CBMP Five-Year Implementation Plan

Developing an Integrated and Sustained Arctic Biodiversity Monitoring Network

CAFF CBMP Report No. 14
March 2008

CAFF
Conservation of Arctic Flora and Fauna

CIRCUMPOLAR BIODIVERSITY
MONITORING PROGRAM

Acknowledgements

CAFF Designated Area

Developing an Integrated and Sustained Arctic Biodiversity Monitoring Network: The CBMP Five Year Implementation Plan

A Supporting Publication to the
Circumpolar Biodiversity Monitoring Program
Framework Document

Prepared by Michael Gill, Martin Raillard, Christoph Zöckler, and Risa Smith.

CIRCUMPOLAR BIODIVERSITY
MONITORING PROGRAM

CAFF

Conservation of Arctic Flora and Fauna

Table of Contents

Executive Summary

The Arctic plays host to a globally significant array of biodiversity and the size and nature of Arctic ecosystems make them of critical importance to the biological, chemical and physical balance of the globe. Dramatic changes (e.g., climate change) now underway are threatening the resiliency and sustainability of the Arctic's biodiversity and the overall balance of its ecosystems. Continued rapid change in the Arctic will have global repercussions affecting the planet's biodiversity as a whole. Current Arctic biodiversity monitoring efforts are insufficient to provide an integrated picture of the status of and trends in key species, habitats, processes, and services. Better coordination of our existing monitoring networks is urgently needed in order to improve our ability to detect important trends on a timely basis, attribute these trends to their underlying causes, and provide this information to decision makers to facilitate effective and timely responses.

In response to the global importance of the Arctic and its biodiversity, the increasing pressures on Arctic biodiversity and human communities, and our limited capacity to monitor and understand these changes, the Arctic Climate Impact Assessment (ACIA) recommended that long-term Arctic biodiversity monitoring be expanded and enhanced. In its acceptance of ACIA's recommendations, the Arctic Council directed the Conservation of Arctic Flora and Fauna (CAFF) Working Group to further examine those findings related to biodiversity conservation and develop follow-up programmes and activities to address key projections for the future of the Arctic. A primary response has been the implementation of the Circumpolar Biodiversity Monitoring Program (CBMP).

The CBMP is a mechanism for harmonizing and enhancing long-term biodiversity monitoring efforts across the Arctic in order to improve our ability to detect and report on significant trends and pressures. The resulting information will be used to assist policy and decision making at the global, national, regional and local levels.

The circumpolar Arctic, as defined by CAFF, covers 14.8 million km^2 of land and 13 million km^2 of ocean. It encompasses highly complex ecosystems, due in part to the interplay between terrestrial and marine species, habitats, and ecosystems both inside and outside the region. Considering the size and complexity of the circumpolar Arctic, it is essential that the CBMP promote and develop an integrated ecosystem-based approach to monitoring.

The delivery of an ecosystem-based approach involves monitoring that bridges ecosystems, habitats, species and processes. It requires information not only on the status and trends in Arctic biodiversity, but also on their underlying causes. It is critical that this information be collected and made available in order to generate effective strategies for responding and adapting to the changes now taking place in the Arctic - a process that ultimately depends on rigorous, integrated, and efficient monitoring programs that have the power to detect change within a reasonable time frame.

The CBMP will pursue a multidisciplinary, integrated ecosystem-based approach through the development of five integrated Expert Monitoring Groups: Marine, Coastal, Freshwater, Terrestrial Vegetation and Terrestrial Fauna. Each group will be comprised of existing site and network-based research and monitoring programs, constituting a diversity of expertise and incorporating both community-based and scientific monitoring capabilities. Special attention will be paid to promoting and utilizing community-based observations and citizen science, understanding the value and significance of Arctic peoples, and maximizing their contributions to biodiversity monitoring.

To facilitate effective reporting, the CBMP has chosen a suite of indices and indicators that can be used to report on the current state of Arctic biodiversity at various scales and levels of detail to suit a wide range of audiences. The current and planned CBMP biodiversity monitoring underpins these indices and indicators.

To guide the implementation of the CBMP, program

Blake Trask

strategies have been produced that detail the development and operation of the major program components: Indicators, Data Management, Community-Based Monitoring, Engagement, and Communications and Outreach.

Grant Gilchrist

Over the next five years, the CBMP will focus its efforts on the following key areas:

- Developing a strategy for building and maintaining a comprehensive and cost-effective circumpolar monitoring program that addresses current deficiencies;
- Coordinating and integrating biodiversity monitoring programs and promoting standardized measures and harmonized data protocols;
- Assessing current monitoring capacity and design to identify elemental, geographic, and statistical design deficiencies and inefficiencies;
- Interpreting, integrating, and communicating existing biodiversity information (establishing statistical baselines and retrospective assessments);
- Developing data-management structures and a Web-based data portal for the synthesis, analysis, and dissemination of biodiversity information;
- Promoting and expanding community-based monitoring approaches to support the engagement of Arctic people in monitoring activities;
- Identifying and initiating pilot monitoring projects, where clear monitoring gaps exist; and,
- Reporting on the status of Arctic biodiversity and the issues facing it, using diverse formats for communication, education and outreach at the global, national, regional and local levels.

1. Introduction

1.1 The Challenge, Need and Opportunity

1.1.1 Global Significance of Arctic Biodiversity

The Arctic's contribution to global biodiversity is substantial. Its brief summers are intensely productive and attract hundreds of migratory species. Two hundred and seventy-nine species of migratory birds breed in significant numbers in the Arctic: of these, 30 reach southern Africa, 26 reach Australia and New Zealand, 22 reach southern South America, and several pelagic species reach the southern oceans. Several species of land and marine mammals, including gray and humpback whales, also participate in the global migration, traveling long distances to the Arctic each year.

While the Arctic has relatively few species compared to the mega-diverse tropics, Arctic biodiversity is notable for its genetic diversity, reflecting the many unique adaptations species have developed in response to extreme environmental conditions. The Arctic also supports globally significant populations, including more than half of the world's shorebird species, 80 percent of the global goose population, several million reindeer and caribou, and 28 percent of the world's commercial marine fish harvest.

The circumpolar Arctic, as defined by CAFF, covers 14.8 million km^2 of land and 13 million km^2 of ocean. The emerging economic importance of Arctic ecosystems often conflicts directly with conservation values, as the region has some of the world's few remaining pristine wilderness areas where humans operate as part of and in concert with the environment. Vast wilderness areas where ecosystem processes continue to function in a largely natural state play a key role in the physical, chemical, and biological balance of the planet. Seven of the world's ten largest wilderness areas are located in the Arctic region, comprising an important contribution to the conservation of the Arctic's unique biological diversity and providing an opportunity to monitor global climate and other changes in a comparatively undisturbed environment. Together with the Antarctic, the Arctic contains the largest freshwater resources on Earth. The Arctic is also home to diverse, vibrant, and unique societies whose indigenous cultures depend on and maintain close ties to the land and sustain hundreds of distinct languages.

Association of Nenets people of "Yasavey"

1.1.2 Arctic Biodiversity Under Pressure

Dramatic changes now underway in the Arctic are threatening the integrity and sustainability of its living resources, directly challenging the resiliency of Arctic residents - particularly indigenous peoples - dependent upon these resources. Of greatest concern is climate change, with its impacts on Arctic biodiversity already being witnessed and much larger impacts (with significant regional variation) expected over this century. By 2100, the Arctic is expected to warm 3-5° C over land and 7° C over the oceans, contributing to dramatic changes in its ecosystems[1]. Predicted impacts include a more than 50 percent decline in the extent of summer sea ice and the displacement of existing Arctic species and ecosystems (e.g.,, polar deserts and tundra) as southern species and ecosystems expand northward. Much of the recent observed change (e.g., 39% reduction in summer sea ice extent in 2007) has outpaced climate model predictions, suggesting that these models are conservative in their estimates.

Although climate change is placing increasing pressure on the resiliency and sustainability of Arctic biodiversity, it is not the only stressor. Others include: environmental contaminants; habitat fragmentation; invasive species; increased shipping and air traffic; and regional development such as oil and gas exploration and production, forestry, hydroelectric projects, and urbanization. Oil and gas development is expected to play a particularly important role in the future, as the Arctic is estimated to contain a quarter of the world's remaining oil and gas reserves. Already, 10% of the world's oil and 25% of the world's natural gas is produced in the Arctic, with the majority coming from the Russian Arctic[2].

1.1.3 Our Current Understanding

Information on Arctic biodiversity, human stressors, and natural changes is currently available in a piecemeal fashion and on an irregular basis. An integrated picture of the status of and trends in key species, habitats, processes, services and ecosystem integrity in the Arctic and along related migratory routes is not fully developed. Although numerous monitoring efforts are currently underway, a lack of coordination, long-term commitment, integration and involvement of local people has resulted in weak linkages between monitoring results and decision making and a corresponding inability to detect and understand change. The communication of results in a manner that dovetails with policy making is a pre-requisite to the successful management and conservation of Arctic biodiversity and prompt adaptation to inevitable changes.   An integrated, interdisciplinary and collaborative Arctic biodiversity monitoring program that enhances our ability to detect important trends on a timely basis, attribute these trends to causal factors, and disseminate this information in both the public and policy arena is urgently needed.

---

[1] Arctic Climate Impact Assessment, 2004.

[2] US Geological Survey Worldwide Oil and Gas Assessment. 2000.

1.1.4 Opportunities

The significant environmental challenges facing the Arctic present a unique opportunity for the development of a world-class, integrated and sustained Arctic biodiversity network. The recent, unprecedented changes witnessed in the Polar Regions have prompted increased demand for accurate, timely and unbiased information on the Arctic. These demands have coincided with renewed support for polar research and monitoring (e.g., International Polar Year (IPY). Indeed, many of the monitoring networks that underpin the CBMP (e.g., CircumArctic Rangifer Monitoring and Assessment Network) have been activated as a result of IPY funding.

Although largely uncoordinated at the current time, there are a great number of research and monitoring networks already observing the Arctic at various scales - from on-the-ground to satellite. There is an opportunity to enhance coordination and output from these existing programs in order to improve our ability to detect, understand, report on and respond to significant trends in Arctic biodiversity.

