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ARCTIC COASTAL BIODIVERSITY MONITORING PLAN
Coastal Expert Monitoring Group, Circumpolar Biodiversity Monitoring Program
The Conservation of Arctic Flora and Fauna (CAFF) is a Working Group of the Arctic Council.

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- Environment and Climate Change Canada, Ottawa, Canada
- Faroese Museum of Natural History, Tórshavn, Faroe Islands (Kingdom of Denmark)
- Finnish Ministry of the Environment, Helsinki, Finland
- Icelandic Institute of Natural History, Reykjavik, Iceland
- The Ministry of Nature and Environment, Greenland
- Russian Federation Ministry of Natural Resources and Environment, Moscow, Russia
- Swedish Environmental Protection Agency, Stockholm, Sweden
- United States Department of the Interior, Fish and Wildlife Service, Anchorage, Alaska

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- Arctic Athabaskan Council (AAC)
- Gwich’in Council International (GCI)
- Inuit Circumpolar Council (ICC) – Greenland, Russia, Alaska and Canada
- Russian Indigenous Peoples of the North (RAIPON)
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The Arctic Coastal Biodiversity Monitoring Plan (Coastal Monitoring Plan) is the fourth and final circumpolar biodiversity monitoring plan to be completed under the Circumpolar Biodiversity Monitoring Program (CBMP), an initiative of the Conservation of Arctic Flora and Fauna (CAFF) Working Group of the Arctic Council. As the Coastal Monitoring Plan was being developed, the Coastal Expert Monitoring Group (CEMG) was able to learn from the experience of the first three CBMP plans – both through the published products, and through conversations with team members that developed the CBMP terrestrial, freshwater and marine monitoring plans. In particular, we were able to meet directly with the team that developed the State of Arctic Marine Biodiversity Report to discuss boundaries for the coastal marine domain and share lessons learned. With these contributions in mind we would like to acknowledge the important input from all the CBMP teams in the development of the Coastal Monitoring Plan.

We would like to acknowledge the contributions of two early co-chairs of the Coastal Expert Monitoring Group, Carl Markon and Rebecca Anderson, who steered the development and direction of the Coastal Monitoring Plan through its early stages.

The Coastal Monitoring Plan is also informed by the important contributions of national experts, scientists and Traditional Knowledge (TK) holders at the three workshops held to gather input on plan development and priorities. The workshops were also attended by, and received input and contributions from, representatives of industry, national government departments, and non-governmental organizations. The names of all workshop participants and sponsoring agencies are listed in the individual workshop reports available at https://www.caff.is/coastal/coastal-monitoring-publications. The information and guidance received at these three workshops was central to the development of the Coastal Monitoring Plan, and was instrumental in identifying key coastal biodiversity issues, threats and drivers, helped prioritize a long list of potential Focal Ecosystem Components (FECs), and provided input that led to the framing of the monitoring questions for the Coastal Monitoring Plan. We gratefully acknowledge the important contributions made by TK holders, scientists and other workshop participants, and thank organizations that hosted the workshops, and those that contributed to travel and accommodation for workshop experts.

We would also like to acknowledge the help of Nuka Research and Planning Group who coordinated the work of the CEMG and provided valuable editing and formatting services for the Coastal Monitoring Plan.

Finally, we would like to thank the experts who have taken the time, energy, and efforts to develop and review the Coastal Monitoring Plan, and those who reviewed the FEC rankings process. These reviews improved the depth and scope of the plan, and helped ensure its relevance to Northerners.

As a caveat, although we have consulted broadly across all participating countries, we would like to acknowledge that there are many other experts and potential contributors who have not had input into the development of the Coastal Monitoring Plan to date. The approach of the Coastal Monitoring Plan is to be incremental where national implementation will continue to engage additional Indigenous and scientific expertise.

The Arctic Council uses the term “Traditional and Local Knowledge.” It is important to note that all the Permanent Participants and Indigenous participants contributing to the development of this plan prefer the term “Indigenous Knowledge” and/or self-identified as Indigenous Knowledge holders. With this in mind, the report uses the term Traditional Knowledge except when quoting a person or document.
The primary goal of the Coastal Expert Monitoring Group (CEMG) is to develop a long-term, integrated, multi-disciplinary, circumpolar Arctic Coastal Biodiversity Monitoring Plan (the ‘Coastal Monitoring Plan’) that relies on science and Traditional Knowledge (TK), and has direct and relevant application for communities, industry, governments, and other users.

Arctic coastal ecosystems include those areas within the Arctic region (as defined by the CAFF Working Group’s established Arctic boundary, Figure ES-1), where fjords, glaciers, rocky coasts, coastal wetlands, estuaries, rivers, lakes, and coastal ocean ecosystems meet and interact in complex ways that significantly influence their composition, structure, function, and their capacity to support a wide spectrum of the Arctic coastal biodiversity. These Arctic coastal ecosystems are the focus of the Coastal Monitoring Plan.

Activities within Arctic coastal ecosystems range from large-scale fishing, industrial development, and seaports, to sustainable, local, subsistence harvesting. Arctic human settlement is largely coastal, and includes the homelands of Indigenous Peoples, as well as many non-Indigenous communities. Recognizing humans are a part of the ecosystem, we embrace a social-ecological systems approach in the Coastal Monitoring Plan, which acknowledges the interdependence of human coastal communities and related activities, and the coastal ecosystems that they rely on.

Given their complexity and overall high productivity, coastal ecosystems create a ribbon of diverse marine, terrestrial and freshwater habitats. These habitats support a wide range of Arctic biota including shorebird and waterfowl species, coastal fish species such as salmon, Arctic char, many whitefish and benthic fish species, and marine mammals such as walrus, seals and whales. Soft bottoms and shallow coastal water harbor important shellfish communities, which provide food for walrus and bearded seal, as well as for diving sea ducks. Extensive coastal mudflats provide invertebrate food for migrating shorebirds, rocky shorelines are a sturdy substrate for rich intertidal and subtidal invertebrate, seaweed and fish communities, and coastal cliffs provide safe nesting habitat for large colonies of colonial nesting seabirds that feed in adjacent coastal marine areas. Assembling available baseline information and identifying knowledge gaps, assessing current status and tracking and reporting biodiversity change in these Arctic coastal species is the key objective of the Coastal Monitoring Plan.

There are increasingly many anthropogenic stressors and changing environmental drivers that have the potential to negatively impact coastal biodiversity and the communities that rely on that biodiversity. A list of the key stressors and drivers of anthropogenic change in coastal biodiversity was developed, based on input received from both TK holders and science experts in three workshops that contributed to the development in this plan, and from a review of the science literature. This work highlighted the fact that Arctic coastal biodiversity is threatened by a diversity of stressors, ranging from climate change-related stressors to direct human interference with the ecosystems such as fishing or oil spills. The combination of stressors has the potential to interact in ways that are difficult to predict. Given this potential, the systems approach...
proposed in this Coastal Monitoring Plan will help design and implement coastal monitoring programs that can identify causal linkages and thus help to predict change and develop proactive adaptation solutions.

The Coastal Monitoring Plan acknowledges the expertise of the TK holders that reside in coastal communities. Arctic coasts have been, for millennia, the homeland of many Indigenous groups across the circumpolar Arctic. Throughout this time Indigenous Peoples have been observing and assessing coastal biodiversity, and adapting to ongoing changes. The development of monitoring programs should begin with the recognition of the history of what has occurred within a given area, and the baseline information held within TK. In developing the Coastal Monitoring Plan, the CEMG is committed to developing a monitoring approach that includes the input of both science and TK experts in coastal ecosystems and coastal biodiversity. Arctic coastal communities rely heavily on coastal ecosystems for the ecological services that coastal biodiversity provides – including commercial and subsistence harvesting, and food security. Arctic residents continuously acquire important knowledge of species, changes in those species, and the environmental factors that are driving shifts in health and numbers. They hold a systematic way of knowing that is passed between generations and is still developing today. Within this knowledge is information on animals, plants and interacting and changing ecosystems. TK is able to identify unique understanding of drivers of change. The Coastal Monitoring Plan will include approaches to systematically utilize this knowledge – knowledge that supports and extends our understanding of the state of and changes in coastal biota.

The Coastal Monitoring Plan is designed to satisfy the information needs of multiple users. To this end, the approach will balance specific inquiry-based monitoring, monitoring methods found within TK, and a broader approach to monitoring ecosystem conditions with key indicators from multiple levels of biological organization included in a large-scale monitoring design. User-driven monitoring questions, regional ecosystem understanding, and knowledge of existing programs were essential for the selection of useful monitoring programs and key monitoring indicators – the Focal Ecosystem Components (FECs).

Through the development of the Coastal Monitoring Plan, a series of three workshops were held that included federal researchers, industry representatives, academic researchers, and TK holders. The first workshop was held in Ottawa, Canada in March 2016, and focused on an identification of monitoring issues and needs, monitoring questions, an overall picture of what types of monitoring were occurring across the Arctic, and an initial version of potential Focal Ecosystem Components (FECs).

Monitoring questions are at the heart of any monitoring program and, based on input from the Ottawa workshop, the CEMG developed the following general, high level monitoring questions, as well as questions specific to the identified knowledge clients of the Coastal Monitoring Plan:

1) What is the status and trend of Arctic coastal ecosystems in terms of their native species composition and condition, new and invasive species, geographic distributions, thresholds with respect to climate drivers, phenological norms, and key processes and functions?
   i) What are primary system drivers and disturbances (biological, chemical, physical, and anthropogenic) and how are they influencing changes in coastal biodiversity and ecosystem function?
   ii) What are the cumulative effects of primary system drivers and disturbances (biological, chemical, physical, and anthropogenic) to coastal ecosystems and biodiversity?

2) If Arctic coastal biodiversity or subsistence food is significantly impacted by any of these factors acting alone or together, which species are affected, how are they affected (mechanisms and drivers of change), where are they affected (geographically), and what is the expectation for the effects of these impacts in the near to medium future (5-20 years)?

3) How will measured and predicted changes in Arctic coastal biodiversity impact the mandated biodiversity obligations of local, Indigenous, territorial and federal governments?

4) Do the following factors (individually and/or cumulatively) significantly impact Arctic coastal ecosystems and associated biodiversity generally; and specifically, do they significantly impact the availability, abundance and quality of subsistence food for Arctic communities?
   - direct and indirect effects of climate change
   - oil and gas activities: exploration, drilling and extraction, and related infrastructure, shipping, and other transportation activities
Coastal Monitoring Plan presents an umbrella approach to monitoring and reporting change in Arctic coastal biodiversity; for Arctic-wide reporting, however, the reports will be organized as an international, coastscape-focused approach. The implementation of the monitoring plan will be developed within each member nation. As the assessments are integrated for Arctic-wide reporting, however, the reports will be organized as an international, coastscape-focused approach. The Coastal Monitoring Plan presents an umbrella approach to monitoring and reporting change in Arctic coastal biodiversity; that is, an international template that provides enough common direction (e.g., common FECs, co-production of knowledge where appropriate, coastscape/systems approach, data management, organizational structure) so that results can be easily integrated and reported internationally, but allowing for national monitoring approaches and variability in coastal systems. The main purpose of the Coastal Monitoring Plan is its implementation across participating countries to produce the first ‘State of Arctic Coastal Biodiversity Report’ (SACBR), a report that will follow similar reporting for CBMP marine (CAFF 2017), freshwater (CAFF, in press) and terrestrial (CAFF, in prep) programs. The SACBR will be developed from national synopses of coastal monitoring data, and recent research information, with results assessed and reported using the approaches outlined in the Coastal Monitoring Plan. It is understood at this time that the SACBR will not be able to comprehensively answer all monitoring questions for all prioritized FECs. The first SACBR will address monitoring questions for FECs where data are currently available, and commit to working with coastal partners to grow the program with the aim to begin to answer these overarching monitoring questions for all FECs across the circumpolar Arctic.

Based on input at the Ottawa workshop we adopted the use of the ‘coastscape’ for the Coastal Monitoring Plan to describe an area of the circumpolar Arctic coast with recurring physiographic features, and where similar terrestrial, marine and freshwater processes are interacting with these physiographic features and local climate to create a relatively predictable range of habitats that support characteristic populations of coastal species. A total of seven coastscales were identified (Fjords, Rocky Coasts and Seacliffs, Lagoons and Barrier Islands, Estuaries, Eroding Shores, Low Gradient Soft Shores, and Ice Fronts) and together provide a coordinated, international, systems-based approach to stratifying Arctic coasts into similar ecological settings with characteristic coastal biota. Coastscales are used in the Coastal Monitoring Plan to stratify the identification and prioritization of key coastal species for monitoring, to understand and communicate the main abiotic factors that drive habitat distribution and productivity for coastal biota, to recognize the important role played by human cultures in coastal ecosystems, and to identify and address potential biodiversity threats. Framing monitoring questions within coastscape social-ecological systems also allows whole system integration based on an Indigenous and ecological interconnectedness perspective.

FECs were evaluated on the basis of their priority according to a set of selection criteria within the individual coastscales. This process required two additional expert workshops: One in Anchorage, Alaska (October 2017), and the other in Tromsø, Norway (January 2018), to eventually prioritize the broad list of potential FECs into Essential and Recommended categories. The workshop in Anchorage worked to further develop a platform for a co-production of knowledge by bringing together TK holders and scientists, and focused on validating the FECs that had been identified, and further identifying attributes and parameters from both TK holders and scientists. The workshop in Tromsø also focused on clarifying potential FECs, in addition to identifying the appropriate attributes and parameters necessary to provide the answers to the questions outlined in the Coastal Monitoring Plan.

The input gathered from the workshops was used to prioritize each FEC against a set of criteria designed to assess suitability for inclusion in the plan. The criteria were assessed for each FEC in each coastscape, with quality assurance provided by a group of researchers. Following the quality assurance, CEMG members used a stochastic dominance process, based on the ability of each FEC to best meet the majority of the selection criteria. This was used as an initial tool to identify and prioritize the FECs deemed as ‘Essential’ for monitoring. FECs not assessed to be Essential were termed ‘Recommended,’ implying that their importance is recognized but they did not meet the criteria for Essential status. This process was then followed by a final CEMG expert opinion to identify any additional FECs deemed to be Essential, but which had not been included due to logical inconsistencies in the prioritization process. It was also recognized that the Coastal Monitoring Plan requires the inclusion of TK holders for both national and Arctic-wide assessments.

Implementation of the monitoring plan will be developed within each member nation. As the assessments are integrated for Arctic-wide reporting, however, the reports will be organized as an international, coastscape-focused approach. The Coastal Monitoring Plan presents an umbrella approach to monitoring and reporting change in Arctic coastal biodiversity; that is, an international template that provides enough common direction (e.g., common FECs, co-production of knowledge where appropriate, coastscape/systems approach, data management, organizational structure) so that results can be easily integrated and reported internationally, but allowing for national monitoring approaches and variability in coastal systems. The main purpose of the Coastal Monitoring Plan is its implementation across participating countries to produce the first ‘State of Arctic Coastal Biodiversity Report’ (SACBR), a report that will follow similar reporting for CBMP marine (CAFF 2017), freshwater (CAFF, in press) and terrestrial (CAFF, in prep) programs. The SACBR will be developed from national synopses of coastal monitoring data, and recent research information, with results assessed and reported using the approaches outlined in the Coastal Monitoring Plan. It is understood at this time that the SACBR will not be able to comprehensively answer all monitoring questions for all prioritized FECs. The first SACBR will address monitoring questions for FECs where data are currently available, and commit to working with coastal partners to grow the program with the aim to begin to answer these overarching monitoring questions for all FECs across the circumpolar Arctic.

- mining activities: exploration, extraction, processing, and related infrastructure, shipping and other transportation activities
- shipping: tourism and adventure cruising, community re-supply, industrial, military and research-related shipping
- subsistence and commercial fishing
- community activities: sewage disposal and other pollution, hunting, trapping, infrastructure, avoidance
- long range and local contaminants: mercury (Hg) and persistent organic pollutants (POPs)
- invasive alien species: especially marine invasive species

Based on input at the Ottawa workshop we adopted the use of the ‘coastscape’ for the Coastal Monitoring Plan to describe an area of the circumpolar Arctic coast with recurring physiographic features, and where similar terrestrial, marine and freshwater processes are interacting with these physiographic features and local climate to create a relatively predictable range of habitats that support characteristic populations of coastal species. A total of seven coastscales were identified (Fjords, Rocky Coasts and Seacliffs, Lagoons and Barrier Islands, Estuaries, Eroding Shores, Low Gradient Soft Shores, and Ice Fronts) and together provide a coordinated, international, systems-based approach to stratifying Arctic coasts into similar ecological settings with characteristic coastal biota. Coastscales are used in the Coastal Monitoring Plan to stratify the identification and prioritization of key coastal species for monitoring, to understand and communicate the main abiotic factors that drive habitat distribution and productivity for coastal biota, to recognize the important role played by human cultures in coastal ecosystems, and to identify and address potential biodiversity threats. Framing monitoring questions within coastscale social-ecological systems also allows whole system integration based on an Indigenous and ecological interconnectedness perspective.

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1. Introduction
1. **Introduction**

Arctic ecosystems host globally-unique assemblages of organisms. The size and nature of Arctic ecosystems make them critically important to the biological, chemical, and physical balance of Earth. Dramatic changes in regional climates are impacting Arctic biodiversity, negatively affecting the resilience of some species while benefiting others, influencing the potential for human use, and in some cases, affecting the overall integrity of northern ecosystems (CAFF 2013, 2017). Increasing development, transportation, and other activities may further impact Arctic biodiversity, ecosystem functions and northern communities in ways that are not yet understood. Moreover, continued rapid change in the Arctic will likely have repercussions for the ecosystems and biodiversity of the entire planet through alterations in surface albedo (reduced snow cover and increased heating), carbon cycling, shifting ocean currents with effects on local climates, loss of sea ice cover, coastal erosion, and changes in breeding habitat for migratory species – from fish and marine mammals to birds harvested in the North and elsewhere.

