



C-CIARN Coastal Zone

State-of-Play Report

2006-2007



C-CIARN Coastal Zone – State-of-Play Report

*The Status of Climate Change Impacts and Adaptation
from the Perspective of C-CIARN – Coastal Zone*

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Preface

In the last year of C-CIARN's mandate (July 2006-June 2007), each C-CIARN office was asked to write a report summarizing their perspectives on the state of climate change impacts and adaptation within their region or sector.

The resulting State-of-Play reports identify, from the point-of-view of C-CIARN, the key climate change impacts, as well as the key stakeholders and adaptation decision-makers (including how these stakeholders/decision-makers were most successfully engaged) of each representative region and sector of Canada. The reports also include a description of the important research questions which, from the perspective of C-CIARN, need to be answered, as well as the steps that need to be taken to both increase the level of engagement on the issue and to facilitate the decision-making that is needed to reduce vulnerability, across Canada, to the impacts of climate change.

It is anticipated that the State-of-Play reports will serve as a valuable point of reference for climate change impacts and adaptation initiatives carried out across Canada, post-C-CIARN.

Executive Summary

Over the past 5 years, C-CIARN Coastal Zone has been working closely with coastal researchers, practitioners, decision-makers and other stakeholders. The result is a wealth of information on issues of concern to Canadians, as well as information on obstacles and outstanding needs necessary for taking action on climate change in the coastal zone. With the new Government of Canada preparing its 'made-in-Canada' approach to climate change, C-CIARN Coastal Zone has compiled a report containing recommendations for achieving tangible results on existing coastal concerns and for the projected impacts of climate change.

From a national perspective, five key themes have been identified where climate change impacts in the coastal zone are expected to be the greatest (Appendix A). Each theme contains a comprehensive list of potential direct and indirect impacts, however the most common concerns for coastal stakeholders focused on:

- sea-level rise (marine coasts)
- lake level decrease (freshwater coasts)
- increased storminess
- increased rates of coastal change
- changes in water quality
- decreased ice cover
- thawing of ground ice or permafrost degradation

- continued uncontrolled coastal development
- maladaptation and lack of long-term coastal planning

Regional differences in geological history, physical character, environmental processes and human use, as well as variations in regional climate and the projected impacts of climate change, mean that the priority of these concerns differ between the coastal regions of Canada.

To help improve knowledge, facilitate research and encourage action on adaptation in Canada, numerous coastal stakeholders have been identified and engaged. To-date, the greatest success has been in engaging researchers, non-government organizations (NGOs) and municipal or provincial decision-makers at the working level. The primary factors that have generated the greatest response from stakeholders include:

- crisis
- perception of acceleration in present-day impacts
- funding opportunities

Significant advances have been made in raising awareness and encouraging action, but to motivate the skeptical and unengaged into action, future efforts need to be directed on raising the acceptance and "buy in" for adaptation strategies by the following groups:

- politicians
- senior level federal and provincial/territorial decision-makers
- planners and engineers
- industry
- general public

Canada' approach for taking real action on adaptation.

Effectively engaging these groups will require carefully targeted efforts aimed directly at the audience or on specific priority issues. The approaches for engaging these new stakeholders will differ from those used to maintain contact with engaged stakeholders.

Research on climate change impacts within Canada's coastal zone has been increasing over the past 5 years, but stakeholders continue to identify areas where more effort is needed. These areas include:

1. availability of and access to data
2. collection of new information to fill knowledge gaps
3. commitment for and improved standards for long-term monitoring
4. climate scenarios and predictive tools useful at a local and regional scale
5. methods and tools for adaptation

Coastal stakeholders from across Canada have expressed their concerns, recommendations and outstanding needs for achieving tangible results on effective coastal management and adaptation in Canada's coastal zone. The identification of these issues by Canadians further emphasizes their importance and the need for incorporating them into a new 'made-in-

1. Introduction

In April 2005, the Government of Canada released 'Project Green – Moving Forward on Climate Change'. The document reiterated the Government of Canada's commitment to the Kyoto Protocol and to reducing greenhouse gas emissions in Canada. However, the Government also acknowledged that emission reduction targets were only a 'good first step', and that more effort was needed to prepare Canadians to meet the challenges of climate change. These efforts included better understanding the science of climate change, its impacts on Canada and developing effective mechanisms for adaptation. By incorporating adaptation into Canada's climate change plans, it would better prepare us to face the impacts of climate change. Within Project Green, the Government of Canada indicated the federal science and adaptation agenda could consist of several components including: increasing knowledge and understanding; enhancing awareness and engagement; developing appropriate adaptation tools.

At the time of writing this report, Canadians are waiting release of the new Government of Canada's 'Project Green II', to clearly define its commitment to climate change. Media releases indicate the Government plans to develop a new 'made-in-Canada' approach to addressing environmental issues and climate change that will be effective and realistic for reducing emissions but ensure a strong economy. Consensus among the scientific community is that climate change is real and that Canada is currently feeling the early impacts of a

changing climate. The level of interest and concern from Canadian citizens regarding climate change impacts is also increasing. It is therefore even more critical to enhance efforts for reducing the vulnerability of Canadians to the impacts of climate change.

C-CIARN may be one mechanism for helping the Government of Canada achieve science and adaptation efforts. In 2001, responding to Canada's earlier commitment to address the potential impacts of climate change, Natural Resources Canada (NRCan) established the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), as part of the Government of Canada's Climate Change Impact and Adaptation Program. C-CIARN is a national network of researchers, practitioners, decision-makers and other stakeholders interested in understanding and addressing the impacts of climate change. The network consists of a national coordinating office, operated by Natural Resources Canada (NRCan) in Ottawa, as well as six regional and seven sector offices located across Canada (Table 1). Part of the mandate for C-CIARN is to raise awareness of Canada's vulnerability to the impacts of climate change and promote the need for effective adaptation to reduce our vulnerability. C-CIARN also facilitates research on climate change impacts and adaptation in Canada. Highlights of activities conducted by C-CIARN Coastal Zone over the past five years can be reviewed in Appendix B

Table 1: C-CIARN Regions and Sectors

REGIONS	SECTORS
Atlantic	Agriculture
British Columbia	Coastal Zone
North	Fisheries
Ontario	Forests
Prairies	Health
Quebec	Landscape Hazards
	Water Resources

C-CIARN Coastal Zone has been working closely with coastal researchers, practitioners, decision-makers and other stakeholders over the past 5 years. The result is a wealth of information on issues of concern to Canadians, as well as information on obstacles and outstanding needs necessary for taking action on climate change in the coastal zone. This report provides an overview of these concerns, as well as detailed recommendations that will assist coastal stakeholders better understand and take more effective action on achieving tangible results for existing coastal concerns and projected impacts of climate change

2. Key Impacts in Canada's Coastal Zone

Meteorological, geological and oceanographic processes currently influence coastal regions in Canada. Vertical land movements, interannual and decadal meteorological processes and long-term oceanographic cycles naturally

influence water levels, weather, storminess and ice cover. These processes and cycles also vary across the country resulting in regional variations in climate. The projected increase in sea-level rise on ocean coasts, water level decline in the Great Lakes, changes in storminess, increase in the magnitude of storm surge, degradation of permafrost, and decrease in sea- and lake-ice cover will have significant impacts for Canada's coastal zone and for Canadians.

Many regions have been experiencing an increase in impacts and damages along the coast. For example, in October 2000 a large storm surge event along the southeast coast of New Brunswick broke the previous record set in 1976. Since 2000, several subsequent storm surges have also exceeded that 1976 record. These events have caused significant damage to the coastline, coastal property and infrastructure, resulting in \$millions for repairs. Hurricane Juan in September 2003 produced storm surge and water levels not recorded since the 1930s. Damage to coastal infrastructure was in the \$millions. A winter storm in southwest British Columbia during February 2006 was the worst event to hit the region in over 30 years. A storm surge and high tide resulted in water overtopping seawalls and flooding parts of Tsawwassen. Flooding required evacuation orders be sent to over 200 people and the mayor declared a state of emergency. In 2005, low water levels in portions of the Great Lakes resulted in draft and access problems for many recreational boaters. The annual forecast for Lake Huron and Lake St. Clair this year suggests another year of low water, with levels potentially falling below those experienced 2005. In the Gulf of St. Lawrence, mild weather in 2006

resulted in a lack of sea ice and resulted in grey seals being forced onshore to give birth. A series of subsequent high water levels placed the vulnerable seal pups at risk to increased rates of mortality. In the Arctic ocean, ice extent in 2005 reach its lowest level in over 25 years, surpassing the previous record minimum set in 2002. Some climate scientists are now suggesting that summer ice cover has reached a 'tipping point' meaning that ice cover will continue to decrease in the future until the Arctic experiences ice-free summers sometime before the end of this century.

Human decisions on the use of coastal areas (e.g. land use practices, coastal development, location of infrastructure, etc...) also impact on the vulnerability of our shores to changing environmental conditions. Many parts of our coast are currently vulnerable to impacts associated with variations in water levels, storm surge, flooding, erosion and ice cover, and climate change may further increase this vulnerability. A better understanding of present coastal processes, climate variability, future changes and cumulative impacts are necessary for more effective decision-making and better management of the coastal zone.

During its mandate, C-CIARN Coastal Zone compiled existing information and information provided by researchers, practitioners, decision-makers and other stakeholders from across the country. The result was a list of coastal impact issues of concern to Canadians, which has been use to identify and promote key geographical areas and topical themes for climate change impacts and adaptation research (Appendix A). These key themes included:

- Oceanographic processes
- Sea and lake water levels
- Sea and lake ice
- Weather, particularly extreme events
- Human use and impact responses

Each of these themes contains a comprehensive list of different direct and indirect impacts that may be associated with changes experienced as a result of climate change. However, a number of specific impacts have been the primary focus of concern for coastal stakeholders:

- sea-level rise (marine coasts)
- lake level decrease (freshwater coasts)
- increased storminess
- increased rates of coastal change
- changes in water quality
- decreased ice cover
- thawing of ground ice or permafrost degradation
- continued uncontrolled coastal development
- maladaptation and lack of long-term coastal planning

However, the priority for concern varies by coastal region because of differences in geological history, physical character, environmental processes and human use,

as well as variations in regional climate and the projected impacts of climate change. In the Arctic for example, the reduction in sea ice cover and permafrost degradation were identified as more pressing issues, while sea-level rise and increased storminess were much more significant concerns for the Atlantic region.

3. Engaging Coastal Stakeholders

To help improve knowledge, facilitate research and encourage action on adaptation in Canada, C-CIARN Coastal Zone has identified and engaged stakeholders from various sectors, disciplines, organizations and interests across the country and internationally. To-date however, the greatest success has been in engaging researchers, non-government organizations (NGOs) and municipal or provincial decision-makers at the working level. The primary factors which have generated the greatest level of interest on climate change impacts and have compelled action on adaptation are:

- crisis
- perception of acceleration in present-day impacts
- funding opportunities

The greatest level of interest in coastal impacts and adaptation has come from researchers in government, academia and industry. This interest is ultimately driven by increased funding opportunities. Despite the extent of Canada's coastline, its environmental significance, economic

importance and cultural value to Canadians, the level of money available for coastal research is disproportionate to the need for information. Funding for research on climate change impacts and adaptation has provided a new avenue for coastal research. However, in some cases this new source of money has simply been an opportunity to secure funding for existing coastal research by somehow linking it to climate change. If financial resources for climate change decrease, coastal researchers will move on to other funding opportunities to continue their work. Evidence of this is seen at Natural Resources Canada, where despite increasing interest in coastal issues and requests for information from stakeholders, a reduction in funding to the Earth Science Sector's climate change program has resulted in the cancellation of the national coastal monitoring program. Coastal researchers are now focusing efforts on other activities, and a much needed resource and tool for enhancing stakeholder decision-making capacity is being lost. On a more positive note, the increased funding for climate change research has created opportunities for coastal researchers to expand activities into typically non-traditional fields, enabled researchers from other disciplines to engage in coastal research and provided opportunities for students. Unfortunately, the demand for research and information still far exceeds the current level of funding, a problem that is not likely change in the near future.