There is considerable existing information (science, local and traditional knowledge based) on environmental change in the Arctic, much of it representing valuable long-term records and perspectives. However, these resources are often overlooked. This information can often be accessed, analyzed and repurposed for relatively little cost in order to establish historical baselines, identify previous trends, and better understand ecological relationships.

1.2 Purpose and Function of the Circumpolar Biodiversity Monitoring Program

The CBMP is, first and foremost, a coordinating entity for:

- existing Arctic biodiversity monitoring programs;
- addressing gaps in knowledge through the identification of new programs;
- gathering, integrating, and analyzing data; and;
- communicating results.

This coordinating function has the potential to add significant value to the ongoing efforts of independently operating local, national, and regional programs. The standardization of data collection methodologies, coordination of data analyses, and presentation of results through a common web-based portal will benefit all stakeholders. The collaborative approach enabled by this coordinating function will provide answers not previously attainable on a circumpolar scale and lead to a broader understanding of the Arctic environment and the effects of its multiple stressors on biodiversity and ecosystem integrity.

The CBMP will serve as a mechanism for harmonizing and enhancing monitoring efforts across the Arctic in order to improve our predictive and reporting capabilities. The resulting information will be made accessible in a broad range of formats geared towards specific target audiences such as northern communities, scientists, governments, and the global community.

Information on Arctic species responses to environmental and development pressures is widely scattered among scientists, government institutions, and northern communities. Through its Expert Monitoring Groups (EMGs), the CBMP will be equipped to identify gaps in data, integrate information and efforts aimed at monitoring and communication, and

Jim Reist: Fisheries and Oceans Canada

encourage the development of new monitoring efforts to overcome gaps in knowledge. A major focus will be on the organisms, services and processes of primary importance to the integrity of Arctic ecosystems and the culture and livelihood of indigenous cultures. Special attention will be paid to community-based observations and citizen science in recognition of the valuable and significant contributions that Arctic residents can make to biodiversity monitoring.

The CBMP serves as an international forum of key scientists and conservation experts from all eight Arctic countries, the six international indigenous organizations of the Arctic Council, and various global conservation organizations. It is strategically linked to other international conservation programs and initiatives such as the Arctic Monitoring and Assessment Programme (AMAP), Sustaining Arctic Observing Networks Initiative (SAON), International Polar Year (IPY), the Arctic Biodiversity Assessment (ABA) and the Convention on Biological Diversity (CBD), thereby ensuring effective coordination and integration with related Arctic and global initiatives.

The CBMP's results will be translated via the Arctic Council into effective conservation, mitigation, and adaptation policies that promote the sustainability of the Arctic's living resources. To do this, information is needed not only on the status of and trends in Arctic biodiversity at the circumpolar level, but also on the natural and anthropogenic stressors driving trends in Arctic biodiversity at all geographic scales. Understanding how and why biodiversity is changing at various scales will enable local communities and decision-making bodies to develop informed policies and responses focused on adaptation, mitigation, and conservation. This information will be provided by the CBMP in a timely fashion using diverse formats.

1.3 Program Clients: Users of Arctic Biodiversity Information

The demand for accessible, current, and accurate information on Arctic biodiversity is increasing. This demand is coming from a broad set of stakeholders, including the general public both within and outside of the Arctic and northern communities, in addition to local, regional, national, global and Aboriginal institutions and governing bodies.

User – Products Pyramid

Non-technical

Public Reports

Policy Recommendations & Assessments; Conservation Plans

Indices, Summary Reports, Ecosystem and Species Maps

Indicators, Predictive models, Ecosystem Vulnerability Assessments, Best management Practices

Raw data (biotic and a-biotic);

Technical

Public, Media, Politicians

Northern Communities Decision Makers; Industry, NGOs

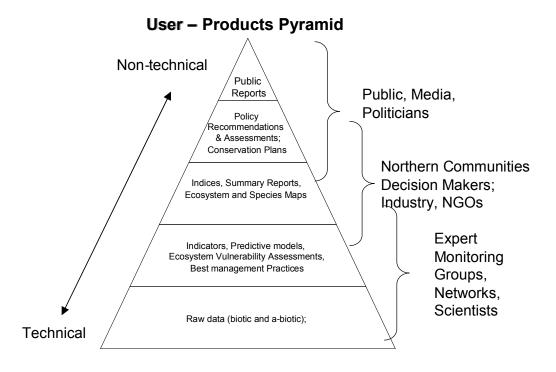Expert Monitoring Groups, Networks, Scientists

Figure 1.   CBMP User-Products Pyramid

Figure 1 depicts the anticipated users of Arctic biodiversity information and the products needed to serve these users. Northern communities are a key target recipient of the CBMP's output, as changes to Arctic biodiversity have a direct and often significant impact on the livelihood of these communities. Products sought out by northern communities include biodiversity indicators that depict regionally relevant status and trends information, summary reports and regional level predictive ecosystem maps, and models that identify anticipated changes to ecosystems in a specific region.

Carsten Egevang/ARC-PIC.COM

Decision and policy makers (e.g., environmental assessment bodies, co-management boards, land-use planning agencies) operating at multiple geographic scales require accurate and current information on the status of and trends in Arctic biodiversity - as well as their underlying causes - in order to make informed and effective decisions. The CBMP products designed to meet the needs of decision and policy makers include the biodiversity indices and indicators (at various scales), ecosystem vulnerability assessments, policy recommendations, conservation plans, and predictive models.

Industry also requires accurate and timely information on Arctic biodiversity in order to continually update best management practices and reduce its impact on the environment. Products anticipated to meet industry needs include regional biodiversity indicators, best management practices, regional habitat and species maps, and ecosystem vulnerability assessments that identify those areas most vulnerable or sensitive.

The scientific community is most likely to be interested in comprehensive, detailed data. Scientists are expected to want a full range of information products from the CBMP indicators and indices (at various scales) to multi-disciplinary data to predictive models.

Finally, the public at large, both within and outside of the Arctic, has a significant need for Arctic biodiversity information. The public's fluctuating interest levels and limited technical underpinnings necessitate the creation of products that are easy to understand, quick to view, high impact, and broad in scope.

Carsten Egevang/ARC-PIC.COM

CBMP products intended for the public, media and politicians include the indices, public reports, and general assessments and newsletters that are written in non-technical language.

Due to the diversity of languages in use around the Arctic, it is expected that many of the CBMP's products will be translated into Russian and other languages to facilitate access for a broader group of users. Also, multiple delivery formats will be used to engage a diverse audience, including the CBMP's Internet-based web data portal, website, and print-based products such as newsletters and reports.

1.4 Circumpolar Biodiversity Monitoring Program and the Arctic Climate Impact Assessment

In 2004, the Arctic Council released the Arctic Climate Impact Assessment (ACIA), which recommended that long-term Arctic biodiversity monitoring be expanded and enhanced. In its acceptance of the ACIA findings and projections, the Arctic Council directed two of its working groups, the Conservation of Arctic Flora and Fauna (CAFF) Working Group and the Arctic Monitoring and Assessment Program (AMAP),

to examine these findings and develop follow-up programmes and activities to address key projections for the future of the Arctic.

A primary response of the CAFF Working Group was the implementation of the CBMP. The development of the CBMP as CAFF's cornerstone program received Ministerial endorsement in both 2004 (Reykjavik Declaration) and 2006 (Salekhard Declaration). Iceland led the Program before Canada assumed the role of Chair in April 2005. The CBMP was formally launched in September 2005 in cooperation with the United Nations Environment Programme–World Conservation Monitoring Centre (UNEP-WCMC) in Cambridge, England.

The CBMP is the primary vehicle through which CAFF will follow up on ACIA's recommendations. It can also be used to promote Arctic biodiversity information in global fora and reports, such as the United Nations Convention on Biological Diversity, the Ramsar Convention on Wetlands, United Nations Millennium Development Goals, International Polar Year, and the International Arctic Science Committee.

2. Towards an Integrated and Sustained Arctic Biodiversity Monitoring Network: Five Year Implementation Plan

2.1 Integrated Ecosystem-Based Approach to Monitoring

The CBMP plans to adopt an integrated ecosystem-based approach to monitoring in its program design, organization, and operation. The ecosystem-based approach to monitoring integrates information on land, water, and living resources and lends itself to monitoring many aspects of an ecosystem in a geographic region. In the context of Arctic biodiversity, the ecosystem-based approach implies the following conditions:

- Recognition that monitoring all elements of ecosystems—including species, habitats, ecosystem structure, processes, functions, and stressors to the ecosystems — is necessary to gain a meaningful picture of what is happening to biodiversity;

- A focus on trends, including recognition of the dynamic nature of Arctic ecosystems and the importance of identifying change that is outside the realm of natural variability;

- Recognition of the interplay between terrestrial, freshwater, and marine systems and the way it shapes Arctic ecology and the goods and services that Arctic biodiversity provides;

- Recognition of the dependence of Arctic biodiversity on conditions outside the Arctic;

- Recognition of humans and their cultural diversity as an integral component of many ecosystems[1]; and,

- Monitoring the interactions between people and biodiversity, such as sustainable use and the ability of biodiversity to provide essential goods.

The ecosystem-based approach to monitoring considers the integrity of entire ecosystems and their interaction with other ecosystems. Although the complexity and data/analysis requirements far exceed those of the species approach, the rewards of the ecosystem-based approach are significant. It identifies important relationships, providing a bridge between ecosystems, habitats, and species and the impacts of stressors on ecological functions. The resulting information contributes directly to adaptive management, thereby allowing for effective conservation, mitigation, and adaptation actions appropriate to the Arctic. Please refer to Figure 2.

2.2 "Network of Networks" Approach

The ecosystem-based approach is being incorporated first and foremost through the establishment of five integrated, multi-disciplinary Expert Monitoring Groups (EMGs): Marine, Freshwater, Coastal, Terrestrial Fauna and Terrestrial Vegetation. These EMGs will involve and be supported by the coordination of a "network of networks", drawing upon existing species, habitat and site-based Arctic biodiversity monitoring

---

[1] Convention on Biological Diversity (COP 5, 2000), http://www.biodiv.org/programmes/cross-cutting/ecosystem/description.asp

networks and linking to abiotic and extra-Arctic monitoring activities where relevant (please refer to Table 1).