Arctic coastal ecosystems are threatened by climate change and human development that can affect their biodiversity. Changing Arctic biodiversity will also affect the lives of Arctic Peoples that are dependent on and part of the coastal ecosystems. This Coastal Monitoring Plan will, as part of the Circumpolar Biodiversity Monitoring Program (CBMP), focus on coastal ecosystems, and build on the framework document developed by the CBMP Coastal Expert Monitoring Group (McLennan et al. 2016). The framework facilitates more rapid detection, communication and response to significant trends in Arctic coastal species, biodiversity and ecosystems. The Coastal Monitoring Plan follows this approach and provides key recommendations and advice for Arctic coastal monitoring.

This CBMP Coastal Monitoring Plan is an agreement within Arctic Council member States and Permanent Participants to work together to coordinate ongoing monitoring, and to compile, harmonize and compare results from existing Arctic coastal biodiversity and ecosystem monitoring efforts, across nations and oceans.

1.1 **CBMP monitoring approach**

The Arctic Council is the leading intergovernmental forum promoting cooperation, coordination and interaction among the Arctic States and Arctic Indigenous Peoples (represented by the Permanent Participants) on common Arctic issues, in particular, on issues of sustainable development and environmental protection in the Arctic.

As the Arctic continues to experience intense and accelerating change, it has become increasingly important to expand access to information on the status and trends of Arctic biodiversity. The Arctic Council has recommended that long-term monitoring efforts and inventories be increased and focused to address key gaps in knowledge to better facilitate the development and implementation of conservation and management strategies (CAFF 2013, ACIA 2004). CBMP monitoring programs provide an assessment of the current state of Arctic biodiversity, identify important gaps in our knowledge, and encourage investment to fill identified gaps.

The CBMP is the cornerstone program of the Conservation of Arctic Flora and Fauna (CAFF), the Arctic Council’s biodiversity working group. The CBMP aims to utilize both Traditional Knowledge (TK) and science, by bringing together an international network of scientists, governments, Indigenous organizations, coastal Indigenous Peoples – harvesters and gatherers, and conservation groups, working to harmonize and integrate efforts to monitor the Arctic’s living resources. Its goal is to facilitate more rapid detection, communication and response to significant biodiversity-related trends and pressures affecting the circumpolar world, while also establishing international linkages to global biodiversity initiatives. The CBMP applies a question-driven and integrated ecosystem-based approach to long-term monitoring to describe ecosystem and biodiversity change, and to identify important trends (Figure 1.1).

It does this by:

- compiling, harmonizing and enhancing Arctic biodiversity monitoring efforts, thereby improving the ability to detect and understand significant trends; and,
- reporting to, and communicating with, key decision makers and stakeholders, thereby enabling effective conservation and adaptation responses to changes in Arctic biodiversity.

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2 The Arctic Council Permanent Participants are Aleut International Association; Arctic Athabaskan Council; Gwich’in International; Inuit Circumpolar Council; Saami Council; Russian Association of Indigenous Peoples of the North

3 The Arctic Council uses the term “Traditional and Local Knowledge.” It is important to note that all the Permanent Participants and Indigenous participants contributing to the development of this plan prefer the term Indigenous Knowledge and/or self-identified as Indigenous Knowledge holders. With this in mind, the report uses the term Traditional Knowledge except when quoting a person or document.
1.2 Goals and objectives

The Coastal Expert Monitoring Group (CEMG) is a forum for scientists, Indigenous Peoples representing their knowledge (TK holders), and data users to promote research and monitoring activities that facilitate coordinated, cost-effective Arctic coastal biodiversity monitoring.

The CEMG is co-led by the U.S. and Canada and currently includes representatives from Canada, Kingdom of Denmark, Norway, Russia, the U.S. and the Inuit Circumpolar Council (ICC). There is no current representative from Iceland. The background and frame established for the CEMG work is fully described in McLennan et al. (2016).
The primary goal of the CEMG is to develop a long term, integrated, multi-knowledge and multi-science disciplinary, circumpolar Arctic Coastal Biodiversity Monitoring Plan (the Coastal Monitoring Plan) that relies on science and TK, and has direct and relevant application for communities, industry, governments and other users.

The primary objectives of the CEMG to attain this goal are to:

► develop a monitoring plan for Arctic coastal biodiversity (‘the Coastal Monitoring Plan’) to identify, assess and coordinate existing monitoring capacity and programs with existing programs (where possible) to detect, understand, assess and report the state of and trends of important species in the circumpolar Arctic; and,

► identify gaps in present monitoring programs in the context of the full suite of identified threats, drivers and at-risk Arctic coastal biodiversity.

1.3 Definition of Focal Ecosystem Components, attributes and parameters

In terms of the structure of the monitoring indicators, the Coastal Monitoring Plan follows the hierarchical approach of the three previous CBMP monitoring plans. To facilitate an international synthesis of coastal biodiversity we will report on Focal Ecosystem Components (FECs). FECs are groups of ecologically-related coastal species that are considered together in order to permit international reporting (Table 1.1), and are agglomerated at a higher level as FEC Groups, e.g., ‘Coastal Birds’, in Table 1.1. FECs are at a level above coastal species, and are used in CBMP monitoring programs to account for the fact that different species occur in different coastal settings around the circumpolar area. This list includes many species already covered in other CBMP plans. Only those species not covered by other plans, or where specific components of their life history, e.g., nesting, are truly coastal, will be covered in the Coastal Monitoring Plan.

FECs are components of the condition of each FEC, as measured by the FEC parameters. FEC parameters are the units of measure for each attribute, and provide standardized categories and units for monitoring and reporting. Not all attributes and parameters will be measured for all species. Typical species within FECs (Table 1.1), as well as FEC species, attributes and parameters are based on input at workshops held for the Coastal Monitoring Plan. Some parameters are measured through TK expert interpretation as can be seen in Table 1.1 on Parameters for measuring ‘Harvest and Accessibility’ and ‘Body Condition’ Attributes, while others may be measured through direct scientific measures. This represents significant integration of the two knowledge systems in providing a broader view of the coastal biodiversity.

1.4 Building a platform for a co-production of knowledge approach

Throughout the development of the Coastal Monitoring Plan, a strong focus was placed on utilizing Indigenous Peoples’ knowledge and worldviews, concepts of biodiversity, and categorization of information, methodologies and processes. Building a platform for a co-production of knowledge requires equity to build a plan that has room for the methodologies, evaluation and validation processes of multiple knowledge sources. Greater focus on this approach was realized through workshops attended by multiple TK holders and Indigenous organization representatives, and the Coastal Monitoring Plan built on that input, as well as literature published by Indigenous organizations. This engagement further informed a stronger holistic approach that recognizes the coastal ecosystem as a nexus of marine, freshwater and terrestrial environments, in the context of abiotic, biotic, social and cultural elements.

While there is more work to be done to further develop an effective platform for co-production of knowledge within the Coastal Monitoring Plan, the process already undertaken increased engagement of TK holders and recognizes the need to bring together TK holders and scientists for the entire process of plan development and implementation. TK holders and/ or Indigenous organization representation has been actively engaged in every face-to-face steering committee and all workshops held. The Coastal Monitoring Plan is designed to be a living plan, and to adjust with a focus on strengthening the co-production of knowledge process through national implementation of the Coastal Monitoring Plan.

To build the Coastal Monitoring Plan a circumpolar survey was conducted (with input from both TK holders and scientists), three workshops and one TK holder meeting were held, and reviews conducted (Figure 1.2).

The TK holder workshop and first CEMG workshop were held in Ottawa, Canada, in March 2016. The workshops focused on the Coastal Monitoring Plan design, identification of monitoring questions, key threats, and importantly recognized and brought together processes found within science and TK through discussions, concept maps, and group work.

The Ottawa workshop was followed by a workshop held in Anchorage, Alaska in 2017. This workshop focused on bringing together TK holders and scientists to discuss the Focal Ecosystem Components (FECs) identified at the Ottawa workshop, and
The attributes and parameters needed to monitor FEC status. The workshop utilized a co-production of knowledge approach with facilitation that focused on creating an equitable environment. The workshop had a North America focus and resulted in attributes and parameters identified through both TK and science.

The Anchorage workshop was followed by a meeting held in Tromsø, Norway (Wegeberg et al. 2018) that was attended by marine scientists and a representative of the Saami Council. This workshop focused on Fjord and Rocky Shore Coastscapes, and expert input was provided on prioritizing potential FECs, improving the conceptual models for these two coastscapes, and identifying most appropriate attributes and parameters for the prioritized FECs.

### Table 1.1. Example of the hierarchical structure used to assess and report change in the Coastal Monitoring Plan. This example is for a FEC group - Coastal Birds, which have been agglomerated into eight FECs. Attributes and parameters apply to all FECs listed but may not all be measured for all FECs.

<table>
<thead>
<tr>
<th>POTENTIAL FEC</th>
<th>TYPICAL SPECIES</th>
<th>ATTRIBUTES</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal shorebirds/songbirds</td>
<td>all shorebirds/songbirds using coastal terrestrial ecosystems (coastal wetlands)</td>
<td>Diversity</td>
<td>Community Alpha diversity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Species genetic diversity, sub-populations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spatial Structure</td>
</tr>
<tr>
<td>Coastal waterfowl</td>
<td>all geese and sea ducks using coastal ecosystems</td>
<td>Abundance</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Density</td>
</tr>
<tr>
<td>Coastal raptors</td>
<td>white-tailed eagle, bald eagle</td>
<td>Phenology</td>
<td>Migration timing, routes, partial migration</td>
</tr>
<tr>
<td>Seabirds: omnivores</td>
<td>glaucous gull, glaucous-winged gull, great black-backed gull, herring gull, ivory gull</td>
<td>Demography</td>
<td>Life cycle events (breeding, nesting, rearing)</td>
</tr>
<tr>
<td>Seabirds: diving planktivores</td>
<td>least auklet, dovekie</td>
<td>Harvest and accessibility</td>
<td>Growth rate and survival</td>
</tr>
<tr>
<td>Seabirds: diving piscivores</td>
<td>common murre, thick-billed murre, Atlantic puffin, tufted puffin</td>
<td></td>
<td>Reproductive rate</td>
</tr>
<tr>
<td>Seabirds: surface piscivores</td>
<td>black-legged kittiwake, northern fulmar, Arctic tern</td>
<td></td>
<td>Genetics and stock structure</td>
</tr>
<tr>
<td>Seabirds: benthivores</td>
<td>black guillemot, pigeon guillemot, great cormorant, shag, pelagic cormorant</td>
<td></td>
<td>Age class distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sex distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Harvest statistics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Subsistence hunting statistics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Harvest usability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hunting strategies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Success of food processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CuHE (distance, fuel, time)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Body Condition</td>
<td>Taste/texture/colour of fat, meat, organs, skin, scales, tongue, hair, feathers, stomach contents, egg-thickness, smell</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lipid/fat amount, energy density</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stress – cortisol levels, skittish animals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Contaminants (Hg, POPs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Disease – frequency of outbreaks, die-offs, unusual mortalities, lesions, unusual mortality events</td>
</tr>
</tbody>
</table>
Figure 1.2. Overview of the four steps to develop the Coastal Monitoring Plan.

FECs were prioritized for plan inclusion by coastscape through workshop input, and a second expert process that involved ranking potential FECs against a series of prioritization criteria, reflecting their effectiveness in answering the monitoring questions. This input was integrated into a draft of the Coastal Monitoring Plan that was sent for review by TK and science experts, whose comments were included in a final draft reviewed by the CAFF Board.

As for all aspects of the Coastal Monitoring Plan, the intention has been to provide an international template within which each country can draw upon national resources and situations to report on the state of their Arctic coastal biodiversity. While the Coastal Monitoring Plan aims to lay a platform for a co-production of knowledge approach, continued emphasis will have to be actualized through national plans and in all CEMG international meetings and activities. The implementation will occur differently depending on the country.
1.5 Understanding Traditional Knowledge and monitoring

Arctic Indigenous Peoples have used their knowledge to make daily and long-term decisions throughout their history. TK has remained in the hands of community members over generations. Children are taught from the beginning of life about the world around them using an evolving knowledge system, keen senses, and constant observation of the ecosystem. Information gathered is further validated and evaluated through and includes an analysis process. “IK monitoring methods are rooted in daily activities, such as hunting caribou or gathering sura (diamond-leaf willow).” (ICC-AK 2015) Acquiring information about the local environment and being aware of changes that are occurring across space and time are crucial skills for maintaining food security and overall survival (ICC-AK 2015). This influences what questions are asked and what information has to be taken in through monitoring. “For example, IK tends to ask questions about the ecosystem in which an animal is found, behavior of the animal, and its interaction with the environment,” taking note of any anomalies (ICC-AK 2015).

“Often within IK, monitoring and decision-making is based on relationships between components and interactions between integrated descriptions of the environment, as opposed to single aspects of it,” (ICC-AK 2015). The Inuit Circumpolar Council (ICC) Alaska food security project reinforces this concept, showing that Inuit observations are not isolated within a single species or abiotic system, but identify multiple connections within each observation. For example, when considering walrus, there will also be a discussion about sea ice thickness, currents, salinity levels, walrus stomach contents – benthic species, and the social aspects of collecting and processing the walrus. This food security approach to monitoring the environment and understanding a strong linkage between all systems may be described as being synonymous with taking a social-ecological systems approach to research (ICC-AK 2015). “IK goes beyond these approaches and encompasses all aspects. Key elements monitored in IK include phenological changes, food webs, social shifts in relation to changes, and amount of effort applied to gathering food,” (Behe and Daniel 2018; Ottawa workshop 2014). “The IK focus on relationships between animals, plants, water, air, culture and all other systems stresses a focus on relationships between components and interlinks multiple elements across, social, biological and abiotic systems” (Behe and Daniel 2018; Ottawa workshop 2014). Here it is important to remember not to give into the temptation to translate one knowledge system into the other, but to appreciate each for its own uniqueness and understanding.

“Monitoring programs in Indigenous Peoples’ homelands should always begin with discussions with Indigenous Peoples. For example, white fish, there is interests in understanding white fish. The researchers come in without the IK holders’ information and try to make a short cut straight to the white fish. This results in waste of energy and money, because they have not asked the IK holders of the white fish cycle, when is the best time to be there, when they should be interacting with the white fish. They should then take the information obtained and combine it with the IK and the IK holders should be involved in the analysis of the information. The findings need to stay with the community. It needs to be of us of the community. Many scientists like to use surveys. But we don’t always see a lot of the information gathered. We need to see the elders’ information directly from them.”

- Indigenous Knowledge (IK) holder participant
1.6 Global linkages

The Coastal Monitoring Plan anticipates the leveraging of ongoing national monitoring efforts that gather coastal biodiversity information directly related to the selected FECs. These monitoring efforts include national initiatives by contributing federal and regional governments, monitoring by industry, long-term academic monitoring programs, as well as community-based monitoring.

Furthermore, because of the way this plan was established, it links directly to the other CBMP international Arctic biodiversity monitoring programs under the CAFF Working Group – the marine, terrestrial, and freshwater monitoring efforts. The Coastal Monitoring Plan is also linked through CAFF to key international programs under the Arctic Council such as Arctic Monitoring and Assessment Program (AMAP), Protection of the Arctic Marine Environment (PAME) and Arctic Migratory Bird Initiative (AMBI), as well as to CAFF objectives listed in the Arctic Biodiversity Assessment (CAFF 2013), targets listed under the Convention on Biological Diversity, and international monitoring networks such as GEOBON and the International Permafrost Network.

Coastal monitoring plan efforts will ultimately provide a rich source of information to a broad set of knowledge clients and international initiatives directly relevant to Arctic system users, because it focuses on areas of the Arctic where the majority of the people live – the Arctic coast.

“I would like to present to you a very old Indigenous Knowledge from our culture about the beluga. We will start with when the beluga is at the wintering site. It would help if we/ since we don't have a map with us about the area, I will say in my area the beluga will be in the Hudson Strait. The beluga will winter in this area where the ice will not move, since it's not moving the beluga will winter in that area. Once the season begins it changes towards springtime, and when the ice begins to move, so does the beluga begin to move, to migrate. The beluga will replenish itself, it will accumulate fat as it prepares itself to give birth in the month of July. The beluga will not necessarily migrate to the immediate shoreline, it is not dumb, it will avoid crushing ice so it will move offshore. When you live in an area with rocky shore and steep cliffs the land-fast ice will accumulate and stick to the cliffs; the beluga will avoid this area. Once the ice starts to fall off the cliffs, the beluga will then move close to the shoreline, when it's that time the beluga will migrate. It migrates from our area a long distance following the shoreline, up past James Bay to the western side of Ontario and go moult its skin in the Churchill area of Manitoba. As the season progresses towards the fall it is the big male beluga that begin its migration as the first group to leave. Its health is very lean; it is not fat when it begins its journey. Thus, on its return migration as it did in the springtime, it will return by the same route back to where it spent the winter. I must add that Inuit might not necessarily be scientists, but through this time this is the lessons they learn through this passage, and this is also what is in a knowledge holder. We also hear of beluga and narwhal that become entrapped because of the ice conditions. It happens in our area and in the Nunavut area. This is a part of Inuit knowledge since time immemorial.” This example stresses the wealth of Indigenous Knowledge of beluga and the multiple variables considered. Such knowledge is crucial in developing a baseline understanding – this is the baseline understanding and should guide future monitoring activities.

