ECO-UNITS AND POTENTIAL PRIORITY CONSERVATION AREAS IN THE WESTERN ARCTIC BIOREGION

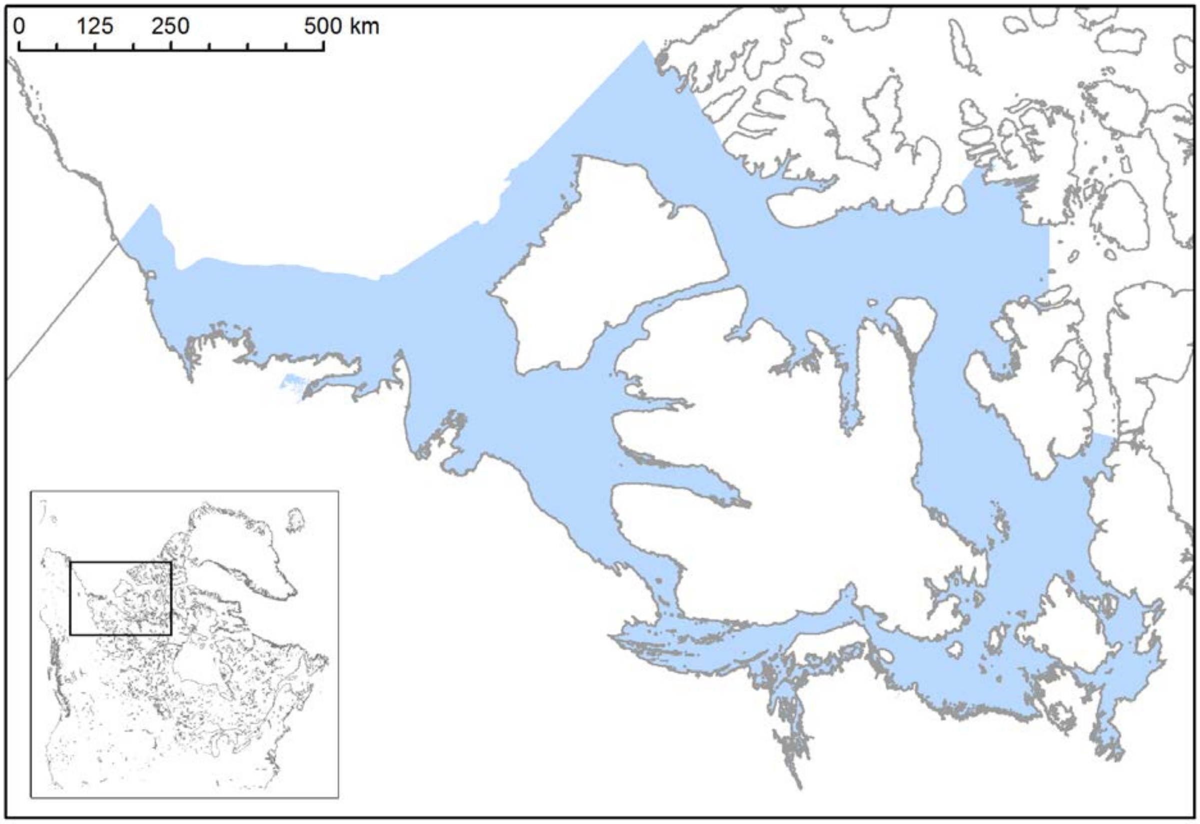

Figure 1. The Western Arctic Bioregion where establishing a Marine Protected Area Network in the Canadian Arctic is initially being focused.

Context:

To meet Canada's obligations to the United Nations Convention on Biological Diversity (UN CBD), a Marine Protected Areas Network following UN stipulated steps is required. The objective of the network will be to help conserve biodiversity, ecosystem functions and natural characteristics of the marine environment.

Ecologically and Biologically Significant Areas (EBSA) have been identified for the Western Arctic Bioregion. The next step in the process is to identify ecological units (eco-units) derived from a biogeographic classification system. Once completed, EBSAs and ecological units are used as inputs to identify potential priority conservation areas as planning inputs to the Marine Protected Areas Network.

Fisheries and Oceans Canada (DFO) Science was asked to peer review a proposed classification system to produce ecological units and identify a conservation objective (CO) and potential priority conservation areas for the Western Arctic Bioregion.

SUMMARY

- The process to plan a network of marine protected areas in the Canadian Arctic was initiated in the Western Arctic Bioregion.
- A biogeographic classification system was developed to divide the Western Arctic Bioregion into types of habitats or ecosystems referred to as eco-units. The Bioregion was divided into 18 eco-units. Dominant ecosystem features, sea-ice data, bathymetric data, sills and water mass information were the primary inputs used to delineate the eco-units.
- The Western Arctic Bioregion currently contains 22 areas identified during previous science peer reviews as being ecologically and biologically significant.
- Proposed Priority Conservation Areas (PCAs) were identified maximizing areas of overlap between the eco-units and Ecologically and Biologically Significant Areas (EBSAs) to capture areas representing all habitat or ecosystem types. Several existing conservation areas with marine components were included as PCAs and expansion of four others currently without marine components were proposed.
- There were 23 proposed PCAs identified in the Western Arctic Bioregion representing, on average, 13% of the area of eco-units and 35% of the area of EBSAs.
- The proposed PCAs captured all EBSAs and eco-units and in most cases, EBSAs and eco-units are represented in more than one PCA.

INTRODUCTION

The Government of Canada has made international commitments under the United Nations (UN) Convention on Biological Diversity (CBD) and has obligations under the *Oceans Act* to develop and implement a national network of marine protected areas. Fisheries and Oceans Canada (DFO) is leading the development of Canada’s Marine Protected Area Network (MPAN). The planning for the MPAN has been broken down, by Ocean (Atlantic, Arctic and Pacific) and by high-level spatial units or biogeographic regions, referred to as bioregions. DFO’s Central and Arctic Region is responsible for five Arctic bioregions out of the 13 total Canadian marine bioregions. The Western Arctic Bioregion is the focus of initial efforts to plan the Arctic portions of Canada’s MPAN (Figure 1) although many of the processes established during this initial focused effort are intended to be transferable to other Arctic bioregions. Place names within this bioregion are identified in Appendix 1.

Two research documents, that provide technical details and the full list of cited material, were reviewed during the meeting. One of the research documents provides information on the development and use of a classification system to identify eco-units (Hodgson et al. 2015a), and the other on Identification of a conservation objective and priority conservation areas (Hodgson et al. 2015b) for marine protected area network planning in the Western Arctic Bioregion.

