Record of Decision from the Regional Peer Review of the Assessment of Factors in the Mortality of Eastern Beaufort Sea Beluga Whales (*Delphinapterus leucas*) Live Captured and Tagged in 2019; February 28–March 02, 2023

Laura Murray, Shannon MacPhee, Patrick Akhiatak, Norman Anikina, Dennis Arey, Dwayne Benoit, Émilie Couture, Marion Desmarchelier, Issiac Elanik, Ryan Galley, Carrie Goertz, Frances Gulland, Richard Gruben, Patt Hall, Lois Harwood, Justine Hudson, Nigel Hussey, Jody Illasiak, Joe Illasiak, Gerald Inglangasuk, Lawrence Kaglik, Jimmy Kalinek, Stéphane Lair, Lisa Loseto, Cory Matthews, Marie Noel, Greg O'Corry-Crowe, Tracy Romano, Teri Rowles, Kevin Scharffenberg, Raphaela Stimmelmayr, Luke Storrie, Michelle Wetton-Salo, David Yurkowski, Joclyn Paulic, Dean Arey

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2026

RECORD OF DECISION FROM THE REGIONAL PEER REVIEW OF THE ASSESSMENT OF FACTORS IN THE MORTALITY OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) LIVE CAPTURED AND TAGGED IN 2019; FEBRUARY 28–MARCH 02, 2023

by

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Eastern Beaufort Sea (EBS) beluga whales (*Delphinapterus leucas*) were tagged in Kugmallit Bay (Mackenzie Estuary) in July 2018 and 2019 as part of a research program co-developed by Fisheries and Oceans Canada (DFO) Science staff and Inuvialuit co-management partners. In 2019, twenty beluga whales were live captured and instrumented with back-mounted transmitters. Of these, 8 individuals were later confirmed to have died, and the survival status of a further 8 individuals could not be confirmed, representing a 40–80% mortality rate. This level of mortality is without recorded precedent and was particularly surprising given that the 2018 program used virtually identical methods without incident. Tagging marine mammals is currently the only tool that can be used to collect large scale movement and dive data over periods of several months or more, and movement data are needed to support a variety of conservation and planning initiatives. Therefore, it is important to gain an understanding of factors related to the mortality event and to document lessons learned so that tagging can be conducted safely and with confidence going forward. To address this need, DFO Science, supported by Inuvialuit community members and co-management partners, undertook an assessment of factors related to the mortality of EBS beluga whales tagged in 2019.

A DFO Canadian Science Advisory Secretariat (CSAS) Regional Science Advisory Meeting was held in Yellowknife, NT, with some participants attending virtually via Microsoft Teams, on February 28–March 02, 2023. Participants included experts from DFO (Science, Fisheries Management sectors), Inuvialuit co-management partners (Inuvialuit Game Council [IGC], Fisheries Joint Management Committee [FJMC]), beluga harvesters with Inuvialuit Knowledge (IK) of EBS beluga whales, tagging crew members, wildlife veterinarians, researchers with marine mammal tagging experience, and physical scientists with knowledge of the regional environment (Appendix 1). Two Working Papers (1 - tagging and 2 - indicators) were prepared to support an assessment of all known possible causes of death and potential contributing factors, with factors divided into direct causes of death (e.g., trauma, infection), and underlying factors (e.g., tagging methods, whale condition, environmental conditions). This Record of Decision document summarizes discussions held during the peer review meeting, including revisions recommended to publish the Working Papers as a Research Document. The conclusions and feedback from this meeting were used to develop a Science Advisory Report. The Science Advisory Report and supporting Research Documents will be published on the DFO Canadian Science Advisory Secretariat (CSAS) website.

RÉSUMÉ

Murray, L., MacPhee, S., Akhiatak, P., Anikina, N., Arey, D., Benoit, D., Couture, É., Desmarchelier, M., Elanik, I., Galley, R., Goertz, C., Gulland, F., Gruben, R., Hall, P., Harwood, L., Hudson, J., Hussey, N., Illasiak, J., Illasiak, J., Inglangasuk, G., Kaglik, L., Kalinek, J., Lair, S., Loseto, L., Matthews, C., Noel, M., O'Corry-Crowe, G., Romano, T., Rowles, T., Scharffenberg, K., Stimmelmayr, R., Storrie, L., Wetton-Salo, M., Yurkowski, D., Paulic, J., Arey, D. 2026. Record of Decision from the Regional Peer Review of the Assessment of Factors in the Mortality of Eastern Beaufort Sea Beluga Whales (*Delphinapterus leucas*) Live Captured and Tagged in 2019; February 28–March 02, 2023. Can. Manuscr. Rep. Fish. Aquat. Sci. 3335. vi + 34 p. https://doi.org/10.60825/dgwy-cj87

Des bélugas (*Delphinapterus leucas*) de l'est de la mer de Beaufort ont été marqués dans la baie Kugmallit (estuaire du Mackenzie) en juillet 2018 et 2019 dans le cadre d'un programme de recherche élaboré conjointement par le personnel scientifique de Pêches et Océans Canada (MPO) et des partenaires de cogestion inuvialuits. En 2019, 20 bélugas ont été capturés vivants et dotés d'émetteurs à montage dorsal. La mort de huit d'entre eux a été confirmée plus tard et il n'a pas été possible de confirmer l'état de huit autres, ce qui représente un taux de mortalité de 40 à 80 %. Ce niveau de mortalité est sans précédent et particulièrement surprenant étant donné que le programme de 2018 a utilisé des méthodes pratiquement identiques sans incident. Le marquage est actuellement le seul outil qui peut être utilisé pour recueillir des données à grande échelle sur les déplacements et les plongées de mammifères marins sur des périodes de plusieurs mois ou plus, et les données sur les déplacements sont nécessaires pour diverses initiatives de conservation et de planification. Il est donc important de comprendre les facteurs liés à cet épisode de mortalité et de consigner les leçons retenues afin de pouvoir effectuer le marquage en toute sécurité et en toute confiance à l'avenir. Pour ce faire, la Direction des sciences du MPO, appuyée par des résidents et des partenaires de cogestion inuvialuits, a entrepris une évaluation des facteurs liés à la mortalité des bélugas de l'est de la mer de Beaufort marqués en 2019.

Une réunion consultative scientifique régionale du Secrétariat canadien des avis scientifiques (SCAS) du MPO a été organisée à Yellowknife (Territoires du Nord-Ouest) du 28 février au 2 mars 2023; certains participants y ont assisté virtuellement sur Microsoft Teams. Les participants étaient des experts du MPO (Direction des sciences et Direction générale de la gestion des pêches), des partenaires de cogestion inuvialuits (Conseil inuvialuit de gestion du gibier et Comité mixte de gestion de la pêche), des chasseurs inuvialuits possédant des connaissances sur le béluga de l'est de la mer de Beaufort, des membres de l'équipe de marquage, des vétérinaires de la faune, des chercheurs ayant de l'expérience dans le domaine du marquage des mammifères marins et des spécialistes des sciences physiques connaissant l'environnement régional (Annexe 1). Deux documents de travail ont été préparés pour faciliter l'évaluation de toutes les causes de la mort possibles connues et des facteurs contributifs potentiels, ces facteurs étant divisés en causes directes de la mort (p. ex. traumatisme, infection) et en facteurs sous-jacents (p. ex. méthodes de marquage, état de la baleine, conditions environnementales). Le présent compte rendu de décision résume les discussions tenues pendant la réunion d'examen par les pairs, notamment les révisions recommandées pour la publication des documents de travail à titre de document de recherche. Les conclusions et les commentaires formulés lors de cette réunion ont servi à élaborer un avis scientifique. L'avis scientifique et les documents de recherches seront publiés sur le site Web du SCAS du MPO.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) regional peer-review meeting was held to assess the factors that contributed to the mortality of Eastern Beaufort Sea (EBS) beluga whales (*Delphinapterus leucas*) captured and tagged in July 2019 in Kugmallit Bay, Mackenzie Estuary, Northwest Territories. The research project was co-developed and undertaken collaboratively with Inuvialuit. After a successful tagging project in 2018, twenty whales were tagged in 2019 with similar methods. However, within 2 weeks of handling, 8 whales were confirmed dead and an additional 8 individuals had tags go offline with survival status unconfirmed, together representing a 40–80% mortality rate. Tagging beluga whales is currently the only tool used to collect movement data over long durations, and it is important to understand factors that potentially contributed to the mortality, as well as lessons learned so that tagging can be conducted safely and with confidence going forward. Regional DFO Science staff have recommended a freeze on any live-capture tagging of belugas until an assessment can be completed and recommendations provided for future programs. This was supported by Inuvialuit community members and co-management partners who have also requested more information about cause of the mortalities. To address these needs, DFO Science convened an assessment of factors contributing to the mortality event. The meeting was held in Yellowknife, NT on February 28–March 2, 2023, with some participants joining remotely via Microsoft Teams. This Record of Decision is published as a manuscript rather than as CSAS Proceedings because CSAS no longer produces proceedings documents.

The Chair opened the meeting by welcoming participants and reviewing the objectives of the Terms of Reference (Appendix 2). Participants introduced themselves and provided a short description of their expertise, followed by an opening prayer. Participants included representation from DFO (Science staff including Chair of the Animal Care Committee, Fisheries Management), Inuvialuit co-management groups (Inuvialuit Game Council [IGC], Fisheries Joint Management Committee [FJMC]), Inuvialuit beluga harvesters with Inuvialuit Knowledge (IK) of beluga whales, tagging crew members, wildlife veterinarians, researchers with tagging experience, and a physical scientist with knowledge of the regional environment (Appendix 1). There was recognition of the importance of coming together and learning what one could from an unfortunate event. The CSAS process and the draft meeting agenda were reviewed.

A participant suggested that community Elders should be included in the meeting because Inuvialuit learn from their Elders in the same way that students learn from professors. The comment was noted and would be raised in a debrief Steering Committee after the peer review. Clarification was requested as to how information from the meeting would be used for future decision-making, as this would affect Inuvialuit. It was clarified that information and advice arising from the meeting would be made publicly available to support future resource management decisions under the co-management framework in the Inuvialuit Settlement Region. There was a question about how information would be sent to communities for final review. It was explained that following the peer review meeting, participants would be sent the revised meeting documents for review, but that community members at-large would not be a part of the review. It was also explained that all documents were confidential until final approval of the science advice. This is a means to prevent miscommunication of advice that is not yet finalized.

There was a question on how Indigenous Knowledge (IK) would be included in the peer review process, recognizing that the CSAS is western science-focused. This is something that has been brought up before as a concern by the FJMC. It was explained that CSAS acknowledges

IK as expertise and as knowledge that should be included, however CSAS does not have a mechanism to differentiate between types of knowledges. Ways that IK had been included in previous CSAS processes was to include IK shared in the Proceedings, in the Science Advisory Report (SAR) under 'Other Considerations' or explicitly within the 'Conclusions' and summary bullets. Inuvialuit members of the EBS beluga tagging field crew had been interviewed for their observations and the results will be published as a report (Worden and Elanik[1]), and this was an additional source of IK used in the review process. The report was not published at the time of the meeting and participants did not have an opportunity to see the results in detail. One of the participants was an author of the report and it was suggested that an amendment to the agenda should be to include a presentation on the results of the report on Day 2 of the peer review meeting (Appendix 3). A co-author of the Working Papers added that full participation by Inuvialuit participants during the peer review was important to achieving the meeting Terms of Reference, recognizing that Inuvialuit bring a significant body of knowledge on topics including the local environment, beluga health and environmental change. The full partnership with Inuvialuit throughout the EBS beluga tagging program was also recognized.

INTRODUCTORY PRESENTATIONS

OVERVIEW OF THE BELUGA TAGGING PROGRAM

Presenter: Shannon MacPhee

An overview of the 2018 and 2019 EBS beluga tagging program was presented to provide context to the request for science advice. It was noted that tagging is known to be an invasive process that comes with risks, and the method is only used when no other alternatives exist to gather the data required to support a resource management need. EBS beluga are considered to be a large and healthy population, which was taken into account in the risk assessment to approve the tagging program. In 2018, a partnered tagging program with DFO, IGC, and FJMC was undertaken to examine drivers of change in beluga distribution (as identified by Inuvialuit observations), to inform the correction factor for an updated population abundance estimate, and to inform marine conservation and planning initiatives. Ten male belugas were tagged, with some tags transmitting for up to 1 year, allowing for collection of data into the EBS beluga winter habitat. No known mortality occurred. A live capture technique originally adapted from use on dolphins and later modified for belugas was used. This capture method has been successfully used for beluga whales for more than 30 years, and was well suited for use in the Mackenzie Estuary due to shallow water depths and high number of whales present in the area.

