ICARP II – SCIENCE PLAN 3

ARCTIC COASTAL PROCESSES

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PREFACE

The Second International Conference on Arctic Research Planning (ICARP II) was held in Copenhagen, Denmark from 10 November through 12 November 2005 and brought together over 450 scientists, policy makers, research managers, indigenous peoples, and others interested in and concerned about the future of arctic research. Through plenary sessions, breakout sessions and informal discussions, conference participants addressed long-term research planning challenges documented in twelve draft research plans. Following the conference drafting groups modified the plans to reflect input from the conference discussions and input from the ICARP II web site. This science plan is the culmination of the process.

ICARP II Science Plans

Science Plan 1	Arctic Economies and Sustainable Development
Science Plan 2	Indigenous Peoples and Change in the Arctic: Adaptation, Adjustment and Empowerment
Science Plan 3	Arctic Coastal Processes
Science Plan 4	Deep Central Basin of the Arctic Ocean
Science Plan 5	Arctic Margins and Gateways
Science Plan 6	Arctic Shelf Seas
Science Plan 7	Terrestrial Cryospheric & Hydrologic Processes and Systems
Science Plan 8	Terrestrial and Freshwater Biosphere and Biodiversity
Science Plan 9	Modeling and Predicting Arctic Weather and Climate
Science Plan 10	A Research Plan for the Study of Rapid Change, Resilience and Vulnerability in Social-Ecological Systems of the Arctic
Science Plan 11	Arctic Science in the Public Interest
Background Document	Contaminants

3.1. Introduction

The coastal zone is the interface through which land-ocean exchanges in the Arctic are mediated and it is the site of concentrated human settlement and activity that occurs at high latitudes. Ecologically, coastal systems are important in many ways, most notably as the interface between marine and continental systems resulting in, for example, extremely high marine productivity and diversity, and a continuous strip of habitat for large numbers of birds, mammals, and fish that migrate long distances. Arctic coasts are highly variable and their dynamics are a function of interactions between environmental forcing and coastal geology (e.g., Figure 3.1), coastal biology and ecology (e.g., Figure 3.2), as well as human activity, society, and culture. The arctic coastal zone is extremely vulnerable to predicted and ongoing environmental change, including decreased sea-ice extent and thickness, sea-level rise, increasing storm frequency, biodiversity destabilization, and anthropogenic impacts. The next few decades are predicted to bring new and important increases in arctic resource development, particularly hydrocarbon extraction in shelf and coastal areas.

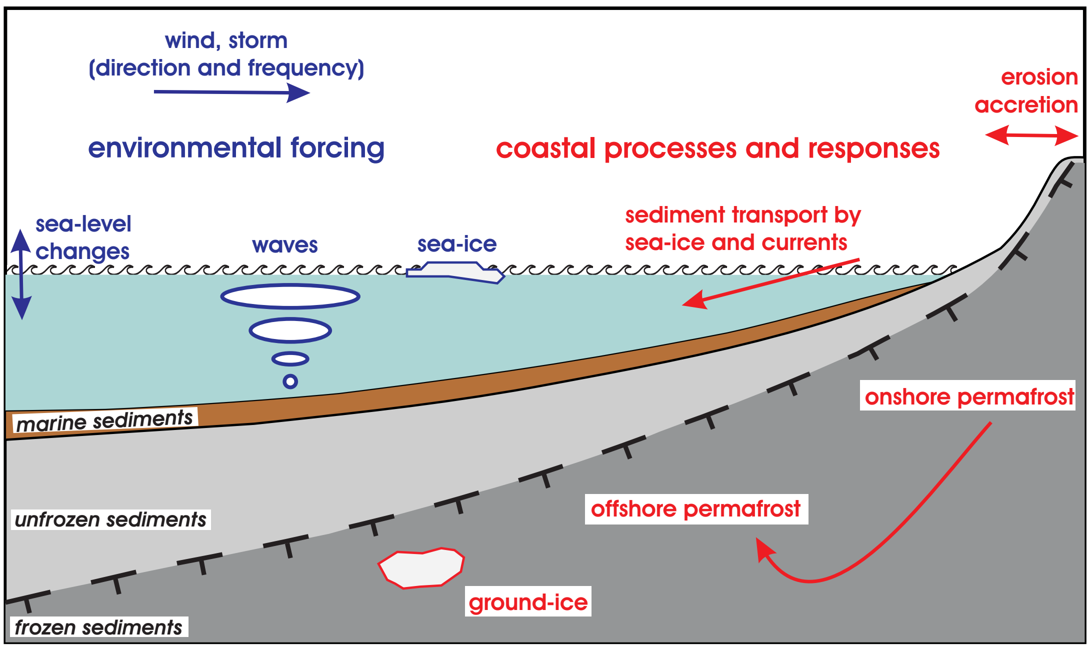

Figure 3.1. Arctic coastal physical processes and responses to environmental forcing (Rachold et al., 2005).