- Quitsak Tarriasuk, Kuujjuaq, Nunavut, as part of discussions at the Ottawa workshop concerning the selection of FECs
2. Key Elements and Monitoring Questions
2. Key Elements and Monitoring Questions

2.1 Coordinated international plan with national implementation

The overall purpose for the Coastal Monitoring Plan is to develop an inclusive international approach that describes a comprehensive coastal biodiversity monitoring program designed and implemented to meet the identified general needs and applications of knowledge clients in all participating countries.

A successful long-term monitoring program will link monitoring initiatives across geographic and temporal scales, and allow for multiple user needs to be addressed (Behe 2017; Angnaboogok and Behe 2017). This requires multiple sources of knowledge and multi-disciplinary methods, and recognizes and brings together multiple approaches to monitoring – from circumpolar observations gathered through satellite data to community-based monitoring.

The approach undertaken in the Coastal Plan provides a holistic view of the environment and greater understanding of cumulative impacts, while providing decision makers, at scales from an Arctic community member, to national and international managers, with the information needed to make adaptive decisions two days or two decades from now. Overall, we plan to implement an ecosystem-based approach with common key monitoring objectives, overarching monitoring questions, and especially an international set of FECs to inform the status of biodiversity. Using these overarching guidelines, participating countries can then implement a coordinated circumpolar approach that meets national needs, but that can be reported internationally, e.g., through the use of common FECs, a shared database, and using a common coastal biogeographic classification (common coastscapes).

2.2 Co-production of knowledge

The CEMG recognizes that co-production of knowledge may not be possible in all Arctic nations. However, the Coastal Monitoring Plan has developed a platform for the co-production of knowledge, where possible, to better understand Arctic change. “Equity is a cornerstone of a co-production of knowledge approach, ensuring fairness and the opportunity of IK holders to engage in all aspects of a project” (Behe and Daniel 2018). The benefit is a better understanding of Arctic change through a holistic view achieved by bringing together different knowledge systems, including that of both Arctic Indigenous Peoples (Behe and Daniel 2018), and scientific disciplines.

“We have been here for thousands of years. We know these animals. Sometimes if they [researchers] just asked us, we would be able to give them the answer. They won’t need to spend so much money and we can get to a more current question.”

– IK holder participant

“Polar bears eat moss before eating seals. The moss helps retain seal oil. So that they do not excrete all of it.”

– Quitsak Tarriasuk (Elder, IK holder participant)

“…for it to work [monitoring plan] in the long term, you need elders and youth.”

– IK holder participant

“…connect with youth groups – plug into modern tech. One idea is to develop animal sounds for the youth to use on their phones. They become familiar with the sound.”

– IK holder participant

“The co-production of knowledge brings together IK holders and scientists to equitably work together throughout all phases of work – from the beginning, i.e. scoping stages, identification of questions, monitoring needs, determining methodologies), through gathering information (i.e. determining what information is needed, how to gather the information, agreements of how the information will be used and accessibility to information), through data analysis (conducted by all included), to output and communication to ensure relevant outputs, culturally appropriate communication, and usable information” (Behe and Daniel 2018; Ottawa workshop 2014).

In addition to ensuring Indigenous Knowledge holders equitably engage in all parts of the Coastal Monitoring Plan, it is important to identify and engage Indigenous organizations and entities that are conducting monitoring programs. As with the engagement of any organization and entity, this will require focus be placed on relationship building throughout the implementation process.
Additionally, reports, assessments and other products will need to accommodate both Indigenous Knowledge and science processes. For example, “Indigenous Knowledge recognizes the interconnecting nature of all components within the Arctic ecosystem. This interconnectivity includes the connection and well-being between social and cultural elements and biodiversity, e.g., between language and biodiversity,” (Behe and Daniel 2018; Ottawa workshop 2014). Holistic, ecosystem-based reports and assessments will include interconnectivity between biodiversity and human dimension parameters analysis.

The implementation of the Coastal Monitoring Plan will include the identification of existing monitoring programs, aggregation of information, analysis of information, and communications through assessments and sharing of information. With this in mind, it is recognized that where appropriate, relevant national teams will need to include both TK holders and scientists.

2.3 Community-based monitoring (CBM)

The CBMP has emphasized the importance of community-based monitoring, including those rooted in science, TK, or both, and has acknowledged that there are multiple methodologies that may be applied, from citizen science observations, to TK-based information, to those that rely on scientific instruments (e.g., satellites, temperature, salinity levels). In addition, it is important to consider longevity, engagement, and ownership of community-based monitoring programs. An often-overlooked component of community based monitoring is the inclusion of youth/school students because of the potential for long-term engagement, ownership and education. All appropriate CBM efforts should be considered for inclusion.

Across the Arctic, Indigenous Peoples have always made observations of changes – where observing changes and analyzing information gathered has been a matter of understanding the world around you, curiosity, and one of survival directly related to food security (ICC 2016). Where a co-production of knowledge approach is being used, these ongoing TK observations and assessments will be a key component of any CBM program.

The Inuit Circumpolar Council (ICC) white paper on Atlas of Community-Based Monitoring & Indigenous Knowledge in a Changing Arctic (Johnson et al. 2013) shares the following about CBM:

“Today, there are multiple methods that may be employed to conduct CBM, including scientific and/or IK methodologies. These are two distinct approaches, and both are needed to gain a better understanding of Arctic ecosystems. For example, scientists may rely on calibrated instruments, such as satellites, and their research is hypothesis-driven, often to gain a better understanding of a single component of a system, focusing on limited variables. While Indigenous Knowledge observation methods rely on multiple variables and focuses on relationships between components across abiotic, biotic, and social-cultural pieces. Bringing together these methods provides a holistic view of the Arctic. Of equal importance are community driven and informed monitoring programs that may be based solely on science or IK.”

Many CBM programs are presently ongoing across the Arctic within Indigenous and non-Indigenous communities. CBM projects have been found to lead to faster utilization of the monitoring results in decision-making (Danielsen et al. 2010). CBM can benefit communities, science, and society in a number of ways (Johnson et al. 2016), and these benefits include a contribution to understanding long-term trends, including how Arctic ecosystems are responding to various drivers of change.

Key resources and programs can be engaged in the implementation of the Coastal Monitoring Plan, such as the Atlas of Community-Based Monitoring & Indigenous Knowledge in a Changing Arctic4, the Local Environment Observation Network5, the Circumpolar Local Environment Observation Network6, The Snowchange Cooperative7, SmartICE8, and PISUNA project9. In addition to these resources and plans, there are many government-funded community-based monitoring programs that should be engaged, such as the Inuvialuit Settlement Region – Community-Based Monitoring Program10.

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4 http://www.arcticcbm.org/index.html
5 https://www.leonetwork.org/en/#lat=60.5312&lng=-165.1061&zoom=7
7 http://www.snowchange.org
8 https://www.smartice.org
10 https://jointsecretariat.ca/isr-cbmp/
The utilization of the resources and engagement of the initiatives listed above will require relationship building with the relevant organizers and communities. Through the development of these relationships it will be important for the relevant communities to determine how and if they would like their information linked to the Coastal Monitoring Plan. The engagement of these communities will need to be addressed within each nation, where appropriate, during the national implementation process.

### 2.4 Systems approach

Another fundamental assumption of the Coastal Monitoring Plan is that ongoing and anticipated change in Arctic coastal biodiversity can be attributed to, and predicted from, changes in the environmental drivers and processes that largely determine the geographic distributions, seasonal behaviours and population health of Arctic coastal species (see Table 3.2). Within this ecological context, coastal biodiversity is also affected by anthropogenic stressors that include long-term relationships with Arctic coastal communities, and the increasing effects of coastal shipping, military activities, and industrial developments. For these reasons the Coastal Monitoring Plan will take a long term, social-ecological systems (food security/food web) approach where targeted biodiversity FECs are related to the environmental drivers and anthropogenic stressors that have the potential to impact them. By establishing a systems approach, and by taking a long-term (multi-decadal) view, annual and decadal variability in coastal FECs can be assessed and understood in terms of driver-outcome relationships. These quantifiable relationships can be used to make predictions of possible future biodiversity scenarios that consider multiple drivers. The coastscapes and associated general conceptual models are intended to demonstrate this holistic approach, to support a co-generation of knowledge method, and to provide a systems-based frame for Arctic coastal monitoring and reporting.

### 2.5 Incremental implementation

The Coastal Monitoring Plan outlines an approach to provide comprehensive monitoring of Arctic coastal biodiversity across the circumpolar area to begin to meet the needs of communities, industry, academia and national governments, as well as international objectives such as those outlined in the recent Arctic Biodiversity Assessment (CAFF 2013) and by the Convention on Biological Diversity (https://www.cbd.int/cop/). Present monitoring of coastal biodiversity and ecosystems is far from comprehensive, and we anticipate that the Coastal Monitoring Plan will be implemented incrementally, starting with those monitoring projects that are ongoing and expected to continue. To this end the first State of Arctic Coastal Biodiversity Report (SACBR) will rely on data gathered from these ongoing projects, many of which are identified and listed in the Appendix to the report on the Ottawa workshop (Thomson et al. 2016; ICC 2016). The first SACBR will also compare existing programs to what is identified in the Coastal Monitoring Plan to develop a national assessment of monitoring gaps and needs.

### 2.6 Program investment and sustainability

The Coastal Monitoring Plan identifies and highlights a critical issue – securing the financial and human investment required to implement, grow, and sustain the long-term and comprehensive monitoring proposed. Many recent synoptic reports on Arctic ecosystems (e.g., ACIA 2004, Forbes 2011, AMAP 2012, ABA 2016) and major Arctic science organizations (e.g., IASC, ISAC) have reported the accelerated amplification of global climate change at Arctic latitudes and its increasing effects on Arctic ecosystems and coastal communities. They have recommended the immediate establishment of comprehensive monitoring of Arctic change. In spite of these recommendations there has been little progress in finding sustained funding for coordinated and comprehensive Arctic monitoring programs such as the CBMP Marine, Freshwater and Terrestrial Plans, or to meet recommendations in the Arctic Biodiversity Assessment (2016) or the Convention on Biological Diversity (1992). To date, biodiversity reporting is assembled from existing monitoring programs, and monitoring gaps and needs are identified as part of the reporting process (CAFF 2017).

Goals for overall sustainability are set forth in the CBMP Strategic Plan 2018-2021 (Christensen et al. 2018). Sustainability of the Coastal Monitoring Plan is contingent upon generating and making available useful, cost-efficient and timely information that serves the needs of identified ‘knowledge clients’ – knowledge clients being defined as those groups who will benefit from the knowledge generated by the monitoring program. Many of these clients have been identified in the Ottawa workshop (Thomson et al. 2016) and include:

- Indigenous, local, national and international governments with mandated biodiversity obligations, e.g., wildlife management boards, national CBD targets, ABA goals, endangered species, protected area conservation targets, ECCC targets for migratory birds, EU Conservation targets;

- Arctic industrial operations, extractive industries and government regulators with biodiversity obligations in
operating permits for coastal development and shipping, e.g., mining, oil and gas, commercial fisheries;

- Arctic ship operations linked to Polar Code targets, e.g., community re-supply, trans-shipping, tourism, military, coast guard; and,

- Arctic coastal communities utilizing Arctic coastal species as an important component of culture and food security.

Each country will need to develop their consultation and engagement activities to most effectively develop their information user and participant structure. The Coastal Monitoring Plan calls for nations to build an inclusive network of experts and knowledge clients, with information relevant to the Plan that will ultimately be provided to the international working groups.

With this in mind the Coastal Monitoring Plan was built from two directions:

- from the ongoing biodiversity monitoring and research already occurring and on which the program will be initiated and built; and,

- from the identified needs of the key knowledge clients and their associated management issues.

Building the Coastal Monitoring Plan from a knowledge client approach affected two key elements of program design: the development of monitoring questions to ensure relevance to the needs of the intended users of the information generated by the program, and selection of the FECs.

2.7 General monitoring questions

At the heart of any monitoring plan is a series of clearly-stated, hierarchical monitoring questions that provide a frame for the monitoring effort and, at the lowest level, generate quantitative hypotheses specific to the individual species or environmental factor being measured, e.g., over the last 5 years has the population of King Eiders at Wellington Bay changed by more than 5%? Many very specific monitoring questions were identified during the course of the three workshops that helped develop the Coastal Monitoring Plan. In particular, participants at the Ottawa workshop identified close to 100 monitoring questions under the categories of climate change, infrastructure needs, resource development and shipping, pollution and food security. These questions helped frame the general questions listed below, and will become part of monitoring programs implemented locally. This section summarizes the general monitoring questions for the Coastal Monitoring Plan.

The overall monitoring objective for the Coastal Monitoring Plan is to monitor, assess and report change in the biodiversity of Arctic coastal ecosystems across the circumpolar area. More specifically, we ask:

- What is the status and trend of Arctic coastal ecosystems in terms of their native species composition and condition, new and invasive species, geographic distributions, thresholds, phenological norms, and key processes and functions?
  - What are the primary system drivers and disturbances (biological, chemical, physical and anthropogenic) and how are they influencing changes in coastal biodiversity and ecosystem function?
  - What are the cumulative effects of primary system drivers and disturbances (biological, chemical, physical and anthropogenic) to coastal ecosystems and biodiversity?

- If Arctic coastal biodiversity or Indigenous subsistence food security or food sources is significantly impacted by any of these factors acting alone or together, which species are affected, how are they affected (mechanisms and drivers of change), where are they affected (geographically), and what are the expected impact effects (biodiversity, mechanisms, spatial extent, etc.) in the near to medium future (5-20 years)?

- How will measured and predicted changes in Arctic coastal biodiversity impact the management of mandated biodiversity obligations of local, Indigenous, territorial and federal governments?

- Management–related monitoring questions: Do the following factors (individually and/or cumulatively) significantly impact Arctic coastal ecosystems and associated biodiversity generally, and specifically, do they significantly impact the availability, abundance and quality of subsistence food for Arctic communities?
  - direct and indirect effects of climate change
  - oil and gas activities: exploration, drilling and extraction, and related infrastructure, shipping, and other transportation activities
  - mining activities: exploration, extraction, processing, and related infrastructure, shipping and other transportation activities
– shipping: tourism and adventure cruising, community re-supply, industrial, military and research-related shipping
– commercial fishing: harvest and overharvest
– community activities: sewage disposal and other pollution, hunting, trapping, infrastructure, avoidance
– long range and local contaminants: mercury (Hg) and persistent organic pollutants (POPs)
– invasive alien species: especially marine invasive species

When considering the sustainability of monitoring programs, information needs to be accessible across scales and to all users. When monitoring is able to address multiple user needs across scales, it has a higher probability of being sustained (Behe and Daniel 2017). Building implementation capacity will require time. As stated above, the approach will be incremental, beginning with what we have and moving towards developing a coalition of monitoring partner-clients. In some cases, this is already in practice. Arctic industries are presently obliged to support considerable compliance monitoring of the potential biodiversity impacts of their activities, government departments monitor mandated components of Arctic biodiversity, and coastal Arctic communities are in many cases already (formally or informally) carrying out community-based monitoring. The approach is to go forward with national implementation building a coalition of those presently engaged in coastal monitoring to work together to implement the Coastal Monitoring Plan.
3. Arctic Coastal Ecosystems
3. Arctic Coastal Ecosystems

3.1 What are coastal ecosystems?

Arctic coastal ecosystems are those habitats at Arctic latitudes where coastal wetlands, estuarine rivers and lakes, tidewater glaciers and coastal marine ecosystems meet and interact in complex ways that determine their composition, structure, and function, and their capacity to support a wide spectrum of the Arctic coastal biodiversity. These coastal ecosystems are the focus of the Coastal Monitoring Plan. Arctic settlements are primarily coastal, and include the homelands of a wide variety of Indigenous People, as well as many non-Indigenous, fishing-based coastal communities and a few industrial-scale seaports. In this Coastal Monitoring Plan, we embrace a social-ecological systems approach which acknowledges the interdependence of coastal communities and the coastal ecosystems that they rely on.

Arctic coastlines are highly variable in geomorphological structure and environmental processes that control their biodiversity assemblages – variability that ranges from the steep fjords and rocky headlands of Norway, Greenland and the eastern Canadian Arctic, through the low gradient soft-sediment shores of the central Canadian Arctic Archipelago and much of the Russian and Alaskan coasts, to the rapidly eroding coastal bluffs of the Siberian coast and along the south shore of the Beaufort Sea in Alaska and western Canada with their low-lying and dynamic lagoon-wetland systems. Given their complexity and overall higher productivity, coastal ecosystems make up a ribbon of diverse marine, terrestrial, estuarine and freshwater habitats for a wide range of Arctic biota. Coastal wetlands provide critical staging, nesting and rearing habitat for Arctic shorebird and waterfowl species. Shallow, brackish coastal waters provide a unique coastal marine zone where coastal fish species such as Arctic char, whitefish, and benthic organisms thrive, and which in turn support fish-eating marine mammals such as seals and whales. Soft bottoms and shallow coastal water benthic communities provide food for walrus and bearded seals, as well as diving seabirds and migrating shorebirds. Rocky coasts provide a sturdy substrate for rich intertidal and subtidal invertebrate, seaweed and fish communities; and coastal cliffs provide safe nesting habitat for large colonies of colonial nesting seabirds that feed in adjacent coastal marine areas.

Coastal ecosystems are also the most human-inhabited areas in the circumpolar Arctic. Arctic coastal ecosystems have been the homeland of many Indigenous groups for thousands of years. Food security within many coastal communities is dependent upon a strong understanding and relationship with the environment; and the harvest and utilization of many coastal species across the Arctic is central to the health and spiritual well-being of the many coastal Indigenous communities. Coastal Indigenous People are on the land and sea in coastal areas throughout the Arctic, and throughout the year.

