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SCIENCE REVIEW OF THE ECOLOGICAL RISK ASSESSMENT SCORING FOR THE TUVAIJUITTUQ MARINE PROTECTED AREA (MPA)

Context

Under the *Oceans Act*, the Minister of Fisheries, Oceans, and the Canadian Coast Guard is responsible for leading and coordinating the development and implementation of Marine Protected Areas (MPAs) on behalf of the Government of Canada. Undertaking an ecological risk assessment to identify risks to the conservation priorities (or conservation objectives) of a MPA is a fundamental step in the MPA establishment process. In August 2019, the Tuvaijuittuq MPA (Figure 1) was established by Ministerial Order, which freezes the footprint of an area for up to five years while the Government of Canada and its partners conduct an assessment of the feasibility and desirability of long-term protection in the area. In anticipation of a decision on long-term protection, DFO is pursuing an ecological risk assessment for Tuvaijuittuq, which will be needed to inform regulatory decisions (i.e., which activities are allowed and which are prohibited) should an *Oceans Act* MPA be established.

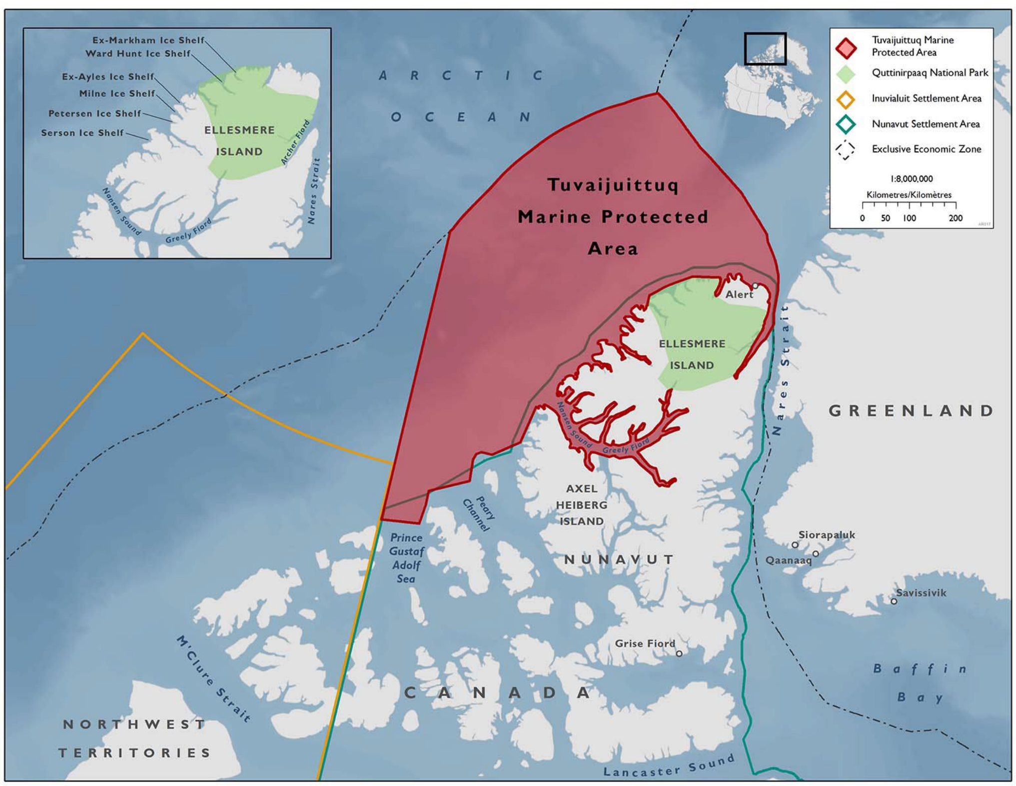

Figure 1. Current boundaries of the Tuvaijuittuq Marine Protected Area established by Ministerial Order (DFO 2019).

Canada

The ecological risk assessment is a systematic and transparent process for gathering, evaluating, and recording information on the risks posed to ecologically significant components (ESCs) within an area by human activities that are occurring or may occur, and which could reasonably be mitigated through regulation. The risk assessment for Tuvaijuittuq will be based on an Ecological Risk Assessment Framework (ERAF) developed for the Arctic, which provides a consistent approach for calculating risk of harm to Arctic ecosystems from stressors associated with human activity. The ERAF was developed by DFO Marine Planning and Conservation (MPC) Arctic Region, with input from a regional DFO risk assessment working group with membership from MPC, the Canadian Science Advice Secretariat (CSAS), Science, and Fisheries Management sectors. The risk scores produced through this CSAS process will draw on previous Science advice (DFO 2020), a summary of existing knowledge for the area (Charette et al. 2020), and a draft Pathways of Effects (PoE) report developed for Tuvaijuittuq.

DFO MPC Arctic Region requires Science advice to validate ecological risk scores for Tuvaijuittuq conservation priorities developed using the Arctic Region ERAF, to ensure that findings are consistent with existing literature and knowledge of the area. These scores are necessary to produce an ecological risk assessment report and guide the establishment of an *Oceans Act* MPA by Governor-in-Council, should one be recommended in Tuvaijuittuq.

This Science Response Report results from the regional peer review of April 21–22, and May 5, 2022 on the Review of the Ecological Risk Assessment Scoring for the Tuvaijuittuq Marine Protected Area (MPA).

Background

Tuvaijuittuq has the oldest and thickest sea ice in the Arctic Ocean. As sea ice continues to decline in the Arctic, the multi-year ice (MYI) in this region is projected to remain the longest. Marine protection is being sought in Tuvaijuittuq in large part due to this presence of MYI and its anticipated role as a refuge for ice-dependent species. A better understanding of this region is critical to characterize sea ice properties and dynamics in the region, particularly MYI thickness and trends which are necessary to improve baseline knowledge and help constrain future climate change predictions (DFO 2020). A better understanding of this region will be critical as climate change continues to result in dramatic declines in sea ice which allow for the Arctic to become more accessible to commercial activities such as shipping, tourism, and mining.

There is very little scientific information available for Tuvaijuittuq compared to other parts of the Arctic, owing to its extreme climate, remoteness, and the presence of thick MYI. This lack of knowledge applies across all areas of study of the natural environment, including biotic and abiotic components of the area and their interconnectivity. While this lack of information is acknowledged, the *Oceans Act* and DFO’s guiding principles promote use of the precautionary approach. In this case, due to the absence of scientific certainty, conservation measures can and should be taken into consideration when there is a high risk of impact, and a lack of certainty should not act as a reason to postpone or fail to take action to preserve the marine environment.

The most significant knowledge gaps for Tuvaijuittuq are discussed in detail by Charette et al. (2020); however, it is recognized that the lack of information for this area is a major constraint to estimating ecological risk. It is also likely that further scientific research in Tuvaijuittuq may identify additional priorities for conservation that are currently unknown. As marine protection measures in Tuvaijuittuq are further advanced, it is expected that this will create additional support and opportunities for concerted data collection from the area, which will also further inform management. For this reason, an adaptive management approach will be essential in order to consider the discovery of new species or ecological features that were previously undetected/unidentified and how to adapt in a rapidly changing environment (e.g., loss of sea ice).

Prior to the peer review meeting, a scoping exercise was conducted to define the spatial and temporal bounds of the assessment and determine which ESCs and human activities should be assessed. ESCs of the Tuvaijuittuq study area are described in Charette et al. (2020). These ESCs (i.e., conservation priorities) were further refined into subcomponents (Table 1). The scoping information was provided as a separate background document to help inform the meeting and the appropriate scoping paragraphs will be added to the final risk assessment report. The geographic extent of this ecological risk assessment was defined by the current boundaries of the Tuvaijuittuq MPA by Ministerial Order (Figure 1), also referred to as the study area. The temporal scope of the assessment aimed to examine activities that are existing and/or foreseeable in the future. For the purposes of this exercise, five primary types of activities were considered to be within the scope of the assessment and likely to have measurable effects on one or more ESC subcomponents: 1) Scientific Research; 2) Recreation and Tourism; 3) Shipping and Vessel Traffic; 4) Mining and Mineral Exploration and Development; and 5) Oil and Gas Development. However, given that Mining and Mineral Exploration and Development and Oil and Gas Development are not feasible within the Tuvaijuittuq area under present conditions, these activities will not be carried forward for assessment. Interactions identified in the PoE report that were not expected to manifest into measurable impacts to ESC subcomponents, or where federal regulations (e.g., *Oceans Act* MPA regulations) are not able to mitigate the stressor, were scoped out of the ecological risk assessment.

