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Central and Arctic Region

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IDENTIFICATION OF ECOLOGICALLY SIGNIFICANT SPECIES, FUNCTIONAL GROUPS AND COMMUNITY PROPERTIES FOR THE WESTERN ARCTIC BIOGEOGRAPHIC REGION

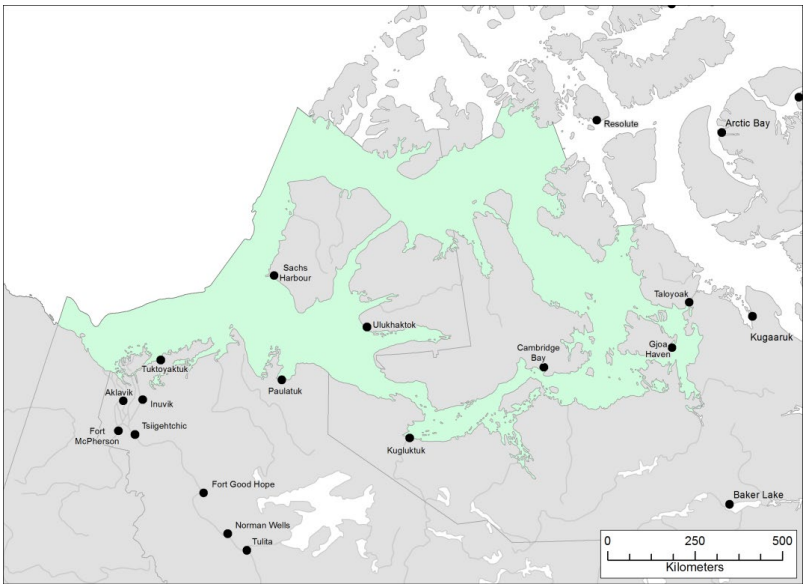

Figure 1. Western Arctic Biogeographic Region, including place names.

Context:

Under the National Conservation Plan, Fisheries and Oceans Canada (DFO) Oceans Program has been tasked with leading the development of a Marine Protected Area (MPA) Network in the Western Arctic Biogeographic Region. DFO Science has identified an overarching MPA Network Conservation Objective, and has provided advice on Eco-units and Priority Conservation Areas for the region. The next step in the MPA Network planning process is to identify the Conservation Priorities.

Canada's Oceans Act authorizes DFO to take an Ecosystem Approach to the integrated management of human activities in the sea. A component of this is to provide enhanced protection to species and community properties that are particularly significant to maintaining ecosystem structure and function. Species and community properties can be ecologically "significant" because of the functions that they serve in the ecosystem and/or because of features that they provide for other parts of the ecosystem to use. To inform ecological conservation priorities for the MPA Network in the Western Arctic Biogeographic Region, Oceans Program has requested identification of Ecologically Significant Species and Community Properties (ESSCPs) for this area.

This Science Advisory Report is from the November 8-9, 2016 meeting: Identification of Ecologically Significant Species and Community Properties for the Western Arctic Biogeographic Region. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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SUMMARY

- Ecologically significant species, functional groups, and community properties were assessed for the Western Arctic Biogeographic Region. National guidance criteria (DFO 2006) for assessing ecological significance were modified to provide more description, to focus less on species of potential commercial value, and to emphasize ecological functionality, adaptations, and processes specific to the assessment area.
- The scope of the assessment was limited to the scale of the biogeographic region. Species were excluded that, at the time of assessment, were not well-established in the study area (i.e., species with recent geographic range extensions, occasional migrants, and potential aquatic invasive species).
- Community properties were difficult to assess because they are not well defined. They were considered to be more relevant as metrics for ecological monitoring than for identifying ecological significance.
- Final criteria used to assess significance included distribution (widespread versus localized, seasonal versus year round occurrence), contribution to ecosystem (% contribution to ecosystem biomass, centralized role in ecosystem), habitat (specialized habitat association, habitat creating or modifying), and energy transfer (feeding type, vertical transfer, horizontal transfer, relative importance to ecosystem).
- Modifiers (functional uniqueness, resistance, resilience) were included as additional information that may be useful for prioritization.
- A total of 37 species and functional groups, and one community property were assessed for ecological significance. The following 12 species and functional groups were identified with Moderate–High or High (bold) relative importance to overall ecosystem structure and function within the Western Arctic Biogeographic Region:
    - Heterotrophic microbes [Moderate–High]
    - Ice-associated algae [Moderate–High]
    - **Pelagic phytoplankton > 5 µm [High]**
    - ***Calanus* spp. [High]**
    - Macrozooplankton [Moderate–High]
    - Mesozooplankton [Moderate–High]
    - Epifauna invertebrates (nearshore soft bottom 0–50 m) [Moderate–High]
    - Epifauna invertebrates (deep soft bottom > 200 m) [Moderate–High]
    - Infauna invertebrates (nearshore soft bottom 0–50 m) [Moderate–High]
    - Infauna invertebrates (shelf soft bottom 50–200 m) [Moderate–High]
    - Fishes (coastal nearshore 0–10 m) [Moderate–High]
    - **Arctic Cod (*Boreogadus saida*) [High]**
- Data limitations and bias in geographic coverage limited the ability to assess certain species and functional groups as ecologically significant. Degree of confidence in data was captured in the scoring of criteria.
- Ecologically significant species and functional groups that were identified for the Western Arctic Biogeographic Region may not meet the criteria for ecological significance within other biogeographic regions.