ASSESSMENT

The fundamental framework for the development of the network describes the required network properties and components. The network is to include Ecologically and Biologically Significant Areas (EBSAs). It is to consist of areas representing the different biogeographical subdivisions that reasonably reflect the full range of ecosystems, including their biotic and habitat diversity. The design of the network should include connectivity to allow for both linkages whereby protected sites benefit from exchanges of larva and/or species, and functional linkages from other network sites. More than one site should contain examples of species, habitats and ecological processes (i.e., features) that naturally occur in the given biogeographic area (i.e., replication). The sites within the network should be of sufficient size and have sufficient protection to ensure the ecological viability and integrity of the features for which they were chosen.

The initial steps in development of a marine protected area network are;

1) scientifically identify EBSAs,
2) develop/choose a biogeographic, habitat, and/or community classification system,
3) use qualitative and/or quantitative techniques to identify potential areas of the MPAN, and
4) assess the adequacy and viability of selected sites.

DFO has identified 22 EBSAs (DFO 2011, DFO 1014) in the Western Arctic Bioregion (Appendix 2).

Eco-units

Hodgson et al. (2015a) describes a biogeographic classification system to divide the Western Arctic Bioregion (WAB) into habitat or ecosystem types referred to as eco-units. It included a decision tree (Appendix 3) coupled with GIS analysis. The target scale of eco-units is intermediary between the scale of the bioregion and the ultimate scale of proposed Priority Conservation Areas (PCAs). For context, each scale used in the planning process roughly changed by an order of magnitude (Bioregion = 100%, Eco-unit = 10%, PCA = 1%). The classification system was meant to capture the spatial nature and diversity of marine ecosystem and habitat types in the WAB. Classification inputs were used to delineate an area representative of the dominant habitat inputs considered or a combination of inputs specific to that area and scale. It is an area-specific prioritization system derived from inputs that roughly reflect or act in proxy for habitat/ecosystem descriptors.

Bathymetry in the WAB were used to extract depth classes (0-20 m, 20-100 m, 100-200 m, 200-500 m, >500 m). Seabed slope was considered as an input to delineate areas, including areas of high slope or areas that are associated with basins or shelves.

Arctic ecosystem dynamics and habitat are dictated to a large extent by sea-ice dynamics (including presence/absence and ice type). So sea-ice data and derived data layers were important inputs into the classification of eco-units. Areas of prolonged ice cover through the entire annual cycle present important habitat and occur due to climate, currents, winds and other ice dynamics (including ice movement after breakup). Thirty year (1981-2010) average ice data were examined at the time of seasonal ice minima (early September) to detect the presence of ice remaining from the previous winter (and/or multi-year ice) as a representation of areas with persistent ice throughout summer.

Break-up and freeze-up dates reflect several important driving forces (e.g., weather and climate including wind, ocean currents and circulation) while providing an indication of habitat conditions that impact ecosystem biological components. In the WAB, April 1 data was used to describe the maximum extent of landfast ice (10/10ths ice). The seasonal retreat of this landfast ice-edge combined with increasing light and temperatures drives productivity cycles, seasonal increases in abundance and growth of biota and the return of migratory species. Sea ice typically breaks up as a result of physical forces acting on it such as wind, tidal fluctuations and water currents as it begins to weaken during melt. This break-up typically separates an off-shore ice pack from land-fast ice and the transition between these two regimes is often called the spring ‘ice edge’.

The ice-edge feature is important ecologically and for local hunters to access the adjacent productive open-water areas. Additionally, as snow and ice melt first from the land, fresh water inputs can accelerate sea-ice melt/break-up in an area offshore from river mouths. The pattern of spring ice reduction in areas along the coast with river outflows was examined to gauge the influence of river inputs.

Polynyas are areas of open water and thin ice that persist in areas of much thicker surrounding ice during winter (and perhaps year-round in perennial-ice areas), and can be created and driven by wind, currents and ice dynamics. The ice-edge is an important habitat feature of polynyas and polynyas are of critical importance to many species and ecosystems. Annually re-occurring polynyas and leads, used as data inputs, provide a predictable general location and unique characteristics. Ice frequency data (frequency of ice occurring at a given time and location based on 30-year historical data) were examined at the end of April to detect the increasing probability of open water associated with polynyas, leads and early breakup areas.

In delineating marine areas, consideration as to the origin and composition of the water masses is important given the marine environment is complex system of water inputs, outputs and internal movements. In the western Arctic, localized inputs from rivers and ice melt combine with older source waters from the Pacific and Atlantic oceans. All of these interactions are made more complex by gradients in temperature, salinity (thereby density), by the physical constraints of the seabed morphology and physical forcings (e.g., Coriolis force). These complexities were distilled to identify areas that could be defined by the locations of physiographic barriers (i.e., sills) that cause the waters on either side to differ in some respect. The location of sills were used to delineate adjacent areas that may have differing water mass/source properties while recognizing this is a simplified two dimensional representation of three dimensional processes.

Combined results of the biogeographic classification system produced 18 eco-units in the WAB (Figure 2). Table 1 provides the primary data source for delineation and the characteristics of the eco-unit.

Proposed Priority Conservation Areas

A PCA is intended to meet the requirements necessary for an individual protected area while also considering the role of the single PCA within a functional network of protected areas. The network is to include adequate representation of EBSAs and reflect the full range of ecosystems, including their biotic and habitat diversity. It should incorporate connectivity between conservation areas to allow exchange and there should be replication of ecological features (i.e., species, habitats, ecological processes). Ultimately, protected areas should be of sufficient size and protection to ensure the ecological viability and integrity of the feature(s) for which they are selected.

The current goal[1] based on UN CBD targets is to protect at least 10% of all marine areas. The Western Arctic Bioregion contains approximately 550,000 km^2 of marine area, 10% of which would be 55,000 km^2. The current average size of Canadian MPAs = 1,234 km^2 (official DFO MPAs), or 71 km^2 (all Canadian protected marine areas). The initial target size for a PCA used in this exercise was 2,500 km^2 (equivalent to 50 km x 50 km). Based on this PCA size, the WAB would require at least 22 PCAs (of average/optimal size) to achieve the target 10%.

[1] CBD Target 11: By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape.