In 2019, 20 male belugas were captured and tagged. For 10 of these whales, a secondary towed tag was also attached. This secondary tag archived and transmitted high-resolution dive data to fill gaps in data collected from the back-mounted tags, and provided information on best placement for this type of tag when deployed on free-swimming belugas. In addition to the 20 captured whales, a further 20 free-swimming whales were remotely tagged (no capture) with towed transmitters using a harpoon attachment method. No evidence for mortality was observed in the harpoon-tagged whales and they were therefore not considered in the current assessment (except for some temperature data from these tags being included in data analyses). After the first 7 whales were tagged and released, post-release monitoring efforts identified that 4 tags had failed prematurely. The science team reached out to the tag manufacturer for support, and it was initially concluded that these tags had likely malfunctioned

[1] This report has since been published (Worden and Elanik 2024)

due to modifications made to increase the sensitivity of the tags to collect data in relatively fresh waters of the Mackenzie Estuary. The science team reached out to co-management partners with the information on tag failures and the decision was ultimately made to proceed with tagging additional whales. Later, after all 20 tags had been deployed, it was realized that these tag failures represented mortality incidents. This determination was based on the mortality function designed into the pop-up archival tags, in which the pop-up tag will release if it remains at a constant depth for 24 consecutive hours. In addition, the carcasses of 3 tagged belugas were discovered when their tags began reporting from a position on land following a significant storm event. Within 2 weeks of instrumentation, 5 whales were confirmed dead based on the mortality function, along with 3 carcasses found, for a total of 8 confirmed mortalities of the live captured whales. Another 8 tags went offline in the same time period, however mortality was not confirmed and their status was considered unknown.

Discussion

There was a question about the timeline of discovering the mortalities. The presenter reiterated that the mortality function in pop-up tags were used to discover the mortality incident, and clarified that that pop-up tags were placed on individuals tagged in the second half of the program, which explained why mortalities were not confirmed until later.

There was some discussion around the placement of the back-mounted tags and the rod attachments. A participant expressed concern that the back-mounted tags were placed on top of the lungs and suggested that while the rods only penetrated blubber, they may still affect deeper tissues. Also, whales rub as part of the moulting process, and it was suggested that this action may move the rods deeper into the animal. It was explained that tag placement, just ahead of the dorsal ridge, is to ensure the tag antennae comes out of the water to transmit when the whale surfaces and this area is known to have a thick blubber layer. Tags are placed in blubber, above muscle and bone, and either stay in place or come off by migrating out. It was also discussed that the dorsal ridge is an important area for thermoregulation. Whales move into estuaries where warmer water temperatures promote molting, and someone suggested that the dorsal ridge likely has a lot of blood flow to the area and that the wound from tagging may have more of an effect because of these factors. A participant asked if any infrared thermal imaging was used pre- and post-tagging, and this was recognized as something that could be done in future programs. It was noted that the blubber of belugas tagged in 2019 had appeared bloodier, which could be from increased vasodilation, and that the dorsal ridge on a few of the whales tagged in 2019 were hot to the touch.

Studies with deer were discussed where a greater stress response was observed when deer were chased versus stalked. In the EBS beluga tagging program, herding was likely a more appropriate term for the method used in beluga capture and restraint, while chasing was a more appropriate term for the harpoon tagging method. It was suggested that data from the harpooned whales be included in the current assessment as they may provide valuable data. It was explained that harpoon tagged whales were excluded from the assessment as there was no health data available for these whales and there was no indication of mortality (the use of pop-up archival tags would have indicated mortality in harpoon-tagged whales). However there may be some analyses where these data would be useful. It was asked if the 2018 tags that went offline could possibly represent additional mortalities, and it was explained that since they went back online outside of the estuary and many lasted for several months, this did not appear to be the case.

A participant stated that different groups of whales arrive to the estuary at different times, and since tagging was done over a short time frame at the beginning of the open-water season, a single group of early-arriving whales may have been tagged. These early arrivers may not be in

as good shape as later arrivers since they are 'rushing'. Some more experienced harvesters wait until the fall when belugas have greater blubber thickness. Another participant noted that the whales tagged in 2019 were all large males and may have been exhausted from breeding activity and therefore more compromised at the time of the tagging program.

A participant asked how common it is to deploy two tags on an animal. One of the authors noted that two tags were also deployed in the 2018 tagging program, however the secondary tag was tethered to the primary tag rather than independently attached. Another participant noted that belugas had been double tagged in Bristol Bay with a protocol that limited the number of insertion points to 4 total, with 2 rods used for the back-mounted tags and 2 prongs for a LIMPET tag. No issues were reported, though 1 whale later necropsied was double tagged. It was noted that in this Bristol Bay beluga tagging program there had been some concern for the number of insertion points used. The EBS beluga tagging program had 3 insertion points in 2018 (3 rods), and up to 4 insertion points in 2019 (3 rods for the primary tag, plus for some whales 1 additional rod to attach either a towed SPLASH10-F-321 tag or an Inuvik Dark anchor implant).

Several participants recognized the information that was gained from the EBS beluga tagging program, as well as the connections between tag data and information from other programs such as the Canadian Beaufort Sea Marine Ecosystem Assessment (aboard the *F/V* Frosti), and the value of the data and information in supporting resource management decision-making. It was also noted that a small number of whales were tagged in comparison to the size of the EBS beluga population overall. Differences between the types of tags deployed were discussed (

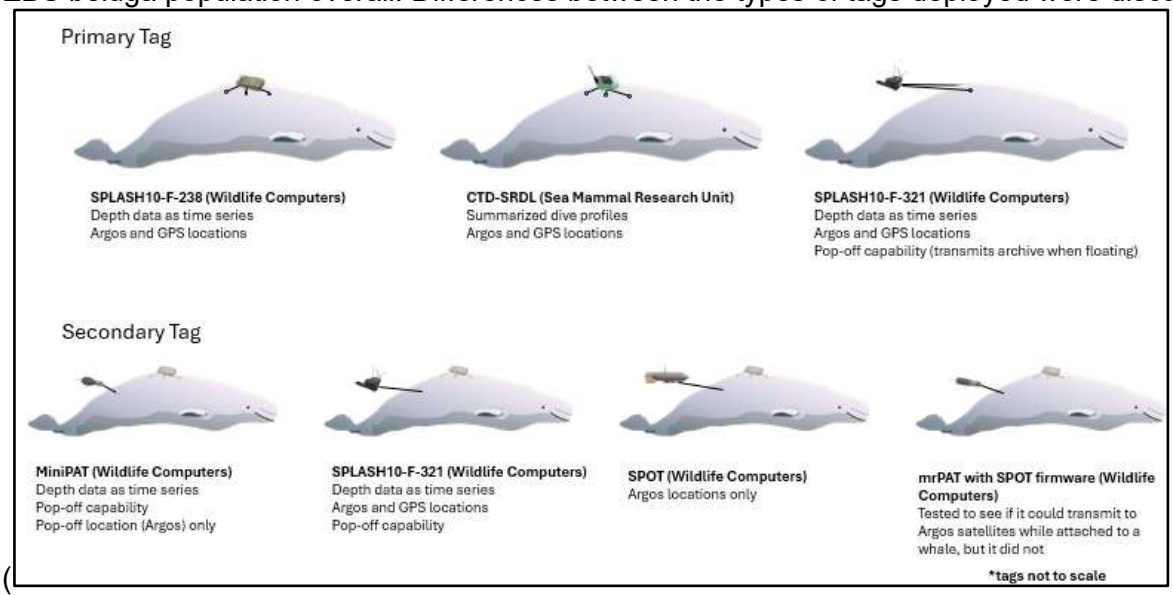

Figure 1). Harpoon-deployed tags have lower retention time than back-mounted tags. Back-mounted tags have longer retention times and will sink when released from a whale.

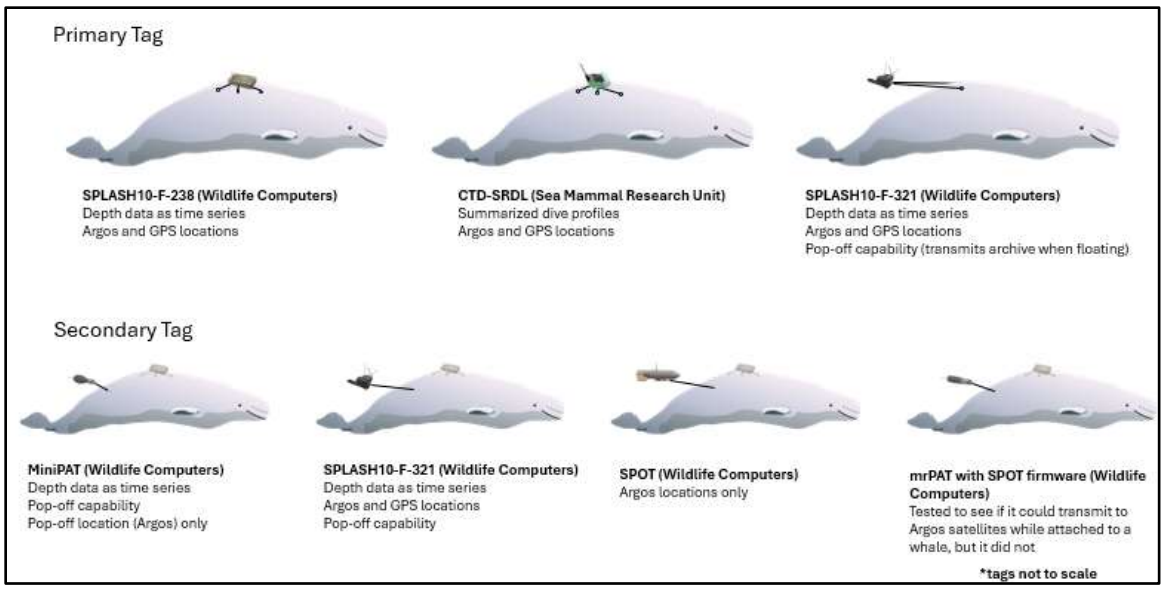

Figure 1. Examples of 2019 live capture tag types and set ups.

CONTEXT OF THE REQUEST FOR SCIENCE ADVICE

Presenter: Michelle Wetton-Salo, Chairperson of DFO's Ontario, Prairie and Arctic Animal Care Committee

The Ontario, Prairie and Arctic Animal Care Committee (OPA-ACC) is the client for this CSAS peer review process. The OPA-ACC membership includes biologists, veterinarians, and community members who review Animal Use Protocols (AUPs) to ensure the ethical use of live fish and marine mammals in research. The committee is certified by, and follows the guidelines of, the Canadian Council on Animal Care (CCAC), a national body that sets out standards for the ethical care and use of live animals. The OPA-ACC was confident in approving the 2019 AUP for the beluga tagging program due to how comprehensive it was, the success of the 2018 tagging program, and the Standard Operating Procedure being based on years of experience tagging beluga whales in the Canadian Arctic and elsewhere (1990's and onward). However, the 2019 mortalities represent a major incident and protocols must now be updated with lessons learned from this major incident event.

OPA-ACC completes post-approval monitoring of every project, with major incidents being reported immediately to the CCAC. The 2019 mortalities were considered a major incident and a CCAC review of the incident has now been completed, with the CCAC issuing a commendation to the project team for their commitment to investigating what happened and their 'ethical use of animals in research'. The incident will be discussed at the next CCAC assessment of the OPA-ACC in January 2024. The CCAC has changed their reporting process and in future AUPs will require specifying an expected level of mortalities, with the CCAC being immediately notified through a 'reportable animal welfare incident (RAWI) report if mortalities exceed this baseline estimate by 20% or more. CCAC is also recommending that an Animal Welfare Assessment process (CCAC guidelines: Animal welfare assessment) be completed for future AUPs to better detect animals in distress.

The OPA-ACC has requested an assessment of factors contributing to the 2019 mortality incident to be completed before issuing future approvals for the live capture of marine mammals for scientific purposes. They are looking for outcomes from the current assessment for guidance on how to refine the current SOP to live capture and tag belugas. The CCAC Guidelines on the

Care and Use of Marine Mammals is intended for Canadian institutions that house marine mammals in aquaria and is not relevant to live capture and tagging of wild animals for scientific study. At present, the CCAC does not have guidelines for live capture and tagging for research purposes.