The lack of information and data available from Tuvaijuittuq was a foremost consideration in scoping this risk assessment. In many cases, there is no direct evidence of impacts of a given stressor to the species or habitats in Tuvaijuittuq simply because there is uncertainty in species distribution and diversity within the study area. Similarly, many unique habitats within Tuvaijuittuq are unknown or very poorly characterized (e.g., ice shelves, MYI). In these cases, and where possible, evidence from other areas of the Arctic was used to inform the development of risk scores. However, extreme diligence and care is required when using direct comparisons to Tuvaijuittuq when assessing activities and stressors, due to the unique nature of the area, and the final assessment will rely heavily on the experience of subject matter experts.

In cases where a stressor manifests from multiple pathways in a similar manner, proxy assessments were used to increase the efficiency of the assessment. In these cases, the assessment of one pathway can cover the other assessment by proxy (e.g., the introduction of non-indigenous species via a grounded vessel can act as a proxy for introduction of non-indigenous species via anchoring/mooring gear). The most sensitive species in an assemblage (e.g., corals and sponges as the most sensitive benthic invertebrates) can also be used as a proxy for other assessments in the same assemblage if adequate rationale is provided.

Though the effects of climate change are already observed and expected to be pronounced throughout the Canadian Arctic, Tuvaijuittuq is uniquely impacted by climate change in that it is a refuge where MYI continues to persist, where in other areas it has been replaced by first-year ice (FYI). Tuvaijuittuq also contains Canada's only ice shelves and associated shelf-coastal ecosystems. As such, conservation priorities in the area may be irrevocably changed by climate change, yet there is a unique opportunity and responsibility to characterize existing diversity ahead of these changes (Michel and Lange 2018, Michel et al. 2019). Where possible, climate change and its ramifications were incorporated in scoring the sensitivity of a conservation priority to a given stressor. Additional considerations related to climate change were discussed and considered throughout this CSAS peer review process.

The risk scores that were the subject of this Science Response Process were developed based on a number of previous assessments of the Tuvaijuittuq study area, including primary studies (e.g., Melling et al. 2002, Mueller et al. 2006, 2008, Vincent et al. 2001, 2011, Michel and Lange 2018, and Michel et al. 2019), a synthesis of existing knowledge and gaps related to the ecologically and biophysically significant features of the area, and further examination of components of the area that warrant conservation measures (Charette et al. 2020, DFO 2020). In addition, DFO MPC Arctic Region, in collaboration with representatives from CSAS, Fisheries Management and Science, has developed foundational components of the risk assessment for Tuvaijuittuq, including the Arctic Region ERAF, and a PoE Assessment for Tuvaijuittuq. The PoE serves as an inventory of potential pathways of effects by which human activities and their associated stressors may affect conservation priorities of the area, while the ERAF provides the methodology required to develop risk scores for those pathways that could manifest into measurable effects to conservation priorities.

Ecologically Significant Components (ESCs)

ESCs (i.e., conservation priorities) of the Tuvaijuittuq study area were identified by Charette et al. (2020). Should an *Oceans Act* MPA be established in Tuvaijuittuq, these priorities would be refined in collaboration with partners into conservation objectives, which would inform the regulations and ongoing management and monitoring of the area. Conservation objectives are statements that describe the desired and measurable state of the conservation priority to achieve conservation goals. As conservation objectives for Tuvaijuittuq have not been developed, the current risk assessment approach was focused on evaluating ESCs by their individual subcomponents (Table 1). For the purpose of this risk assessment, the ECSs were broken down into subcomponent groups of species, other biota and community assemblages, or habitats. This overall approach allows for greater flexibility as ESCs inform the development of conservation objectives.

Table 1. Breakdown of Ecologically Significant Components (ESCs) into subcomponents of species, other biota and community assemblages, and habitat characteristics.

Ecologically Significant Component (ESC)	Applicable ESC subcomponents
Sea ice	• Ice algae • Ice-associated biota • Multi-year ice • First-year ice (includes mobile and landfast ice)
Ellesmere Island Ice Shelves	• Seabirds • Ice-shelf biota
Tuvaijuittuq Fiords	• Northern Ellesmere Island Fiords • Nansen Sound/Greely Fiord Complex • Marine mammal habitat in Lady Franklin Bay/Archer Fiord
Sea Ice-associated Communities	• Arctic cod (*Boreogadus saida*) • Narwhal *(Monodon monoceros)* • Atlantic walrus (*Odobenus rosmarus rosmarus)* • Bearded seal (*Erignathus barbatus*)

Ecologically Significant Component (ESC)	Applicable ESC subcomponents
	• Ringed seal (*Pusa hispida*) • Polar bear (*Ursus maritimus*) • Seabirds • Ice algae • Other ice-associated biota
Benthic Communities	• Benthic biota • Benthic substrate
Offshore and Coastal Pelagic Food Webs	• Arctic char *(Salvelinus alpinus)* • Arctic cod • Narwhal • Atlantic walrus • Bearded seal • Ringed seal • Polar bear • Seabirds • Other pelagic biota
Nesting Habitat for Seabirds	• Seabirds • Northern Ellesmere Island Fiords • Nansen Sound/Greely Fiord Complex

Analysis and Response

The comments presented in this Science Response pertain to a draft Tuvaijuittuq risk assessment data report prepared by LGL Consultants, which consisted of the ecological risk assessment tables with scores and rationale for each of the assessed interactions. The findings of this review will allow MPC to update and revise the draft risk assessment tables to ensure the appropriate changes are made to finalize the risk assessment report. The objective of this peer review was to provide expert validation of the scoring against the ESC subcomponents. This involved ensuring that the most relevant and appropriate information was used and correctly interpreted for the ESC subcomponents, activities, and stressors. This assessment focused on activities that can be mitigated through regulation. Activities that cannot be prohibited (e.g., international commitments under the United Nations Convention on the Law of the Sea [UNCLOS] for the right to innocent passage, national defense, safety and security) were not included in the assessment. The focus of the peer review was not to discuss any management measures or recommendations as these considerations and decisions will be informed by this, and other, future processes.

This Science Response Report documents the discussions and advice received for validating the scoring against the ESCs as well as the general and unique challenges associated with conducting a risk assessment for an area like Tuvaijuittuq that is large, remote, data poor, and especially susceptible to the impacts of climate change. This advice will be considered and applied towards finalization of the risk assessment and may be used to inform future ecological risk assessments within the Arctic Region.

This was the first CSAS process of its kind to review Arctic ecological risk assessment scoring. As such, there were some major challenges to overcome, particularly relating to the complexity of the process and large data gaps. The first two meeting days focused mainly on overall discussions to provide meeting participants with greater clarification on the scoring process. A number of overarching review comments were provided for application to all scoring tables. Many of the initial review comments were resolved through discussion within the first two days and are therefore not summarized in detail in this report. An additional third meeting was required to review the remaining activities. A list of interactions from the draft report that was peer reviewed is provided in Appendix A. Since overarching and specific advice provided in the CSAS meeting led to a number of changes to the assessed interaction scores and the rationale for the scoring, the original scores presented to participants are not outlined in this report.

Overarching Review Comments

The following points were discussed throughout the meeting and are captured here for consideration in the final risk assessment. These points may also be used to help strengthen future Arctic ecological risk assessment processes.

