

Proceedings of a Workshop on Coastal Impacts and Adaptation Related to Climate Change: the C-CIARN Coastal Node

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The coastal zone is recognized as a particularly sensitive environment to projected future climate change due to global warming. This includes sensitivity to increases in air, sea and ground temperatures; variations in the frequency of and intensity of storms; variations in sea and lake levels; variations in amounts, patterns, and styles of precipitation; and changes in sea ice extent, duration, and thickness; these changes are likely to affect coastal structures and a wide-variety of human activities. The special sensitivity of the coastal zone to climate change impacts has prompted the Government of Canada to establish a “Coastal Node” as part of the Canadian Climate Impact and Adaptation Network (C-CIARN). A workshop with a broad representation of stakeholders from all coastal regions of Canada was held in Dartmouth, Nova Scotia in March 2001 to outline the role of a “Coastal Node”, identify a range of sensitive coastal resources and associated climate change issues, and provide guidelines for research priorities; this report summarizes the results of that workshop.

C-CIARN

The discussion of the C-CIARN Coastal Node was predicated on the understanding that Natural Resources Canada (NRCan) would provide some funding for a Coastal Node Coordinator, who would constitute the Secretariat. The workshop considered the integration of the node function with one or more of the regional nodes or with the fisheries node. While integration with regional nodes where coastal issues comprise a large portion of the climate change concern (e.g., Atlantic and Northern regions) is logical, exclusively urban concerns may significantly overshadow coastal issues in other regions (e.g., West Coast and Great Lakes). Similarly, the combination of the Coastal and Fisheries nodes is logical as there is significant overlap in the ecosystems of interest to each; however, participants voiced the concern that “coastal issues” would be over-shadowed by focus on “fisheries management issues” (e.g., forecast of Total Allowable Catch). While the workshop generally resisted the concept of a combined Coastal and Fisheries Node, it is recommended that some Steering Committee Members be cross-appointed, that research frameworks be coordinated, and that co-hosting of different nodes at the same institution be considered.

In terms of function, the C-CIARN Node would serve a communication role between coastal stakeholders and other ongoing efforts in climate change research (e.g., other regional or international programs, other nodes). This communication role would include the coordinator attending other node meetings to monitor research and to promote coastal issues, and discussing research priorities with stakeholders on an ongoing basis. Special effort should be directed to communication with stakeholders that are not represented in professional or scientific communities (e.g., Canadian Federation of Municipalities, First Nations, insurance industry); existing networks or hubs should be used as much as possible (e.g., coastal community networks). It was also recommended that the C-CIARN node act as a linkage or contact point for coastal climate change queries (e.g., Coastal_climate_change.ca; 1-800-COASTS). While the regional location of the Secretariat was contentious, most participants felt that the dynamic, pro-active, multi-disciplinary and nationally-focused qualities of the individual selected as the coordinator were more important than location. Participants also indicated that the Secretariat

should be located in an organization with a strong coastal and climate research program. A portion of the participants indicated a preference for a Secretariat located outside of a government office.

Assessment of Climate Change Coastal Research

A wide range of potential climate change impacts were reviewed in the Scoping Study for the Workshop (Appendix F; Rolston 2001) and during the workshop. These involved both *direct* impacts on coastal infrastructure or human-use activities as well as *indirect* impacts that might result from ecosystem change. Participants were reluctant to rank research priorities although general criteria were developed:

research priorities are regionally dependent – the marine and coastal environments for each of Canada’s four major regions are significantly different in terms of: existing environmental processes, climate change scenarios and regulatory regimes (e.g., provincial jurisdictions) for instituting adaptation.

multi-disciplinary research is needed – projects that involve a combination of physical, biological and social sciences are required to ensure that science results are relevant to and incorporated into public policy (e.g., the CCAF-sponsored PEI coastal impacts project). Research should consider both *direct* effects of climate change (e.g., reduction of tourism due to increased precipitation), as well as *indirect* effects as a result of ecosystem change (e.g., reduction in tourism due to reduced recreational fishing opportunities).

outreach is part of the project – outreach or communications must be included in the project design to ensure that scientific information about climate change reaches policy makers, regulators, politicians and the Canadian public. Adaptation will not occur unless information about climate change reaches policy-makers and those outside the scientific community.

extreme events – coastal and nearshore ecosystems are commonly driven by infrequent, high energy events (e.g., storm waves, storm surges, extensive open-water seasons, floods from stream runoff and nutrient pulses). It is therefore important to incorporate extreme events into analyses of climate-change impacts for realistic prediction of coastal change and its implications.

long-term, time-series data are extremely important – quantitative, instrument-recorded data are essential to climate change prediction and documentation of coastal climate change impacts. Many environmental monitoring networks have been severely reduced over the last decade with significant reductions in runoff, water level, and wave measurement programs (e.g., there are no tide-recording stations left in the arctic). High resolution data collected during the most recent period of change are essential for defining trends. These data should be considered a fundamental resource inventory program (like topographic mapping) and CCAF should provide resources and lobby strongly to have essential monitoring re-established immediately with appropriate resources to sustain key monitoring functions in the long term.

Case Studies

Because the climate change framework was judged to be fundamentally different for each coastal region, it is recommended that a series of case studies be considered as the initial research priority - one for each of the major coastal regions of Canada. Research priorities for each region could be delineated through separate regional workshops, a systematic regional survey or could be required as part of proponents proposals (justification of research).

In addition to the general above-listed guidelines, some additional criteria are suggested for case studies:

research that will show demonstrable results in the short term are preferable. This will assist in the establishment of climate change credibility. News articles are still appearing in the media questioning predictions of climate change, an artifact of “over-selling” during the previous decade. Projects that generate data showing credible trends are essential and may be achieved in part through examination of existing data.

research showing clear linkages to climate change is preferable. Projects that unambiguously link coastal change to climate change are important in the establishment of credibility. These will assist in the establishment of climate change awareness, including wider understanding of the need for adaptation in the coastal zone.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	2
TABLE OF CONTENTS	5
1.0 INTRODUCTION	
1.1 Overview of C-CIARN	6
1.2 Objectives of Workshop	7
1.3 Organization of Workshop.....	7
1.4 Representation of Coastal Stakeholders	7
2.0 C-CIARN NODE DESCRIPTION	
2.1 Rationale for a Coastal Node	8
2.2 Functions of a Coastal Node	8
2.3 Location of a Coastal Node.....	9
2.4 Coordinator of a Coastal Node.....	9
2.5 Steering Committee for a Coastal Node	10
3.0 REVIEW OF COASTAL RESOURCE SENSITIVE TO CLIMATE CHANGE	
3.1 Classification of Coastal Climate Change (CCC) Issues	11
3.2 Categorization of CCC Issues by Region	12
4.0 RESEARCH PRIORITIES	
4.1 General.....	13
4.2 Case Studies/Demonstration Projects.....	14
5.0 REFERENCES	16
APPENDICES	
A – Participant List	17
B – Poster Abstracts	22
C – Summary of Breakout Session One	31
D – Summary of Breakout Session Two	34
E – Acronyms.....	38
F – Workshop Scoping Report (Rolston 2001)	41

[cover photo compliments of: Don Forbes]

1.1 Overview of C-CIARN

Climate Change Impacts and Adaptation (I&A) research is a relatively new field of study. It is predicated on understanding and accepting that our climate is in fact changing and that there will be impacts as change occurs. We need to adapt both to minimize the potential impacts and to maximize the potential gains. A pro-active approach is required. However, until 1998, adaptation was not widely accepted as either an issue or a need in Canada.

Earlier I&A research focused largely upon the primary impacts of climate change. Where it was carried out, researchers and stakeholders would come together to address a specific I&A project, but the connections would fade as the project ended. Now, researchers recognize the need to have ongoing stakeholder involvement that extends well beyond the scope of any one project.