Discussion

A participant suggested that it would be difficult to obtain community support for future tagging programs if an expected level of mortality was proposed. Alternatively, it was noted that people wanted to be transparent about the risks posed by tagging, and that the current assessment process had been requested by the IGC and Tuktoyaktuk Hunters and Trappers Committee (THTC). A participant noted that there are CCAC guidelines for wildlife capture that are currently under review that will help inform future programs and SOPs.

WORKING PAPER PRESENTATIONS

ASSESSMENT OF THE MOVEMENTS AND DIVE BEHAVIOUR OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) TAGGED USING THE LIVE-CAPTURE METHOD, 2019, IN RELATION TO MORTALITY EVENTS

Presenter: Luke Storrie

The aim of the analyses within this assessment were to examine movement and dive behaviour to investigate if there were differences between whales classified by survival status as: 'Alive', 'Dead', and 'Unknown'. Alive whales (n = 4) were individuals with tags that transmitted for an extended period of time (35–138 days), Dead whales (n = 8) were individuals confirmed to have died based on discovery of a carcass or the mortality function of a pop-up tag, and Unknown whales (n = 8) were individuals where tags stopped transmitting within a short period of time (29 –79 h) but mortality was not confirmed. The mortality function consisted of programming a pop-up tag to release if it was at a consistent depth for a specified period of time. These analyses were challenged by the small sample sizes (therefore, no statistics were done), incomplete data for many of the whales, and different types of data from the different tag types used. Factors examined included: movement, speed, time spent in Kugmallit Bay, time-at-depth, and dive profiles. These factors were analyzed separately over a period of 3 days post-release.

Movement speed was fairly slow overall, with overlap between groups. Alive whales tended to remain in Kugmallit Bay for the longest duration post-release, and whales in the Unknown group the shortest. There was no general movement pattern by group, but there was some correlation with the timing of tagging (julian date, suggesting that movement was potentially related to social groups). Dives on Day 1 (the first day post-release) were more shallow, and dives on Day 2 and Day 3 were slightly deeper, which likely was related with location and seafloor depth as whales moved out of Kugmallit Bay into deeper waters offshore.

Overall there were no clear differences in the movement or dive behaviour between whales of different survival statuses. Other tagging studies have reported tags going offline and these were assumed to be either tag failures or tag detachments. The addition of the mortality function in tags is an important tool to identify potential mortality incidents. The use of secondary pop-up archival tags was suggested for future live-capture tagging programs. Pop-up archival tags can also provide additional data and more complete datasets than traditional back-mounted tags.

Discussion

Participants discussed beluga diving behaviour. It is usually inferred that beluga are feeding when they dive, but it was recognized that they may also be diving for other reasons (e.g., navigating by seafloor features). A participant suggested that the whales may have been trying to 'knock their tag off' when diving, but others noted that this behaviour would be more likely to occur in shallower water. There were questions around which data represented actual dive behaviour versus gaps in the data, and it was explained that for many whales, gaps in data made it appear that there were diving clusters surrounded by time at the surface, but this was due to data gaps and did not represent actual behaviour. The possible effects of ice on diving behaviour was discussed, as this could affect when and where belugas surface. With less sea ice present in recent years, dive data from past programs may not be entirely comparable to contemporary data. A participant asked for a definition of 'normal dive behaviour' for the EBS beluga population. It was explained that use of the term 'normal' was based on data from the 2018 program as well as past programs, but it was recognized that there may be too much uncertainty/not enough data to use the term 'normal' for the whales that had died.

A participant suggested that blubber thickness should be measured before attaching a tag to a beluga. It was explained that harvest-based data on average blubber thickness of EBS belugas was used to determine tag placement, as well as visual assessments, and harvester knowledge. A few times the tagging process was called off because a whale appeared too thin to tag. Blubber had been measured in other programs by ultrasound (Cornick et al. 2016), and this could be done in future. Photos were taken of all whales during instrumentation and these could be looked at as another way to assess body condition for comparison between whales of different survival classes.

It was suggested that the Dead and Unknown status whales may have left Kugmallit Bay earlier than Alive whales to seek out cooler water for thermoregulation. Overall there did not seem to be a movement pattern related to temperature, and movement seemed to be driven by some other factor(s). A participant asked for clarification on how Unknown status whales were defined, and the author explained that this was based on the short time frame in which their tags went offline. A participant asked about tag duration for harpoon-deployed tags. It was explained that some harpooned tags were programmed to release within a few days and others by end of September, and the longest tag transmitted data for 6 weeks. A participant suggested combining Dead and Unknown status whales together into a single category to increase sample size for data analysis.

It was stated that whales likely expend a substantial amount of energy when they dive and are likely seeking food. Were they fit to do this after tagging? It was also stated that an animal with capture myopathy would not travel long distances. A participant asked if tagged whales had traveled less in 2019 versus 2018, and the author explained that they had not done that comparison for this Working Paper. A participant stated that whales are strong, and shared an example from a Husky Lakes entrapment event when it took 5 people to restrain starving whales after they had been harpooned. He noted that after a whale is harpooned it can still pull a boat backwards if the restraining rope gets wrapped around the propellor.

A participant asked for clarification on modifications made to the saltwater switch. It was explained that the saltwater switch was to allow tags to differentiate between water versus air and therefore know when to transmit data to satellites. If this 'switch' (i.e., the resistor) is not calibrated properly it can drain the battery because the tag will continue to attempt to transmit data when submerged. One of the key modifications was to lower the conductivity at which the tag would transmit data and there is no reason to believe that any other aspect was affected. A participant asked what time frame would give the fastest confirmation on mortality. It was

explained that in the EBS beluga tagging program the mortality pop-up function was set to 24 hours at constant depth and the data were accessed in real-time through an online portal.

The group discussed when whales may sink versus float after death. A harvester explained that this depended on the salinity of the water (water is saltier in the fall and whales tend to float, while in the springtime water is fresher and provides less buoyancy), but that there are cases where whales with thick blubber reserves may float even in fresher water.

Overall, consensus on suggested revisions to Working Paper #1 were to:

- Include context on what is meant by 'normal' dive behaviour (surface intervals, dive depth, distance travelled), from both 2018 data and past programs.
- Compare dive behavior to sea ice, potentially not as an analysis but as an addition of a map of sea ice coverage. But there was also recognition that environmental data were included in the Working Paper #2.
- Conduct additional analyses with Unknown and Dead whales lumped into one group due to similarities between these groups (specifically, that all tags failed within ~ 3 days). Sample size is low but combining these two survival classes could provide more information.
- Potentially combine other data into these analyses (e.g., vocalizations/contact calls) to test for behavioural differences between survival classes.
- Add a discussion on the potential reasons whales dive (thermoregulation, feeding, moulting, navigation via seafloor, etc.).
- Add a discussion on whale physiology (the energy it takes to dive, the long distances they travel, their resilience to endure stress).
- Include a tag with a programmable mortality function in future studies, with the type of tag TBD based on study design.
- Explicitly state that 2019 was a pilot year for different types of tags, to help address confusion over the many different tag configurations used.

PHASE I: INFORMATION TO SUPPORT AN ASSESSMENT OF POTENTIAL CONTRIBUTING FACTORS IN THE MORTALITY OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) TAGGED IN JULY 2019: CATEGORIES OF CAUSES INVESTIGATED (DIFFERENTIAL DIAGNOSIS)

Presenter: Dr. Émilie L. Couture

Some modifications had been made to the presentation compared to what was included in the Indicators Working Paper. Specifically, cause of death (COD) and underlying causes were differentiated and defined, with COD being the final disease, injury, or complication directly causing the death, and underlying causes being the intermediate causes preceding the COD, without which death would not have occurred at the same time or in the same manner (Figure 2). Both COD and underlying causes are important to determine to paint a complete portrait on the situation leading to death and allow identification of potential mitigation points. This presentation focused on possible COD, using a differential diagnosis process. Differential diagnosis is a structured way of listing all of the possible causes of death, and then ranking them from most to least likely. Context to be considered in determining possible causes included that there were multiple deaths that are supposed to have occurred between 1–3 days of tagging. Data available for the process included the video footage, physical exam, and sample/data collection (blood samples, blow swabs, skin/blubber samples) during the

instrumentation process, telemetry data, and limited post mortem data from the three partially decomposed carcasses of tagged belugas.

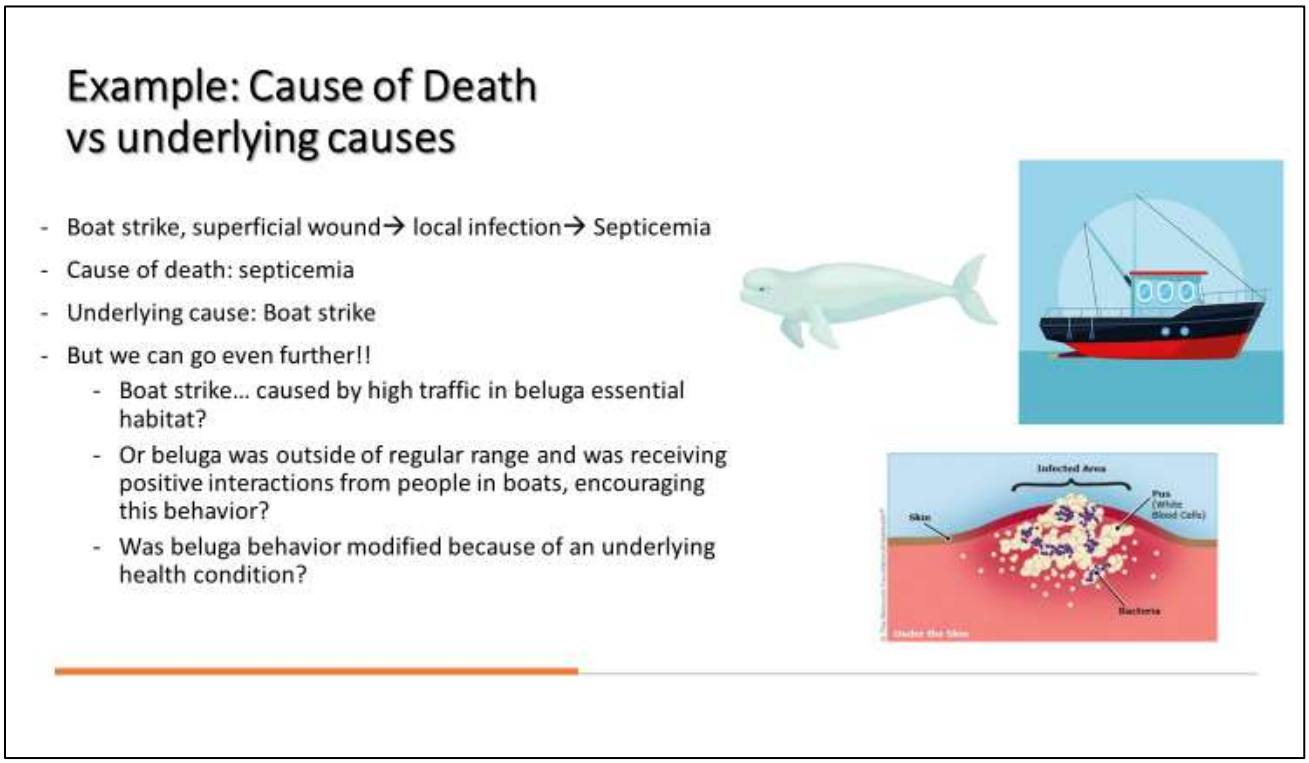

Figure 2. Example of cause of death versus underlying cause.

The CODs included in the differential diagnosis process were presented and discussed below.

Trauma

No evidence for trauma was found including: no significant lesions observed prior to or during capture and restraint, no evidence for injury in the post-release behaviour, and the limited post-mortem carcass evaluation showing no evidence of gunshot, vessel strike, or predation. Comparing whale movement to Automatic Identification Systems (AIS) data for ship traffic in the region showed no evidence for overlap between confirmed dead belugas and ships, and therefore no evidence for vessel strike. Therefore the authors concluded with 'high confidence' that trauma relevance to the mortality of multiple individuals following handling was 'nil to low'.

Discussion

It was noted that AIS data do not capture all ship traffic; some vessels do go undetected (those less than 300 gross tonnage, submarines) and this was therefore a limitation of the analysis. It was unlikely that the large number of deaths would have been caused by vessel strike, particularly over a period of several days. Some ships may have been using sonar, but this is known to deter belugas.