The CBMP will act as coordinator for this "network of networks", promoting standardization and integration of information across biodiversity networks, establishing links to relevant extra-Arctic, umbrella and abiotic monitoring networks, and providing value-added services in the areas of data management, communications, reporting, and decision-making (Please refer to Figure 2).

The CBMP will work with partners to develop and promote best methods for monitoring biotic elements and promote abiotic measures relevant to Arctic biodiversity across the entire circumpolar region. Coordinating the "network of networks" also involves

supporting research into the mechanisms driving biodiversity trends – information critical to effective management decision making. It also includes research into the impacts of ecosystem changes on humans - the societal-biota interface - thereby facilitating the development of effective mitigation and adaptation strategies for Arctic communities. The discovery of and access to existing knowledge (scientific, local and traditional) will also be promoted to facilitate cost-effective establishment of historical baselines.

The "network of networks" approach recognizes the following:

• The importance of some species and species groups to the people and biodiversity of the Arctic;
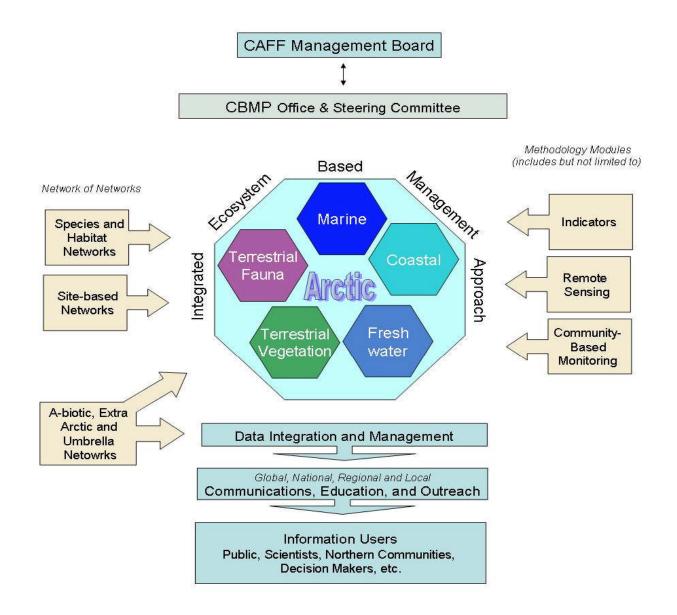

Figure 2. Organisational Structure of the CBMP

Table 1. Examples of Monitoring Networks Relevant to the CBMP

Active Monitoring Network	Network Type	Geographic Coverage	Parameters Measured
African-Eurasian Waterbird Agreement (AEWA)	Species-based	118 countries from the European Community (EC) Asia, Canada, the Middle East and Africa	Biotic
Arctic Borderlands Ecological Knowledge Coop (ABEKC)	Ecosystem-based	Porcupine Caribou herd range and adjacent areas	Biotic and abiotic
Arctic Monitoring and Assessment Program (AMAP)	Species-based	Circumpolar	Biotic and abiotic (contaminants, pollution, climate)
Arctic Regional Ocean Observing System (Arctic ROOS)	Ecosystem-based	Circumpolar	Abiotic
Bering Sea Sub-Network (BSSN)	Ecosystem-based	Bering Sea	Biotic and abiotic (Marine)
Bird Life International	Global	Planet-wide	Biotic and abiotic (birds)
Conservation of Arctic Flora and Fauna (CAFF) Flora Group	Species-based	Circumpolar	Biotic (Terrestrial vegetation)
Canadian Biodiversity Information Facility (CBIF)	Species-based	Canada	Biotic and abiotic measures.
Canadian Biodiversity Information Network (CBIN)	Species-based	Canada	Biotic and abiotic measures
Census of Marine Life (CoML)	Global	Planet-wide	Biotic and abiotic measures (marine)
Char Monitoring Network	Species-based	Circumpolar	Biotic and abiotic
CircumArctic Rangifer Monitoring and Assessment Network (CARMA)	Species-based	Circumpolar	Biotic (Wild Caribou and Reindeer (and relevant abiotic measures)
Circumpolar Seabird Group (CBird)	Species-based	Circumpolar	Biotic and relevant abiotic
Earth Portal	Global	Planet-wide	Biotic and abiotic
Ecological Monitoring and Assessment Network (EMAN)	Site-based	Canada	Biotic and abiotic
Integrated Ecosystem Approach to Conserve Biodiversity and Minimize Habitat Fragmentation in the Russian Arctic (ECORA)	National	Arctic Russia	Biotic and abiotic
Finnish Long Term Socio-Ecological Research Network (FinLTSER)	National	Finland	Biotic and abiotic
Freshwater Biodiversity Monitoring Network	Habitat-based	Canada	Biotic and abiotic
Global Biodiversity Information Facility (GBIF)	Global	Planet-wide	Taxonomic
Global Earth Observation System of Systems (GEOSS)	Global	Planet-wide	Biotic and abiotic

Association of Nenets people of "Yasavey"

Global Population Dynamics Database (GPDD)	Global	Planet-wide	Biotic
GLOBIO	Global	Planet-wide	Human footprint
Global Observation Research Initiative in Alpine Environments (GLORIA)	Ecosystem-based	Planet-wide	Biotic and abiotic
Interagency Taxonomic Information System (ITIS)	Global	Planet-wide	Taxonomic database
International Tundra Experiment (ITEX)	Ecosystem-based	Northern Hemisphere (Arctic)	Biotic and abiotic
Joint Assessment and Monitoring Programme (JAMP)	Species-based	North-East Atlantic	Biotic
World Conservation Union (IUCN) Goose Specialist Group	Species-based	Northern Hemisphere	Biotic
World Conservation Union (IUCN) Polar Bear Specialist Group	Species-based	Circumpolar	Biotic
Knowledge Network for Biocomplexity (KNB)	Global	Planet-wide	Biotic and abiotic
Monitoring Program for Svalbard and Jan Mayen (MOSJ)	Species-based	Arctic Norway	Biotic
National Biological Information Infrastructure (NBII)	Global	Planet-wide	Biotic and abiotic
National Monitoring of the Marine Environment and Living Resources	National	Barents and Norwegian seas	Biotic and abiotic
National Oceanic and Atmospheric Administration (NOAA)	Global	Planet-wide	Biotic and abiotic
National Snow and Ice Data Center (NSIDC)	Global	Planet-wide	Abiotic
NatureServe International	Global	Planet-wide	Biotic
Northern Forum Brown Bear Network	Species-based	Northern Hemisphere	Biotic
Ocean Biogeographic Information System (OBIS)	Species-based	Planet-wide	Biotic
Seabird Population Program (SEAPOP)	Species-based	Norway	Biotic
Scandinavian/North American Network of Terrestrial Field Bases (SCANNET)	Site-based	Northern Europe	Biotic and abiotic
SnowChange	Global	Circumpolar	Biotic and abiotic
Streamlining European Biodiversity Indicators for the 2010 goal (SEBI2010)	National	Pan-Europe	Biotic and abiotic
United Nations Environment Programme Global Environmental Monitoring System (UNEP GEMS/Water)	Global	Planet-wide	Biotic and abiotic
Wetlands International	Habitat based	Planet-wide	Biotic and abiotic

- The importance of building upon, integrating and expanding existing monitoring capacity, which is typically organized around regional networks;

- Species-based monitoring is an established and effective method to be standardized across the circumpolar Arctic;

- The relative ease with which non-technical people understand species trends and their implications using the species-based approach (compared to the ecosystem approach);

- The importance of building on the focused use of a multidisciplinary approach by some networks (e.g., Circumpolar Arctic Rangifer Monitoring and Assessment Network (CARMA)); and,

- The importance of building on the strong links between scientific and community-based monitoring found in some networks (e.g., CARMA).

2.2.1 Species, Ecosystem and Habitat-Based Networks

The Arctic has a well-established history of monitoring through species, ecosystem and habitat based networks. A number of these programs are already active (e.g., seabird, caribou, goose, International Tundra Experiment, etc.) and many are now partnered with the CBMP. The CBMP is already working with partners to identify and develop new network-based monitoring programs to fill key gaps. One example is the recent collaboration between the U.S. Marine Mammal Commission and the CBMP to develop pan-Arctic marine mammal monitoring plans. The International Polar Year has provided a catalyst for the establishment of new networks (e.g., Freshwater Biodiversity Monitoring Network) and the strengthening of existing networks (e.g., CARMA).

2.2.2 Site-Based Networks

A number of research stations are currently active in the Arctic and more are planned (e.g., Canada's High Arctic Research Station initiative), offering a cost-effective approach to developing integrated, site-based sampling programs.

Site-based monitoring programs (e.g., Scandinavian/North American Network of Terrestrial Field Bases (SCANNET) will assist in identifying important gaps and possibly allow for the addition of new sites to fill those gaps. Replicated, multi-disciplinary measures across site-based networks also lend themselves to the investigation of ecological relationships and the causes of underlying trends. Some existing research-station networks already employ consistent, repeatable, and standardized measures that span a large bio-geo-climatic gradient.

2.2.3 Other Arctic and Extra-Arctic Networks

Despite its focus on biotic data, the CBMP will link to and draw from a number of existing abiotic networks that monitor key ecosystem elements potentially driving changes in Arctic biodiversity (e.g., changes in sea ice extent and impacts of duration and distribution on marine mammals).

Due to the migratory nature of a number of key Arctic species, it is important that the CBMP establish links to extra-Arctic monitoring programs that monitor habitat (e.g., stopover sites, wintering grounds) critical for these species. Without considering the entire range of a migratory Arctic species and the stressors impacting within it, it is difficult to identify the fundamental mechanisms driving trends in these species and make appropriate management decisions.

