Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2021/001

Central and Arctic Region

Proceedings of the Regional Peer Review on Science Advice to Assist in the Development of an Ecological Monitoring Plan for the Anguniaqvia niqiqyuam Marine Protected Area

Meeting dates: February 18–20, 2020
Location: Winnipeg, MB

Chairpersons: Joclyn Paulic and Jason Stow
Editor: Kayla Gagliardi

Freshwater Institute
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba, R3T 2N6

February 2021

Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1701-1280

Correct citation for this publication:

DFO. 2021. Proceedings of the Regional Peer Review on Science Advice to Assist in the Development of an Ecological Monitoring Plan for the Anguniaqvia niqiqyuam Marine Protected Area; February 18–20, 2020. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2021/001.

Aussi disponible en français :

MPO. 2021. Compte rendu de la réunion régionale d'examen par les pairs de l'Avis scientifique à l'appui de l'élaboration d'un plan de suivi écologique pour la zone de protection marine d'Anguniaqvia niqiqyuam; du 18 au 20 février 2020. Secr. can. de consult. sci. du MPO, Compte rendu 2021/001.

TABLE OF CONTENTS

SUMMARY

Under the Health of the Oceans initiative, Fisheries and Oceans Canada (DFO) Science is required to provide support and advice on Marine Protected Areas (MPAs) for DFO Oceans Management. Indicators, protocols, and strategies are intended to allow DFO to evaluate whether the regulatory conservation objectives (COs) are being met for an MPA. A monitoring plan is currently being developed for the Anguniaqvia niqiqyuam Marine Protected Area (ANMPA) by the ANMPA Working Group (WG) and the Western Arctic Marine Protected Area Steering Committee (WAMPA) as a cooperative process between appointed members of the Paulatuk Hunters and Trappers Committee (HTC) and co-management partners DFO and FJMC. This monitoring plan will provide a structured approach to gathering information in support of the management of the ANMPA, including meeting its COs. These COs are: (1) to maintain the integrity of the marine environment offshore of the Cape Parry Migratory Bird Sanctuary so that it is productive and allows for higher trophic level feeding; and, (2) to maintain the habitat to support populations of key species (such as beluga whales [*Delphinapterus leucas*], Arctic char [*Salvelinus alpinus*], ringed seals [*Pusa hispida*] and bearded seals [*Erignathus barbatus*]). A regional Science Advisory meeting was held February 18-20, 2020 at the Alt Hotel in Winnipeg, MB to focus on information gathering to support the development of an ecological monitoring plan for the ANMPA. The first objective of the meeting was to review a generalized monitoring framework that used the nearshore ANMPA as a case study to outline a suggested process to consider when developing the generalized ecological aspects of an MPA monitoring program which incorporated both scientific knowledge and guidance from partners. The second objective was to identify, review, and summarize existing scientific information/data and published local and traditional ecological knowledge relevant to the area to inform future monitoring plan development (i.e., potential indicators, protocols, and strategies), and identify key data gaps.

As a result of the Science Advisory meeting, the series of indicators and associated monitoring protocols and strategies which had been initially requested from the previous CSAS regional peer review meeting for the ANMPA in 2014 were discussed, modified, and updated. This Proceedings report summarizes the relevant discussions and presents the key conclusions reached during the meeting. Additional publications from this process will be posted on the DFO Canadian Science Advisory Secretariat website as they become available.

INTRODUCTION

Under the Health of the Oceans initiative, Fisheries and Oceans Canada (DFO) Science is required to provide support and advice on Marine Protected Areas (MPAs) for DFO Oceans Management. Currently, this includes the identification of indicators, protocols, and strategies that are to be incorporated into MPA monitoring plans. Indicators, protocols, and strategies are intended to allow DFO to evaluate whether the regulatory conservation objectives (COs) are being met for an MPA.

In 2014, prior to the official designation of the Anguniaqvia niqiqyuam Marine Protected Area (ANMPA), DFO Science provided advice on the selection of ecological monitoring indicators and strategies capable of informing on the status of the northern CO. This assessment was only requested for the Cape Parry priority area and did not address indicators for habitats south of Bennett Point or for adjacent, offshore waters that are inextricably linked to the ANMPA ecosystem. Therefore, an update to advice was required. A key component of the ANMPA management will be the ANMPA monitoring plan, which includes ecological, socioeconomic, and governance indicators and is currently being developed by the ANMPA Working Group (WG) as a cooperative process between appointed members of the Paulatuk Hunters and Trappers Committee (HTC) and co-management partners DFO and FJMC. The process is intended to ensure community-level leadership in the development and implementation of the monitoring plan. The ANMPA monitoring plan will also be reviewed by partners through the Western Arctic Marine Protected Area Steering Committee (WAMPA).

This monitoring plan will provide a structured approach to gathering information that will support management efforts and allow the evaluation of whether the ANMPA COs are being met.

The COs for the ANMPA are:

- to maintain the integrity of the marine environment offshore of the Cape Parry Migratory Bird Sanctuary so that it is productive and allows for higher trophic level feeding by ensuring that the Cape Parry polynyas and associated sea-ice habitat, and the role of key prey species (e.g., Arctic Cod [*Boreogadus saida*]), are not disrupted by human activities (DFO 2011); and,
- to maintain the habitat to support populations of key species (such as beluga whales [*Delphinapterus leucas*], Arctic char [*Salvelinus alpinus*], ringed seals [*Pusa hispida*] and bearded seals [*Erignathus barbatus*]).

The monitoring plan developed by the ANMPA WG will ultimately address multiple themes. However, this request for Science Advice was focused only on the ecological components. Specifically, the objectives of this Canadian Science Advisory Secretariat (CSAS) process were to:

1. review a generalized monitoring framework that used the nearshore ANMPA as a case study to outline a suggested process to consider when developing the generalized ecological aspects of an MPA monitoring program which incorporates both scientific and indigenous knowledge; and,
2. identify, review, and summarize existing scientific information/data and published local and traditional ecological knowledge relevant to the area to inform future monitoring plan development (i.e., potential indicators, protocols, and strategies), and to identify key data gaps.

One of the co-chairs provided an overview of the housekeeping/ground rules for the meeting, the CSAS process and guiding principles, and the expected output publications and document

timelines. The Terms of Reference (Appendix 1) were then reviewed and the meeting agenda was presented and agreed upon by participants (Appendix 2). Participants at the meeting included affiliates from DFO Science and Marine Protection and Conservation (MP&C, formally known as Oceans Program) programs, the Fisheries Joint Management Committee, the University of Manitoba, Université Laval, the Wildlife Conservation Society Canada, Environment and Climate Change Canada Canadian Wildlife Service, and Natural Resources Canada (Appendix 3).

A series of presentations were made to provide background and context to the ANMPA and to provide additional information about recent research and projects in the area. Following these presentations, participants discussed and accepted or updated the series of indicators, protocols, and strategies which had been initially requested from the previous CSAS regional peer review meeting for the ANMPA in 2014. These proceedings summarise the meeting discussions and present the key conclusions reached at the meeting. Additional publications from this process will be posted on the DFO Canadian Science Advisory Secretariat Website as they become available.