Impacts from ongoing processes include rapid erosion of ground-ice-rich, permafrost-dominated coastlines. This coastal retreat has serious implications for ecosystems and northern communities (for example, infrastructure damage, loss of housing, or damage to hunting and fishing grounds). One of the key findings of the Arctic Climate Impact Assessment was that many coastal communities and facilities face increasing exposure to storms (ACIA, 2004: key finding #5). Changes in the arctic coastal zone will not only affect regional biological and human systems but are also likely to exert influence on the global system. The degradation of permafrost, which can lead to decomposition of gas hydrates and release of greenhouse gases preserved in permafrost, is concentrated in the coastal zone. Fluxes of sediment, carbon, and nutrients resulting from coastal erosion play an important role in the material budget of the Arctic Ocean.

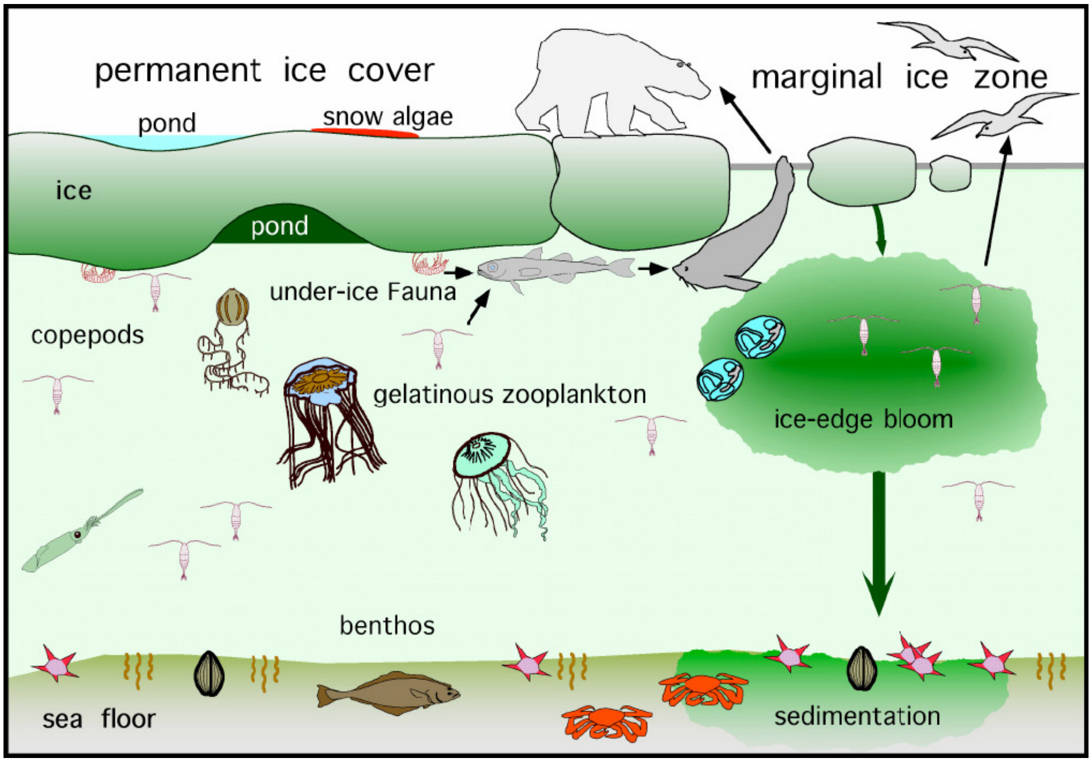

Figure 3.2. Schematic representation of the arctic coastal marine ecosystem and typical interacting species (Gradinger et al., 2004).