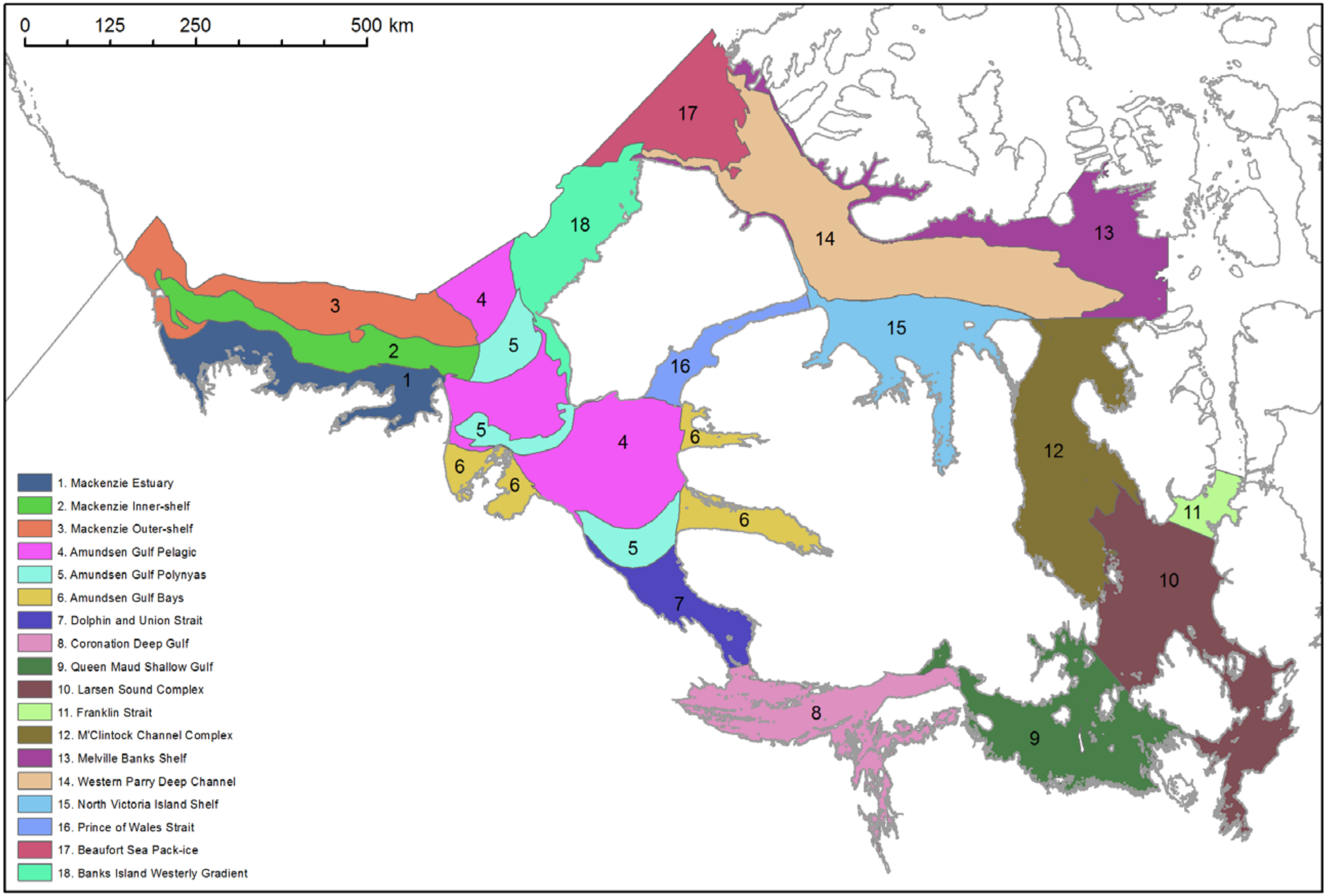

Figure 2. Proposed Western Arctic Bioregion eco-units.

Table 1. Eco-units in the Western Arctic Bioregion, their primary source and delineation characteristics based on the GIS analysis not on general characteristics or observations. Percentages are area-based, as derived from GIS data layers (i.e., percentage of the eco-unit area containing the feature layer)

Eco-unit name	Primary source delineation	Characteristics
Amundsen Gulf Bays	Fast-ice edge	98% fast ice, fast ice-edge forms first half of July, no old ice, mixed shallow depths, mid-July breakup, late October freeze-up, 19% river influence, Amundsen water mass
Amundsen Gulf Pelagic	Bathymetry	60% fast ice, no fast ice-edge, no old ice, small chance of late season ice, 76% moderately deep (200-500 m), mid-July breakup, late October freeze-up, 11% river influence (Mackenzie), mostly Amundsen water mass with 26% Beaufort water
Amundsen Gulf Polynyas	Ice Frequency Analysis	47% fast ice, no fast ice-edge, no old ice, small chance of late season ice, 80% moderately deep (200-500 m), mid-July breakup, late October freeze-up, 7% river influence (Mackenzie), mostly Amundsen water mass with 37% Beaufort water
Banks Island Westerly Gradient	Bathymetry	29% fast ice, some ice edge forms first half of July, significant amounts of old ice, mixed depths (slope), area of persistent ice throughout season, undetected river influence, Beaufort water mass
Beaufort Sea Pack-ice	Ice Frequency Analysis	27% fast ice, no obvious fast ice-edge, significant old ice, 90% moderately deep, undetected river influence, Beaufort water mass
Coronation Deep Gulf	Ice Breakup Seabed Morphology	99% fast ice, fast ice-edge until mid-July, no old ice, mixed depths, mid- late-July breakup, late October freeze-up, 30% river influence, Gulfs water mass
Dolphin and Union Strait	Ice Frequency Analysis	100% fast ice, fast ice edge in until early July, no old ice, mixed depths, mid-July breakup, late October/early Nov freeze-up, undetected river influence, Amundsen water mass
Franklin Strait	Sills	99% fast ice, fast ice-edge until end of July, generally little or no old ice, chance (30% at 50% concentration) persistent ice, mixed moderately deep, early July breakup, early October freeze-up, undetected river influence, Franklin Strait/Peel Sound water mass
Larsen Sound Complex	Sills	99% fast ice, fast ice-edge until end of July, generally little or no old ice, but 57% chance of persistent ice at 50% concentration, mixed shallow-moderate depths, mixed late season breakup, mixed early freeze-up, 13% river influence, Larsen Sound /Chantrey water mass