Non-government organizations (NGOs), particularly environmental and community groups, have been actively engaged in coastal issues in the past. For coastal regions, climate change is only one of many

stressors and therefore has not typically emerged as a priority issue. However, by emphasizing the links between existing coastal issues and the cumulative impact from climate change, interest and action has been growing. For example, climate change impacts on the coast are now identified as an important issue by the Ecology Action Centre, Coastal Coalition of Nova Scotia, Southern Gulf of St. Lawrence Coalition on Sustainability, Lake Huron Centre for Coastal Conservation, Georgian Bay Association and the B.C. Coastal Communities Network to name a few. Many of these organizations are volunteer-based, and as such have limited resources and/or capacity, so they embrace collaborative or partnership opportunities in order to share resources, expertise and advance action on achieving results.

Coastal communities and municipalities are also beginning to express an interest in climate change impacts and on adaptation strategies. While energy efficiency, mitigation and greenhouse gas reduction have been incorporated into community and municipal planning for some time, adaptation has been slower to gain acceptance. Interest from community and municipal decision-makers has generally been sparked by response to a crisis such as a public safety situation, extreme storm event or threat to an economic resource. In Halifax Regional Municipality for example, a number of “one-in-a-hundred” year events culminating with Hurricane Juan in 2003, triggered increased concern in the potential impacts of climate change and resulted in the city incorporating climate change into its long-term regional plan. In the Eastern Arctic, an increasing number of community residents stranded on ice floes have

increased awareness of climate change impacts to sea-ice and has driven interest in satellite capabilities to monitor ice conditions and the development of community ice advisories.

Provincial/territorial decision-makers are also slowly beginning to express interest in the impacts of climate change on the coast. The identification of links between current coastal issues and the potential impacts, as well as crisis situations have meant that climate change adaptation has slowly started to be incorporated into policy and long-term planning for coastal development. For example, the New Brunswick Coastal Policy 2002, the Nova Scotia Sustainable Coastal Tourism Strategy 2006 and British Columbia’s Coastal Environment 2006 contain discussions on the implications of climate change induced sea-level rise, storm surges, erosion and/or flooding to coastal environments and resources.

Focus for the Future

While significant advances have been made in raising awareness of coastal climate change impacts and the need to incorporate adaptation into our long-term coastal and climate change planning, there have been a number of key stakeholders that have yet to be engaged. In order to take more effective action on climate change adaptation in the future, it will be critical to focus efforts on engaging the following groups:

- politicians
- senior level federal and provincial/territorial decision-makers

- planners and engineers
- industry
- general public

Despite the advances in raising awareness and promoting action on climate change impacts and adaptation, the message seems to be continually lost at the political level - both provincial/territorial and federal. Given the nearly infinite number of politicians that need to be engaged, and their rates of turnover, it may be more effective to look at engaging scientific advisors of key political figures. By engaging and developing relationships with these advisors, information can be filtered to the appropriate individuals. Another approach may be to develop training sessions or background information that can be distributed to new politicians and their staff executives.

Unlike other sectors, there is no single governing body or authority responsible for the coastal zone in Canada. In many coastal areas, jurisdictions and decision-making responsibility can range from the municipal to the federal level, with numerous departments or agencies involved at the various levels. Lack of communication between the various departments within and between the different levels of government also creates complications. To effectively engage all of the decision-making bodies with coastal jurisdiction, considerable time and effort will be needed to actually identify the relevant governing, determine their actual responsibilities and then determine the appropriate contacts. This will likely be further complicated because jurisdictional

responsibility at the municipal and/or provincial/territorial level may vary across the country.

Planners and engineers play a key role in advising local and provincial decision-makers. Working more closely with planners and engineers can ensure adaptation strategies are incorporated into long-term coastal planning, design criteria for coastal infrastructure is upgraded, and effective adaptation techniques are employed. Therefore, future efforts should focus on engaging and interacting with national and/or regional governing bodies or professional associations such as the Federation of Canadian Municipalities, Union of BC Municipalities, Canadian Institute of Planners, Atlantic Institute of Planners, Engineering Institute of Canada, Canadian Society for Civil Engineering and Provincial/Territorial Engineering Societies.

Certain industry stakeholders should also be engaged as part of efforts to move forward on coastal adaptation. Large international insurance companies such as Swiss-Re and Munich-Re are already concerned about the impacts of climate change on their businesses. As a result, they are advocating adaptation and risk management strategies for disaster mitigation and to reduce future impacts from climate change. In the United States, recent increases in claims and payouts associated with hurricane damage, have resulted in some insurance companies restricting or cancelling coverage in areas along the Gulf of Mexico and Atlantic coasts. In Canada, the Institute of Catastrophic Loss Reduction and the Insurers' Advisory Organization have been engaged, but engaging the other sectors of the insurance

industry may help to advance efforts at developing coastal management and adaptation strategies. The tourism industry will be another key stakeholder group to engage in the future. The economic importance of tourism continues to increase, and it has become a key component for the economy for many coastal regions. Climate change will have significant implications on the coastal resources and infrastructure that are critical to a healthy coastal tourism industry. In addition, decisions made by stakeholders within the coastal tourism industry may have significant implications on the vulnerability of coastal regions to climate change impacts.

In the past, C-CIARN was discouraged from engaging the general public. In coastal areas however, climate change impacts from water level change, reductions in ice cover and increased storminess will affect many citizens directly. Rapid coastal development continues to occur with little or no awareness of the environment, natural coastal processes, potential coastal hazards or the impact of climate change. As a result, Canadians push further into coastal areas that should be left undeveloped and natural, putting themselves at risk to current conditions and at even greater risk to coastal impacts under a changing climate. In addition, there is little awareness or understanding of the impacts human actions have on the coast and its ability to changes naturally. Therefore, a large scale coastal education and awareness program is required to teach Canadians the value and benefits of a natural coast. However, for those citizens currently residing in coastal areas, efforts are needed to provide information on the approaches, pros and/or cons for coastal adaptation

Continued effort should also be made to engage aboriginal groups. C-CIARN Coastal Zone has engaged numerous northern aboriginal groups but success in south Canada has been limited. In northern communities, climate change is also one of many issues that needs to be addressed, however the current rate of change and the impacts to northern communities have dramatically raised interest and concern. Coastal issues associated with changes in sea-ice and impacts to wildlife, traditional food supplies, coastal stability and transportation. However, to effectively engage northern aboriginal stakeholders there needs to be a more concerted collaborate effort between existing organizations and groups. A number of different groups including inuit organizations, federal and territorial departments and various academic institutions are already working on climate change impact and adaptation issues in northern communities. Community and stakeholder burn-out is quickly becoming a problem. For southern aboriginal stakeholders, climate change is only one of many issues that need to be addressed, and issues such as land ownership, health, education and environment have taken priority. To advance coastal adaptation issues, it may be more effective to focus on linkages with other sectors such as water resources and/or fisheries.

4. Strategies for Engaging Stakeholders

A number of approaches and techniques have been employed in the program for engaging stakeholders. Based on experience, some techniques have been more effective for engaging new stakeholders; others were more valuable for maintaining contact and interacting with stakeholders.

To engage new stakeholders, the most effective strategies and communication tools included:

- participating and/or partnering in larger conferences
- smaller, more focused workshops
- one-on-one communications
- case studies

To maintain contact with engaged stakeholders, the most effective strategies and communication tools included:

- participating and/or partnering in larger conferences
- newsletter and website

Initially sector workshops were emphasized as an effective tool for engaging stakeholders. When dealing with the coastal zone sector however, this type of workshop has not proven to be an effective use of resources. Coastal zone issues vary significantly across the country and climate change concerns differ among

stakeholders. A large sector workshop therefore requires a broad theme, making it difficult to provide an agenda which interests and engages all participants. The audience at these workshops also tended to include those who are already interested in climate change impacts and adaptation, and the same individuals frequently attend multiple region and sector workshops. While these workshops were initially useful for bringing together supporters of climate change impact and adaptation, and were an important venue for these stakeholders to reconnect, their value for engaging new stakeholders was limited.

For the coastal zone sector, engaging new stakeholders has been more effectively accomplished by participating and/or partnering in larger conferences, where resources and efforts can be shared. For example, participating on a organizing committee, hosting special sessions, chairing working groups, providing presentations and being available for face-to-face discussions was equally, if not more, effective at engaging both new and previously engaged stakeholders, than the time, effort and expense required for organizing an event independently.

For engaging new coastal stakeholders, workshops that were smaller and focused on a specific issue of local relevance were more effective. Interactive discussions, such as scenario building or problem solving exercises, have also helped to create better dialogue and linkages between the various stakeholders. By focusing on specific local issues, more emphasis and effort could be placed on identifying and contacting potential participants. In many cases, these potential participants were neither

previously engaged nor aware of the link between their interest and climate change, so pre-workshop contact and discussions were often required. Even if the stakeholder was unable to participate in the workshop, they were engaged, awareness raised and information exchanged. Post-workshop follow-up is also important to ensure continued engagement and to assist stakeholders with advice or assistance in incorporating climate change into their activities.

Highlighting case studies and illustrating successes have also provided a useful tool for engaging new stakeholders, particularly when done in partnership with participants from the case studies. Case studies or research projects such as the *'Halifax Regional Municipality ClimateSmart Initiative'*, *'Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of southeastern New Brunswick'*, *'Study of Shoreline Sensitivity & Community Vulnerability to Climate Change Impacts in the Gulf of St. Lawrence'* and *'Corporation of Delta Case Study: Sensitivity of the Roberts Bank Tidal Flats to Accelerated Sea-level Rise & Intensified Storminess'* have provided tangible examples of municipalities and decision-makers taking action on climate change. The projects have generated interest and enthusiasm from other stakeholders and provide a basis for developing initiatives in other regions. For example, many of the above projects developed out of interest generated from the *'Sea Level Rise and Climate Change: Impacts and Adaptation Needs in Prince Edward Island'* project that was completed in 2002. The PEI project provided a mechanism to raise awareness of climate change issues and the importance of

adaptation in coastal regions. It also provided a catalyst for stakeholders to develop similar projects in other coastal regions across the country. Acting as a template, the PEI study provided valuable information on approaches, success and challenges. This enabled new projects to adjust and/or expand activities accordingly, as well as focus on developing outcomes to address local concerns and needs for adaptation. In the process of developing and refining these projects, numerous new stakeholders were identified and engaged.

Based on discussions and comments from engaged stakeholders, a monthly newsletter with links to a regularly updated website provided an effective tool for continued interaction and communication with stakeholders. The key to the success of this communication tool has been a brief, concise newsletter which contained hyperlinks to the website for more information. The newsletter and website also provided information and links to ongoing coastal research that might be of interest to both the climate change and greater coastal stakeholder community.

