Challenges in Environmental Management in the Bay of Fundy-Gulf of Maine

Proceedings of the 7th Bay of Fundy Science Workshop,
St. Andrews, New Brunswick
24–27 October 2006

Editors

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Dedication

We dedicate this Fundy Proceedings to the memories of three scientific colleagues and friends who recently passed away. They spent their careers striving to protect coastal watersheds and marine living resources and habitats.

Susan A. Snow-Cotter (1961-2006)
Massachusetts Office of Coastal Zone Management, Boston, Massachusetts

John Gibb (1946-2007)
Environment Canada, Dartmouth, Nova Scotia

Ransom Myers (1952-2007)
Killam Chair in Ocean Studies, Department of Biology, Dalhousie University, Halifax, Nova Scotia

The Editors

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Preface

Hosted by the Huntsman Marine Science Centre (HMSC), the 7th Bay of Fundy Science Workshop was held on October 25-27, 2006 at the Fairmont Algonquin Hotel in historical St. Andrews by-the-Sea. This marked the 10-year anniversary of these popular workshops. With the US-Canada coastline facing the influx of more resource-based industry, such as by liquefied natural gas and quarry operations in the neighbourhood of the conference site, the Workshop theme on “Challenges in Environmental Management in the Bay of Fundy - Gulf of Maine” was indeed appropriate. The inclusion of the Gulf of Maine was deliberate, as the Bay of Fundy is a complex and interlinked component, with both bodies of water facing similar environmental challenges. In this regard it was particularly satisfying to see attendance of US representatives with a shared interest in the issues.

Amongst the 160 participants were students and researchers from universities, government, and NGOs, as well as representatives of community groups and businesses, environmental managers and interested citizens. During an intense 2.5 days, over 80 scientific papers and posters were presented in 13 oral sessions and two poster sessions. This covered a wide range of topics, including biodiversity and ecology, climate change, salt marshes, sea birds, fish ecology, sea-floor mapping, resource management and environmental monitoring. The last session involved all participants, culminating in a discussion on ecosystem-based management and governance – “can we get there from here?”

Four keynote speakers in three sessions helped frame the issues, first with Fred Page from the St. Andrews Biological Station discussing the challenges in managing the environment from an oceanographic perspective. The Bay’s very dynamic and ever-changing physical environment, short and longer-term cycles, sea level rise and climate change were among the topics covered. Graham Daborn, from Acadia University, gave a vivid biological perspective. Using the analogy of the ever unfinished shroud, made by the Greek mythical figure Penelope, Daborn described the progress over the years in trying to understand the Bay of Fundy and Gulf of Maine ecosystems, with new ‘threads’ of knowledge forcing scientists to rework them to reflect new understanding. As a fitting contrast, gkisedtanamoogk of the Mashpee Tribe and Mi’gMa Nation, and Hugh Akagi of the Passamaquoddy Tribe, provided an emotional twelve thousand year perspective on the issues faced by all.

Among the awards presented was the BoFEP “Environmental Stewardship Award” given to an individual who “contributed significantly to the environmental health or sustainability of the Bay of Fundy”. Very deservedly, Peter Wells, recently retired from Environment Canada, became the recipient of this honour for his tireless environmental work and support for BoFEP since its inception. In addition, four student awards were given for best papers and posters, including Alexander Bond and David Drolet of the University of New Brunswick, and Koreen Millard and Shannon O’Connor of Acadia University.

The BoFEP Annual General Meeting was held during the workshop. On the eve of the BoFEP workshop, the HMSC also hosted a complementary workshop on “Climate change & thermal sensitivity of commercial marine species with a focus on Atlantic Canada”. Summary findings were presented in the BoFEP meeting. Plans for the next BoFEP workshop are well underway, being hosted by Acadia University at the Old Orchard Inn in Wolfville, October 21-24, 2008. We are looking forward to seeing you all there.