- Participants acknowledged that it was not useful to compare overall risk scores among ESCs or activities since each score is unique and dependent on a number of different factors that take sensitivity and exposure into consideration. Rather than focus on the scores themselves, it was more beneficial to ensure that the correct information was used to produce the scores.
- There was an overall need for consistency throughout scoring tables. For example, in cases where the same rationale and reference was used, but a different score was assigned, rationale or, in some cases, a revised score, was needed. Differences should be reconciled for the final risk assessment report.
- Risk statements should be as specific as possible to avoid misinterpretation. The activity/stressor of focus (i.e., expected to have the highest impact) should be clearly stated and the taxonomic organism or group of focus (i.e., expected to be the most sensitive) for the assessment should also be specified.
- The majority of temporal overlap scores required adjusting based on advice to interpret the temporal definition differently. The ERAF defines temporal scores based on the potential co-occurrence of the activity/stressor and when the ESC subcomponent is present over the course of a year (i.e., duration of stressor/duration of presence of ESC); however, many of the original scores were calculated based on using duration of activity/stressor as the denominator (i.e., duration of presence of ESC/duration of stressor/activity), which resulted in an overestimation of most temporal overlap scores.
    - For example, for noise disturbance (stressor) from scientific research (activity): although scientific research would only be planned to occur when the species is present, which means the potential overlap is very high as initially calculated, the temporal overlap should consider the limited period of time the research would be conducted (i.e., only a limited number of days or hours depending on the research project) relative to the amount of time the ESC is present in the area (i.e., weeks, months or year-round), resulting in lower scores.
- There was lengthy discussion about the spatial scale of the assessment being considered for each ESC subcomponent and how it affects the scoring of sensitivity across the entire population in the study area. Typically, an ERAF assesses risk to an ESC subcomponent

throughout the entire area of study. However, some ESC subcomponents have a restricted distribution within Tuvaijuittuq (e.g., walruses are only known to occur in Archer Fiord). Therefore, if the interaction was examined assuming that walruses occur throughout the entire study area it would offer a lower estimation of risk, especially if the activity (i.e., vessel traffic) is also largely present in Archer Fiord. The inverse situation was also highlighted, for example with Arctic cod as they are assumed to be widely distributed throughout the study area. As sensitivity scores are assessed on the population as a whole, for an activity that is spatially restricted (i.e., all activities in the case of this study area) it became difficult to rationalize measurable impacts to the entire population of Arctic cod. These examples highlighted a challenge with designating a large protected area which supports a widespread species or a large portion of a population in a localized area. In cases where the subcomponents were spatially restricted, such as for walruses and narwhal, it was recommended to focus the assessment on the area where they occur so as not to dilute the overall risk. In cases where the subcomponents are known to have large distributional ranges and/or there is a lack of data for the population, such as for seals and Polar bears, the study area as a whole remained as the focus of the assessments.

- The term “foreseeable future” was used throughout the document. A specific time frame was not recommended so as to allow flexibility; however, it was generally agreed upon that 10 years was reasonable for the purposes of assessment in most cases. It was decided that statements about how activities may increase or not in future should be removed from the tables as the assessment should focus on the current state of the area and information available.
- Regulations and current standards that limit certain activities, such as marine mammal regulations, or protection measures associated with the *Species At Risk Act*, should be included where appropriate within assessment tables (i.e., under the intensity rationale, potential mitigation options, or likelihood rationale).
- Clarifications in the rationales for likelihood scores are needed throughout the draft risk assessment tables and more justification should be provided where possible, expanding on the particulars of the species and activity involved. It was clarified that likelihood should consider the probability of demonstrable effect resulting from the stressor rather than just the probability of the activity.
    - For example, for the assessment of biota loss (stressor) from scientific research (activity) on ice algae, an interaction would occur if scientific research involving ice algae sampling took place; however, the likelihood of detectable biota loss from these interactions would be very low.
- Available scientific knowledge relating to the ESC subcomponents should be added where possible to inform the uncertainty scoring and rationale (i.e., information should not be limited to the activity).

Participants were invited to this peer review based on their expertise related to ESC subcomponents, activities/stressors, or both, and provided advice to ensure that the best available information was used to asses the interactions. In cases where additional information was provided, scores were updated where appropriate (e.g., recovery factors, species distribution, stock information). A detailed summary of all of the updates to ESC subcomponent information is not provided in this report, but the changes will be reflected in the final risk assessment. Some examples of discussions and recommended edits included:

- The need to highlight the importance and uniqueness of MYI and how it is unlikely to regrow given the effects of climate change. This should be reflected in the recovery factor scores.
- Information should be updated regarding best available knowledge for seasonal distribution and stock information for narwhal in the area.
- Life history information should be updated for Polar bears and reflected in the recovery factor scoring.
- The option of removing seabirds from the draft risk assessment report was discussed since DFO does not have jurisdiction on land; however, since seabirds have life history critically tied to the study area, which is marine, it was agreed to keep the original approach of including them in the assessment.
- The option of grouping Ringed and Bearded seals together was discussed given that much of the rationale for risk factors and overall scores were similar; however, it was agreed to keep the original approach of assessing them separately based on significant differences in life history.
- The ESC subcomponent “landfast ice” should be re-named to “first-year ice (FYI)” to include both mobile and landfast components.
- Ice algae should be scored based on the “habitat” recovery factors (i.e., habitat availability, growth rate, and ability to recover from physical disturbance) rather than the “species” recovery factors since it functions more as a community and therefore did not align with the associated life history traits of the species recovery factor criteria.

Activities and Stressors

As information inherent to the ESC subcomponents was agreed to (such as life history characteristics and recovery factors) it was noted that these changes would be applied to each of the relevant tables. The remainder of the peer review meeting was primarily focused on reviewing the different activities (e.g., vessel traffic) and associated stressors (e.g., vessel strikes), with the aim of reaching consensus on the information and parameters used to produce the scores. The following subsections summarize information relating to the stressors and activities discussed and associated recommendations. Recommendations are listed as they occurred throughout the peer review and since many apply to more than one activity/stressor the final risk assessment report will be adjusted accordingly.

Scientific Research

To date scientific research has been limited in space and time in Tuvaijuittuq and a small number of sites have been explored as part of specific research projects (DFO 2020). It is recognized that there are numerous platforms and methods by which research can be conducted; however, the purpose of the assessment is to focus on the most impactful activity. It was recommended to include a statement in the scoping rationale to better clarify that other activities were considered but these would be accounted for by addressing the most impactful activity. As scientific research would be anticipated to occur throughout short periods within the year (i.e., only a number of hours per day and few days per year), the temporal overlap scoring for the following assessments was low.

Noise disturbance

The most likely source of noise disturbance during scientific research in the area is from the platform used during surveys or to travel to study sites. Platforms most likely to be used are fixed-wing aircraft (e.g., de Havilland Twin Otters) for surveys and drones for behaviour and life history studies. Helicopters may also be used for transferring scientists but are assessed in the recreation and tourism section. Vessels and icebreakers are other possible platforms but are assessed in the shipping and vessel traffic section. Snowmobiles may also cause noise disturbance as they can be used for traveling over ice to access research camps, typically in spring; however, fixed-wing aircraft were the focus of these assessments since they are expected to have the most measurable impact. This section also considered periodic aircraft overflights from supply flights out of Eureka and CFS Alert and potential Twin Otter charter flights from Resolute to the Tanquary Fiord camping site as part of recreation/tourism to account for additional fixed-wing aircraft noise, both of which would be primarily short-term, point source disturbances associated with take-offs and landings. It was noted that although there are regulations in place for both drones and aircraft that regulate approach distances for marine mammals, special permits can be attained for scientific research purposes that allow for reduced approach distances.

Atlantic walrus, narwhal, Ringed and Bearded seals, Polar bears, and seabirds were assessed in this section. There was lengthy discussion regarding the spatial scale of the assessment and how it affects the scoring for species that are locally distributed in Tuvaijuittuq such as Atlantic walrus and narwhal, both of which are only known to occur in Archer Fiord, as opposed to seals and Polar bears which are expected to be more widely distributed. Subsequent to advice from the peer review, the Atlantic walrus and narwhal assessments were updated to base the interactions on taking place in Archer Fiord (i.e., by assuming that the activity/stressor would be occurring there where they are found) to avoid potentially diluting the overall risk. This change was applied to all Atlantic walrus and narwhal tables within the assessment.