The author clarified that while no significant lesions were detected during the physical exam, lesions were observed in the form of superficial capture-related injuries (fluke notches, abrasions, cuts). While not serious these could serve as points of entry for infection (infection would be discussed later as a separate possible COD). There was not full confidence from some participants that there were no differences seen in diving behaviour between Alive and Dead status whales. Musculoskeletal impairment could have been present but not impeded

movement. It was explained that later sections would discuss muscle impairment, and that the current section dealt with the ability to move. It was commented that if an animal is weak a predator would go after it. An incident where a polar bear had eaten a beluga was mentioned (referring to an incident where the fluke of a beluga in Hudson Bay was bitten). A predator-prey interaction had been observed in a Bristol Bay tagged beluga that was necropsied. This was not something observed in the EBS beluga tagging program.

The possibility of psychological stress caused by the tagging was discussed. The herding, injury from tagging, and general stress of the event may have caused a psychological effect. A participant suggested that depression leading to potential suicide could be a factor, and was compared to people taking their lives after a traumatic event. It was noted that there was no known evidence for this in the wild and that most animals have a strong will to survive. One case of depression was known that led to death in the case of a captive dolphin that had lost a calf, but this occurred over a longer time period than the mortalities in the EBS beluga tagging program (M. Desmarchelier, Canadian Wildlife Health Cooperative, pers. comm). Knowledge of beluga stress physiology is known from measurements taken in captive belugas being transported, from which baseline levels of cortisol exist, as well as the pattern of response from acute stressors. Cortisol levels were measured in stranded calves that were brought into captivity and were found to be very high at first but did come down to normal levels with time, and the animals appeared to adapt to capture conditions (Goertz et al. 2021). It was also noted that these tagging methods had been used in the past and there is a known process of healing after tagging.

There was a question about the age of the tagged whales. All tagged animals were large white adult males with the exception of one younger male individual with slight gray colouration which was in the Alive category. Preliminary analysis of tagged whales age was analyzed through epigenetic aging, and were found to average 30 years old, with no differences between years or between survival status.

There was agreement that trauma was unlikely the COD. There was a suggestion to refine the title of this COD to ‘physical trauma’ to differentiate from psychological trauma.

Infectious/Inflammatory

No indications of significant underlying health conditions were detected in tagged whales, based on hematology values (white blood cell counts, fibrinogen). No viruses were detected, and proportionately more untagged belugas would be expected to have been found dead if mortalities were due to a virus. Limitations to detecting viruses included that data were only from a blowhole swab which would not detect viruses in other parts of the body, that routine virus isolation does not investigate for all possible viruses, and that the presence of a virus does not necessarily translate to manifestation of a disease. No indications of post-tagging infection were observed in the three post-mortem investigations of tagged beluga carcasses, and no gross signs of infection were observed. In addition, the timeline for infection would be expected to be longer than 3 days, and the number of mortalities observed in this incident would not be expected from infection. Therefore it was concluded with ‘high confidence’ that the likelihood of infection/inflammation as a COD was ‘nil to low’.

Discussion

It was argued that post-tagging infection could not be excluded because the carcasses examined were in an advanced state of decomposition. In addition, the rate of carcass decomposition was very fast and may be indicative of septicemia, or more theoretically of necrotizing soft tissue infection (which has been described in captive cetaceans). There were a limited number of trocars used in the field and they were therefore field disinfected but not

sterilized, which was a weak point in the sterilization process and could be linking all the animals together, and may explain the high number of mortalities. It was also commented that the disinfection protocol used was one used in many past studies with no mortalities, but newer guidelines include a slightly higher level of disinfection. The disinfection process was not perfect, and there could be a re-analysis for any pathogens known to be resistant to Virkon (disinfectant used), but overall this was still considered unlikely as the cause of mortality. There was agreement to move away from use of 'excluding' or 'including' a COD, towards language with more room for uncertainty such as 'more likely' and 'less likely'.

It was suggested that whales may have had pre-existing infections at the time of tagging. In response, it was noted that overall the EBS population was observed to have a low level of pneumonia from lungworm but t this did not seem to affect their survival, and there seemed to be an equilibrium with the parasite. Possible effects from the blowhole swab were brought up, as whales have been seen to close their blowhole after breathing. This was not thought to have an effect on the data or results.

Participants discussed observations that 2019 was an 'unusual' year. For example, more marine mammal carcasses were observed and there were more storms than usual, and these observations were recognized as important. It was discussed that animals have natural life cycles where some will die when they are young from trauma, and some die from old age, as well as population cycles such that overpopulation is reduced by disease or other events.

It was recognized that many items being discussed had moved into underlying causes and away from direct COD. There was consensus that infection/inflammation was a 'less likely' COD.

Toxic Events

The possibility of harmful algal blooms (HABs) as a COD was explored by testing 2 of the tagged whale carcasses for domoic acid and paralytic shellfish toxins, neither of which were detected. Also with HABs, a higher level of mortality would be expected overall for marine mammals and seabirds in the region. Therefore it was concluded that toxic events were not a likely COD.

Discussion

There was agreement that the data did not support HABs as a COD. These toxins are relatively stable and likely would have been detected if present. There was some evidence for HABs in 2019 in the Alaskan food web from concentrations seen in clams and other prey items, as well as fecal concentrations in walruses and bowhead whales (Lefebvre et al. 2022). A participant noted the observation of a white plume near Ulukhaktok and Sachs Harbour from tunicates (Pettitt-Wade et al. 2020). A participant asked if there were other types of toxic events other than HABs, and it was explained that in the St. Lawrence river low oxygen zones develop that affect beluga prey species. This was something that could be discussed in later sections on environmental conditions.

There was agreement that toxic events was 'less likely' the COD.

Metabolic/Nutritional

From physical examinations, most of the 20 tagged whales were assessed as being in good overall body condition. One individual was assessed as 'thin' and 1 individual was not assessed. Biochemistry from blood work found changes associated with travel/migration in some whales including a mild increase in creatinine with no urea increase (muscle metabolism), and marginal hypoalbuminemia and hypokalemia (reduced food intake). These may indicate whales were in

suboptimal condition, but there was no indication of starvation as the COD. Therefore it was concluded with ‘high confidence’ that the relevance of metabolic/nutritional causes was low, but that this information on condition could be considered further as a potential underlying factor.

Discussion

It was noted that the tagging team selected for healthy whales, so it made sense that most whales were assessed as being in good condition. It was commented that it may be difficult to identify between immediate versus underlying causes for the mortalities. The whales were evaluated as not at risk for starvation, but they had recently completed a long-distance migration and stress could have contributed to mortality. It was suggested that the wording be changed to being confident that whales did not die of starvation but that poor nutritional status could be a contributing factor. It was also noted that little was known of the conditions faced by EBS beluga in their winter habitat, and the prey availability there.

There was agreement that starvation was less likely the source of mortality, but that poor nutrition could be a contributing factor.

Neoplastic/Congenital/Degenerative/Endocrine

Neoplastic diseases/disorders were defined as abnormal growths of cells (e.g., cancer), congenital diseases are present at birth, degenerative diseases get worse with age, and endocrine diseases are related to hormones (e.g., diabetes). These diseases/disorders could not be fully evaluated, but some information could be obtained from physical examinations, bloodwork, and the few post-mortems conducted. It would also be unlikely for these conditions to result in such a high number of mortalities, and overall it was concluded with ‘high confidence’ that their relevance as a COD was ‘nil to low’.

Discussion

It was noted that these diseases were observed at only minimal levels in the 2015–2016 health assessment for EBS belugas (Lair and Couture 2021). There was a suggestion to reference this health assessment in the Working Paper. There was agreement that these conditions were not likely a cause of the mortalities observed in tagged EBS belugas.

Harvester observations were shared about whales having different colours of blubber in different years. One year blubber was orange and tended to rot easier, and the next year blubber was pink. Different whales are known to go to different places in the same way that people go to different places on vacation, and we may only be looking at one subpopulation here. It was noted that genetic analyses had been conducted on EBS whales, but that it was limited in samples sizes from some locations and so may not have picked up on any variation in population structure. Climate change has caused coastal erosion into the ocean and this may be adding substances to the water that whales are then picking up. EBS belugas have a large range and there may be something in other locations (e.g., Russia) that is affecting their health. It was noted that larger whales of 17–18 ft in length tended to be harvested in the past, and now people are lucky to harvest a 14 ft whale.

Concerns were raised about the potential harmful effects of sonar. It was noted that sonic trauma is usually associated with deep diving species, and that animals would be expected to die at the same time from this type of stressor (vs over a period of 7 days observed in the current study), but that this additional factor could be included in the assessment. The possible effects of having whales out of the water was discussed, potentially from their lungs being flattened or their breathing otherwise affected from the increased pressure from their body weight while beached for tagging.

It was commented that whales may have drowned in the bigger and more frequent storms in 2019, but it was also noted that whales are adapted to storms and that for drowning to occur, whales would have likely had to be impaired in some way. The idea that the movement of a carcass in the ocean may have mimicked movements of an Alive status whale (and causing inaccuracy on time of death) was discussed, with a carcass possibly rolling with waves and/or being moved by strong currents. However it was thought that this would have been detected in the tag data.

Cardiovascular/Muscular

Capture myopathy is a grouping of disease presentations that are well-described in terrestrial mammals, and have also been reported in marine mammals. It is caused by a combination of fear, the stress response (activation of the sympathetic nervous and adrenal systems), and muscular activity, that together overcome the physiological capacity of an animal to compensate. It has been found to occur due to capture but also due to other stressors such as live strandings. The alternative terminology of ‘exertional myopathy’ was suggested as being more representative of the possible causes of the syndrome. Pathophysiology includes hyperthermia (oxidative damage), muscle damage (creatine kinase [Ck], aspartate aminotransferase [AST], potassium, cardiac troponins), changes in metabolism (decreased pH, increased lactates), and hormone release (cortisol, catecholamines). In excess these can cause cell damage/death, leading to skeletal muscle, cardiac, and kidney injury, and death.

Hyperthermia was not measured objectively, however it was subjectively observed during animal handling that the dorsal ridge of a few captured animals in 2019 were hot to the touch. Also, blubber biopsies were noticed to be bloodier (possibly due to vasodilation) in 2019 compared to 2018. No indication of muscle damage was observed (no increase in CK, AST, or potassium), however it is possible that this was sampled too early in the tagging procedure for an increase, due to capture effects, to be present. Cardiac muscle damage was investigated through troponins and no differences were detected between whales tagged 2018 or 2019, or between the survival classes of whales tagged in 2019. Post-release behaviour (from telemetry data) showed no obvious differences in behaviour between survival classes, which indicated no obvious signs of impairment. Post-mortem evaluations of carcasses found mild and multifocal acute muscle degeneration that was not considered to be clinically significant (however there was limited data for this analysis from only 2 carcasses that were very decomposed).

No signs of kidney damage were seen (no azotemia), however the sampling interval may once again have been too early to detect this. And no differences were observed for antioxidants (vitamin E, trace metals, essential elements, selenoneine) between years (2018, 2019) and survival classes (2019). Changes in metabolism were observed through blood gas analyses including low pH, high lactates, low bicarbonate concentrations, and high anion gaps, which indicated that aerobic metabolic capacity was exceeded. The changes observed would have been significant in terrestrial animals; however, diving marine mammals may be better able to cope with anaerobic activity. There was no relationship between the magnitude of change and survival status. Limitations to these data included that in many cases, the values measured exceeded the thresholds of instruments, and there were limited measurements from 2018 available for comparison.

Despite the lack of association between blood gas parameters and survival status, the magnitude of overall changes observed may indicate exertional myopathy as the COD by extrapolation, with knowledge of this condition in terrestrial mammals. This COD would fit with the short time period of death following capture and the multiple deaths observed. Information from a capture myopathy workshop that was held in February 2021 ((under the National Marine Fisheries Service of NOAA) may help to further define the vocabulary employed in the current

assessment. Why exertional myopathy may have occurred in 2019 but not 2018 requires an investigation into underlying causes and contributing factors.

Discussion

Exertional myopathy has been observed in marine mammal strandings, as well as from pursuit/hunting. There was a question about whether adrenal glands or cardiac muscle were sampled from the 3 carcasses. The adrenals were not sampled due to multiple challenges (decomposition/scavenging, bear activity, limited helicopter time, and a veterinarian not being present during the post-mortem investigations to identify them). Cardiac muscle could be examined in a single tagged whale, and methods from Câmara et al. (2019) for examining cardiac troponin as well as several immunohistochemistry (IHC) biomarkers from sampled carcasses were suggested as additional items to explore. The Working Paper authors had been aware of these methods but there had been issues in being able to perform the analysis as well as marked limitations to the interpretation due to the level of decomposition in the sample from the single individual available for analyses. There were also criticisms of these methods including that these were possible overinterpretations of changes that may occur post-mortem.