Eco-unit name	Primary source delineation	Characteristics
Mackenzie Estuary	Freshwater Input	98% fast ice, fast ice-edge mid-June, no old ice, shallow 20 m depth, early July breakup, Late October freeze-up, 87% river influence (Mackenzie), Beaufort water mass
Mackenzie Inner-shelf	Ice Frequency Analysis	9% fast ice, fast ice edge defines southern edge, no old ice, mixed shallow-moderate depths, mid-July breakup, late October freeze-up, 24% river influence (Mackenzie), Beaufort water mass
Mackenzie Outer-shelf	Bathymetry	9% fast ice, no significant ice edge, no old ice, 87% 100-200 m depths, mixed July breakup, 87% late October freeze-up, 21% river influence (Mackenzie), Beaufort water mass
M'Clintock Channel Complex	Ice Frequency Analysis	100% fast ice, no fast ice-edge, 67% old ice, with 96% chance of persistent 50% and 90% ice concentrations, mixed depths (channel), no discernable breakup, no discernable freeze-up, undetected river influence, M'Clintock water mass
Melville Banks Shelf	Ice Analysis	99% fast ice, possible fast ice-edge in late July, chance of old ice, with 90% chance of persistent 50% ice concentration, mixed moderate depths, no discernable break-up, no discernable freeze-up, 8% influence (possible river or other), Beaufort water mass
North Victoria Island Shelf	Ice Frequency Analysis	99% fast ice, no fast ice-edge, 61% 4-8 10ths old ice, with 99% chance of persistent ice, mixed shallow-deep water depths, no discernable breakup, no discernable freeze-up, undetected river influence, Beaufort water mass
Prince of Wales Strait	Similar to Amundsen Gulf Bays, except channel has water throughput and undetected river influence	99% fast ice, fast ice edge mid-July, no old ice, with 10% chance of persistent ice, mixed shallow-moderate depth channel, mid-late July breakup, early-mid October freeze-up, undetected river influence, Influenced by Amundsen and Beaufort water masses
Queen Maud Shallow Gulf	Ice Breakup	99% fast ice, fast ice edge until end of July, generally little or no old ice, mixed shallow depths, end of July breakup, Late October freeze-up, 5% river influence, Gulfs water mass
Western Parry Deep Channel	Bathymetry	100% fast ice, possible fast ice-edge in late July, 68% 4-8 10ths old ice, with 100% chance of persistent ice, moderate-deep water, no discernable breakup, no discernable freeze-up, undetected river influence, Beaufort water mass

These input parameters served as a guide only and outputs were not restricted to these guideline parameters.

The analysis of the intersection between eco-units and EBSAs created 46 areas of overlap. A ‘moving-window’ analysis with a window size equal to that of the 50 km x 50 km target PCA was used to evaluate potential PCA placement. This optimises the placement of PCAs to capture ecosystem diversity through overlapping EBSAs and eco-unit areas. Twelve potential PCAs captured a minimum of four EBSAs and/or eco-units to justify their placement (Figure 3, Table 2).

Placement of eleven areas capitalized on existing (or proposed) protected areas (as is or through expansion) (Figure 3, Table 2). The Tarium Niryutait Marine Protected Area (TNMPA), comprised of three separate areas, is currently the only official MPA in the WAB and the Anuniaqvia Niqiqyuam area of interest (ANAOI) is an area proposed for MPA designation. There are also four Marine Bird Sanctuaries (MBS) with coverage in the marine environment including Kendal Island Bird Sanctuary, Anderson River Delta MBS, Banks Island #1 MBS and Queen Maud Gulf MBS. There are also two National parks with coastal components, Ivvavik and Aulavik. One Nunavut Wildlife Area (Polar Bear Pass) and one Marine Bird Sanctuary (Banks Island #2 MBS), currently include little or no marine components. By expanding them into marine areas, they capture eco-units that otherwise have little representation. The extent of the proposed expansions for these two areas into marine areas was based on a 2,500 km^2 size area.

Nine PCAs were positioned to achieve adequate representativity of EBSAs and eco-units including EBSAs from DFO (2011) that were not captured in the moving window analysis (Table 2). A PCA was placed in Dolphin and Union Strait capturing two eco-units and the Lambert Channel EBSA identified as a polynya and estuary feature. Chantrey Inlet EBSA in its entirety, an estuary feature located within the Queen Maud Shallow Gulf eco-unit, was identified as a PCA. Another PCA was identified in Bathurst Inlet capturing that EBSA and the Coronation Deep Gulf eco-unit. A PCA in Franklin Strait captured the Peel Sound EBSA and Franklin Strait eco-unit. James Ross Strait PCA, within the King William Island EBSA, and Dyer Bay PCA at the intersection of three eco-units, Melville Banks Shelf, Western Parry Deep Channel, and Beaufort Sea Pack-ice were specifically added to ensure adequate eco-unit representation (Figure 3, Table 2).

There were 24 proposed PCAs identified in the Western Arctic Bioregion (Figure 3, Table 2).