For the Atlantic walrus assessment there was discussion about how the time period that the flight is overhead, the altitude flown at (typically at 1,000 feet to avoid disturbance), and frequency of flights should be considered in the scoring rationale. The chronic change score was discussed in relation to haulout abandonment. DFO conducts scientific surveys for walruses on a regular basis in other areas of the Arctic and it is known from previous studies that walruses are highly sensitive to disturbance in general (DFO 2019). There are examples of measurable impacts such as repeated disturbance resulting in stampedes that lead to temporary abandonment of haul out sites; although there is uncertainty regarding the source of disturbance (e.g., from aircraft or other sources) and if it can be linked to permanent abandonment of sites. Although there are no known haulout sites in Tuvaijuittuq (Charette et al. 2020), a precautionary approach should be taken since there is high uncertainty regarding the potential impacts of noise disturbance to walruses.

Although DFO does not have jurisdiction on land, participants agreed with the original approach of including seabirds in this section of the assessment since their life histories are tied to the study area, which is marine. It was recommended to add more explicit information to the risk statements and assessment information to clarify why seabirds were assessed.

Biota encounters/handling

Biota encounters as part of scientific research may occur occasionally in Tuvaijuittuq at low density. The two ESC subcomponents assessed in this section were seabirds and Polar bears. The possibility of scoping out the interaction for biota handling on seabirds was discussed at length, given that this is almost certain to occur on land and beyond the jurisdiction of a marine protected area. It was clarified that the interaction refers to handling but also encounters overall, which could include activities such as incidental take, harassment, or displacement from boating disturbance. Biota encounters as part of scientific research may therefore occur occasionally and at low density. Encounters would most likely occur when snowmobiles are used on the ice thus this was the focus in the assessment table. Effects on seabirds specifically from vessels were assessed in the recreation and tourism/vessel underway sections instead.

Few studies have been conducted on Polar bears in the study area due to the remote location and high cost of doing research there. Future studies are not likely to be large scale or intensive, including the establishment of scientific camps on the ice which have the potential to attract Polar bears. A measurable increase in mortality to Polar bears may occur because of a defense of life and property kill at a scientific research camp, although this would be negligible in terms of population level effects. As defense kills have been low in scientific camps across the Arctic, this occurrence would not be expected to have measurable effects on population levels or overall fitness of populations.

Biota loss

Ice algae was the only interaction assessed for this section. Scientific research has been limited in space and time in the area and studies that have occurred in the region are not expected to cause significant biota loss. For example, scientific sampling for ice algae or disruption of ecological communities through ice coring would occur in relatively few, restricted locations within the study area, overlapping the ice algae habitat range at single point source locations (e.g., Mundy et al. 2005, Kohlbach et al. 2020). It was agreed that these activities would have a very small footprint compared to the distribution of ice algae.

Habitat alteration/removal

This section assessed interactions for MYI and FYI. Scientific research impacting MYI and FYI, in particular ice coring (Michel and Lange 2018, Michel et al. 2019), but also activities that involve drilling through the ice to enable mooring deployments, CTD profiles, and zooplankton net hauls is infrequent and has an extremely small footprint compared to the current area covered by MYI and FYI. Melting holes for diver-ROV access could occur in the future but would represent a similar intensity to drilling/coring. Climate monitoring at weather stations on land do not spatially overlap with MYI and FYI. Even when considering an increase in research activities involving drilling or coring in MYI and FYI in the future (e.g., for monitoring), the intensity is still expected to be low.

Participants discussed whether to score MYI as a physical feature or as a habitat that supports biota. Since MYI is a space that supports biological interactions, the loss of this habitat would be significant. Reflecting its importance as a habitat, the scoring rationale for this interaction was updated to include biota in the narrative with regard to sensitivity.

There was discussion and consensus to rename the original ESC subcomponent “landfast ice” to “FYI” so that it would include both mobile and landfast ice that is formed and melts on an annual basis. Participants were more comfortable with replacing landfast ice with FYI instead of assessing both subcomponents separately, so as not to mix the two different types of classifications.

Recreation and Tourism

At present, marine-based tourism in Tuvaijuittuq has been very limited due to persistent ice cover throughout the majority of the study area. An analysis of vessel traffic by Maerospace Corp. (2019) revealed that between 2012 and 2019, one icebreaking cruise ship (the Kapitan Khlebnikov, in September 2016) entered Tuvaijuittuq at Greely Fiord through Eureka Sound. Prior to 2012, there are also records of the Kapitan Khlebnikov sailing into both Tanquary Fiord and Fort Conger, providing passengers with access to Quttinirpaaq National Park at two locations (Stewart et al. 2008). It is recognized that tourism is a key concern for many communities and while interest in cruise ship tourism in Tuvaijuittuq may grow as MYI declines, this type of activity is currently minimal due to accessibility issues and dangerous ice conditions. Recreation and tourism activities would be expected to occur primarily during the period of maximum open water (i.e., August and early September) therefore the temporal overlap scoring for the following assessments was low.

Biota encounters/handling

The interaction between seabirds and biota encounters from recreation or tourism was assessed since tourism could potentially overlap with areas of seabird habitat. Biota encounters as part of recreation and tourism may occur occasionally and at low density. Since an icebreaking cruise ship has visited Quttinirpaaq National Park in the past, this assessment was focused on biota encounters from small boats that could ferry tourists to shore to access the park. Such encounters may include close approach to active bird nests; however, biota handling would likely not be permitted by regulatory agencies.

Noise disturbance

Seabirds, Ringed and Bearded seals, and Atlantic walrus were assessed in this section. The most likely platforms for recreation and tourism in the area are cruise ships, icebreakers and possibly fixed-wing charter flights. Since the risk of noise disturbance from icebreakers and fixed-wing charter flights are covered in separate sections related to vessel noise and scientific research, this section focused on noise disturbance from helicopter excursions associated with cruise ships as this is currently the only air traffic associated with cruise travel. It was noted that there are regulations in place under the *Fisheries Act* that restrict aircraft approaches to marine mammals to minimize disturbance, which should be factored into the scoring.

Shipping and Vessel Traffic

Tuvaijuittuq has a low density of vessel traffic. Between 2012 and 2019 the only confirmed vessel tracks identified were from five icebreakers (Amundsen Science 2019, Maerospace Corp. 2019). The vessels were present only in two regions, Greely Fiord or Hall Basin and Robeson Channel. Since the stressor occurs at low density (e.g., effort, number of events, amount) and/or demonstrates low persistence, the intensity scores for the majority of shipping related interaction tables were low. After discussion about the time period vessels would be expected to be present in the area it was determined that the original temporal scores would need to be lowered. Even though vessels have occurred in the study area mainly during August with some occurring in September, or 7–8 weeks out of the year, the cumulative days that vessels are expected to be active in the area is low.

Small vessels such as zodiacs could be launched from cruise ships and are often used to take people to shore when visiting Arctic communities, however the impact would be short term and localized. It was noted that since the nearest communities are hundreds of kilometers away, small vessels are unlikely to occur within the study area, and therefore were not included in the assessments of this section. This section also did not assess submarines as data were not available. Although the right to innocent passage could apply to all vessels, there are still mitigation measures that can be applied (e.g., voluntary vessel slowdowns) as per UNCLOS obligations.

Vessel Underway

Noise disturbance

The potential impact of noise generated by vessels to marine fauna, including marine mammals, Arctic cod, and seabirds, was assessed in this section. These assessments focused on noise produced by vessels underway (i.e., from engines, propellers, and sonar equipment) regardless of vessel type. Additional noise produced from deliberate icebreaking was considered in the noise disturbance from icebreaking section.

There was a brief discussion on the depth score for Arctic cod. Arctic cod are widespread but can be distributed at the bottom or in the pelagic zone. A thermocline could affect sound penetration at depth, and there was some discussion about possibly reducing the depth score, but since the original values were based on the most sensitive aspect of the ESC subcomponent (i.e., there are places within the study area where the sound will interact with Arctic cod) there were no recommended changes to the depth scores.

Similar to the other noise disturbance assessments for Atlantic walrus and narwhal, the assessments were updated based on advice to restrict the spatial scope of the interactions to Archer Fiord.