3.2 Monitoring domain and FEC selection

One challenge in developing the Coastal Monitoring Plan is that it overlaps both geographically, and in terms of biota, with all three other CBMP programs. The overlap with the marine system is the most pronounced, and this leads to a number of questions for plan development in terms of the coastal marine domain, and the species to be included as FECs. In the background paper for the Coastal Monitoring Plan (https://www.caaff.is/coastal/coastal-monitoring-publications) the 30m depth contour was proposed as the coastal-marine boundary, as this was the inner boundary proposed for the Marine Plan. The exception to this was Norway where a prior definition of ‘coastal’ had already been adopted. As input was received through the workshops for the Coastal Monitoring Plan it became clear that such a rigid definition of the marine-coastal domain boundaries would not encompass the geographic range and critical life history components and habitats of many important coastal FECs.

The following is the definition of the coastal domain for the Coastal Monitoring Plan:

“The coastal domain is that component of the marine-land interface directly influenced by coastal processes, used by FEC/species as habitat, and is significant within the social ecological system of coastal communities. This boundary is thus fluid and varies by season, geographic situation, FECs/species, management context and human use.”

Coastal processes are the collective and dynamic physical, chemical and biological drivers that shape environmental conditions near the marine and terrestrial interface. Coastal processes such as riverine discharge or storm events vary seasonally and from year to year. This variability significantly impacts coastal ecosystems and the species that utilize them.

The need to track changes in coastal FECs and their close links with coastal peoples results in the overlap of coastal and other CBMP domains. However, this more fluid approach to understanding domain boundaries works well for coastal physical and biological variability. The recognition of the need for a more fluid definition of the boundaries for the Coastal Monitoring Plan also reflects the input of contributing TK holders at the Alaska workshop – especially with regard to migratory species or the
behaviour of coastal animals. This definition reflects social-cultural reasons for having a more fluidly defined coastal boundary: considerations for human interactions in Arctic coastal ecosystems.

3.3 Coastscapes

The term ‘coastscape’ has been adopted for the Coastal Monitoring Plan to describe an area of the circumpolar Arctic coast with recurring physiographic features, and where similar coastal processes interact with these physiographic features to create a relatively predictable range of habitats that support characteristic populations of coastal species. A coastscape will contain a relatively predictable range of habitat elements (e.g., beaches, mudflats, soft benthos, wetlands, rock cliffs, estuaries) and often will contain small elements of other coastscapes (e.g., lagoons or estuaries). Seven coastscapes have been identified (Table 3.1) and together provide a coordinated international systems-based approach to stratifying Arctic coasts by similar ecological settings with characteristic coastal biota. Within the Coastal Monitoring Plan, coastscapes are used to identify and prioritize key coastal species (FECs) for monitoring; to understand and communicate the main abiotic factors that drive habitat distribution and productivity for coastal biota; to include the important roles played by human cultures in coastal ecosystems; and to identify and address potential biodiversity threats.

<table>
<thead>
<tr>
<th>COASTSCAPE</th>
<th>GENERAL DESCRIPTION AND DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fjords</td>
<td>Long narrow inlets with steep sides and cliffs usually formed by Quaternary sub-sea level glacial erosion. They are commonly headed by tide water glaciers with associated melt water streams, and feature frequent small lateral side streams with small deltas and estuaries. Fjords are the predominant coastscape in Norway, Iceland, Greenland and the eastern Canadian Arctic.</td>
</tr>
<tr>
<td>Rapidly Eroding Shores</td>
<td>Coastal areas with soft shores, often containing significant ground ice, that are eroding at moderate to rapid rates to create offshore bars, spits and mudflats. Occur mostly along the southern coasts of the Beaufort, East Siberian, and Laptev Seas.</td>
</tr>
<tr>
<td>Lagoons and Barrier Islands</td>
<td>Coasts that feature low-lying, shallow, brackish lake and wetland systems protected from the ocean by barrier bars and spits, usually connected by a relatively small stream that flows in both directions with the tide. Frequently flooded by storms that can significantly alter salinity and turbidity characteristics. Often occur with Rapidly Eroding Shore and Low Gradient Soft Shores Coastscapes that supply sediment for land building. Common in Russia, Alaska, and Canada along the Bering, Chukchi, and Beaufort Seas, and along the Iceland coast.</td>
</tr>
<tr>
<td>Rocky Shores and Sea Cliffs</td>
<td>Low gradient to steep coasts (including sea cliffs) with exposed bedrock to the waterline that frequently include rock pools, beaches and small wetlands. Scattered throughout the Arctic and often associated with the Fjord Coastscape.</td>
</tr>
<tr>
<td>Estuaries</td>
<td>Estuaries develop at the mouths of most rivers where sediments are deposited. Often featuring extensive low gradient networks of wetlands, streams and brackish ponds with broad mudflats. Occur along the Arctic coast wherever rivers enter the sea; ranging from very small to very large estuaries such as the Lena, Ob, Yukon and Mackenzie.</td>
</tr>
<tr>
<td>Low Gradient Soft Shores</td>
<td>Low gradient coasts with varying thicknesses of surficial materials over bedrock, and characterized by mudflats, wetlands, and beaches. Scattered throughout the Arctic but cover large coastal areas of the Canadian Arctic Archipelago, along the Alaskan Chukchi and Beaufort Seas, and along the Russian and Icelandic coasts.</td>
</tr>
<tr>
<td>Ice Fronts</td>
<td>Ice Fronts develop where glaciers reach the sea and usually produce floating ice by calving from the glacier front. They occur predominantly on the east coast of Greenland, but also in the Baffin Bay area, in southern Alaska and on Svalbard, Norway. Meltwater emanating seasonally from the bottom of the glacier rises as a plume to the surface providing nutrients for lower trophic levels, and supports productive populations of surface feeding seabirds, diving seabirds and marine mammals.</td>
</tr>
</tbody>
</table>

One characteristic of all Arctic coastal systems is their variability throughout the seasons. Most coastscapes feature sea ice-ice edge systems in the winter and all are dynamic, so it is important to state that coastscapes are generally described here from a summer perspective, but have distinct seasonal aspects. Winter ice and ice edge habitat (Figure 3.1) provide habitats that are critical to the survival of many ice dependent birds and mammals. These areas provide resting and feeding habitat, and can extend far beyond the summertime coastal interface. Pressure ridges in ice form steep terrain features, and may drag across the benthos as the ice moves. In shallow coastal areas, sea bottoms may freeze seasonally as well. Pressure ridges are also important safe havens for ice fauna and flora as ice thins and declines in extent. The ice edge system also moves and changes...
with coastal currents. Ice thickness varies significantly and can be several meters thick in multiyear ice. Ice concentrations change throughout the year, and human, bird, and mammal use and interactions correlate with these changes. Spring breakup is often associated with major phytoplankton and zooplankton blooms. When the ice is thin enough, icebreakers and other vessels operate along the shoreline.

Figure 3.1. Winter Ice Edge Habitat (adapted from Lawler et al. 2009)
3.4 Fjords

Fjords (Figure 3.2) are formed from drowned glacial valleys, and are generally characterized by steep lateral walls of exposed rock and deep sedimentary basins, which can reach depths of over 1,000 m. One or more sills are often present. These can be quite shallow, and represent submerged moraines. Sediments are largely restricted to basin areas. Rivers bring melt water and other runoff, including sediments from land, into the fjord. Land surrounding many fjords is steep and rocky (e.g., Svalbard) but other shores can be vegetated (e.g., northern Norway) and contribute considerable amounts of nutrients and organic material to the seafloor of fjords from runoff.

Fjords exhibit estuarine circulation: freshwater input from rivers, which can be substantial, creates a surface layer that exits the fjord. Simultaneously, a compensating inward-flowing current transports shelf water into the fjord. Presence of a strong sill can virtually isolate a saline bottom-water layer within the basin that is only periodically refreshed from offshore waters or increased water dynamics caused by upwelling. Circulation in most fjords can vary seasonally due to periodicity in river discharge from snowmelt or precipitation cycles.

Since they are inland water bodies by definition, most fjord environments have relatively low wave energy, except at their mouths. Very large fjords have the potential for long fetch in some directions. This can result in locally high wave energy, as well as strong tidal currents. Fjord coastlines may include other coastscape such as Rocky Coasts, small Estuaries, Low Gradient Soft Shores and Ice Front.

Macroalgal and seagrass communities may be found in shallow subtidal habitats in fjords. Rocky substrate in the littoral zones of fjords is dominated by attached organisms, including macroalgae and benthic fauna. Gravel shorelines, which are a more unstable substratum than rocky coasts and hence do not host attached organisms, may be important spawning habitat for anadromous fish. Deep basins usually have considerable organic-rich sediments that are home to rich infraunal communities. Some whale species such as narwhal gather in summer in fjords along the eastern coast of Ellesmere Island and western Greenland for foraging and calving.
3.5 Rapidly Eroding Shores

The Rapidly Eroding Shores Coastscape occurs where a combination of permafrost-rich, soft coastal sediments, often with a significant component of ground ice, are exposed to wave action and the thermal effects of coastal oceans, resulting in moderate to very rapid rates of shoreline erosion (Figure 3.3). In the Arctic, the key areas for this coastscape are along the south shore of the Beaufort Sea in Canada and Alaska, and along the coast of the Laptev and Eastern Siberian Seas in Russia (Lantuit et al. 2012). Within the Eroding Shores Coastscape, the wave energy to drive the erosion varies with windiness and storms, shore exposure in relation to fetch, and with the presence of shore fast ice or sea ice that dampens wave energy and shortens the season for erosion. Rates of erosion are anticipated to increase as a result of climate change and its associated increase in storm frequency and intensity, shortened sea ice season, decreased sea ice coverage, and global sea level rise. (Lantuit et al. 2012). Shores susceptible to rapid erosion will respond differently to sea level rise depending on regional scale differences in the processes of isostatic rebound and subsidence which may either aggravate or ease these impacts.

Circulation in the Eroding Shores Coastscape responds locally to onshore wave activity and wind, but is often driven as well by longshore currents responding to freshwater inputs from rivers. Erosion in one area can result in progradation in others and also contributes sufficient amounts of terrestrial carbon to affect marine food webs. The marine component of this coastscape is generally shallow due to the high rates of sedimentation and overall low slope of the terrestrial shoreline, with soft benthic areas reflecting deposition of eroded land materials. Freshwater transport, eroded ground ice and sea ice melting and freezing processes all result in a variable marine coastal system with changing salinities with varying suspended and dissolved chemical loads.

Except possibly for the occurrence of extensive mudflats, where shorebirds may find food, the high wave energy and sediment deposition of this coastscape provides poor overall habitat for coastal biota. However, sediments eroded from terrestrial shores are redeposited in complex shallow marine landforms including silty to sandy bars and spits, which often enclose substantial areas where lagoons and coastal wetlands may develop. Along the Beaufort Sea coast for example, a complex of coastal wetlands and lagoon-wetland complexes resulting from riverine inputs, and coastal erosion and deposition are common and provide important staging, nesting and rearing habitat for many species of shorebirds and waterfowl, as well as significant fish spawning and rearing areas. Vegetation is primarily low-lying coastal tundra on land, and limited macroalgae in the marine environment.
3.6 Lagoons and Barrier Islands

Lagoons (Figure 3.4) are complex shallow-water coastal features with restricted oceanic connectivity. The lagoon itself is separated from the open sea by dynamic, low elevation land barriers, such as a spit or barrier island. These coastal features form in areas with small tidal ranges where the upland morphology is typically low gradient coastal plain or eroding shores. The oceanic connections may be either continuous or periodic. During storms, inlets may open or close, and ocean waters may wash over the land barriers. Lagoons frequently have riverine input into a portion of the lagoon creating a gradient of waters from more brackish to more oceanic across the lagoon habitat.

Because of their shallow nature, the circulation and mixing patterns within the water body tend to be heavily influenced by the surrounding topography and bathymetry. Lagoons generally do not have a stable salinity structure. They can range from near freshwater to hypersaline, as a result of changes in both the degree of oceanic connectivity and the amount of freshwater input through riverine, ice formation, evaporation, groundwater and surface flow runoff.

The majority of the lagoon body is protected from direct oceanic waves and currents by surface or subsurface barriers that may include islands, sand bars, or reefs. Thus, the lagoon's interior tends to have relatively low energy systems, while the exterior may be subject to the full range of oceanic conditions.

Because they are low-energy systems, lagoons typically have a substrate consisting of well-sorted sand, gravel, or pebbles, which may provide habitats for sea grasses, macroalgae, and benthic invertebrates. Habitats typically associated with lagoons include laidas, marsh massifs, spits, river mouths, estuaries, and highly productive shallows. The lagoon environment frequently serves as a nursery ground for many marine associated species including seabirds, shorebirds, waterfowl and fish. Marshes and estuaries are common along the terrestrial margins of lagoons and barrier islands, supporting abundant birds, anadromous fish and other wildlife.

Barrier islands may be remnant or geologically newly constructed features. Remnant features may consist of tundra and permafrost features, while constructed features represent the parent geology and tend to have more limited vegetation. Barrier islands are subject to erosion and deposition, and subsequently migrate in their position as well as change the locations of the oceanic inlets to the lagoons (Gibbs and Richmond 2015). Barrier islands can provide nesting, breeding and feeding habitat for seabirds and shorebirds, as well as haulout sites for marine mammals, and many vegetation communities depending on the size and type of barrier island (Hopkins and Hartz 1978).

![Lagoons and Barrier Islands Coastscape](image)

**Figure 3.4.** Lagoons and Barrier Islands feature low-lying, shallow, brackish lake and wetland systems protected from the ocean by barrier bars and spits, usually connected by a relatively small stream that flows in both directions with the tide. Frequently flooded by storms that can significantly alter salinity and turbidity characteristics. Often occur with Rapidly Eroding Shores and Low Gradient Soft Shores Coastscape that supply sediment for land building. Common in Russia, Alaska and Canada along the Bering, Chukchi, and Beaufort Seas, and along the Iceland coast (adapted from Lawler et al. 2009).
The Rocky Shores and Sea Cliffs Coastscape (Figure 3.5) is a predominant coastscape in Greenland, Norway and in the eastern Canadian archipelago. The rocky coast is a biologically rich environment and can include many different habitat types like steep rocky cliffs, platforms, rock pools and boulder fields. Rocky coasts are often exposed areas where the energy from waves or strong currents has removed all loose material, leaving only the rocky substrate. Shores may be steep and considerable ocean depths may be reached within a short distance from land. Shallower offshore areas, however, are common where the coasts are more protected from wind exposure, or where relatively shallow waters are present as a shelf along parts of the east coast of Greenland.

On a rocky shore, there are several characteristic zones: the supratidal zone, the intertidal zone, and the subtidal zone. The supratidal zone is only covered with water during storms and extremely high tides, and is moistened by the spray of the breaking waves. The intertidal zone (and associated tidal pools) is located between the highest and lowest limit of the tides. Below the intertidal is the subtidal zone, which is always water covered. Stressors such as desiccation, severe temperature changes and changes to salinity due to salt spray and rain increase with height above the water level.

Only a few resistant organisms live in the supratidal zone such as some species of lichens, filamentous green macroalgae, cyanobacteria and semi-terrestrial invertebrates. The intertidal zone, the area that floods during tidal fluctuation, is inhabited by a variety of benthic species and macroalgal species. In the subtidal zone the environment is much more constant. Here, meadows and forests of macroalgal species may be present and provide shelter and feed for diverse communities of benthic organisms, as well as nursery areas for pelagic and demersal fish species.

The rocky coast may be impacted by sea ice in very different ways. Sea ice, and the snow upon it, has a shadowing effect, reducing light penetration into the water column. Ice floes may have an abrading effect, preventing organisms from establishing and living on such ice-scoured rocky coasts. However, if an ice foot, (a belt of sea ice frozen to the coast), is established it may provide protection for the tidal communities from low air temperature and ice scouring.

Figure 3.5. Rocky Shores and Sea Cliffs. Low gradient to steep coasts (including sea cliffs) with exposed bedrock to the waterline that frequently include rock pools, beaches and small wetlands. Scattered throughout the Arctic and often associated with the Fjord Coastscape (adapted from Lawler et al. 2009).
3.8 Estuaries

The Estuaries Coastscape (Figure 3.6) describes those areas of the Arctic shoreline where the input of fresh water from river discharge is the predominant influence on the coastal marine system, and where the processes of sedimentation, resuspension and redeposition create characteristic mosaics of mudflats and low-relief islands, often with extensive areas of shallow estuarine and deltaic wetlands, serpentine channels, shallow ponds and lakes. Estuary Coastscapes vary in size from those associated with very large rivers, through abundant medium-sized rivers, to the many very small rivers and creeks that are scattered along Arctic shores.

The marine system of the Estuaries Coastscape is strongly influenced by nutrients, freshwater flow rate and volume, sediments, and organic materials brought by river transport to the ocean so that, in the open water season, waters are turbid with low salinity, and are usually warmer than adjacent marine areas. Inputs of dissolved elements (e.g., suspended sediments, organic and inorganic carbon and nitrate) in river discharge depend on the drainage basin characteristics, time of year and interaction with landfast ice and sea ice (McLelland et al. 2012). In the winter, effects from river discharges are less due to the effects of land-fast ice and sea ice. Because land-fast ice, sea ice and riverine inputs are important features of this coastscape, climate-driven changes in the timing and magnitude of both estuarine ice and river discharge will have important impacts on estuarine processes and habitats. Estuaries may be prograding in areas of deposition, or may be eroding and retreating where shores are exposed to strong winds and associated wave action.