PRESENTATIONS

FISHERIES AND OCEANS CANADA POLICY PERSPECTIVE AND DEVELOPMENT OF THE ANMPA MONITORING PLAN

Presenter: Jasmine Brewster

Summary

The ANMPA was designated October 2016. It is the second Western Arctic MPA, and the first to have one of the conservation objectives solely based on community priorities. In the Inuvialuit Settlement Region (ISR), there is a governance structure established for the monitoring and management of MPAs. This structure includes the Western Arctic MPA Steering Committee (WAMPA), with members from DFO, co-managers FJMC, and representatives from the TNMPA and ANMPA WGs. Since the establishment of the ANMPA WG, work has begun towards developing a monitoring plan from a community perspective. To develop this plan, the ANMPA WG organized indicators identified in the 2014 CSAS process for the Anguniaqvia niqiqyuam Area of Interest (ANAOI) into eight themes for monitoring (five ecological, one traditional and local knowledge (TLK), one governance, and one socioeconomic theme) for the MPA. Both long-term and short-term actionable goals were identified for each ecological indicator theme. Originally, it was planned to have science experts attend each theme meeting with the WG and help flesh out the themes and select indicators to monitor. However, a CSAS process was required to receive Science Advice on indicators pertaining to the southern portion of the MPA CO and region, as well as the need to update current scientific knowledge of the area. Therefore, the WG went ahead with developing the plan from a community focus, and agreed to provide community priorities to be incorporated into the CSAS process. The ANMPA WG decided not to attend this CSAS process as they were uncertain their TLK would be captured in a meaningful way through this science process and because Inuvialuit knowledge had already been captured through the ANMPA WG-led process. The ANMPA WG supports and respects this science process.

The WAMPA and ANMPA WG intend to run a workshop in Paulatuk following the CSAS process to bring the Science Advice to the WG and collaborate on refinement of the monitoring plan.

Discussion

A participant noted that the monitoring priorities of the ANMPA WG were not the same as those focussed on in the CSAS Research Document. The presenter clarified that the community prioritized monitoring indicators that pertain to key species on which they rely. However, the community acknowledges that there are other components that will need to be monitored, which is why they wish to work with science for ecologically-focused advice. A participant emphasized that a key part of the CO is “to maintain the integrity of the marine environment,” and thus any component that affects the integrity of the marine ecosystem should be open for scientific discussion on strategies for monitoring/understanding the ecological implications/interactions of that component. There was also a discussion on whether budgetary constraints for the implementation of a monitoring plan should be considered in the CSAS process. It was decided that the focus should instead be on feasibility and capacity to implement suggested strategies.

ARCTIC COAST: A TRANSFERRABLE COMMUNITY-BASED COASTAL MONITORING FRAMEWORK (WORKING PAPER #1)

Presenter: Karen Dunmall

Summary

The Arctic is experiencing rapid environmental changes that are impacting its ecosystems, species, and Indigenous cultures. These changes are also fueling ambitious and urgent conservation goals, resulting in a recent substantial increase in Arctic protected areas which need to be managed and monitored. Monitoring these changes is difficult, but necessary, in order to address community concerns as well as inform management and decision making. Linking Indigenous knowledge and scientific knowledge together provides a powerful approach to assess ecosystem change as the lack of scientific information about Arctic species and their habitats is juxtaposed by the wealth of Indigenous knowledge about Arctic environments. Locally-based monitoring can provide a successful and cost-effective option for monitoring effects of environmental change. A lack of consistent objectives, indicators, and protocols, however, often limits the application of these efforts beyond the local level. Here we present an opportunity to connect among people and places through monitoring by outlining a transferrable community-based monitoring framework for Arctic coastal ecosystems, called Arctic Coast. Amidst rapid change and great uncertainty, the Arctic Coast framework connects people and places under a common priority that informs decision making and contributes to conservation priorities, while also building resilience in northern communities. This framework was developed to be transferable and provides an opportunity for collaborative research among traditional knowledge and science with the goal of creating a network of community-led monitoring to better understand coastal ecosystems

Discussion

Participants agreed that the report was missing relevant policy-related literature and guidance frameworks. Some participants were concerned that the current draft went outside of the scope of the meeting which was to focus on ecological indicators for monitoring. Since the paper only discussed community-based monitoring experience in three areas/locations, participants suggested adding more references to other community-based monitoring projects in the background information. It was also suggested that the author review lessons learnt from the existing community-based monitoring programs to identify effectiveness and potentially build on any key lessons. Participants expressed concerns about “Arctic Coast” being too broad of a title and the report being too broad in general. Suggestions were made to highlight more of the network development as well as connections among the indicators. There were also concerns about creating a false dichotomy by contrasting science and community knowledge. There were

several suggestions to guide community input into the paper, including meaningful consultation with indigenous organizations and co-authorship. For the objectives of the report, it was suggested to focus on the ANMPA and how the Arctic Coast process led to what is now being monitored. Participants also emphasized the need for the development of a clear science hypothesis to be considered as a baseline which should be built into the framework and embedded in the initial choices for the monitoring parameters.

Since Inuvialuit partners decided not to participate in this scientific peer-review process it was suggested that the author shift to a narrower scope that focused on the ANMPA. Since major revisions are needed, this paper was not accepted as a Research Document. It could, however, be published outside of the meeting after community support and Inuvialuit governing body consultation, and would have benefited already from the review provided by meeting participants. It was suggested that elements from the report could be used as a specific case study focused on experience within the ANMPA and could be taken back to the community for input/additional ideas.

POTENTIAL ECOLOGICAL MONITORING INDICATORS AND STRATEGIES FOR THE ANGUNIAQVIA NIQIQYUAM MARINE PROTECTED AREA AND A SYNOPSIS OF AVAILABLE INFORMATION (WORKING PAPER #2)

Presenter: Ashley Ehrman

Summary

An overview of the history of related CSAS processes for the area was provided. In 2014, prior to the official designation of the ANMPA, DFO Science provided advice on the selection of ecological monitoring indicators and strategies capable of informing on the status of the COs. Assessment was only requested for the Cape Parry priority area, and did not address indicators for habitats south of Bennett Point or for adjacent, offshore waters that are linked to the ANMPA ecosystem. Since advice was initially provided, substantial research and baseline data collection have occurred in the region and the ANMPA WG identified a set of priorities for ecological monitoring. An update to advice was thus required. The goal for this portion of the current CSAS was defined as reviewing the 18 indicators suggested by the 2014 CSAS process in order to update them with new information that has since been obtained, expand them to include the southern portions of the ANMPA and adjacent waters, and identify any gaps in the indicators. The discussion would be aimed at gaining consensus on which of the original 18 indicators would continue to be included in Science Advice, and if any new ones should be added. A second key goal of discussions would be to develop tools and strategies for collecting monitoring data for each indicator at the community level. It was emphasized that the final set of monitoring indicators including in the Science Advisory Report should additionally be capable of addressing the community priorities provided by ANMPA WG.

It was re-emphasized that the ANMPA COs are not to maintain the ecosystem itself, but to maintain the integrity of the ecosystem and habitat, so that the area remains productive in ways that that support higher-trophic feeding. The focus is on protecting key functions and core characteristics, allowing management strategies to remain adaptable to changing stressors, priorities, and states of knowledge.

Discussion

A participant suggested to update the spatial organization of information since there are four geographic components to the overall system which are: 1) the ANMPA itself (includes at least three distinct areas); 2) the coast line (includes the southern and eastern margins and Hornaday River); 3) the offshore area within Darnley Bay; and, 4) the offshore area outside the ANMPA

and outside of Darnley Bay. Another participant suggested adding a section to the working paper on connectivity between indicators selected for the ANMPA and those implemented for the Tarium Niryutait (TN) MPA to provide some insight into how they are applicable to the larger MPA Network strategy. Participants agreed that structuring the available information into these sub-components within each section could be useful for distinguishing the parameters of the indicators to monitor, which will help with establishing cause-effect relationships.

As a group, the scientific considerations for a monitoring plan that were outlined in Section 3 (from DFO 2015a) of the report were modified to the following:

To successfully evaluate whether the COs for the ANMPA are being met, the monitoring plan should be:

1. able to distinguish between anthropogenic-related change and environmental variation (high signal to noise ratio);
    - able to recognize the complexity of the system and be sensitive to seasonality;
2. standardized, long-term, and follow specific established protocols;
    - adaptable rather than static (e.g., hypotheses should be revisited regularly to incorporate new findings; being careful that changes are conducted with overlap to ensure a cumulative record);
3. based on a hypothesis associated with predictions/expectations at all stages of the monitoring program, to achieve meaningful outcomes from data collected by all co-management and scientific partners to evaluate complementarity between hypotheses and data collection;
4. assessed on a regular reporting schedule (e.g., report on progress every five years);
5. incorporated with data analysis and conclusions, the dissemination of results to both local and scientific communities, and archiving of data/results in a standardized fashion; and,
6. coordinated among co-management groups, government, and community partners.