It was also noted at workshops and other fora that a continuous interaction between scientists involved in these impacts and adaptation studies would be helpful. It was also identified that there was a need to formalize or raise the visibility of this research community so that it could more effectively interact both internally and with other groups such as the climate science community, planners, design engineers etc.

The Objectives of C-CIARN Program are:

1. To contribute to the coordination and interaction of the impacts and adaptation research community to provide greater visibility and understanding of the issues and needs.
2. To provide a mechanism for stakeholder involvement in impacts and adaptation research and in developing research priorities.
3. To provide a source of information on I&A research to communities, governments, business and industry.
4. To involve a broader range of researchers in this area in order to increase the climate change impacts and adaptation research capacity in Canada.
5. To assist in coordination of climate change vulnerability assessments.

The process of establishing C-CIARN began in 1999. Initially, the network will be comprised of six regional and eight sectoral nodes (right).

C-CIARN Nodes

Sectoral	Regional
Agriculture	British Columbia
Coastal Zone	Prairies
Communities	Ontario
Fisheries	Quebec
Forestry	Atlantic
Health	Northern Territories
Landscape	
Water Resources	

1.2 Objectives of Coastal Zone Node Workshop

The objectives of the Coastal Node Workshop were:

1. to present the results of the scoping study (Appendix F; Rolston 2001) and refine it based on workshop discussions.
2. to identify deficiencies in climate change information and delivery to users, and identify strategies to address these deficiencies.
3. to identify and prioritize deficiencies in our understanding of coastal processes at middle to high latitudes that constrain our ability to predict climate change impact and adaptation strategies.
4. to define the role of a C-CIARN Coastal Node in implementing recommendations.

1.3 Organization of Workshop

The organization of the workshop is shown in Table 1. A major snow storm occurred on 6 March forcing closure of Bedford Institute of Oceanography and early closure of the workshop.

1.4 Representation of Coastal Stakeholders

A total of 46 individuals attended the workshop (Appendix A) with strong Atlantic region and professional scientist participation and some municipal politicians, hunter/trapper representatives, and NGO's. There were few biological and social scientists at the workshop.

Table 1 Organization of Workshop

<u>5 March</u>	
Plenary Session	Introduction to C-CIARN – Eric Taylor (C-CIARN Secretariat) Keynote Speech on Climate Change Science and Scenarios – Gary Lines (Environment Canada) Panel Discussion on Regional Impacts and Adaptation Issues Summary of the Scoping Document – John Harper (Coastal & Ocean Resources Inc.) East Coast – Don Forbes (Geological Survey of Canada) West Coast - Vaughn Barrie (Geological Survey of Canada) Great Lakes – Robin Davidson-Arnott (University of Guelph) North – Norm Snow (Joint Secretariat) Steve Solomon (Geological Survey of Canada)
Poster Session (over lunch)	
Breakout Session I – Stakeholder I&A Needs and Research Requirements	Groups discussed the coastal scoping study report and identified gaps/deficiencies in the report in terms of stakeholder information needs, presently available information and Canadian projects which have been undertaken to address coastal I&A issues.
Plenary Summary on Breakout Session I –	Improved list of stakeholder needs and Canadian coastal I&A research projects and results.
Poster Session	
<u>6 March</u>	
Plenary: Role of CCIARN Coastal Node	Communication between info users and providers and the role of a C-CIARN coastal node. This session addressed mechanisms to involve stakeholders on all four coastal regions in the process of identifying and prioritizing impacts and adaptation information needs and also discussed ways to improve the communication of research results to coastal stakeholders.
Breakout Session 2 – Regional Issues	In that participants felt research priorities were unique to each region, regionally-focused break-out groups discussed possibilities for case studies within each region.
Plenary Session – Summary of Regional Issues	[Early closure of workshop]

2.1 Rationale for a Coastal Node

There are a number of potentially direct impacts of climate change to coastal environment and infrastructure, such as those resulting from sea level rise and indirect impacts of climate change through ecosystem changes, such as changes to coastal tourism patterns due to changes in temperature and precipitation. The coastal zone is considered uniquely vulnerable in its position at the land-sea interface to small changes in sea or lake levels, changes in wave climate and changes in storm-surge potential.

The workshop discussed whether there is a need for a coastal node and whether the function could be incorporated within other sectoral nodes or within regional nodes. It was noted that the *coastal node* and *fisheries node* address many of the same ecosystems and for this reason combining these nodes could be considered. However, the impacts and adaptation strategies focus on different regulatory regimes (e.g., coastal land-use planning versus fisheries management); so even though the same ecosystem is being effected (i.e., the coastal and shelf ecosystem), the adaptation strategies for accommodation of ecosystem change will be quite different. Since the development of adaptation strategies is a key component of the C-CIARN program, there was a participant preference for separate fisheries and coastal nodes.

***Recommendation** – Coastal and Fisheries Nodes should be separate but closely linked through cross-appointment of Steering Committee members. The Coastal and Fisheries Nodes should promote integrated approaches to ecosystem monitoring and adaptation strategies (i.e., avoid the “stove-pipe mentality” of managing change for a single resource).*

Combination of the Coastal and Regional Nodes was also discussed. While this approach is logical for some regions where there is a strong coastal community voice (e.g., Atlantic and Northern Regions), there was concern that coastal issues could be overshadowed by urban issues in more populous, urbanized regions (e.g., Great Lakes). It is important that Coastal and Regional node programs be coordinated and cross-appointed Steering Committee members should be considered.

2.2 Functions of a Coastal Node

Many of the functions of the Coastal Node Secretariat are outlined in the C-CIARN mandate. The main goal of the Secretariat will be in communication, networking and facilitation. Some of the key functions identified at the workshop are:

- the Secretariat would act as a point contact or clearing house for stakeholders wanting information of coastal climate change. This could take the form as a web site with links or a “1-800-COASTS” type of approach.

- the Secretariat should track research in Canadian *and* other international programs of interest. Of particular importance would be bridging with other C-CIARN Nodes.
- the Secretariat should have an outreach component that reaches non-scientific stakeholders such as the Canadian Federation of Municipalities, politicians and insurance community.
- the Secretariat should take advantage of existing coastal community networks to disseminate information
- the Secretariat would have a multi-targeted promotional role including: (a) lobbying for enhanced temporal and geospatial data collection network and free data dissemination (i.e. elimination of existing “cost recovery approach of Federal and Provincial Agencies) (b) lobbying for ongoing coastal monitoring, (c) promotion of coastal research priorities to research funding agencies and (d) “upward” delivery of information (i.e., getting information to policy-makers).
- the Secretariat should be pro-active in organizing workshops that piggy-back on other meetings.

2.3 Location of a Coastal Node

The location of the Coastal Node was regionally contentious and no agreement was reached about possible sites for a Coastal Node Secretariat. It was felt that the individual selected to coordinate the Coastal Node was much more important than the location of the Secretariat (see suggested qualifications below). Participants also indicated that the Secretariat be located in an organization with a strong coastal and climate research program.

The relative merits of a government or university location for a Coastal Node Secretariat were discussed. Location of a Secretariat within an institution that has strong existing coastal expertise would be beneficial in providing additional depth of to the Coastal Node Secretariat. Some participants suggested that a university location would be more independent from federal department mandates and initiatives.

2.4 Coordinator of a Coastal Node

The Coordinator of a Coastal Node Secretariat was considered more important than the Secretariat location to the ultimate success of the program. The individual should have a broad-based background with a track-record of discipline bridging. A dynamic, pro-active individual was considered key to promoting coastal change climate issues within the research community and to other C-CIARN nodes and stakeholders.

***Recommendation** – C-CIARN solicit proposals for operation of a Coastal Node Secretariat and that as part of the solicitation, proponents would identify the*

individual(s) that would meet the above-listed criteria (this might require re-location).