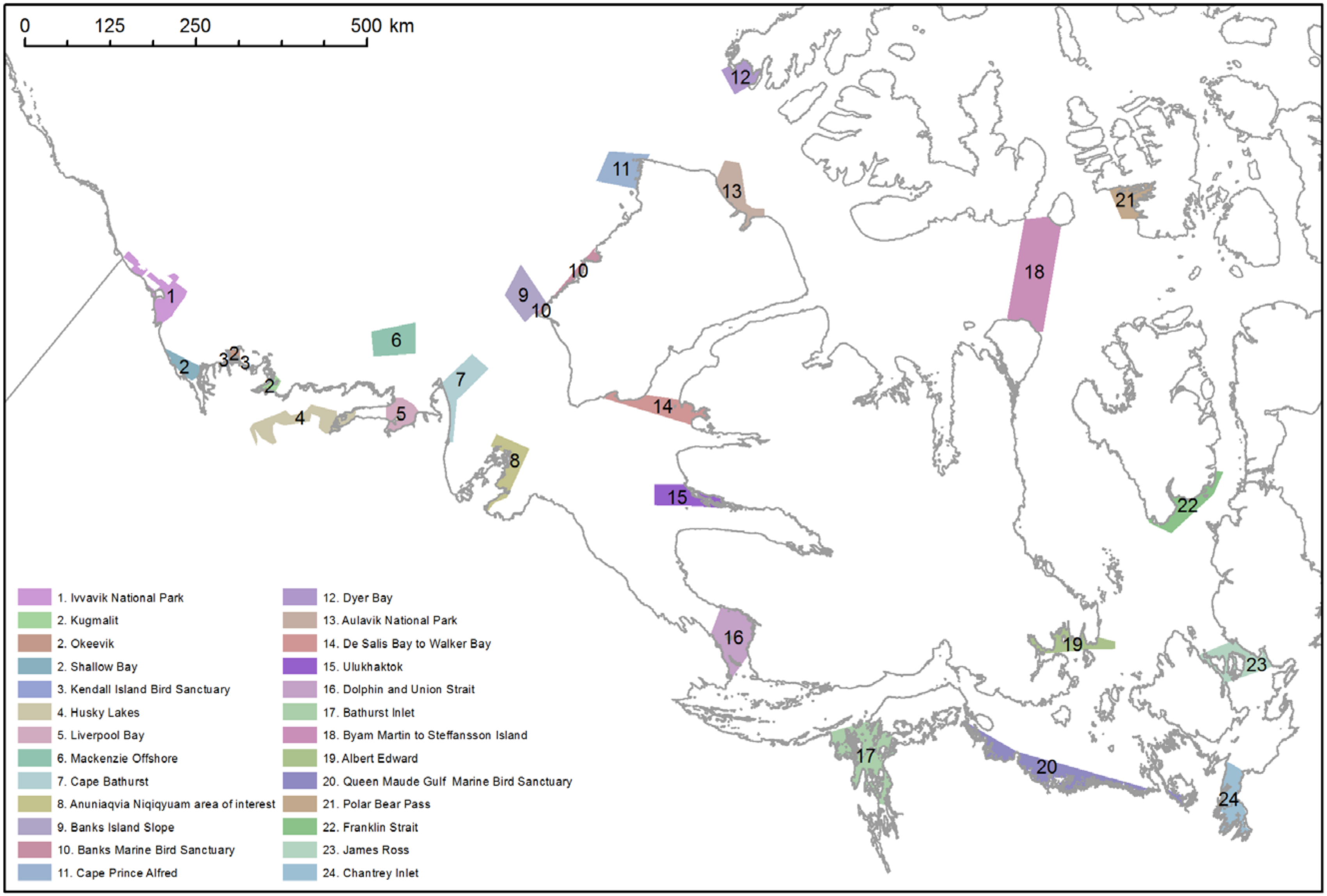

Figure 3. Proposed Priority Conservation Areas in the Western Arctic Bioregion.

Table 2. Components for the proposed Priority Conservation Areas (PCAs) in the Western Arctic Bioregion. Initial PCAs were placed to overlap with at least four EBSAs and/or eco-units. Existing conservation areas were included as PCAs, some as is, and some with expansion proposed into marine areas. The remainder of PCAs were chosen to add representation of EBSAs or eco-units.

PCA number	Location	EBSAs	Eco-units	Existing or proposed conservation area
1	Ivvavik National Park	Yukon North Slope Mackenzie Trough	Mackenzie Estuary Mackenzie Inner -shelf Mackenzie Outer-shelf	✓ Expansion proposed
2	Tarium Niryutait Marine Protected Area [Shallow Bay, Okeevik, Kugmallit]	Mackenzie Estuary and Nearshore Beaufort Shelf	Mackenzie Estuary	✓
3	Kendall Island Bird Sanctuary	Mackenzie Estuary and Nearshore Beaufort Shelf	Mackenzie Estuary	✓
4	Husky Lakes	Husky Lakes	Mackenzie Estuary	✓
5	Liverpool Bay	Liverpool Bay	Mackenzie Estuary	✓ Expansion proposed
6	Mackenzie Offshore	Kugmallit Canyon Cape Bathurst / Baillie Island	Mackenzie Inner-shelf Mackenzie Outer-shelf	
7	Cape Bathurst	Cape Bathurst / Baillie Island Horton River Southern Amundsen Gulf Cape Bathurst Polynya Liverpool Bay	Amundsen Gulf Polynyas Amundsen Gulf Pelagic Mackenzie Inner-shelf Mackenzie Estuary	
8	Anuniaqvia Niqiqyuam area of interest	Southern Amundsen Gulf Darnley Bay Nearshore Migration and Feeding Corridor	Amundsen Gulf Bays Amundsen Gulf Polynyas Amundsen Gulf Pelagic	✓
9	Banks Island Slope	Western Banks Island	Banks Island Westerly Gradient Amundsen Gulf Polynyas Amundsen Gulf Pelagic	

PCA number	Location	EBSAs	Eco-units	Existing or proposed conservation area
10	Banks Marine Bird Sanctuary	Western Banks Island	Banks Island Westerly Gradient	✓
11	Cape Prince Alfred	Western Banks Island	Banks Island Westerly Gradient Beaufort Sea Pack-ice Melville Banks Shelf Western Parry Deep Channel	
12	Dyer Bay		Beaufort Sea Pack-ice Melville Banks Shelf Western Parry Deep Channel	
13	Aulavik National Park		Melville Banks Shelf Western Parry Deep Channel Beaufort Sea Pack-ice	✓ Expansion proposed
14	De Salis Bay to Walker Bay	De Salis Bay Diamond Jenness	Amundsen Gulf Bays Amundsen Gulf Pelagic Prince of Wales Strait	
15	Ulukhaktok	Diamond Jenness	Amundsen Gulf Bays Amundsen Gulf Pelagic Amundsen Gulf Polynyas	
16	Dolphin and Union Strait	Lambert Channel	Dolphin and Union Strait Coronation Deep Gulf	
17	Bathurst Inlet	Bathurst Inlet	Coronation Deep Gulf	
18	Byam Martin to Steffansson Island	Viscount Melville Sound	Melville Banks Shelf Western Parry Deep Channel M'Clintock Channel Complex North Victoria Island Shelf	
19	Albert Edward	Southern Victoria Island Coastline King William Island	Queen Maud Shallow Gulf Larsen Sound Complex	
20	Queen Maude Gulf Marine Bird Sanctuary	Queen Maud Gulf Coastline	Queen Maud Shallow Gulf	✓

PCA number	Location	EBSAs	Eco-units	Existing or proposed conservation area
21	Polar Bear Pass		Melville Banks Shelf	✓ Expansion proposed
22	Franklin Strait	Peel Sound	Franklin Strait Larsen Sound Complex	
23	James Ross	Kind William Island	Larsen Sound Complex	
24	Chantrey Inlet	Chantrey Inlet	Larsen Sound Complex	

Representativity

On average, 13% (Standard Deviation SD=5.6) of the area of each eco-unit is captured within the proposed PCAs. However, five eco-units are under- and two are over-represented (i.e., more than 1 SD from the mean). Beaufort Pack Ice and Franklin Strait eco-units have skewed representativity because the ecosystems these eco-units represent extend beyond the Bioregion boundaries. In the case of the Beaufort Pack Ice eco-unit, there would be opportunities to increase representativity when planning a MPAN into the Arctic Basin or Arctic Archipelago bioregions. The M'Clintock Channel Complex, North Victoria Island Shelf and Prince of Whales Strait eco-units are all under-represented with the proposed PCAs. As there was insufficient data or information to rationalize the placement of PCAs in these areas, no additional PCAs were added to resolve the under-representation.