3.2. Focus

Until recently, research concerning the circum-arctic coastal regions has been oriented along various discrete themes. Research on arctic coastal processes that furthers an integrated understanding serves two objectives: first, it provides a basis for better assessing the impact on arctic coasts of large-scale climate change trajectories, and second, it improves capacity to more precisely identify and quantify feedbacks and parameterizations required for input into large-scale forecast models, ultimately to improve the reliability of the forecasts. The challenge at the coastal margin, perhaps more than anywhere else, is the region's juxtaposition of numerous and varied processes and states that exist within a web of interrelationships. Consideration of any one process in isolation, an approach that still often typifies scientific work, does not properly represent the whole. Thus, current research needs call for a methodological shift to frame research questions in a broader ecosystem-based context. Such a systemic approach does not abandon traditional research on processes, but instead calls for process studies to be embedded within collaborative efforts among disciplines, such that opportunities for identifying linkages are not lost. Such an approach can also provide more information about possible "surprise" factors, that is, non-linear responses within the system. In response to these needs, this ICARP II science plan proposes two major thematic foci to explore the consequences on circum-arctic coastal systems of (a) continued identification of critical natural processes and changes currently underway in those processes (e.g., permafrost, sea ice, coastal morphology, changing biological community structure and productivity, or environmental stressors) and (b) changes in human activities (e.g., shipping, mineral and hydrocarbon exploitation, construction of infrastructure, fisheries, hunting, herding, and tourism). By "critical" is meant a natural process that serves as a keystone, the disruption of which leads rapidly to compromise of numerous, interrelated systems. As indicated, these must be related to the broader system, and should consider such major interdisciplinary themes as coastal biodiversity, society, and sustainability. The connections and relationships between (a) and (b) should also be carefully considered by the direct incorporation of the human dimension into multidisciplinary projects. Additional priorities include bi-directional linkages to the global system, as well as local responses to changing cultures (globalization) and populations among the inhabitants of the arctic coastal zone (AHDR, 2004).

In this ICARP II science plan the coastal zone is broadly defined to include marine benthic and pelagic zones extending from the intertidal zone to the shelf break, as well as from the intertidal zone to the landward side of the terrestrial coastal plain. Within this region, the science plan focuses on the near-shore marine areas in both benthic and pelagic zones, and the near-shore terrestrial areas that act as drivers to the marine systems or that are under a distinct marine influence. While working with fine-grain data, it will be appropriate to further narrow the definition, following for example the Ramsar Convention (Ramsar Convention Secretariat, 2004) which defines coastal wetlands as waters to a maximum depth of six meters below mean low tide. Such an adaptive definition is important, because coastal processes and biodiversity function at multiple spatial scales, and require corresponding research methodologies.

Ecosystem-based research and management is based on concepts of biodiversity. Biodiversity studies are common in the terrestrial and marine ecological literature, however upon closer examination, many publications can more appropriately be described as taxonomic or species richness studies. In this ICARP II science plan, the full definition of biodiversity is adhered to, encompassing structural, compositional, and functional elements operating at a range of thematic, spatial, and temporal scales. It is only with this full complement of biodiversity components that meaningful assessments of biological stability, sustainability, and uniqueness can be performed (Cogan and Noji, in press; Noss, 1990; UNEP, 1992). In practice not all biodiversity elements are practical to measure, although with the knowledge of theory, the focus on goals, and the use of sensible surrogates or indicators, it is possible to significantly advance understanding of the biological communities in the circum-arctic coastal zone within a timeframe appropriate for critical policy and management needs.

3.3. Key Scientific Questions

The issues described in the previous section are now considered from three major systemic perspectives – physical, ecological, and social – in order to devise measures for identifying changing impacts on the physical environment (including possible linkages to the global system, e.g., greenhouse gas emission, organic carbon), biodiversity (including coastal ecosystems, distinctive areas, habitats, and species), and human activities at different scales (such as local and regional resource use to globalization in terms of renewable resources, quality of the environment, industrial activities and contaminants).

As a starting point in the development of this ICARP II science plan, it is important to identify the key driving processes, characteristics, and threats that can be used as measures to assess coastal ecosystems. Emphasis should be directed towards those elements that most strongly impact biodiversity, culture, society, and the economy and/or exert influence on the global system. The key scientific questions for the arctic coastal zone are directly related to these elements. A variety of key scientific questions are outlined in this science plan. They are mostly framed in more traditional, process-oriented language, with the expectation that systemic integration comes via implantation through a multidisciplinary team.

These physical, ecological, and social research perspectives provide a base from which to identify the outcomes to be strived for, to prioritize research goals, and to generate specific scientific questions. Four general outcomes are focused on as a starting point: decreasing uncertainty of the functioning of biophysical processes and possible impacts on ecosystems; ecoregion-based coastal zone management; scientific support of sustainable development in the arctic coastal zone; and improved access to internet-based fundamental data for coastal zone research and education.