Vessel strikes

The potential impact of vessel strikes to marine mammals and seabirds was assessed in this section. For seabirds it was discussed and noted that impacts from artificial light would likely be the key stressor from vessels underway, although this is species-dependent. Collisions with vessels underway may cause fatalities in some individuals of susceptible species, and of the species known to occur in the study area, only King Eider (*Somateria spectabilis*) are expected to be particularly susceptible to this stressor based on susceptibility of the closely related Common Eider (*Somateria mollisima*) (Kingsley 2006, Merkel 2010). These collision events are unlikely during the day and vessels are mainly present in the area during the time of year when daylight is extensive, although collisions may occur during periods of poor visibility such as fog (Merkel 2010). Although mortality may occur in a collision between a seabird and vessel, it is not expected that mortality rates would be detectable against background variation unless it were to occur for an at-risk species.

It was flagged during the peer review meeting that of the marine mammals that occur in the area, Bowhead whales are the most susceptible marine mammal to vessel strikes and potential mortality from these strikes. Bowhead whales were not identified as a key marine mammal species in the biophysical and ecological overview for the Tuvaijuittuq area since they may only occur there rarely and were therefore not originally assessed. It was recommended to assess marine mammal habitat in Lady Franklin Bay/Archer Fiord and base the scores and rationale on Bowhead whales. Although Bowhead whales may be more susceptible to a ship strike in areas of open water than other Arctic cetaceans, the likelihood of the interaction occurring, particularly in Lady Franklin Bay/Archer Fiord considering the density of vessel traffic was scored as rare.

Water displacement

The only interaction assessed in this section was for seabirds. It was noted that nest inundation due to the wake from vessels underway would be spatially limited to shorelines within a few hundred metres of the vessel, and that vessel activity in close proximity of the shoreline is expected to be minimal in the study area. The low density of vessels and the small percentage of nests that would occur just above the high-tide line result in a rare likelihood of nest inundations.

Icebreaking

Active icebreaking is an infrequent activity in the area that occurs mainly during August with some vessels occurring in September. This section investigated all potential stressors that could impact ESC subcomponents as a result of icebreaking, under the assumption that it does occur. Most, if not all, icebreaking traffic would be expected to occur during the summer and early fall period, resulting in low temporal overlap scores for the following assessments. Icebreaking could occur throughout a large portion of the area depending on the time of year and would be expected to occur primarily in consolidated pack ice or landfast ice and unlikely to occur in areas of thick MYI. Icebreaking in FYI would be expected to occur mainly in fiords and inlets.

Noise disturbance

The potential impact of noise generated by icebreakers to marine fauna, including marine mammals, Arctic cod, and seabirds, was assessed in this section. Icebreaking is one of the noisiest activities expected to occur in the area and in addition to the noise produced by vessels underway (i.e., from engines, propellers, and sonar equipment) active icebreaking can produce additional, often stronger and more variable sounds if the vessel hulls are colliding with ice (Roth et al. 2013). As many of the interactions were assessed in the vessel underway noise disturbance section, to distinguish between the two activities the generally louder sounds associated with active icebreaking were the focus of the assessment in addition to the sounds of a vessel underway.

Similar to other noise disturbance assessments for Atlantic walrus and narwhal, the assessments were updated based on advice to restrict the spatial scope of the interactions to Archer Fiord.

Habitat alteration/removal

The potential impact of habitat alteration/removal from icebreaking to marine fauna, ice (MYI and FYI), ice algae, and key ice habitats was assessed in this section. Icebreaking could occur throughout a large portion of the study area, and would be expected to occur primarily in consolidated pack ice or landfast ice and unlikely to occur in areas of thick MYI. Although icebreaking is intended to carve a path through ice, there may be areas where the icebreakers most likely to visit the area (i.e., non-nuclear) would not be able to penetrate thick MYI. It was noted that the acute and chronic change scores for MYI should be high since it cannot regrow as MYI if altered or removed and the altering or removing of MYI could significantly change the long-term viability of the habitat as it relates to its function in the ecosystem. Icebreaking in FYI is expected to occur mainly in fiords and inlets, such as Nansen Sound. During the meeting it was flagged that there was a greater focus on species/communities than on habitats; therefore, it was recommended to add an assessment for Nansen Sound/Greely Fiord as an ESC subcomponent to address this concern. For the Northern Ellesmere Island Fiords assessment, a higher areal exposure score was assigned to account for the potential high overlap with where icebreaking would be expected to occur compared to throughout FYI and MYI which are more widespread throughout Tuvaijuittuq.

It was recommended to note and take into consideration how landfast ice is used as a critical platform for Ringed seal life history and how Bearded seals tend to occur in areas with mobile ice and open water.

Water displacement

It was recommended to scope in an assessment to look at the interaction that could occur involving ice-associated habitat in the Nansen Sound/Greely Fiord complex and water displacement from an icebreaker underway through open water. Vessel traffic through open water (defined as ice concentration < 3/10; open drift ice which may be surrounded by areas of higher ice concentration) would mainly occur in fiords and inlets and would likely consist of icebreakers as they encounter areas of lower ice concentrations along their icebreaking route. As this area is dominated by FYI, icebreaking could lead to habitat fragmentation as well as injuries or mortality to ice-associated biota.

Vessel strikes

Although there are no specific studies on seal mortality from icebreaking, since Ringed and Bearded seals are ice-breeding species they were assessed in this section to consider how pups could be vulnerable to icebreaking strikes. Ringed seal pups could be particularly vulnerable to strikes if a vessel were to pass through a birth lair; however, it was noted that vessel transits are not anticipated to occur during spring when pupping season occurs for both seal species.

Vessel at Rest

An analysis of vessel traffic for the area (Maerospace Corp. 2019) revealed that vessels may remain in one place for multiple days but are unlikely do to so over multiple weeks or longer, resulting in low temporal overlap for most of the vessel at rest interactions. Participants discussed how vessels could potentially overwinter for long-term scientific research purposes; however, since this is an activity that is not currently occurring in the area it was not the focus of the assessment. It was noted that there is also potential for military vessels to be at rest long-term but this would be beyond the scope of management measures that could be implemented as part of the creation of an *Oceans Act* MPA.

Disturbance from artificial light

Arctic cod, Arctic char, and pelagic biota were assessed in this section. Vessels at rest maintain the use of navigational safety lights at all times but since vessels would most likely be present in the area during extended periods of daylight, more powerful lights associated with nighttime deck lighting would not be in use. There would likely be a minimal difference between ambient light levels and those introduced by the vessel, resulting in low intensity scores for this section.

Based on conversations from the meeting it was decided to remove the initially included interaction for seabirds and disturbance from artificial light as mortality occurring via this stressor for the species in the area is unlikely. Although eiders can collide with vessels, since this can occur in both day and night this interaction was assessed in the vessel strikes from vessels underway section instead, as artificial light is typically not the cause for collisions.

Noise disturbance

Atlantic walrus, narwhal, Ringed and Bearded seals, Arctic cod, and seabirds were assessed in this section. Vessels at rest produce low-intensity sounds from the use of pumps, auxiliary engines, generators, and other machinery (Hannah et al. 2020). It was advised to better distinguish between what would be expected from noise disturbance from vessels underway compared to vessels at rest. Although the density of vessel traffic is currently low in the study area, a higher intensity score than for disturbance from artificial light was assigned to account for the possibility of a vessel remaining at rest and producing noise within the area for extended periods.

Grounding and Foundering

Grounding refers to the temporary impact of an operational vessel with marine substrate and foundering refers to vessels that sink to the seafloor, becoming a shipwreck. Grounding can be accidental or intentional in certain cases such as for transferring cargo to communities without docking facilities available. Since Tuvaijuittuq has a low density of vessel traffic there are consequently few opportunities for potential vessel grounding or foundering, resulting in low intensity scores throughout this section.