It was asked if the evidence for exertional myopathy was mostly due to the change observed in lactic acid. It was explained that the current discussion focused on blood gas analysis. The timeline of lactic acid response was discussed, with an increase from activity being observed after 10 minutes. It was assumed that most of the exertion by tagged whales was experienced during the herding and capture, and that during the instrumentation process they may be recovering. This was a short window overall to be sampling. It was also noted that herding was timed and if it went too long it was called off, and that total time from finding the whale to bringing it to shore was important to consider.

Body temperature was raised as an important factor to consider. Hyperthermia causes an increased need for oxygen which can lead to cell necrosis. Following anesthesia animals can die from cardiac necrosis associated with hyperthermia and the need for oxygen. In recent publications, hyperthermia is considered as a metabolic consequence of exertional myopathy (Breed 2019). The effects of whales being post-rut were discussed. It was mentioned previously that the whales that arrive the earliest to the estuary are often in poorer body condition – could these be post-rut males? Male belugas expend a lot of energy mating with multiple females. A sex bias post-rut occurs for deer species. However, it was noted that in 2018 all whales were male as well. Also most whales in 2019 were considered to be in good condition.

There was a question on the molt status of whales, as this could be an indicator of physiological timing. It was noted that all tagged whales were primarily white. There had been one very large white male with significant yellow patches around the head area that had avoided capture at one point. There was also a question on comparing skin microbiomes between years. This had not been examined and the availability of remaining samples would be looked into for this purpose.

There was agreement that exertional myopathy was the most likely COD.

PRESENTATION: INTERVIEWS WITH INUVIALUIT MEMBERS OF THE 2018/19 BELUGA TAGGING FIELD CREW

Presenter: Issiac Elanik

The presenter shared details of a report that summarized interviews with ten Inuvialuit members of the beluga tagging crew held in 2021 (Worden and Elanik 2024). The purpose of the interviews was to identify and document any differences observed between the two years of the tagging program and to identify factors potentially contributing to the mortality incident based on

beluga harvester knowledge. A structured interview guide was developed and included background questions to establish the expertise of the interviewee (harvester vs non-harvester, other experience with belugas, specific years and role in the tagging program). Subsequent interview questions were grouped by various stages of the tagging procedure (herding and capture, towing and handling, tagging and release) and environmental conditions in the two years of the program. A final set of questions was used to summarize overall impressions on potential cause of the mortalities that could be investigated further. Responses were summarized and reviewed in a validation workshop for participant clarification and group consensus on final conclusions

Overall, interviewees did not identify any major differences between 2018 and 2019 in tagging methods, whale body condition, or in whale behaviour. However, a range of observations of whale behaviour during tagging were reported, including whales acting calm, whales seemingly in distress, and one whale that attempted to bite. Participants suggested exploring several factors in the mortality assessment, including water and ice conditions in the Bering Sea during winter/spring and in the Canadian Beaufort Sea during summer, and body condition based on observations of thin blubber in whales landed in 2019. Several participants noted the importance of data obtained from the program and were supportive of more tagging in the future. While not initially an objective of the interview project, a set of recommendations for future beluga tagging programs emerged from the results validation workshop. These included that DFO provide high-level information on the cause of tagging mortalities, for any future tagging programs to have the same field crew (or to have experienced crew members provide a briefing to new participants), to prioritize the harpoon tagging method over the live capture method for any future work, to conduct consultation via a community tour, to involve youth and to have more gender equality, and to provide regular updates (especially during whaling season) during any programs. It was also recommended to complete interviews with additional harvesters and beluga monitors who were active in 2019 (the year of the mortality event). The report documents Inuvialuit Knowledge that supports several categories of the assessment, such beluga behavior and body condition. The report will also serve as an important resource for consultation and planning for any potential future tagging programs.

Discussion

The Worden and Elanik report summarizing the interview results would be published soon after this meeting and could be included as a reference in the Working Paper. It was noted that the interview report represented an independent assessment by Inuvialuit members of the tagging crew and created a more complete review process. A participant shared that biting behaviour of a tagged whale had been observed in the 1990s near Churchill, MB, and unfortunately, this whale had died.

PHASE II: INFORMATION TO SUPPORT AN ASSESSMENT OF POTENTIAL CONTRIBUTING FACTORS IN THE MORTALITY OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) TAGGED IN JULY 2019: UNDERLYING CAUSES

Information had been restructured from the initial draft of the Working Paper circulated to meeting participants. Phase II now covered local and time-specific environmental conditions, tagging procedural considerations, whale response to tagging, and post-tagging evaluation.

Environmental Data

Presenter: Dr. Lisa Loseto

Air temperature (based on daily mean air temperatures from Environment and Climate Change Canada) was warmer in 2019 vs 2018 overall, but when looking specifically at temperature at the time of tagging there was no significant difference between years. Water temperature data taken from a mooring at East Whitefish (Kugmallit Bay) showed that water was several degrees warmer in 2019 vs 2018 overall as well as specifically on the days following tagging, especially on the second day after release. Wind speeds were 2–3 km faster in 2019, with winds coming mostly from the north during the tagging. Data from remote imagery showed no difference in sea surface temperature (but data were patchy due to cloud cover in 2019 — note these data were not included in the Working Paper).

Discussion

The higher sea surface temperatures observed regionally in the Pacific Arctic in 2019 (the 'blob') was discussed, as was sea ice. The author noted that these items would be discussed in Phase III of the assessment, when regional context would be examined.

Tagging Methods

Presenter: Dr. Lisa Loseto

Tagging methods were very similar between 2018 and 2019. The same capture and handling method was used in both years, and tagging crews were virtually identical. The 2019 program did have the addition of harpoon tagging on 20 free-swimming belugas, use of a drone to film the capture and tagging procedure, and deployment of a hydrophone to record vocal activity of tagged whales. Average herding time was approximately 20 min in each year. Instrumentation and handling time were slightly longer in 2018 compared to 2019 (average instrumentation of ~ 28 minutes in 2018 vs ~ 21 minutes in 2019; average handling of ~ 37 minutes in 2018 vs ~ 23 minutes in 2019). Overall tagging time in 2018 averaged ~ 87 minutes and ~ 66 minutes in 2019. These times are relatively short in comparison to other beluga tagging programs. For example, the 2016 Bristol Bay program had an average overall tagging time of 119 minutes.

Discussion

The methods used in 2018 and 2019 were recognized as common methods used in multiple beluga tagging programs across the circumpolar north, and that these herding and handling times were very short in duration (possibly the shortest on record). Participants discussed that most of the Dead whales had 2 tags, and that this secondary tag may have been an additional stressor in a cumulatively stressful event. However, it was again noted that the secondary tag was how mortality was detected and confirmed in most cases (causing bias toward Dead whales having a secondary tag), and that it did not add to the overall handling time.

Some additional differences were noted in methods between years. In 2018, zodiac boats followed the herding boats whereas in 2019 they waited near shore. The zodiacs were not always needed as the team became more proficient and so to save gas (and to save people from a bumpy ride) they were not as actively used in 2019. In 2019, there was an additional drone boat, and it was suggested that this addition could be considered as a stressor, as well as the overall compounding effects of adding multiple new stressors.

A whale that was being tagged when a depth sounder was being used in the area demonstrated an escape response (to flee). The whale appeared to calm down once the boater was asked to turn off the sonar. The effects of depth sounders on cetaceans was also noted from Japanese whaling ships using them to pursue minke whales.

Participants discussed results from the Inuvialuit field crew interview report stating that some whales were stressed and in pain. It was also communicated from interviews that younger

whales were often more responsive and older whales more docile. It was noted that overall, tagging involves interacting with wild animals and humans are never totally in control. Whales will react. The tagging team became more proficient as they gained experience and improved their methods (e.g., stopped walking ahead of the melon as that led to a 'head thrashing' response).

Herding Impacts, Size of Whales, Drone Data analysis, and Breathing Rates

Presenter: Dr. Émilie Couture and Luke Storrie

Herding methods were analyzed to see if any differences could be found between years (2018 and 2019) or survival status classes (2019). Herding was separated into phases (herding pod, herding single whale, and chase) and given scores based on interventions, boat speed, duration of herding, breathing rate, direction and timing of phases. 'Interventions' consisted of human action aimed at modifying whale behaviour, such as boat speed surges and banging on the boat. Some of these details were missing for 2018 so could not be fully compared, however overall no differences were found. Size of whales was looked at and all were large males of similar size classes across years and survival status classes.

A drone was used in 2019 to film the tagging process. This was done for training purposes rather than for use in data analyses, and methods were therefore not standardized (e.g., variable flying altitude). Also, not all tagging events were filmed. Flight metadata were not available for this analysis but options to obtain and analyze these data are being explored.

Breathing rates of whales being tagged were assessed for any erratic changes. They were found to be consistent at approximately 5 breaths/minute and comparable across years. This breathing rate is faster than what is observed in captive (aquarium) belugas.

Discussion

No discussion.

Behavioural Analyses

Presenter: Marion Desmarchelier

The behaviour of tagged whales during instrumentation was analyzed using GoPro and drone video footage taken in 2019 only. The videos were not collected with the purpose of being analyzed, and therefore there were limitations to the analyses. No statistics were possible due to the small number of individuals in the three survival status classes. It is also important to note that stress may manifest as different, possibly contrasting behaviours (e.g., freeze vs fight response) across individuals. Overall, whales appeared calm and either were still or displayed slow movements during instrumentation. Back arching/flexing was observed more in the Dead and Unknown survival classes than for whales classified as Alive. Head moving was also observed more in the Dead and Unknown classes. Tail flapping was observed more in the Alive group, and biting was observed for one whale of Unknown survival status.

Discussion

It was noted that the tagging team changed the time of day they worked at some point during 2019, and that this may affect whale behaviour. Recommendations for future analyses were to consider time of day as a factor in the behavioural analyses as well as to include vocalization as a behaviour. A participant asked about the behaviour of non-tagged whales from the same pod as captured individuals, and it was explained that no additional whales were nearby during tagging. Sometimes single whales were herded and sometimes a herd was followed. Notes were taken about group size but not group behaviour. It was noted that the tagging crew tried to

minimize movement near a captured whale's melon, and this may have influenced behavioural response. There was a recommendation to have a specific crew member collect video for future tagging programs to be able to more systematically record behavioural information, which would fit with the CCAC's new guidelines for animal welfare assessments including behaviour assessments. The effort by the authors to record and assess behaviour and to reduce handling times was recognized as important.

Vocalization

Presenter: Dr. Lisa Loseto

One addition to the 2019 program was to place hydrophones near the whales during instrumentation to record vocalizations. Contact calls were expected to be heard as they are thought to be made more often during stressful events (e.g., entrapments, separation from group, aggressive interactions). It was found that whales tagged within a few days of each other seemed to vocalize in similar ways (i.e., whales tagged in the first four days made a lot of contact calls, while whales tagged during the next seven days made very few contact calls), possibly indicating similar vocal characteristics among different groups of whales. Temperature also appeared to be a factor in vocalizations, however temperature increased over the tagging period so this may be a spurious relationship. Alive status whales were recorded as making more contact calls than whales in the other two survival classes, however the small sample sizes must be kept in mind (no statistics were possible).

Discussion

One participant from the Inuvialuit field crew interviews could feel the pulse of a whale's echolocation in the water. It was also noted that this would have been felt near the head (an area the tagging crew actively avoided). It was commented that with animals, if a group knows that one of its members is not in good health, they will not communicate much with it, as the herd knows that this individual is unable to keep up. Another participant shared that when pursuing a herd of belugas, one individual will act as a decoy to give themselves up. They will take off right away, and this was the one the tagging crew would select. This is observed in wolf packs as well. The decoy may even stop and wait for you. An experienced hunter will leave the decoy alone though, as they want to harvest a healthy individual.

Information on the different waves of whales that come into the area was shared. The first whales are big old bulls, then the cows with their calves come, and then the young bulls. This was seen in 2019 when the ice broke earlier than usual and there were females and calves present during tagging. In contrast, in 2018 there was still ice present during tagging operations and the females and calves arrived to the estuary on the day that the program shut down. It was also shared that calves travel to the inner side of Kugmallit Bay.