INTRODUCTION

The identification of ecologically significant species and community properties is an important step towards an ecosystem based management approach for the marine environment. Identification of ecologically significant species and/or community properties (ESSCPs) and functional groups[1], which play a particularly important role in the structure or function of an ecosystem, and/or fill an important gap in existing management tools. Identification of ESSCPs will, in part, address some Federal Government commitments related to developing a network of Marine Protected Areas (e.g., Arctic Council, United Nations Convention on Biological Diversity) and will provide guidance for a number of regional planning initiatives. Specifically, ESSCPs support the Marine Protected Area (MPA) network planning process by identifying species that should be considered as potential Conservation Priorities. However, the identification of ESSCPs has direct application to other oceans management initiatives, such as the identification of indicators for monitoring and key ecosystem components for threats assessments.

In 2006, Fisheries and Oceans Canada (DFO) provided national guidance and criteria for the identification of ESSCPs (DFO 2006). The criteria focused on operationalizing the term 'significant' from an ecological (functional) perspective, with the objective of drawing attention to species and community properties that warrant, from an ecological perspective, enhanced protection (DFO 2006). Although ESSs are generally identified by marine protected area practitioners as a key information layer in the MPA network planning process, the ESSCP criteria have previously been applied on only two occasions (DFO 2009a, DFO 2014). This may be due in part to data limitations and challenges with eliminating bias in the prioritization of species' functional roles. The information contained herein represents the first application of ESSCP criteria in a Canadian biogeographic region.

This Science Advisory Report (SAR) contains a summary of ESSCPs, including a listing of the key attributes used to identify them. Detailed scientific information supporting ESSCP identification and a full list of references can be found in the Research Document (Cobb et al. in press). The Proceedings (DFO 2019) include a summary of meeting discussions.

ASSESSMENT

The Western Arctic Biogeographic Region (WAB) encompasses about 550,000 km^2 (Figure 1). The boundary between the WAB region and the Arctic Basin biogeographic region occurs at approximately the 200 m depth contour. The assessment was restricted to assessing ecological significance within the WAB Region. Species that are not well-established in the region, including those with recent geographic range extensions, occasional migrants, and potential aquatic invasive species were excluded from the assessment.

The ESSCP criteria (DFO 2006) have been applied by DFO Science (DFO 2009a) and an assessment of the applicability of the criteria to define ecological significance was also completed (DFO 2014). During this review, the national guidance criteria (DFO 2006) were further defined to better reflect functional properties and processes of the Arctic ecosystem.

[1] Functional groups are collections of organisms that share similar characteristics (e.g., physiological, behavioral, ecological niches, trophic level). Species for this assessment were grouped due to limited availability of data for species and our current understanding of ecosystem structure and function with the Western Arctic Biogeographic Region.

For example, the criterion for import/export of nutrients and energy was sub-divided into horizontal and vertical components to capture seasonal versus year-round residency in the biogeographic region, and vertical processes such as pelagic-benthic (passive) and benthic-pelagic (active) coupling.

The criteria used to identify ESSCPs in the WAB region were divided into subcategories as follows:

- Distribution
    - Widespread (ubiquitous) vs localized distribution across the biogeographic region.
    - Seasonal vs year-round occurrence.
- Ecosystem component contribution
    - Contribution to overall ecosystem biomass (based on ecosystem model outputs).
    - Centralized ecosystem component – A species or functional group that controls rates and directions of trophic ecosystem processes (productivity, respiration, waste production). This captures the idea of keystone species whose effect on a community or ecosystem is large, and disproportionately large relative to its abundance (e.g., Arctic Cod, Ringed Seal). It also includes consideration of the number of ecological nodes as a measure of the linkages and the complexity in the food web. This concept may work for species, but it does not necessarily work for communities.
- Energy transfer
    - Vertical transfer of energy and material, which includes active movement of organisms (diurnal, seasonal) and passive vertical transfer (e.g., detrital fall).
    - Horizontal transfer (import and export) includes the physical movement of biomass and nutrients (with physical drivers) within the WAB region (i.e., connectivity within the biogeographic region).
    - Feeding type identified species or functional groups as being selective or non-selective and active or passive feeders.
- Habitat
    - Some species may fill a specific ecological function within specific, localized habitats, these are considered key habitat associations (e.g., ice-associated fauna, hot vents associated with specialized species).
    - Species that have a three-dimensional shape and occur in significant densities can be used by other species for refuge, providing hard substrate for anchoring, or for spawning or nursery areas, and are considered habitat-creating or habitat-modifying species. Other species (mainly infauna in soft bottoms, but also some epifauna), modify their environment through bioturbation. These species perform important ecological services through the re-suspension of nutrients and essential chemicals and minerals that are then available to other species.
- Modifiers
    - These modifiers are not considered as ESSCP criteria, however, were useful in ranking species based on the above criteria.
    - Functional uniqueness refers to species and/or functional groups that fill an important and functionally unique role in the ecosystem. If lost, functionally unique species are not easily replaced, and their loss would have implications to the ecosystem overall.