Mark Mallory

The CBMP can also interact with a number of 'umbrella' (multi-disciplinary monitoring mandate including both biotic and abiotic elements) and global monitoring networks found both in the Arctic (e.g., Arctic Observing Network (AON)) and around the globe (e.g., Global Earth Observation System of Systems (GEOSS)). Much of this interaction would involve the two-way transmission of metadata, data records, and reports between these networks and the CBMP, thereby contributing to global reporting and assessments and improving the breadth and quality of the CBMP's analyses.

Carsten Egevang/ARC-PIC.COM

2.3 Biodiversity Indices and Indicators

Effective monitoring is the foundation of responsive decision making; however, unless the right information is reported in the right formats to the right audiences, the results of such monitoring are effectively lost. In light of this, targeted and consistent reporting is a cornerstone of the CBMP.

To facilitate effective and consistent reporting, the CBMP has chosen a suite of indices and indicators (please refer to *A Strategy for Developing Indices and Indicators*) that provide a comprehensive picture of the state of Arctic biodiversity – from species to habitats to ecosystem processes to ecological services. They were chosen through an expert consultation process and reflect existing monitoring capacity and expertise.

Criteria used to select the indicators included: sensitivity to natural or anthropogenic drivers;

scientific validity; relevance to and resonance with diverse audiences (e.g., local communities, decision makers, global public); ecological relevance; sustainability of monitoring capacity; subjection to targets and thresholds; and practicality. The indices and indicators were also chosen to represent and incorporate the following: major Arctic biomes at various scales; known Arctic pressures; major trophic levels, major Arctic biodiversity components (e.g., genes, species, habitat) including humans; and critical ecosystem services and functions — using both community and science-based monitoring approaches. Data generated by the CBMP's networks will underpin these indicators and indices.

The suite of indicators and indices will be developed in a hierarchical manner allowing clients to 'drill' down into the data from the high-order indices, to more detailed indicators underpinning a particular index, to - where the data allows - specific population, subpopulation or regional habitat trend data. This approach will maximize the utility and reach of the information by addressing the varying data needs of end users (please refer to Figure 1).

The CBMP Biodiversity Indicators and Indices will facilitate the reporting of the Arctic's progress towards the Convention on Biological Diversity's 2010 target to reduce the rate of loss of biodiversity. In recognition of the CBMP's Arctic biodiversity reporting expertise, the CBMP is an affiliate partner in the 2010 Biodiversity Indicators Partnership (2010 BIP), assuming responsibility for conducting the Arctic analyses of CBD relevant indicators. The CBMP will develop agreements with its partner Arctic monitoring networks to identify how each network's data will contribute to the development of the Arctic biodiversity indicators and indices.

The CBMP' indicators and indices will also form the foundation of the Arctic Biodiversity Assessment Summary Report (Phase 1) to be completed by 2010. The 2010 BIP partnership and the Arctic Biodiversity Assessment Summary Report have concurrent timelines, providing an opportunity to cost share the development of the CBMP's indicators and indices. (It is expected that the CBMP indicators and indices will be supported by CAFF country funding and external funding, as opportunities arise.)

The biodiversity indicators and indices will be developed in two phases. Phase 1 indicators reflect currently accessible data, network capacity and existing indicator methodologies. Phase 2 indicators and indices are those where methodologies have yet to be developed or supporting data is not yet available. Phase 1 (2008 to 2010) will involve development of the following indices and indicators:

- Arctic Species Trend Index
- Trends in Abundance of Key Species
- Changes in Tundra Vegetation
- Arctic Red List Index
- Change in Status of Threatened Species
- Trends in Total Species Listed at Risk
- Arctic Land Cover Change Index
- Trends in Extent of Biomes, Habitats and Ecosystems
- Arctic Habitat Fragmentation Index
- Trends in Patch Size Distribution of Habitats
- Trends in Extent, Frequency, Intensity and Distribution of Natural Disturbances
- Trends in Phenology
- Trends in Decomposition Rates
- Coverage of Protected Areas

Phase Two (2011 to 2012) will involve development of the following indices and indicators:

- Arctic Trophic Level Index
- Water Quality Index
- Arctic Human Well-being Index
- Trends in Other Species Parameters (e.g., distribution, productivity, etc.)
- Trends in Availability of Biodiversity for Traditional Food and Medicine
- Trends in Use of Traditional Knowledge in Research, Monitoring and Management
- Trends in Incidence of Pathogens and Parasites in Wildlife
- Fragmentation of River systems
- Extent of Seafloor Disturbance

3. Five Year Workplan

Over the next five years, building on the capacity of existing Arctic monitoring efforts and working in partnership with these networks, CAFF countries, and the Permanent Participants, the CBMP Office will focus its efforts on the key areas outlined in Table 2. These are discussed in further detail in the following sections.

3.1 Program Coordination

Coordination is a core function of the CBMP office. Coordination involves working closely with many partners, including: all Arctic countries (through CAFF); other Arctic Council working groups (e.g., AMAP, PAME); Arctic Council Permanent Participants; partner organizations (e.g., UNEP-WCMC, UNEP/ Global Resource Information Base-Arendal); and, in particular, circumpolar, national and regional Arctic monitoring programs and networks. It also involves ensuring that program objectives are met and that direct and regular communication is achieved with partners through meetings, workshops, newsletters, website updates, and conference calls. The CBMP's Engagement Strategy and Communications Strategy detail how effective communications between the CBMP office and CBMP partners will be ensured.

3.2 Establishment of Expert Monitoring Groups

Five Expert Monitoring Groups (EMGs) representing the major Arctic biomes - marine, coastal, freshwater, terrestrial vegetation, and terrestrial fauna - will be created to lead the development of multi-disciplinary, integrated, pan-Arctic monitoring plans and to provide ongoing scientific and traditional knowledge input towards the enhancement of current monitoring. The establishment of these five EMGs is seen as a logical approach for facilitating an integrated, ecosystem-based approach to the monitoring of Arctic biodiversity.

These EMGs will be responsible for designing and implementing on-the-ground monitoring in their area of expertise and developing strategies to fill critical monitoring gaps (see Assessment of Current Monitoring Capacity below). Each EMG will be expected to make full use of existing monitoring and data, draw on expertise from both inside and outside the Arctic and from other relevant disciplines (i.e., climate science), incorporate both local knowledge and science-based approaches, develop standardized protocols and analytical tools, and use existing and emerging technologies such as remote sensing and genetic barcoding, where appropriate.

Tom Barry

Table 2. Key Areas of Activity

Activity	Description
Program Coordination	Coordinating and integrating biodiversity monitoring programs
	Linking Arctic monitoring efforts and outputs to global, national, regional, and local biodiversity-monitoring efforts and reporting
Establishment of Expert Monitoring Groups	Creating five expert monitoring groups that represent the Arctic's major biomes: marine, coastal, freshwater, terrestrial vegetation, and terrestrial fauna
	Developing pan-Arctic integrated monitoring plans that include standardized measures and harmonized data protocols and encouraging the use of new technologies and approaches
Assessment of Current Monitoring Capacity	Inventory of current Arctic biodiversity monitoring programs and existing information
	Interpreting, integrating, and communicating existing biodiversity information, including establishing statistical baselines and retrospective assessments
	Assessing current monitoring capacity to identify elemental, geographic, and statistical design strengths and deficiencies
	Developing a strategy for building and maintaining a comprehensive and cost-effective circumpolar monitoring program that addresses current deficiencies
Data Management	Developing data management structures and a Web-based data portal for the dissemination, integration, analysis, and synthesis of biodiversity information
Capacity Building	Developing training modules to support the engagement of Arctic people in monitoring activities
	Facilitate, promote and expand community-based monitoring programs and approaches
	Partnering with research organizations to fill monitoring gaps and develop new protocols, where needed
Communications, Education and Outreach	Nurturing frequent and effective communication among and between experts and communities that are implementing biodiversity monitoring
	Implementing an engagement strategy to nurture current CBMP partners and solicit new partners and funders
Pilot Projects	Experimenting with methodologies for filling monitoring gaps
	Identifying and initiating pilot monitoring projects, where clear gaps exist
	Supporting local monitoring initiatives and linking local monitoring to broader circumpolar networks
Reporting	Frequent, coordinated, and effective reporting on the status of Arctic biodiversity and the issues facing it, using diverse formats to reach diverse audiences
	Providing Arctic biodiversity information to global, national, regional, and local biodiversity monitoring and reporting efforts
	Developing the suite of Arctic biodiversity indices and indicators that underpin the CBMP's reporting

Note: Program activities in the above table are not ordered on the basis of priority. Refer to Table 3 for specific activity timelines.

Each group will include and engage community, scientific, and indigenous experts. They will not only work with existing research stations and monitoring networks to develop integrated, forward-looking monitoring programs, but also focus efforts on the retrieval and use of existing historical information, be it traditional knowledge or archived scientific data.

Each of the five EMGs will be developed as follows:

1. CAFF country leads or co-leads will be identified to provide the sponsorship and development of each Expert Monitoring Group.

2. Terms of reference will be developed to outline the EMG's responsibilities, objectives and interaction with the CBMP office and the other EMGs.

3. Members of each EMG will be identified.

4. Background papers will be developed for each EMG, providing an overview of the main issues facing the biome in question, the current monitoring capacity, and suggested criteria for choosing biodiversity elements and parameters to monitor. It is anticipated that development of these background papers will be concurrent with the Assessment of Current Monitoring Capacity (see below). The results of the inventory of current monitoring programs and the work of

the Assessment will be directly linked to the development of the background papers. This will allow the background papers to identify gaps in monitoring coverage and suggested strategies for filling gaps.

5. Each background paper will undergo a 30 day peer review process, with revisions completed prior to commencement of the workshop series.

6. Over the course of two workshops, the following issues will be addressed within the context of the background papers:

   a. What key elements and parameters should be monitored for this biome? Why? What key information would each parameter provide?

   b. What priority should be assigned to each parameter?

   c. What, if any, monitoring or assessment has been or is being conducted that addresses these priority elements and parameters? Where/when? What organizations and networks are responsible for this monitoring?

   d. What methods have been, are, or should be used (including novel technologies)?

   e. At what scale and frequency should each parameter be monitored (e.g., pan-Arctic vs. regional vs. local, seasonal vs. annual vs. longer periods)?

   f. Where and when should each parameter be monitored?

   g. What research and monitoring networks will be involved in the monitoring?