Gerhard Pohle
Workshop Chair
January 2007

Acknowledgements

The well-recognized biennial BoFEP workshop requires extensive planning, arranging and organizing that no single individual can accomplish. It is only through the ready participation of enthusiastic individuals and groups that the staging of the 7th workshop was possible.

At the top of the list in extending warm thanks are the 21 members of the Organizing Committee, spanning all sectors, who regularly participated in planning the program and other activities well over a year prior to staging the event. A special thank you to Marianne Janowicz in working with Jon Percy to “find” awards judges, and session chairs and co-chairs; Marianne was also instrumental in organizing the silent auction with Hugh Akagi, and in securing funding from the New Brunswick government. Jon Percy graciously took on other duties, including coordinating various activities related to judging presentations and in organizing much of the onslaught of abstracts.

Susan Rolston deserves a special thank you, not only for again lending the skills as copy-editor of the proceedings but also for working with authors and presenters from start to finish at the workshop. The intrepid Peter Wells, as always, lent his hands whenever the need arose at whatever task was necessary, culminating with the editing of these proceedings. Through Anna Redden of Acadia University, BoFEP obtained the valuable services of Leanna McDonald in workshop preparatory work and in manning the front desk throughout the workshop. Lew Incze, of the University of Southern Maine, is thanked for stepping up to the plate in providing advice, making possible US support, and speaking out on the need for cross-border cooperation. Mark TeKamp is thanked for co-ordinating student input and in handling aspects of the production of a new edition of commemorative workshop T-shirts.

The staff at the Huntsman Marine Science Centre helped out in many of the preparatory activities, from administration Mabel Ketchum, Debbie Harmon, Kimberly Arseneau, and particularly Sandra Clark in keeping track of all things financial. From Huntsman’s Atlantic Reference Centre, Rebecca Milne deserves special mention for having taken on a large burden just prior to the workshop as do-it-all assistant, very ably replacing Sara Kohler on short notice, and in continuing work right to the end on a post-workshop analysis. Lou Van Guelpen, Mary Greenlaw, Karen Ross and Ashley Holmes also helped with mailings and various preparatory activities.

The workshop would not have been occurred without our sponsors, from a variety of sectors, who graciously provided crucial funds to make this important event possible. Local media also helped in publicizing the event.

Staff at the St. Andrews Biological Station helped generously, including Trish Hopkins, Maria-Ines Buzeta, and Suzanne Taylor in logistics and equipment, Peter Lawton in taking on all things related to biodiversity, and Rob Stevenson, who with Ellen Kenchington from the Bedford Institute of Oceangraphy, made possible crucial support from the Department of Fisheries and Oceans.

Last, but certainly not least, I need to thank all contributing authors who have made possible the diverse sessions. The participation of 19 students was particularly welcome. All awards judges, session chairs and co-chairs are thanked for their contributions in successfully running the respective events.

Gerhard Pohle
7th BoFEP Workshop Chair

Workshop Organizers

Chair

Gerhard Pohle

Committee Members

Hugh Akagi ~ Fisheries and Oceans Canada, St. Andrews, NB
Gail Chmura ~ McGill University, Montreal, PQ
Sandra Clark ~ Huntsman Marine Science Centre, St. Andrews, NB
Maria Ines-Buzeta ~ Fisheries and Oceans Canada, St. Andrews, NS
Jessie Davies ~ University of New Brunswick, Fredericton, NB
Lewis Incze ~ University of Southern Maine, Portland, ME
Marianne Janowicz ~ NB Department of the Environment, Fredericton, NB
Barry Jones ~ Gryffyn Coastal Management, Fredericton, NB
Ellen Kenchington ~ Fisheries and Oceans Canada, Dartmouth, NS
Mabel Ketchum ~ Huntsman Marine Science Centre, St. Andrews, NB
Peter Lawton ~ Fisheries and Oceans Canada, St. Andrews, NB
Art MacKay ~ St. Croix Estuary Project, St. Stephen, NB
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Jon Percy ~ Sea Pen Communications, Granville Ferry, NS
Debbie Perry ~ Atlantic Salmon Federation, St. Andrews, NB
Donna Porter ~ Acadia University, Wolfville, NS
Rabindra Singh ~ Fisheries and Oceans Canada, St. Andrews, NB
Mark TeKamp ~ TeKamp Urban and Coastal Planning, Halifax, NS
Thomas Trott ~ Suffolk University, Boston, MA
Peter Wells ~ Environment Canada, Dartmouth, NS/Dalhousie and Acadia Universities, NS