MEETING STRATEGY

The goal of the following discussion on the second working paper was to gain consensus on which indicators and criteria to accept and include in the final Science Advisory Report, with flexibility to modify or combine some as a group. Another aim was to develop tools and strategies for monitoring the data at the community-level while considering effectiveness and feasibility.

Participants emphasized that unless indicators are directly related to key species they can get forgotten. Therefore, it will be important to demonstrate how each indicator is linked and tied to the COs and associated high-trophic feeding species.

ASSESSMENT

INDICATORS

Freshwater and terrestrial inputs

The group agreed that freshwater and terrestrial inputs should be added as a separate indicator to consider land-based environmental changes. Factors that were mentioned to be considered

included permafrost, land degradation, and transport of nutrients or contaminants into the system by means of freshwater, all of which can cause direct or indirect effects on organisms or components within the MPA. Therefore, it is important to understand the mechanisms through which freshwater and terrestrial inputs affect the marine ecosystem, as well as steps for potential mitigation and adaptation to these changes. An example of a study which showed precipitation to have significant effect on char growth was mentioned to underscore the correlation between marine and land-based indicators (Chavarie et al. 2019).

Core oceanography

Participants suggested adding a table with key oceanographic processes to be monitored under the general indicator of core oceanography. It was emphasized that the importance of oceanographic measurements should be explained, as well as how they have visible effects on biota (e.g., the effects of water temperature on stratification and fish). A participant suggested coming up with and prioritizing a “shopping list” for potential parameters to measure for oceanography. A participant noted that, aside from sporadic measurements, there is a large knowledge gap in oceanographic information, such as how Darnley Bay interacts with the larger ocean. The most important oceanographic parameters to measure were summarized as:

1. temperature profile;
2. salinity profile;
3. fluorescence profile;
4. oxygen profile;
5. nutrients;
6. carbon chemistry;
7. water clarity/turbidity;
8. oxygen isotope fractionation;
9. currents and water movement;
10. ancillary information (e.g., atmospheric drivers, photosynthetically active radiation);
11. background sounds (e.g., anthropogenic or natural such as during storms); and,
12. isoscapes (e.g., to assess movement of materials delivered by coastal erosion and freshwater inputs).

Participants discussed if these parameters should be presented together as an indicator group or separate, and it was agreed that lumping them together could become challenging. A participant noted that since parameters are important for understanding the linkages between indicators, the linkages should be explained as well. Another participant questioned how the wide scope of potential parameters should be narrowed down, since the goal is to provide MP&C/WAMPA with the core set of indicators relevant to the health and changes of the system. In response, a participant noted that for core oceanography, there is one instrument that can easily measure and collect most of the priority oceanographic parameters. It was noted that although it may not be feasible to monitor all of the parameters on the above list at the moment, they could still be included for the future planning. A participant agreed that having too many indicators is not very realistic and another reminded the group that unless the indicators are directly related to key species they often get forgotten. Therefore, it is necessary to show how key indicators are linked and tied to the COs and species of interest. The importance of

capturing the temporal and spatial elements of the indicators along with their description was emphasized.

From past CSAS advice (DFO 2012), the idea of “3 perfect moorings” was discussed as an example for how perfect scenarios could still be described in Science advice to provide guidance for future planning even if there may not be the capacity to do everything. This was also a good example for monitoring biodiversity in the Canadian Arctic since monitoring is done the same between coastal and offshore areas, therefore lots of information can be gained at once. It was re-iterated that there is a need to explain why the list of parameters is important. A participant mentioned that seasonality should also be considered for oceanography since temporal resolution and coverage can be compromised for certain aspects such as measuring nutrient renewal. Satellites or numerical simulation/biophysical modelling were suggested as potential measurement methods. A participant noted that without good bathymetric information it will not be possible to get good modelling information and bathymetry was highlighted as a large knowledge gap.

Concentration of nutrients

A participant noted that information regarding light and nitrate concentrations as drivers should be added since they are believed to be the limiting factors for blooms. Also, a section about bloom dynamics in the area from general cases and programs should be added. The group was reminded that nitrate concentrations should not be used as an indicator for the magnitude of primary productivity and suggested to remove this from the text. A participant noted that there are publications available for the region that could be added to the working paper which generally describe compositions of blooms and how they are linked to the form of nitrate available as well as how different nitrogen sources are affecting phytoplankton composition in the Western Arctic (Hill et al. 2005, Garneau et al. 2007, Tremblay et al. 2009, Ardyna et al. 2011, Tremblay et al. 2015). A participant questioned if it would be relevant to measure concentration of nutrients outside of primary production. It was explained that since there is such a high spatial variability, this would probably not be useful as an indicator.

Benthic habitat distributions

Big knowledge gaps in bathymetry and benthic habitat mapping were identified with regards to information availability for benthic habitat distributions. It was agreed that pre-monitoring/mapping of benthos is needed to accurately monitor the ANMPA. It may be possible to obtain bathymetric LiDAR from the nearshore, which could aid in defining where suitable habitat may be as well as if benthic communities are supported. Other suggestions for data collection included nearshore geological mapping, using a transect method for the adjacent shoreline type, and looking at surficial geology of the immediate coastline to determine benthic habitats from the substrate, which also links to oceanographic factors. A participant noted that a bottom habitat survey will be required in the ANMPA in advance of any monitoring program that incorporates bottom-contact sampling to avoid destruction of sensitive or rare habitats. It was agreed that habitat mapping is the highest priority for benthic habitat. A participant added that the extent of macroalgae should also be looked at as it could be connected to fish habitat use. A participant reminded the group how habitat mapping certain communities will be linked to certain habitats. For example, bedrock and kelp forests will help predict the benthic community composition. It was therefore questioned if these linkages between community and habitat should be described within this section of the working paper or if a separate section should be added to describe these connections. A participant reminded the group of the importance of clearly defining the link to higher-trophic species so that certain indicators do not get overlooked or forgotten. For example, it might not be as accurate to look at seal stomach contents to determine benthic invertebrate presence/absence compared to looking at the actual benthic

community. Participants agreed that it is important to establish early warning/background environmental baseline data which can be collected as a “one time shot”. Without this baseline data, it will be difficult to perform hypothesis testing. It was suggested that perhaps a whole section dedicated to linkages of background environmental indicators be added to the forefront of the working paper to ensure certain indicators are not forgotten.

A participant noted that the need to fill basic knowledge gaps regarding the ecosystem should be clearly separated from the need to conduct ongoing monitoring on other aspects of the ecosystem relevant to evaluating the COs, and that these gaps should be acknowledged in the Science Advisory Report (SAR).

Ice structures, ice/snow thickness, ice break-up/freeze-up timing

The group agreed that ice freeze-up should be added to the title of this indicator section as it is just as important as ice break-up. A participant explained how ice charts can be used to easily calculate break-up and freeze-up on a yearly basis to help determine baselines, and instructions on how to do so could be provided for a community-based monitoring program. However, the percent concentration of ice cover to define them will need to be determined. Ice structure and thickness are more difficult to measure and would require radar imagery which takes a lot of time to process and analyze. Therefore, break-up and freeze-up should be the monitoring priority (presence of open water). Ice break-up and freeze-up are drivers of the entire ecosystem, which can be important indicators for changes that will affect key species. Break-up caused by shipping can alter the natural timing, which will also need to be considered. It was suggested that there should be a brief discussion added to better define break-up as well as the different stages and their importance to different ecological components. The variability in timing of break-up and freeze-up among different areas in the MPA was discussed and it was agreed that likely different areas will need to be looked at since large differences can occur geographically. A participant noted that similar patterns may occur throughout the MPA from North to South, and that perhaps the stability of these patterns could be a focus of monitoring that could be observed over longer time scales. If major changes in pattern were to occur, it would signify large ecological changes, which could provide an early signal for the larger system.