3.3.1. Physical Perspectives

Physical Measures to Assess Coastal Ecosystems

- High-frequency environmental forcing – atmospheric (winds, thermal) and oceanographic (this includes long-term implications for the atmosphere and ocean under scenarios of continued loss of sea-ice cover):
  - available information includes preliminary storm, wind and wave climatologies, storm dynamics for northern Alaska, and modeled grids (two global reanalyses, one regional reanalysis, one regional model);
  - information required includes better definition of the regional trends in these parameters, including the incorporation of variable sea-ice conditions (as determined from observational and modeled results) and the translation of large-scale Intergovernmental Panel on Climate Change projections into specific regional-scale forcing projections, better reanalysis grids, and assessments of reanalysis fields for use.
- Sea-level changes (eustatic and isostatic): better measured trends should be established at more locations so that model projections can be placed in a more meaningful context.
- Onshore and offshore permafrost dynamics and gas hydrate stability: investigations have only recently begun in selected areas; research programs should be expanded to gain a better understanding of these parameters, with special focus on their response to projected warming.
- Sea-ice dynamics: a multidisciplinary question in this regard asks what happens to near-shore sea ice in the face of possible changing wind conditions – this has direct links to incident wave energies and sediment transport.
- Biogeochemical transformations: details of the fate of various carbon species (particulate inorganic carbon, dissolved organic carbon, dissolved inorganic carbon) that are moved across the coastal zone into the marine environment.
- Sediment dynamics / lithodynamics: response of sediments to changing temperature regimes, as a function of material type and ice content.
- Terrestrial snow and ice cover levels and variability.
- Natural hazards and extreme events: ice push events, seismicity, tsunamis.
- Identification of risks arising from projected long-term changes to environmental forcing parameters, for example, projected disappearance of sea ice in 50 to 150 years.

Physical Science Research Questions

How does high-frequency environmental forcing (atmospheric and oceanographic, sea-level change) control arctic coastal dynamics?

What are the responses of on/offshore permafrost dynamics and gas hydrate stability to projected warming?

How do biogeochemical transformations and sediment dynamics in the coastal zone affect the marine environment?

What are the potential consequences of natural hazards and extreme events (ice push events, seismicity, and tsunamis)?

What are the risks for the coastal zone arising from projected long-term changes in environmental forcing parameters, for example, the projected disappearance of sea ice in 50 to 150 years?

These research questions are linked to ICARP II Science Plan 6 and Science Plan 7. ICARP II Science Plan 6 calls for changes in cross-shelf transport to be investigated; providing a link to coastal studies on sediment dynamics and biogeochemical transformations. One broad scientific question addressed by ICARP II Science Plan 7 is how changes in arctic land-surface hydrological processes will affect regional and global feedback to the climate system. This suggests a useful linkage to the coastal investigations on onshore and offshore permafrost dynamics and gas hydrate stability.

3.3.2. Ecological Perspectives

Ecological Measures to Assess Coastal Ecosystems

- Structural biodiversity, including physical habitat parameters and possible critical thresholds, depth, light, and salinity measured and evaluated at multiple spatial scales. Data on structural biodiversity needs to be collected in a consistent, spatially explicit, documented (metadata) database. This represents an entry point for geographic information system (GIS) geodatabase creation.
- Compositional biodiversity, including ecoregion occurrence, community, species, and genetic diversity, as well as floristic habitat indicators. These measures will provide a representative collection of information on what is present, from the perspective of multiple spatial and thematic scales.
- Functional biodiversity, including productivity regimes influenced by terrestrial factors, currents, mixing, predation, demographics, migration, and ecological vulnerability.
- Ecological impact of human activities, including: fisheries, hydrocarbon development and extraction, shipping, persistent organic pollutants, radioactivity, aquaculture, introduction of alien species, coastal development, increased access to remote areas and increased human population density.
- Ecological indicators and surrogates for biodiversity elements, providing standard measures within and between observatory sites for the assessment of current conditions and monitoring and detection of future change.
- Indicators of ecosystem changes integrated from local and traditional knowledge, monitoring, and scientific studies.

Ecological Science Research Questions

Where are the unique and special biodiversity features?

Why are they there? What are the underlying ecological processes for these features?

Are these biodiversity features likely to persist in the face of climate and other changes?

If the biodiversity features do not persist, what will be their fate?

What are the consequences of the loss of these elements, specifically, in relation to food web dynamics, sustainability, human services and resources, resource extraction and our predictive ability for occurrences and function of related ecosystem elements – in other words, would these lost biodiversity features also provide key indicators?

These ecological science questions are linked to ICARP II Science Plan 8 which has identified major focal points on ecosystem function and structure in terrestrial and freshwater systems. In addition, these research questions can be linked to the ongoing efforts of the Arctic Council's program on the Conservation of Arctic Flora and Fauna (CAFF).

3.3.3. Cultural/Socio-economical Perspectives

Social Science Measures to Assess Coastal Ecosystems

- Globalization – Arctic as an arena of transnational corporate activity.