- Resistance is the ability of species or functional group to withstand perturbation and maintain its functional role when subject to disturbance.
- Resilience is the capacity of a species, functional group or community to recover quickly following disturbance. Long-lived slow reproducing species generally are considered to have lower resilience than short-lived fast reproducing species.

Application of Criteria

An initial list of species and functional groups was developed based on a comprehensive literature review (Cobb et al. in press). The number of species represented within functional groups is greater for lower trophic level taxa, and, related to this, the ecological role of individual species tends to be poorly known for highly diverse groups. Functional groups were classified based on several ecological attributes, including taxonomy (sea ducks, some zooplankton), mobility (anadromous fishes), feeding mode (benthic versus pelagic-feeding anadromous fishes), habitat association (euryhaline versus stenohaline coastal fishes, depth categories of marine fishes and benthos, epibenthos versus infauna), size classes (zooplankton, prokaryotes and eukaryotes), and trophy (autotrophic vs. heterotrophic bacteria). Representative species were identified for each functional group, and these tended to be numerically dominant taxa. Marine mammals, Arctic Cod, Greenland Halibut (*Reinhardtius hippoglossoides*) and *Calanus* spp. were assessed as individual species and were not included in the assessment of their respective functional groups. A total of 37 species and functional groups, and one community property were assessed for ecological significance using the final criteria (Appendix 1).

Percent contribution to ecosystem biomass was derived from a biomass-based model developed for the Beaufort Sea Shelf (C. Hoover, Fisheries and Oceans Canada, pers. comm.) and was calculated for each of the 8 trophic groupings (Figure 2). This approach was applied due to data limitations for each candidate ESSCP within the WAB region, therefore, relative biomass of broader groups was used in the assessment.

The relative importance to the ecosystem criterion was an integration of the results of the assessment and was used to rank the overall ecological significance. This criterion was assessed following a Delphi approach and there was strong consensus for the relative rankings (low, moderate, high) for each of the assessed species, functional groups and the community property (DFO 2019).

Degrees of data confidence were categorized and this information was included as part of the assessment (Appendix 2). Scores for uncertainty are embedded within the summary table of ESSCP criteria scores (Appendix 1).

Assessment Results

A total of 37 species and functional groups, and one community property were assessed for ecological significance (Appendix 1). Overall, 12 species and functional groups were identified with moderate to high or high relative importance to overall ecosystem structure and function within the WAB region. Only Arctic Cod, *Calanus spp*., and pelagic phytoplankton were identified with high ecological significance. Ringed Seal (*Phoca hispida*), Arctic Cod, and *Calanus spp*. were the only taxa identified as centralized ecosystem components, indicating the large flow of energy through these species that feed on a wide variety of prey items and are consumed by many higher trophic level species (Figure 2).

The majority of ESSCPs with moderate to high ranking were lower trophic level functional groups. This is due to their greater proportion of overall biomass within the ecosystem and their

important role in supporting upper trophic levels through various mechanisms of energy transfer (Figure 2). They are also present in the biogeographic region year-round.

