajectory of several typically monitored behaviors. The first occurrence and developmental trajectory for each behavior are described to identify variation and to document differences between successful calves, those that survived the 30-day period, and unsuccessful calves, those that did not survive the 30-day period. A single-case time series design analyzed developmental pattern differences within the 30 days for the successful calves. Overall, beluga whales exhibited similar developmental trends to those previously documented in the literature. Nursing behaviors and slipstream behaviors of the unsuccessful calves were either inconsistent or delayed compared to the successful calves. The results of this study may be used to better understand norms of cetacean development and to stimulate future research in the early identification of abnormal development in the hopes of increasing calf survival rates.

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Poster #25: The Development of Socio-Sexual Behavior in Beluga Whales (*Delphinapterus leucas*) Under Human Care

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Abstract
Observations of beluga whales in human care allow researchers to better understand many aspects of their daily lives and life histories that are difficult to assess in wild populations, including socio-sexual and mating behavior. Thus far, a catalog of beluga socio-sexual behavior has been established based on observations of a small number of study subjects; however, the development of socio-sexual behavior is not well-understood. The present study explored how socio-sexual behavior developed in beluga whales under human care by recording the behavior of 5 belugas between years 4 and 10 of their lives and coding for socio-sexual behavior. Overall, the presence of young male conspecifics was the most influential predictor of whether the subjects engaged in socio-sexual behavior during any given observation session.

The subjects of the present study were also more likely to be involved in socio-sexual behavior as they matured and were more likely to be involved if they were male. In contrast, the presence or absence of environmental enrichment devices (EEDs) did not affect the prevalence of socio-sexual behavior. Additionally, specific behaviors of the socio-sexual repertoire, including horizontal s-postures and pelvic thrusts, increased in prevalence throughout development. This information is important for the management of beluga whale populations both in human care and in the wild. Understanding that social group composition may contribute to the reproductive success of beluga whales lays the groundwork for future research of socio-sexual behavior in wild belugas. Additionally, because socio-sexual behavior composes a relatively large portion of belugas' activity budgets and the majority of the time spent socializing in sub-adult years, it is likely crucial for social bonding and well-being in belugas. Thus, it is important that managed care facilities take this information into consideration when making housing decisions for the animals in their care.

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Poster #26: Measuring Group-Based Individual Differences in the Behavioral Characteristics of Beluga Whales in Human Care

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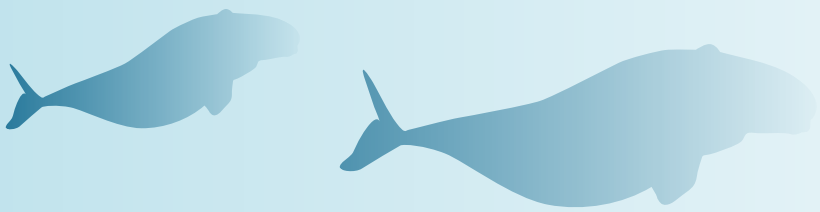
Abstract
Linked to foraging specialties and cultural innovation, individual variability continues to be examined in a wide range of species. Beluga whales (*Delphinapterus leucas*) exhibit many traits often associated with a high degree of variability in behaviors and dispositions across individuals: foraging specialties, flexible social structure, migratory patterns, and sociability. Using a mixed method approach (i.e., spontaneous behavioral recordings, behavioral ratings, or adjective ratings given by trainers), we measured the consistency of 33 behavioral traits over time or observers for a population of mixed age and sex beluga whales ($n = 41$). Age and sex differences were also assessed. The results indicated that 22 of the 33 behavioral traits showed consistent individual differences over time. Although identifiable factors related to boldness, playfulness, sociability, did not emerge, some behavioral measures, primarily those involving play measures or ratings by humans, did intercorrelate, and some significant age differences emerged. Immature whales were more likely to look at stimuli such as the window or a novel object in their environment and be rated as more spontaneous. Adult whales were more likely to swim in different body orientations, display vigilant behavior, and be rated as dominant. These age differences in behavior support anecdotal reports collected from wild belugas and other captive populations. This study provides evidence that behaviors in belugas can be rated reliably and behaviors are consistent over different time frames, suggesting that belugas evidence behavioral syndromes. To determine if individual variability exists at a personality level, future research needs to evaluate consistency of behavior by belugas over time and contexts.



Acknowledgements
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Poster #27: Behavioral Responses of Beluga Whales *(Delphinapterus leucas)* to Environmental Variation in an Arctic Estuary

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Abstract
Some Arctic estuaries serve as substrate rubbing sites for beluga whales *(Delphinapterus leucas)* in the summer. These habitats represent a specialized resource for the species. Understanding how environmental variation affects beluga behavior is essential to management of these habitats. Spatiotemporal and environmental variables were recorded for behavioral observations, during which focal groups of whales were video-recorded for enumeration and behavioral analysis in an Arctic estuary. Multiple polynomial linear regression models were built and optimized in order to identify the effects of spatiotemporal and environmental conditions on group size and composition, as well as the frequency of behaviors being performed. Results suggest that belugas may exploit environmental variation to behave in ways that 1) protect young, *e.g.,* by bringing calves close to shore during cloudier days, thereby obscuring visualization from terrestrial predators; 2) avoid predation, *e.g.,* by rubbing against substrates at higher Beaufort sea states to obscure visualization, and resting during low tides while swimming on outgoing tides to avoid stranding in channels in the delta; and 3) optimize bioenergetic resources, *e.g.,* by swimming during lower Beaufort sea states and clearer days. Predictive models like these can inform conservation management strategies as environmental conditions change in future years.

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Poster #28: Do Belugas (*Delphinapterus leucas*) Form Expectations That Can Be Violated When Looking at Novel Humans or Objects?

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Abstract
The ability to recognize sudden changes in the environment is an important skill for survival in waters shared by other species, including an anthropogenic presence. Representational skills of non-human animals can be assessed by examining their reactions to unexpected changes to the characteristics of stimuli. Using a violation-of-expectation paradigm within a free swim context, we investigated the representational capacity of 11 belugas (*Delphinapterus leucas*) from two facilities. We investigated differences in gaze duration among stimuli of various familiarity levels, as well as humans and inanimate objects. Two different stimuli were presented consecutively, appearing from behind a curtain, and creating an "unexpected" change (violation of expectations) for all trials. It was predicted that the belugas would look longer at unexpected outcomes than at expected outcomes. Belugas did not show significant gaze duration variation between either humans and objects, or familiar/ unfamiliar stimuli, contrary to previous findings. No trends in laterality were seen based on stimulus type, but difference in eye preferences were observed. Belugas showed greatest use of binocular vision, both in frequency and gaze duration. Our results may also be similar to humans who experience change blindness. Implications of these results may indicate that when in the natural habitat, belugas may not notice a change in environmental factors right away much like other cetacean species that utilize coastal waters, i.e., boat traffic, vessel changes in speed and/or course.