The amount of EBSAs captured in proposed PCAs ranges between 5% and 60% (average 35%). The Mackenzie Estuary, Kugmallit Canyon and Bathurst Polynya are under-represented (under 10%) reflecting the size of the EBSA relative to the size of the optimal PCA (6 to 10 times the size). Many more EBSAs are highly represented (i.e., over 40%) including Lambert Channel, Chantrey Inlet, Queen Maud Gulf, Yukon North Slope, De Salis Bay, Darnley Bay, and Horton River. This can be explained by the small size of these EBSAs relative to the optimal PCA (0.1 to 4 times the size).

This process to delineate PCAs has achieved full representativity of all EBSAs and eco-units within the WAB. Proposed PCAs capture 13% of the bioregion (approximately 71,000 km^2) which exceeds the target of 10% total marine area.

Replication

Most eco-units are represented in more than one PCA except Dolphin and Union Strait, Franklin Strait, M’Clintock Channel Complex, Prince of Wales Strait, and North Victoria Island Shelf eco-units. Just under half of the EBSAs are represented in more than one PCA. Southern Victoria Island, Queen Maud Gulf, Peel Sound, Mackenzie Trough, Lambert Channel, Kugmalit Canyon, Husky Lakes, Horton River, De Salis Bay, Darnley Bay Nearshore, Chantrey Inlet and Bathurst Inlet are each represented by one PCA.

The M'Clintock Channel Complex, North Victoria Island Shelf and Prince of Whales Strait eco-units are all under-represented within the proposed PCAs. To achieve better representation of these eco-units, additional PCAs or expansion of the proposed PCAs could be considered in each of these areas as network development proceeds. There were insufficient data or information available to rationalize the placement of additional PCAs in these areas at this time.

Marine Protected Area Network Conservation Objective

The following conservation objective was created the WAB MPAN:

The Marine Protected Area Network is established to ensure as much as possible that ecosystems and ecosystem services of the Western Arctic Bioregion remain healthy and productive for future generations. This will be accomplished by enhanced management including ongoing knowledge acquisition such that all ecological diversity and ecologically significant areas are represented thereby providing better knowledge and adequate management options to deal with future changes and pressures. Explicitly this includes all four levels of diversity of the UN CBD.

Sources of Uncertainty

Much of the Western Arctic Bioregion is uninhabited. Available scientific data are limited for much of the area and many of the information sources are incomplete. Data are biased to socially, culturally and economically important species and areas. Research has focused on coastal areas within close proximity of established communities.

Division of the bioregion into eco-units was limited by the available data. Some of the ecosystem features, particularly those related to ice, vary spatially, seasonally and annually. Although changes in seasonal sea ice are occurring as a result of climate change (e.g., freeze-up dates, break-up dates, type of ice present, i.e., multi-year ice versus seasonal ice), the Arctic ecosystem will still be dominated by sea ice in winter. Sea-ice data were therefore used in the delineation of most eco-units. Eco-units and EBSAs influenced by the Mackenzie River are also sensitive to seasonal and annual variability. Some features, ecosystems and habitat types are highly variable although the eco-unit boundaries were positioned to capture the range of variability. Several eco-units captured polynyas and leads even though their presence may only be a fraction of the annual cycle and their location fluctuates annually.

Maximum representativity of eco-units and EBSAs is accomplished by locating PCAs such that boundaries between eco-units and EBSAs are selected preferentially. In the case of eco-units, because they boarder one another to achieve full coverage of the bioregion, boundaries may be less representative of the eco-unit target features than the centre of the eco-unit although it might be of benefit in a conservation strategy to capture transition zones between eco-units. This potential ‘edge-effect’ needs to be considered in the final evaluation of PCAs. The overall edge-effect is also reduced because of the influence of EBSAs. Since EBSAs have no requirement to cover the entire area of the bioregion, edge-effects are much reduced in comparison to eco-units.

CONCLUSIONS AND ADVICE

The process to identify a network of marine protected areas in the Canadian Arctic was initiated in the Western Arctic Bioregion. A biogeographic classification system was developed to divide the Western Arctic Bioregion into habitats or ecosystems and resulted in 18 eco-units being identified. Dominant ecosystem features (e.g., Mackenzie River estuary, Mackenzie/Beaufort Shelf, polynyas and leads (winter/spring ice features), and persistent Ice (summer/fall ice features) were used to delineate several eco-units. Sea-ice data, bathymetric data, sills and water mass information were the primary inputs used to delineate the remainder.

Twenty-three EBSAs have been identified in this Bioregion (DFO 2011, DFO 2014). Proposed Priority Conservation Areas (PCAs) were identified to maximise areas of overlap between the eco-units and EBSAs. This approach was intended to capture areas of diverse habitat or ecosystem type. Several existing conservation areas with marine components were included as PCAs and expansion of four areas currently with little or no marine components was proposed. The areas identified as PCAs do not necessarily capture areas that are the best individual area to represent a single ecosystem type. They are intended to represent ecosystem diversity within the bioregion.

There were 23 proposed PCAs identified in the Western Arctic Bioregion representing, on average, 13% of the area of eco-units and 35% of the area of EBSAs. The proposed PCAs captured all EBSAs and were replicated within most eco-units. Since eco-units comprise 100% of the bioregion, the percentage of the bioregion represented by PCAs is also 13% or approximately 71,000 km^2.