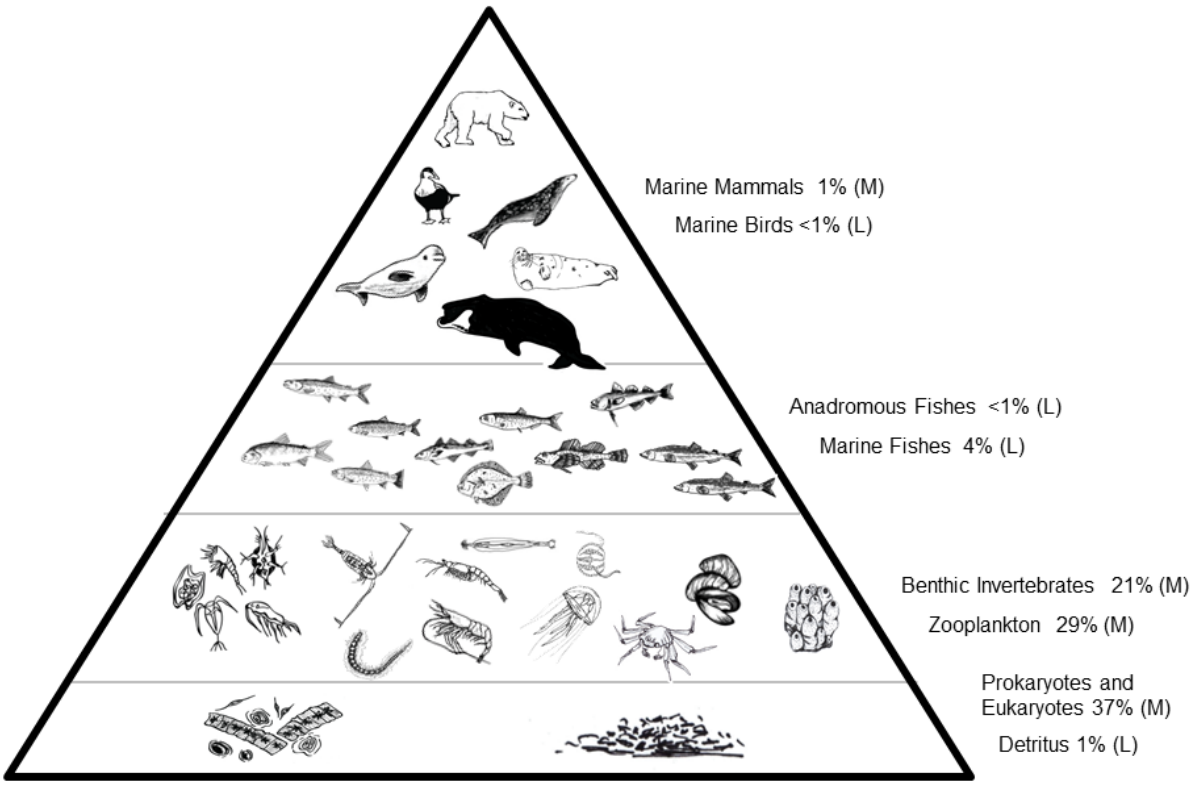

Figure 2. Approximate percent biomass contribution for each trophic grouping assessed using EcoPath model for the Beaufort Shelf (C. Hoover, Fisheries and Oceans Canada, pers.comm.). Categories for degrees of certainty are identified in brackets and are defined in Appendix 2.

Those species that fill an important and a functionally unique role in the ecosystem, if lost, would not be easily replaced, and thus likely impact the rest of the ecosystem were defined as functionally unique. This can include species/groups that inhabit a special place in the food web (e.g., relatively short trophic link) or occupy important but poorly populated habitats (e.g., water masses or sea ice). Within the WAB, 8 species or functional groups were identified as functionally unique, this included the heterotrophic microbes, pelagic pico-phytoplankton and nano- and micro-phytoplankton, ice-associated algae, pelagic fishes (> 50 m), Narwhal (*Monodon monoceros*), Bowhead (*Balaena mysticetus*), and Polar Bear (*Ursus maritimus*).

The only community property that was assessed was detritus (Appendix 1). Detritus is organic material that includes living and non-living components (i.e., bodies or fragments of dead organisms as well as fecal material), and may therefore be considered a property of ecosystems rather than of a single community. Detrital material may be present in the water column, and slowly settles to the sea floor. Detritus is an important source of nutrients to the communities of microorganisms that act to decompose the material and also the benthic environment, where many bottom feeding organisms rely on the sinking materials. Benthic-pelagic coupling and the recycling of nutrients in the water column are critical components of ecosystem function.

Sources of Uncertainty

Scientific research is limited, both spatially and temporally within the WAB region and is biased to data collected in the southeastern Beaufort Sea, Mackenzie Delta and Amundsen Gulf during the open-water season. Many areas within the WAB remain largely unexplored.

More information was available for certain species and functional groups relative to others (e.g., marine mammals, subsistence fishes). Lower trophic level functional groups were generally data limited (e.g., phytoplankton, detritus) although these groups were typically ranked relatively high in their relative importance to the ecosystem (Appendix 1).

There were challenges with applying certain criteria to functional groups that contained many species (e.g., feeding type, functional uniqueness), and the criterion for percent contribution to total ecosystem biomass could only be assessed for broad ecosystem components in each trophic grouping.

Detailed information on energetic pathways within the food web, both with respect to amount and direction of energy flow, was limited. As a result, some species may have been identified with low ecological significance, but through some energy pathways may actually be quite important.

An ecological model was used as the best available source of information for percent biomass contribution. While the model serves as an important heuristic tool, it was limited in geographic scope to the Beaufort Shelf. Data were input into the model where available, but the data spanned a variety of years and sampling protocols. Also, biomass for some data-poor groups (e.g., marine fishes) was estimated based on food-web relationships developed within the model. Importantly, while similar, the model groupings differed from those identified under the ESSCP regional peer-review process because different methods were used to identify major ecosystem components.

As in all peer-review processes, the science advice developed depends on which experts were present at the meeting. Best attempts were made to include the full range of expertise needed to assess ecological significance for the WAB region, but the process would have benefitted from participation of other knowledge holders, and this may have impacted the science advice. Subject matter experts for Polar Bear and marine birds were unable to attend the meeting but provided feedback on the Research Document (Cobb et al. in press).

CONCLUSIONS AND ADVICE

Although all species and community properties hold some ecological role in the ecosystem, the ESSCPs call attention to those that have particularly high significance. ESSCPs are a management tool used to provide information about important species, functional groups, and community properties. ESSCPs fill an important gap in existing management tools by focusing on species and processes that are poorly represented by spatial information layers, such as Ecologically and Biologically Significant Areas (EBSAs). Specifically, widespread species that are known to be important to ecosystem function, but are difficult to map, were identified as ecologically significant (Arctic Cod, Ringed Seal). ESSCPs may be considered as conservation priorities for the WAB region Marine Protected Area Network.