Snow on sea ice was noted as a very important factor that was not discussed enough in the report. Therefore, it was also added as a parameter for this indicator section. Participants noted that snow and ridges are important for key species such as seals and Polar bears and that the community is aware of this. The importance of snow and ice thickness/structures was also emphasised as it affects the travel of community members as well as leads and habitat availability for marine mammals. Snow depth also has a relationship to productivity as it is a moderating factor for light, which affects primary producers. A participant noted that not a lot of work has been done with regards to snow in Darnley Bay. They suggested that measuring snow depth along transects is a relatively simple method to use at the community level. It is important to note that snow and ice vary over small spatial scales, therefore the scale, size, and space of transects would need to be considered.

A participant suggested that a hypothesis be added to each indicator statement, which justifies the need for monitoring. For example, a hypothesis that, with climate warming, there will be earlier ice break-up. Another participant suggested to include a retrospective trend analysis to better integrate existing data which could have potential relevance for long-term monitoring and could be a specific focal section in the SAR. The group was reminded that the SAR is a product from this meeting that could be used to develop a science plan with achievable goals to prepare for the next step in the process for monitoring of indicators, and not necessarily a place to

integrate data. However, it was acknowledged that the retroactive trend analysis would be useful to provide baseline information.

Coastal change

There are currently several knowledge gaps in data available for coastal erosion including rate of change, impacts to primary productivity, and impacts between light and nutrients. A participant suggested highlighting the potential increase in sedimentation (changes/destruction of nearshore habitat) and impacts of increased erosion as important in the SAR. Another participant suggested that describing the north-south transition from rocky cliffs to soft sediment along the ANMPA coastline in the working paper would help provide some context for where coastal erosion poses the most significant threat. It was noted that it is also important to consider factors that cause erosion, such as storms, and these may increase with climate change. Contaminant delivery (e.g., of heavy metals) and the need for baselines was discussed and the group decided that contaminants should be added as a separate indicator. The change hypothesis discussed for coastal erosion was that increasing storminess, a longer open water season, and increasing permafrost melt will cause greater coastal erosion in the southern ANMPA.

Under ice biota, ice-associated biota, and open-water biota

It was agreed that the term biota is too broad and it was suggested it should be changed to something more specific, such as primary producers and protists. Participants underscored chlorophyll *a* as the most important parameter to measure for monitoring primary producers. Chlorophyll *a* is easy to measure without toxic chemicals and would be feasible to measure as part of a community-based program. A gap in the working paper was identified with regards to the significance of characterizing primary production. A participant suggested, from the environmental DNA perspective, a remote sensing technique that was applicable for implementation at the community level. A participant agreed that real-time numbers from chlorophyll *a* extraction in field can be obtained by the community, as this is done in Iqaluit for tracking algal blooms. A participant noted that there is a new equipment that could be used, although expensive, that determines an approximation of photosynthetic parameters for small amounts of water and can also measure hydrocarbons.

It was suggested to add more citations to the working paper with regards to sea ice and primary production as well as the effects of stratification on species composition. Another participant suggested possibly including a series of schematic figures to illustrate the interconnectedness of nutrient concentrations, the proliferation of different kinds of primary producers and overall primary production, and to illustrate how those properties affect the marine ecosystem. General hypotheses discussed for this section included: a. changes in the timing of algal blooms will lead to a mismatch between primary producers and primary consumers; and, b. greater freshwater inputs, and consequently stronger stratification in the water column, will change the cell composition of primary producers. Both hypotheses will have follow-on consequences for energy transfer to upper trophic levels.

A participant noted that while toxin-producing algal species had been confirmed in the vicinity of the ANMPA, the algae only produce toxins under specific conditions. It was suggested that if monitoring for toxin-producing algae is conducted, it should be linked to sampling bivalves to determine whether the toxin is actually being produced, as toxins can be present in benthic invertebrates in low, but detectable levels. A participant added that recent studies on harmful algae concluded that toxins are likely more widespread in the Arctic than what was previously thought, although the effects are still unclear (Lefebvre et al. 2016, Pućko et al. 2019, Bates et

al. 2020). Pathogens were also discussed in this section, but it was decided as a group to include them as a separate indicator.

Biodiversity of lower-trophic species

It was clarified that lower-trophic species were considered as species smaller than fish for the working paper (i.e., zooplankton and phytoplankton). A participant noted that although it is important to look at the general composition of phytoplankton, as this has an impact on primary production, it may be easier to look at zooplankton to relate changes to effects of higher trophic levels. It was suggested that measurements of phytoplankton community composition, if they were of interest, be limited to very specific locations or less frequent sampling. Many monitoring questions relevant to phytoplankton community composition could probably be answered using measurements of chlorophyll *a* and nutrient concentrations, which are easier to collect and analyse. It was noted that selecting species to monitor that are directly linked with higher trophic feeding species would provide specificity to the monitoring plan and help to narrow the scope. Two potential research questions were suggested, which were to look at: a. is the abundance/biomass of gelatinous zooplankton species changing (linked to temperature and water quality)?; and, b. is a shift in size of copepods occurring (a shift in body size would affect the transfer of energy to upper trophic levels)? It was also suggested to look at the presence of sea jellies which could be done by local observations.

Benthic community composition, structure, function, and energetics

A participant suggested adding more information about how benthic biodiversity and benthic habitat mapping are linked and can be used together. They also suggested to add more information about fluxes as indicators for benthic functioning since benthic invertebrates are strongly linked to biogeochemical cycling of nutrients that could be used as indicators for habitat. A knowledge gap was highlighted towards the lack of data available on benthic community composition for the ANMPA offshore and coastal area. Participants suggested using less destructive methods for sampling in the region, such as ROVs, which could provide more descriptive, although opportunistic, baseline information. Key species of benthic communities, such as corals and sponges, could be important indicators to monitor long term; however, it first needs to be determined which species are present in the area. As previously mentioned, environmental DNA could be an important tool for monitoring key species, and this could be done by community members.

General hypotheses to note for this section were: a. climate change will cause shifts in the community which could impact higher trophic levels and could also include indirect impacts such as changes to the strength of coupling with pelagic phytoplankton; and, b. the benthic community is very sensitive to habitat alterations (also higher trophic linkages).

Inshore and offshore fish community composition, structure, function and energetics

The parameters of high relevance to be monitored for inshore and offshore fishes are essentially the same (i.e., community composition, structure, function and energetics). Therefore, participants discussed both groups of fishes together, although they will still be treated as separate indicators. Similar to the lower trophic level species section, it was noted that identifying specific species at each trophic level which link to the CO will help narrow the scope when looking at methods to monitor indicators.

Relative abundance was highlighted as the key monitoring parameter of interest for these indicators since there is a large amount of data available from a collection of inshore/offshore

fish distribution studies in Darnley Bay area (McNicholl et al. 2020) A participant suggested adding that knowledge gaps for these indicators are the stability of community structure and the temporal variance in relative abundance of important key species, which are important for detecting change in fish community composition. It was noted that the working paper did not mention ichthyoplankton, which may be important to consider as fish are likely to be vulnerable during early life history stages.

General research questions were discussed and provided as a group which included: a) does the timing of ice/temperature affect growth/development of ichthyoplankton (as an indicator of potential survival/recruitment)?; b) do changes in zooplankton communities influence fish relative abundance?; and, c) is the presence of birds/whales related to fish biomass availability offshore in Cape Parry? These questions are relevant because currently, the primary diversity of fishes in the Arctic is in benthic species, which appears to be the result of both the amount and the nature of the delivery of lower trophic production (under-ice). The long-term implications of climate change could shift production pathways towards a greater overall pelagic open-water production, which, in turn will favour increased diversity and abundance of pelagic fishes relative to benthic fishes. A participant noted that this benthic to pelagic shift has been documented for the Chukchi Sea.