Delineation of proposed PCAs in this initial step of MPAN planning did not specifically examine connectivity (physical and biological linkages between proposed PCAs). Connectivity should be examined more closely during the later stages of network development. The PCAs may be far from the final size, shape and location of a fully designated marine protected area or other conservation area. The type of protected area is also not fully defined at this stage of network development. The adequacy and viability of selected sites was not assessed and would need to be evaluated in the future. Further work will be required to synthesise any existing data and information about each of the proposed areas and further research may be required.

OTHER CONSIDERATIONS

The majority of the Canadian Arctic is part of comprehensive land claims agreements. The Western Arctic Bioregion includes areas covered by both the Inuvialuit Final Agreement and the Nunavut Land Claims Agreement. The bioregion is large and includes six communities in the Inuvialuit Settlement Region, Aklavik, Inuvik, Tuktoyaktuk, Paulatuk, Sachs Harbour, and Ulukhaktok. The remaining six communities in the Bioregion are located in the Kitikmeot Region of Nunavut and include Hamlets of Kugluktuk, Cambridge Bay, Gjoa Haven and Taloyoak and communities of Umingmaktok and Bathurst Inlet (both located on Bathurst Inlet).

Many Arctic marine ecosystems are characterised by highly changeable conditions (e.g., sea ice) and populated by highly mobile species (e.g., mammals, birds, fishes). Protecting these ecosystems with fixed conservations areas will be difficult. MPAN planning should consider alternatives to fixed designated conservation areas that are adaptable to spatial and temporal changes. Within the defined national and international guidelines on MPANs, this issue is well noted. Despite the lack of guidance and the obvious logistical difficulties in protecting such ecosystems, options need to be considered as the process to define PCAs and the overall MPAN continues beyond this preliminary identification of potential sites.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 17-19, 2014 peer review on Developing a marine protected area network in the Western Arctic Bioregion – validating the process and identifying Priority Conservation Areas. Additional publications from this meeting will be posted on the DFO Science Advisory Schedule as they become available.

DFO. 2011. Identification of Ecologically and Biologically Significant Areas (EBSA) in the Canadian Arctic. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/055.

DFO. 2014. Re-evaluation of Ecologically and Biologically Significant Areas (EBSAs) in the Beaufort Sea. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/052.

Hodgson, R., Martin, K., and Melling, H. 2015a. Marine protected area network planning in the Western Arctic Bioregion: development and use of a classification system to identify ecological units as required planning components. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/020. v + 41 p.

Hodgson, R., Martin, K., and Melling, H. 2015b. Marine protected area network planning in the Western Arctic Bioregion: Identification of a conservation objective and priority conservation areas as required planning components. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/021. iv + 25 p.

APPENDIX 1. PLACE NAMES

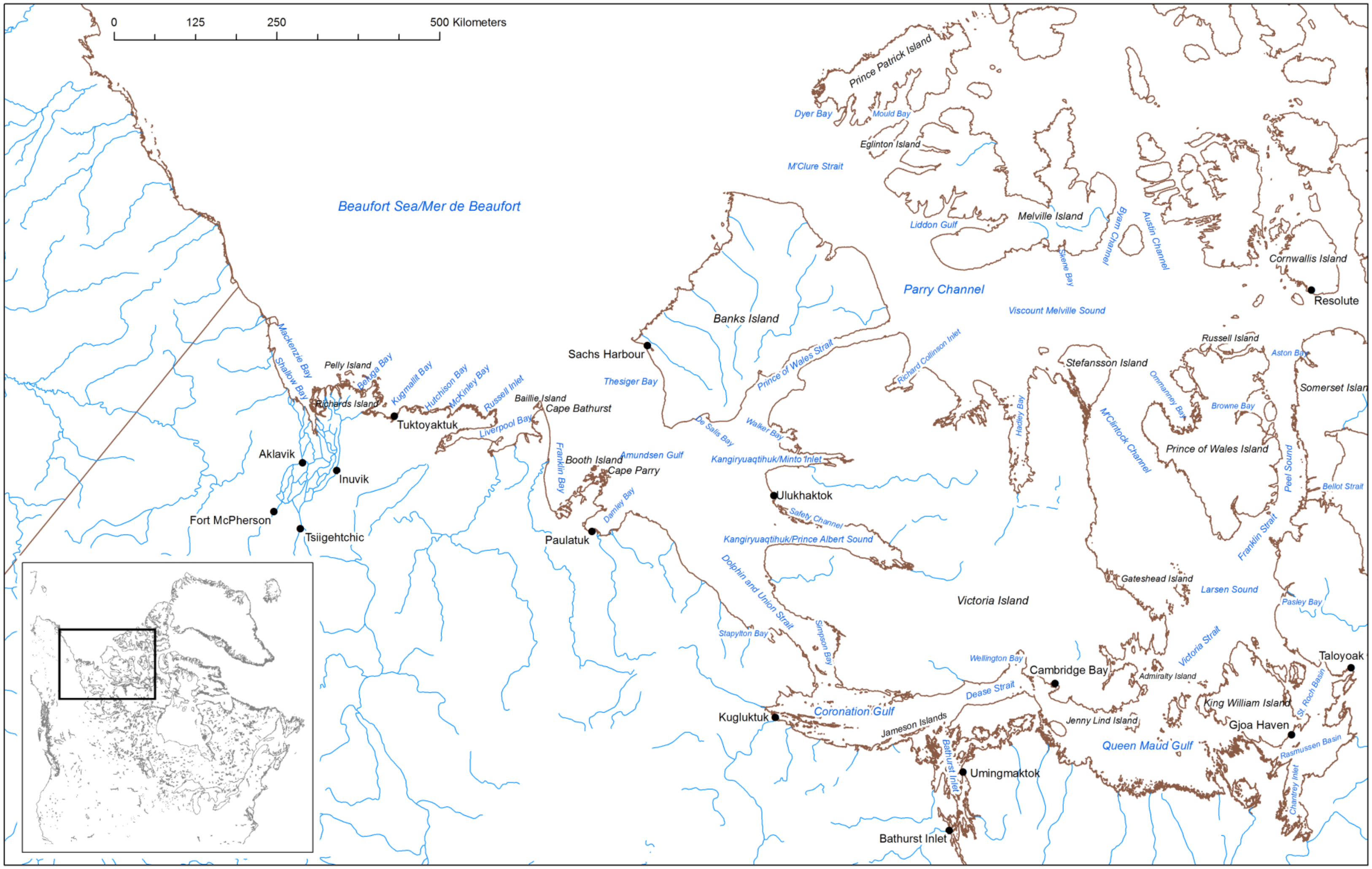

Figure A1. Place names in the Western Arctic Bioregion.