This assessment represents the first application of the national guidance criteria (DFO 2006) to identify ESSCPs in the Canadian Arctic. The assessment provides a relative ranking, based on the best available information, to call attention to species, functional groups, and ecosystem properties of particular ecological significance within the WAB region. Given the data limitations

and unique features (e.g., sea ice) within the Arctic the criteria were adapted to improve the assessment and allow for greater transparency in relative ranking of ESSCPs (DFO 2019, Cobb et al. in press). The new criteria captured in more detail, the vertical and horizontal connectivity of the ecosystem components and better reflected the diverse functional roles of ESSCPs in the Arctic. Specifically, connectivity was considered within the criteria for distribution (e.g., migratory species), energy transfers (e.g., pelagic-benthic coupling), and key habitat associations (e.g., sea ice). The criteria to identify ESSCPs also addressed the importance of three-dimensional ecosystem components, such as habitat creating or modifying species.

Community Properties were not adequately defined in DFO (2006), but examples were provided and include size-based properties and the frequency distributions of abundance or biomass across species. Knowledge gaps and relevance of the metrics related to properties of ecosystems make it challenging to operationalize criteria for assessing ecological significance above the species level (DFO 2006). Community properties were considered to be more relevant as indicators for ecological monitoring (e.g., DFO 2015).

Inherent in their classification, biogeographic regions differ with respect to many large-scale environmental factors including bathymetry and oceanography, which drive regional-scale differences in ecological communities (DFO 2009b). Abiotic features influence the distribution of biological diversity, biomass productivity and therefore affected the grouping of species into functional groups. Functional groups were defined based on our current knowledge and spatial scale of the ecosystem and may be different in other biogeographic regions. While many species identified as ESSCPs for the WAB region also occur in other Canadian biogeographic regions, they may not meet the criteria for ecological significance elsewhere. Additionally, other species and community properties may be present and should be assessed. Given the above considerations, the criteria should be applied on a biogeographic region-by-region basis.

In many cases, knowledge gaps and the use of older data limited the ability to assess the criteria. The assessment results (Appendix 1) relied on best available knowledge and included a category of uncertainty (Appendix 2) to highlight knowledge gaps and indicate confidence. Ultimately, the identification of ESSCPs should be considered a living process, with periodic re-evaluations as new information becomes available.

OTHER CONSIDERATIONS

Arctic regions, including the WAB region, are undergoing accelerated rates of climate change. The degree of change and associated impacts on the distribution, abundance, seasonal phenology, and functional role of ESSCPs are difficult to predict, but are likely to have cumulative impacts on ecosystem structure and function. The WAB region contains species with changing ranges (e.g., Pacific salmons), species that make transient forays into the biogeographic region (e.g., Grey Whale [*Eschrichtius robustus*], Killer Whale [*Orcinus orca*]), and aquatic invasive species. These species have the potential to become established and significantly influence the ecosystem. Their presence in the WAB region (abundance, location, and frequency of occurrence) should be monitored.

LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Ayles, Burton	Fisheries Joint Management Committee
Cobb, Don	DFO Science
Enders, Eva (Chair)	DFO Science
Gallagher, Colin	DFO Science
Grandmaison, Vanessa (Rapporteur)	DFO Oceans Program
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SOURCES OF INFORMATION

This Science Advisory Report is from the November 8-9, 2016 Identification of Ecologically Significant Species, and Community Properties for the Western Arctic Biogeographic Region. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Cobb, D.G., MacPhee, S., Paulic, J., Martin, K., Roy, V., Reist, J., Michel, C., Niemi, A., Richardson, E. and Black, A. 2019. Information in support of the Identification of Ecologically Significant Species, Functional Groups and Community Properties (ESSCP) in the Western Arctic Biogeographic Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/027. *In press*.

DFO. 2006. Identification of Ecologically Significant Species and Community Properties. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/041.

DFO. 2009a. Does eelgrass (*Zostera marina*) meet the criteria as an ecologically significant species? DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/018.

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DFO. 2014. Assessment of freshwater Ecologically and Biologically Significant Areas (EBSA) and Ecologically Significant Species (ESS) criteria. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/025.

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

DFO. 2019. Proceedings of the regional peer review for the identification of ecologically significant species, and community properties for the Western Arctic Biogeographic Region; November 8–9, 2016. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2018/009.

APPENDIX 1: SUMMARY TABLES OF CRITERIA AND SCORES FOR ECOLOGICALLY SIGNFICANT SPECIES, FUNCTIONAL GROUPS AND COMMUNITY PROPERTIES

Table A1. Summary of criteria used to evaluate species and species groups in the Western Arctic Biogeographic (WAB) Region. Certainty categories are identified in brackets and described in Table A2. Not applicable = n/a. Under feeding type: S = selective, NS = non-selective, A = active and P = passive. Categories: H = high, M = medium, L = low, and U = unknown.