2.5 Steering Committee for a Coastal Node

The Steering Committee needs to have representation of coastal stakeholders while being small enough to be effective. The representation must accommodate regional representations and coastal sectoral representation (e.g., physical scientists/engineering, ecologists, planners, social scientists). If an eight to ten member committee is a target, members will have to wear multiple hats to achieve broad representation; individuals with a history of multidisciplinary studies and integrated coastal zone management will be key to the success of the program. At least one steering committee member should be cross-appointed to the Fisheries Node Steering Committee.

Recommendation – *the Steering Committee for the Coastal Node incorporate a broad representation of coastal stakeholders including regional representatives, physical, biological and social scientists and coastal community representatives.*

3.0 REVIEW OF COASTAL RESOURCES SENSITIVE TO CLIMATE CHANGE

3.1 Classification of Coastal Climate Change (CCC) Issues

The Scoping Report (Appendix F; Rolston 2001) that was prepared in preparation for the workshop outlined a large number of climate change impacts and potential adaptation strategies (approximately 10 pages). It is useful to categorize these impacts in terms of two conceptual classifications (Table 2).

Table 2 Conceptual Types of Climate Change Impacts

<i>Impact Affects</i>	Impacts on Coastal Infrastructure – impacts on coastal structures or land-use, including fishing harbours, larger ports, navigational aids, commercial plants, bridges, coastal protection structures, residences farmland and parks.	Impacts on Human-Use Activities – impacts on human activities that take place in the coastal zone, including subsistence activities, commercial harvesting activities (e.g., aquaculture and commercial fisheries), transportation and tourism.
<i>Impact Linkages</i>	Direct Impacts of Climate Change – change in coastal climate will directly impact an infrastructure or activity (e.g., an increase in precipitation will cause a decrease in tourist activities).	Indirect Impacts of Climate Change – a change in coastal climate will alter the coastal ecosystem that will in turn affect may human-use activities (e.g., an increase in precipitation and freshwater runoff will alter estuarine stratification, potentially reducing salmon productivity which in turn affects recreational fishery potential).

It is natural to focus on the *direct impacts* of climate change on fixed structures (e.g., sea level rise causing increased coastal flooding) as the forcing process, linkages, impacts and adaptation strategies are fairly obvious (e.g., land-use planning for flood zones). It is much more difficult to focus on *indirect impacts* to human-use activities that are likely to occur through ecosystem change (e.g., changes in fisheries abundance). The linkages are not as clear; there may be many other anthropogenic factors that complicate the interpretation of the impact (e.g., commercial fishing) and the appropriate adaptation strategy is not as obvious. Coastal tourism, which generates enormous revenues for coastal communities throughout Canada, will likely be impacted both *directly* and *indirectly* by climatic change; there will be multiple impacts, some of which may be considered positive (e.g., warmer water) and some negative (e.g., more precipitation). The point is that linkages between climate forcing and a specific resource or human-use activity, are extremely complex; it is likely that for most coastal resources and activities, there will be a cumulative impact involving a multitude of linkages.

3.2 Categorization of Coastal Climate Change Issues by Region

In addition to the Workshop Scoping Report (Appendix F; Rolston 2001) which identified types of climate change and associated impacts, additional coastal zone change and adaptation issues were reviewed during the introductory plenary panel discussions (Table 1). A very abbreviated summary of the predicted climate changes and *key* issues by region is presented in Table 3.

Table 3 Summary of Climate Change Scenarios and Issues from Panel Presentations

Region	Climate Change Scenarios	Key Issues of Concern
Atlantic (Forbes)	<input type="checkbox"/> sea level rise <input type="checkbox"/> increased storms <input type="checkbox"/> changes in sea ice distribution <input type="checkbox"/> air temperature increase? <input type="checkbox"/> sea temperature increase?	<ul style="list-style-type: none"> • increase in coastal flooding due to storm surges and sea level rise • increase in wave exposure from greater storm frequency and decreases in ice cover • accelerated coastal erosion and tidal inlet destabilization • loss of wetland where landward transgression is blocked • saline groundwater intrusion • uncertain impacts on coastal dune systems
Great Lakes (Davidson -Arnett)	<input type="checkbox"/> decreased Lake levels <input type="checkbox"/> decrease in seasonal ice <input type="checkbox"/> increased temperatures <input type="checkbox"/> increased Lake temperatures	<ul style="list-style-type: none"> • shoaling of ports and harbours • increased exposure of shorelines to wave energy with reduced ice cover and increased storm intensity • changes in Lake stratification • changes in wetland distribution and associated impacts on flora and fauna • impacts of altered hydrological regimes on the flows between connecting channels and in the St. Lawrence River system
North (Snow & Solomon)	<input type="checkbox"/> sea level rise <input type="checkbox"/> dramatic changes in sea and ground ice <input type="checkbox"/> air temperature change <input type="checkbox"/> sea temperature change <input type="checkbox"/> increase in storms <input type="checkbox"/> precipitation increase	<ul style="list-style-type: none"> • coastal flooding increase due to sea level rise and storm surge increase • increased wave exposure due to substantially large fetch • changes in coastal habitat for subsistence species • traditional transportation routes lost (e.g., ice travel) • dramatically increased coastal erosion due to thermal sensitivity of permafrost, increased wave exposure and sea level rise • increased river flooding (Mackenzie) associated with precipitation increase and thaw subsidence • changes in shipping due to greater open water
Pacific (Barrie)	<input type="checkbox"/> sea level rise <input type="checkbox"/> precipitation increase <input type="checkbox"/> air temperature increase <input type="checkbox"/> sea temperature increase <input type="checkbox"/> increase in storms	<ul style="list-style-type: none"> • flood hazard of lowland areas due to sea level rise and storm surge increase • changes in regional circulation patterns (e.g., ENSO) • changes in Strait of Georgia circulation (and other estuaries) • accelerated erosion of soft-sediment coasts

As was noted during the discussions, many of the impacts may be difficult to assess because of existing and on-going anthropogenic changes to the coastal zone, ranging from disturbance of watersheds (e.g., dams) to introduction of zebra mussels in the Great Lakes to destruction of wetlands.

4.1 General

Regionalization of Issues

A number of break-out sessions were held to attempt prioritization of research related to coastal climate change. In almost all cases, participants were reluctant to prioritize specific research issues. Most participants felt that the issues varied widely among Canada's coastal regions and that comparison of issues between regions was not possible. In hindsight, it was recognized that the prioritization issue is difficult because climate change scenarios are different for each region (e.g., water levels are predicted to drop in the Great Lakes) and the regulatory and policy framework that is required for adaptive change, varies from province to province.

***Recommendation:** coastal climate change research priorities should be established separately for each region as the climate change scenarios vary markedly among regions and the regulatory and policy framework for implementation of adaptive change varies from province to province.*

Time Series Monitoring

Each of the breakout groups noted that times series data is extremely important for change detection but that many monitoring stations have been discontinued over the last decade - an important example is the discontinuation of tide-recording stations in the Canadian Arctic. The removal of these tide-gauge stations results in data gaps in the most recent ten years of data – **exactly where change detection is most critical.**

***Recommendation:** the climate change program should strongly support and lobby for renewal and strengthening of critical environmental monitoring programs and free dissemination of climatic and geospatial data.. Collection of monitoring data should be considered a core inventory function, similar to the collection of air photos, topographic mapping or seabed charting.*

Communication of Results

It was noted that research needs to involve more than hard science. If the science is not communicated appropriately, policy will not be changed and transitional adaptation will not occur. Participants noted that research programs must be accompanied by an outreach program that includes an effective communication plan and pro-active promotion of information to policy-makers and the general public. The PEI Coastal Impacts Assessment Project was identified as a program that involved collection of critical scientific data, development of maps and products that clearly related flood and erosion hazard to individual property owners, and articulated possible adaptation strategies such as zoning.