5. Current Trends in Coastal Impacts and Adaptation Research

Since 2001, there has been an increasing interest in conducting research on the impacts of climate change in Canada's coastal zone. For example, the Canadian Climate Impacts and Adaptation Program (CCIAP) has contributed funding to 20 research projects (Appendix C). These projects address many issues identified by C-CIARN Coastal Zone at both the regional

and national scale. Projects have been spread across the country and focus on issues such as the impacts from sea-level rise, sea ice conditions, extreme events/storminess or flooding and erosion. Research has also been conducted on a number of different topics including communities, health and safety, transportation and ecosystems. Several projects also focus on physical and/or socio-economic adaptation and the implications of adaptation.

Numerous other organizations and institutions are supporting or conducting climate change impacts and/or adaptation research in coastal regions across Canada. Some of these include: ArcticNet, Ocean Management Research Network (OMRN), Ouranos Consortium, Canadian Foundation for Climate and Atmospheric Sciences (CFCAS), Social Sciences and Humanities Research Council of Canada (SSHRC) and Natural Sciences and Engineering Research Council of Canada (NSERC). Academic institutions across the country, including Memorial University, Mount Allison University, University of Quebec, University of Toronto, University of Guelph, University of British Columbia and University of Victoria to name a few, also support undergraduate, graduate and faculty research on related coastal and climate change impact and adaptation issues.

At the provincial and municipal government level, climate change impacts are also becoming more of a focus. For example, the Halifax Regional Municipality Draft Regional Municipal Planning Strategy (December 2005) states “Sea level has slowly risen along the Atlantic Coast, accelerated by global warming. This rise in sea level can

result in increased damage to coastal communities. Changing water levels can have significant impacts on coastal infrastructure, environmental assets, utilities, property and community economic development. The following policy mitigates the potential impact that changes in water levels could have on human safety. It is intended as an interim measure pending the completion of a Coastal Inundation and Storm Surge Event Functional Plan. E-16 HRM shall...prohibit all residential development on the coast within a 2.5 metre elevation above the ordinary high water mark...Permitted uses shall be restricted to marine dependent uses, open space uses, parking lots and temporary uses.” In Delta, British Columbia, the recently re-elected Mayor, Lois Jackson, stated in her inaugural address that “[T]here is one very important issue that has emerged over the past six years, and that Delta Council and staff have not addressed. The issue is climate change...Climate change will have a great impact on Delta. We must recognize that this change is coming and prepare for it. We need to look at our dykes, and dredging, to accommodate rising water levels...Climate change will affect our daily lives. Therefore, I will be asking Council and staff to make climate change and its effects on Delta a priority in the coming three years.” In Vision 2020, Hamilton’s Sustainable Communities Initiative sets out goals for addressing climate change. The goals include “[T]o have effective plans that identify, reduce and manage risks”. In an associated vulnerability study, two basic policies that are identified to help manage vulnerability include adjusting shoreline management practices and designing flexible/resilient infrastructure.

Initially, much of the climate change impacts and adaptation research focused on impacts to the physical environment, however there is now much more emphasis on impacts to the socio-economic and cultural environment. For example, three of the five coastal research projects recently supported by CCIAP include a significant socio-economic or cultural component. There has also been an increasing trend toward incorporating adaptation into research. Unfortunately, outside of the general scoping or theoretical look at adaptation, developing specific adaptation options, approaches or tools for decision-makers has proven challenging. It is hoped that the most recent round of projects, including those receiving support for research targeted on communities, will help address these past limitations by focusing on approaches, methods and tools to assist with adaptation (Appendix D).

6. Outstanding Needs for Advancing Adaptation

C-CIARN Coastal Zone compiled its first list of knowledge gaps and outstanding needs based on information provided by researchers and stakeholders during a special workshop on the impacts of climate change and adaptation for the Great Lakes held at Coastal Zone Canada 2002. Since that time, the list has been updated and modified to include new information from other coastal regions of Canada. To highlight the need for new and continued coastal research and to influence the future direction of coastal impacts and adaptation research in Canada, these lists were widely distributed to the C-CIARN Coastal Zone

membership and to various levels of government.

During the past 5 years, C-CIARN Coastal Zone has continued to work closely with coastal researchers, practitioners, decision-makers and other stakeholders. Research on climate change impacts and adaptation within Canada's coastal zone has been increasing and the amount of information available to stakeholders is improving. However, stakeholders continue to identify a number of key areas where more effort is needed in order to advance action on adaptation within Canada's coastal zone. These issues fall under 5 key themes:

1. availability and access to data
2. collection of new information to fill knowledge gaps
3. commitment for and improved standards for long-term monitoring climate scenarios and predictive tools useful at a local and regional scale
4. methods and tools for adaptation

Where possible, examples which highlight approaches or techniques successfully used by other Canadian or international organizations are provided as ideas that could be incorporated into a 'made-in-Canada' approach for adaptation (Appendix D). The role that C-CIARN, or a subsequent network, could play in advancing these outstanding needs is also discussed.

6.1 Availability and Access to Data

Identifying and locating research information such as reports, graphics or geo-spatial data is often the first challenge for many coastal practitioners, decision-makers and researchers. While most of this information

and data is now archived in some type of digital format, it is often kept in-house or with a primary researcher. Unless there is pre-existing knowledge of the information, it may even be difficult to identify its existence. Access to existing data also presents another challenge.

a) Promote Metadata and On-line Data Warehouses

Metadata directories, or databases, contain information about existing data. These directories can provide a valuable tool for practitioners, decision-makers and researchers searching for available information. Although metadata does not provide access to an actual dataset, it does tell a user the 'who, what, when, where, why and how' of the data. There are a number of existing metadata directories currently available. The GeoConnections Discovery Portal provides a good example of such a Canadian on-line source for searching data. The Portal enables users to search and discover information on millions of geospatial data products and services in Canada. Promoting such metadata directories may be one mechanism to assist data users in determining if and/or where existing information can be found.

b) Populate Metadata and On-line Directories

Unfortunately a major challenge for metadata directories such as the GeoConnections Discovery Portal is that individual members or data holders are responsible for adding information or populating the directory. While many data users indicate that access to data is essential, populating these types of

directories with new data, not to mention the older or legacy data, does not have the same level of priority. To help address some of these issues, populating metadata and searchable on-line metadata directories must have a higher priority.

c) Free On-line Data

Another challenge for practitioners, decision-makers and other researchers is access to existing data. Even if a metadata directory identifies an existing dataset(s), it may not be easily accessible on-line and may still require directly contacting the data holder or distributor. In addition, some information may also require a fee. Currently, initiatives such as Geogratias and Geobase provide on-line access to geospatial base information and Landsat orthoimages at a national scale, and sites such as GeoNova, Ontario Geospatial Data Exchange and BC Base Map On-line provide geospatial information at a more provincial scale. The data on these sites is typically available for free download or can be accessed once a membership is established. This data should also conform to an accepted standard which helps to ensure data quality and compatibility for different users. The data from academic institutes, the private sector or other sources may be more difficult to acquire because of copyright, propriety, legal or cost recovery issues. In addition, this data may not conform to an accepted standard and data quality, standards and/or compatibility with different software or data analysis systems may pose a challenge.

Promoting data warehouses which currently provide free access to data may assist researchers and stakeholders in acquiring

existing base information and conducting preliminary analysis. However, efforts are also needed to establish initiatives or agreements for the information that is currently more difficult to access, to at least provide access to free summary data files and/or images in an on-line data warehouse or other website. The actual information would remain the property of the data collector or institution. Individual data sharing agreements could be established and/or fees charged for acquisition or full access to the data. Not all stakeholders require access to full datasets, so summary data files and/or images may also be more appropriate where large datasets exist.

d) Conform with National Data Standards

To ensure compatibility and quality of data between different data users, it is important to ensure that data conforms to an accepted standard. The Canadian Geospatial Data Framework, a national data standard and protocol initiative, currently provides such a framework at the national level, as well as conforming to internationally defined standards. Initiatives and agreements are being developed between the various levels of government to ensure new data conforms to this national standard, and provides consistent, high quality data which is easily shared among the different participants. Efforts are also needed to develop initiatives and agreements on data standards with academic institutes, the private sector or other relevant sources. The Canadian Council on Geomatics (CCOG) represents the largest geomatics and geospatial knowledge network in Canada. CCOG currently oversees the Geobase initiative and might potentially act as an organization for helping to promote and facilitate efforts

with other non-government data collectors and producers.

A potential role for C-CIARN, or its subsequent program, could be to assist with promoting awareness of existing metadata directories and data warehouses. C-CIARN could also work with funding organizations and/or research institutions to raise awareness and promote the importance of complying with accepted data standards, recording metadata and providing on-line accessibility to data products in future research. In addition, C-CIARN could work with initiatives such as GeoConnections to link to educational material and/or training opportunities which would help researchers and other data holders to become more aware of data standards, metadata, metadata directories and data warehouses. Finally C-CIARN could continue to work with researchers, practitioners, decision-makers and other stakeholders to monitor and evaluate progress or continued needs for data availability and access.

6.2 Collection of New Information to Fill Knowledge Gaps

While work has advanced on identifying and understanding the physical impacts of climate change to the coastal zone, stakeholders continue to emphasize the need for additional information in this area. Only the needs most commonly identified by researchers, stakeholders and decision-makers are presented here.

a) Regional Rates of Climate Induced Sea-level Rise

The Intergovernmental Panel on Climate Change (IPCC) projects that eustatic global

mean sea-level will rise by 9-88 cm by 2100 (IPCC 2003). These projections are based on the outputs of several climate models which consider a range of future emission and temperature scenarios. Church and White (2006) have been reconstructing data on global sea-levels and have recently reported on updated global rates of change and acceleration in sea-level. In the upcoming IPCC 2007 report, sea-level rise projections will likely be revised. However, these values will still be a global eustatic mean sea-level change, and will not accurately reflect more regional variations in sea-level nor factor in regional subsidence rates.

There is still considerable uncertainty regarding sea-level changes in Canada. Currently, most Canadian researchers use the average or mean value of from the IPCC 2003 projections (i.e. 48-49 cm). This approach provides a moderate estimate of how sea-level may change in Canada. However, given the range in sea-level rise projected by the IPCC (2003), actual changes could theoretically be ± 40 cm from this average value. The average value also does not take into consideration that mean sea-level changes around Canada may differ.

b) Regional Rates of Vertical Land Adjustments

Rates of crustal movement in coastal regions are also important in understanding relative sea-levels in coastal regions of Canada. In the past, these rates of crustal motion were typically calculated from tide gauges, however the geographic coverage and availability of continuous, long-term data has made it difficult to provide accurate

rates for all regions. Efforts are currently underway to better measure and more accurately determine these rates, but it could be some time before results are available. In Eastern Canada, Koozare et al. (2005) has produced an updated estimate of vertical crustal movements, however the research identifies several locations where rates of movement differ significantly from previous work (Carrera et al., 1998) so further validation may be required. New information on both relative sea-level rise and regional variations in climate change induced sea-level rise are therefore required to provide more accurate and realistic information for coastal practitioners and decision-makers in Canada.

c) High Resolution Maps and Digital Elevation Models

High resolution topographic and bathymetric maps are also indicated as a major need for coastal impacts and adaptation research, as well as for effective coastal planning and management efforts. These maps provide the basis for producing high resolution digital elevation models (DEMs). In many coastal regions however, past mapping efforts have excluded the nearshore zone because of technological challenges with operating equipment or acquiring data in very shallow and/or cloudy waters. This is an important zone in terms of understanding coastal processes, therefore more efforts are needed to develop equipment and/or conduct mapping surveys that will result in the production of continuous, seamless coastal digital elevation models. The U.S. Army Corps of Engineers has developed an example of such technology. In 1994, they developed a Scanning Hydrographic

Operational Airborne Lidar Survey (SHOALS) as a tool for mapping and monitoring nearshore bathymetric environments. SHOALS has been used in support of the International Lake Ontario-St. Lawrence River Study to map the shoreline and nearshore from land elevations to maximum water depths of 18 metres. The study also combined SHOALS with topographic LIDAR data and deep water sonar to produce high resolution seamless DEMs for the study area.