7. The answers to these questions will guide the development of pan-Arctic integrated monitoring plans. Regional working groups (inter-agency/ network teams) will be responsible for adopting and implementing the Integrated Monitoring Plans in specific regions of the Arctic.

8. Each EMG will then be re-organized into a smaller 'steering group' which will facilitate ongoing communication amongst and between the regional working groups implementing the integrated monitoring plans and the CBMP office.

Establishment of the EMGs and development of integrated monitoring plans began with an implementation planning workshop held in Anchorage, Alaska in 2006. This workshop saw the initial development of draft monitoring plans organized around conceptual models of each system highlighting the most important drivers, elements, fluxes and

Björn Frantzen

processes to be monitored. These draft monitoring plans will provide both the foundation and starting point for the background papers and workshops to come, and be reflected in the resulting integrated monitoring plans.

Christoph Zöckler

The CBMP Office will be responsible for the overall coordination of the EMGs, ensuring their connectivity, linkages, and compatibility (please refer to Figure 2). Once EMG lead coordinators are identified, the CBMP Office will establish regular conference calls to facilitate consistent development of the EMGs and connectivity between them. As well, a designated member of each EMG will participate in the other EMG workshops to ensure consistency and prevent overlap between monitoring plans.

The CBMP Office will, in cooperation with the EMGs, provide progressive and state-of-the-art data management, assessment, outreach, and communication services. The integrated monitoring plans will focus on the main pressures facing their particular systems and enable identification of the functional relationships between these systems and the forces driving them. The information from these integrated monitoring plans will not only directly contribute to and inform the current CAFF indices and indicators (please refer to Tables 1 and 2), but also provide additional assessments beyond their scope, thereby encouraging ongoing data development and progress.

3.3 Assessment of Current Monitoring Capacity

In order to serve as an early warning system, an effective circumpolar biodiversity monitoring program must be able to perform the following functions:

- Detect significant trends in Arctic biodiversity within a reasonable time frame;

- Clearly identify mechanisms driving trends and distinguish them from natural fluctuations;

- Identify key species, populations, habitats, and ecosystems under threat;

- Identify emerging issues/stressors most likely to critically impact Arctic biodiversity;

- Inform predictive modeling in order to identify future scenarios;

- Inform appropriate and effective conservation, mitigation, and adaptation actions;

- Increase public knowledge concerning Arctic biodiversity issues and public support for conservation actions; and,

- Build and maintain a cost-effective monitoring capacity (e.g., identify links and overlaps among programs, identify and fill gaps).

An over arching assessment of existing Arctic biodiversity monitoring capacity and data is the pre-requisite to identifying what – if any – critical gaps exist and how best to address them. The first step in such an assessment is to conduct an inventory of existing programs and biodiversity trend information (e.g., historical data, traditional knowledge). Such an inventory will not only underpin a comprehensive assessment of current monitoring capacity, but will also support the establishment of historical baselines and trends for key elements of Arctic biodiversity. It will also serve as a metadata library of current biodiversity monitoring protocols in use around the Arctic – a valuable resource for promoting best monitoring practices.

Compared to on-the-ground monitoring, the retrieval and analysis of existing biodiversity trend data can offer tremendous value. For example, indigenous peoples have inhabited Arctic regions for many millennia and have observed changes in plants, animals, and habitats and the relationships within and between Arctic ecosystems over time. This traditional knowledge, preserved through their oral history, presents a unique opportunity to establish historical baselines and trends.

The second step in the assessment is a technical gap analysis. Incorporating the results of the inventory and input from the EMGs, the gap analysis will assess the current elemental (i.e., biodiversity components) and geographic coverage of biodiversity monitoring, design deficiencies and inefficiencies, and the CBMP's ability to fulfill the above noted functions for each of the five Arctic biomes. This analysis will inform all aspects of the CBMP, from overall design (i.e., which indicators to track, where and at what spatial and temporal scales data collection should occur, opportunities for standardization, methods to ensure timely trend detection, appropriate benchmarks, the identification of causal mechanisms) to how the information can be integrated, analyzed, and communicated. It is envisioned that this analysis will be conducted collaboratively by the responsible EMG, with technical support provided by two post-doctoral students.

The results of the comprehensive assessment of current monitoring capacity for each biome will then be translated into specific recommendations for filling critical gaps in monitoring coverage as part of the integrated monitoring plans produced by the EMGs.

An inventory and analysis of the current monitoring capacity for different regions and biomes would include all types of Arctic biodiversity monitoring programs and would ideally be conducted by a lead country or international organization in close cooperation with the EMGs, CAFF countries, and Permanent Participants to ensure accuracy and objectivity. In cooperation with the EMGs, projects involving the acquisition, analysis, and interpretation of existing biodiversity trend information identified in the inventory will be initiated, where relevant. This information will, in many cases, allow for the establishment of historical baseline conditions, thereby providing valuable and cost-effective assessments of the historical and current status of and trends in key elements of Arctic biodiversity.

3.4   Data Management

A large number of groups currently generate Arctic biodiversity data. This information is rarely coordinated and often inaccessible. There is an increasing demand for easily accessible, accurate and understandable information on biodiversity trends

and their underlying causes. Consolidating the vast amount of disaggregated data across all Arctic sub-regions and biomes would not only facilitate access to current information on biodiversity trends, but would promote a deeper understanding of inter-relationships at the local, regional, circumpolar and global scale.

Tom Barry

The CBMP is proposing to develop a Web-based data portal in collaboration with UNEP-WCMC that accesses, integrates, analyzes, and displays biodiversity information from a multitude of stand-alone web servers. The portal will provide both a focal point for current information on Arctic biodiversity and a common platform for all participating networks. It will be accessed from multiple entry points, such as various species networks, and could become part of the Arctic Council's Arctic Portal.

The data portal will be hierarchical in structure, with geo-referenced data permitting analyses at various spatial, temporal, and taxonomic scales (e.g., populations, regions, nations, circumpolar, biomes, habitats). The portal will provide standards and schemas for sharing data and permit data integration, analyses, and correlation. Biodiversity data (response or dependent variables) and physical data (independent variables) will be synthesized by the portal to enable the exploration of relationships and the factors driving change.

The web-based data portal will provide for access to and integration and communication of emerging trends in Arctic biodiversity and will be continually updated as new information becomes available. The management of this data will be in accordance with the Conservation Commons and the International Polar Year (IPY) data policies. As such, international standards and procedures for data archiving and metadata documentation will be used in consultation with the IPY Data Information Service. All information housed within the web-based data portal will be in the public domain.

The CBMP's web-based data portal will be developed as follows:

1. Initial pilot projects (e.g., Seabird Information Network) will be launched to develop web-user interface for data entry and web software for accessing, integrating and depicting data in real-time.

2. A set of ten Arctic biodiversity monitoring networks (and related indicators) will be selected for Phase 1 development based on readiness to participate.

3. A core set of consistent schemas, standards and platforms will be developed for the Phase 1 networks. The developed platforms will allow for the real-time transmission of data between disaggregated data servers to an integration platform (web-based data portal) that integrates, analyses and disseminates information on Arctic biodiversity trends based on the CBMP indicators and indices. Resources and expertise will be required at the data source point to develop standardized databases. A workshop will be convened to develop a consensus-based approach to data standards, schemas and platforms for consistent data management and effective analyses of CBMP indicators.

4. Query outputs will be developed at various levels of detail (i.e., from broad indices to indicators to population and sub-population or regionally specific trends).

5. Application interface software will be developed to run the user interface component of the web-based portal.
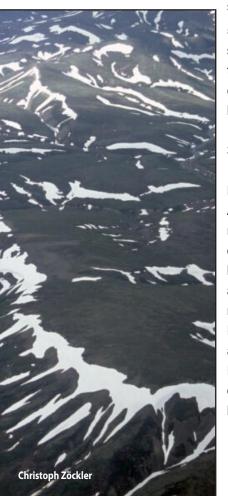
3.5 Capacity Building

Building capacity around Arctic biodiversity monitoring will be a key objective of the CBMP in light of the significant value and contributions that Arctic residents have to offer. Priority capacity building activities can focus on Russia, where the amount of Arctic territory and biodiversity is significant

Christoph Zöckler

and the needs and potential are great. Russia has a number of research stations with corresponding long-term datasets that could be accessed to develop historical baselines and enhanced with the addition of new relevant data. The activation of the EMGs presents the primary mechanism for engaging and building upon existing and historical monitoring in regions that are currently under-represented and/or lack the capacity to sustain monitoring activities. The EMGs will also provide a forum where best monitoring practices and techniques can be identified, shared and adopted by Arctic monitoring programs.

The Arctic leads the world in developing and employing community-based monitoring (CBM) approaches, thereby presenting the CBMP with an excellent opportunity to utilize and integrate these methods alongside science-based approaches. A number of programs are currently underway that employ community-based approaches to understand changes in Arctic biodiversity (e.g., CBM utilizing local knowledge (Arctic Borderlands Ecological Knowledge Co-op) and citizen-based science in Bering Sea Sub-Network)). There is an opportunity and need to expand upon and replicate these efforts around the Arctic to maximize the contributions of Arctic peoples to biodiversity monitoring. The CBMP can play a supporting role, providing assistance with data management, training and other materials to help new programs develop and existing programs expand. The return of monitoring data and interpretation to allow Arctic communities to make use of the results of the CBMP's work.

The CBMP will foster the continued development and use of community-based approaches using two strategies. The first strategy will be to develop these approaches and capacities within the EMGs on equal footing with other science-based approaches, involving the analysis and interpretation of monitoring data in addition to data collection. The second strategy will be to work with existing and future CBM programs to promote the development of a variety of approaches. These community-based approaches would in turn be integrated with science-based approaches and expanded to other areas of the Arctic.