APPENDIX 2. ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS

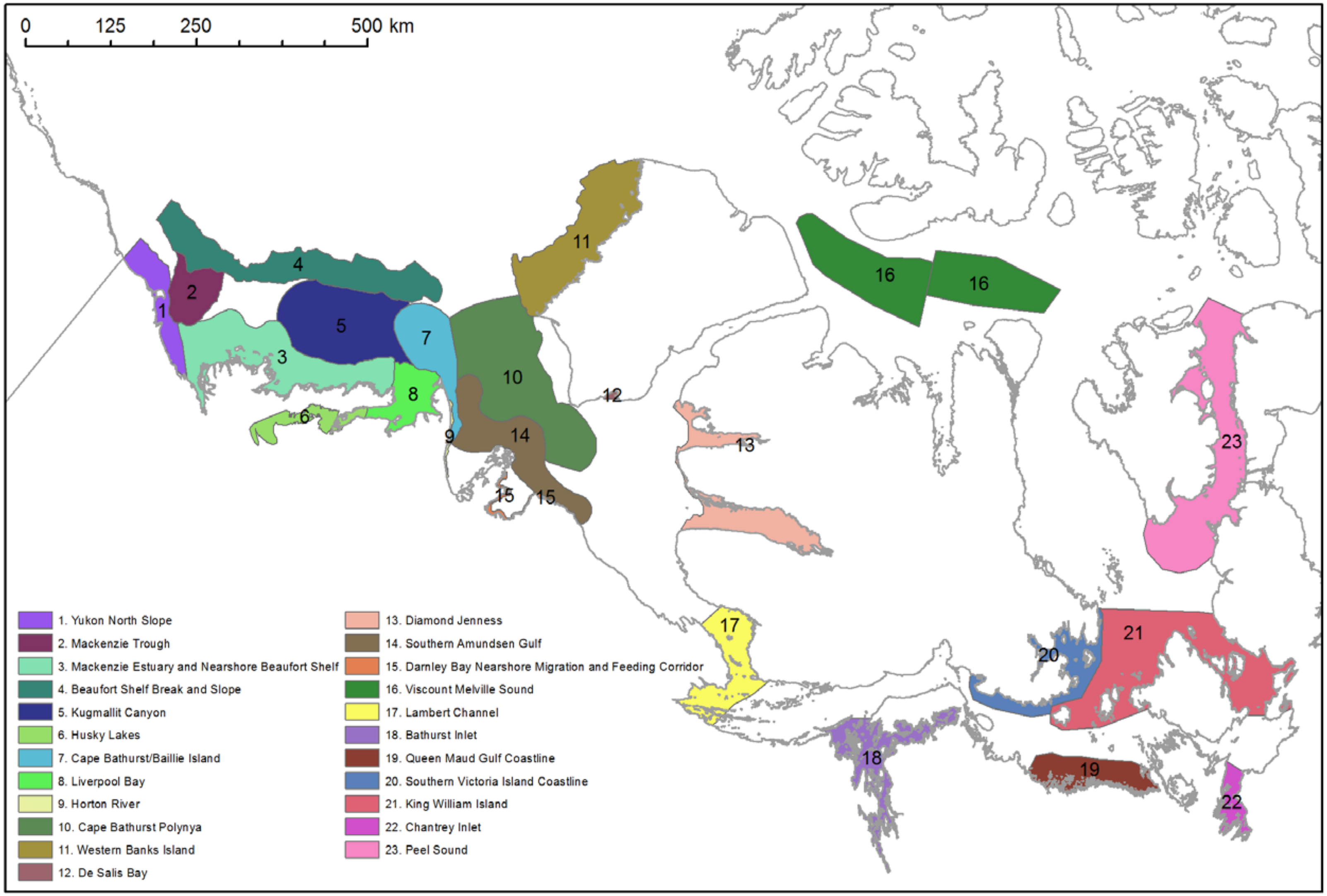

Figure A2. Ecologically and Biologically Significant Areas in the Western Arctic Bioregion (DFO 2011, DFO 2014). The two sections to the Viscount Melville Sound EBSA were identified at two different meetings and there was no attempt to align the boundaries.

APPENDIX 3. SUBDIVISION OF THE BIOREGION

An initial subdivision of the bioregion into eco-units followed a decision tree coupled with a GIS analysis. The decision tree used for eco-unit delineation within the WAB is outlined as follows:

1) Is there a dominant habitat feature in the area?

   For the WAB this includes but is not restricted to;

   - Mackenzie Estuary,
   - Mackenzie/Beaufort Shelf,
   - Polynyas and Leads (winter/spring ice features),
   - Persistent Ice (summer/fall ice features).

   a. Yes – GO TO 2
   b. No – GO TO 3
2) Do other habitat features coincide (e.g., > 90% overlap of the secondary feature with the primary feature) within the area in question?
   a. Yes – adjust (expand, contract) the boundary where necessary to accommodate coinciding habitat features and complete delineation (i.e., delineation will be based on two or more habitat features).
   b. No – finalize delineation based on scientifically defensible information.
3) Using available input data – isolate a definable area.
   a. If an area defined by appropriate data can be delineated at an appropriate scale THEN GO BACK TO 2
   b. no spatially appropriate area can be defined due to inappropriate or insufficient data THEN GO TO 4
4) If areas remain – undertake a Residual Area Analysis.
   a. If insignificant in size (<2% of the bioregion), include by expanding neighbouring eco-units with the least fixed boundaries.
   b. If significant in size examine neighbouring eco-unit characteristics and determine the unique aspects of each area – Use these criteria to define as a potential eco-unit THEN GO TO 5
5) Finalize All Eco-units.
   a. After all potential eco-units are labeled and no other residual areas exist – are there spatially disconnected areas with the same or similar defining characteristics?
      i. Yes – can a case be made (based on geospatial properties – or scientific information) that these areas are in fact part of the same eco-unit? Keep in mind that not all spatially disconnected areas may have representation in protected area strategies/planning. If this may be problematic, then a case should be made for separate eco-units. Finalize one or more eco-units.
      ii. No – delineate as separate eco-units.

The use of this decision tree cannot be separated from the use and manipulation of information within a GIS analysis. In the same sense, the classification system is not a GIS tool that can be implemented or automated based on information inputs alone.

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