***Recommendation:** research proposals should be accompanied by outreach plans – plans for communicating results to coastal zone users and policy makers that are not likely to be familiar with scientific terminology or literature. Where*

possible, researchers should take advantage of existing networks (e.g., the coastal community network) and public awareness programs.

Extreme Events

Extreme events play a huge role in shaping the coastline and affecting coastal processes. Most sediment transport along the coast is associated with a few episodic high energy events each year. Storm surge is strongly related to extreme wind events. Design criteria for most coastal structures are strongly dictated by storm-wave and storm-surge estimates. For these reasons, coastal researchers are strongly interested in changes in storm patterns and frequencies that are hypothesized in most climate change scenarios. That is, are storms likely to be more or less frequent, more seasonally dependent; is the storm path likely to change so that storm winds are altered (e.g., will tropical storms at hurricane strength make landfall in Atlantic Canada more frequently?).

Recommendation: *climate change model grids and scenarios must be refined to quantify coastal storm characteristics as these are extremely important to predicting potential changes in coastal wave climate, coastal sediment transport, coastal erosion/accretion, and coastal storm surges.*

Multidisciplinary Research

A number of breakout groups noted that an ecosystem-type focus is important to research efforts. While there are clearly direct impacts of climate change on coastal environment and infrastructure and activities (e.g., sea level rise on coastal infrastructure), there will be *many* indirect impacts that will pass through the ecosystem (e.g., the effect of reduced fishing opportunity on coastal tourism). That is, there will be a number of climate-change impacts on the coastal ecosystem (e.g., changes in air and water temperatures, changes in freshwater runoff, changes in storm frequency) that will drastically influence human-use activities in the coastal zone (e.g., changes in aquaculture potential and subsistence hunting activities). In addition, climate change impacts on coastal ecosystems may be difficult to separate from anthropogenic impacts on coastal ecosystems (e.g., introduction of zebra mussels into the Great Lakes).

Impact scenarios for specific infrastructures or human-use activities must consider the cumulative impact of direct and indirect stresses.

Recommendation: *climate change research should consider impacts within a holistic, multidisciplinary framework, recognizing that there will be multiple impacts of climate change on both coastal infrastructure and human activities (e.g., the productivity of a coastal lagoon may be altered by changes in flushing as a result of tidal inlet dynamics, by changes in precipitation and freshwater runoff, by changes in predator-prey relationships due to introduction of new species and by changes in commercial harvesting patterns).*

4.2 Case Studies/Demonstration Projects

Participants noted that there is still much skepticism about climate change effects within the general public, partly due to the “overselling” of climate change impacts over the last decade. A recent copy of the Halifax newspaper was shown with the headline “University Professor

Rebukes Climate Change Theories”. Part of the article focused on previously predicted sea level changes of +6m over the next century.

Participants noted that it was very important the proposed research address topics that could produce clearly demonstrable results over the short term. The PEI Coastal Impacts Project was identified as a possible template because the results directly linked climate change effects to land-owners and municipalities. The project required only a few years of research to produce tangible results that can be translated directly into adaptive land-use policies.

Participants also noted that research priorities or issues would vary region by region (see Section 4.1) and that a number of demonstration projects or case studies be implemented in each of the regions.

***Recommendation:** the Coastal Node of C-CIARN advocate for a series of regional case studies or research that provides a clear demonstration of climate change impacts on the coastal zone. Case studies should focus on relevant regional issues that incorporate sensitivity to change as well as the potential degree of socioeconomic impact.*

Some types of potential case studies were identified during the Breakout Session 2; however, several of these groups were very small (3-4 individuals) and lacked adequate regional representation of stakeholder groups. Summaries of the discussions are included in Appendix D and may be useful in the development of a regional coastal climate change priorities. However, because of the early closure of the workshop, the regional case studies were not discussed in a plenary session.

In terms of a process for implementation of case studies, the C-CIARN coastal node could proceed with the following options:

- attempt to develop a regional framework for research priorities related to coastal change, either through a review within the region or a regional workshop,
- solicit regional research proposals based on the general guidelines outlined in this report and select the proposal(s) that best address regional issues. This process would place much of the onus on the proponents for justification of their research.

5.0 REFERENCES

[note all regional and sectoral node reports available at the C-CIARN Web site]

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APPENDIX A
Participant List and Steering Committee List

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REPRESENTATION

Total on Committee:	10
Physical Scientists:	8
Biological Scientists:	1
Social Scientists:	1

REGIONS

BC	1
Great Lakes	2
Atlantic	5
North	1
Other	1

APPENDIX B
Abstract of Posters Presented at the Coastal Node Workshop

Modelling Lake Huron Shoreline Change at Goderich, Ontario

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Abstract

Climate change could have a significant long-term impact on water levels in the Great Lakes. Recent research has indicated that water levels are projected to decline toward the end of this century. To date, little research has focused on the potential impact this change may have on the socioeconomic and biophysical systems of the Lake Huron shore. This poster outlines a methodology to assess and quantify the potential impact of declining water levels on the Lake Huron shoreline at Goderich, Ontario. The methodology utilizes a geographic information system (GIS) to combine topographic and bathymetric data sets. A continuous digital elevation surface of the shore and nearshore areas is produced upon which projected water levels derived from hydrologic and general circulation model (GCM) output are plotted. By creating a series of hypothetical shorelines at Goderich, a range of sensitivities, impacts and costs can be identified for the Goderich Harbour and adjacent marinas. The model is validated by comparison with observed and recorded water level data as well as historical aerial photography corresponding to current and record low water level conditions. The shoreline model is used to provide initial estimates of the potential impacts of climate change and is envisioned as a planning tool for local decision and policy makers. The methodology could be expanded to explore the implications of changes in climate and water levels on other Lake Huron and Great Lakes coastal communities.

Climate Change and Conservation of Coastal Wildlife Habitat in Atlantic Canada

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Abstract

The coastline of Atlantic Canada is home to many species of migratory birds. Historically, coastal wildlife habitat was lost as a result of conversion of salt marshes to agricultural lands. Upwards of 85 % of salt marshes in the Upper Bay of Fundy have been drained.

Recently, coastal wildlife habitat has been destroyed and degraded through the construction of roads, cottages, and recreational developments. With an aging population in Canada, there is an increasing prevalence of year-round residences being constructed in the coastal zone.

Coastal habitats are dynamic, and wildlife species have adapted to annual variation in habitat availability. However, the rate of sea-level rise associated with climate change, and the existence of human structures may result in net losses of wildlife habitat for certain species. Efforts to conserve wildlife will only be successful in the long-term, by understanding how climate change induced sea-level rise, and increased storm frequency, will affect the abundance and distribution of coastal wildlife habitat.

The Canadian Wildlife Service, and its partners, have many ongoing population monitoring programs for migratory birds. CWS researchers are developing habitat suitability models for species that are most vulnerable to changes in habitat availability. These models can be used to develop coastal habitat conservation and restoration priorities for Atlantic Canada in response to development pressure and climate change.

Many different species of migratory birds inhabit a variety of habitats within the coastal zone. These habitats may be affected in a variety of ways by changes in climate.

Colonial Nesting Seabirds (Auks)

Many species of seabirds are pelagic, spending much of the year on the open seas, coming ashore only to breed. The timing of breeding by seabirds coincides with a local abundance of spawning fish. Timing of breeding in seabirds is controlled by photo period, and the requirement for nestlings to fledge and gain independence before the end of summer. Spawning in fish is proximally determined by water temperature. Climate change may result in a decoupling between the timing of breeding of seabirds and maximum abundance of food supplies, with resulting lower food availability reducing seabird breeding success.