Training manuals will be developed as the primary means to engage Arctic residents in monitoring

activities. Manuals highlighting specific CBM methods (e.g., body condition sampling) will promote the adoption of these techniques within other regions and monitoring programs. An overarching training manual that examines the full spectrum of successful and established CBM programs (i.e. from citizen science programs to local and traditional knowledge) will also be developed to direct the creation of new programs. Both types of training manuals can also form the basis for an informal network of CBM practitioners who can share with one another their experiences and lessons learned.

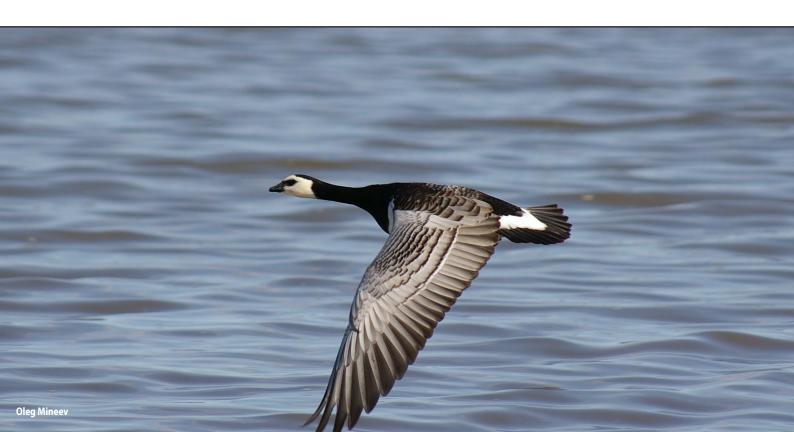In collaboration with its partners, the CBMP will perform the following roles:

- Identify existing community-based monitoring programs and gaps in coverage (as part of the inventory and analysis of current Arctic monitoring capacity);

- Develop and promote best monitoring protocols and specific indicators that can generate circumpolar-scale status and trends;

- Develop and promote regional programs and monitoring approaches in other areas to build cooperation and linkages;

- Promote coordination and integration of existing CBM programs; and,

- Provide an avenue for communicating local and

regional information on Arctic biodiversity trends to global audiences using multiple formats.

3.6 Communications, Education and Outreach

One of the key challenges facing the CBMP is how to make biodiversity information relevant to decision makers and helpful to those who are adapting to the drastic changes taking place in the Arctic. As such, a comprehensive CBMP Communications Strategy has been developed that identifies the main audiences for biodiversity information in the Arctic and describes specific approaches to reach these audiences (please refer to Figure 1).

While scientists will benefit from the increased integration of monitoring information, northern communities and decision makers stand to benefit most from the CBMP's activities. They will not only have access to relevant biodiversity information, but will also receive this information in a format tailored to their needs, which will be identified through consultation. The web-based data portal will meet many of these needs by providing interactive maps and reports; however, it is anticipated that many communities will find printed products more helpful. Ultimately, the CBMP aims to reach a global audience. Changes in the Arctic are of growing international concern and are being watched as closely by educators and schools as by the general public.

Oleg Mineev

Grant Gilchrist

audiences will be a trademark of the CBMP. The CBMP will use the internet as a data management and reporting tool to the extent that technology will allow. Interactive mapping has already begun and will continue to be enhanced as data comes in from the networks. From the documentation of protocol details to newsletters for non-technical audiences, the Program intends to report on implementation progress and program results in a highly visible manner. Reporting activities will range from the frequent release of indicators designed for local and regional decision making to the provision of information for less frequent initiatives such as national and circumpolar reports. An early recipient for the CBMP's reporting efforts will be the Arctic Biodiversity Assessment Summary Report, which will be based upon the CBMP's indicators and indices.

3.9   Implementation Timelines and Anticipated Costs

While countries inside and outside of the Arctic are already spending substantial amounts on biodiversity monitoring, very little is currently being invested in coordinating this monitoring and providing regular, integrated reporting. As a result, much of the collected information never reaches decision makers or the interested public and important links between data sets are never made. However, as Table 4 outlines, an average annual investment in the CBMP of just 1.2 million dollars over the next five years could greatly increase the value of the data collected by addressing these gaps.

3.7   Pilot Projects

The CBMP will take a phased approach to filling gaps in monitoring as they are identified. Pilot projects will be encouraged to test new methodologies and engage both researchers and local communities in the development of new monitoring components. The identified pilot projects will be based upon the results of the Assessment of Current Monitoring Capacity.

3.8   Reporting

The frequent release of products tailored to specific

Table 3. Implementation Timeline.

Timeline by quarter

Milestone	Description of Activities and Deliverables
1. Fully staffed program office coordinates overall program operations and monitoring networks	a. Hire office staff and develop office infrastructure (2008/2009) b. Overall program operation and coordination (ongoing)
2. Establishment of Expert Monitoring Groups (EMG's)	a. Identify lead or co-lead countries for each of the five EMG's (2008) b. Convene all five EMG's (2008/2009) c. Background papers (2008 to 2010) d. Workshops to develop integrated circumpolar monitoring plans (2008 to 2012) e. Publish integrated monitoring plans (2010 to 2012) f. Implement integrated monitoring program via regional working groups (2010 onwards)
3. Establishment of Data Mgmt system and Web-based Data Portal	a. Pilot projects (2008 to 2009) b. Development of web-based data portal (2009 to 2011) c. Operation and management of web-based data portal (2009 onwards)
4. Assessment of Current Monitoring Capacity completed	a. Conduct inventory of current, available Arctic biodiversity information and monitoring programs (2008 to 2009) b. Establish two post-doctoral positions (to work with inventory results and EMG's to conduct gap analysis of current monitoring by EMG biome) (2009 to 2010) c. Address key monitoring gaps through pilot projects and additional monitoring (2011 onwards)
5. Include data from existing in-country monitoring programs in CBMP data management system	Ongoing
6. Implementation of Community-based Monitoring Strategy	a. Develop a Community-based Monitoring Strategy for the CBMP (2008) b. Add Community-based monitoring modules for expert workshops (2008 to 2012) c. Community-based Monitoring Program Development Manual (2008) d. Community-based Monitoring Best Methods Manual (2010) e. Establish CBM Guidance Group (2008) f. Recruitment of CBM projects (2008) g. Data Management (2008 onwards) h. CBM Expert involvement in data interpretation (2008 onwards)
7. Establishment of statistical baselines, using historic data, so current trends can be interpreted.	a. Utilize existing data to generate statistical baselines and retrospective assessments (2008 to 2011) b. Contribute these assessments to the Arctic Biodiversity Assessment (2009 to 2011)
8. Establishment of Outreach and Education program	a. Complete website (2008) b. Maintain website (2008 onwards) c. Quarterly newsletter production and other plain language outreach materials in a number of languages (ongoing) d. Coordinate internal communications and develop products to facilitate internal communications (2008 onwards)
9. Establishment of Biodiversity Indicators and Indices	a. Develop Phase 1 indicators (2008 to 2010) b. Develop Phase 2 indicators (2011 to 2012)

Timeline columns: 2008 (Jan, Mar, Jun, Sept), 2009 (Jan, Mar, Jun, Sept), 2010 (Jan, Mar, Jun, Sept), 2011 (Jan, Mar, Jun, Sept), 2012 (Jan, Mar, Jun, Sept)

Table 4. CBMP Key Milestones, Activities, and Resources (in thousands US$) from 2008 - 2012

Milestone	Description of Activities and Deliverables	Total Annual Cost	Current Investment (08/09 Fiscal Year¹)	Additional Investment Needed
1. Program office is fully staffed and coordinating overall program operations and monitoring networks	a. Hire communications specialist and data specialist and develop office infrastructure (2008/2009) b. Manage and coordinate overall program (ongoing)	350K (Salary) + 80K (O&M)	Canada: 150K Salary + 32K O&M Finland: 10K O&M Sweden: 10K O&M	Communications Specialist: 100K per year (Salary) Data Management Specialist: 100K per year (Salary) Additional operating costs: 28K per year
2. Expert Monitoring Groups (EMGs) are established	a. Identify lead or co-lead countries for each of the five EMGs (2008) b. Convene all five EMGs (2008/2009) c. Write background papers (2008–2010) d. Host workshops to develop integrated circumpolar monitoring plans (2008-2012) e. Publish integrated monitoring plans (2010-2012) f. Implement integrated monitoring program via regional working groups (2010 onwards)	200K (O&M)	Norway and United States: Sponsoring Marine EMG (Funding TBA – estimated at 52K per year for 2 years)	200K per year for remaining four EMGs. Background papers: 20K per EMG Workshops: 40K per EMG per year for 2 year period Publish Integrated Monitoring Plans: 10k per EMG Ongoing coordination: 30K per EMG
3. Data management system and web-based data portal established	a. Launch pilot projects (2008–2009) b. Develop web-based data portal (2009–2011) c. Operate and manage web-based data portal (2009 onwards)	2008: 52K (O&M) 2009 to 2011: 140K (O&M) per year 2012 onwards: 40K (O&M) per year	Canada: 46K Norway/Russia: 4K Finland: 2K	Development of web-portal: 100K per year for 3 year period Maintain and Update web-portal: 40K per year
4. Assessment of Current Monitoring Capacity completed	a. Conduct inventory of current and available Arctic biodiversity information and monitoring programs (2008–2009) b. Establish two post-doctoral positions (to work with inventory results and EMGs to conduct gap analysis of current monitoring by EMG biome) (2009–2010) c. Address key monitoring gaps	2008/09: 105K (O&M) 2009 to 2010: 110K (O&M) per year (1500K estimated annual investment to address key gaps)	None	Inventory: 105K (15K per country; Canada completed) Two Post-Docs: 110K per year (two post docs)
5. Data from existing in-country monitoring programs included in CBMP data management system		Covered under Milestones 1, 3 and 5.		
6. Community-Based Monitoring (CBM) Strategy implemented	a. Develop a CBM Strategy for the CBMP (2008) – complete b. Add CBM modules to EMG workshops (2008 to 2012) c. Complete CBM Program Development Manual (2008) d. Complete CBM Best Methods Manual (2010) e. Establish and operate CBM Guidance Group (2008 onwards) f. Recruit CBM projects (2008) g. Manage CBM data (2008 onwards) h. Involve CBM experts in data interpretation (2008 onwards)	2008: 58K (O&M) 2009: 120K (O&M) 2010: 108K (O&M) 2011 onwards: 58K (O&M) per year	Canada: 25K (CBM Program Development Manual)	Establish + Operate CBM Guidance Group and Data Management: 33K (2008); 120K (2009); 73K (2010); 57K (2011 onwards) CBM Best Methods Manual: 35K (2010)