Focal forage fish presence/absence, relative abundance, and energetics

The group agreed to change the indicator from “Capelin” (*Mallotus villosus*) to “focal forage fish” to include Arctic cod since both have key functional roles for the ecosystem which overlap substantially. A participant cautioned using the word “abundance” to describe Capelin since whether someone is there or not to collect them does not truly represent the abundance. It was also suggested to remove from the report that Capelin were captured only in low numbers at Bennett Point in 2012 since the Capelin were likely still there, just not observed at that time. A participant warned that with episodic aggregations it may look like there are higher numbers of fish than there actually are, therefore using the relative abundance of Capelin as indicators for changes ecologically driven by climate change would not be a well-founded hypothesis.

Current knowledge gaps for Capelin were identified as overwintering location, where larval Capelin are being dispersed from, genetics of Capelin in the area, and water mass use during the summer for spawning. Capelin was acknowledged by participants as an important prey source for Arctic char, Ringed seals, and beluga. It was noted that since Capelin are a prey source for key predators that the community values, there is high interest for community members to observe when they are spawning. A participant explained that sampling could be done relatively easily and would help determine the ratio of male to female which could indicate if spawning is occurring. Sandlance was also acknowledged as an important prey source for beluga, especially if prey shifts from Arctic cod occur.

A participant noted that by monitoring the diets of char (subsistence catches) and seabirds (Cape Parry), this could provide an indication of availability (i.e., presence/relative abundance) of forage species that would complement scientific surveys of relative abundance/biomass. Metrics for relative abundance/biomass of forage species could then be compared to what is being consumed by char/birds to assess food web variability and shifts. Another point made was that moored Acoustic Zooplankton and Fish Profilers (AZFPs) provide an option to monitor the biomass of offshore forage species such as Arctic Cod at key locations (e.g., offshore of Cape Parry) both seasonally and inter-annually. AZFP’s would require periodic vessel-based surveys for echo validation.

Anadromous fish abundance, size, condition, and population structure

It was suggested that a simple and effective parameter to consider for monitoring change in fishes would be the timing of key life history events (e.g., timing of upstream/downstream migrations, spawning of Capelin, etc.). A participant commented that there were some unclear references to age in the text, and reiterated that age, size-at-age, condition, and catch-per-unit-effort were key parameters that should be monitored to look at changes in abundances and growth rates.

It was suggested to add more detail to the information referenced about population structure of char, such as genetics and morphological differences. There was also a knowledge gap identified with understanding Tippi char and their relationship to other char in the southeastern area of Darnley Bay. However, it was noted that an archive is being built from samples collected to try to figure out how they are related as well as the interactions between them. Upwelling was discussed as an example of an environmental process occurring outside of the MPA that still affects the species inside, as local Arctic char are known to feed at an area of frequent upwelling on the eastern edge of Darnley Bay. Understanding how Arctic char use this habitat and what they are feeding on will be important to understanding their habitat use in general. Such knowledge could be applied to monitoring decisions for the MPA. The issue of habitat usage and the issue of tracking environmental use by key species, such as chars, would seem to be important both as baseline information but also as a potential indicator of habitat changes (e.g., if the feeding zones of fish change over time that would indicate an underlying ecosystem change).The diet of char in this area, and their prey, could also be a potential indicator to monitor. The group also agreed to add a subsection for changing migratory patterns, vagrancy, and range-expansion to include newly colonizing/invasive species such as salmon and potentially other species.

Participants questioned the importance of monitoring Broad whitefish (*Coregonus nasus*) as there is currently limited capacity to monitor them, limited concern over their abundance, and uncertainty regarding their habitat use within ANMPA. If monitoring whitefish was desired, it would likely require a program designed specifically for them, rather than relying on by-catch data from other fish monitoring programs. The group was reminded that Science Advice should be provided within the scope of applicable fish within the MPA, therefore the key question is how Broad whitefish/other species use the area.

A nuance was suggested to add to the SAR that some monitoring initiatives underway may not necessarily need to be done directly within the funding of the MPA. It could also be possible to use the same monitors to extend the length and species focus of existing monitoring programs and combine efforts. For example, the existing Arctic char monitoring program could provide information relevant to monitoring. However, one participant pointed out that fishery-dependent stock assessments are designed for specific purposes and using those data for monitoring will require careful consideration on how to perform meaningful analyses for long-term trend analyses (harvest-independent data may be more appropriate). A participant suggested that species could be divided into sub-sections of: a. species with naturally occurring changes in distribution/range expansions (e.g., salmon, zooplankton); and, b. artificially delivered/potentially invasive species.

Changing migratory patterns, vagrancy, and range-expansion

The group agreed to create this sub-section to include more species than char such as salmon and potentially Greenland halibut (*Reinhardtius hippoglossoides*) and Dolly Varden (*Salvelinus malma*). This indicator would document changes in species biodiversity associated with new arrivals, migratory patterns, timing, and number of organisms. New arrivals should be categorized into a. natural range expansions (e.g., Pacific species moving east with changing

ocean temperatures); b. invasive colonizing species (e.g., those delivered by shipping that actually become established), and c. vagrants (e.g., one-off occurrences of a few individuals that don't appear to actually have established a population). Management actions may be different depending on the categorization, but ecologically they may have a similar impact on ecosystem. As discussed in the anadromous fish section, the tracking of habitat and environmental use by these potentially key species would also seem to be important both as baseline information, as well as for a potential indicator of habitat changes.

Trophic interactions

Participants agreed that the indicator should be changed from "fish diet composition" to "trophic interactions" and that key prey should be discussed for each key species within the COs. It was also decided that within this section trophic interactions could be lumped together, and that the tools for capturing trophic interactions could possibly also be included (including pros and cons of each). Participants suggested making this a separate indicator to add more information about energy pathways, transfer, and connectivity. Emphasis was placed on focusing on the structure of the pathways and on the energy flows between them (e.g., caloric content) as key indicators for monitoring the ecosystem. Key hypotheses for these monitoring indicators would include: a. environmental change will impact the relative availability of different sources of energy; and, b. consequently, dietary overlap between species and/or the diet compositions of upper trophic species will change in response to environmental change.

Composition of fish diet

A participant suggested the following hypotheses to see if: a. there is a change in dietary overlaps; or b. if stable isotopes or stomach contents are changing (potentially seasonally). For example, available information from Broad whitefish summer foraging activity has shown that they are eating more terrestrial prey. Therefore, carbon sources are not overlapping with Arctic cisco and char, which provides some inferences in regards to habitat use from diet data for these species.

Marine bird presence/absence, timing, and prey composition

A participant explained that Canadian Wildlife Service (CWS) will be starting to build a co-management plan for migratory bird sanctuaries (including Cape Parry Migratory Bird Sanctuary), but that will take 7-8 years to achieve. However, CWS is still open to research and monitoring and wants to keep lines of communication open with DFO as the future plans for monitoring are between CWS and DFO. There are currently many knowledge gaps relating to birds. From the MPA perspective, bird diet and range of the colony has been a gap since 2014, but a participant noted that it would also be useful to obtain more information about overwintering and population (to inform indicators). It was suggested by the group to strongly highlight the need for bird data since they are a big ecological component of the MPA and could be used as leverage for funding (e.g., for geolocators).

Marine mammal presence/absence, timing, and group composition

Participants agreed that for marine mammals, presence/absence is a difficult indicator to measure since absence does not necessarily prove there were not any animals there if they might have just not been observed. For seals, there has been limited telemetry work and to date there is a large gap in data available for bearded seals, especially regarding diet. It was emphasized again that snow and ridges play an important role in seal distribution. For beluga, there is also a large gap in data available as to why they are entering the Darnley Bay area, which the community is interested in determining and would require more research.