This type of data would provide an effective tool for community planning, navigation and nautical charting, coastal development and/or emergency management efforts by helping to identify information such as the extent and areas at risk to flooding from sea-level rise and/or different storm surge events. For example, the DEMs generated for Charlottetown from the 'Sea Level Rise and Climate Change: Impacts and Adaptation Needs, Prince Edward Island' project has enabled Emergency Measures Offices in the area to take forecasted storm surge information, determine approximate flood extents and make informed decisions on evacuation or other appropriate actions.

d) Impacts to Coastal Biological and Chemical Systems

Many coastal communities in Canada have resource-based economies. The productivity or sustainability of the coastal resources that these communities depend on is closely linked to the state or health of the coast. Additional research is therefore needed to better understand the biological and chemical systems that operate along the coast, including their functions and the potential impacts and implications of climate

change to ecosystems, habitats, species and biodiversity along the coast. Improving knowledge on existing coastal circulation patterns, temperature regimes, vertical mixing, salinity, nutrient cycles, contaminant release, as well as the implications of climate change will also contribute to better understanding of the natural biological and chemical processes. This knowledge will contribute to more informed decision-making for current coastal management efforts and for developing adaptation strategies to more effectively address impacts from a changing climate.

e) Impacts to Socio-Economic and Cultural Environments

Understanding the potential impacts of climate change on socio-economic and cultural components within the coastal zone also remains a high priority for practitioners and decision-makers. Identifying and mapping coastal populations, development, land- and resource-use, as well as landscape values such as the aesthetic, social and historical value of the coast to residents and users, would provide important information for determining the potential socio-economic impacts from climate change. Calculation of realistic cost estimates for implementing different adaptation options, as well as short and long-term cost/benefit analysis, would provide valuable information in the decision-making process.

f) Compilation and Analysis of Historic and Present-Day Data

While conducting research and collecting new information will advance efforts to better understand the physical coastal

environment and the potential impacts of climate change, compilation and analysis of existing data could provide ample information for reducing vulnerability to current coastal hazards and for initial adaptation efforts. For example, information on present-day and historical rates of coastal change would help practitioners and managers make more informed decisions about current coastal development and future coastal planning strategies. Local inventories of existing coastal development, land use, infrastructure and resources would also provide valuable information to practitioners and decision-makers. This information could help determine areas at higher risk to coastal flooding or erosion, identify vulnerable populations, infrastructure or resources, and develop priorities for further research and/or adaptation initiatives. The New Brunswick Coastal Geomorphology Database is currently available from the New Brunswick Department of Natural Resources and Energy. This database contains a compilation of information on bedrock geology, physical, sediments, slope, soils, shoreline protection works and coastal erosion. The data is an important source of information for coastal erosion and change which can assist coastal planning and decision-making as it relates to land-use activities.

C-CIARN has successfully compiled existing information provided by researchers, practitioners, decision-makers and other stakeholders to identify and promote geographic areas and topical themes for climate change impacts and adaptation research. Much of information has been compiled from local stakeholders and little effort is needed to promote the

research needs at this level. The major challenge for these stakeholders is often a lack of capacity or financial support to move forward, and C-CIARN has not been in a position to provide such support. For the next phase, C-CIARN should have a more direct role in supporting research or play a more significant part in promoting research needs to upper levels of management, funding organizations or other bodies who decided on research priorities and funding within Canada.

6.3 Monitoring

a) Long-term, Continuously Recorded Data

Long-term, continuously recorded data is critical for determining and understanding atmospheric and meteorological trends in storminess, storm surge and flood frequencies, local water level changes, as well as coastal stability or rates of shoreline change. These long-term trends contribute to present-day analysis and projection of future conditions. The trends also provide useful information for validating and/or refining climate and ecosystem models. In addition, monitoring is a valuable tool in assessing the impacts of coastal development and effectiveness of coastal management strategies or adaptation measures. Gaps in this type of data create uncertainty and reduce confidence in efforts to analyze conditions, trends and future projections.

b) Commitment and Funding for Monitoring Programs

Efforts are needed to maintain and build on existing monitoring programs such as local climate and weather data collection, tide

and water level gauge networks, geodetic monitoring networks, ice phenology, as well as repetitive shoreline surveys. Many coastal research projects have established important data collection and monitoring programs. Efforts are needed to maintain these programs and ensure long-term data records without gaps in the information. Greater institutional commitment and additional financial support are required for monitoring programs. Given the limited resources of many institutions, it may be necessary for researchers and practitioners to form partnerships to maintain existing monitoring activities. For example, local stakeholders could assist in recording site specific storm impacts or conducting simple activities to monitor shoreline changes between site visits from a researcher.

c) Monitoring Partnerships

Where extensive monitoring programs may not be feasible, partners could work together to identify key indicators or priority areas to focus monitoring efforts that would provide the most valuable information. Monitoring partnerships would also mean local capacity building as stakeholders become trained in coastal monitoring, techniques and related technologies. Monitoring partnerships also increase community or local involvement in coastal research projects and can contribute to a sense of ownership and empowerment for local stakeholders.

d) Standards for Collecting and Recording Monitoring Data

To maximize the value of individual coastal monitoring activities, efforts should also be made to develop a set of standards,

methods or protocols for collecting, capturing and recording relevant information for key indicators. By establishing a set of accepted standards, data quality would be more reliable. Analysis of information over different temporal and spatial scales could also be less complicated and could potentially contribute to analysis of larger regional and/or national scale trends.

Over the past four years, C-CIARN has organized over 100 workshops. These workshops have been very successful in raising general awareness of impact and adaptation issues, sharing information, developing research needs, as well as networking researchers and stakeholders. To advance the success of these workshops, it may be time to focus future efforts on workshops targeted to specific groups or focused on specific needs. For example, C-CIARN Coastal Zone could organize national scale workshops that bring together coastal researchers to begin the process of developing a set of standards and/or protocols for coastal monitoring activities. C-CIARN Coastal Zone could also help to coordinate and facilitate monitoring partnerships and/or organize local level training or capacity building workshops for stakeholders.

6.4 Climate Scenarios and Predictive Models

a) Regional Climate Models and Scenarios

In Canada, climate change and its impacts will vary by region. Therefore actions to address and adapt to these impacts will likely be carried out at regional or local level. Topography, hydrology and other meteorological factors greatly influence

regional variations in current climate and cannot be appropriately represented in a global or national scale climate model which projects future climate scenarios. To assist in making more effective decisions, improved regional climate models and scenarios are needed. Several Canadian climate modelling groups are currently developing and using regional climate models to assist in generating higher resolution climate projections. The Climate Change Scenarios Network, hosted by Environment Canada and in collaboration with universities and the Ouranos Consortium, has recently been formed to help address the requirement for and distribution of climate change scenario information from global and regional models.

b) Predictive Coastal Process and Ecosystem Models

Researchers and decision-makers have also expressed the need for improved predictive models and tools. In coastal regions, models simulating physical and ecosystem processes could help to improve understanding of local coastal dynamics and evolution, as well as provide scenarios of future shoreline stability, rates of shoreline change, flood risks and/or changes to coastal ecosystems and biodiversity. This type of information would also be valuable for assisting coastal practitioners and policy-makers in making more informed decisions on coastal planning, shoreline management or adaptation strategies. In the UK for example, the Tyndall Research Centre has been developing a downscaled regional model to simulate coastal processes and shoreline response under changing climate

conditions. The model results have also been linked with a GIS tool to provide graphic representation of results, as well as enable analysis with other existing datasets such as current land-use. In Canada, as part of the project 'Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick', flood model results were incorporated with digital elevation models to generate images depicting areas at risk of flooding under different sea-levels and storm surge heights.

c) Economic Impact Models

Due to a variety of environmental and/or economic factors, many coastal regions are currently undergoing a transition from a resource-based economy to a more service-based economy. Climate change is likely to affect coastal resources and coastal economies. It would therefore be valuable for practitioners and decision-makers to have access to predictive models showing potential changes to resources and economies under different climate scenarios.

To assist in developing regional climate models and predictive tools necessary to advance adaptation efforts, C-CIARN could facilitate networking between model developers and users of the results. By fostering better linkages between these groups, C-CIARN could contribute to the development of more results-oriented models focused on specific stakeholders needs. Researchers, practitioners and decision-makers could provide input and feedback on the value of information generated by particular models, as well as recommend additional model outputs that would provide more value for stakeholders.

Model developers could also draw on the expertise and information available from researchers and practitioners, such as data on the extent and level of particular flooding events, to assist with validation or refinement of models.

6.5 Methods and Tools

a) Central Point of Contact for Information

An important component for advancing efforts at adapting to climate change is on-going and/or continued access to information and expertise on research and/or technological developments. In terms of coastal zone research, one issue that has been identified is access to data, information and research results when project leaders have moved on to other opportunities. For example, the project manager of the CCIAP supported 'Sea-Level Rise and Climate Change: Impacts and Adaptation Needs in PEI' project transferred to a new position outside of the region shortly after the project was completed in 2001. A similar issue may shortly arise for the CCIAP supported project 'Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick' because the project manager and key contact will be retiring. Currently, a project website provides background information with links to updates and contact information for various sub-project leaders. However, given that the project is wrapping up, it is unclear whether a new project contact will be identified or if the website will be maintained after the current project manager retires.

To provide easily accessible information and expertise to interested stakeholders, it

is necessary to provide a 'one-stop' source for information, data and expert contacts. Metadata directories, such as the GeoConnections Discovery Portal discussed previously, would provide a useful source for data users, but a source for background information, reports, general inquiries and referrals would also be valuable.

b) Education and Communications

Another important issue for advancing climate change impacts and adaptation in coastal regions is education and outreach. Many coastal regions do not understand, nor are they addressing present-day coastal hazards or their vulnerability to storm surge and coastal flooding. Improving the understanding of present-day processes, coastal evolution and the role of different landforms is critical for effective decision-making and implementing appropriate responses. Climate change related impacts such as sea-level rise and increased storminess simply adds an additional dimension that needs to be incorporated into planning and management strategies.

Education and outreach can also be critical to the success of implementing coastal planning or management initiatives. A good example is the New Brunswick coastal policy. When the policy was initially developed, coastal stakeholders rushed to purchase and/or establish a footprint on coastal property, to ensure they were grandfathered from regulations implemented when the policy became legislation. While the policy was designed to protect the natural environment, increase natural coastal resilience to storms, minimize coastal contamination, reduce

threats to personal safety and decrease financial burdens to the public, the perception of coastal stakeholders was of an infringement on personal and property rights. A preliminary education campaign aimed at raising awareness of coastal processes, hazards and vulnerability may have helped reduced the negative perception of the policy.