Coastal wetlands are a recurring and important feature of the Estuaries Coastscape, and may cover very large areas where there are interactions of daily saline tidal flooding, sedimentation and erosion, and freshwater inputs from adjacent rivers. As a result, these important areas are highly vulnerable to rising sea levels, changes in coastal sea ice, changes in the quantity, quality and seasonality of riverine discharge, pollution, and other climate driven changes.

The shallow, often turbid, brackish and relatively warm marine waters of the Estuaries Coastscape provide habitat for coastal fish groups such as chars and whitefish, as well as more widespread benthic fish species (e.g. sculpins). Soft bottom areas support rich benthic invertebrate communities and associated species that feed on them, including sea ducks and marine mammals. The larger Arctic estuaries and deltas such as the Lena, Ob, Yukon, Kuskokwim and Mackenzie support very large complexes of interlocking wetlands, mudflats, delta streams and shallow turbid lakes, providing important staging and nesting habitat for many Arctic shorebird and waterfowl species; feeding areas and protective refugia for beluga whales; migratory pathways for anadromous and catadromous fishes; and important spawning and foraging habitat for estuarine fish species. Many Arctic estuaries are also critical summering areas for beluga that find food and refuge from predators in the warm, shallow waters.

Figure 3.6. Estuaries develop at the mouths of most rivers where sediments are deposited as river-borne sediment load enters the ocean. Often featuring extensive low gradient networks of wetlands, streams and brackish ponds with broad mudflats. Occur along the Arctic coast wherever rivers enter the sea; ranging from very small to very large estuaries such as the Lena, Ob, Yukon and Mackenzie. Adapted from Lawler et al. 2009.
3.9 Low Gradient Soft Shores

The Low Gradient Soft Shores Coastscape (Figure 3.7) occurs where unconsolidated glacial surficial materials overlie bedrock, and terrestrial surfaces slope gradually away from the ocean shore. Marine coastal areas in this coastscape are characteristically shallow due to the low shore gradient, with benthic textures reflecting the glacial deposit, ranging from silts through sands to cobbly gravels. Extensive shoreline tidal mudflats and offshore bars are typical.

This coastscape is widely distributed along the shores of the northern mainland and archipelago islands of the central Canadian Arctic, along large areas of the Arctic coast of Russia, and in Alaska where it may be strongly associated with Lagoon Coastsapes. The Low Gradient Soft Shores Coastscape may include areas of other coastsapes such as Rocky Shores, small to medium River Estuaries, and Soft Eroding Shores. The Low Gradient Soft Shores also feature a range of scattered coastal wetlands, sandy to cobbly beaches with small dunes in some areas, and shallow ponds. In Greenland, coasts of boulders, cobbles and pebbles may occur from moraine deposits, and as alluvial and colluvial fans. Along the Chukotka coast of Russia and the Bering Strait coast of Alaska, this coastscape alternates with the Lagoon Coastscape and so shares many of the species and habitats described for that coastscape.

As a function of their shallow nature and soft bottoms, and depending on their proximity to freshwater inputs, the ocean component of this coastscape may feature turbid waters with very low salinities overall, as evidenced by the common presence of brackish wetlands along the shore. These shores may be exposed to strong winds depending on shore orientation and local fetch, and small to broad eroding shoreline areas may occur. Land fast ice and sea ice are important features and changes in the ice-free season and sea level rise have the potential to significantly impact the Low Gradient Soft Shores Coastscape.

[Diagram: Low Gradient Soft Shores Coastscape]

Figure 3.7. Low Gradient Soft Shores are coasts with varying thicknesses of surficial materials over bedrock, and characterized by mudflats, small wetlands, and beaches. Scattered throughout the Arctic but cover large coastal areas of the Canadian Arctic Archipelago, along the Alaskan Chukchi and Beaufort Seas, and along the Russian and Icelandic coasts. Adapted from Lawler et al. 2009.

If shallow, the often turbid, brackish and relatively warm marine waters of the Low Gradient Soft Shores Coastscape provide habitat for true coastal fish groups such as anadromous species, and for demersal fish species. Potentially, the soft bottoms may support rich benthic invertebrate communities and associated species that feed on them, including sea ducks and marine mammals.
3.10 Ice Fronts

The Ice Fronts Coastscape (Figure 3.8) is a glacial coast, where glaciers reach the sea and usually produce floating ice by calving. However, some glaciers are more or less stagnant and do not calve. Glaciers which reach the sea are termed ‘tidewater glaciers’ (Van der Veen 1996). Ice fronts are found especially in the Baffin Bay area, on the west coast of Greenland, in western Alaska and on Svalbard, Norway. Many tidewater glaciers are located in the head of fjords, but especially in Greenland, glaciers reach the marine environment along exposed coast lines, e.g., in Melville Bay, along the east Greenland coast and at Nordostrundingen.

Glacial meltwater, most of which is released from the underside of the glacier, rises in a plume to the surface just in front of the glacier (Meire et al 2017). This upwelling can be very strong and force fish and zooplankton to the surface (Lydersen et al. 2017). The meltwater can also be an important source for nutrients for phytoplankton (Steen et al. 2017).

Surface-feeding seabirds concentrate at such events during the breeding season, and diving seabirds are attracted to the ice front (Urbanski et al. 2017). Some species of marine mammals concentrate and feed in such locations. Narwhals, however, stay here during summer, apparently without feeding. The floating ice produced by the glaciers act as important platforms for resting seals and as hunting grounds for polar bears.

A typical feature of the Ice Fronts Coastscape is upwelling, which results in high nutrient concentration stimulating productive phyto- and zooplankton communities, and hence, the presence of feeding organisms on higher trophic levels like pelagic and demersal fish, seabirds and marine mammals.

Ice fronts are susceptible to climate change, and many are retreating. Ultimately, the ice-sea interface habitat may be lost as well as the presence of associated organisms.

Colder waters in front of a glacier may create and serve as a refuge for marine Arctic species in a warming sea, and glacial ice in fjords may replace sea-ice habitats for marine mammal species that breed and hunt on ice.

Figure 3.8. Ice Fronts develop where glaciers reach the sea and usually produce floating ice by calving from the glacier front. They occur predominantly on the east coast of Greenland, but also in the Baffin Bay area and in Svalbard, Norway. Meltwater emanating seasonally from the bottom of the glacier rises as a plume to the surface providing nutrients for lower trophic levels, and supports productive populations of surface feeding seabirds, diving seabirds and marine mammals.
3.11 Environmental drivers, anthropogenic stressors and potential impacts to coastal biodiversity

There are many active and increasing anthropogenic stressors and changing environmental drivers that have the potential to negatively impact coastal biodiversity and the communities that rely on these ecosystems (Table 3.2). In this plan, we define anthropogenic stressors as direct, human-driven factors that may directly or indirectly degrade ecosystem composition, structure, or ecological processes, and impairs ecological integrity and/or biological diversity. We also define environmental drivers as dominating environmental factors and processes that directly or indirectly shape the ecosystem, including predominant climatic and disturbance regimes, as well as atmospheric, geomorphic, biogeochemical oceanographic, hydrologic and terrestrial effects (Western Alaska LCC; accessed February 2018).

The environmental drivers, anthropogenic stressors and potential biodiversity impacts listed in Table 3.2 are based on input received from experts (TK holders and scientists) in the workshops that contributed to the development of this plan, and a review of the science literature, as summarized in Forbes (2010). The list is not meant to be exhaustive but to show the breadth of workshop input received.

Table 3.2. Potential Environmental Drivers and Anthropogenic Stressors and Impacts

<table>
<thead>
<tr>
<th>DIRECT/INDIRECT CHANGES IN ENVIRONMENTAL DRIVERS</th>
<th>INCREASING ANTHROPOGENIC STRESSORS</th>
<th>POTENTIAL BIODIVERSITY IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• quantity and quality of freshwater inputs from streams and rivers</td>
<td>• ship-borne marine invasive alien species</td>
<td>• negative effects on spawning and Indigenous fishing area</td>
</tr>
<tr>
<td>• changes in relative sea level</td>
<td>• shipping pollution including oils spills, noise, light, and marine debris (e.g. plastics)</td>
<td>• seasonality changes in freshwater/saltwater inputs on timing of fish migration and increased health status from longer ocean feeding times</td>
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<tr>
<td>• seawater temperature and salinity regimes</td>
<td>• community sewage</td>
<td>• reduced security for marine mammal spawning areas</td>
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<tr>
<td>• sea ice phenology, distribution and thickness</td>
<td>• contaminants</td>
<td>• increased risk of disease in a warming climate</td>
</tr>
<tr>
<td>• increased storm frequency, intensity and duration</td>
<td>• oil and gas development</td>
<td>• phenological mismatches due to changing seasonality</td>
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<tr>
<td>• increased coastal erosion and altered sedimentation regimes</td>
<td>• large scale commercial overfishing</td>
<td>• negative effects of sea ice changes on seal, walrus and polar bear</td>
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<tr>
<td>• acidification of coastal waters</td>
<td>• channel dredging</td>
<td>• changes in the number, composition, health and behaviour of resident and migratory birds</td>
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<tr>
<td>• timing, duration and frequency of marine flooding water temperature and salinity regimes in estuarine lakes and wetlands</td>
<td>• water chemical parameters, e.g. DOC/POC, nutrients, pH, contaminants alkalinity/salinity</td>
<td>• negative impacts of climate change on migration patterns, and on feeding and breeding areas</td>
</tr>
<tr>
<td>• water chemical parameters, e.g. DOC/POC, nutrients, pH, contaminants alkalinity/salinity</td>
<td>• changes in storm frequency and intensity</td>
<td>• impacts on benthic species due to increased shoreline erosion and deposition, from changes in the timing and intensity of estuarine outflow patterns, e.g., turbidity, increased pollution and bioaccumulation of toxins</td>
</tr>
<tr>
<td>• changes in storm frequency and intensity</td>
<td>• amount of snow melt water on top of sea ice in spring</td>
<td>• increased inundation by seawater on vulnerable coastal ecosystems (through sea level rise or storms)</td>
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<tr>
<td>• displacement of native species/altered food webs due to ingress of southern species</td>
<td></td>
<td>• biofouling on infrastructure</td>
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<tr>
<td>• negative effects of changing ocean and nutrient circulation</td>
<td></td>
<td>• negative habitat effects in southern wintering grounds</td>
</tr>
<tr>
<td>• potential increases in harmful algal blooms</td>
<td></td>
<td>• water quality on coastal wetlands</td>
</tr>
<tr>
<td>• northern range expansions of species</td>
<td></td>
<td>• displacement of native species/altered food webs due to ingress of southern species</td>
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<td></td>
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<td>• northern range expansions of species</td>
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</table>
TK holders have continuously stressed the significance of cumulative impacts and the importance of understanding how multiple stressors interact to increase threats to the ecosystem and the ability to adapt and mitigate these impacts. With this understanding, it is important to monitor through a socio-ecological approach and using a food security/food web lens in order to gain knowledge of cumulative impacts across abiotic, biotic, social and cultural elements that are directly related to biodiversity. Given this direction, the systematic approach proposed in the Coastal Monitoring Plan will help coordinate coastal monitoring programs that can identify these causal linkages and thus provide the possibility for predicting change, and for developing proactive adaptation solutions.
4. Selecting and Prioritizing FECs, Attributes and Parameters
4. Selecting and Prioritizing FECs, Attributes and Parameters

A main goal of the Coastal Monitoring Plan is to identify and work with ongoing initiatives, and to recommend new programs as needed, to develop a coordinated, comprehensive, international approach to measure and report important changes to Arctic coastal biodiversity. To accomplish this, a process was developed that would result in a prioritized list of Essential FECs, attributes and parameters to be included in the Coastal Monitoring Plan, with an overall objective to create a sustainable monitoring system that can be integrated with CBMP marine, freshwater and terrestrial monitoring plans to track and report important changes in Arctic biodiversity.

4.1 Overlap with other CBMP programs

One factor in FEC selection is the spatial overlap between the CBMP coastal-marine sub-system and other CBMP monitoring programs. Overlap with the CBMP Terrestrial program is minor and includes only coastal wetlands and the distal areas of estuaries. Overlap with the CBMP Freshwater program is more significant in that coastal fish species such as Arctic char use coastal marine areas in the summer and winter in freshwater lakes that may be many kilometers inland. The Coastal Monitoring Plan will focus on those stages of coastal fish species that occur in coastal waters.

The most important overlap is with the CBMP Marine program since benthic and pelagic components are continuous, colonial seabirds nest on coasts and forage in marine and coastal marine areas, belugas use river estuaries for important parts of their life cycles, narwhals calve in the shallow areas of fjords, and walrus use shallow coastal-marine benthic species and are hauling out more on shore as sea ice diminishes. The approach of the Coastal Monitoring Plan for FEC selection takes the view that FEC overlap between the Marine and Coastal programs is inevitable, but that FEC attributes and/or parameters may differ between the two domains because of the stronger emphasis on community-based approaches and social-ecological systems in the Coastal Monitoring Plan in some countries. Some FECs may be the same between the two programs but monitoring questions will differ, and in many cases life history stages will differ, e.g. egg laying in coastal wetlands, so that different FEC properties will be measured and reported. Also, as the Coastal Monitoring Plan is implemented, there may only be a subset of the entire FEC list that can be reported on – as evidenced by the FECs reported on in the recent SAMBR – so FEC overlap may not be an important issue in the short term. Another consideration is that the new CBMP Strategic Plan (Christensen et al. 2018) is moving towards an integrated approach to monitoring and reporting biodiversity changes across all four CBMP programs (Marine, Freshwater, Terrestrial and Coastal) so the question of which FEC is reported within which CBMP program may become less relevant.

4.2 Input to FECs

FECs were selected in a multiple step process that began by taking advantage of the work already done by other CBMP programs (Appendix Table 1). All FECs, attributes and parameters were listed across programs as a starting point for the Coastal Monitoring Plan. This process was especially useful for science-based attributes and parameters, where they had previously been assigned to FECs by science experts for the other CBMP programs. Input from Indigenous and science experts at three workshops was used to refine and append this original list of potential FECs.

At this first workshop in Ottawa, Canada, a number of conceptual models representing different aspects of Arctic coastal ecosystems were displayed to help visualize and support discussions of FECs and social-ecological issues. Models were selected from government technical reports, published journal articles, and from the ICC AK Food Security Report (2015), which were built from Indigenous Peoples’ Knowledge (specifically Inuit knowledge). All models selected for the workshops included the main ecosystem components, their relationships and linkages, as well as predominant ecosystem functions and processes. Workshop participants were asked to discuss, comment and improve on the models, and this input from both science and TK perspectives was added to the evolving list of potential FECs, and to the list of important components to be displayed in the coastscape conceptual models. The coastscape models were then presented to TK holders and scientists at two subsequent workshops to visualize coastal ecosystems, identify any missing components, and to highlight important linkages between biota and typical stressors and drivers.

The revised and compiled FEC list was organized into groups of related FECs (‘FEC Groups’) – coastal birds, invertebrates, pathogens/parasites, plankton, benthic organisms, mammals, fishes, vegetation, and social/cultural factors. The compilation of FECs into FEC groups was imperative because, in the Ottawa workshop many individual species and social/cultural relationships between people and coastal species were recommended and considered. However, not all species or cultural relationship connections are present across the circumpolar Arctic. FEC groups were necessary so that similar ecological functions/roles could be aggregated and reported across the circumpolar coast.
A second coastal expert workshop took place in Anchorage, Alaska, to revisit the list of potential FECs and determine appropriate attributes and parameters, with emphasis on a TK perspective. Participants included TK holders, scientists, Arctic Council State and Permanent Participant representatives; and representatives from non-governmental organizations, academia, and government agencies. There was an emphasis at this meeting on ensuring that the FECs, their attributes and parameters, and monitoring questions would be relevant to coastal people living in the Arctic. Specifically, we attempted to:

- review/gather expert input on FECs, and FEC parameters and attributes for the Coastal Monitoring Plan;
- create a platform that allows for a co-production of knowledge approach that brings together TK and science; and,
- address remaining issues for finalizing the Coastal Monitoring Plan.

CBMP Marine Steering Group experts participated in the meeting to provide expert input, and to facilitate communication between the coastal and marine expert groups.

Ultimately, in considering the potential FECs and their attributes and parameters, the potential FEC list was expanded to include several non-biological factors considered important for interpreting what biological changes would mean to coastal ecosystems, and to those living in and utilizing the coastal systems of the Arctic. The meeting resulted in a final list of attributes, broadly applicable to all FECs grouped by category.

A third coastal expert workshop took place in Tromsø, Norway, primarily focusing on the Rocky Coast and Fjord Coastscapes. The workshop included scientific experts, an expert on coastal fish from the Saami Council, and CEMG members from The Kingdom of Denmark, Canada and Norway.

At the Tromsø workshop participants:

- reached consensus on FEC lists by coastscape, primarily Fjords and Rocky Shores, as well as for those FECs in common with other coastscapes and monitoring plans;
- evaluated, provided input, and reached consensus on conceptual models for Fjords and Rocky Shores Coastscapes;
- proposed final FEC rankings and prioritized FEC lists for monitoring of the Rocky Shores and Fjords Coastscapes;
- prepared a list of suggestions for FEC attributes and parameters for the Rocky Shores and Fjords Coastscapes; and,
- merged workshop results with the Anchorage and Ottawa workshop results to ensure and maintain a circumpolar approach and input to the CBMP Coastal Monitoring Plan.

Due to available expertise on marine mammals and seabirds at the workshop, these FEC groups were selected and ranked for all coastscapes.

### 4.3 Prioritization process

Recognizing the number of potential FECs necessary to monitor if all were included, a prioritization process was carried out (Appendix Table 2). Following the lead of the CBMP Terrestrial Monitoring Plan (Christensen et al. 2013) the process assessed FECs as either ‘Essential’ for monitoring, or ‘Recommended’ – to be addressed if countries had the capacity or a specific need to monitor those components.