Species/Species Group/community property	Distribution		Ecosystem component contribution		Energy Transfer					Habitat			Modifiers		
	Widespread (W) vs Localized (L)	Seasonal (S) vs year-round (Y)	Contribution to ecosystem biomass (%)	Centralized ecosystem component Yes (Y) or No (N)	Vertical Transfer (active movement) Yes (Y) or No (N)	Passive Vertical Transfer (e.g., detrital fall) Yes (Y) or No (N)	Horizontal Transfer (within WAB region) Yes (Y) or No (N)	Relative importance to Ecosystem	Feeding type	key habitat association	Habitat creating Yes (Y) or No (N)	Alters habitat (Bioturbation) Yes (Y) or No (N)	Functional uniqueness Yes (Y) or No (N)	Resistance (high or low)	Resilience (high or low)
Marine Prokaryotes and Eukaryotes			37%(M)												
Pelagic phytoplankton [< 5 µ] (pico plankton) (e.g., *Micromonas* sp.)	W(VH)	Y(VH)		N(M)	N(M)	Y(M)	Y(L)	H(VH)	n/a(M)	Euphotic Zone	N(L)	N(L)	Y(L)	H(VL)	H(VL)
Pelagic phytoplankton [> 5 µ] (nano and micro plankton) (e.g., *Chaetoceros* spp.)	W(VH)	Y(VH)		N(M)	N(M)	Y(M)	Y(L)	H(VH)	n/a(M)	Euphotic Zone	N(L)	N(L)	Y(L)	M(VL)	H(VL)
Ice-associated algae (e.g., *Nitzchia frigida*)	W(VH)	Y(VH)		N(L)	Y(L)	Y(H)	Y(L)	H(M)	n/a(L)	Ice-associated	Y(H)	Y(H)	Y(H)	L(M)	H(M)
Toxin producing algae (e.g., *Pseudonitzschia* spp.)	L(M)	S(L)		N(L)	N(L)	Y(L)	Y(L)	L(L)	n/a(L)	Euphotic Zone	N(L)	N(L)	N(L)	M(VL)	H(VL)
Heterotrophic Microbes	W(VH)	Y(VH)		N	N	N	Y	M(L)	n/a		n/a	n/a	Y(L)	H(VL)	H(VL)
Macrophytes + Kelp	L(VL)	Y(VH)		N(L)	N(L)	N(L)	N(L)	L(L)	n/a	Substrate attachment (hard stable substrates) Euphotic Zone; depths below zone of ice scour	Y(M)	N	N(L)	H(VL)	H(VL)

Species/Species Group/community property	Distribution		Ecosystem component contribution		Energy Transfer					Habitat			Modifiers		
	Widespread (W) vs Localized (L)	Seasonal (S) vs year-round (Y)	Contribution to ecosystem biomass (%)	Centralized ecosystem component Yes (Y) or No (N)	Vertical Transfer (active movement) Yes (Y) or No (N)	Passive Vertical Transfer (e.g., detrital fall) Yes (Y) or No (N)	Horizontal Transfer (within WAB region) Yes (Y) or No (N)	Relative importance to Ecosystem	Feeding type	key habitat association	Habitat creating Yes (Y) or No (N)	Alters habitat (Bioturbation) Yes (Y) or No (N)	Functional uniqueness Yes (Y) or No (N)	Resistance (high or low)	Resilience (high or low)
Detritus			1%(L) minimum												
Detritus (living and non-living) Community Property	W(VH)	Y(VH)		N	N(L)	Y(L)	Y(L)	L-M(L)	n/a		Y(L)	N	N(L)	n/a	n/a
Zooplankton			29%(M)							Species-specific association with Pacific or Atlantic water masses					
Microzooplankton [<200 µm] (e.g., flagellates, dinoflagellates, ciliates)	W(VH)	Y(H)		N(L)	N(L)	Y(L)	N(L)	L-M(M)	A, S (H)		N(L)	N(L)	N(L)	H(VL)	H(VL)
Mesozooplankton (e.g., *Pseudocalanus* spp.)	W(VH)	Y(H)		N(L)	Y(L)	Y(L)	N(L)	M-H(M)	A, S (M)		N(L)	N(L)	N(L)	M(VL)	H(VL)
Macrozooplankton (e.g., *Themisto* spp., *Thysanoessa* spp.)	W(VH)	Y(H)		N(L)	Y(L)	Y(L)	N(L)	M-H(M)	A, S (M)		N(L)	N(L)	N(L)	M(VL)	H(VL)
Pteropods	W(M)	Y(H)		N	U	Y	N	L?	P, NS		N	N	N	L(VL)	U
Gelatinous species	W(M)	Y(H)		N	Y(L)	U	N	L-M?	Mixed		N	N	N	U	U
Calanus spp.	W(VH)	Y(H)		Y(VH)	Y(H)	Y(VH)	N(L)	H(VH)	A, S (L)		N(L)	N(L)	N(L)	M(VL)	H(VL)