Pathogens/NIS introductions

Despite the rare frequency of grounding or foundering in the study area, it was noted that the duration could potentially be very long should a vessel ground and not be able to get free on its own or founder indefinitely. Although the capability of fouling non-native, invasive species (NIS) to survive and persist in the Arctic is unknown, a precautionary approach was taken to account for the potential for fouling NIS to establish as long as they remain reproductively viable on the foundered vessel, resulting in high temporal overlap. Benthic substrate and benthic biota (focused on sessile invertebrates as the most sensitive taxonomic group) were assessed and considered both the introduction and establishment of NIS. The differences were highlighted in the acute and chronic change rationales but it was noted that nuances between pathogens and NIS should be more clearly distinguished. As a future consideration, DFO’s Canadian Marine Invasive Screening Tool (CMIST) could potentially be used to identify the most likely species of concern that would pose a risk for the study area.

Anchoring and Mooring

Since Tuvaijuittuq has a low density of vessel traffic there are few opportunities for potential vessel anchoring/mooring. The activity of anchoring/mooring implies persistence in the study area; however, a vessel would not be expected to anchor/moor in the area for extended periods of time, resulting in low intensity scores throughout this section.

Habitat alteration/removal

The extent of habitat alteration/removal from anchoring and mooring will depend on various factors including the substrate type, where the interaction is occurring, weight and size of the anchor, and length of the anchor chain. Benthic substrate and benthic biota (focused on sessile invertebrates as the most sensitive taxonomic group) were assessed. Although persistent or frequent anchoring and mooring can cause disturbance, this activity would be infrequent and only affecting a very small portion of the area at once.

Foreign object/obstacle

Benthic biota (focused on sessile invertebrates as the most sensitive taxonomic group) was assessed for this section. Since Arctic benthic macroinvertebrates are generally long-lived with predominantly sessile lifestyles and slow colonization rates (Bonsell and Dunton 2021), no or very limited colonization would be expected to occur on an anchor or anchor moorings/chains in the time frame that they would be expected to be present in Tuvaijuittuq (i.e., a number of days to possibly up to several weeks at most for research expeditions).

Vessel Discharge

Discharge from a vessel includes any ballast water, wastewater, sewage, petroleum products, and other contaminants that are intentionally or unintentionally discharged from marine vessels (Davenport and Davenport 2006, Hannah et al. 2020). Vessel discharge can affect the marine environment through a number of stressors including introduction of biological material (i.e., wastewater and sewage), introduction of pathogens and NIS, petroleum products, atmospheric emissions, and other contaminants. Since Tuvaijuittuq has a low density of vessel traffic there are generally few opportunities for vessel discharge, resulting in low intensity scores throughout this section.

Biological material

Pelagic biota, benthic biota, and ice algae were assessed in this section. Participants agreed that the specific types of materials to be considered in this assessment should be sewage, greywater, nutrients, and the potential for eutrophication, with the focus being on the effects of nutrient enrichment due to the discharge of nutrients and other organic matter associated with human waste from sewage and greywater. Concerns were raised about the persistence of biological material uptake into ice, suggesting that this might warrant a higher temporal score. It was noted that persistence (i.e., the length of time that the stressor is occurring from the activity) should be considered in the intensity scoring and the importance of considering the duration of the stressor's impact was emphasized. It was flagged that there is high uncertainty regarding the exposure scores since little is known regarding the persistence of biological material from vessel discharge into Arctic ecosystems. It was also noted that although the discharge of wastewater from vessels is prohibited under the *Arctic Waters Pollution Prevention Act*, the *Arctic Shipping Safety and Pollution Prevention Regulations* include some exemptions for the discharge of untreated sewage and greywater (Transport Canada 2015, Dawson et al. 2018).

Pathogens/NIS introductions – ballast water

Marine mammals, fish, ice-associated biota, and benthic substrate were assessed in this section. This section focused on pathogens/NIS that could occur in ballast water discharged from a vessel. If Transport Canada's Ballast Water Regulations are followed, the discharge of ballast water should only occur if required for vessel safety reasons (Transport Canada 2021). There was discussion about whether temporal scores should be high or be similar to the other sections that looked at NIS introductions but since discharge is not persistent in the same way that grounding/foundering is, a higher temporal score would not be justified since it is a completely different activity. Even if discharge was frozen in ice, it would be expected to contaminate only a very small area resulting in low temporal overlap for this section. It was flagged that only some of the assessment rationales were focused on persistence of pathogens in prey while others focused more on when ships were present. Differences may be due to the more localized nature of ecological components but this should be checked for consistency throughout the tables.

Participants discussed the difficulty in determining depth scores without knowing the species of pathogens/NIS that could be introduced as this is currently unknown. To be precautionary, high depth scores were assigned since depending on the nature of the pathogens/NIS, it could be possible for them to sink through the water column and reach the seabed. If specific examples of pathogens or NIS become of concern for Arctic marine ecosystems, future assessments could be done to focus on AIS in the area more specifically.

Petroleum products spill and leaks – small operational spill

The only interaction assessed for this activity was that with seabirds. Intensity scoring considered the persistence of petroleum products in cold conditions. Spilled/leaked petroleum product from a small, operational discharge would likely remain in the vessel's immediate vicinity and, due to low dispersion in the Arctic environment (Gomes et al. 2022), the greatest concentration of petroleum product would occur at a single restricted location within the total seabird range in the study area. Though vessel density is very low in the study area, small operational spills/leaks are a common occurrence during normal vessel operation (Lee et al. 2015). Petroleum spills can have strong potential for negative effects on seabirds; however, only a small number of individuals would come into contact with the small operational spills that would result from the low density of vessel traffic in the area.

Petroleum products spill and leaks – large accidental leaks

The potential impact of large accidental petroleum product spills and leaks to marine fauna, ice algae and ice-associated biota, ice (MYI and FYI), and benthic substrate was assessed in this section. Based on existing oil spill response frameworks and standards (WWF n.d.) and historical spill records in Canada, the probability of a large, accidental vessel discharge of petroleum product in the area is very low (WSP 2014, Lee et al. 2015). Although the likelihood of the event occurring is low, intensity was scored high for the assessments in this section to account for the persistence of oil under optimal conditions for dispersion and how it can move around and remain in the water column for a long period of time after the spill. The temporal, areal, and depth exposure scores varied and are highly dependent on the distribution of the ESC. For the purposes of this risk assessment, petroleum product spills/leaks from large, accidental vessel discharge events were presumed possible any time vessels are present in the area and the oil would remain in the water beyond the initial accident. This resulted in high temporal overlap for most ESC subcomponents depending on the time period that the subcomponent spends in the AOI. If spill modelling were to occur for the area it would provide more accuracy for future assessments.

Contaminants

Ice algae, ice-associated biota, pelagic and benthic biota, and benthic substrate were assessed in this section. It was recommended to provide more clarification on the nature of contaminants being considered for these assessments, particularly with respect to distinguishing between contaminants with predominant sources that are long-range vs. potential point sources within the study area, although it was recognized that some sources can come from both local point and long-range sources. Since this is a specialized topic, it was challenging to accurately review the scoring for these assessments and it was recommended to follow up with an expert to verify the most appropriate information was used for the parameters. Since the import of globally sourced contaminants require broad, coordinated efforts to manage at the international level, this is beyond the scope of management measures that could be implemented for an *Oceans Act* MPA or other federal measure and should not be included in the assessment tables.

Atmospheric emissions

This section assessed the potential impact of atmospheric emissions on MYI and FYI. It is recognized that there are a suite of contaminants that will have a baseline presence in the Arctic (e.g., mercury, persistent organic pollutants, polycyclic aromatic hydrocarbons); however these will be dispersed into the environment and join the global pool in the atmosphere. Since the focus of this ecological risk assessment is on localized impacts to the MPA that can be mitigated, it was discussed and decided at the CSAS meeting to focus the assessment in this section on black carbon emissions. There were discussions on how to reflect the effects of black carbon since it settles on the ice and snow and can have chronic impacts as it accelerates the melting of ice, and it was noted that the progression of this type of melt is uncertain. It was recommended to look further into the proportion of global vs. local emissions as other work has been done on this topic.