7. Statistical baselines are established, using historic data, so that current trends can be interpreted	a. Utilize existing data to generate statistical baselines and retrospective assessments (2008 to 2011) b. Contribute these assessments to the 2010 Arctic Biodiversity Assessment (2009 to 2011)	80K (O&M)	None	Research and analyse historical baseline data: 80K per year for 4 years
8. Outreach and Education program implemented	a. Complete website (2008) b. Maintain website (2008 onwards) c. Produce newsletter and other plain language outreach collateral materials in a number of languages (ongoing) d. Coordinate and facilitate internal communications with appropriate products	90K (O&M)	Canada: 15K (website maintenance and newsletter production)	Communications products: 75K per year (55K communications materials; 20K translation costs)
9. CBMP Biodiversity Indicators and Indices implemented	a. Develop Phase 1 Indicators (2008 to 2010) b. Develop Phase 2 Indicators (2011 to 2012)	2008 to 2010: 180K (O&M) per year 2011 to 2012: 270K (O&M) per year	Canada: 20K (begin development of Arctic Species Trend Index) Finland: 10K	Phase 1 Indicators: 2008: 150K 2009: 180K 2010: 180K Phase 2 Indicators: 2011: 270K 2012: 270K
TOTALS		2008: 1155K 2009: 1310K 2010: 1250K 2011: 1220K 2012: 1120K	376 K (202K of which is ongoing costs (CBMP office salary and operating costs)	Total additional (salary and operational funds) required: 2008: 953 K 2009: 1108 K 2010: 1086 K 2011: 1026 K 2012: 926 K External funds to address key monitoring gaps: 1500K annually.

Appendix A: Arctic Climate Impact Assessment Follow-up

Arctic Climate Impact Assessment (ACIA) Key Findings and Recommendations Addressed, Fully or in Part, by the CBMP

ACIA 10 Key Findings:

Finding 1:
Arctic climate is now warming rapidly and much larger changes are projected

Finding 2:
Arctic warming and its consequences have worldwide implications

Finding 3:
Arctic vegetation zones are very likely to shift, causing wide-ranging impacts

Finding 4:
Animal species' diversity, ranges, and distribution will change

Finding 5:
Many coastal communities and facilities face increasing exposure to storms

Finding 6:
Reduced sea ice is very likely to increase marine transport and access to resources

Finding 7:
Thawing ground will disrupt transportation, buildings, and other infrastructure

Finding 8:
Indigenous communities are facing major economic and cultural impacts

Finding 9:
Elevated ultraviolet radiation levels will affect people, plants, and animals

Finding 10:
Multiple influences interact to cause impacts to people and ecosystems

Chapter by Chapter Analysis

Although the CBMP is clearly focused on tracking the status and trends of Arctic biodiversity, it will, to a large extent, be accounting for and tracking impacts to biodiversity derived from climate change, thereby fulfilling, fully or in part, some of the recommendations made by the Arctic Climate Impact Assessment. The following lists the ACIA recommendations partially or fully relevant to the CBMP and provides a short explanation as to how the CBMP might address them.

Chapter 2

ACIA Recommendation: As the Arctic is a region of large natural variability and regional differences, more uniform coverage must be obtained to clarify past changes. In order for the quantitative detection of change to be more specific in the future, it is essential that steps be taken now to fill in observational gaps across the Arctic, including the oceans, land, ice and atmosphere.

CBMP's Role: The CBMP is mandated with improving the coverage and frequency of long-term biodiversity monitoring across the Arctic, in all biomes. It will also compile and synthesize existing information involving not only biodiversity variables, but also physical variables such as sea-ice extent.

Chapter 3

ACIA Recommendation: For some areas, such as the central and eastern Russian Arctic, few or no current records of indigenous observations are available. To detect and interpret climate change, and to determine appropriate response strategies, more research is clearly needed.

CBMP's Role: Community-based monitoring techniques will be employed by the CBMP to track the status and trends of Arctic biodiversity and understand the mechanisms driving this change, such as those from human-induced climate change. The CBMP's approach will likely be through several regional partnership programs, new or existing, that utilize indigenous observations on changes, specific to Arctic biodiversity.

ACIA Recommendation: In Eurasia and Greenland, little systematic work on indigenous knowledge has

been done, and research in these regions is clearly needed. Indigenous observation networks have been set up in Chukotka, Russia, and some projects have taken place in Alaska, but little systematic work has been done to set up, maintain, and make use of the results from such efforts.

CBMP's Role: Systematic long-term community-based biodiversity monitoring programs that involve indigenous observations are expected to developed in different parts of the Arctic such as in parts of Eurasia, where feasible.

ACIA Recommendation: Problems to be tackled: determining how indigenous knowledge can best be incorporated into scientific systems of knowledge acquisition and interpretation; and; finding ways to involve indigenous communities in scientific research and to communicate scientific findings to indigenous communities.

CBMP's Role: Through the CBMP's development of pilot community-based biodiversity monitoring programs, the program will be exploring ways for involving, utilizing and synthesizing information regarding that the status and trends of Arctic biodiversity derived from scientific, indigenous and citizen science based approaches.

Chapter 6

ACIA Recommendation: A climatology of the spatial distribution of snow-water-equivalent in each month is a critical need for model validation and hydrological simulations; this is especially urgent in high latitudes.

CBMP's Role: The CBMP has applied for funding through IPY Canada to collect, ground-truth, and interpret snow-water-equivalent data derived from satellite observations for parts of Northern Canada.

Chapter 7

ACIA Recommendation: There is also a need to identify and monitor currently widespread species that are likely to decline under climate change, and to redefine conservation and protection in the context of climate and UV radiation change.

CBMP's Role: The CBMP will be monitoring a number of Arctic species, some of which are likely to decline under climate change.

ACIA Recommendation: The dominant response of current Arctic species to climate change is very likely to be relocation rather than adaptation. Relocation possibilities are very likely to vary according to region and geographic barriers. Some changes are already occurring. However, knowledge of rates of relocation, impact of geographic barriers, and current changes is poor. There is a need to measure and project rates of species migration by combining paleo-ecological information with observations from indigenous knowledge, environmental and biodiversity monitoring, and experimental manipulations of environment and species.

CBMP's Role: The CBMP will be monitoring, over time, the distribution of a number of biodiversity elements, such as the distribution and extent of Arctic species and biomes.

ACIA Recommendation: Long-term environmental and biological monitoring are becoming increasingly necessary to detect change, to validate model projections and results from experiments, and to substantiate measurements made from remote sensing. Present monitoring programs and initiatives are too scarce and are scattered randomly. Data from the Arctic are often not based on organized monitoring schemes, are geographically biased, and are not long-term enough to detect changes in species ranges, natural habitats, animal population cycles, vegetation distribution, and carbon balance. More networks of standardized, long-term monitoring sites are required to better represent environmental and ecosystem variability in the Arctic and particularly sensitive habitats. Because there are interactions among many co-varying environmental variables, monitoring programs should be integrated. Observatories should have the ability to facilitate campaigns to validate output from models or ground-truth observations from remote sensing. There should be collaboration with indigenous and other local peoples' monitoring networks where relevant. It would be advantageous to create a decentralized and distributed, ideally web-based, metadatabase from the monitoring and campaign results, including relevant indigenous knowledge.

CBMP's role: The CBMP will be integrating and standardizing information from current monitoring programs using a decentralized, distributed web-based data portal and will be filling gaps in

geographic, temporal and elemental biodiversity monitoring coverage as resources become available. The approach taken will utilize both remote sensing information as well as community-based monitoring techniques involving indigenous observations.

ACIA Recommendation: Monitoring requires institutions, not necessarily sited in the Arctic, to process remotely sensed data. Much information from satellite and aerial photographs exists already on vegetation change, such as treeline displacement, and on disturbances such as reindeer/caribou overgrazing and insect outbreaks. However, relatively little of this information has been extracted and analyzed.

CBMP's Role: With a circumpolar perspective, the CBMP will be implementing some remote sensing pilot projects that utilize remotely sensed data to determine the status and trends in the distribution of various Arctic biomes as well as the extent of human impact on these biomes.

Chapter 8

ACIA Recommendation: Integrated circumpolar monitoring of freshwaters – key scientific gaps: the limited records of long-term changes in physical, chemical and biological attributes throughout the Arctic; differences in the circumpolar availability of biophysical and ecological data (e.g.,, extremely limited information about habitat requirements of Arctic species); a lack of circumpolar integration of existing data from various countries and disparate programs; a general lack of integrated, comprehensive monitoring and research programs, at regional, national, and especially circumpolar scales; a lack of standardized and networked international approaches for monitoring and research.

CBMP's Role: The CBMP's mandate includes Arctic freshwater systems where they pertain to the monitoring of biodiversity. Through partnerships with existing monitoring programs, the CBMP will assist in building capacity and coverage for long-term monitoring of Arctic freshwater biodiversity and will assist in the standardization, compilation, analysis, synthesis and reporting of status and trends information.

Chapter 9

ACIA Recommendation: The existing monitoring programs should be continued and expanded (high priority), both spatially and in breadth of measurement. New monitoring activities should be established in areas where they are presently lacking and these should be designed to address the effects of climate change. Issues to be addressed include the timing and amount of primary and secondary production, larval fish community composition, and reproductive success in marine mammals and seabirds. Key ecosystem components, including non-commercial species, must be included.

CBMP's Role: The CBMP is working with its marine biodiversity monitoring partners to develop monitoring strategies and build capacity and coverage of current monitoring and assist with standardization, compilation, analysis, synthesis and reporting of marine biodiversity status and trends information.