Inter-Tidal Shorebirds (Sandpipers)

The Upper Bay of Fundy is internationally recognized for its importance to migrating shorebirds. Roughly 90% of the world's population of Semipalmated Sandpipers rely on the mudflats of the Chignecto and Minas Basins to fuel their migration to South America. Changes in sea-level could adversely affect the extent and nature of these mudflats and the abundance of the mud-shrimp, *Corophium volutator*, which is the sandpipers main food source.

Beach Shorebirds (Plovers)

Undisturbed beach habitat is a limiting factor for many species of shorebirds. The Piping Plover, which is listed as an Endangered Species, is perhaps the most well-known example. Nesting between the surf's edge and vegetated dunes, the Piping Plover relies on a narrow strip of habitat. Summer storms can destroy most nests in certain years. Loss of habitat and increased frequency of severe storms during nesting season, would be critical for this species which is on the brink of extinction.

Wading Shorebirds (Willetts, Yellowlegs)

The barachois ponds that form on the landward side of dunes, and the saline ponds associated with salt marshes, are habitat for many species of wading shorebirds. The Willet breeds in Atlantic Canada and requires ponds with water depths less than 10 cm, as well as adjacent grassy areas for nesting. Increased sea-level could result in habitat loss.

Salt Marsh Passerines (Nelson's Sharp-tailed Sparrow)

The salt marshes of eastern Canada are the original prairies of North America. These grasslands are important coastal ecosystem components because of their high rates of primary productivity and role as fish habitat. There are also many species of migratory birds that use salt marshes. In Atlantic Canada, Nelson's Sharp-tailed Sparrow is heavily dependent on salt marsh habitat. Being a ground nesting species it requires areas of upper marsh (*Spartina patens*) in which to nest as well as lower salt marsh (*Spartina alterniflora*) where it feeds in the wrack. The existence of cottages, breakwaters, and roads adjacent to salt marshes may mean that salt marshes will not be able to migrate inland in response to sea-level rise.

Newly-Discovered Evidence of Mid-early Holocene Climate-Induced Closed Low Water Levels in the Great Lakes

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Abstract

Recent interpretation of submerged paleo-shore features and tree stumps in growth position (7490±80 and 8560±70 radiocarbon years BP) suggest that lakes in the Erie and Huron-Georgian Bay basins were below their outlet sills for periods of several centuries during late glacial and early post-glacial times. An unconformity in lakebed sediments representing non-deposition at least 7600-7900 years BP, paleo-beach ridges now submerged 52 m, and the above tree stumps submerged 3 m and 18 m respectively demarcate former low-stands in the Georgian Bay and Huron basins. Channels down the face of the submerged Niagara Escarpment between Bruce Peninsula and Manitoulin Island likely represent erosion by periodic overflows of the low lake phases. A low-stand in eastern Lake Erie is indicated by a mud-buried paleo-beach and shoreface 21-27 m below present lake level.

A plot of water level changes in the Lake Huron-Georgian Bay basin interpreted from all available lake surface indicators reveals three periods of low lake levels (about 10,000, 9300-9100, and 7900-7600 radiocarbon years BP) when upstream glacial Lake Agassiz discharge from northwestern Ontario and Manitoba was blocked or diverted away from the Great Lakes basins. The low-stands are progressively lower relative to the basin rim with time, and by the 7900-7600 BP period are up to 30-40 m below the sill of the lowest possible outlet. Without overflow the lakes were hydrologically closed as a result of enhanced evaporation and/or reduced precipitation and runoff in a dry climate. By removing the effects of glacio-isostatic crustal warping, the Ontario, Erie and Huron basins were restored to their original topographic/ bathymetric configuration at 7600 years BP. The shorelines of the reconstructed low-stands are offset kilometres to 10s of kilometres offshore from positions they would have taken if the lakes had been overflowing their outlets.

These observations are significant for portraying natural past examples of the impact of a dry climate, not recognized previously, on these large lakes. With additional research of sedimentary proxy climate records, it should be feasible to quantify the hydro-climate parameters responsible for these past episodes of dry-climate effect. In the context of anticipated global warming and climate change, these past effects could become useful benchmarks for testing regional climate models and for illustrating extreme dry-climate impacts.

Shoreline Erosion and Climate Change in the Beaufort Sea

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Abstract

Coastal erosion occurs along the Beaufort Sea due to the interaction of rising sea level, storms and sea ice with the geology and morphology of the shoreline. Storms produce high waves and elevated water levels, the combination of which causes beach overwash and cliff retreat. Retreat occurs rapidly along the Beaufort Sea due to the presence of ice-bonded, but unconsolidated sediments and massive ice in coastal bluffs, a characteristic unique to Arctic shorelines. The presence of sea-ice from October to June is also unique to high latitude shores. The complete ice cover for three-quarters of the year reduces or eliminates the impacts of waves and surges. Historical wind records at Pelly Island and Tuktoyaktuk show that storminess has been variable since 1958 and increased after 1993. Sea level is, according to the Tuktoyaktuk tide gauge (now inactive), rising at 3 mm/a, a rate that is comparable to geological estimates and to global eustatic rates. Predictions of future sea level rise under climate change are poorly constrained. Historical sea-ice data appears to show a trend towards lengthening of the open water season. Warming in the Arctic due to climate change is likely to cause increased active layer thickness and permafrost warming which would reduce the strength of coastal cliffs and increase thermokarst activity, accelerated sea-level rise, increased storminess, and reduced extent of sea ice. The combination of these is expected to cause accelerated coastal retreat. Research is continuing into the development of historical time series of retreat rates at monitoring sites, the impacts of individual storms on Arctic shorelines, unique aspects of coastal processes in high latitudes and the impacts of changing climate on storminess, sea level, and ice extent in the Beaufort Sea.

COASTAL IMPACTS OF CLIMATE CHANGE ON PRINCE EDWARD ISLAND

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Extended Abstract

This multidisciplinary study of climate-change impacts on the coast of Prince Edward Island focuses on two contrasting coastal settings – the City of Charlottetown and the central North Shore – chosen to represent the major environmental issues involving sea-level rise, storm-surge flooding, changes in sea ice, coastal erosion and a mix of rural and urban socioeconomic contexts. The choice of project area was influenced by results of a national coastal sensitivity assessment (Shaw *et al.*, 1998), which identified parts of the PEI coast as among the most vulnerable in Canada. Funded largely by the Climate Change Action Fund [CCAF] and the various partner agencies, this project aims to identify critical coastal impacts associated with climate warming and sea-level rise, to develop a template for coastal impact assessments in other parts of the country, and to identify appropriate adaptation strategies for coastal communities.

The coast of PEI is highly indented, the result of long-term relative sea-level rise causing back-flooding of river valleys to form elongate estuaries. Charlottetown (Fig. 1) is located on a sheltered harbour forming the confluence of two such flooded valleys. The North Shore consists of low sandstone headlands and sandy beaches with dunes; some of the beaches form barriers protecting large estuarine embayments, connected to the sea through tidal inlets of varying stability. Multibeam bathymetry and marine geological data recently acquired by the GSC demonstrate that former valleys extending seaward across the inner shelf contain estuarine sediments deposited 3-5 km seaward of the present coast, 20 m below present sea level, approximately 6000 years ago. With typical estuarine depths <5 m, this implies a long-term mean rate of relative sea-level rise between 2.4 and 3.4 mm/yr (~0.3 m/century). The mean rate of rise in relative sea level at Charlottetown this century, based on a reanalysis of tide-gauge records going back to 1911, is 3.2 mm/yr, somewhat higher than the estimated rate of 2 mm/year over the past 2000 years. The geological data also imply long-term retreat of the coast at rates >0.5 m/yr.

Other work undertaken in this project includes climatological analyses of wind, wave, sea-ice, and water-level records by project partners from MSC, CIS, and GSC. The objective is to identify major storm events and years of reduced sea-ice duration or extent when winter storms may have been more damaging. Partners from Dalhousie University have applied a regional storm-surge model to observed events in the region and completed a statistical analysis of

flooding potential under scenarios of accelerated sea-level rise and increased storminess. A major innovation of the project was the acquisition of airborne laser altimetry and CASI (compact airborne spectrographic imager) data over extensive parts of the North Shore and Charlottetown.