Species/Species Group/community property	Distribution		Ecosystem component contribution		Energy Transfer					Habitat			Modifiers		
	Widespread (W) vs Localized (L)	Seasonal (S) vs year-round (Y)	Contribution to ecosystem biomass (%)	Centralized ecosystem component Yes (Y) or No (N)	Vertical Transfer (active movement) Yes (Y) or No (N)	Passive Vertical Transfer (e.g., detrital fall) Yes (Y) or No (N)	Horizontal Transfer (within WAB region) Yes (Y) or No (N)	Relative importance to Ecosystem	Feeding type	key habitat association	Habitat creating Yes (Y) or No (N)	Alters habitat (Bioturbation) Yes (Y) or No (N)	Functional uniqueness Yes (Y) or No (N)	Resistance (high or low)	Resilience (high or low)
Marine Benthic Invertebrates			21%(M)												
Epifaunal Nearshore [0–50 m] Hard bottom (e.g., Echinoderms)	L(M)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	M(L)	Mixed (L)	associated with high currents	Y(L)	N	N(L)	H(L)	H(L)
Epifaunal Nearshore [0–50 m] Soft bottom (e.g., Bivalves)	W(VH)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	M-H(M)	Mixed (H)		Y(L)	Y(L)	N(L)	H(M)	H(M)
Epifaunal Shelf [50–200 m] Hard bottom (e.g., Sponges, Echinoderms and Cnidarians)	L(M)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	L(M)	Mixed (H)	associated with high currents	Y(L)	N	N(L)	M(M)	M(M)
Epifaunal Shelf [50–200 m] Soft bottom (e.g., Echinoderms, Arthropods and Bivalves)	W(VH)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	M(M)	Mixed (H)		Y(L)	Y(L)	N(L)	M(M)	M(M)
Epifaunal Deep [> 200 m] Hard bottom (e.g., Sponges, Echinoderms and Cnidarians)	L(M)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	L(L)	Mixed (H)	associated with high currents	Y(L)	N	N(L)	L(L)	L(L)
Epifaunal Deep [> 200 m] Soft bottom (e.g., Echinoderms, Arthropods and Bivalves)	W(VH)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	L(M)	Mixed (H)		Y(L)	Y(L)	N(L)	L(L)	L(L)
Infaunal Nearshore [0–50 m] Soft bottom (e.g., Polychaetes, Bivalves and Arthropods)	W(VH)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	M-H(M)	Mixed (H)		N	Y(L)	N(L)	H(M)	H(M)

Species/Species Group/community property	Distribution		Ecosystem component contribution		Energy Transfer					Habitat			Modifiers		
	Widespread (W) vs Localized (L)	Seasonal (S) vs year-round (Y)	Contribution to ecosystem biomass (%)	Centralized ecosystem component Yes (Y) or No (N)	Vertical Transfer (active movement) Yes (Y) or No (N)	Passive Vertical Transfer (e.g., detrital fall) Yes (Y) or No (N)	Horizontal Transfer (within WAB region) Yes (Y) or No (N)	Relative importance to Ecosystem	Feeding type	key habitat association	Habitat creating Yes (Y) or No (N)	Alters habitat (Bioturbation) Yes (Y) or No (N)	Functional uniqueness Yes (Y) or No (N)	Resistance (high or low)	Resilience (high or low)
Infaunal Shelf [50–200 m] Soft bottom (e.g., Polychaetes, Bivalves and Arthropods)	W(VH)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	M-H(M)	Mixed (H)		N	Y(L)	N(L)	M(M)	M(M)
Infaunal Deep [> 200 m] Soft bottom (e.g., Polychaetes, Bivalves and Arthropods)	W(VH)	Y(VH)		N(L)	n/a(L)	Y(L)	N(L)	L(M)	Mixed (H)		N	Y(L)	N(L)	L(M)	L(M)
Anadromous Fishes			< 1%(L) minimum												
Nearshore pelagic anadromous fishes, geographically mobile [0-5 m, 5+ m] (e.g., Arctic Char, Dolly Varden, Arctic Cisco and Rainbow Smelt)	W (H-VH)	S (VH)		N(H)	n/a	N(VH)	N(H)	L(H)	A, S (H)	Coastal and possibly upper pelagic area of the shelf	N(VH)	N	N(VH)	M(M)	M(H)
Nearshore anadromous fishes, not geographically mobile; restricted to estuarine zone [0–5 m] (e.g., Broad Whitefish, Lake Whitefish, Least Cisco)	L(VH)	S(VH)		N(H)	n/a	N(VH)	N(H)	L(H)	A, S (VH)	Soft-bottomed sediments	N(VH)	N	N(VH)	H(M)	H(H)
Marine Fishes			4%(L) minimum												
Arctic Cod	W(VH)	Y(VH)		Y(VH)	Y(H)	N(H)	Y(H)	H(H)	A, S (VH)	Possible regular association with slope (300-500 m)	N(VH)	N	N(L)	M-H(M)	H(M)