To facilitate the analysis, FEC species were organized into the following FEC Groups: Coastal Birds, Coastal Marine Mammals, Coastal Fish, Coastal Benthos, Coastal Marine Plankton, Coastal Pathogens, Coastal Arthropods, Coastal Terrestrial Vegetation, and Coastal Terrestrial Mammals.

FEC prioritization followed criteria listed in Appendix Table 2 and were sent to selected scientists to provide input within their specific areas of expertise. These reviews were used as a quality control check on the initial assessments completed by the members of the CEMG. Following this assessment, contributing science experts were asked to respond to the following questions:

- Are there FECs/species missing that should be added?
- Are the criteria relevant? Are there others we should consider?
- Are some criteria more important than others? Should we weight criteria in our analysis?

Scientists were then asked to assess the FECs in terms of the monitoring questions to ensure that the prioritized FECs,
attributes and parameters could collectively address the monitoring questions targeted by the Coastal Monitoring Plan (Appendix Table 4).

Additionally, those attributes and parameters that were identified in the Alaska meeting as extremely or highly important by either scientists or TK holders were designated Essential.

A stochastic dominance process (Casella and Berger 1990) was used to identify Essential FECs for the Coastal Monitoring Plan by listing FECs in order of the number of High ratings, followed by the number of Medium ratings (Figure 4.1 shows Fjord Coastscape as an example; See Appendix Figure 1-5 for the remaining coastscapes). Priority was based on FECs for a coastscape that met the High criteria values, with tie-breaking factors using the Medium criteria value factors. The prioritization of the selected FECs then proceeded from left to right. The CEMG determined that an appropriate cutoff line would initially be assessed at 30% of the total potential FECs in a coastscape to be utilized. Given a total of 37 potential FECs across all coastscapes, this meant that approximately 8-9 FECs per coastscape were selected as Essential.

As a final step in the selection process, a few FECs were added to account for logical inconsistencies in the prioritization process, or based on input through the review process. For example, because we did not consult coastal plant ecologists as part of the prioritization process, coastal wetland communities were not found to be essential through the process. They were added to the Essential list of FECs for some coastscapes, given their importance as habitat for many coastal species. Table 4.1 lists the results of the prioritization exercise identifying Essential FECs for all coastscapes.

The list of Essential FECs in Table 4.1 was developed to provide a practical number of FECs for reporting across countries to
support a sustainable circumpolar synopsis of Arctic coastal biodiversity. We recognize that, based on the input we received at the three workshops, all of the FECs are important, and FECs not listed as Essential are still recommended in the Coastal Monitoring Plan. Where possible, additional monitoring can and should be conducted, as this will only enhance the ability to assess the implications and understanding of changes within the system.

Table 4.1. List of Essential FECs by coastscape based on prioritization process. The selection of FECs for each coastscape followed a stochastic dominance process based on selection criteria established by the CEMG. They were assessed based on input from CEMG FEC workshops and selected scientists.

<table>
<thead>
<tr>
<th>ESSENTIAL FECS</th>
<th>Rocky Shores</th>
<th>Eroding Shores</th>
<th>Lagoons</th>
<th>River Estuaries</th>
<th>Soft Shores</th>
<th>Fjords</th>
<th>Ice Fronts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterfowl</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Seabirds: omnivores</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seabirds: diving planktivore</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Seabirds: surface piscivores</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seabirds: diving piscivores</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seabirds: benthivores</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtidal flora, intertidal macroalgae</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pinnipeds</td>
<td>x</td>
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<tr>
<td>Whales</td>
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<td></td>
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<tr>
<td>Pelagic fishes</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
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<td></td>
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<tr>
<td>Demersal fishes</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Salmonids</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Phytoplankton</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meso- and macro-zooplankton</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benthos</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Large herbivores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coastal wetlands</td>
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</tr>
</tbody>
</table>

Following the determination of the Essential FECs for each coastscape, their parameters and attributes to be monitored were addressed (Table 4.2). Based on the expert input, the parameters marked Essential were used as a first assessment to determine if all of the monitoring questions would be addressed using the recommended attributes and parameters. Because all of the monitoring questions could be addressed using the attributes identified by the expert opinion as high priority, these attributes were selected as the final assessment attributes and parameters.
Table 4.2 Final list of all potential FECs (Essential and Recommended) with their associated attributes and parameters. Parameters with ‘TK’ noted indicate the requirement of local participation from individuals with an expertise in TK related to that parameter to gather and interpret information.

<table>
<thead>
<tr>
<th>FECS ALL COASTSCAPES</th>
<th>ATTRIBUTES</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diversity</td>
<td>Community Alpha diversity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spatial structure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Species composition</td>
</tr>
<tr>
<td></td>
<td>Phenology</td>
<td>Migration timing (dates)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Migration routes (location)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Degree of partial migration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Breeding area location changes (TK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nesting and rearing timing (date)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Habitat change (acres)</td>
</tr>
<tr>
<td></td>
<td>Demography</td>
<td>Reproductive rate (no. of eggs, nesting success)</td>
</tr>
<tr>
<td></td>
<td>Harvest and Accessibility</td>
<td>Harvest usability (TK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hunting strategies and accessibility (TK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harvest success (CPUE, distance, fuel, time)</td>
</tr>
<tr>
<td></td>
<td>Body Condition</td>
<td>Taste, colour, meat, organs (TK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Egg thickness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contaminants (Hg, POPs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disease - (frequency of outbreaks [die-offs, unusual mortalities, lesions])</td>
</tr>
<tr>
<td></td>
<td>Behavior Ecology</td>
<td>Changes in movent behavior (TK)</td>
</tr>
<tr>
<td>Subtidal flora, intertidal macroalgae</td>
<td>Biomass</td>
<td>Mass per unit area</td>
</tr>
<tr>
<td></td>
<td>Diversity</td>
<td>Species composition (number, diversity, community structure)</td>
</tr>
<tr>
<td></td>
<td>Diversity</td>
<td>Species composition (number, diversity, community structure)</td>
</tr>
<tr>
<td></td>
<td>Abundance</td>
<td>Biomass - per area cored/trawled (measured or converted from size-mass relationships)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td>Harvest and accessibility</td>
<td>Commercial/sport harvest statistics</td>
</tr>
<tr>
<td></td>
<td>Harvest feasibility</td>
<td>Harvest usability (TK)</td>
</tr>
<tr>
<td></td>
<td>Harvest feasibility</td>
<td>Harvest success (TK)</td>
</tr>
<tr>
<td></td>
<td>Harvest feasibility</td>
<td>Contaminants</td>
</tr>
<tr>
<td></td>
<td>Habitat</td>
<td>Success of food processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water quality (temp, conductivity, pH, DO)</td>
</tr>
<tr>
<td>Sub-Tidal/Inter tidal Macrofauna</td>
<td>Diversity</td>
<td>Species composition (based on microscopy/genetics, cell imaging), diversity indices</td>
</tr>
<tr>
<td></td>
<td>Size structure</td>
<td>Size classes and ratios (based on microscopy/flow cytometry/cell imaging)</td>
</tr>
<tr>
<td></td>
<td>Productivity</td>
<td>Primary production c/m2/day (C-14 method)</td>
</tr>
<tr>
<td></td>
<td>Phenology</td>
<td>Bloom peak, ocean color (remote sensing), fluoroescence timeseries</td>
</tr>
<tr>
<td></td>
<td>Toxicity</td>
<td>Toxin concentration</td>
</tr>
<tr>
<td>Phytoplankton</td>
<td>Diversity</td>
<td>Species composition (based on microscopy/genetics, diversity indices)</td>
</tr>
<tr>
<td></td>
<td>Size structure</td>
<td>Size classes and ratios (based on microscopy)</td>
</tr>
<tr>
<td></td>
<td>Productivity</td>
<td>Primary production c/m2/day (C-14 method)</td>
</tr>
<tr>
<td></td>
<td>Phenology</td>
<td>Bloom peak, ocean color (remote sensing), fluoroescence timeseries</td>
</tr>
<tr>
<td>Zooplankton</td>
<td>Biomass</td>
<td>Biovolume calculations</td>
</tr>
<tr>
<td></td>
<td>Diversity</td>
<td>Species composition (based on microscopy, diversity indices)</td>
</tr>
<tr>
<td></td>
<td>Size structure</td>
<td>Size classes and ratios (based on microscopy)</td>
</tr>
<tr>
<td></td>
<td>Phenology</td>
<td>Peak abundance</td>
</tr>
<tr>
<td>FECS ALL COASTSCAPES</td>
<td>ATTRIBUTES</td>
<td>PARAMETERS</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Pinnipeds</strong></td>
<td>Phenology</td>
<td>Migration timing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Migration routes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial migration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Birthing timing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Breeding timing</td>
</tr>
<tr>
<td></td>
<td>Demography</td>
<td>Growth rate and survival</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age class distribution</td>
</tr>
<tr>
<td></td>
<td>Harvest and accessibility</td>
<td>Harvest usability (TK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Success of food processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harvest success (CPUE, distance, fuel, time)</td>
</tr>
<tr>
<td></td>
<td>Body Condition</td>
<td>Texture, ivory colour and brittleness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stomach contents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disease - (frequency of outbreaks [die-offs, unusual mortalities, lesions])</td>
</tr>
<tr>
<td></td>
<td>Habitat</td>
<td>Places of refuge (size, locations)</td>
</tr>
</tbody>
</table>

| **Pelagic Fishes**   | Diversity  | Community Alpha diversity |
|                      |            | Spatial structure |
| **Demersal Fishes**  | Phenology  | Migration timing |
| **Salmonids**        |            | Breeding timing |
|                      |            | Spawning timing |
|                      | Demography | Age class distribution |
|                      |            | Length at age |
|                      | Harvest and accessibility | Harvest statistics |
|                      |            | Harvest usability (TK) |
|                      |            | Success of food processing (TK) |
|                      | Body Condition | Taste/texture/color meat, organs, skin, scales (TK) |
|                      |            | Contaminants concentrations (Hg, POPs) |
|                      |            | Disease - (frequency of outbreaks [die-offs, unusual mortalities, lesions]) |

| **Large herbivores** | Phenology  | Migration timing |
|                      |            | Migration routes |
|                      |            | Life cycle events (breeding, parturition, rearing) |
|                      | Demography | Reproductive rate |
|                      | Harvest and accessibility | Harvest statistics |
|                      |            | Subsistence hunting statistics |
|                      |            | Harvest usability (TK) |
|                      |            | Hunting strategies and accessibility (TK) |
|                      |            | Success of food processing (TK) |
|                      |            | Harvest success (CPUE, distance, fuel, time) |
|                      | Body Condition | Taste/texture/color meat, organs, skin, scales (TK) |
|                      |            | Contaminants concentrations (Hg, POPs) |
|                      |            | Disease - (frequency of outbreaks [die-offs, unusual mortalities, lesions]) |
Because of the nature of the selected FECs, their attributes, and their measurement parameters, a combination of knowledge systems is required to appropriately quantify the monitoring parameters in several cases. Because some of the parameters are collected by TK holders, the assessment and interpretation of those parameters requires their involvement in any assessment utilizing those parameters. This establishes a platform to integrate knowledge systems in assessing the state of the coastal ecosystems.

While this FEC prioritization process has not been perfect in complete integration of multiple knowledge systems throughout the entire development process, it does represent a significant step forward. Full inclusion of the combined efforts of knowledge holders in all knowledge systems did not happen completely throughout the process. However, most steps within the process did provide for input from a broad base of knowledge holders across knowledge systems. Additionally, the requirement that TK holders be included in the collection and interpretation of their data supports the process of inclusion of TK for providing a more complete assessment of the status and trends of Arctic coastal biodiversity.
5. Towards Implementation of Arctic Coastal Biodiversity Monitoring
5. Towards Implementation of Arctic Coastal Biodiversity Monitoring

The main purpose of the Coastal Monitoring Plan is its implementation across participating countries to produce the first State of Arctic Coastal Biodiversity Report (SACBR), a report that will follow similar reporting for CBMP marine (CAFF 2017), freshwater (CAFF, in press) and terrestrial (CAFF, in prep) programs (Figure 5.1). The SACBR will be developed from national synopses of coastal monitoring data, science and TK expert input, and recent research information and information gathered from TK, with results assessed and reported using the approaches outlined in the Coastal Monitoring Plan. In the same manner as other CBMP reports, and to increase the impact of the results and academic participation in the process, we will propose that we lead a special journal issue on the State of Biodiversity in Arctic Coastal Ecosystems. These articles and other information will inform the SACBR. This section outlines the process for producing the SACBR.

Figure 5.1. Implementation plan for the coastal monitoring. The Coastal Monitoring Plan is used as a frame to coordinate national coastal monitoring initiatives and for development of the State of Coastal Biodiversity Report (SACBR).

5.1 Governance and responsibilities

Following the lead of other CBMP programs, producing the SACBR will be the main responsibility of the Coastal Steering Group (CSG). The CSG will implement, coordinate and track the progress of all work stemming from the Coastal Monitoring Plan. The composition of the CSG will include one representative and an alternate from each Arctic nation, and from interested Permanent Participants. The CSG is responsible for setting the overall course of the evolving monitoring program, providing ongoing programmatic non-financial support and recommendations as needed, adjusting the implementation approach as necessary and reporting on the status of the SACBR and other issues to CAFF. (Figure 5.2)

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11 Consideration and intent will need to be put forward for the equitable engagement of TK in the development of reports. Resources will be needed to gather and aggregate documented relevant TK. Within this process, the involvement of Indigenous Peoples and TK holders in the review and aggregation of information will be needed. Additionally, TK holders will need to be included in every step of the process, from identification of what type of information needs to be gathered, location of information, and analysis of information.
The CSG will inform and guide the activities of participating national Coastal Expert Networks (CENs). CENs will be comprised of national experts who can contribute to assessments of the status and trends of the FECs identified in the Coastal Monitoring Plan. In particular, the CENs will work together to support their CSG representative to coordinate national coastal monitoring activities, and contribute to the work to identify, aggregate, analyze and report on existing national datasets that will make up the SACBR.

The CENs will also provide TK and science experts for an international Coastscape Expert Network who will work together to provide synoptic reporting for each of the seven coastscapes (Figure 5.2). The coastscape expert groups are similar to thematic groups in the other three CBMP monitoring plans, except that they will be multi-disciplinary, will take a social-ecological systems approach, and where appropriate, will co-generate monitoring information from both TK and science approaches.

## 5.2 Approach

The general goal of the SACBR is to analyze available data on circumpolar Arctic coastal biodiversity to report timely and relevant information on important changes in monitored elements of Arctic coastal biodiversity, in the context of the key environmental drivers and anthropogenic threats that are affecting it.

The Coastal Monitoring Plan outlines a series of both overarching and focused monitoring questions that the SACBR will attempt to address. The Coastal Monitoring Plan also identifies and prioritizes a number of Focal Ecosystem Components (FECs), with associated Attributes and Parameters, that have been identified by science and TK experts as the most relevant to monitor to measure and report important biodiversity change in Arctic coastal ecosystems.

Other key elements of the Coastal Monitoring Plan are:

- where applicable and desirable, to develop monitoring programs and assessments through a co-production of knowledge approach where TK holders and scientists work collaboratively;
- to organize our knowledge of coastal ecosystems (coastscapes) into conceptual social-ecological models that link targeted elements of coastal biodiversity (FECs) to the abiotic drivers and anthropogenic stressors that may threaten it; and,
- to link monitoring initiatives across geographic and temporal scales, i.e., community-based monitoring and large-scale international initiatives.
It is understood that, at this time, the SACBR will not be able to comprehensively answer all of these monitoring questions for all prioritized FECs. The first SACBR will address those monitoring questions for those FECs where data are presently available, and commit to working with coastal partners to grow the program to eventually begin to answer these overarching monitoring questions for all FECs across the circumpolar Arctic.

To the greatest extent possible, information developed under the Coastal Monitoring Plan will be provided at the local scale to serve local decision-making. This will be achieved partly through local-scale, community-based monitoring, but also through interpolation and modeling techniques to provide information that Arctic residents can use to make effective adaptation decisions.

As the SACBR rolls out it may be necessary to review the approach outlined in the Coastal Monitoring Plan based on feedback from contributing experts. Also, as monitoring and reporting continues, and national programs grow, further changes may be necessary to account for new developments and situations.

### 5.3 Roles of the CAFF CBMP Coastal Steering Group (CSG) and the Coastal Expert Networks (CENs)

The CSG should be established as soon as possible after the Coastal Monitoring Plan has been accepted by the CAFF Board in February 2019. Given the strong focus in the Coastal Monitoring Plan on a co-production of knowledge approach, the participation of Permanent Participants on the CSG is a high priority. CSG Chairs will be determined in 2019.

In the short term, CENs will have the critical job of identifying, assessing and tabulating any data that can contribute to reporting the status and trends of Arctic coastal biodiversity within their countries. Depending on their expertise, they may also contribute to the publications in the Special Issue and to the analysis of assembled monitoring data for the SACBR. CEN members may also become members of a national Arctic coastal biodiversity monitoring network that will look to establish and sustain long term monitoring of coastal ecosystems, based on key gaps identified through the SACBR process.

As discussed in the Coastal Monitoring Plan, the sustainability of long-term monitoring of a nation’s coastal ecosystems will rely on ongoing support from those agencies and organizations that rely on the data developed to meet their own mandates or needs. These may include groups with mandated biodiversity obligations (e.g., protected areas managers, wildlife and fisheries managers, agencies with national/international conservation obligations, Indigenous organizations), industrial operators working in and travelling through coastal areas (e.g., commercial shipping, oil and gas operations, commercial fisheries, tourism), and Arctic coastal communities who utilize Arctic coastal species as an important component of culture and food security. As a result of their obligations, potential impacts, or long reliance on coastal biodiversity, these are also the potential partners who have been monitoring coastal biota either formally through science approaches, or informally through TK approaches and are likely candidates for membership in national CENs.