Education and outreach initiatives must also clearly identify target audiences and provided relevant information in a manner that is easily understood by the audience. For example: C-CIARN has recently released 'Adapting to Climate Change: An Introduction for Canadian Municipalities' which is intended to raise awareness of elected municipal officials and senior staff. The document outlines processes for informed decision-making related to adaptation and highlights several municipal adaptation strategies from across Canada. In 2003, Fisheries and Oceans Canada (Maritime Region) published 'A Guide to Land Use Planning in Coastal Areas of the Maritime Provinces'. This guide contains detailed overviews and fact sheets of key coastal land-use planning and related topics, including coastal environments and marine ecosystems, legislative frameworks for coastal land-use planning and coastal engineering structures. It also provides information on best management practices and approaches for coastal land-use planning from experiences in Canada and other areas. The Living By Water Project provides another example of such an initiative. In 2002, the Project published several regionally focused handbooks for coastal residents. These books titled 'On the Living Edge: Your Handbook for Waterfront Living' provides information for

maintaining a 'healthy shoreline' that enables the shoreline environment to perform its natural function.

c) Coastal Planning and Management

A critical need for addressing or adapting to both current coastal impacts and the impacts anticipated from climate change is the development and implementation of effective coastal planning and management strategies. In recent decades, many coastal regions across Canada have seen an increasing trend in coastal development. Much of this has been an increase in residential development and associated infrastructure. The demand to live near the coast has resulted in significant increases in coastal property values and the 'mansionization' of the coast, where large and expensive year-round dwellings replace the traditionally smaller and more modest seasonal accommodations. Unfortunately much of this development has occurred and continues to occur with little or no regulation. As a result, there has also been increased pressure to armour the shoreline in an attempt to protect properties and infrastructure, and essentially trying to transform a highly dynamic and continually changing environment into a more static system.

'Protecting' the shoreline from impacts associated with flooding and erosion have often been reactive, piecemeal and site- or event-specific responses. In addition, flood and erosion protections are often installed by individual property owners, rather than as a coordinated response. Overall, this means that little consideration is given to short- or long-term changes these responses or potential maladaptations have on coastal processes, the environment or

other coastal property. Given the projected impacts anticipated from climate change, it is becoming increasingly important to develop strategic, coordinated coastal planning and management to effectively address present vulnerability, as well as reduce the anticipated impacts of climate change.

Unlike other sectors, there is no single governing body or authority responsible for the coastal zone. The numerous jurisdictions and government departments with mandates in the coastal zone can create difficulty in clearly understanding the roles and responsibilities associated with developing and implementing coastal management plans. A national coastal zone strategy with collaboration from all relevant jurisdictions and levels of government would be ideal, however strategic and coordinated coastal zone planning will still need to be developed and implemented at a regional or provincial level. In addition to addressing present coastal issues, such a coastal management plan will need to incorporate adaptation for climate change. In New Brunswick for example, the provincial government has been developing a “Coastal Areas Protection Policy for New Brunswick” to sustainably manage the province’s land-based coastal resources. The goal of the policy is to ensure a balance between growth and environmental integrity in New Brunswick’s coastal areas. In addition to looking at development pressures and the natural environment, the policy also highlights climate change as one of the factors which has contributed to the decision for developing the coastal area management plan.

d) Rapid, Real-Time Data Dissemination

Practitioners and decision-makers have also expressed a need for more effective and rapid dissemination of information such as real-time meteorological, water levels and other related data. This information is particularly important for emergency management planning and public safety. A standard warning system that broadcast bulletins or information via local television, radio or other methods such as email or mobile communications should also be established or strengthened. For example, Environment Canada’s Hurricane Bulletin e-Services or the Alberta Emergency Public Warning Systems may provide possible templates. The Hurricane e-Service makes information available electronically through a subscription service, as well as provided specially formatted versions of the information for mobile communication technology, while the Alberta system is a joint public alerting initiative with a provincial media outlet and provides rapid information dissemination via television and radio.

e) Tools and Guides

In addition to raising awareness, practical tools such as checklists, guidelines and/or best practices have also been identified as an important need for helping practitioners and decision-makers address adaptation. The UK Climate Impacts Programme (UKCIP) provides an international example of an adaptation tool for stakeholders. This program has developed an on-line ‘Adaptation Wizard’ which assists users in developing an understanding of climate change and how climate change can be integrated into a decision-making processes. At the time of this report, specific ‘made-in-Canada’ tools for adapting to the impacts of climate change were limited,

however the last round of CCIAP funding supported a number of projects which proposed to develop such tools and/or toolkits. Completion of these projects is anticipated sometime in late 2006 or early 2007.

Tools should be targeted to specific stakeholders. They should also address the need to mitigate or adapt to present day hazards and vulnerability, as well as future climate change impacts. Several good examples of practical products can be found internationally, and might provide ideas for the development of related products in Canada. NOAA's Coastal Services Center has produced a coastal vulnerability assessment tool. This tool is targeted to emergency managers, planners, building officials and others concerned with coastal hazards. The tool is available on CD and contains a step-by-step tutorial for conducting a community-wide risk and vulnerability assessment, a community case study and additional information on different types of data and tools available to assist with hazard-related decision-making. The Coastal Services Center also offers several on-line mapping products to view and interact with data on specific issues, as well as provides downloadable software tools and extensions to assist coastal resource managers and decision makers. In addition, the New Jersey Sea Grant College Program has produced a CD containing a 'Manual for Coastal Hazard Mitigation'. The manual introduces the concept of coastal hazard mitigation and provides an overview of different options or techniques, from natural to hard engineering options, for reducing these hazards. U.S. Sea Grant offices have also produced a number of factsheets, checklists or guides for different targeted

audiences. Examples include: questions to ask before you buy shoreline property; identifying your shoreline erosion problem; and controlling coastal erosion through community action.

GIS data viewers and Internet Map Servers (IMS) also provide valuable tools for enabling stakeholder to view data and create customized maps, as well as query information, without the need for expensive computer software and/or large quantities of space for file storage. For example, ArcReader is a free, interactive mapping application for viewing, exploring and printing maps. It is easy to use, and can be freely distributed on CD with a data producer's geographic data.. The final report from the CCIAP project 'Adaptation to Rising Sea level in the Bras d'Or Lakes, Canada's Largest Inland Sea' is accompanied by a CD containing an ArcGIS project with base maps from the Bras d'Or Lakes and map layers displaying coastline classifications, seafloor topography, information on marine survey data collected during the project and hotlinks to aerial, ground and seafloor photos. In addition, the U.S. Geological Survey Coastal Marine Geology Program provides an Internet Map Server which provides users with the capability to access, view, navigate and create maps from published CMGP datasets, as well as query spatial and attribute data. Datasets includes base map layers, geomorphology, erosion and accretion rates, coastal vulnerability index, bathymetry, sampling data, to name a few. The IMS also provide information on data catalogues, metadata and links to where these datasets can be downloaded.

C-CIARN Coastal Zone has played an active role in developing and maintaining relationships with participants of coastal research projects from across Canada. Part of this work has been keeping up to date on the status of current research, research findings, as well as key contacts. This has enabled the Coordinator to disseminate information and respond to general inquiries on coastal research in Canada, as well as direct interested stakeholders to relevant reference material, documents and appropriate 'real-life' contacts. A new role for C-CIARN could include acting as a point of contact for information on impacts and adaptation, as well as a clearinghouse of research information, data and project findings.

C-CIARN has also been successfully raising awareness of climate change impacts and adaptation with researchers and stakeholder groups throughout Canada. Building on this success, C-CIARN could easily contribute to future education and outreach activities. However, it may be more effective for C-CIARN to focus efforts on specific target audiences or specific issues. For example, C-CIARN has successfully targeted elected municipal officials and senior staff with its publication 'Adapting to Climate Change: An Introduction for Canadian Municipalities'. Future publications containing similar, but audience specific information, could be produced for community planners, engineers, emergency management officials or specific resource users. C-CIARN could also take a role in developing or working with partners to produce practical products such as variations of those mentioned above.

7. Summary

In 2001, Natural Resources Canada (NRCan) established the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), as part of the Government of Canada's Climate Change Impact and Adaptation Program. Part of C-CIARN's mandate is to raise awareness of climate change impacts and promote adaptation as a mechanism to reduce vulnerability, minimize negative impacts and take advantage of potential opportunities. The first phase of C-CIARN wrapped up in March 2006. At the time this report was produced however, C-CIARN had received an additional year of funding to compile knowledge acquired over the past five years of the program and to provide recommendations for the next phase of an adaptation program. It is also hoped that this information will contribute to the 'made-in-Canada' approach to addressing climate change anticipated from the new Government of Canada.

Over the past five years, C-CIARN Coastal Zone has been interacting with researchers, practitioners, decision-makers and other stakeholders from across Canada. Outcomes of these interactions include a compilation of the issues of greatest concern to coastal stakeholders. The coastal impact issues have been compiled under five key themes (Appendix A), with each theme containing a comprehensive list of different direct and indirect impacts of concern. From a national perspective however, the most common concerns for coastal stakeholders focus on:

- sea-level rise (marine coasts)
- lake level decrease (freshwater coasts)
- increased storminess
- increased rates of coastal change
- changes in water quality
- decreased ice cover
- thawing of ground ice or permafrost degradation
- continued uncontrolled coastal development
- maladaptation and lack of long-term coastal planning

C-CIARN Coastal Zone has also compiled information on knowledge gaps and outstanding needs identified by coastal stakeholders over the past five years. While progress has been made on advancing coastal research on climate change impacts in Canada, stakeholders continue to identify a number of concerns, recommendations and outstanding needs. Unfortunately many of these outstanding needs were initially identified by C-CIARN Coastal Zone back in 2002, and there has been little progress on solutions. Continued identification of these needs by researchers, practitioners, decision-makers and other stakeholders at all levels, only serves to emphasize their importance and stresses a need for action. To assist coastal stakeholders in moving forward to achieve real and tangible results on adaptation in Canada's coastal zone, it will be essential that efforts are taken to address the following needs:

1. Availability of and Access to Data
 - a) Promote Existing Metadata Directories and On-line Data Warehouses
 - b) Priority for Metadata and Populating On-line Directories
 - c) Priority for Free On-line Data
 - d) Conforming with National Data Standards
2. Collecting New Information
 - a) Regional Rates of Climate Induced Sea-level Rise
 - b) Regional Rates of Vertical Land Adjustments
 - c) High Resolution Maps and Digital Elevation Models
 - d) Impacts to Coastal Biological and Chemical Systems
 - e) Impacts to Socio-Economic and Cultural Environments
 - f) Compilation and Analysis of Historic and Present-Day Data
3. Monitoring
 - a) Long-term, Continuously Recorded Data
 - b) Commitment and Funding for Monitoring Programs
 - c) Monitoring Partnerships
 - d) Standards for Collecting and Recording Monitoring Data
4. Climate Scenarios and Predictive Models
 - a) Regional Climate Models and Scenarios
 - b) Predictive Coastal Process and Ecosystem Models
 - c) Economic Impact Models

5. Methods and Tools

- d) Central Point of Contact for Information
- e) Education and Communications
- f) Coastal Planning and Management
- g) Rapid, Real-Time Data Dissemination
- h) Tools, Guides and Best Practices

Over the past five years, C-CIARN has been interacting with researchers, practitioners, decision-makers and other stakeholders from across Canada. C-CIARN was developed by Canadians, for Canadians and is already delivering a 'made-in-Canada' approach toward adaptation. At the end of the first phase of the program, C-CIARN was becoming a recognizable point-of-contact for climate change impacts and adaptation information within Canada and internationally. It takes time to develop a network of stakeholders and to establish credibility as an organization, therefore to build on C-CIARN's success and maintain momentum, it would be more effective for the next phase of the program to retain the C-CIARN branding. With that said, C-CIARN must adapt to the needs of its membership and stakeholders, so the mandate and objectives of the program should be revised accordingly.