Stress Markers (Cortisol, DHEA/DHEAS, Lactic Acid)

Presenter: Dr. Lisa Loseto

Blood samples were taken pre- and post-instrumentation and were analyzed for a suite of stress biomarkers. Overall levels of cortisol were similar between 2018 and 2019; however, in 2019, levels were lower at the beginning and then rose after instrumentation. Levels of cortisol measured from tagged belugas were similar to those measured in other studies of beluga experiencing various types of stressors (i.e., hunting, capture, and transport). DHEA and DEAHS (dehydroepiandrosterone and dehydroepiandrosterone sulfate) levels were analyzed as a ratio with cortisol to reflect chronic stress. The 2019 ratio was higher than in 2018 (comparably more cortisol and less DHEA/DHEAS), indicating lower stress management capacity.

Unfortunately, no comparable data are available for these measurements in beluga. There were challenges measuring lactic acid levels in the field (levels measured exceeded instrument threshold) and metabolomic methods were used instead. In 2018, tagged whales had no significant difference in lactic acid levels pre- and post- tagging procedure. In 2019, higher levels of lactic acid were observed post-tagging procedure. Levels of lactic acid following the tagging procedure were lower than levels observed in harvested whales from the EBS beluga population, but higher than in captive (aquarium) whales from other studies. Pre-tagging procedure samples were collected earlier in the procedure in 2019 than in 2018, which may have affected the levels measured.

Discussion

DHEA/DHEAS were discussed in more detail. They are a new biomarker of chronic stress with animals having higher values at younger ages, and chronic stress causing a decrease at a faster rate. A ratio of cortisol to DHEA and DHEAS provides a better marker of chronic stress than from cortisol alone (Guilliams and Edwards 2010). Animals with a higher ratio can be more susceptible to acute stress and be less resilient overall. This has been observed in deer whereby after the breeding season they are more vulnerable to capture myopathy.

Cortisol levels measured from other studies were discussed. It was noted that while aquarium whales were used as an example of low stress levels, these whales may have totally different responses than wild animals. Baselines reported in the literature are usually approximately 10–15 ng/dL, and can go up to approximately 80 ng/dL, with these very high levels usually measured from stranded whales. When measured over a time-course, cortisol is usually observed to increase over a period of an hour and then drop back down to lower levels. Relating this information to the current dataset, it was recognized that the lower pre-tagging cortisol levels observed in 2019 may be from the samples being collected earlier in the tagging process than in 2018. Cortisol can be measured in breath, saliva, blood, and feces.

Participants discussed the possible impact of working with beached whales. One participant described experiences working with dolphins in the water and on floating mats (to support the animal but not have them on hard ground). Animals are taken out of the water to weigh them if they are doing well, but returned to the water if they appear to be unstable or hyperactive. Some animals are never taken out of the water. However, being out of water may not be as stressful for beluga compared to a dolphin, as belugas become stranded more frequently. Cook Inlet beluga whales have been observed to purposefully beach themselves as predator avoidance from killer whales. Belugas at Cunningham Inlet, Nunavut, are often in shallow water and can miss the tides and become temporarily stranded. A beluga at Point Lay, Alaska was stranded for several hours and then swam away. Another participant noted that belugas from different populations may have various tolerance to being stranded, for example based on their habitat.

A participant asked about the linkage between stress levels and behaviour in beluga whales. Other methods to measure stress were brought up such as measuring aldosterone, catecholamines, and leucocyte coping capacity (Huber et al. 2019). The potential value of these methods was recognized and that they could be looked into further depending on the amounts left in samples at this time. It was recognized that observing a stress response to tagging is positive and a sign of health. In almost all cases measured, animals will demonstrate a response to tagging. Only one situation was noted where animals did not exhibit a behavioural response to stress (a case of bottlenose dolphins tagged after the Deepwater Horizon oil spill). The individual nature of the stress response was also recognized. Just like with people, some whales are likely better at dealing with stress than others.

Tag Temperature

Presenter: Luke Storrie

Temperature data from tags were examined to identify temperatures that whales experienced in the first three days post-release (Day 1, 2, 3). On Day 1, whales experienced high water temperatures in both 2018 and 2019, and during Days 2 and 3 whales in 2019 experienced higher water temperatures than whales tagged in 2018. No clear differences were seen for 2019 whales based on survival status (Alive, Dead, Unknown). Overall it appeared that the temperature experienced by tagged whales was a function of location; water temperatures were warmer in Kugmallit Bay compared to the open ocean. Analyses were limited by incomplete data obtained from the tags (which was expected based on tag programming and capability in a low salinity estuary).

Discussion

The analysis of water temperatures experienced by tagged belugas in the days following release was done in consideration of hyperthermia and the thinking that it likely takes longer for whales to cool down in warmer waters. This information can be considered as supplemental when considering the possibility of exertional myopathy, as endogenously produced heat is the most significant factor in the syndrome, and environmental factors are secondary factors to consider. It was also recognized that, as an Arctic-adapted species, belugas have evolved to retain heat and thus may be more susceptible to hyperthermia than other marine mammals.

Participants discussed how to interpret the data. Specifically, they wondered whether whales that chose to seek cooler water had a better chance of survival, or if whales became weakened from the capture and tagging and were unable to move to select cooler water habitats. No clear pattern was observed for the three survival classes in 2019. Whales appeared to travel based on something other than temperature, and may have been following their herd. It was noted that a few degrees Celsius can be biologically significant for a beluga, and the temperature differences observed between years exceeded a few degrees. A participant asked about the temperatures experienced by harpooned-tagged whales. The authors had not addressed this in the Working Paper, but this could be explored further.

A participant asked for the water depths associated with the temperature data. It was explained that for this analysis it was the depth at which the whale was located, but that the same results were obtained by using sea surface data (0–5 m). A question was asked on the difference in temperature between air and water temperature, and if the whales may have experienced a shock when they were out of water during the tagging procedure. The difference between air and water temperature had not been examined but could be done in the revised Working Paper. The dorsal ridge was exposed (in air) during the tagging procedure. This is an important area for thermoregulation, and cooling down is less efficient in air than in water. However, the procedure time was fairly short and this likely did not play an important role. Limitations with using data from the weather station were noted, as conditions can be variable in Kugmallit Bay.

Participants discussed the potential for a lack of sea ice to cause stress. Whales may use ice as a place to shelter and rest from storms. Ice was present in 2018 but not in 2019. In general, the reduction in sea ice may be why whales are being found inland after storms – they may be getting pushed upriver when looking for shelter. The potential for effects from the moon was also raised. The moon effects how animals behave and harvesters know to pay attention to lunar conditions, and storms often occur one week before the full moon.

Summary of Phase II (Underlying causes)

Presenter: Dr. Lisa Loseto

The author provided a summary of the information that had been discussed, including:

- Overall, 2019 was a warmer year than 2018 with respect to both water and air temperature. Warmer water temperatures were experienced by belugas tagged in 2019 in the first few days post-release.
- Tagging procedures were comparable in 2018 and 2019. However, fewer behavioural data were collected in 2018, which challenged the ability to compare behavioural responses to tagging between years.
- Similar individuals were tagged in both 2018 and 2019 with respect to size, age, sex, and body condition.
- Blood analyses revealed differences in the stress biomarkers cortisol and DHEA/DHEAS ratio.

Discussion

The timing of mortalities in comparison to when whales had been tagged was discussed. Many of the whales in 2019 had been tagged in quick succession, followed by a break in time before more whales were tagged, forming 'waves' of tagged whales. Only 1 or 2 individuals in the first wave of whales tagged were confirmed dead, 5 were confirmed dead in the middle wave, and there were only a few confirmed mortalities in the last wave. It was noted that this pattern may at least partially be due to when the secondary tags (with mortality function) were deployed. The revised Working Paper should include a table of the 'waves' of whales tagged (i.e., clusters of whales tagged within a short period of time) and their survival status. Other information to contextualize the seasonal differences between 2018 and 2019 included that harvesting was occurring in the same time frame as tagging in 2019 (less so in 2018), and that females with calves were present in the estuary during tagging operations in 2019 (but only appeared on the day of camp shut-down in 2018). A suggestion to calculate the number of dives per hour was made to attempt to deal with the patchiness of data. This could potentially be done for the small dataset available for deeper water, however most of the data was for shallow water where dives were difficult to identify.

A participant suggested exploring the effects of tides on water level. The author explained that daily tides had been examined and no effect was observed. However, the effect of the moon on tides on a larger scale could be examined. A participant noted that water levels are rising with ice melting in the polar regions, and in summer water levels in the Mackenzie Estuary often remain above normal. An observation was shared that the whales appeared to be actively selecting cooler water. It was explained that cooler waters were available to all whales but only some individuals selected cooler water habitats, with some individuals from all survival classes remained in warmer water areas. A participant asked if a change in water temperature could lead to thermal shock. One of the authors explained that there was no evidence to suggest that thermal shock had occurred.

Participants discussed at what point the potential chronic stress identified from blood analysis in 2019 could have larger effects on the EBS beluga population overall. The underlying factors identified here may make them more susceptible to other stressors, but they may be resilient to the stress and it is possible that no other effects may be seen. The negative effects observed in the tagging program may be something that may be measurable at the population level in future. Harvesters have observed thinner whales, which is another potential indication of an underlying issue related to environmental change and population health status.

Genetic testing was raised as a tool to investigate if one particular group of closely related whales had been tagged. This group would likely follow the same migration path and may have

been exposed to a common stressor at another location. The authors have longer-term plans to conduct genetic and epigenetic analyses to examine the cumulative effects of stressors. It was also noted that due to the late break-up of sea ice over the Mackenzie Estuary in 2018, the early arriving whales (that have generally been observed to be in lower body condition compared to later arriving whales) may have not been tagged in that year.

PHASE III: INFORMATION TO SUPPORT AN ASSESSMENT OF POTENTIAL CONTRIBUTING FACTORS IN THE MORTALITY OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) TAGGED IN JULY 2019: HEALTH, REGIONAL PHASE III: ENVIRONMENTAL AND ECOSYSTEM PROCESSES, BERING SEA WINTER HABITAT

Condition Measures

Presenter: Dr. Lisa Loseto

Condition measures were examined for both harvested and tagged EBS beluga whales. Blubber thickness (corrected for size and age) was analyzed and it was found that whales tagged in 2018 had a higher blubber thickness index than whales tagged in 2019 (2018 average of 9.5", 2019 average of 7.5"). However, this was not a large difference when compared to the variability observed over a longer time series. Fatty acids were analyzed to investigate diet, and it was found that there was an overall decline in the relative proportion of Arctic Cod (an important prey species) in the diet of EBS belugas over recent years. However, there were no significant differences in the relative proportion of Arctic Cod in 2018 and 2019. Relative proportions of the fatty acids DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid) were analyzed to investigate antioxidant levels, and a higher ratio of DHA/EPA was found in 2018 whales, suggesting they had a better ability to deal with inflammation. Lipid content in blubber was analyzed and it was found that lipid levels tended to decline over time, with lower levels observed in 2019. Harvesters were encouraged to share observations on blubber thickness and body condition, as well as observations on the rendering of uqsuq (oil from blubber).

Discussion

The importance of standardized methods for sampling blubber was discussed, as blubber varies in thickness and texture depending on location on the whale. Blubber from some areas of a whale render more oil than blubber from other places. It was noted that harvesters are selective when they go after whales, and that the population would be expected to have more variability in body condition than what is captured by in the harvest monitoring data. It was also noted that while some harvesters are selective, others may be more opportunistic in their hunting. A harvester shared a story about a dry cow with thick blubber that was hunted on the same day as a bull with much thinner blubber. They noted that in caribou, harvesters often go after dry cows because they know they are in good condition. It was also shared that the colour of beluga blubber changes after a female has a calf. Observations of changes in blubber colour could indicate changes in lipid composition. Community members have observed skinny whales near Paulatuk in recent years, and these are thought to be mostly large, older bulls. DFO had also observed and sampled these skinny whales in 2022. Seasonal changes in blubber thickness of bowhead whales was also noted, with bowheads hunted in the spring typically having thinner blubber than individuals hunted in the fall.

Participants discussed possible impacts of environmental conditions, in the Bering Sea's wintering habitat for EBS belugas, on the survival status of tagged whales. The Pacific Arctic is warming and changes are being observed in various species. Belugas depend on this area to

feed and build energy reserves in advance of the spring migration to their calving grounds. One participant also expressed concerns about exposure to pollutants in Russian waters.