Consideration will need to be put forward for the equitable engagement of TK in the gathering of information. Resources will be needed to gather and aggregate documented relevant TK. Within this process, the involvement of Indigenous Peoples and TK holders in the review and aggregation of information will be necessary.

### 5.4 Reporting by coastscape

One of the major directions from the Coastal Monitoring Plan is to maintain a systems approach for the SACBR that would ensure that the identified coastal FECs are presented and assessed in a social-ecological framework. Ultimately, the SACBR should be coastscape-based in a manner that recognizes seasonality and connectivity, and is multi-knowledge and multi-science discipline based. To this end, conceptual models for each of the seven Arctic coastscape have been developed in the Coastal Monitoring Plan as an aid to help visualize the ecological and social context for targeted coastal FECs. These models can be used by the Coastal Expert Networks to develop a common understanding, both nationally and internationally, of how the FECs relate to each other, to their physical environment, and to the different anthropogenic stressors that may threaten them, either individually or cumulatively. Based on our feedback from workshops for the Coastal Monitoring Plan with both TK holders and scientists, such a systems approach can also provide a common frame for effective co-generation of knowledge for coastal ecosystems.

A second task will be to illustrate the relationships expressed in the conceptual models by developing an overview map of national coastal areas showing, for example:
distribution of coastscapes;
locations and activity areas of coastal communities;
protected areas and important habitat areas, e.g., spawning/birthing areas, migration routes;
major threats to coastal biodiversity;
major coastal use zones, e.g., large and small ports, coastal industrial facilities, commercial fishing areas, and key shipping lanes; and,
any other mappable information that informs the SACBR.

These maps can be combined in the SACBR to present a summary account of coastal ecosystems and associated issues across the circumpolar area.

5.5 Data compilation and synthesis

An important task for the CENs will be to identify, acquire and tabulate a national synopsis of available monitoring data that can contribute to an international assessment of Arctic coastal biodiversity. A preliminary identification of relevant monitoring data for each country was conducted during the development of the Coastal Monitoring Plan. Based on this exercise it would appear that useful data for the first SACBR will come from:

government departments with management or conservation mandates such as departments responsible for managing coastal fisheries or other harvesting activities, and protected areas managers;
government departments with obligations to report under various national Acts or directives;
industrial operators required to monitor the potential impacts of their operations;
well-established research sites with long running monitoring programs;
community-based monitoring programs; and,
Indigenous organizations.

It is clear from this exercise that, although there are some useful data available from ongoing monitoring programs and other sources, there will not be long-term status and trends data for all FECs across the geographic and coastscape areas of interest. For this reason, it will also be useful to include any relevant research on coastal ecosystems that may provide insight into the status and trends of the coastal FECs, or for threats and drivers.

In addition to data on coastal species, and in the interest of developing a systems approach, the data collection process should also look at the availability of information on abiotic drivers of coastal systems. For example, information for most countries is available on the quantity and quality of freshwater inputs to coastal marine systems, on sea level changes as they may impact coastal wetlands and lagoon systems, on changes in sea ice phenology, and on rates of coastal erosion and patterns of sedimentation. Many of these drivers are changing with a warming Arctic climate so a time series approach can provide insights into how and how rapidly these factors are changing, and what this may mean for coastal habitats, and for the species that rely on those habitats.

The SACBR will also develop and utilize remote-sensing based approaches as appropriate to generate principally abiotic information at regional scales that can be relevant to changes in the habitats of coastal species. Measures of coastal marine chlorophyll (chl a), coloured dissolved organic matter, and sea surface temperature are all important drivers of marine coastal ecosystems and any changes in these factors can be developed as a time series using satellite imagery to cover large areas of coastline where no surface data are available, and to support or extend surface measures.

The data synopsis from each country will need to be carefully coordinated to support an international synthesis for analysis in the SACBR. Data will need to be organized by Coastscape, FEC, Attribute and Parameter, and it will be the role of the CSG to develop a standardized data structure, format and nomenclature that will permit collation and analysis of all data across coastscapes and countries. National data sets used for the SACBR will be contributed to the CAFF Arctic Biodiversity Data Service (ABDS) to act as international baselines for ongoing coastal monitoring and reporting.

There is a general standard that should be adhered to when utilizing information originating from TK holders. How the information will be utilized, ownership, and accessibility should be agreed upon prior to beginning work.
5.6 Co-production of knowledge

Through the development of the Coastal Monitoring Plan there has been a strong commitment to working with Permanent Participants to invite the participation of Indigenous experts in developing a monitoring plan for coastal systems – individuals named by their communities as those with a high level of knowledge and experience in coastal systems. Each country that implements the Coastal Monitoring Plan using a co-production of knowledge approach will do so through effective engagement and input of national Indigenous organizations, regional land-claim bodies and coastal communities, and it is anticipated that the process will vary among countries.

For those nations pursuing a co-production of knowledge approach, key elements for the implementation of the Coastal Monitoring Plan were identified through the Ottawa workshop (CBMP 2016):

- trust and respect;
- recognize TK (Indigenous Knowledge) as a systematic way of knowing that holds its own methodologies, validation, and evaluation processes (Ottawa Indigenous Knowledge Principles 2014);
- avoid translation of one knowledge system into the other;
- recognize that only TK holders can analyze their information;
- create equitable partnerships;
- credit all input and findings, and all products; and,
- develop culturally appropriate communication products.

To effectively have a co-production of knowledge program CENs will need to:

- develop an effective data plan that allows for communities to have continuous access to collected information;
- include both TK holders and scientists in all activities;
- engage and build relationships with national- and community-level Indigenous organizations and entities; and,
- fund TK holders in all activities.

Key actions that will need to occur to effectively engage CBM programs include:

- relationship building;
- relevant communities determining how and if they would like their information included; and,
- information/data agreements developed.

5.7 Assessing and reporting status and trends

The primary objective of the SACBR is to collect and analyze the best available information from across all nations with Arctic coastlines to document the present status and trends of Arctic coastal species, as represented by the prioritized coastal FECs. It is fortunate that similar reports on marine, freshwater and terrestrial species will already have been produced for CAFF so that much can be learned from the process of producing those reports. As for those other reports, a second important objective for the SACBR will be to document gaps in the present state of monitoring of coastal species and ecosystems.

The Arctic Marine Biodiversity Monitoring Plan organized marine FECs into six biotic groups – sea ice biota, plankton, benthos, seabirds, fish and marine mammals – and so the State of Arctic Marine Biodiversity Report (SAMBR) reports current monitoring, status and trend, and drivers for each of these groups. Similarly, the State of Arctic Freshwater Biodiversity Report (SAFBR) provides assessment of patterns and trends of algae from benthic samples, phytoplankton, macrophytes, zooplankton, benthic invertebrates and fish. Both of these reports emphasize the importance of the ecological context and potential biodiversity threats, as separate sections of the report. The Coastal Monitoring Plan differs somewhat from the approach taken by the other three CBMP monitoring programs in that there is a stronger focus to report FEC status and trends in the context of the social-ecological context of the coastscapes in which the FECs find habitat. To this end the SACBR will consider all FECs together within a coastscape in terms of their relationship to each other, to the drivers that largely control them, to the anthropogenic factors that threaten them, and to their use and importance to coastal communities.
The Coastal Monitoring Plan outlines a nested, multi-scale framework to determine baseline conditions and evaluate changes with respect to the long-term integrity of Arctic coastal ecosystems and biodiversity. Methods and strategies for monitoring range from site-based focal studies to pan-Arctic remote sensing and global modeling approaches, and incorporate data collection through scientific procedures, TK, local knowledge, and community-based monitoring. The Coastal Monitoring Plan recommends building on robust standardized techniques that are feasible and already in use across circumpolar regions where possible, and suggests additional techniques (e.g., genetic analyses, stable isotope signature analysis, satellite-based or other technology-based tracking and telemetry systems, and remote sensing) where infrastructure and capacity exists.

It is difficult at this time to describe the exact type of analyses that will be used to develop the coastal FEC status and trends FECs, in that we are not sure of the quantity and quality of data that will be available for the assessment. Given the general lack of spatial and temporal coordination between measures of biota and contextual information on drivers and threats, it is anticipated that this will be a major challenge. An additional complexity will be to link across scales from local to regional data using remote sensing tools. Finally, the focus on a co-generation of knowledge approach is novel and will require active participation and leadership by Permanent Participants to be successful.

5.8 Data management

The most onerous task for the development of the SACBR will be the identification, organization and tabulation of available and relevant monitoring data for each contributing nation, and it is anticipated that this step will take several years to complete. This process includes not only data on the Attributes and Parameters of the FECs themselves, but also the data on environmental drivers and anthropogenic threats that is brought into the analysis to inform the assessment of FEC status and trends. One of the most important roles of a long-term monitoring program is to ensure that the data that are collected, compiled and analyzed to make assessments of status and trends in the identified FECs are properly archived and curated for future use by subsequent assessments. In that this is the first SACBR, these data are the critical baseline information against which future trends will be compared. In keeping with an open data policy, and following publication of the SACBR, these data should also be readily available, with appropriate metadata, and in a format that facilitates public access.

As for previous CBMP monitoring reports, data sets compiled for the SACBR will be made available on the Arctic Biodiversity Data Service (ABDS), the online interoperable system for managing data generated via CAFF projects and activities. The goal of the ABDS is to facilitate access, integration, analysis and display of biodiversity information for scientists, managers, policy makers and others working to understand, conserve and manage the Arctic's wildlife and ecosystems. National teams will want to also manage data within their own nations for internal reporting and link to other monitoring initiatives.

Data/information management plans and agreements (e.g., MoUs, collaborative agreements) will need to be established for the utilization of government data, TK and engagement with CBM programs. It will be important that TK holders and communities retain ownership of their information and for agreements to reflect the ethical utilization of information. The Arctic Council Permanent Participants and other Indigenous groups are working on the topic of information sovereignty. It will be important to rely on their guidance and expertise to aid in developing these agreements.

5.9 Special journal publication

As with the CBMP freshwater and terrestrial reports, a key step in producing the SACBR is to solicit coastal science and TK experts to contribute to co-authored, multidisciplinary articles that would together comprise a special issue of a journal to be named, and provide refereed, expert input to the SACBR. We will work to identify an open access journal to improve overall access to included articles. Special issue articles will take advantage of new or established multidisciplinary science, as well as co-production of knowledge partnerships arising from the SACBR process to analyze emerging and historical data to provide a systems context that links, within coastscapes, key abiotic drivers and anthropogenic stressors to prioritized FECs identified in the Coastal Monitoring Plan.

5.10 Proposed timelines to produce the SACBR

Following approval of the Coastal Monitoring Plan by the CAFF Board, a potential schedule to develop the first SACBR (Table 5.1) proposes the establishment of the Coastal Steering Group, and the formation of national Coastal Expert Networks in 2019. These groups will work together to agree on a general data structure and convene an initial meeting to develop an
implementation plan and approach at the end of 2019. The implementation plan developed may take the direction suggested in the Coastal Monitoring Plan, or it may be altered based on the input and direction of the assembled experts. According to the schedule in Table 5.1, national CENs will gather and analyze data to produce the first SACBR in 2023, with subsequent articles for submittal for a special journal publication in 2024. This schedule is optimistic given the time taken to produce other CBMP monitoring plans. We hope to anticipate many of the hurdles and apply the lessons they have learned over the course of developing their plans to shorten the overall delivery of the SACBR. The CSG will also be responsible for generating brief annual progress reports and work plans and encouraging the CENs to produce national one-pagers on coastal biodiversity issues.

Table 5.1. Proposed implementation schedule to develop the first SACBR.

<table>
<thead>
<tr>
<th>MILESTONE</th>
<th>ACTIVITIES AND DELIVERABLES</th>
<th>START YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan published</td>
<td>Final plan endorsed by CAFF Board and published</td>
<td>2019</td>
</tr>
<tr>
<td></td>
<td>Executive summary report published (if needed)</td>
<td>2019</td>
</tr>
<tr>
<td>Governing structure activated</td>
<td>CBMP-CSG established</td>
<td>2019</td>
</tr>
<tr>
<td></td>
<td>National CENs established</td>
<td>2019</td>
</tr>
<tr>
<td>Data structure and management</td>
<td>CSG develops common data structure and management approach</td>
<td>2019</td>
</tr>
<tr>
<td>Implementation meeting</td>
<td>Initial meeting to establish implementation steps and goals</td>
<td>2019</td>
</tr>
<tr>
<td>Indicator development</td>
<td>Existing national and international data sets identified and aggregated</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>Data analyzed to establish FEC baselines</td>
<td>2022</td>
</tr>
<tr>
<td></td>
<td>FECs updated based on SACBR</td>
<td>2023</td>
</tr>
<tr>
<td>Reporting</td>
<td>Annual progress reports and work plans</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>National &quot;one pagers&quot;</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>State of the Arctic Coastal Biodiversity Report</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td>Special journal publications</td>
<td>2024</td>
</tr>
<tr>
<td>Program review</td>
<td>Lessons learned and gap analysis</td>
<td>2024</td>
</tr>
</tbody>
</table>

Table 5.2 shows estimated efforts to initiate and manage the SACBR process, including general activities and deliverables. Costs will be associated with these efforts but will vary by country. Detailed estimates of costs for locating, aggregating, analyzing and reporting monitoring data for the SACBR will be developed by the CSG in 2019, as a component of the implementation plan.

Table 5.2. CSG activities and deliverables.

<table>
<thead>
<tr>
<th>GOVERNING AND OPERATIONAL STRUCTURE</th>
<th>ACTIVITIES AND DELIVERABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiate SACBR Process</td>
<td>• identify chairs&lt;br&gt;• set long term schedule for SACBR delivery&lt;br&gt;• national reports&lt;br&gt;• data structure and management</td>
</tr>
<tr>
<td>Annual meetings 2020 - 2024</td>
<td>• annual progress reports&lt;br&gt;• issues and developments&lt;br&gt;• review schedules&lt;br&gt;• annual updates</td>
</tr>
</tbody>
</table>
6. Reporting and Communications
6. Reporting and Communications

6.1 Context

A key objective of the Coastal Monitoring Plan is to report to knowledge clients the present state and trends of Arctic coastal biodiversity, and provide an analysis of stressors and drivers that impact that diversity. In fact, broad communication of Coastal Monitoring Plan assessments of the status and trend of Arctic coastal biodiversity is one of the most important components of the plan. The communication approach, main communication goals, and targeted audiences with a potential interest in the Coastal Monitoring Plan are presented and discussed below.

6.2 Communications goals

Key goals for communication of monitoring and reporting products under the Coastal Monitoring Plan are to:

► provide target audiences with timely, relevant and accurate information on Arctic coastal biodiversity for use in decision-making;
► encourage partnership and information sharing among target audiences and the CBMP;
► support Arctic coastal biodiversity monitoring funding opportunities and partnerships; and,
► raise the CBMP profile among target audiences as a credible, reliable and authoritative voice in Arctic biodiversity research and monitoring.

6.3 Target audiences and key messages

There are four key target audiences: policy and decision-makers, wildlife and ecosystem research and monitoring communities, citizens of Arctic coastal communities, and influential business and industry. Each of these is a relatively homogenous group (in terms of current knowledge, attitudes, practices or interest in the issue). Each target audience requires a different communication approach according to their motivations and interests. Target audiences are instrumental in solving the problem of biodiversity loss. Note that Indigenous audiences are integrated across all four audiences. Additional consideration has been provided for their perspectives and contexts within these groups.

Policy and decision makers that influence biodiversity management in the Arctic

These audiences will benefit from increased quality, quantity and comparability of data and advice needed to develop effective practices and policies to support the sustainable use of Arctic resources. Examples include: Arctic Council Ministers, Senior Arctic Officials and junior staff, Arctic Council working groups (AMAP, SDWG, etc.), CAFF National Representative organizations and partner federal departments/agencies (environment, parks, natural resources, land management), Permanent Participants, Observer Countries and Organizations, Nordic Council of Ministers, the Arctic Parliamentarians, Northern Forum, Barents Euro-Arctic Council, EU, UNEP, global multilateral agreements such as the UN CBD, sub-national governments, wildlife management boards, joint management committees, hunters, trappers, fishers, local community-monitoring experts, Indigenous governments and regional corporations.

Arctic wildlife and ecosystem research and monitoring communities

Those practitioners and managers actively involved in Arctic coastal monitoring will benefit through increased cooperation, benefits of scale, increased accessibility to data, identification of circumpolar knowledge gaps, and information to inform prioritization of resources. Examples include: federal, regional and local government scientists and monitoring professionals, academia, NGOs, Nordic Council of Ministers, Global Monitoring for Environment and Security (GMES), Group on Earth Observations (GEO), Sustaining Arctic Observing Network (SAON), the Barents Euro-Arctic Council, UN World Conservation Monitoring Centre, UNEP GRID-Arendal, IUCN, International Arctic Science Committee (IASC).

Citizens of coastal communities in the Arctic

This audience will benefit from increased understanding of activities that constitute a conservation concern for Arctic species and ecosystems, and adjust activities to support conservation. Examples include: local wildlife boards, local subsistence resource councils, local community leaders, elders, municipalities, schools, project participants, local radio, newspapers, TV.