Presence/absence of beluga is difficult to measure as mentioned above, also since there has been no consistent aerial survey program or tagging in this area. Beluga data available are mostly from harvest/traditional ecological knowledge (TEK) which may support the second ANMPA CO. However, it was emphasized that harvest data has many human-related biases (e.g., data will only be available for good weather days when harvesters could safely hunt). For Bowhead whales, foraging is mostly driven by upwelling events near Cape Parry, although there are still a lot of missing data (no telemetry data available). Data gaps identified for Bowhead whales include diet, population structure, and sex. One of the primary research questions for this indicator was identified as: why do beluga enter Darnley Bay?

Marine mammal prey composition

Participants agreed marine mammal prey composition is still a gap in knowledge. For seals there is some stomach content information available, although it can be biased since it is obtained from harvest monitoring programs. A participant suggested looking more at monitoring condition, which relates back to energy and resource availability/abundance or diet shifts. Basic morphometric data are taken for both seals and beluga during sampling but they provide limited information on condition. For beluga it was suggested to focus more on a biotracer approach as opposed to stomach contents (since stomachs are empty the majority of time they are sampled), but recognizing that biotracers have a time lag and will reflect general diet from before the whales entered Darnley Bay

Anthropogenic stressors (anthropogenic underwater noise)

Participants questioned how many anthropogenic influences should be included in detail and whether anthropogenic underwater noise should be put into a broader group of anthropogenic stressors to include others such as ship strikes or contaminants. It was emphasized that not all noise is shipping noise, and noise is not the only impact of shipping. A participant reminded the group that noise was identified as an indicator in the original request by the community since shipping is a present concern, therefore, it should be kept as a separate indicator for now. The participant suggested noting in the science advice that other anthropogenic activities and stressors will need to be considered in the next step for future monitoring. The group agreed the current lack of baselines is problematic for monitoring change caused by potential anthropogenic stressors and highlighted this as a need to consider for the future.

A participant is working on gathering baseline noise data and agreed it should be grouped with other anthropogenic influences and could also be referenced in the SAR as a potential risk. A participant noted a recent study on the effects of vessel noise on Arctic cod (Ivanova et al. 2020) and suggested this be added to the working paper. The importance of the impact of noise is that it masks the vocalizations of marine mammals. A participant noted another recently published study (Girdlestone et al. 2018) which looked at hair on the eardrum of belugas to see the impact from shipping. This study could be cited and training could potentially be provided to community members to collect the ear drums. Another participant suggested measuring cortisol as well to indicate chronic stress. It was discussed that a direct link between chronic stress and cortisol can not be made with regards to shipping, however, it could be used as a potential baseline to monitor change.

A participant pointed out that another linkage to consider when monitoring underwater noise is the measurements of ocean properties such as velocity, temperature, and salinity to determine sound speed through water. A participant also noted the importance of oceanographic and bathymetry data to monitoring noise.

Episodic environmental occurrences

The importance of the need to establish baselines for the MPA was emphasized again as it is difficult to determine what is considered as episodic or uncommon with no baseline to compare to. It was suggested that TEK could be used for monitoring of these events. A participant noted a new program called National Ecological Observing Network (NEON) in Alaska that was designed for unusual observations which could possibly be used to compare to Darnley Bay as it may expand to the circumpolar region.

Contaminants

It was decided as a group to add contaminants as a separate indicator as it is an example of an overarching theme. A participant noted that there is potential for a nickel mine in the southeast of the ANMPA and questioned if baseline data on heavy metals in the area should be established. Participants agreed that contaminant delivery of heavy metals should be summarized here, but it was questioned if baselines should also be established or if this is outside the focal component of monitoring. It was suggested that baselines should be identified as an issue that will need to be addressed for monitoring for future projects to be able to inform mitigation measures for conservation. For now, available baseline information from areas outside the MPA could be used.

Pathogens and parasites

Participants questioned if pathogens and parasites would be appropriate to include for monitoring. As a group, it was determined that the focus should be on ecological consequences as opposed to effects on humans. It was explained that pathogens and contaminants were not originally listed as indicators since they are difficult to link to the COs as they generally do not originate within the ANMPA or are not indicative of processes occurring within the boundaries. Toxins may be directly related to the COs, for example in beluga; however, beluga move in and out of the MPA. It was noted by a participant that even if the pathogens or parasites do not inform on the state of the MPA in particular, it is still a concern of the community and informs on the health of important species. It was agreed that some examples of pathogens of concern for certain key species such as Brucella in beluga should be included for potential monitoring.

REVIEW OF LINKAGES BETWEEN INDICATORS

Summary

Participants were split into groups based on expertise (lower trophic level, fish, and marine mammals) with the objectives of completing a table to determine and rank the strength of linkages among indicators. Groups were instructed to include potential hypotheses for the strongest linkages where possible.

Discussion

The participants agreed that oceanography should be emphasized as an indicator that is foundational to everything. It was emphasized again that the COs should be used to guide the choice and filtering of indicators and how they can be used for monitoring. A participant reminded the group that the goal of monitoring should not be just to show if something changed or not, but rather to explain how it changed and what can be done about it

A participant suggested to use a “diet approach” to have a more functional look at objectives towards the integrity of the system. A participant agreed it would be helpful to focus on energy pathways (through diet) by showing key species and their diets and then factoring in stressors

and how this will impact them. Although the quantity of prey in the system is often looked at (e.g., how many cod, or how thick is the blubber?) what is lacking is looking at the quality of the food items (e.g., caloric content differences between Capelin and cod). It was agreed that measuring parameters associated with diet and also adding stressors will translate into how the quality and quantify of energy between trophic levels can be measured. Possibilities discussed for measuring included to use direct measures as proxies (e.g., blubber) or monitor sentinel components of change within the ecosystem integrity. A participant added that in terms of monitoring, it could be possible to also look at the number of feeding links within a pathway as well as the width of these links. If this information is available, it could be used for models for different scenarios such as climate change.

It was agreed that hypotheses should be used to guide the selection of monitoring parameters and indicators that have direct cause/effect linkages to ecosystem integrity. Over-arching hypotheses should be formulated and can be used to make predictions about how the system will change in general. Those same hypotheses should then be narrowed down to make predictions about how/why each specific indicator of interest will change. By going through this exercise, one should be able to determine the expected mechanism of change and therefore have a list of important species to monitor.

A participant questioned if the focus should be more on the stressors that can be mitigated (with climate change still as a background threat). However, the group was reminded that since the MPA was not created due to a specific initial problem (e.g., commercial fishing) or threat, climate change should be considered an important focus. Additional threats identified include, colonizing species, vessel traffic, climate change, dumping from vessels (e.g., grey water, invasives), and coastal erosion. There was discussion of how the results of the previous CSAS process on Pathways of Effects could be used in the future to identify the indicators most important for monitoring change related to anthropogenic stressors.

Three classes of parameters were determined based on the updated list of indicators discussed to use to arrive at a minimum set of indicators to be monitored:

1. context parameters (e.g., oceanographic data, ice, etc.);
2. ecosystem integrity parameters (e.g., beluga presence/absence, zooplankton community composition, fish diet, etc.); and,
3. proxies for the issues associated with threats/stressors.

It was noted that these classes of parameters will need to be considered in parallel with each other.

DRAFTING OF THE SCIENCE ADVISORY REPORT

An overview and summary of next steps were discussed for the SAR. Summary bullets were roughly drafted and reviewed, however it was decided that a teleconference call would be needed to conclude.

Suggestions throughout the meeting of information to add to the SAR included:

- a summary of the changes in the MPA to date to recognize that the monitoring plan is not being started from a “pristine or undisturbed area” which sets the stage for the COs;
- the importance of oceanographic information that helps us to understand change within and outside the MPA (since the ANMPA is a small part of a broader regional area [Beaufort Sea] and therefore other monitoring plans and results should be considered in decision making processes); and,

- a reflection on what has occurred since the first SAR and what has been learnt as of now as far as information gained (add a statement of how science knowledge has exponentially increased in the region).

OTHER CONSIDERATIONS

It was suggested to possibly include connectivity to the TNMPA to compare and aid with the selection of common indicators for the ANMPA or for next steps moving forward. This could be done by adding a section about what has been done in the TNMPA for overlapping biological connections such as beluga.