Looking to the future, the revised program should contribute to the development of communication materials and/or practical products for various stakeholder audiences. C-CIARN has already acquired significant knowledge on the types of information and materials that would be of value to stakeholders. In addition, C-CIARN also has developed an extensive communications and distribution network which could deliver these value-added products to stakeholders and decision-makers.

Environmental monitoring continues to be a high priority for researchers and stakeholders, despite the lack of commitment and financial support from government organizations and funding providers. A future C-CIARN may want to look at increasing awareness on the value of monitoring, or try to facilitate the development of partnerships between stakeholders and researchers to develop monitoring initiatives. Another role for C-CIARN could be promoting more communication and information exchange between researchers and stakeholders. The new C-CIARN could also take a more proactive role in promoting and working with existing metadata and data warehouse programs, encouraging researchers to record and archive data in a manner that would be easily accessed and understood by other stakeholders.

Finally, the new C-CIARN should continue to monitor current research and initiatives, as well as communicate with stakeholders, to evaluate efforts at addressing the identified knowledge gaps and outstanding needs.

8. References

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Parkinson, R., 2006. Outcomes Flourish with ERCC. Natural Resources Canada, Earth Science Sector Staff News, April 18, 2006.

9. Resources

Data Access

Canadian Council on Geomatics -
<http://www.geobase.ca/geobase/en/about/cog.html>

Canadian Geospatial Data Framework -
<http://www.geoconnections.org/CGDI.cfm/fuseaction/aboutGcs.welcome/gcs.cfm>

GeoConnections Discovery Portal -
<http://geodiscover.cgdi.ca/gdp/index.jsp?language=en>

Geogratis -
<http://geogratis.cgdi.gc.ca/geogratis/en/index.html>

Geobase -
<http://www.geobase.ca/geobase/en/index.html>

GeoNova -
<http://www.gov.ns.ca/geonova/home/default.asp>

Ontario Geospatial Data Exchange -
<http://www.lio.gov.on.ca/spectrasites/interne/l/lio/oqdedescription.cfm>

BC Base Map On-line Store -
<http://ilmbwww.gov.bc.ca/bmqs/ecommerce-intro.html>

Atlantic Coastal Mapping Portal -
<http://aczisc.dal.ca/acip/>

New Data

SHOALS -
http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=RD_Applications!41

New Brunswick Coastal Geomorphology Database -
http://qcmd.nasa.gov/records/CANADA-CGDI_CANEMRCCRSNBCOASTGEO.html

Scenarios and Models

Climate Change Scenarios Network -
<http://www.ccsn.ca/index-e.html>

Ouranos Consortium -
http://www.ouranos.ca/intro/intro_e.html

Tyndall Centre for Climate Change Research -
<http://www.tyndall.ac.uk/index.shtml>

Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick -
<http://atlantic-web1.ns.ec.gc.ca/slr/default.asp?lang=En&n=61BB75EF-11>

Guides and Tools

Adapting to Climate Change: An Introduction for Canadian Municipalities -
http://www.ciarn.ca/index_e.asp?CaId=13&PgId=154

A Guide to Land-Use Planning In Coastal Areas of the Maritime Provinces -
<http://www.mar.dfo-mpo.gc.ca/oceans/e/ocmd/final%20version%20-%20a%20guide%20to%20land%20use%20planning.pdf#search=%22A%20Guide%20to%20Land-Use%20Planning%20In%20Coastal%20Areas%20of%20the%20Maritime%20Provinces%22>

On the Living Edge: Your Handbook for Waterfront Living -
<http://www.livingbywater.ca/prodservices.html#on>

UK Climate Impacts Programme -
<http://www.ukcip.org.uk/>

NOAA Coastal Services Center -
<http://www.csc.noaa.gov/>

Manual for Coastal Hazard Mitigation, New
Jersey Sea Grant College Program
US SeaGrant Coastal Factsheets -
<http://nsgl.gso.uri.edu/libraries/hazard.html>
Sea Level Rise and Climate Change:
Impacts and Adaptation Needs, Prince
Edward Island - [http://atlantic-
web1.ns.ec.gc.ca/slr/default.asp?lang=En&
n=9BA12067-1](http://atlantic-web1.ns.ec.gc.ca/slr/default.asp?lang=En&n=9BA12067-1)
U.S. Geological Survey Coastal Marine
Geology Program -
<http://coastalmap.marine.usgs.gov/>

Appendix A

Coastal Climate Change Impact Issues National Summary

Using the Canada Country Study and other reference documents, as well as discussions with researchers and stakeholders from each of the four coastal regions across Canada, preliminary lists of the most important coastal climate change issues for each region were compiled. From these regional lists, a national summary of the most issues for Canada was compiled. This list describes the set of national issues that could be used to identify climate change vulnerability in the coastal zone & to help identify research priorities.

Please Note: For the purpose of this document, the term 'impact' refers to potential environmental, social, cultural and/or economic impacts

Changing Oceanographic Processes

- Impact of potential changes in ocean temperature, salinity, density, currents & circulation

Changing Sea and Lake Levels (including storm surge, erosion and flooding)

- Impact of changing water levels on tidal spectrum, wave climate, coastal circulation, sediment redistribution & other physical processes
- Impact of changing water levels on coastal stability, particularly along vulnerable low-lying coasts, soft sediment shores, ice-rich coasts & tidewater glacier shores
- Impact of changing water levels on coastal ecosystems

- Impact of changing water levels on estuaries & freshwater supplies
- Impact of changing water levels on coastal communities & existing coastal infrastructure
- Impact of changing water levels on archaeological & cultural resources
- Impact of changing water levels on human activities such as agriculture, commercial shipping, fisheries, hunting & trapping, transportation, navigation or tourism & recreation
- Impact of changing water levels on human health & safety, emergency preparedness, property loss or gain, insurance or construction, maintenance & repair of coastal infrastructure
- Impact of changing water levels on shoreline development, real estate & legal issues
- Impact of changing water levels on property ownership, legal boundaries & jurisdictional issues

Changing Weather Conditions

- Impact of changes in precipitation on runoff, drainage, slope stability, sediment redistribution & flooding, as well as water levels for the Great Lakes
- Impact of changing wind regime & storm activity on wave climate, coastal circulation, sediment redistribution & other physical processes
- Impact of changing storm activity on storm surge events
- Impact of changing storm activity on coastal stability, particularly along vulnerable low lying coastal regions, soft sediment shores & ice-rich coasts

- Impact of changing storm activity on coastal ecosystems
- Impact of changing storm activity on coastal communities & coastal infrastructure
- Impact of changing storm activity on human activities such as agriculture, commercial shipping, fisheries, hunting, transportation, navigation or tourism & recreation
- Impact of changing storm activity on human health & safety, emergency preparedness, search & rescue, property loss, insurance or construction, maintenance & repair of shore protection structures

Changing Sea Ice and Lake Ice Conditions (including extent, thickness, location and season)

- Impact of changes in ice on waves & currents (e.g. more open water means larger fetch & more significant wave development)
- Impact of changes in ice on coastal circulation, sediment redistribution & other physical processes
- Impact of changes in ice on coastal stability & flooding (e.g. less shore protection from ice, increased ice pile-up & ice ride-up, flooding due to ice jamming in bays, river mouths & estuaries)
- Impact of changes in ice on coastal & marine ecosystems
- Impact of changes in ice on coastal communities & existing infrastructure
- Impact of changes in sea ice on human activities such as fishing, commercial shipping, hunting, transportation, navigation, oil/gas exploration & extraction, search & rescue or tourism & recreation

- Impact of changes in multi-year sea ice extent on Canadian defense & sovereignty issues

Changing Human Use

- Impact of the lack of understanding on how the coastal system naturally responds to erosion, flooding & sea-level rise
- Impact of lack of planning to consider coastal system response to climate change
- Impact of increased demand for use, access to, development & protection of the coast

Appendix B

C-CIARN Coastal Zone Highlights FY 2001-2006

In August 2001, a letter of agreement between Earth Sciences Sector, Natural Resources Canada and the Geological Survey of Canada (Atlantic) was prepared to establish the coordinating office of the Coastal Zone Sector of C-CIARN. The letter of agreement was officially signed October 2001 and the office opened in December 2001. In May 2002, the Honourable Herb Daliwal, former Minister of Natural Resources Canada, visited the Bedford Institute of Oceanography to officially announce the opening of the C-CIARN Coastal Zone office.

At the end of C-CIARN Coastal Zone's first year, membership was approximately 50. At the end of FY 2005-2006, membership numbers were in the range of 550. Total membership numbers include both individuals who had officially signed up to the network on the C-CIARN National website, as well as those who the C-CIARN Coastal Zone coordinator personally communicated with on a regular basis. Contact was made with many other stakeholders, such as during sessions chaired by C-CIARN Coastal Zone at larger conferences. In 2003, a database of C-CIARN Coastal Zone members, both official and unofficial, was developed. The database enables the membership to be queried based on criteria such as province, organization and affiliation.

During the fall of 2002, a C-CIARN Coastal Zone website was launched. The website provided visitors with an introduction to

C-CIARN, information about C-CIARN Coastal Zone, downloadable C-CIARN Coastal

Zone reports and publications, an outline of current research projects across Canada, news articles related to coastal or climate change issues and various announcements including funding opportunities, jobs and training opportunities, upcoming events and potential collaborative research opportunities. A major revision in the format and content of the website was then completed in 2005. At the end of FY 2005-2006, information on the website included: information on coastal climate change impacts in Canada by region; summaries and links to nearly 40 coastal climate change related research projects in Canada; a compilation of over 180 relevant publications, references, data sources and web links; information and links for C-CIARN Coastal Zone hosted and/or sponsored events including workshop communication materials, reports, speaker presentations and links; and information on available C-CIARN Coastal Zone reports and posters.

A C-CIARN Coastal Zone newsletter was also developed in 2003. The newsletter highlighted updates to the website and included information on funding opportunities, upcoming events, new data sources and recent publications. The newsletter also showcased a coastal research product currently being conducted in Canada. Since 2003, nearly 30 newsletters had been published and distributed to members.

C-CIARN Coastal Zone also provided information on numerous potential funding sources to the C-CIARN Coastal Zone membership. In particular, C-CIARN Coastal Zone actively promoted the Climate Change Action Fund (CCAF)/Climate Change Impacts and Adaptation Program (CCIAP) Call for Letters of Interest for research on coastal zone management and communities. Funding opportunities were announced in June 2002, July 2004 and December 2004. The Coordinator helped to encourage, identify and facilitate collaborative research teams and stakeholder partnerships. In addition, C-CIARN Coastal Zone provided review and editorial assistance to several groups or potential project leaders by reviewing draft LOIs and full proposals.

C-CIARN Coastal Zone has produced or contributed to numerous abstracts, papers and reports. Most notable were three workshop reports from C-CIARN Coastal Zone events and the document 'Adapting to Climate Change: An Introduction for Canadian Municipalities', which was released in 2006 with the endorsement of the Federation of Canadian Municipalities. Eight C-CIARN Coastal Zone posters were also produced. The posters were created as contributions to different conferences, or as part of a national series to look at significant coastal and climate change impacts for different coastal regions across Canada.