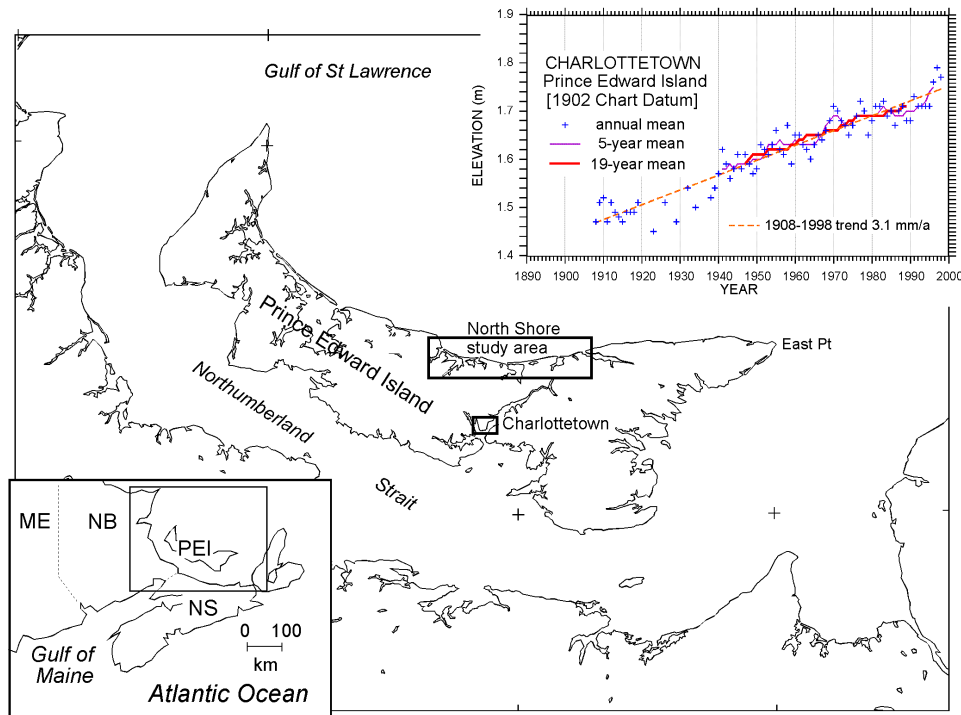


Fig. 1. Prince Edward Island showing study areas and observed rise of relative sea level at Charlottetown (inset).

The new imagery provides an unprecedented basis for high-resolution digital elevation modeling and mapping of coastal morphology, undertaken jointly by COGS and GSC. Results have been used to develop flood hazard maps for events of specified probability under climate change. New urgency was recognized for this task following a major storm in January 2000, which caused record flooding at Charlottetown, up to 0.4 m above the previous observed high water, as well as at other locations in Northumberland Strait (Bobanovic *et al.*, 2000; Forbes *et al.*, 2000). Also as part of this project, CHS has undertaken new DGPS surveys to establish a common datum for water levels in the southern Gulf of St. Lawrence, while GSC personnel carried out RTK-DGPS surveys to measure observed water levels from the January storm and expand the network of shoreline erosion monitoring in northern Prince Edward Island. These surveys combined with photogrammetric analysis of historical air photographs dating from 1935 to the present provide data on erosion rates, with observed retreat as high as 3 m/year through the 1980s in an area where buildings have been lost to the sea. A related activity used observed erosion rates and coastal geomorphology to develop an erosion hazard map for the North Shore as a contribution to improving setback regulations under climate change.

An important part of this project completed by EC/CA in cooperation with other partners involved an economic analysis of climate-change impacts, both in the urban area of

Charlottetown (largely related to flooding risk) and on a representative part of the North Shore (related primarily to coastal erosion). The latter used observed erosion rates and models for accelerated coastal erosion combined with assessed property values as one measure of the economic impact. Realistic projections include complete disappearance of some residential properties within coming decades. In Charlottetown, an earlier study (Lane & Associates, 1988) identified many important properties and components of infrastructure that would be seriously affected by a 1 m rise in sea level. The CCAF project refined the limits of potential flooding and associated impacts, recognizing that Charlottetown has experienced a rise of >0.32 m in mean sea level since 1900 and may face a rise of ~0.7 m by 2100, assuming 0.2 m/century crustal subsidence and 0.5 m/century global sea-level rise (IPCC, 2001; Parkes et al., 2001). The physical and economic impacts identified in this project have been communicated to stakeholders through another CCAF project on municipal infrastructure risk and adaptation to climate change, sponsored by the Federation of Canadian Municipalities. In this connection, possible adaptation measures are being identified, including such things as hazard mapping, public education, improved flood forecasting capacity, coastal protection (where feasible and cost-effective), accommodation (e.g. modification of infrastructure), retreat from risk (e.g. amendment of zoning bylaws and setback requirements), and enhanced natural resilience (e.g. protection of coastal dunes).

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High Resolution Coastal Baseline Mapping

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Abstract

Remote Sensing offers the potential to develop high resolution Digital Terrain Models (DTMs) of coastal areas, including the land adjacent to the shoreline, the near-shore and the inter-tidal zone. Synthetic Aperture Radar (SAR) and laser ranging (LIDAR) technology have demonstrated capability in producing DTMs with footprints of less than a few meters, and vertical resolution varying from a few meters to sub-decimeter levels (LIDAR). This presentation focuses on results recently obtained from a project testing the **Airborne Laser Terrain Mapper (ALTM-1020)**. Demonstrations were carried out to assess the cost effectiveness and viability of the ALTM-1020 to provide accurate, high resolution data which can be integrated with existing Canadian Hydrographic Service (CHS) data to produce more effective products by enhancing coastal charting (near shore and coastline).

LIDAR is laser ranging technology defined as **L**ight **D**etection **A**nd **R**anging. Pulses of light are sent and the return (reflectance) detected. The frequency of the pulses can be adjusted. Normal parameters would be up to 10,000 pulses per second. The time of return is translated to a distance (range). Coupled with an Inertial Reference System (IRS) to compensate for aircraft roll, pitch, and yaw, and differential Global Positioning System (GPS), a highly accurate position (<15 cm vertical and <1.5 m horizontal) can be determined for each pulse using post-processing software. Swath width or ground coverage is dependent on flying height. Swath width is approximately 70% of flying height, therefore collection area and densification is dependent on flying height as is total area coverage.

The inter-tidal zone is difficult and costly to chart accurately. Data depicting rocks and shoals are extremely difficult to acquire in shallow water. In addition there is a horizontal limit to which shallow soundings may be safely acquired (shoreline proximity). By acquiring inter-tidal zone data at low tide using the ALTM-1020, the CHS can have continuous, full bottom coverage allowing a seamless merge of the LIDAR data with existing multi-beam bathymetry. Rocks, shoals, and near shore infrastructure are critical features for the mariner and accurate description of wharves, docks, and navigation channels are required for CHS charts. Potential flood areas of coastline can also be accurately determined with high resolution DTM's using the ALTM LIDAR.

The following issues were addressed in this project:

Issue 1: Flood mapping of coastal lowlands due to rising sea levels and increased storm surge threat.

Flooding and coastal erosion due to storm surges have potentially severe impacts on the low-lying coasts of many parts of Canada. The Bay of Fundy and the north shore of Prince Edward Island are particularly susceptible and have thus been chosen as ideal locations for pilot projects.