ACIA Recommendation: An Arctic database should be established that contains all available physical and biological data.

CBMP's Role: The CBMP is currently developing a web-based data portal that will access distributed databases, including ones containing marine biodiversity monitoring data, for the compilation, analysis and synthesis of biological information to determine status and trends.

ACIA Recommendation: Past physical and biological data from the Arctic should be recovered. There are many data that are not presently available but could be recovered.

CBMP's Role: If resources became available, the CBMP could assist with the recovery of archived biodiversity monitoring data that is not currently accessible.

Chapter 10

ACIA Recommendation: There are many areas of Arctic taxonomy that require exploration and research; it is vital to the conservation of the Arctic's biodiversity that these taxonomic subjects are addressed.

CBMP's Role: Many of the CBMP's partner species networks are putting resources towards taxonomic classification of Arctic species.

ACIA Recommendation: Monitoring is important

for understanding how the Arctic's biodiversity is changing and whether actions to conserve biodiversity are being successful; monitoring needs to occur at both the system level and the species level.

CBMP's Role: The CBMP's mandate is to coordinate monitoring of Arctic biodiversity including the tracking of the effectiveness of conservation efforts and the monitoring of species and systems.

ACIA Recommendation: There needs to be a supply of trained ecologists who can devise appropriate circum-Arctic classifications of habitats and then survey them so as to measure their extent and quality and to establish their dynamics.

CBMP's Role: Through collaborations with its partner monitoring networks, the CBMP will be developing a Circumpolar Boreal Vegetation Map, involving standardized habitat classifications and acting as a baseline for future monitoring of the trends in extent and quality of these habitats.

ACIA Recommendation: Inventories need to be generated for the Arctic's biodiversity (both species and habitats), indicating for each entry in the inventory where it occurs and either the size of the overall species population or the extent of the habitat. Such inventories need to be on a circum-Arctic basis rather than on a national basis as nations with Arctic territory also have territory south of the Arctic.

CBMP's Role: While the CBMP is not directly developing inventories, its partners will, in many cases, be the holders of information such as species populations and extent of habitats that will be accessible, in most instances, through the CBMP's web-based data portal.

ACIA Recommendation: The genetic diversity of many of the Arctic's species is presently poorly known or unknown. Much research is needed to explore this aspect of the Arctic's biodiversity and conservation management will need to ensure that genetic diversity is not lost.

CBMP's Role: Through its partner monitoring networks, many aspects of genetic diversity of Arctic species are being researched (e.g., Arctic Char).

ACIA Recommendation: Models need to be further developed to explore changes in biodiversity under the various scenarios of climate change. These models will need to explore biodiversity change in the sea, in freshwater, and on land.

CBMP's Role: Biodiversity monitoring information managed by the CBMP will contribute to model development through the comparisons of regional differences in climate change impacts and the response of biodiversity to these impacts.

ACIA Recommendation: Circum-Arctic monitoring networks need to be fully implemented throughout the Arctic. Data on the state of the Arctic's biodiversity, on the drivers of change in that biodiversity, and on the effectiveness of responses to those changes, need to be collected, analyzed, and used in the development of future Arctic biodiversity policy.

CBMP's Role: The CBMP will directly address all of these recommendations.

ACIA Recommendation: Attention needs to be given to establishing the kinds of subsidiary aspects of monitoring, such as integrated monitoring and monitoring of phenology, genetic diversity, and invertebrate fauna. These are vital if a holistic view is to be taken of the Arctic's biodiversity, its conservation in the face of a changing climate, and the management of the biodiversity resource for future generations of people to use and enjoy.

CBMP's Role: The CBMP's biodiversity indicators include phenology and the monitoring of some invertebrate fauna.

ACIA Recommendation: A suite of indicators needs to be devised and agreed, monitoring for them undertaken, and the results made publicly available in a format (or formats) so as to inform public opinion, educators, decision-makers, and policy-makers.

CBMP's Role: The CBMP has a draft list of biodiversity indicators for circumpolar monitoring. The resulting status and trends information from these indicators will be reported on regularly in a diversity of formats to reach the wider public as well as decision and policy makers.

ACIA Recommendation: Best practice guidelines need to be prepared for managing all aspects of the Arctic's biodiversity. These need to be prepared on a circumpolar basis and with the involvement of all interested parties.

CBMP's Role: While not directly focusing on best management practices, the CBMP's biodiversity information will aid industry and governments in the development of best practices as the CBMP will not only track changes in biodiversity but investigate the

causal mechanisms driving those changes, thereby informing best management practices.

ACIA Recommendation: Integrated forms of management, incorporating the requirement for biodiversity conservation, need to be explored for all uses of the land, freshwater, and sea in the Arctic.

CBMP's Role: The CBMP will produce policy recommendations based upon the status and trends it produces, especially where information regarding the mechanisms driving biodiversity change is available. This information could be used to develop integrated management approaches for the conservation of biodiversity.

ACIA Recommendation: Biodiversity conservation needs to be incorporated into all policy development, whether regional, national, or circumpolar.

CBMP's Role: The CBMP will produce policy recommendations for biodiversity conservation based upon the results produced through its circumpolar monitoring.

ACIA Recommendation: All nations with Arctic territory should be working toward full implementation of the Convention on Biological Diversity, coordinating their work on a circumpolar basis, and reporting both individually and jointly to the regular Conferences of the Parties.

CBMP's Role: The CBMP has adopted many of the CBD biodiversity indicators, when relevant to the Arctic. These indicators will allow the entire Arctic region to be able to report on progress made towards the 2010 CBD target.

Chapter 11

ACIA Recommendation: Achieving effective conservation and management of wildlife in a changing Arctic will require a team-building approach among governments at all levels that relate to the environment and human well-being, and with all other groups with an interest in the Arctic. This effort should include the indigenous peoples and other residents of the Arctic, and scientists undertaking research in the Arctic, representatives of industry and business seeking development of Arctic resources or other economic opportunities in the Arctic, those who travel to the Arctic for recreation or tourism, and the non-governmental organizations seeking

to protect or sustain environmental, aesthetic, and other less tangible values of the Arctic in the broader interest of society. The successful management and conservation of Arctic wildlife requires that these groups be represented in the management process and that adequate information is available for equitable consideration of the diverse interests that relate to Arctic wildlife. The role of international, non-governmental environmental organizations is particularly important in maintaining focus of the public on the broad spectrum of environmental values existing in the Arctic when proposals for large-scale industry- or government-sponsored projects become politicized at the regional or national levels.

CBMP's Role: The CBMP represents a multiple partner (governments, NGO's, indigenous people's, northern communities, industry, etc.), holistic approach to the monitoring and conservation of Arctic biodiversity. It strives to bring together diverse partners towards the common goal of conserving Arctic biodiversity in order to ensure human well-being both inside and outside the Arctic.

Chapter 13

ACIA Recommendation: Present monitoring of the physical and biological marine environment must be continued and in many cases increased. Basic research is a prerequisite for understanding biological processes. Modern technology enables the automation of many of the time-consuming tasks previously conducted from expensive research vessels, e.g.,, buoys can now be deployed in strategic locations on land and at sea for continuous measurement of many variables required in marine biological studies. The monitoring of commercial stocks must also continue, applying new technologies as these become available. There is a general shortage of ship time for sea-based work. Administrators or governments are often unaware of this, also that despite computers enabling more extensive and deeper analyses of existing datasets, people are still required to operate and program the computers.

CBMP's Role: The CBMP will be working with its marine biodiversity monitoring partners towards the goal of continuing and increasing the effectiveness of current Arctic marine biodiversity monitoring efforts.

Chapter 14

ACIA Recommendation: Forest advance into tundra has the potential to generate a large positive temperature feedback. Unfortunately, the understanding of change at this crucial ecological boundary comes from a small number of widely separated studies undertaken to achieve many different objectives. A coordinated, circumpolar treeline study and monitoring initiative will be necessary to address definitively the question of how and why this boundary is changing at the scale required to address its potential global importance.

CBMP's Role: The CBMP, while not planning on directly monitoring treeline position, will be monitoring the distribution and extent of various terrestrial Arctic biomes. This information may be able to contribute, over time, to a greater understanding of the impacts of an advancing treeline on climate, but it may not be at an appropriate temporal scale for climate modelling.

Chapter 15

ACIA Recommendation: There is a need for a carefully planned strategy, at the community and regional level, to monitor and document environmental change. Arctic Council members and program workgroups should provide technical assistance regarding monitoring strategies, climate impact mitigation and pilot studies, data analysis, and evaluation.

CBMP's role: The CBMP is developing a biodiversity monitoring strategy based on a set of indicators and including community-based and regional approaches.

ACIA Recommendation: There are few data on climate change impact on regional biota. A critical need exists for the monitoring of wildlife diseases, and human–wildlife disease interaction. There are few data on climate-induced changes in the diet of subsistence species, which affects their nutritional value in traditional diets. Arctic Council programs have the expertise to design effective regional and international monitoring programs in cooperation with communities. This critical activity should be given a high priority.

CBMP's Role: The CBMP, in collaboration with its partner species monitoring networks, is developing a set of biodiversity indicators for long-term monitoring, that includes monitoring the presence and distribution of such impacts on wildlife as disease.

Chapter 18

ACIA Recommendation: Regional impacts: The ACIA mostly addressed impacts at the large-scale circumpolar level. The attempt to differentiate between impacts within the four ACIA regions was exploratory and did not cover these regions in depth. There is a need to focus future assessments on smaller regions (perhaps at the landscape level) where an assessment of impacts of climate change has the greatest relevance and use for residents in the region and their activities.

CBMP's Role: The CBMP, in some cases, may be able to shed light on the impacts of climate change on biodiversity at the regional level, where regionally specific programs are implemented and data rigour allows for such an analysis.

ACIA Recommendation: Observations and process studies: To improve future climate impact assessments, many Arctic processes require further study, both through scientific investigations and more detailed systematic documentation of indigenous knowledge. Priorities include collection of data ranging from satellite, surface, and paleo data on the climate and physical environment, to rates and ranges of change in Arctic biota, and to the health status of Arctic people.