To enhance the visibility of C-CIARN Coastal Zone, the Coordinator attended and participated in numerous conferences, workshops and meetings, in all of the four coastal regions in Canada. The Coordinator also communicated one-on-one with innumerable stakeholders across the country. The C-CIARN Coastal Zone

Coordinating office provided numerous oral and/or poster presentations, as well as verbal overviews of C-CIARN and/or climate change during numerous roundtable discussions. In addition, the Coordinator met with representatives of different organizations to discuss and promote C-CIARN. C-CIARN Coastal Zone also sponsored, organized and/or hosted over 10 workshops and special sessions. These events were held at different locations across Canada and focused on various themes or issues of concern to stakeholders. During these events, participants contributed to the identification of key coastal impacts, knowledge gaps and research needs, as well as the development of recommended actions for moving forward on adaptation in Canada's coastal regions.

In June 2002, C-CIARN Coastal Zone hosted two special sessions on climate change impact and adaptation issues for the Great Lakes coast at the Coastal Zone Canada 2002: Managing Shared Waters Conference held in Hamilton, Ontario. Approximately 400 coastal researchers, managers, policy-makers and stakeholders, from government, academia, the private sector, NGOs, and aboriginal communities attended this biennial conference. In October 2002, C-CIARN Coastal Zone co-hosted a plenary session at the Ocean Management Research Network (OMRN) National Workshop. The session focused on potential impacts of climate change to coastal communities, and participation included researchers from both physical and social science backgrounds.

In February 2003, C-CIARN Coastal Zone hosted its first annual workshop in North Vancouver, British Columbia. Over 60 participants from across Canada attended

the workshop including representatives from all levels of government, academia, aboriginal organizations, community groups, industry and NGOs. The workshop focused on the potential vulnerability of coastal communities to water level changes. Speakers presented examples of water level issues from numerous communities across Canada, as well as from various sectors. In April 2003, the Climate Change Impacts & Adaptation Directorate (CCIAD), C-CIARN Atlantic and C-CIARN Coastal Zone organized and hosted a workshop to look at the vulnerability of the Bay of Fundy coasts to climate change. In addition to refining specific research needs for the region, the objective of the workshop was to encourage the development of collaborative partnerships in anticipation of the Call of Letters of Interest for coastal zone research. In November 2003, C-CIARN Coastal Zone co-hosted another special interactive workshop at the Ocean Management Research Network (OMRN) National Conference. This workshop focused on vulnerability to climate change and the challenges of adaptation for Canada's coastal communities. Again, participants were from both physical and social science backgrounds.

In May 2004, C-CIARN Coastal Zone and C-CIARN Atlantic hosted a special workshop on the vulnerability of coastal trails and boardwalks to extreme storm events and climate change. The objective of the workshop was to raise awareness on the vulnerability of coastal trails and boardwalks and promote the need for better planning, maintenance and management. Approximately 40 participants attended the workshop. Participants were from a wide variety of backgrounds, including trail and recreational groups, NGOs, all levels of

government, academia and the planning and engineering communities. In October 2004, C-CIARN Coastal Zone participated in organizing and co-leading a special working group on human dimension of coastal change at the international Arctic Coastal Dynamics conference. As a result of this working group, a project proposal to assess of the current state of knowledge and activity related to the human dimension of arctic coasts was developed for submission to the International Arctic Science Committee and International Polar Year. During the fall of 2004, C-CIARN Coastal Zone also participating in organizing and sponsoring a 2-day national workshop on coastal communities and climate change. This workshop, entitled Climate Change & Coastal Communities: Concerns & Challenges for Today & Beyond, brought together approximately 100 representatives from academia, government, community groups and environmental organizations from across Canada. In November 2004, C-CIARN Coastal Zone and the Climate Change Impacts & Adaptation Program (CCIAP) organized a 1-day meeting for project leaders of coastal zone research projects supported by CCIAP. The purpose of this meeting was to facilitate networking and dialogue among the various project leaders.

In May 2005, C-CIARN Coastal Zone, The Living by Water Project and Adapting to Climate Change in Canada 2005 Conference co-sponsored a special workshop entitled 'From Science to Action'. The workshop focused on approaches to effectively communicate "science based" messages to a variety of audiences. The workshop provided practical tips for gaining "buy-in" of messages, and moving audiences along the continuum from

knowledge to action. C-CIARN Coastal Zone also participated in the Steering Committee to organize the 12th Canadian Coastal Conference 2005 held in Dartmouth, Nova Scotia during November 2005. This biennially conference is held at different locations across Canada and provides a forum for geoscientists, engineers and coastal planners. In November 2005, C-CIARN Coastal Zone, with the assistance of the Climate Change Impacts & Adaptation Program (CCIAP), organized a second meeting for project leaders from on-going CCIAO projects and new projects that had received CCIAP support during the 2004 round of coastal zone research funding. In December 2005, C-CIARN Coastal Zone organized the session 'Shifting Shores: Sharing Adaptation Experiences for Coastal Environment' as part of the C-CIARN/CCIAP hosted Parallel Event 'Living with Climate Change: Sharing Adaptation Experiences' held during the 11th Conference of Parties to the United Nations Framework Convention on Climate Change (COP11). The session offered presentations from a number of international speakers who discussed how coastal communities are adapting to current vulnerabilities and projected climate change impacts in such places as Québec, the Caribbean, Pacific and Indian Ocean island states and the U.S. coast of the Gulf of Mexico.

Appendix C

Climate Change Impacts & Adaptation Program (CCIAP): Coastal Zone Projects

1. Adaptation to Rising Sea Level in the Bras d'Or Lakes, Canada's Largest Inland Sea

Principal Investigator: John Shaw, Natural Resources Canada

Funding Call: Coastal Zone Management

Status: Reporting

This study will provide information for the management of the coasts of the Bras d'Or Lakes, Nova Scotia. The project will define past, present, and future trends of water level increases in the lakes. By mapping the coastal environment using multibeam bathymetry data collected by the Department of Fisheries and Oceans, the research team will assess its evolution and the potential impacts of climate change on a range of sensitive coastal environments. The project will ultimately transfer information on the vulnerability of this region to sea level rise to local decision-makers.

2. Assessing Vulnerability to Sea Ice Change: An Example from Igloolik, Nunavut

Principal Investigator: William Gough, University of Toronto

Funding Call: Communities

Status: On-going

The primary objective of this project is to assess current and future community vulnerability to sea ice variability and change in Igloolik, Nunavut. The project will facilitate the synthesis and expansion of three existing projects initiated by members of the research team in this region. It is anticipated that the project's results will be

transferable to other communities in Canada's North in an effort to understand and enhance adaptive capacity.

3. Assessment of the Capacity of the Emergency Response & Public Health Systems in Atlantic Coastal Communities to Cope With & Adapt to Extreme Weather Events Exacerbated by a Changing Climate

Principal Investigator: Jacinthe Seguin, Health Canada

Funding Call: Coastal Zone Management

Status: On-going

The goal of this project is to assess the capacity of coastal management systems in two Atlantic coastal communities to cope with extreme weather events exacerbated by a changing climate. The project involves the design and delivery of a simulation exercise involving key participants from two coastal management systems - one responsible for Channel-Port-aux-Basques area in Southwestern Newfoundland, the other for the Shédiac-Cap-Pelé area in Southeastern New Brunswick. The project will engage participants in a functional simulation exercise to explore how the coastal management systems manage risks associated with extreme coastal weather events, how planned and unplanned actions influence outcomes in coastal communities, and the system's capacity to deliver appropriate responses to coastal zone challenges.

4. Climate Change and Sea-level Hazards on the Canadian Beaufort Sea Coast

Principal Investigator: Steve Solomon,
Natural Resources Canada

Funding Call: Coastal Zone Management

Status: Complete

This project focussed on the low-lying, ice-rich Western Arctic coast where, under current conditions, erosion rates can exceed 20 metres per year. More than 100 metres of coastal retreat has occurred at Tuktoyaktuk since 1947. Researchers refined and calibrated storm-surge models for the Beaufort Sea; developed scenarios of the impact of climate change on storm frequency, intensity, direction, and ice conditions, and mapped areas of sensitivity to flooding and potential erosion under present and future storm-surge scenarios.

5. Climate Change Adaptation Options for Coastal Zone Management in the Great Lake Basin

Principal Investigator: Mark Taylor, AMEC
Earth and Environmental

Funding Call: Coastal Zone Management

Status: Reporting

The purpose of this study is to identify coastal features and processes that are likely to be affected by climate change and to determine sustainable management practices that will reduce the vulnerability of these features and processes. The project will provide an assessment of knowledge on adaptive management plans and activities that address climate variability, extremes, and climate change for Provincial and National Parks, Wildlife Areas, Important Bird Areas, significant spawning and nursery areas for fisheries, and Areas of Concern on the Great Lakes. The project will utilize climate and hydrologic data from

the Great Lakes Basin to examine a range of climatic and Great Lakes coastal variables, the frequency of extreme events, and changes that are likely to occur under various climate change scenarios. The research will focus on existing integrated data sources and the development of transfer functions which link Great Lakes Basin studies to global climate models.

6. Climate Change Impacts and Adaptation in Newfoundland Coastal Communities

Principal Investigators: Norm Catto,
Memorial University

Funding Call: Communities

Status: Complete

Consulting with community residents to identify impacts of local concern was the critical first step of this study in Conception Bay south, Newfoundland. These concerns included coastal erosion, infrastructure damage and implications for town management and development. Researchers then used historic data to evaluate past climatic impacts and to identify which parts of the coast are most sensitive to flooding and erosion. Finally, options (preventing development in areas of known vulnerability, implementing setback limits) were recommended as a proactive means of limiting future impacts.

7. Climate Change Impacts and Adaptations on Sea Ice Transportation in Canada's Northwest Passage

Principal Investigators: Roger De Abreu,
Environment Canada

Funding Call: Transportation

Status: On-going

The relatively short and sparse climate data record of Canada's Arctic hampers our

ability to predict its future conditions. The Canadian global climate models (GCM=s) suggests that if warming trends continue, by 2050 sea ice in the Canadian Arctic will no longer be present during summer months. This loss of seasonal ice could have significant impacts in northern Canada, as it plays an important role in the biological, economic, and cultural components of the Arctic ecosystem. Researchers will: (1) identify what sea ice thresholds and parameters affect transportation usage, and how these may influence future behaviour; (2) increase communication and interaction between northern communities, shippers and researchers and; (3) interpret and synthesize climate change scenarios that describe future sea ice conditions. The goal of this project is to define the potential impacts of climate change on sea ice in Canada's Northwest Passage in order to make useful and understandable adaptation and policy recommendations to decision makers and stakeholders.

8. Climate Change Impacts, Infrastructure Risks & Adaptive Capacity of Arctic Coastal Communities

Principal Investigators: Norm Catto, Memorial University and Barry Smit, University of Guelph

Funding Call: Coastal Zone Management

Status: On-going

This research will focus on coastal hazards and adaptation strategies, with particular attention to infrastructure vulnerability in light of environmental and climate change in the Canadian Arctic. The broad goals of the research are to assess the biophysical exposure and hazards on Arctic coasts subject to effects of climate change, identify past and current management strategies employed to manage risks in coastal

communities which have already experienced environmental change, and to assess the adaptive capacity of communities for dealing with coastal hazards throughout the Arctic. The project has a broad scope and will include fieldwork and a number of community visits.