The fundamental data requirement for flood level prediction is an accurate representation of the land surface at a resolution of less than 0.5 m. This surface must also be referenced to the water level reference surface so that run-up and flooding can be forecast. This project investigates the potential of LIDAR for the generation of dm-scale digital terrain models. Note that demonstration of the capability to generate dm-scale coastal DTM's from Remote Sensing holds considerable export potential as a tool for coastal sensitivity mapping.

To test the application of 3D modeling to address natural disaster mitigation of coastal flooding and tsunamis (i.e. storm surge and tsunami “run-up” maps), the town of Truro, its surrounding floodplains and the village of Maitland were surveyed for this purpose.

Issue 2: Off-Datum navigation charts in remote frontier areas (Arctic, Labrador).

Numerous Arctic bathymetric charts are coarsely positioned from early surveys where plotting errors at times exceed kilometers. Remote sensing offers tremendous potential to “rubbersheet” extensive northern regions to modern standards without requiring expensive hydrographic surveys.

Issue 3: Measurement of shoreline for hydrographic field surveys and coastal erosion.

High resolution, high accuracy inter-tidal zone mapping is a goal common to several needs. The use of modern Remote Sensing technology to expedite HW shoreline definition must meet one or more of the following criteria - faster, cheaper or better !!

Detection of offshore bathymetric features for international boundary baseline nodes in remote areas like the Arctic archipelago are possible from the air. Digital terrain models of the intertidal zone can best be obtained by “sounding from the sky”.

Frequent mapping of high-energy shoreline erosion zones is necessary to determine short and long term management of coastal resources and urban planning. To test application of this technology to accurate position and detect near-shore and inter-tidal zone infrastructure for coastal mapping. Chezzetcook Inlet (Storey Head), and Halifax Harbour and approaches were surveyed for this purpose.

Issue 4: Precise spatial models for vertical hydrographic datums.

DGPS is presently being used to calibrate hundreds of tidal stations in Canada. This is being done to create ellipsoid separation models of several tidal datum surfaces including Mean Water Level (MWL), various high / low water datums, extreme flood levels, etc. Satellite altimetry (e.g. Topex-Poseidon, ERS) in concert with tidal models are necessary to extend these models into offshore waters. These separation models are urgently required for next-generation hydrographic databases presently being designed to manage extremely dense, bathymetric data sets resulting from modern (multi-beam) technology.

Issue 5: Investigation of LIDAR capability for rapid and precise mapping of an air disaster site.

In the aftermath of the Swiss Air Flight 111 tragedy, the Transportation Safety Board wanted an accurate, high resolution terrain model of Flight 111’s final passage in St. Margaret’s Bay. A detail survey of witness locations would allow line-of-sight testimony corroboration. Also, a subordinate site (a local scrap metal yard) was selected to determine the potential to rapidly survey a simulated air crash on land.



Airborne Laser Terrain Mapper (ALTM) image of Chezzetcook Inlet, east of Halifax, Nova Scotia, collected in December 1998. The area of coverage measures 2.2 km by 1.4 km. The image shows drumlins surrounded by estuarine environments including mud and sand flats and salt marsh. Excellent detail of channels (typically 1 m deep) in the salt marshes are visible. A sandy barrier beach 3 m high connects the large island at right of centre - Conrods Island - to another island at top right.

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Modeling Lake Huron Shoreline Change at Goderich, Ontario

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Abstract

Climate change could have a significant long-term impact on water levels in the Great Lakes. Recent research has indicated that water levels are projected to decline toward the end of this century. To date, little research has focused on the potential impact this change may have on the socioeconomic and biophysical systems of the Lake Huron shore. This poster outlines a methodology to assess and quantify the potential impact of declining water levels on the Lake Huron shoreline at Goderich, Ontario. The methodology utilizes a geographic information system (GIS) to combine topographic and bathymetric data sets. A continuous digital elevation surface of the shore and nearshore areas is produced upon which projected water levels derived from hydrologic and general circulation model (GCM) output are plotted. By creating a series of hypothetical shorelines at Goderich, a range of sensitivities, impacts and costs can be identified for the Goderich Harbour and adjacent marinas. The model is validated by comparison with observed and recorded water level data as well as historical aerial photography corresponding to current and record low water level conditions. The shoreline model is used to provide initial estimates of the potential impacts of climate change and is envisioned as a planning tool for local decision and policy makers. The methodology could be expanded to explore the implications of changes in climate and water levels on other Lake Huron and Great Lakes coastal communities.

APPENDIX C
Summary of Discussion from Breakout Group 1
Identification of Research Gaps

Summary of Break-Out Session One – Identification of Data Gaps and Research Priorities

[note: the following is a highly editorialized summary of the information from the breakout groups based on notes and overhead summaries. If I have missed anything major, please let me know – John Harper]

Group 1 Leader: John Harper; Recorder: Norm Snow

This group focused initially on the issue of coastal retreat due to climate change. It was noted that the lack of tide gauges in the Arctic made analyses of sea level change difficult and prediction of change difficult. Other climate change factors that will have an important influence on coastal stability will be changes in sea ice distribution and resulting fetch changes, increases in storm intensity and frequency, the thermal sensitivity of permafrost areas to both air and sea temperature change and the increased flooding potential for major delta areas (e.g., Mackenzie and Fraser Deltas).

The direction of all these climatic changes will result in increased coastal retreat rates in most regions (Great Lakes is the exception) and it was noted that Tuktoyaktuk is likely to be the most-affected community in Canada due to the permafrost sensitivity and dramatic changes in sea ice cover, although it will be typical of other unconsolidated coastal areas between Cape Lisburne, Alaska and Cape Bathurst, NWT.

Group 2 Leader: Gary Lines; Recorder: Bob Taylor

In reviewing the scoping report and data gaps, the group noted that there were a number of generic issues of concern. *Process monitoring* devices (tide gauges, wave recorders, precipitation records) provide a key data source for climate change detection and many monitoring programs had been discontinued over the last decade.

An ecosystem approach to climate change research is required as there will be many indirect effects of change through the ecosystem (e.g., like impacts on fisheries that affect coastal tourism). There may be a variety of changes that are both in a positive and negative direction; the net cumulative change on a resource may be difficult to distinguish from anthropogenic changes to the ecosystem (e.g., introduction of zebra mussels to the Great Lakes).

There are strong regional differences in climate change scenarios; for example water levels in the Great Lakes are predicted to decrease whereas sea levels along most of Canada's ocean coasts are likely to increase. As such it is difficult to develop a "national" set of research priorities. Research priorities will have to be developed regionally. The group could not agree on a ranking criteria – applying the question "so what?" could be one approach or evaluating the degree of socioeconomic impact could be a criteria.

It was noted the jurisdictional overlap that occurs in the coastal zone makes the whole issue of mandates complicated. And climate change projects need to address "positive" impacts and benefits of climate change as well as the negative impacts, which always have a higher profile.

Group 3 Leader: Norm Catto

This group noted that there are significant weaknesses in the climate change scenario predictions, especially at a local level, and this uncertainty is carried through predictive models; as such our model predictions are often of low confidence. The group also noted that our monitoring programs were also very weak (e.g., tide gauge networks) so we will have little data against which model results can be compared.

The group felt that high-resolution coastal bathymetric and topographic mapping (e.g., the PEI Flood Hazard Mapping Project) was highly beneficial but is currently available only in a few, very localized areas. The multiple uses of these datasets make their collection cost effective relative to conventional mapping (e.g., surveying, aerial photography).

The group also felt that the scientific community should have a more pro-active role in communicating results to users and stakeholders. This is regarded as a significant challenge to research programs in that researchers must communicate with groups that do not routinely attend scientific meetings or understand scientific jargon.

Some specific initiatives that the group recommended: (a) the particular sensitivity of Northern New Brunswick, which consists of low, unconsolidated coast easily impacted by sea level rise and high wave exposures, (b) coastal retreat that will be affected by sea level change, storm surges and increased wave exposure during storms, (c) the use of *indicator species* as a tool to demonstrate the effects of climate change (e.g., how salmon is changing due to climate change), (d) research must incorporate “marketing” or outreach to communicate results (e.g., involve both physical, biological and social scientists) and (e) centralized data collection, archiving and exchange must be facilitated.