Potential Future Activities

Interactions were initially included and assessed for activities relating to mining and mineral exploration and oil and gas development. However, since these activities are not currently occurring in the area, and could not occur under current conditions, hypothetical scenarios and assumptions were used to attempt to recognize the impacts and risk. It proved to be a challenge to produce results for this assessment with confidence without having the specific details about these activities such as the distance from shore, when operations would be expected to occur throughout the year, and the span of days where discharge or dust fall-out occur. In addition to the lack of accurate scenario information, the impacts of future activities (those that may only occur if the conditions in the area change significantly, i.e., disappearance of sea ice) cannot be assessed accurately against current conditions.

Although activities not currently possible in the Tuvaijuittuq area were initially included in this risk assessment process, additional, more detailed risk assessments and impact reviews would be needed if these activities were to be considered in the future. It should be noted that risk characterization through future processes should supersede the scores produced in this current assessment.

Additional Considerations

Climate Change

While a protection measure in Tuvaijuittuq may prohibit activities that can exacerbate climate change impacts, managing and/or mitigating climate change and subsequent direct and indirect impacts would require action at a global scale. For this reason, climate change was not assessed as a stand-alone stressor in this risk assessment. Climate change should, however, be addressed within the preamble of the final risk assessment report and documented within the tables when the relevant data exist to predict and or detect change (e.g., within recovery factors where appropriate such as for MYI). Throughout this risk assessment climate change impacts were often highlighted in the uncertainty scores, and included as a factor for consideration in concluding statements. There are existing National DFO working groups that are working to influence this discussion further and as more guidance becomes available from these working groups as well as from international organizations (e.g., Arctic Council working groups), future assessments may be more informed to better understand and address the implications and impacts of a changing Arctic climate.

Scoping of Additional Interactions

Although the scoping document was included as supporting information and not specifically included in the peer review, reviewers were asked to make note if they felt strongly that changes should be made to the scoping document (i.e., if additional interactions should be included in the assessment or not). Since this ecological risk assessment process was iterative, additional interactions that were recommended to be scoped in by reviewers were considered for inclusion into the risk assessment after the meeting. Where warranted the changes will be added to the scoping pieces of the final risk assessment report. It should be re-iterated that ecological risk assessments are not meant to score every possible interaction for the study area, but rather to evaluate the activities that pose significant risk and may need to be regulated/mitigated.

Sources of Uncertainty

The main source of uncertainty for Tuvaijuittuq is the lack of data, across all ecosystem components in the study area. A combination of best available information, expertise, and proxies were therefore necessary to produce the risk scores for this assessment. It should be taken into consideration that expert opinion can be somewhat subjective for scoring with regard to perspective and approach.

Since only a very small area of the marine environment of Tuvaijuittuq has been studied overall, there is a strong need for more dedicated baseline information in order to be able to assess impacts with more confidence. The extremely rapid changes associated with climate change such as the dramatic loss of ice shelves and epishelf lakes requires immediate mobilisation to establish the rapidly changing baseline (DFO 2020). As there are still many gaps in knowledge relating to the distribution of marine mammals (e.g., Bowhead whales), stocks, and other species and communities (Charette et al. 2020, DFO 2020), filling these gaps would help refine the risk assessment.

It was recommended that throughout the assessment it should be clearly indicated when information used in the scoring matrix is specific to Tuvaijuittuq or when information is borrowed from other areas. If information was borrowed from other areas of the Arctic but is consistent across different regions, this should result in a higher level of certainty. It was noted that for the context of this assessment, the description of certainty refers to the quantity of information, rather than quality or type of study. Although in some cases there may be relatively more literature to support the information included in a table; consideration with respect to where the study took place, and how well the study was able to identify and quantify impacts should also be taken into account. This may require further refinement of the definitions for uncertainty scores in the future to avoid misinterpretations.

There is high uncertainty associated with risk scores for the ecosystem components across the study area as well as the activities assessed. There are many unknowns around the possibility of increased frequency and intensity of activities and if/when this would be expected to occur. Future assessments for the area should be updated as more information becomes available.

There are several uncertainties with respect to the timing and/or the impacts of climate change throughout the Arctic. It is recognized that climate change is the most significant risk to the Tuvaijuittuq area, but in the absence of accepted guidance for inclusion it cannot be explicitly captured by the ERAF. The impacts of climate change will need to be considered as a source of uncertainty in risk assessments for any area, but especially those in Tuvaijuittuq since conservation priorities such as MYI and ice shelves may be irrevocably altered. A more fulsome assessment of climate change with respect to modelling exercises (e.g., climate, drift response models) to better understand the potential impacts of climate change on certain variables and stressors (e.g., oil spills) will be needed in the future to better incorporate the scope and scale of the expected impacts.

Conclusions

An ecological risk assessment is a large endeavor involving the examination of multiple interactions with supporting evidence. The benefit of conducting the ecological risk assessment is that it allows managers the ability to see where the greatest impact from activities is occurring on ESC subcomponents and/or which ESC subcomponents are most vulnerable within an area. The ERAF provides a consistent quantitative approach to assess the potential impact of existing activities (stressors) on ESCs in the Tuvaijuittuq area.

Generally, the greatest challenge associated with the application of an ERAF is that the definitions need to be well-defined so that they can be interpreted consistently by those conducting the assessment, yet flexible enough to cover a wide range of possible interactions. Although the Arctic Region ERAF was reviewed and agreed to by DFO Science prior to the meeting, edits were advised in certain cases to strengthen definitions. For example, for the temporal bounds it was recommended to specify that activities/sub-activities occurring or expected to occur in the foreseeable future would be appropriate to include if expected to occur within the next 10 years. Risk statements should also be well-defined and clearly state the activity/stressor and the taxonomic organisation or group of focus. Any necessary modifications to an ERAF need to be consistently applied for all interactions as the scoring is relative throughout the assessment and considerations of these challenges should be made when undertaking future ecological risk assessments. Participants agreed that the resulting risk scores from this assessment are not comparable or assumed to be interchangeable with other Arctic area risk assessments, as the results are only relative to each other and are specific to Tuvaijuittuq. This also highlights that the risk scores for sensitivity are not necessarily applicable elsewhere (with the exception of the species recovery scores), since they are specific to the population present within the study area. This is also the case with the exposure scores as they are unique to the area.

The first step in an ecological risk assessment is undertaking a scoping exercise to determine which interactions should be assessed. Interactions can be scoped in or out depending on the objectives of the assessor and the conservation priorities. Interactions that were not expected to manifest in measurable impacts to ESC subcomponents, or where MPA regulations are not able to offer any mitigation for the stressor, were scoped out of the assessment. Additionally, where there is no overlap in the occurrence of a human activity and an ESC subcomponent, the interaction was also scoped out of the assessment. Over the course of the Tuvaijuittuq CSAS meeting, participants identified interactions that were outside the scope of the assessment as well as others that were recommended to consider adding. Subsequent discussion revealed that in some cases a more clearly defined risk statement would help to understand why an interaction was scoped in or out.

When undertaking a risk assessment that covers a large geographic area, it may be more appropriate to assess by sub-area/priority area (based on prevalence of the ESC subcomponent and stressor/activity). The presence and distribution of each ESC subcomponent should be considered when information is available since they may manifest differently in different parts of the area (e.g., preferred habitats) or use multiple areas in different seasons for different purposes. For example, in cases where the subcomponents were spatially restricted, such as for walrus and narwhal, it was recommended to focus the assessment on the area where they occur so as not to potentially dilute the overall risk because they exist in a very small portion of the study area. In cases where the subcomponents are known to have large distributional ranges and/or there is a lack of data for the population, such as for seals and Polar bears, it was appropriate to assign risk scores based on their presence across the entire study area. In addition, since the intensity of the various stressors is not spatially or temporally homogenous across the study area, assessing at the scale of the entire area could result in a diluted risk level. This is an important consideration since the risk assessment is intended to inform the discussions on regulatory intent of a potential future protected area. The assignment of high risk to an entire area when it is only relevant to a small sub-area would have an impact on the validity of the risk. With respect to revising the consultant's draft risk assessment, it was recommended to focus assessments on local impacts (local populations/areas) where possible/appropriate and to provide more clarity on the spatial coverage of the risk interaction being assessed, by including more information in the risk statements and/or using maps to clearly identify the area(s) under consideration.