- Growing threats: hydrocarbon pollution of cold waters through accidental oil spills and “routine” (legally accepted and illegal) pollution.
- Ship traffic (e.g. the actual and potential threat to introduce alien species).
- Community sewage.
- Coastal hydrocarbon processing facilities construction, community planning, and infrastructure development.
- Urbanization and population growth.
- Mineral and resource extraction (including coastal zone infrastructure development of new oil and gas facilities and related transport facilities).
- Changing accessibility to remote areas (expansion of tourism, hunting etc.).
- Use of renewable resources (subsistence activities of local peoples, commercial fisheries, conflicts of resource use and sustainable models).
- Abandoned commercial sites: military, oil and gas, mines, shipyards.
- Space allocation, conflicts for land use, resources, shore zone priorities.
- Reliability of the functioning of social and industrial infrastructure under changes of climate and environment.
- Vulnerability of coastal communities affected by storms, thawing of permafrost, and shore destruction.
- Impacts of a warming climate on livelihoods of indigenous peoples and understanding responses and adaptations.

Social Science Research Questions

How do humans interact with coastal environments in the Arctic?

How do these human-environment relationships change between different coastal regions in the north and how have they changed over time?

How do present (and how might future) environmental and other changes (social, political, etc.) affect these relationships? What is (and can be) done in response?

How do different groups (industry, fisheries, subsistence hunters, etc.) prioritize the use and protection of arctic coasts?

What kinds of decision-making processes are related to the coastal zone and what information is needed to assist in these decisions?

These social science questions are linked to ICARP II Science Plan 1 and ICARP II Science Plan 2. One key scientific question addressed by Science Plan 1 is: What are the determinants of sustainability in the arctic context, for example, the roles of government policies, environmental change, globalization, and infrastructure? Where these issues are strongly affected by coastal processes, linkage between the two working groups will be particularly effective. A main thematic issue proposed by Science Plan 2 is the well-being and health of indigenous peoples. This will also form an important link to several elements considered this ICARP II science plan.

3.3.4. Interdisciplinary Integration

Maintaining the three-phase physical, ecological, and social approach, science questions are listed by disciplinary category; however we emphasize the critical need for interdisciplinary research integration in the proposal and implementation stages.

There are several synergistic benefits that arise from integrating the series of physical, ecological, and social science questions focused on the coastal zone. These benefits will not only enhance coastal research, but will also cross-over to provide interdisciplinary linkages to other ICARP II science plans. The following benefits are emphasized:

- Education – research action on the science questions will increase awareness of coastal processes, facilitating stakeholder involvement.
- The interdisciplinary approach will foster improved linkage between environmental issues and socio-economics of northern communities.
- The coastal group research questions are logically placed in context to best take advantage of local and traditional knowledge (LTK).
- The coastal group will join other ICARP II groups in the need for detailed coastal topography data, and increased access to remote sensing data. This unified call for arctic data will support a combined, international initiative originating from high-level government response to both the ICARP II process and the International Polar Year.

3.4. Scientific Approach

This ICARP II science plan addresses a series of coordinated interdisciplinary science questions, outlining a methodological shift towards a systematic approach to arctic coastal research. The emphasis is on coordination, standardized monitoring and data capture, comprehensiveness, and a coordinated data infrastructure for analyses and modeling. To accomplish this, the science plan advocates an arctic coastal research program guided by a network of circum-arctic coastal observatories, including long-term ecological research areas. These observatories are proposed as a series of sites for high-resolution studies within a broader eco- and socio-regional frame of reference. Monitoring studies will be used as the basis for understanding processes and will provide data for calibrating models to be developed. Location and mandate of these observatories should be coordinated with related activities of other ongoing circum-arctic projects including planning for the International Polar Year (see section 3.5).

Sensitive sites with different levels of human use and impact ("protected areas" versus intensively used areas) should be selected for broad representation. Participation by local communities (note this does not always mean "indigenous", e.g., in Russia) will be essential, to lend expertise and to give the monitoring sites complete temporal continuity, and thus site selection should be coordinated with local communities. Site selection should also consider the availability of existing data, site accessibility, and the regional context. Potential key sites are shown in Figure 3.3.

The recommended strategy involves four steps (the specific work programs will be site-specific and the details of coordinated project standards are yet to be determined).

Step 1: Initial Site Characterization

Initial site characterization should include a compilation of historical data and the acquisition of comprehensive, high-resolution imagery of the circum-arctic coastline to provide overall context. Each observatory site will require the integration of three types of study:

- physical data: characterization of atmospheric, terrestrial, and marine conditions;
- ecological data: marine and terrestrial classification, habitat mapping, biodiversity assessment, and ecological community modeling; and
- cultural and socio-economical data: characterization of the socio-economic situation, interaction of resource users, assessment of the type and amount of resources used, local and traditional knowledge of coastal processes and changes, and the status of legal and administrative regulations.