It was suggested to include more information about harvester biases and observations possibly in the second working paper or SAR as it was not discussed in much detail.

It was noted that sampling design for any chosen indicator will still require expert consultation (i.e., the specific protocols) and will likely vary spatially for many indicators (north/south differences). It was suggested that the North/South geography issue will need to be addressed as monitoring of the different areas will likely require different approaches. It was also noted that since the area is an embayment, it will be important to consider environmental renewal for ecosystem integrity (e.g., water renewal which changes with rivers and circulation).

A section could be added on the baseline products the group identified that could be developed in the near future from retrospective analyses (sea ice patterns from historical ice charts, fish distribution maps, comparison of indicators to pathways of effects, etc.). These could be used to develop a Science Plan to accomplish these goals in collaboration with the ANMPA WG and WAMPA.

Although key species were not specifically identified in this meeting, it was recommended to use the COs to guide choices in identifying them, keeping in mind that they should be used as examples instead of as the sole focus. To allow such flexibility, it was also proposed to use broader functional groups instead of only certain species for planning purposes.

CONCLUDING REMARKS

A consensus was reached for each of the presented working papers. The chairs decided that that a second convening of participants through teleconference call would be needed to finalize the SAR. The chairs thanked the participants and the meeting adjourned.

REFERENCES CITED

Ardyna, M., Gosselin, M., Michel, C., Poulin, M., and Tremblay, J.-É., 2011. Environmental forcing of phytoplankton community structure and function in the Canadian High Arctic: contrasting oligotrophic and eutrophic regions. Mar. Ecol. Prog. Ser. 442: 37–57.

Bates, S.S., Beach, G.D., Comeau, L.A., Haigh, N., Lewis, N.I., Locke, A., Martin, J.L., McCarron, P., McKenzie, C.H., Michel, C., Miles, C.O., Quilliam, M.A., Rourke, W.A., Scarratt, M.G., Starr, M., and Wells, T. 2020. Marine harmful algal blooms and phycotoxins of concern to Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3384: x + 322 p.

Chavarie, L., Reist, J.D., Guzzo, M.M., Harwood, L., and Power, M. 2019. Influences of environmental variation on anadromous Arctic charr from the Hornaday River. Hydrobiologia 840:157–172.

DFO. 2011. Identification of Conservation Objectives and Boundary Delineation for the Darnley Bay Area of Interest (AOI). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/009.

DFO. 2012. Science Advice for Identifying Indicators for Monitoring Arctic Marine Biodiversity in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/053.

DFO. 2015a. Anguniaqvia niqiqyuam Area of Interest: Monitoring indicators, protocols and strategies. DFO Can. Sci. Advis. Secr. Sci. Advis. Rep. 2015/025.

DFO. 2015b. Proceedings for the regional peer review of the Anguniaqvia Niqiqyuam Area of Interest: monitoring indicators, protocols and strategies; February 19-21, 2014. Can. Sci. Advis. Secr. Proc. Ser. 2015/015.

Garneau, M.-E., Gosselin, M., Klein, B., Tremblay, J.-É., and Fouilland, E., 2007. New and regenerated production during a late-summer bloom in an Arctic polynya. Mar. Ecol. Prog. Ser. 345: 13–26.

Girdlestone, C.D., Piscitelli-Doshkov, M.A., Ostertag, S.K., Morell, M., and Shadwick, R.E. 2018. Description of cochlear morphology and hair cell variation in the beluga whale. Arctic Sci. 4(3): 279–291.

Hill, V., Cota, G., and Stockwell, D., 2005. Spring and summer phytoplankton communities in the Chukchi and Eastern Beaufort Seas. Deep Sea Res. II 52(24–26): 3369–3385.

Ivanova, S. V., Kessel, S.T., Espinoza, M., McLean, M.F., O'Neill, C, Landry, J., Hussey, N.E., Williams, R., Vagle, S., and Fisk, A.T. 2020. Shipping alters the movement and behavior of Arctic cod (*Boreogadus saida*), a keystone fish in Arctic marine ecosystems. Ecol. Appl. 30(3): e02050.

Lefebvre, K.A., Quakenbush, L., Frame, E., Huntington, K.B., Sheffield, G., Stimmelmayr, R., Bryan, A., Kendrick, P., Ziel, H., Goldstein, T., Snyder, J.A., Gelatt, T., Gulland, F., Dickerson, B., Gill, V., 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae 55: 13–24.

McNicholl, D.G., Dunmall, K.M., Majewski, A.R., Niemi A., Gallagher, C.P., Sawatzky, C., and Reist, J.D. 2020. Distribution of marine and anadromous fishes of Darnley Bay and the Anguniaqvia niqiqyuam marine protected area, NT. Can. Tech. Rep. Fish. Aquat. Sci. 3394: x + 90 p.

Schimnowski, O., Chmelnitsky, E., Hedges, K. and Loseto, L. 2017. Potential monitoring indicators, protocols and strategies for the Anguniaqvia Niqiqyuam Area of Interest. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/003. v + 23 p.

Pućko, M., Dionne, K., Michel, C., 2019. Occurrence of toxin-producing marine algae in the Canadian Arctic and adjacent waters. Can. Manuscr. Rep. Fish. Aquat. Sci. 3180: vii + 27 p.

Tremblay, J.-É., Anderson, L.G., Matrai, P., Coupel, P., Bélanger, S., Michel, C., and Reigstad, M., 2015. Global and regional drivers of nutrient supply, primary production and CO2 drawdown in the changing Arctic Ocean. Prog. Oceanogr. 139: 171–196.

Tremblay, G., Belzile, C., Gosselin, M., Poulin, M., Roy, S., and Tremblay, J.-É., 2009. Late summer phytoplankton distribution along a 3500 km transect in Canadian Arctic waters: strong numerical dominance by picoeukaryotes. Aquat. Microb. Ecol. 54: 55–70.

APPENDIX 1. TERMS OF REFERENCE

Science Advice to Assist in the Development of an Ecological Monitoring Plan for the Anguniaqvia niqiqyuam Marine Protected Area

Regional Peer Review – Central and Arctic Region

February 18-20, 2020
Winnipeg, MB and teleconference/WebEx

Chairperson: Jason Stow

Context

Fisheries and Oceans Canada (DFO) Science sector provides advice in support of the management and monitoring of Marine Protected Areas (MPAs). As part of the steps to establish Anguniaqvia niqiqyuam MPA (ANMPA), DFO Science provided advice on identifying monitoring indicators, protocols, and strategies (DFO 2015) that allows for the future evaluation that conservation objectives of the ANMPA are being met. A monitoring plan is currently being co-developed by DFO Oceans Program and the ANMPA Working Group as a key component for ANMPA management. This monitoring plan will provide a structured approach to gathering information to support the management and monitoring of ANMPA, to meet its conservation objectives.

The conservation objectives for ANMPA are:

- To maintain the integrity of the marine environment offshore of the Cape Parry Migratory Bird Sanctuary so that it is productive and allows for higher trophic level feeding;
- To maintain the habitat to support populations of key species (such as beluga whales, Arctic char, and ringed and bearded seals).

DFO Science will provide advice on the ecological themes identified in the draft monitoring plan developed by the ANMPA Working Group. Ecological monitoring advice will place previously identified indicators, protocols, and strategies (DFO 2015) in the context of recently published scientific and traditional (e.g., Kavik-Axys 2012, McNicholl et al. 2017) knowledge; and other information, and data available for ANMPA and the surrounding ecosystem. In addition, a generalized framework for the process of developing MPA monitoring plans that incorporates both scientific and indigenous knowledge will be reviewed using ANMPA as a case study. The resulting advice will inform the development of a monitoring plan by the ANMPA Working Group. A separate future CSAS review meeting will build on this advice to describe how the resulting plan may be implemented ‘on the ground,’ including the mechanics of data collections, analyses (e.g., strategy, threshold, sensitivity analysis), data management, and reporting.