Legacy Contaminants and Gene Analyses

Presenter: Dr. Lisa Loseto

Levels of legacy contaminants (polychlorinated biphenyls [PCBs] and mercury) were examined in both tagged and harvested EBS beluga whales, with no major differences observed. Lower levels of PCBs were measured in whales tagged in 2018. However this was believed to be because blubber biopsies were of shorter depth in 2018 and therefore contained less blubber than biopsies collected in 2019. Targeted genes that respond to stressors were evaluated and only subtle differences were observed between years. RNA gene sequence analyses were also conducted with subtle differences detected between years. However, this was recognized as a complex dataset and further analyses were needed to fully interpret the data with confidence.

Discussion

There was a suggestion to revisit the contaminant data once epigenetic age analyses are completed, as these levels are known to increase with age in males. There was further discussion about the previous comment that oil rendered from some whale blubber spoils faster than from others. This process of spoilage is due to oxidation, which is the same process as what is going on with exertional myopathy. A change in fatty acids occurs because the whales are eating something different, which then changes their omega 3:6 ratio, which is what protects them against oxidation (which is stress). If oil from a whale is spoiling faster than usual, this is an indication that that whale would have been less resilient to stress. These observations are important to monitor over time. The importance of diet to overall health was also discussed, with the analogy that Inuvialuit elders used to get everything they needed from their diet whereas nowadays many people take pills to supplement their nutrient intake.

Environmental and Ecosystem Processes

Presenter: Dr. Lisa Loseto and Dr. Ryan Galley

Environmental conditions and ecosystem processes for the Beaufort and Bering Seas were assessed to account for both the summer and winter ranges of the EBS beluga population. In 2019, the Beaufort Sea had anomalous conditions including a very early spring break-up of sea ice (3 weeks earlier than in 2018), and less sea ice cover in general. This led to increased levels of solar radiation reaching the ocean and greater accumulation of energy. In 2019, the Bering Sea had high sea surface temperatures. Over time this area has had less ice, as well as a decline of the cold water pool. This pool is located at the bottom of the Bering Sea and is important for cold water fish species such as Arctic Cod, a species that is in decline in the area.

Discussion

Observations on changes in sea ice were shared, including that in 2022 ice left the Mackenzie River through the East and West Channels, and that it would be good to look at data related to this observation. Last year (2022), lake ice around Sachs Harbour was thicker than usual, though participants were unsure of the relationship between lake and sea ice. Several participants suggested that changes in sea ice may affect whale migration, with whales possibly remaining in the Beaufort Sea year round in future. Conditions in the Bering Sea wintering ground were also discussed, with a focus on whether EBS belugas begin their annual spring migration with sufficient energy reserves.

It was noted that the decline in Arctic Cod biomass appeared to be larger than the decline in the relative proportion of Arctic Cod in beluga diet, suggesting that whales may be working harder and expending more energy to obtain less of their preferred prey, resulting in poorer body condition. There was some discussion as to whether the deep dives that whales were observed to be making were to feed or to search for prey unsuccessfully. It was asked if diving data could identify what whales were feeding on, it was explained that it could be inferred from both diving data and dietary markers (i.e., fatty acids). Linkages to data from the Canadian Beaufort Sea Marine Ecosystem Assessment (*F/V* Frosti program) could also help answer these questions. This program collects data on the distribution and abundance of invertebrates, fishes, and other ecosystem components, including bathymetry. Work is currently underway to overlay data on prey distribution to whale dive data. A participant also asked if Arctic Cod could be a potential source of contaminants. This had not been explored but prey samples do exist from the Canadian Beaufort Sea. Arctic Cod were considered here more as a preferred prey item containing a high amount of antioxidants.

A die-off of zooplankton (*Thermisto* spp.) in the region in 2016 was discussed, and potentially how long a die-off at the bottom of the food chain like this would take to affect higher levels (like whales). North Atlantic Right whales were identified as an example of a marine mammal that appeared to be shifting distribution and suffering health impacts due to a lack of their preferred prey (amphipods). Changes in quality and distribution of food can have effects on whale ecology, distribution, and health. The changes observed in EBS beluga distribution in 2014 were discussed; many more belugas than usual were harvested in Ulukhaktok this year and these whales had stomachs full of Sand Lance. It was thought that this occurred because the abundance of Arctic Cod was low that year, so the whales had to travel to different areas to consume alternative prey types. It was noted that 2014 was a warm year, especially in the North Pacific Ocean. Harvesters shared observations of changes in fish distribution, including more whitefish, coney (Inconnu), crooked backs, loche, and jackfish (northern pike) at Shingle Point. An area of upwelling near Richards Island was identified as a place with lots of fish. A participant also stated that animals will change their distribution to follow their food – otherwise they starve.

The importance of describing environmental change at different scales (local, regional, transboundary) was recognized. A participant suggested developing an annual ‘report card’ as a tool to describe and track observations in the Beaufort Sea. Looking into linkages and the bigger picture is important, and it was recognized that a lot of data required to do this analysis was obtained from beluga whale tagging programs. Some of the data was sobering and may indicate a larger scale issue. A participant noted that the tagging data was important because they would provide evidence of beluga behaviour and habitat use to measure impacts if there was ever a need to file for compensation from an environmental disaster (e.g., Exon-Valdez oil spill).

2019 Marine Mammal Mortalities

Presenter: Dr. Lisa Loseto

Several Unusual Mortality Events (UMEs) were declared for marine mammal species across the Alaska and Pacific coast in 2019, including for grey whales and ice seals. A nutritional deficiency was the suspected cause based on the poor condition of the carcasses. The 2019 Aerial Survey of Arctic Marine Mammals (ASAMM) observed the highest number of bowhead carcasses on record at 11. Within the Mackenzie Delta and Yukon North Slope, a higher than usual number of marine mammal carcasses were observed in 2019 compared to what had been reported in past years (recognizing that no standard survey program exists). This included 3 beluga neonates, 1 non-tagged adult beluga, 3 bowhead whales, and 1 bearded seal.

Discussion

More information on UMEs was shared, including that a grey whale UME had also occurred in 1999-2000. In the case of the 2019 grey whale UME, calf production declined before the UME was declared, and the population declined by 26%. The underlying cause appeared to be nutritional deficiency, but there may have been effects of killer whales as well. Ice seals were most affected in the Bering Strait likely due to environmental shifts (loss of the cold pool, sea surface temperature, shifts in fish distribution), which challenges seal pups to acquire proper nutrition. The ice seals now appear to be in recovery. A participant shared that various whale species were known to frequent the Beaufort Sea (grey whales, bowheads, killer whales), and that bowheads can be identified by their v-shaped blow.

GLOBAL SUMMARY: INFORMATION TO SUPPORT AN ASSESSMENT OF POTENTIAL CONTRIBUTION FACTORS IN THE MORTALITY OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) TAGGED IN JULY 2019

Presenter: Dr. Lisa Loseto and Dr. Émilie Couture

Information from Phase II (underlying causes) included that in 2019 compared to 2018: air temperature was warmer on tagging days, water temperature experienced by whales after tagging was also warmer, and capture protocols were similar with the exception of being shorter in duration and with the addition of the secondary tag and drone. The acute response to stress did not differ between years; however, the DHEA data did support that whales in 2019 were more chronically stressed. No conclusions could be drawn from the behavioural evaluation due to low sample size.

Information from Phase III (health status, environmental conditions and ecosystem processes) included changes to EBS beluga's wintering habitat (reduced ice cover, loss of the cold water pool, lower availability of Arctic Cod), as well as environmental change in spring migration and summer habitat (early ice break-up, warmer water temperatures, greater frequency and intensity of storms). Changes in the nutritional status of EBS belugas were likely driven by a lower relative proportion of Arctic Cod in their diet and included reduced lipid content and thinner blubber thickness for EBS belugas in 2019, which together suggested reduced favored prey availability (of Arctic Cod) along with increased energy expenditure to search for this preferred prey item.

Overall, based on the data available, it appeared that the most likely cause of the major mortality incident of EBS belugas tagged in 2019 was exertional myopathy (information from Phase I – direct cause of death). In addition, the similarity in tagging methods used in both years and the known tolerance of belugas to live capture methods suggests that underlying factors played a role in the mortalities. Factors such as reduced sea ice cover, warmer temperatures, and more frequent and intense storms in 2019 likely contributed to more stressful environmental conditions, and ecosystem changes may have reduced the whale's nutritional condition. Together this may have reduced the physiological ability of whales to cope with the stress of capture, handling, and tagging. Finally, the warmer temperatures experienced post-release may have affected the ability of tagged whales to maintain homeostasis in body temperature.

DISCUSSION

It was recommended that vocalizations be grouped as a behaviour and included in the summary. A participant noted that at a capture myopathy workshop that they participated in February 2021 (under the National Marine Fisheries Service of NOAA), vocalizations were

targeted as an indicator for behavioural assessment, and in general vocalization was recognized as likely very important for belugas as a highly organized and social species. Key references were shared on beluga vocalization (Castellote and Fossi, 2006, Garland et al. 2015). A question was asked about comparing the tagging vocalization data to other data from whales in the wild under normal conditions, and it was explained that data existed from hydrophones in the Mackenzie Estuary, however this data could not be identified to individual whales. Contact calls were known to be heard during stressful events such as entrapments and separation events, but can also be heard when whales are moving together and trying to maintain contact under normal conditions. In past studies with restrained wild belugas, only a few made contact calls, and it was concluded that this response was likely at the individual level.

It was suggested that the condition of large males be compared to other groups of whales based on the observations that this group is often in worse condition and exhausted after the breeding season. The authors explained that limited data are available for comparison due to the bias towards selecting large males for harvesting and tagging. The significance of the increase in salmon in the region was discussed as a signal of environmental change. It was also noted that the salmon may have 'invited more people to dinner' and caused killer whales to move into the area in larger numbers as well. Bowhead carcasses observed in Alaska in 2018 and 2019 were ultimately determined to be a result of killer whale predation. The importance of wind direction in driving environmental conditions was discussed. A participant noted that south winds may cause carcasses to float out to open ocean and not be found. Wind had been looked at and no effect on mortality had been observed. It was recommended to include this information in the summary. A participant also noted that the number of marine mammals strandings in the Canadian Beaufort Sea in 2019 could be considered normal.

Other suggested changes/additions to the summary included:

- Add whale diet information for the Mackenzie Estuary area from harvester knowledge.
- Clarify the cortisol data description to ensure the summary statement clearly identifies that data are difficult to interpret due to the timing of sample collection.
- Add compound specific stable isotope data and look at how nitrogen cycling may match up with blubber cycling. This would potentially add more information about nutrition.
- Clarify that while no behavioural effects were observed in the GoPro footage, there may be more information from the drone footage once analyzed further.
- Clarify that in 2019, whales would likely have been exposed to warmer water temperatures before being pursued for capture and tagging, as well as in the three days post-release that were examined using telemetered data.
- For context, add comparisons to how the tagging protocol used in this study compares to other beluga tagging studies.

WORKING PAPERS

The Chair explained that the CSAS process includes reviewing, discussing, and revising Working Papers, and then, if agreed upon by meeting participants, to publish the Working Papers as DFO Research Documents. There was consensus to include Working Paper #1 (movement and dive behaviour of tagged belugas) as a chapter within Working Paper #2. This would ensure that all information was kept together and context was not lost. The Inuvialuit tagging crew interview paper could be published as an FJMC report and made available on the FJMC website, with a weblink on the CSAS website. There was consensus that having the

interview report available was important because the summary shared at the meeting did not cover all of the content of the findings.

Working Paper #2 would be restructured. The challenge of how to make the paper less dense and more readable was discussed, with possible solutions including moving technical details/methods to appendices or supplementary materials (but keeping figures and graphs in the document for flow), or publishing supporting technical reports and referencing these reports in the Working Paper. There was also a suggestion to include a summary of key points/take-home messages at the end of every section in a consistent format to help with readability.

Participants discussed ways to recognize Inuvialuit contributions to the mortality assessment and to the EBS beluga tagging program overall, as the strength of this partnership was not well reflected in the two Working Papers. Lack of appropriate acknowledgement of the important contributions from Indigenous peoples to western science was recognized as a long standing issue, and participants felt that the current authorship team was well-positioned to address the issue better than it had been dealt with in past science advisory processes. One suggestion was to include Inuvialuit co-authors on the final Research Document. Inuvialuit contributions to the program should also be described in the Research Document and Science Advisory Report. This would include information on co-production of the tagging program, reliance on data from the long-term harvest-based monitoring program, and the important contributions of Inuvialuit Knowledge of EBS belugas in the Inuvialuit Settlement Region.