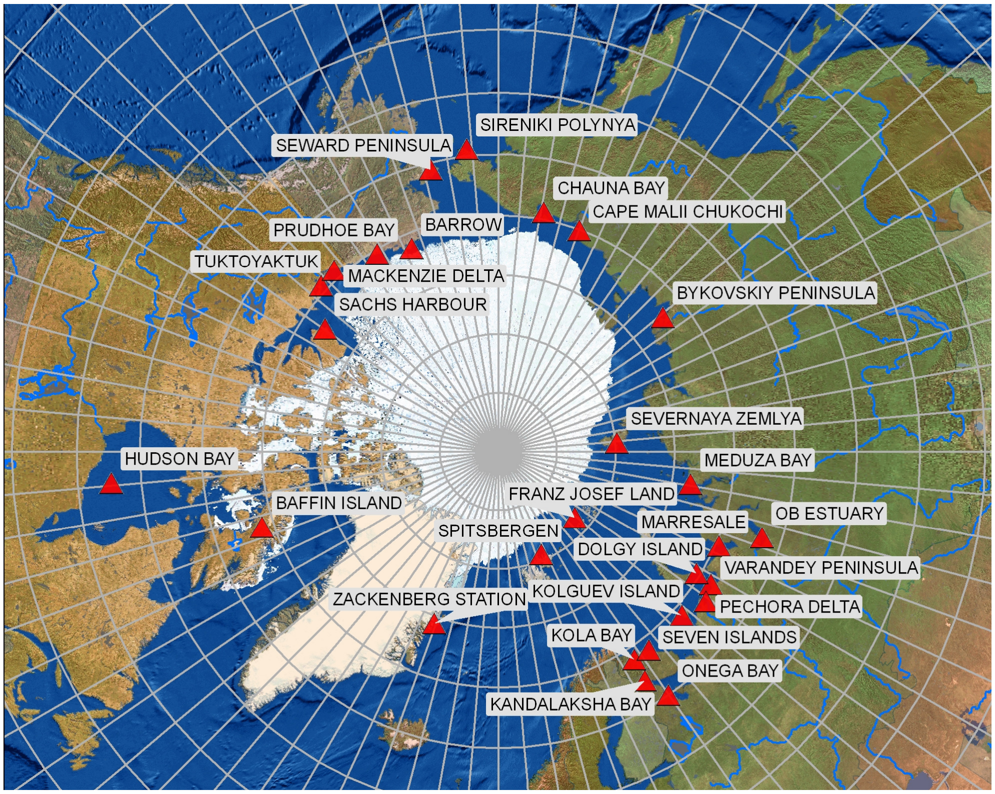

Figure 3.3. Potential observatory sites. Sites are designed to be representative of their surrounding region.

Step 2: Monitoring

Monitoring, which should involve observations, knowledge and expertise of local people, should include the following:

- physical data: environmental forcing (atmospheric and oceanographic), permafrost parameters (temperature, etc.), coastal morphology, sea-bed conditions, sea ice, seismicity, sedimentology, and chemistry;
- ecological data: change detection in habitats, changes in biodiversity, indicators of environmental quality, and validation and testing of ecological models; and
- cultural and socio-economical data: change in subsistence activities and/or harvests, industrial production and perspectives, dynamics of quality of life indicators, state of the local economy (resource base), population and demography (culture, migrations, local employment, living conditions), and interregional and global linkages.

Step 3: Data Analyses and Management

Data analyses and management needs associated with this ICARP II science plan include interaction with other international and national projects on data management and the involvement of local people in the analysis, product development, and data management decisions. These partnerships are an important mechanism for data interoperability and usefulness.

Site characterization and monitoring data should be cross-compatible with several types of analysis. These applications include: detection of change; improved understanding of coastal processes; identification of relations and interdependencies among physical, biological and ecological parameters (e.g., critical physical parameters responsible for biodiversity changes); known and potential impacts of natural changes on social systems; assessment of anthropogenic impacts on natural processes; and evaluation of effectiveness of coastal management, including management of resources and protected areas.

Current standards for scientific practice call for data to be collected, harmonized, synthesized, distributed, and archived in a manner which supports ISO metadata standards to promote data access and value; an international arctic spatial data infrastructure; internet accessible databases for GIS spatial data and linked site specific observations/measurements; and accessibility and usability by local communities. At present there is no such data management system for circumpolar community-based observations. Data management strategies for local and traditional knowledge and observations require development, together with appropriate standards and attention to associated issues such as intellectual property rights, appropriate access and use, and control over data.