Group 4 Leader: Ollerhead; Recorder: Sherin

This group actually worked through a formal matrix, as requested, to identify information gaps as related to coastal infrastructure impacts and coastal transportation as related to climate change. Some of the gaps identified within the impact matrix included: (a) tidal records were often not adequate to assess existing rates of change (e.g., subsidence + sea level change) or to assess return periodicity of storm surges for use in design criteria, (b) coastal sediment budgets and sedimentation rates are known in only a few locations so it is difficult to predict the extent of change or the secondary impact of increased coastal armoring in response to sea level rise, (c) digital elevation models (e.g., high resolution bathymetry and topography data) are required for coastal change prediction and these models are available in only a few locations of coastal Canada.

Some additional issues raised in the discussion were: data archiving (it is important to have a system in place for data), litigation issues associated with tradeoffs between protecting shorelines and assuring that a natural sediment supply to nearshore continues, ship-building standards for vessels transiting a more ice-free Northwest Passage, and localized adaptation initiatives to mitigate the effects of coastal change by breaching natural or artificial barriers.

APPENDIX D

Summary of Break Out Session 2

Identify Possible Regional Case Studies for Coastal Climate Change Research

Atlantic Coast – Leader: Don Forbes; Recorder: Jocelyn Issacs

The group considering potential Atlantic case studies outlined their guidelines in terms of a number of categories.

1. Locations of Concern

In general these are low, unconsolidated portions of coastline including: Cornerbrook and Placentia Bay in Newfoundland, the northeastern coast of New Brunswick (Buctoche/Miramichi/Shippigan), locations around the perimeter of the Bay of Fundy, Prince Edward Island, the Bras D'Or Lakes and the Halifax Regional Municipality.

2. Case Study Criteria

- a. climate change is the key issue and must not be confused with other anthropogenic impact issues,
- b. case studies that *integrate* a broad range of issues rather than being just *comprehensive* are preferable.
- c. case studies should address biological and socio-economic change, particularly to social and health issues which are more difficult to evaluate.
- d. case studies may have to address new institutional mandates where existing frameworks are not suited towards addressing impacts or toward adaptive change
- e. high resolution digital elevation models (DEM's) are considered essential baseline data.

3. Potential Partners

Potential partners in case studies include: BOFEP, the Nova Scotia/Canada Sustainable Communities Initiative, the Bouchtouche Sustainable Communities Development Project and Esckasouri.

4. Strategies for Case Studies

- a. run multidisciplinary studies like the PEI Flood Hazard Study, but somewhere else.
- b. broaden the PEI hazard study
- c. build on the New Brunswick Coastal Land Use Policy

5. Concerns about Case Studies

The major concern was that budget levels may not be sufficient for the diverse team that would be required.

British Columbia – Leader: Vaughn Barrie; Recorder: John Harper

This small group (3) did not feel that there was sufficient stakeholder involvement within the group to develop even a sample list of priorities. In particular, no First Nations or provincial government representatives were included.

A number of projects were discussed, mostly focusing on the Strait of Georgia area where there are large populations and most ownership of the shoreline is private. The Strait of Georgia also has a high proportion of (a) unconsolidated shoreline (~30%), which is more sensitive to climate change impacts and (b) low, estuarine shoreline, which is sensitive to flooding. The Strait of Georgia is also a major estuary of the Pacific Northwest and will be sensitive to alterations in water temperature and freshwater input. A number of possible case studies were considered, including an assessment of coastal retreat related to climate change but it was felt that it would be very difficult to separate climate change impacts from existing and on-going anthropogenic impacts. Estuaries were also noted to be a coastal type of concern in that they comprise a small portion of the coast (~10%), are sensitive to climate change impact and will be reduced in area under sea level change scenarios.

Northern Coast – Leader: Norm Snow; Recorder: Steve Solomon

This group identified at least five issues that were of significant concern to Northern Communities:

- (1) *how the Mackenzie Delta ecosystem will be affected by climate change.* Increased flood frequency, sensitivity to higher air and sea temperatures, greater frequency of storm surges and increased wave exposure are all process that are likely to significantly alter the Mackenzie River delta. Beluga and water fowl are important subsistence resources that are likely to be effected.
- (2) *migratory fish patterns are likely to change.* This trend is supported by observation of sockeye salmon to latitudes as high as 72° N (Sachs Harbour) over the past decade.
- (3) *climate change scenarios predict large changes in sea ice cover* that will translate into greater wave exposure, and greater storm surge potential. There will also be direct impacts on subsistence resources such as seals and polar bears. Traditional fly-over corridors for snow geese are also likely to change.
- (4) it very uncertain as to how *fish populations are likely to change* as a result of climate impacts as well as to secondary impacts on fish habitat as coastal retreat accelerates.
- (5) *the Arctic involves a very large geographic area* and a community-by-community assessment of climate change impacts is required.

The group thought that a case study of Tuktoyaktuk might address a number of these issues including sensitivity to coastal erosion, to increased open-water conditions, to increased storm surges and wave exposure, to thermal sensitivity to air and water temperature increases, to changes in subsistence food sources for the aboriginal community and potential socioeconomic

impacts from changes in tourism and recreation. The group also discussed potential partners and identified several including existing joint management boards and the recently reinvigorated northern oil and gas industry.

Great Lakes Case Studies –

Leader: Robin Davidson-Arnott; Recorder: Patrick Donnelly

The Great Lakes Breakout Group was small (4 people) and no specific case study was identified by the group during the breakout session. However, a number of general guidelines were identified during the discussions.

- 1) Information data gaps are relatively few compared to the ocean coasts. One that is significant is related to *the role of ice cover in protecting shorelines* that are subject to varying water levels and temperature regimes. Tools and technologies aimed at assessing shore fast ice (or lack of it) will assist in determining impacts to shorelines, wetlands and river mouths. As the climate changes, it is expected that ice cover characteristics will change, resulting in change to the length of open-water season and wave fetch characteristics. The cumulative effect will be changes to the wave energy regimes for the lakes which drive morphodynamic changes to the shoreline.
- 2) Economic impacts will play an important role due to the highly urbanized nature of the Great Lakes basin, especially in the lower and middle lakes. Storm severity and unusual events will be important to consider.
- 3) Any basin-wide research must include the international component of the Great Lakes Basin. The International Joint Commission (IJC) may provide a useful role in such research.
- 4) Opportunities to incorporate existing research may exist with IJC projects (Criteria Review for Lake Ontario – St. Lawrence River Levels and Flows) or other basin approaches (Lake Huron Local Area Management Plan).
- 5) The Great Lakes water levels are projected with climate change to *decrease* in level (emerging shore), in contrast to the ocean coasts (submerging shore). Due to this fact and the hydrologic connection of the lakes, consideration of a basin-wide project that incorporates Lake Huron, Lake St. Clair and the two connecting rivers, and Lake Erie is an example of a potential case study. This project would examine the hydrologic impacts of climate change on a deep lake, connecting channels, and a shallow lake in the Great Lakes system. Lake Huron and Lake Erie both include consolidated and unconsolidated shoreline types that could be incorporated into the coastal change evaluation process.

APPENDIX E
List of Acronyms Used in this Report

BOFEP	
CCC	coastal climate change
CVC	climate variability and change
CCAF	Climate Change Action Fund
C-CIARN	Canadian Climate Impact and Adaptation Research Network
ENSO	el Niño – Southern Oscillation
GCC	Global Climate Change
GHG	greenhouse gases

APPENDIX F

Workshop Scoping Report

NOTE: Appendix F is Available as a separate download:
Coastal_Scoping.pdf