Objectives

The monitoring plan developed by the ANMPA Working Group will ultimately address multiple themes, however, this request for Science Advice will be focused only on the ecological components. Specifically, the objectives of this CSAS are to:

1. Review a generalized monitoring framework that uses the nearshore ANMPA as a case study to outline a suggested process to consider when developing the generalized ecological aspects of an MPA monitoring program which incorporates both scientific and indigenous knowledge;

2. Identify, review, and summarize existing scientific information/data and published local and traditional ecological knowledge relevant to the area to inform future monitoring plan development (i.e., potential indicators, protocols, and strategies), and to identify key data gaps. The summary will build on past Science Advice provided for the Anguniaqvia niqiqyuam Area of Interest, providing an update on information that has since been acquired, and expanding the scope of review to include southern portions of the ANMPA, offshore regions that are not within the ANMPA but may be key to consider for meeting conservation objectives, and priorities defined by the ANMPA Working Group.

Expected Publications

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

Expected Participation

- Fisheries and Oceans Canada (DFO) (Science, Ecosystem Management sectors, and Fisheries Management)
- Environment and Climate Change Canada
- Canadian Wildlife Service
- Academia
- Other invited experts

References

DFO. 2015. Anguniaqvia Niqiqyuam area of interest: monitoring indicators, protocols and strategies. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/025.

Kavik-Axys. 2012. Traditional and Local Knowledge Workshop for Paulatuk Area of Interest. Report prepared for Fisheries and Oceans Canada by Kavik-Axys Inc., 123510605. Inuvik, NWT, and Calgary, AB. 46 p.

McNicholl, DG, Wolki, B., and Ostertag, S. 2017. Traditional Ecological Knowledge and local observations of Capelin (*Mallotus villosus*) in Darnley Bay, NT. Can. Manu. Rep. Fish. Aquat. Sci. 3144: vi + 20 p.

APPENDIX 2. LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Andrea Niemi	DFO – Science, Central and Arctic Region
Andy Majewski	DFO – Science, Central and Arctic Region
Ashley Ehrman	DFO – Science, Central and Arctic Region
Darcy McNicholl	DFO – Science, Central and Arctic Region
David Yurkowski	DFO – Science, Central and Arctic Region
Jasmine Brewster	DFO – Science, Central and Arctic Region
Jason Stow (Co-Chair)	DFO – Science, Central and Arctic Region
Jim Reist	DFO – Science, Central and Arctic Region
Joclyn Paulic (Co-Chair)	DFO – Science, Central and Arctic Region
Karen Dunmall	DFO – Science, Central and Arctic Region
Kayla Gagliardi (Rapporteur)	DFO – Science, Central and Arctic Region
Kimberly Howland	DFO – Science, Central and Arctic Region
Lisa Loseto	DFO – Science, Central and Arctic Region
Monika Pućko	DFO – Science, Central and Arctic Region
Neda Mehdipour	DFO – Science, Central and Arctic Region
Steven Alexander	DFO – Science, National Capital Region
Humfrey Melling	DFO – Science, Pacific Region
Jane Eert	DFO – Science, Pacific Region
Erica Wall	Environment and Climate Change Canada
Burton Ayles	Fisheries Joint Management Committee
Dustin Whalen	Natural Resources Canada
Stephen Insley	Wildlife Conservation Society Canada
Valerie Cypihot	Université Laval
John Iacozza	University of Manitoba

APPENDIX 3. MEETING AGENDA

Science Advice to Assist in the Development of an Ecological Monitoring Plan for the Anguniaqvia Niqiqyuam Marine Protected Area

National Peer-Review
Central and Arctic Region

February 18-20, 2020
Location: Fuschia Room, Alt Hotel, 310 Donald Street, Winnipeg, MB
Chairpersons: Jason Stow and Joclyn Paulic

DAY 1 – TUESDAY, FEBRUARY 18

8:45 a.m. Coffee/tea and settling in

9:00 a.m. Welcome and Meeting Introduction (Chairs)
- Participant Introduction (Please be prepared with a few sentences about your background, knowledge and expertise for this meeting)

9:30 a.m. Overview of the CSAS Peer Review Process (Joclyn Paulic)
- Review Terms of Reference
- Review Meeting Agenda

9:45 a.m. Fisheries and Oceans Canada Policy Perspective (Jasmine Brewster)
- Historical context of ANMPA
- Progress to date on monitoring plan development
- Anticipated outcomes from the current request for science advice

10:15 a.m. Health Break (coffee, tea, and water provided)

10:30 a.m. Working Paper #1 Overview (Karen Dunmall)
- Using the ANMPA to build a framework for linking Indigenous and Scientific knowledge in a monitoring plan
- Open discussion and input

12:00 p.m. Lunch (not provided)

1:00 p.m. Working Paper #2 Overview (Ashley Ehrman)
- Review and discussion on scientific considerations for an ecological monitoring plan, criteria for indicators, and general list of indicators

1:45 p.m. Discussion – applicability of indicators that provide background environmental context
- Core oceanography
- Benthic habitat distributions
- Ice structure, thickness, and break-up timing
- Coastal erosion

2:30 p.m. **Health Break (coffee, tea, and water provided)**

2:45 p.m. Continued Discussion

3:15 p.m. Discussion – applicability of indicators that inform the status of the conservation objectives

- Under-ice, ice-associated, and open-water biota
- Concentration of nutrients
- Biodiversity of lower trophic level species
- Benthic community composition, structure, function, and energetics

4:50 p.m. Summary of Day 1 and review Day 2 agenda (Chairs)

5:00 p.m. Day 1 Adjourns

DAY 2 – WEDNESDAY, FEBRUARY 19

8:45 a.m. Coffee/tea and settling in

9:00 a.m. Summarize Day 1 and review Day 2 agenda (Chairs)

9:10 a.m. Discussion – applicability of indicators that inform the status of the conservation objectives

- Offshore fish community composition, structure, function, and energetics
- Inshore fish community composition, structure, function, and energetics
- Presence/absence, timing, and semi-quantitative abundance of Capelin spawning on beaches
- Anadromous fish abundance, size, condition, and population structure
- Fish diet composition
- Marine bird presence/absence and prey items
- Marine mammal presence/absence, timing, locations, and group composition
- Marine mammal prey composition
- Anthropogenic underwater noise
- Uncommon ecological occurrences

10:30 a.m. **Health Break (coffee, tea, and water provided)**

10:45 a.m. Continued Discussion

12:00 p.m. **Lunch (not provided)**

1:00 p.m. Review of linkages between indicators (Ashley Ehrman)

- Completion of Table 2 from Working Paper #2 as a group

2:00 p.m. Review of existing data collection and research programs that can address monitoring needs (Karen Dunmall and Ashley Ehrman)
- Completion of Table 3 from Working Paper #2 as a group

2:30 p.m. Health Break (coffee, tea, and water provided)

2:45 p.m. Continued discussion

3:15 p.m. Identification of key knowledge gaps and next steps

4:00 p.m. Acceptance of working papers (Karen Dunmall and Ashley Ehrman)

4:10 p.m. Presentation and discussion of draft Science Advisory Report (Chairs)

4:50 p.m. Summary of Day 2 and review Day 3 agenda

5:00 p.m. Day 2 Adjourns

6:00 p.m. Group dinner for those interested. Location TBD.

DAY 3 – THURSDAY, FEBRUARY 20

8:45 a.m. Coffee/tea and settling in

9:00 a.m. Summarize Day 2 and review Day 3 agenda (Chairs)

9:10 a.m. Continue drafting Science Advisory Report and summary bullets

10:15 a.m. Health Break (coffee, tea, and water provided)

10:30 a.m. Continue drafting Science Advisory Report and summary bullets

11:00 a.m. Finalization and acceptance of summary bullets

11:45 a.m. Summary of meeting, outcomes, and next steps

12:00 p.m. Meeting complete – THANK YOU