Step 4: Synthesis

Synthesis, i.e., modeling and scenario development, should focus on the design of different levels of model (from conceptual to numerical) of interdependent physical, biological, social, and environmental changes in response to natural and human forcing, i.e., biodiversity assessments under different forcing scenarios; assessment of ecosystem potential for providing goods and services for society; assessments of the vulnerability and adaptive feedbacks in social systems to natural hazards; and development of response strategies.

The four steps will constitute an observatory for detecting and monitoring arctic coastal zone processes and events. Coordinating multiple sites allows for multiple spatial, temporal, and thematic scales to be integrated, bridging the current divide between circum-arctic and site-specific knowledge. Initial focus topics should simultaneously address:

- Baseline measures: information required to define and understand problems (coastal erosion state, greenhouse gas emission, habitat mapping, biodiversity parameters, human use and impacts, and socio-economic needs).
- Important problems: such as predicted conditions which may pose no immediate threat to the environment or society, but which without intervention will become the next emergencies. These focus topics include the determination of physical and ecological indicators useful for detecting and monitoring changes thought to be imminent stressors (e.g., hydrates, changes to near-coastal water structure, and marine ecosystems).
- Urgent problems: representing immediate and direct hazards – including short term prognosis for the impact of coastal erosion on property structure damage, the impact of coastal changes on local subsistence hunting and travel, the sensitivity of coastal habitats and human settlements to oil spills or heavy industrial activity, in particular development of the coastal infrastructure for increased oil and gas activities (terminals, pipelines, and liquefied natural gas plants).

Simultaneous focus on these three areas is designed to build knowledge of critical processes in the coastal zone, while at the same time applying best scientific practice and current knowledge to address immediate issues.

3.5. Linkages / Users

This ICARP II science plan is built upon and contributes to ongoing and planned arctic programs, such as IASC/IPA/LOICZ (International Arctic Science Committee/ International Permafrost Association/ Land-Ocean Interaction in the Coastal Zone), the IASC Arctic Coastal Dynamics (ACD) and IASC Arctic Coastal Biodiversity (ACBio) projects. Collaboration with related initiatives such as COMAAR (Coordination of Monitoring and Observation in the Arctic for Assessment and Research), CEON (Circum-Arctic Environmental Observatory Network), CAFF (Conservation of Arctic Flora and

Fauna) and the proposed U.S. National Science Foundation Arctic Observing Network will be emphasized. Table 3.1 presents a more complete list of linkages (with coastal programs italicized).

The suggested program seeks affiliation as a regional project consortium to the new IGBP/IHDP (International Geosphere-Biosphere Program/ International Human Dimensions Program) LOICZ II project through which a global interface for exchange and dissemination is provided including the IGOS (Integrated Global Observing Strategy) coastal theme and the human dimensions community. Data collection will involve local communities in the monitoring and young scientists and students in the fieldwork and analyses. Data dissemination will ensure data usability by local communities and the general public and will support decision-makers in developing response strategies. The project will benefit from LOICZ II's infrastructure for broad dissemination and communication of information.

Table 3.1. Potential Linkages.

- *Arctic Coastal Biodiversity (IASC-ACBio)*
- *Arctic Coastal Dynamics (IASC-ACD)*
- Arctic Monitoring and Assessment Program (AMAP)
- Canadian Arctic Shelf Exchange Study (CASES)
- *Canadian Arctic-Net*
- Carbon flux and ecosystem feed back in the northern Barents Sea in an era of climate change (CABANERA)
- Census of Marine Life (CoML)
- Circum-Arctic Observatory Network (CEON)
- Climate and Cryosphere (CliC)
- Conservation of Arctic Fauna and Flora (CAFF)
- Coordination of Monitoring and Observation in the Arctic for Assessment and Research (COMAAR)
- Cryospheric System (CRYSYS)
- Global Environmental Observing System (GEOS) (C-GOOS, GTOS)
- Global Terrestrial Network on Permafrost (GTN-P)
    - Circum-Polar Active-Layer Monitoring System (CALM)
    - Thermal State of Permafrost (TSP)
- *IGBP-LOICZ (Land-Ocean Interaction in the Coastal Zone)*
- *IPA Coastal and Offshore Permafrost WG (COP)*
- Land-Ocean Interactions in the Russian Arctic (LOIRA)
- Northern Eurasia Earth Science Partnership Initiative (NEESPI)
- *NSF-SNACS (Study of the North Alaska Coastal System)*
- *Russian-American Initiative in Land-Shelf Environments (RAISE)*
- *Russian-German Cooperation Permafrost Dynamics in the Laptev Sea*
- Study of Environmental Arctic Changes (SEARCH)
- *UNEP/GEF Projects, e.g. ECORA*
- UNESCO MAB Program on biosphere reserves/ areas
- Western Arctic Shelf-Basin Interactions (SBI)
- WWF
    - Arctic and coastal programs
        - Barents and Bering Ecoregion Conservation programs
        - Mackenzie Delta (WWF Canada)
        - WWF Arctic Program

The proposed activities must be closely linked to the other ICARP II science plans, in particular: Science Plan 1, Science Plan 2, Science Plan 6, Science Plan 7, Science Plan 8 and Science Plan 9.