Species/Species Group/community property	Distribution		Ecosystem component contribution		Energy Transfer					Habitat			Modifiers		
	Widespread (W) vs Localized (L)	Seasonal (S) vs year-round (Y)	Contribution to ecosystem biomass (%)	Centralized ecosystem component Yes (Y) or No (N)	Vertical Transfer (active movement) Yes (Y) or No (N)	Passive Vertical Transfer (e.g., detrital fall) Yes (Y) or No (N)	Horizontal Transfer (within WAB region) Yes (Y) or No (N)	Relative importance to Ecosystem	Feeding type	key habitat association	Habitat creating Yes (Y) or No (N)	Alters habitat (Bioturbation) Yes (Y) or No (N)	Functional uniqueness Yes (Y) or No (N)	Resistance (high or low)	Resilience (high or low)
Greenland Halibut	L(L)	Y(VH)		N(L)	Y(H)	N(L)	Y(L)	L (L)	A, S (L)	Bentho-pelagic zones >500 m as adults	N(VH)	N	Y(L)	U	L(L)
Coastal marine fishes [0–10 m] (e.g., Fourhorn Sculpin, Arctic Flounder, Saffron Cod)	W(VH)	S(VH) (excluded from habitat in winter)		N(H)	n/a	N(VH)	N(H)	M-H(M)	A, NS (L)		N(VH)	N	N(VH)	H(M)	H(M)
Nearshore benthic marine fishes [10–50 m] (e.g., Arctic Staghorn sculpin, Stout Eelblenny, Canadian Eelpout)	W (L-M)	S(L) (excluded from habitat in winter)		N(H)	Y(L-M)	N(VH)	N(L)	M(H)	A, NS (H)		N(VH)	N	N(VH)	H(L)	H(L)
Benthic or bentho-pelagic marine fishes [50–200 m] (e.g., Arctic Alligatorfish, Twohorn Sculpin)	W (L-M)	Y(L)		N(L)	Y(L-M)	N(M)	N(L)	L(L)	A, NS (VH)		N(VH)	N	N(VH)	M(L)	M(L)
Benthic marine fishes [> 200 m] (e.g., Longear Eelpout, Arctic Skate, snailfishes)	W(L)	Y(L)		N(L)	Y(L-M)	N(L)	N(L)	L(L)	A, NS (L)		N(VH)	N	N(L)	L(L)	L(L)
Pelagic > 50 m marine fishes (e.g., Pacific Herring, Capelin, Polar Cod)	L(L)	Y(VL)		N(L)	Y(M)	N(L)	N(L)	M(L)	A, S (L)		N(VH)	N	Y(L)	M-H(L)	M-H(L)
Marine Mammals			1% (M)												
Polar Bear	W(H)	Y(VH)		N(H)	N(VH)	N(VH)	N(H)	L(H)	A, S (VH)	Ice (first-year ice)	N(VH)	N	Y(VH)	L(M)	L(H)

Species/Species Group/community property	Distribution		Ecosystem component contribution		Energy Transfer					Habitat			Modifiers		
	Widespread (W) vs Localized (L)	Seasonal (S) vs year-round (Y)	Contribution to ecosystem biomass (%)	Centralized ecosystem component Yes (Y) or No (N)	Vertical Transfer (active movement) Yes (Y) or No (N)	Passive Vertical Transfer (e.g., detrital fall) Yes (Y) or No (N)	Horizontal Transfer (within WAB region) Yes (Y) or No (N)	Relative importance to Ecosystem	Feeding type	key habitat association	Habitat creating Yes (Y) or No (N)	Alters habitat (Bioturbation) Yes (Y) or No (N)	Functional uniqueness Yes (Y) or No (N)	Resistance (high or low)	Resilience (high or low)
Bowhead Whale	W(H)	S(VH)		N(H)	Y(L-M)	N(VH)	Y(H)	L(H)	A, NS (VH)	Upwellings	N(VH)	N	Y(VH)	L(M)	L(H)
Beluga	W(VH)	S(VH)		N(H)	Y(L-M)	N(VH)	Y(H)	L(H)	A, NS (VH)		N(VH)	N	N(VH)	H(H)	L(H)
Narwhal	L(M)	S(VH)		N(H)	Y(L-M)	N(VH)	Y(H)	L(H)	A, S (H)		N(VH)	N	Y(VH)	H(H)	L(H)
Bearded Seal	W(M)	Y(H)		N(H)	Y(L-M)	N(VH)	Y(H)	L(H)	A, S (VH)	Ice obligate (multi-year ice)	N(VH)	N	N(VH)	H(L)	M(H)
Ringed Seal	W (VH)	Y(H)		Y(VH)	Y(L-M)	N(VH)	Y(H)	M(H)	A, S (VH)	Ice obligate (first-year ice)	N(VH)	N	N(VH)	H(M)	M(H)
Marine Birds			< 1%(L)												
Sea ducks (eiders, loons, gulls)	W (VH)	S(VH)		N(L)	Y(L-M)	N(L)	N(L)	L(L)	A, S (L)	Polynyas, leads	N(H)	Y	N(L)	L(L)	L(L)

APPENDIX 2: CERTAINTY CATEGORIES AND DESCRIPTIONS

Table A2. Certainty categories and descriptions used in the assessment of ecologically significant species, functional groups and community properties.

Category	Description
Very High Certainty (VH)	Extensive peer-reviewed scientific information or data specific to the area including long-term relevant datasets.
High Certainty (H)	Substantial scientific information or recent data specific to the area. This includes both peer-reviewed and non-peer-reviewed sources.
Moderate Certainty (M)	Moderate amount of scientific information mainly from non-peer reviewed sources and first hand, unsystematic or opportunistic observations. This includes both scientific information and expert opinion. This may include older data from the area and may also include information not specific to the area.
Low Certainty (L)	Little scientific information but expert opinion relevant to the topic and area.
Very Low Certainty (VL)	Little or no scientific information. Expert opinion based on general knowledge.
Unknown (U)	No information.

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