SCIENCE ADVISORY REPORT

Discussion of the Science Advisory Report (SAR) document focused on the summary bullets. It was recommended to include a contextual bullet that described the co-development of the tagging program with extensive consultation and collaboration, the value of tagging data for marine mammals, the recognition of risk involved in tagging, and that this specific tagging program built on past programs in the region. This bullet should also include the importance of the site as a place of harvest where Inuvialuit have hunted for centuries.

It was important to identify the specific place where the tagging occurred (since different whales go to different places), and a map could be added. It was also recommended to include that the protocols used were similar to past methods used over decades, and to describe the process of how mortality was discovered through tag transmission failure. This was an important finding to highlight for other tagging programs that may also experience premature tag failure.

It was recommended to highlight that there were limited direct data available from the few decomposed carcasses that were sampled, and therefore the assessment relied on contextual data and information. From the overall assessment it was found that ecosystem and dietary changes likely impacted whale condition and antioxidative capacity, which then reduced their ability to recover from the physiological response to capture. It was noted that exertional myopathy was more of an exclusionary diagnosis, and that the language in the SAR needed to reflect this lack of certainty. It was recommended to categorize underlying factors as those that occurred pre- vs post- tagging, to include both emotional and physiological responses to tagging, and to highlight the importance of considering temperature when handling animals. Veterinarian participants shared that they do not conduct procedures over a certain temperature threshold. For example, some procedures are only performed in the cooler early morning hours.

Participants recommended including a summary bullet to discuss the potential implications of the mortalities and what they may tell us about the population as a whole. The EBS population is large and appears to be in good condition, but are these mortalities an early warning sign that the whales are stressed? In contrast, there was other evidence that the population was in good

condition (e.g., harvesters are not observing skinny whales overall and other condition indices appeared to be within a normal range), as well as concerns over how the media may portray such a statement. The wording needed to be careful and reflect uncertainty.

There was a discussion on whether 2019 may have been an anomalous year causing whales to be in low condition, or if this was a pattern that may continue with time. Questions were asked about the status of other beluga populations, and it was discussed that there is no clear comparison since other populations are adapted to different environmental conditions. Existing literature reviews or general life history information could be gathered to support a review of belugas capacity to adapt to environmental change. It is known that belugas can live in much warmer water temperatures than those experienced in the current study, but that these temperatures may not be optimal for them. Whales living in these warmer temperatures may be studied for potential signs of stress.

The bias in the type of whales selected for both tagging and harvesting was recognized, with almost all being large, white, apparently healthy males. There have also been changes in hunting practices over time, with more ‘weekend’ hunters now that have less time and opportunity to select for a certain type of whale, and they may be more opportunistic with their harvest. The importance of the harvest monitoring program was recognized along with the knowledge it has generated, as well as the importance of studying the entire food chain and taking into account the timing and frequency of when sampling is conducted (one day there may be no fish in an area, but the next day there may be lots).

Sources of uncertainty in the assessment to include in the SAR were also discussed. These included the number of tagged whales that were of Unknown survival status, small sample sizes, different data collected in 2018 versus 2019 that limited comparisons, the individual nature of whale responses to tagging, limited carcass evaluations due to level of decomposition, uncertainty of whale ages, and the fact that some analyses were still ongoing. The incomplete understanding of beluga group substructure and their social cohesion was also recognized as an important source of uncertainty.

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APPENDIX 1. LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Dean (Manny) Arey (Co-Chair)	Aklavik Hunters and Trappers Committee, Inuvialuit Game Council
Joclyn Paulic (Co-Chair)	DFO – CSAS, Ontario and Prairie Region
Laura Murray (Rapporteur)	DFO – Science, Ontario and Prairie Region
Carrie Goertz (virtual)	Alaska SeaLife Centre
Cory Matthews (virtual)	DFO – Science, Ontario and Prairie Region
Patrick Akhiatak (virtual)	Olokhatomiut Hunters and Trappers Committee
David Yurkowski (virtual)	DFO – Science, Ontario and Prairie Region
Dennis Arey	Aklavik Hunters and Trappers Committee
Dwayne Benoit	Aklavik Hunters and Trappers Committee
Émilie Couture	University of Montreal, Canadian Wildlife Health Cooperative
Frances Gulland	University of California, Wildlife Health Centre
Gerald Inglangasuk	Fisheries Joint Management Committee
Greg O'Corry-Crowe	Florida Atlantic University
Issiac Elanik	Fisheries Joint Management Committee
Jason Stow (virtual)	DFO – Science, Ontario and Prairie Region
Jimmy Kalinek	Inuvialuit Game Council (past representative)
Jody Illasiak	Paulatuk Hunters and Trappers Committee
Joe Illasiak	Paulatuk Hunters and Trappers Committee
Justine Hudson (virtual)	DFO – Science, Ontario and Prairie Region
Kevin Scharffenberg (virtual)	DFO – Science, Ontario and Prairie Region
Lawrence Kaglik	Inuvik Hunters and Trappers Committee
Lisa Loseto	DFO – Science, Ontario and Prairie Region
Lois Harwood	Fisheries Joint Management Committee
Luke Storrie	DFO – Science, Ontario and Prairie Region
Marie Noel (virtual)	OceanWise, Ocean Pollution Research Program
Marion Desmarchelier	University of Montreal, Canadian Wildlife Health Cooperative
Michelle Wetton	DFO – Science, Ontario and Prairie Region
Nigel Hussey (virtual)	University of Windsor
Norman Anikina	Sachs Harbour Hunters and Trappers Committee
Patt Hall (virtual)	DFO – Fisheries Management, Arctic Region
Raphaela Stimmelmayr (virtual)	North Slope Borough
Richard Gruben	Tuktoyaktuk Hunters and Trappers Committee
Ryan Galley (virtual)	DFO – Science, Ontario and Prairie Region
Shannon MacPhee	DFO – Science, Ontario and Prairie Region
Stéphane Lair (virtual)	University of Montreal, Canadian Wildlife Health Cooperative
Teri Rowles (virtual)	National Oceanic and Atmospheric Administration, Marine Mammal Health Science
Tracy Romano (virtual)	Mystic Aquarium, University of Connecticut

APPENDIX 2. TERMS OF REFERENCE

Assessment of Factors in the Mortality of Eastern Beaufort Sea Beluga Whales (*Delphinapterus leucas*) Live Captured and Tagged in 2019

Regional Peer Review – Ontario and Prairie Region

February 28 – March 3, 2023
Yellowknife, NT

Chairperson: Joclyn Paulic, Dean Arey

Context

In July 2018, the first program to tag Eastern Beaufort Sea (EBS) beluga whales (*Delphinapterus leucas*) since 2005 took place in Kugmallit Bay in the Mackenzie Estuary, Canadian Beaufort Sea. In total, 10 belugas were live-captured and instrumented with back-mounted transmitters following standard methods. The program was highly successful, with tags reporting data between 14–356 days. The following year, an additional 20 EBS belugas were tagged using the same protocols and a virtually identical field crew. However, within two weeks eight whales were confirmed dead based on the mortality function from a secondary pop-up archival tag, along with the discovery of three beachcast carcasses of tagged belugas. An additional eight tags went offline within the same timeframe as those beluga confirmed dead, with no known cause. This represents a mortality rate of 40% percent based on confirmed cases, and potentially as high as 80% if the additional offline tags represent whales that died. This level of mortality is without precedent in any small cetacean live capture program. Tagging belugas with methods used in this program (live capture with dorsal ridge attachment) is currently the only approach that provides movement data (both horizontal and vertical) over long durations (i.e., up to a year). Movement and dive data for Arctic cetaceans is needed to inform stock assessments, integrated marine spatial planning, and to evaluate cumulative effects caused by a changing climate and anthropogenic activities. Currently, the Department has put a freeze on any live capture tagging of belugas and narwhals until an assessment of factors affecting the mortality event is completed and recommendations are provided for future programs. Inuvialuit community members and wildlife co-management partners have also requested more information on potential causes of the mortality event.

Objectives

To identify and assess likely cause(s) and/or contributing factor(s) in the mortality of tagged EBS beluga using expert elicitation and assigning levels of certainty for each factor. Specifically, to:

1. Review and evaluate the role of the tagging procedure in the mortality events;
2. Evaluate the role of underlying health condition(s) in the mortalities using individual and population-level data;
3. Determine if external factors (e.g., environmental) may have contributed to the mortalities; and,
4. Discuss lessons learned and identify recommendations for future beluga tagging programs and protocols.

Expected Publications

- Science Advisory Report
- Research Document(s)
- Proceedings

Expected Participation

- Fisheries and Oceans Canada (DFO) (Ecosystems and Oceans Science and Ecosystems and Fisheries Management sectors)
- Inuvialuit Co-management Management Boards (Inuvialuit Game Council, Fisheries Joint Management Committee)
- Inuvialuit beluga knowledge holders
- Academia (e.g., University of Windsor, Florida Atlantic University)
- Wildlife Veterinarians (e.g., Canadian Wildlife Health Cooperative)
- Other invited experts (e.g., North Slope Borough Department of Wildlife Management)

APPENDIX 3. MEETING AGENDA

ASSESSMENT OF FACTORS IN THE MORTALITY OF EASTERN BEAUFORT SEA BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) LIVE CAPTURED AND TAGGED IN 2019

Regional Peer Review: Ontario and Prairie Region and Arctic Region

February 28–March 2, 2023

Hybrid Meeting
Chateaux Nova, Yellowknife, NT and via MS Teams
Time in Mountain (MST)

Chairpersons: Joclyn Paulic, Dean Arey

DAY 1 – Tuesday, February 27, 2023

8:30 a.m. Coffee/tea and settling in

9:00 a.m. Orientation to Working Papers and Meeting Format for External Participants

10:00 a.m. Opening Welcome and Meeting Introduction (Chair)

- Participant Introduction (Please be prepared with a few sentences about your background, knowledge and expertise for this meeting)

10:15 a.m. Overview of the CSAS Peer Review Process (J. Paulic)

- Terms of Reference (Chair)
- Review Meeting Agenda (Chair)

10:45 a.m. Health Break

11:00 a.m. Overview of the Beluga Tagging Program (L. Loseto)

11:15 a.m. Context for the Request (M. Wetton-Salo)

11:30 a.m. Working Paper #1 Presentation: Beluga Movements and Dive Behaviour (L. Storrie)

12:30 p.m. Lunch (not provided)

1:30 p.m. Continue Discussion and Questions Working Paper #1 (Chair)

2:00 p.m. Working Paper #2 Presentation: Phase 1 (L. Loseto)

2:30 p.m. Health Break

2:45 p.m. Continue Discussion and Questions Working Paper #1 (Chair)

3:30 p.m. Review outcomes of Phase 1 – Summary Table (Chair)

4:30 p.m. End of Day 1

DAY 2 – Wednesday, March 1, 2023

8:30 a.m. Coffee/tea and settling in

9:00 a.m. Summarize Day 1

9:10 a.m. Working Paper #2 Presentation: Phase 2 (L. Loseto)

10:30 a.m. Health Break

10:45 a.m. Continue Discussion and Questions Working Paper #2: Phase 2 (Chair)

11:00 a.m. Review outcomes of Phase 2 – Summary Table (Chair)

12:30 p.m. Lunch (not provided)

1:30 pm Working Paper #2 Presentation: Phase 3 (L. Loseto)

2:30 p.m. Continue Discussion and Questions Working Paper #2: Phase 3 (Chair)

3:30 p.m. Review outcomes of Phase 3 – Summary Table (Chair)

4:00 p.m. End of Day 2

DAY 3 – Thursday, March 2, 2023

9:00 a.m. Summarize Day 2

9:10 a.m. Review and Complete and Outstanding Conclusions for the Summary Tables

10:00 a.m. Summarize Changes and Outcomes for the Working Papers; Determine if Working Papers adopted as Research Documents

10:15 a.m. Review list of recommendations (Chair)

10:45 a.m. Health Break

11:00 a.m. Review Structure of the Science Advisory Report and Objectives (Chair)

11:30 a.m. Draft and Review of the key sections of the SAR (Chair)

12:30 p.m. Lunch (not provided)

1:30 p.m. Continue Drafting key sections of the SAR (Chair)

2:30 p.m. Summarize Meeting Participant expectations and CSAS Publication Timelines

3:30 p.m. Meeting Complete – THANK YOU!