The establishment of a MPA allows for dedicated monitoring of its conservation objectives, which in turn, can address data gaps and potentially identify change in the ecosystem (in- and outside the boundaries). Any new monitoring information can be used to improve the potential effectiveness of management and mitigation decisions in the future. Adaptive co-management is an important aspect of *Oceans Act* MPAs and is a core principle in DFO's ocean management policies. For an area that is changing at an accelerated rate, adapting management decisions with the results of monitoring will be essential. Additionally, a reduction in sea ice cover is expected with limited ability to predict if, and how human activities and stressors in the region will change as well (e.g., increased shipping access). Since the assessment undertaken considered the current activity within Tuvaijuittuq, it is recommended to management that if a significant or catastrophic event occurs within the area (e.g., significant loss of ice shelf causing change detected by monitoring, change in knowledge about the distribution of marine mammals, change in the intensity and frequency of a stressor, etc.) a review of the original risk scores should be considered to ensure the appropriate management measures are in place for protection.

Throughout the discussion of risk and risk scoring, climate change impacts were often highlighted and discussed, as well as the high level of uncertainty associated with these changes. This is a significant challenge for the management of the area, particularly because it is the main stressor on this system. Any future management and monitoring plans for Tuvaijuittuq will be most effective if they can account for climate change. This is particularly important given the critical need to characterize ecology and biodiversity in Tuvaijuittuq before it disappears. Adaptive co-management will be a key consideration moving forward as the habitat continues to change.

The advice received during this CSAS process was intended to aid DFO MPC in refining their risk assessment report for Tuvaijuittuq and may also be useful for improving future ecological risk assessments within the Arctic Region.

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Appendix A

Table A1. List of assessed interactions that were reviewed at the CSAS meeting.

ESC Subcomponent	Activity	Stressor
Ringed seals	Scientific Research	Noise Disturbance
Bearded seals	Scientific Research	Noise Disturbance
Narwhals	Scientific Research	Noise Disturbance
Polar Bears	Scientific Research	Noise Disturbance
Seabirds	Scientific Research	Noise Disturbance
Atlantic walrus	Scientific Research	Noise Disturbance
Polar Bears	Scientific Research	Biota Encounters/Handling
Seabirds	Scientific Research	Biota Encounters/Handling
Ice algae	Scientific Research	Biota Loss
Multi-year ice	Scientific Research	Habitat Alteration/Removal
First-year ice	Scientific Research	Habitat Alteration/Removal
Seabirds	Recreation/Tourism	Biota Encounters/Handling
*Atlantic walrus	Recreation/Tourism	Noise Disturbance
Ringed seals	Recreation/Tourism	Noise Disturbance
Bearded seals	Recreation/Tourism	Noise Disturbance
Seabirds	Recreation/Tourism	Noise Disturbance
Narwhals	Vessel Underway	Noise Disturbance
Atlantic walrus	Vessel Underway	Noise Disturbance
Arctic char	Vessel Underway	Noise Disturbance
Arctic cod	Vessel Underway	Noise Disturbance
Ringed seals	Vessel Underway	Noise Disturbance
Bearded seals	Vessel Underway	Noise Disturbance
Polar Bears	Vessel Underway	Noise Disturbance
Seabirds	Vessel Underway	Noise Disturbance
Narwhals	Vessel Underway	Vessel Strikes
Atlantic walrus	Vessel Underway	Vessel Strikes
Seabirds	Vessel Underway	Vessel Strikes
Marine Mammal Habitat in Lady Franklin Bay/Archer Fiord (Bowhead Whale)	Vessel Underway	Vessel Strikes
Seabirds	Vessel Underway	Water Displacement
Arctic cod	Icebreaking	Noise Disturbance
Ringed seals	Icebreaking	Noise Disturbance
Bearded seals	Icebreaking	Noise Disturbance
Polar Bears	Icebreaking	Noise Disturbance
Seabirds	Icebreaking	Noise Disturbance
Narwhals	Icebreaking	Noise Disturbance

ESC Subcomponent	Activity	Stressor
Atlantic walrus	Icebreaking	Noise Disturbance
Bearded seals	Icebreaking	Vessel Strikes
Ringed seals	Icebreaking	Vessel Strikes
Northern Ellesmere Island Fiords	Icebreaking	Habitat Alteration/Removal
*Nansen Sound/Greely-Fiord Complex	Icebreaking	Habitat Alteration/Removal
Multi-year Ice	Icebreaking	Habitat Alteration/Removal
First-year Ice	Icebreaking	Habitat Alteration/Removal
*Ice algae	Icebreaking	Habitat Alteration/Removal
Ringed seals	Icebreaking	Habitat Alteration/Removal
Bearded seals	Icebreaking	Habitat Alteration/Removal
Narwhals	Icebreaking	Habitat Alteration/Removal
Atlantic walrus	Icebreaking	Habitat Alteration/Removal
Seabirds	Icebreaking	Habitat Alteration/Removal
*Nansen Sound/Greely-Fiord Complex	Icebreaking	Water Displacement
Pelagic biota	Vessel at Rest	Disturbance from Artificial Light
Arctic char	Vessel at Rest	Disturbance from Artificial Light
Arctic cod	Vessel at Rest	Disturbance from Artificial Light
Arctic cod	Vessel at Rest	Noise Disturbance
Ringed seals	Vessel at Rest	Noise Disturbance
Bearded seals	Vessel at Rest	Noise Disturbance
Narwhals	Vessel at Rest	Noise Disturbance
Atlantic walrus	Vessel at Rest	Noise Disturbance
Seabirds	Vessel at Rest	Noise Disturbance
Benthic biota (sessile invertebrates)	Grounding and Foundering	Pathogens/NIS
Benthic substrate	Grounding and Foundering	Pathogens/NIS
Benthic biota (sessile invertebrates)	Anchoring and Mooring	Habitat Alteration/Removal
Benthic substrate	Anchoring and Mooring	Habitat Alteration/Removal
Benthic biota (sessile invertebrates)	Anchoring and Mooring	Foreign Object/Obstacle
Ice algae	Vessel Discharge	Biological Material
Pelagic biota	Vessel Discharge	Biological Material
Benthic biota	Vessel Discharge	Biological Material
Benthic biota	Vessel Discharge (Ballast Water)	Pathogens/NIS
Arctic char	Vessel Discharge (Ballast Water)	Pathogens/NIS
Atlantic walrus	Vessel Discharge (Ballast Water)	Pathogens/NIS
Benthic substrate	Vessel Discharge (Ballast Water)	Pathogens/NIS
Ice-associated biota	Vessel Discharge (Ballast Water)	Pathogens/NIS

ESC Subcomponent	Activity	Stressor
Arctic cod	Vessel Discharge (Ballast Water)	Pathogens/NIS
Ringed seals	Vessel Discharge (Ballast Water)	Pathogens/NIS
Bearded seals	Vessel Discharge (Ballast Water)	Pathogens/NIS
Narwhals	Vessel Discharge (Ballast Water)	Pathogens/NIS
Polar Bears	Vessel Discharge (Ballast Water)	Pathogens/NIS
Seabirds	Vessel Discharge	Petroleum Product Spills/Leaks (Small Operational)
Ice algae	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Ice-associated biota	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Pelagic biota	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Benthic biota	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Arctic char	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Arctic cod	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Ringed seals	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Bearded seals	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Narwhals	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Atlantic walrus	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Polar Bears	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Seabirds	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Multi-year Ice	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
First-year Ice	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Benthic substrate	Vessel Discharge	Petroleum Product Spills/Leaks (Large Accidental)
Ice algae	Vessel Discharge	Contaminants
Ice-associated biota	Vessel Discharge	Contaminants
Pelagic biota	Vessel Discharge	Contaminants
Benthic biota	Vessel Discharge	Contaminants
Benthic substrate	Vessel Discharge	Contaminants
Multi-year Ice	Vessel Discharge	Atmospheric Emissions
First-year Ice	Vessel Discharge	Atmospheric Emissions

*denotes interactions that were not originally included but recommended to add to the assessment

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