3.6. Outcome / Achievements

The research perspectives and focused research questions highlighted in this ICARP II science plan, combined with the systematic approach and interdisciplinary linkages are designed to deliver a series of explicit outcomes and achievements:

- Decreased uncertainty about the functioning of biological and physical processes and resulting possible impacts on ecological and social systems.
- Data supply and support for ecoregion-based management.
- Scientific and local and traditional knowledge support for sustainable development.
- Data supply for decision-making support systems, for local communities (including education), for regional planning (including protected areas), environmental impact assessment, and the components of strategic environmental assessment.
- Improved linkage between scientific and local and traditional knowledge.
- Improved access to fundamental data for fine-grain coastal zone research.
- A basis for an improved circum-arctic coastal zone classification, including local observatory data for validation studies of coarse scale biodiversity and biological community models.
- Parameterizations of coastal input for general circulation models, regional climate models and ocean-coupled models such as greenhouse gas models.
- An international, circum-arctic coastal network monitoring key environmental variables in the context of ecosystems and quality of life for humans.
- Enhanced monitoring capacity – because measurements from different regional sites are standardized they can be readily compared.
- Information of importance for the Arctic Ocean as a whole, such as the distribution of nutrients, pollutants, and species migration patterns.

3.7. Implementation

The main objective of this ICARP II science plan is to establish an internationally coordinated network of coastal observatories. This needs to be done in consultation and coordination with local and indigenous communities and their international organizations (e.g., Inuit Circumpolar Conference). The establishment of the observatories and the maintenance of the monitoring program require general transport logistics to the key sites (helicopters, snow terrain vehicles, etc.) and logistic support to coordinate and build capacity for local observers. A suite of automatic monitoring equipment is envisioned, which requires onshore and offshore access including permafrost-drilling capability. A training program for local people to operate and maintain various monitoring equipment is also envisioned, along with a system for local people to input observations based on local and traditional knowledge and methods.

The overall program should be coordinated at the international level, whereas individual sites will be operated by national groups with international participation. Involvement of local residents should be integral to maintain year-round monitoring. Logistics depend on national policies and can be different for individual sites. Support can partly be provided by (or appended to) existing field stations. Sites will be selected to minimize logistical costs for remote locations.

A project office should be established with a secretariat to coordinate monitoring, data quality objectives and data management, and to maintain international communications. An international steering committee will assist the secretariat. The responsibilities of the international steering committee will be to oversee the general development of the program and the national activities, and to liaise and coordinate actively with other international organizations and programs. Annual meetings or workshops will be used to review progress and to modify the plan as required.

The coastal observatories will remain as a legacy for continuing monitoring within international, national, and community-based programs and management of coastal protected areas and multiple use areas. Involving local communities early in the process will help to ensure the prolongation of the infrastructure and the development of new observing networks/approaches such as coordinated observing efforts by local hunters or fishers using traditional skills. Satellite imagery will also provide a permanent record of coastal conditions for future change detection.

Based on this ICARP II science plan, an Expression of Intent proposing an internationally coordinated Arctic Circum-Polar Coastal Observatory Network (ACCO-Net) has been developed and submitted for the International Polar Year (IPY). This Expression of Intent has been selected as the IPY lead project for the cluster "Coasts and Margins – Arctic". The IPY will be an ideal opportunity to promote the scientific approach outlined in this science plan.

3.8. Funding

Funding will be mainly provided by national funding agencies (e.g., national government departments with legal mandates for coastal monitoring and management, the Canadian National Science and Engineering Research Council, the U.S. National Science Foundation, the Russian Foundation for Basic Research, or the Russian-German program "The Laptev Sea System"). European programs will also provide funding (e.g., the European Science Foundation; the International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union) and additional support by international organizations is anticipated (the International Arctic Science Committee, the International Permafrost Association, and the International Geosphere-Biosphere Program/ International Human Dimensions Program LOICZ II project, and the World Wildlife Fund). Aboriginal or private consortiums that have a stake in improving coastal understanding (e.g., the International Petroleum Industry Environmental Conservation Association (IPIECA) and the Bering Sea Fishermen alliance (food resources)) may also provide support.

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