Influential business and industry working in the Arctic

The goals with this audience are to increase the visibility of the Coastal CBMP to utilize CBMP data (specifically monitoring information) in company decision making, to understand which industrial activities constitute a conservation concern for
Arctic species and ecosystems, and to adjust activities to support sustainable use. Finally, we anticipate that industry will want to engage in CBMP activities and partnerships and circulate Arctic biodiversity information and recommendations within their sphere of influence.

6.4 Products, channels, activities, coordination, roles, timelines

The following is a list of communication products that relate to the Coastal Monitoring Plan and to targeted audiences (Table 6.1):

- State of Arctic Coastal Biodiversity Report
- Workshop reports
- Peer-reviewed publications
- Performance reports and work plans
- Program review
- Events (community events to international conferences)
- Other communications material
  - Website
  - Video/interviews
  - Presentations
  - Social media

The CAFF Secretariat will work with CBMP Coastal group members, co-chairs and their respective organizations and the CAFF Board to deliver communications activities, and develop communications materials.

All members of the CBMP Coastal group participate in promoting the work of the group as appropriate within their national system and conferences in which they participate.

CBMP Co-Leads, CAFF national representatives, Permanent Participants, observer country representatives and observer organization representatives ensure that information arising from the CBMP Coastal group’s projects and activities are shared amongst their governments and organizations, and factor into decision making at different levels.

Table 6.1. Products of the monitoring plan and their intended audience

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>AUDIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Policy and decision makers that influence natural resource, land and wildlife management in the Arctic</td>
</tr>
<tr>
<td>State of Arctic Coastal Biodiversity Report</td>
<td>x</td>
</tr>
<tr>
<td>Other reports</td>
<td>x</td>
</tr>
<tr>
<td>Peer-reviewed publications</td>
<td></td>
</tr>
<tr>
<td>Performance reports and workplans</td>
<td>x</td>
</tr>
<tr>
<td>Program review</td>
<td>x</td>
</tr>
<tr>
<td>Events</td>
<td>x</td>
</tr>
<tr>
<td>Other communications</td>
<td>x</td>
</tr>
</tbody>
</table>
6.5 Resources

The CAFF Secretariat provides in-kind support for limited communications activities. Additional funds are raised during project fundraising and may be necessary to complete the activities identified in the plan.

6.6 Evaluation of goals

Table 6.2. Goals and Evaluation Metrics

<table>
<thead>
<tr>
<th>GOAL</th>
<th>POTENTIAL EVALUATION METRICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>To provide target audiences with timely, relevant and accurate information on Arctic coastal biodiversity for use in decision-making</td>
<td>References to CBMP Coastal documents and products used during international, national and local government and community decision making and planning. Increased focus on Coastal Focal Ecosystem Components. Increased requests for information from target audiences. Increased presence of CBMP Coastal at appropriate meetings and within relevant projects.</td>
</tr>
<tr>
<td>To encourage partnership and information sharing amongst target audiences and with the CBMP on Arctic coastal biodiversity monitoring</td>
<td>Achievement of a co-generation of knowledge approach. Increased number of organizations in partnerships with CBMP Coastal group. Increased level of information sharing within partnerships. Increased trust amongst partners. Number of different target audience organizations partnering with CBMP Coastal.</td>
</tr>
<tr>
<td>To support Arctic coastal biodiversity monitoring funding opportunities and partnerships</td>
<td>Increased quantity of funding for Coastal Focal Ecosystem Components. Increased diversity of funding sources. Increased number of partnerships. Increased number of funding opportunities that were the result of CBMP involvement amongst both CBMP Coastal representative organizations and other partners.</td>
</tr>
<tr>
<td>To raise the CBMP profile amongst target audiences as a credible, reliable and authoritative voice in Arctic biodiversity research and monitoring</td>
<td>Increased mention of CBMP coastal work in Arctic Coastal Monitoring Planning. Increased number and diversity of requests for information from CBMP. Increased number of plan downloads. Increased number of speaking engagements with CBMP Coastal representatives. Increased positive feedback from CBMP Coastal projects, products and events.</td>
</tr>
</tbody>
</table>
7. Literature Cited


For further information on the Focal Ecosystem Components developed for the CBMP Arctic Coastal Biodiversity Monitoring Plan, regarding their parameters, attributes and selection criteria please see here: https://caff.is/files/CBMP_Coastal_Plan_supplementary_info-3Jan2019.xlsx
Cambridge Bay. Photo: ©Carolina Behe

Berry picking in the Yukon-Kuskokwim region of Alaska. Photo: ©Mary Peltola

Paulatuk. Photo: ©Carolina Behe

Utqiagvik. Photo: ©Carolina Behe

Flying within the Inuvialuit Settlement Region. Photo: ©Carolina Behe

Cyrus Harris finding Sura in Iceland. Photo: ©Carolina Behe
8. Appendix
Appendix Table 1. A representative comparison table of potential Coastal FECs compared to CBMP working group FEC attributes. Blank indicates no overlap with this FEC.

<table>
<thead>
<tr>
<th>POTENTIAL COASTAL FECS</th>
<th>FRESHWATER CBMP ATTRIBUTES</th>
<th>MARINE CBMP ATTRIBUTES</th>
<th>TERRESTRIAL CBMP ATTRIBUTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BIRDS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorebirds</td>
<td></td>
<td>Abundance, spatial structure, demography, phenology</td>
<td></td>
</tr>
<tr>
<td>Waterfowl</td>
<td>Abundance and phenology of resident and non-resident species</td>
<td>Diversity, composition, spatial structure, health</td>
<td></td>
</tr>
<tr>
<td>Raptors</td>
<td></td>
<td>Abundance, spatial structure, demography</td>
<td></td>
</tr>
<tr>
<td>Seabirds: omnivores (glaucous gull, glaucous-winged gull, great black-backed gull, herring gull, ivory gull)</td>
<td>Diversity, composition, spatial structure, health, prey cycling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seabirds: diving planktivores (least auklet, dovekie)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seabirds: diving piscivores (common murre, thick-billed murre, Atlantic puffin, tufted puffin)</td>
<td>Colony size, survivorship, reproductive success, chick diet, harvest statistics, phenology</td>
<td>Abundance, spatial structure, demographics</td>
<td></td>
</tr>
<tr>
<td>Seabirds: surface piscivores (black-legged kittiwake, northern fulmar, Arctic tern)</td>
<td>Colony size, survivorship reproductive success, chick diet, harvest statistics, phenology</td>
<td>Abundance, spatial structure, demographics</td>
<td></td>
</tr>
<tr>
<td>Seabirds: benthivores (common eider, king eider, black guillemot, pigeon guillemot, great cormorant, shag, pelagic cormorant)</td>
<td>Colony size, survivorship, reproductive success, chick diet, harvest statistics, phenology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix Table 2. Criterion for experts to analyze for all potential FECs in all Coastscapes.

<table>
<thead>
<tr>
<th>Ecosystems</th>
<th>CRITERION</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensitivity to climate-driven ecosystem drivers</td>
<td>a change in climate-driven ecosystem drivers will directly impact this FEC</td>
<td>a change in climate-driven ecosystem drivers will have a moderate effect on this FEC</td>
<td>a change in climate-driven ecosystems drivers will have minor to no effect on this FEC</td>
<td></td>
</tr>
<tr>
<td>potential for causing ecosystem change</td>
<td>a change in his FEC will create important cascading ecosystem effects</td>
<td>a change in this FEC will have a moderate effect on ecosystem structure and processes</td>
<td>a change in this FEC will have minor to no effect on ecosystem structure and processes</td>
<td></td>
</tr>
<tr>
<td>sensitive to anthropogenic stressor drivers</td>
<td>very susceptible to many different anthropogenic stressors</td>
<td>moderately susceptible to a moderate number of anthropogenic stressors</td>
<td>not susceptible to anthropogenic stressors</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relevance</th>
<th>CRITERION</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>relevance to management questions</td>
<td>relevant to most management questions</td>
<td>relevant to some management questions</td>
<td>not relevant to any management questions</td>
<td></td>
</tr>
<tr>
<td>significance for supporting community food security</td>
<td>very important for coastal community food security</td>
<td>locally to regionally important for community food security</td>
<td>not important for community food security</td>
<td></td>
</tr>
<tr>
<td>relevance to legislation</td>
<td>many species fall under some category of legislation or management regime</td>
<td>a few species fall under some category of legislation or management regime</td>
<td>no species fall under some category of legislation or management regime</td>
<td></td>
</tr>
<tr>
<td>relevance to diverse audiences</td>
<td>highly relevant to policy, academic, industry, and community audiences</td>
<td>relevant to one or more policy, academic, industry, or community audiences</td>
<td>not relevant to policy, academic, industry, and community audiences</td>
<td></td>
</tr>
<tr>
<td>cultural and/or science relevance</td>
<td>very important to cultural considerations of coastal communities or to science</td>
<td>somewhat important to cultural considerations of coastal communities or to science</td>
<td>not important to cultural considerations of coastal communities or to science</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitoring Status</th>
<th>CRITERION</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>presently being adequately monitored</td>
<td>present monitoring provides sufficient data to reliably report circumpolar status</td>
<td>present monitoring occurs, but is limited either spatially or temporally</td>
<td>no or very limited present monitoring</td>
<td></td>
</tr>
<tr>
<td>availability/ sustainability of monitoring capacity, expertise and protocols</td>
<td>monitoring capacity/ experts readily available monitoring protocols are well established</td>
<td>some availability of monitoring capacity/ expertise some monitoring protocols/methods established in some areas</td>
<td>limited to no monitoring capacity/ expertise no monitoring protocols established</td>
<td></td>
</tr>
<tr>
<td>ability to access existing data</td>
<td>data are available with required metadata</td>
<td>some data are available with/without required metadata</td>
<td>no data are available</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geographic Status</th>
<th>CRITERION</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>pan-Arctic distribution</td>
<td>occurs in all Arctic countries</td>
<td>occurs across at least 3 Arctic countries</td>
<td>occurs in less than 3 Arctic countries</td>
<td></td>
</tr>
<tr>
<td>occurrence across coastscapes</td>
<td>occurs in 4 or more coastscapes</td>
<td>occurs in 2-4 coastscapes</td>
<td>occurs in 1 coastscape</td>
<td></td>
</tr>
<tr>
<td>relative importance of the coastscape</td>
<td>coastscape provides critically important and abundant habitat and resources</td>
<td>coastscape provides some habitat and resources</td>
<td>coastscape provides very little to no habitat and resources</td>
<td></td>
</tr>
</tbody>
</table>
The following descriptions were used to clarify criterion for the FEC assessments:

‘Climate-driven ecosystem drivers’: Dominating climatic factors and processes that shape the ecosystem, including predominant climate, wind direction and timing, disturbance regimes; and atmospheric, geomorphic, biogeochemical oceanographic, hydrologic and terrestrial abiotic effects – some FECs can adapt to these changes while others may be more susceptible.

‘Ecosystem change agents’: Some species are considered ‘keystone’ or more critical to ecosystem function than others. For example, changes in important prey species such as lemmings or Arctic cod can be expected to have potential ecosystem cascading effects; or predators may be ecosystem change agents where systems are top-down driven. In addition to ecological keystone species, the Coastal Monitoring Plan recognizes the need to monitor with an understanding of cultural keystone species. There is a direct relationship between people and the flora and fauna in a shared environment. Consider how a change in caribou can cause drastic change within an area, inclusive of cultural changes such as hunting patterns, and change in which animals are used for food. With this understanding the monitoring program is able to recognize the interconnective health of all within an ecosystem.

‘Stressor drivers’: Anthropogenic drivers that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological processes in a manner that may impact its ecological integrity and biological diversity, such as an invasive species, pollution, contaminants, large-scale commercial fishing, divergence of migration patterns caused by human activities, such as low flying planes and noise, overhunting, contamination, infrastructure development and related disruption, icebreaking, disruption of a natural disturbance regime.

‘Management–related Monitoring Questions’:

Do the following factors (individually and/or cumulatively) significantly impact Arctic coastal ecosystems and associated biodiversity generally, and specifically, do they significantly impact the availability, abundance and quality of subsistence food for Arctic communities?

1. direct and indirect effects of climate change: reduced sea ice, ocean acidification, increased wind and storminess, rising sea level, permafrost degradation, changes to freshwater discharge regimes, warmer temperatures, shortened snow season, longer growing season, earlier lake/river ice break-up and later freeze-up, new pathogens, new species, other effects;
2. oil and gas activities: exploration, drilling and extraction, and related infrastructure, shipping, and other transportation activities;
3. mining activities: exploration, extraction, processing, and related infrastructure, shipping and other transportation activities;
4. shipping: tourism and adventure cruising, community re-supply, industrial, military and research-related shipping;
5. commercial fishing: harvest and overharvest;
6. community activities: sewage disposal and other pollution, hunting, trapping, infrastructure, avoidance;
7. long range and local contaminants: Hg and POPs;
8. invasive alien species: especially marine invasive species.


‘Diverse audiences’: Include policy and decision-makers, wildlife and ecosystem research and monitoring communities, coastal communities and industry.
### Appendix Table 3.

Representative sample of the attributes associated with different potential FECs. The potential FECs are found in the first column. Typical species associated with the FEC are found in the second column. The third and fourth columns list potential attributes and associated parameters for that FEC. Colour coding is indicative of the FEC, e.g. coastal raptors are in purple, typical coastal raptor species are in medium purple, attributes of the coastal raptors are in dark purple, and the parameters for those attributes are in light purple. Where more than a single FEC is found of the same colour, the attributes and parameters apply to all the FECs of that colour.

<table>
<thead>
<tr>
<th>FECS</th>
<th>TYPICAL SPECIES</th>
<th>ATTRIBUTES</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal raptors</td>
<td>white-tailed eagle, bald eagle, jaegers</td>
<td>Abundance</td>
<td>number, density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phenology</td>
<td>dates for arrival, egglaying, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Demography</td>
<td>number of eggs, hatching success, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Health and body condition</td>
<td>diet composition and amount, nutritional value, feeding rate and energy budget, contaminant load</td>
</tr>
<tr>
<td>Coastal shorebirds and songbirds</td>
<td>all shorebirds and songbirds using coastal terrestrial ecosystems</td>
<td>Abundance</td>
<td>number, density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phenology</td>
<td>dates for arrival, egglaying, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Demography</td>
<td>number of eggs, hatching success, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diversity</td>
<td>spatial structure</td>
</tr>
</tbody>
</table>
Appendix Table 4. The five sets of questions for the parameters to be answered Y, N or M as indicated above were:

| What is the status and trend of Arctic coastal ecosystems in terms of their native species composition and condition, new and invasive species, geographic distributions, thresholds, phenological norms, and key processes and functions? |
|---|---|---|---|---|---|
| native species composition | native species condition | new and invasive species | geographic distributions of new and native species | thresholds of species decline | phenological norms of native species | key processes and functions of coastal ecosystems |

If Arctic coastal biodiversity or subsistence food is significantly impacted by any of these factors acting alone or together, which species are affected, how are they affected (mechanisms and drivers of change), where are they affected (geographically), and what is the expectation for the effects of these impacts in the near to medium future (5-20 years)?

| Which species are affected? | How are they affected (mechanisms and drivers of change)? | Where are they affected (geographically)? | What is the expectation for the effects of these impacts in the near to medium future? |

What and how are primary system drivers and disturbances (biological, chemical, physical, and anthropogenic) influencing changes in coastal biodiversity and ecosystem function? What are the cumulative effects?

| primary system drivers (temperature, precipitation, seasonality, etc) | disturbance (biological, chemical, physical, and anthropogenic) |

Do the following factors (individually and/or cumulatively) significantly impact Arctic coastal ecosystems and associated biodiversity generally, and specifically, do they significantly impact the availability, abundance and quality of subsistence food for Arctic communities?

| direct and indirect effects of climate change¹ | oil and gas activities² | mining activities¹ | shipping⁴ | commercial fishing: harvest and overharvest | community activities⁵ | long range and local contaminants⁶ | invasive alien species: especially marine invasive species |

How will measured and predicted changes in Arctic coastal biodiversity impact the mandated biodiversity obligations of local, Indigenous, territorial and federal governments?

| mandated biodiversity obligations of local, Indigenous, territorial and federal governments? |

---

1 such as reduced sea ice, ocean acidification, increased wind and storminess, rising sea level, permafrost degradation, changes to freshwater discharge regimes, warmer temperatures, shortened snow season, longer growing season, earlier lake/river ice break-up and later freeze-up, new pathogens, new species, other effects
2 exploration, drilling and extraction, and related infrastructure, shipping, and other transportation activities
3 exploration, extraction, processing, and related infrastructure, shipping and other transportation activities
4 tourism and adventure cruising, community re-supply, industrial, military and research-related shipping
5 sewage disposal and other pollution, hunting, trapping, infrastructure, avoidance
6 for example Hg and POPs
Appendix Figure 1. FECs for the Rocky Shores Coastscapes are ranked from left to right based on the number of criteria that each FEC meets at the High level, followed by a secondary sorting of those criteria the FEC meets at the Medium level.
Appendix Figure 2. FECs for the Eroding Shores Coastscape are ranked from left to right based on the number of criteria that each FEC meets at the High level, followed by a secondary sorting of those criteria the FEC meets at the Medium level.
Appendix Figure 3. FECs for the Lagoons Coastsscape are ranked from left to right based on the number of criteria that each FEC meets at the High level, followed by a secondary sorting of those criteria the FEC meets at the Medium level.
Appendix Figure 4. FECs for the River Estuaries Coastscape are ranked from left to right based on the number of criteria that each FEC meets at the High level, followed by a secondary sorting of those criteria the FEC meets at the Medium level.
Appendix Figure 5. FECs for the Low Gradient Shores Coastscape are ranked from left to right based on the number of criteria that each FEC meets at the High level, followed by a secondary sorting of those criteria the FEC meets at the Medium level.