9. Coastal Vulnerability to Climate Change and Sea Level Rise, Graham Island, Haida Gwaii, British Columbia

Principal Investigator: Ian Walker, University of Victoria

Funding Call: Coastal Zone Management

Status: Reporting

This study will examine the potential physical, socio-economic, and cultural impacts of climate change on one of Canada's most sensitive coasts – northeastern Graham Island, Haida Gwaii (Queen Charlotte Islands), B.C. This region is subject to high tides and frequent extreme storm events, which produce ongoing erosion of 1-3 metres per year. Projected sea level rise of 0.15 metres per century could increase the vulnerability of sensitive ecological reserves, cultural sites and activities, parks and tourism, natural resources, livelihoods, and infrastructure. The project proposes an integration of scientific research with traditional community knowledge to assess past, as well as future changes, in order to determine what these changes may mean for the biophysical and socio-cultural integrity of this region. Projected physical impacts will be mapped to identify regions at risk to enhanced erosion, flood inundation, tidal encroachment, and ecosystem change, and sensitive areas and activities of socio-economic and cultural significance will be evaluated in consultation with local

stakeholders in an attempt to develop appropriate adaptation strategies.

10. Co-management of Climate Change in Coastal British Columbia: Social Capital, Trust & Capacity

Principal Investigator: Ralph Matthews, University of British Columbia
Funding Call: Coastal Zone Management
Status: On-going

This project will examine climate change impacts and adaptation by communities located in the central and north coast regions of British Columbia. Specifically, it will study how key communities are responding to current and potential climate change threats, including what social, institutional and governance opportunities exist to enhance successful adaptation, and which of the above might be introduced or modified to locally specific needs so as to optimize resilience in the face of climate change. In this context, the research will focus on three key areas of research related to climate change impacts and adaptation in the coastal communities identified, including management processes, climate change knowledge and perspectives, and social capital relations.

11. Evaluation of Risk of Erosion and Flooding in British Columbia

Principal Investigator: William Crawford, Fisheries and Ocean Canada
Funding Call: Coastal Zone Management
Status: Complete

Researchers studied the role of winds, storms and tide levels to analyse the risks of coastal flooding in British Columbia and identified steps that could be taken to improve warnings of extreme sea levels.

12. An Evaluation of Salt Marsh Restoration as an Adaptation Strategy to Future Climate Change & Sea Level Rise in Maritime Canada

Principal Investigator: Jeff Ollerhead, Mount Allison University
Funding Call: Coastal Zone Management
Status: On-going

The primary objective of the project is to evaluate the socio-economic and biophysical conditions necessary for communities to embrace the conversion of dyked lands to salt marsh in Maritime Canada as an adaptation strategy to future climate change and sea level rise. A key component is identifying stakeholder concerns with employing this adaptation strategy and assessing whether communities have the adaptive capacity to do this. A centrepiece of the project will be documenting the restoration of a former salt marsh at Musquash, New Brunswick as a case study.

13. The Fate of Salt Marshes in Atlantic Canada

Principal Investigator: Gail Chmura, McGill University
Funding Call: Coastal Zone Management
Status: Complete

By comparing past rates of accumulation of marsh sediments with tide gauge records, researchers determined to what degree four salt marshes in Atlantic Canada would be threatened by increases in sea level associated with climate change. The sedimentation rates for each marsh, the estimated reduction in deposits over time, and the degree of variability within and among regions were established.

14. Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change & Response to Adaptation Strategies

Principal Investigators: Linda Mortsch and Joel Ingram, Environment Canada
Funding Call: Coastal Zone Management
Status: Reporting

In this study, researchers intend to supplement pre-existing GIS databases on recent changes in plant communities of the marginal wetlands of the Great Lakes with further analysis of historical air photos and fieldwork in selected areas. The database will then be queried to determine the relationship between changes in lake levels and plant community extent. The results will be used to develop a model which will: (1) forecast future community plant distribution as a function of changing water levels; (2) assess concomitant changes in bird and fish assemblages, and; (3) assess water regulation strategies. A report intended for government and non-governmental resource management agencies will explain the vulnerability of Great Lakes coastal wetland ecosystems to water level change (as a surrogate for climate change), document implications for ecosystem remediation and protection, and assist in identifying and developing both management policy instruments and infrastructure adaptation strategies to maintain ecosystem function and values.

15. Impacts of Sea-Level Rise & Climate Change on the Coastal Zone of Southeastern New Brunswick

Project Manager: Réal Daigle
Funding Call: Coastal Zone Management
Status: Reporting

This project will quantify impacts of climate change and more specifically sea level rise, storm surge, and coastal erosion on the Gulf of St. Lawrence coastal zone of southeastern New Brunswick, in support of sustainable management, community resilience, and the development of adaptation strategies. Researchers will study an area of the Gulf Shore of New Brunswick from Kouchibouguac National Park to Little Shemogue Bay. This area of the NB Gulf coast faces increasing pressures of coastal development and is important for ecosystem sustainability. This work will provide information for the development of appropriate adaptation strategies.

16. Policies, Governance & Building Community Capacity to Adapt to Climate Change in Island & Continental Coastal Zones

Principal Investigator: Steve Plante, Université du Québec à Rimouski
Funding Call: Communities
Status: On-going

The primary objective of this project is to evaluate public policies governing coastal zones, the development and management of sanitary infrastructures, and local services that take anticipated climate change into account and to determine whether they are appropriate.

17. Response Strategy to Maintain Shipping and Port Activities in the Face of Climate Change - Reduced Water Levels in the Great Lakes / St. Lawrence Seaway

Principal Investigator: Pierre D'Arcy,
Fisheries and Oceans Canada
Funding Call: Transportation
Status: On-going

Climate change could lead to a significant drop in water levels in the Great Lakes / St. Lawrence Seaway system over a relatively short period of time. Some models estimate that levels could drop as much as one metre below chart datum, the reference point against which water levels are currently measured. Should this estimate prove accurate, it could have significant economic consequences, not only for port infrastructure located along the shoreline, but also for marine activity as a whole.

18. Sea Level Rise and Climate Change: Impacts and Adaptation Needs, Prince Edward Island – A Case Study

Principal Investigator: Martha McCulloch/Don Forbes
Funding Call: Coastal Zone Management/Natural Resources Canada
Status: Complete

The twenty three-member research team undertook a comprehensive analysis of the risk posed by sea level rise to Charlottetown and a section of the north coast of PEI. The work produced high-resolution topographic maps of the study areas and climatological analysis of sea level, storm surges, winds, waves and ice cover in the Gulf of St. Lawrence. It also contributed to the development of a storm surge model, which was used to analyse the flood potential for Charlottetown at three critical water levels.

Socio-economic analysis estimated the number and value of properties in Charlottetown at risk from these three flooding scenarios. For the north shore, an assessment was carried out on the effects of increased erosion on real property loss for cottage and non-cottage properties, and on non-market values for wetlands, forested land, beaches and dunes. A review of adaptation measures was also undertaken.

19. Sensitivity of Roberts Bank Tidal Flats to Accelerated Sea-Level Rise & Intensified Storminess

Principal Investigator: Philip Hill, Natural Resources Canada
Funding Call: Ecosystems
Status: Reporting

The Fraser Delta has been identified as being highly sensitive to sea level rise. The purpose of this research is to examine the potential impact of climate change on the Fraser River tidal flats and to identify adaptation strategies. Addressing these impacts would affect a broad range of evolving community, commercial, and conservation interests, several of which are already in conflict with each other. Furthermore, eventual resolution of the issues and development of a common adaptation strategy would involve four levels of government: federal, provincial, municipal, and First Nations. The research is intended to provide sound technical background for decision-making, to raise the level of awareness of the climate change impacts, and to develop integrated biophysical and socio-economic scenarios upon which realistic, implementable adaptation strategies might be based. For the purpose of this research, the impacts of climate change on Roberts Bank are considered to be physical, biological and

socio-economic, for which specific objectives of these study components have been developed.

20. Study of Shoreline Sensitivity & Community Vulnerability to Climate Change Impacts in the Gulf of St. Lawrence

Principal Investigator: François Morneau, Ouranos

Funding Call: Coastal Zone Management

Status: On-going

The objective of this project is to incorporate climate change impacts into the process of integrated shoreline management currently under development in the Gulf of St.

Lawrence. A climate change impacts assessment will be undertaken to improve the ability of decision-makers and stakeholders to identify coastal areas sensitive to climate change, to better understand the processes that control the interactions between climate and erosion, to assess the vulnerability of existing or planned uses and infrastructure in order to harmonize adaptation strategies, reduce resistance to adaptation, and to generally optimize management in the coastal zone.

Three coastal areas will be studied, including the Magdalen Islands, the Sept-Iles region (Gallix to Matamec) and the Percé region (Cap d'Espoir to St-Georges de la Malbaie). These sites are characterized by a wide range of socio-economic and environmental issues and are representative of the range of Quebec coastal areas in the Gulf of St. Lawrence.

Appendix D

Climate Change Impacts & Adaptation Program (CCIAP): New CCIAP Projects Focused on Tools & Toolkits

1. Adaptive Decision and Planning Tools (ADAPT) in Canadian Arctic Communities

Principal Investigator: Hadi Dowlatabadi,
University of British Columbia

Arctic communities face multiple forces of change at the same time, including climate change. The purpose of this research in the north is to develop decision-aiding tools to assist communities in planning strategically under conditions of high uncertainty. Currently there are no analytic tools that can be easily adopted by Arctic communities to work toward assessing their own vulnerability and plan to adapt to a change in climate. This project will work collaboratively with the communities of Cambridge Bay, Baker Lake and Pond Inlet to create these tools.

2. Climate Change Adaptation for Land Use Planners

Principal Investigator: Jeffrey Parks, Birch Hill GeoSolutions

The project will develop a toolkit for Land Use Planners to assist them in assessing potential climate change impacts and alternative land use adaptation scenarios, and in implementing climate change adaptation planning techniques. The resulting toolkit will be developed and tested with two sites in Nova Scotia. Qualitative impacts analyses will be studied at these sites, as well as in-depth risk analyses of climate change impacts and adaptations for flooding in one community, and drought in the other.

3. Community Planning Tools and Approaches for Protecting Freshwater Shorelines in the Thompson-Nicola-Shuswap Region of the BC Interior in Response to Climate Change

Principal Investigator: Sara Kipp, The Federation of British Columbia Naturalists

This project is focused on the Thompson-Nicola-Shuswap region of the interior of British Columbia. The aim of the project is to identify and develop community planning and management tools to help adapt to the impacts of climate change upon freshwater shorelines. This project will use a consultative process, including use of community focus groups and there are plans to have a forum to engage the public

4. Climate-SMART (Climate-Change Sustainable Mitigation & Adaptation Risk Toolkits)

Principal Investigator: Rob Young, Dillon Consulting Limited

A collaborative project involving the private and public sectors, with the overall objective of assisting Halifax Regional Municipality (HRM) in the mainstreaming of greenhouse gas (GHG) emission reduction and climate change impact/adaptation considerations into HRM's decision-making processes. The project will provide HRM with: an emissions management plan; statistically downscaled climate change scenarios; climate change hazard mapping; and tools to facilitate adaptation to climate change. The project is designed so that the lessons learned and

the tools developed during the process can be applied to other municipalities in the future.

5. Climate Change Planning Tools for First Nations: Adapting to Climate Variability and Change

Principal Investigator: Lisa Hardess

This project will develop user-friendly, adaptable First Nation climate change planning tools, through participatory research and partnerships with a First Nation in Manitoba and another in Saskatchewan. The tools will focus on process and decisions for planning, as opposed to specific impacts but will use specific examples and scenarios for illustration. The tools will take the form of a series of guidebooks and will include both western and indigenous approaches and information.