Student Awards

Coordinators

Marianne Janowicz and Jon Percy

Judges for "Best Papers"
Jon Percy
John Roff
Mark TeKamp
Thomas Trott

Judges for "Best Posters"
Larry Hildebrand
Patricia Hinch
Lew Incze

BoFEP Environmental Stewardship Award Committee

Graham Daborn (chair)
Patricia Hinch
Marianne Janowicz

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Fisheries and Oceans Canada – Maritimes Region
Government of New Brunswick
Gulf of Maine Council on the Marine Environment
Huntsman Marine Science Centre
The Nature Trust of New Brunswick

Awards Presented at the Workshop

Second BoFEP Environmental Stewardship Award

Peter G. Wells

This award recognizes an individual who has contributed significantly to the environmental health and sustainability of the Bay of Fundy. Dr. Peter Wells is recognized for his steadfast dedication, knowledge, leadership and service toward a healthy Bay of Fundy and Gulf of Maine.

He exemplifies an individual who generously and enthusiastically contributes his time, knowledge and expertise in aquatic and marine ecotoxicology, and estuarine and coastal ecology to further the mission and mandate of BoFEP. He was a founding member of FMESP (Fundy Marine Ecosystem Science Project, the forerunner of BoFEP), and has served on the Executive of BoFEP and on numerous scientific committees for many years. He has been intimately involved with the organization of BoFEP workshops, and has worked to secure Environment Canada financial support for BoFEP activities. On a regional basis, he has served as Canadian Co-Chair of the Environmental Quality Monitoring Committee, responsible for the Gulf of Maine Council's sentinel species, GulfWatch Monitoring Program.

BoFEP is proud to honor Peter with this Environmental Stewardship Award as a tribute to his scientific and managerial achievements over many years of service to the Bay of Fundy.

First Place Oral Student Presentation

Alexander Bond, University of New Brunswick, Fredericton, NB
[Supervisor: Antony Diamond]
Comparing adult and chick diet in two Alcid species using stable isotopes

Second Place Oral Student Presentation

David Drolet, University of New Brunswick, Fredericton, NB
[Supervisor: Myriam Barbeau]
Effect of density of the gastropod Ilyanassa obsoleta on distribution and movement of the amphipod Corophium volutator

First Place Student Poster

Koreen Millard, Nova Scotia Community College, Lawrencetown, NS, and Acadia University, Wolfville, NS
[Supervisor: Timothy Webster]
High-resolution LIDAR elevation data of inter-tidal areas: A potential tool for examining salt marsh vegetation communities

Second Place Student Poster

Shannon O'Connor, Acadia University, Wolfville, NS
[Supervisor: John Roff]
The Atlantic Coastal Zone: All the little fishes

About Key Sponsors of BoFEP

The Bay of Fundy Ecosystem Partnership (BoFEP)

The Bay of Fundy Ecosystem Partnership (BoFEP) was formed to identify and try to understand the problems confronting the Bay and to find ways of working together to resolve them. It is a flexible and still evolving organization for encouraging and facilitating communication and co-operation among individuals and groups with a stake or an interest in Fundy and its resources. BoFEP is set up as a “Virtual Institute”, whose main objective is to foster wise conservation and management of the Bay’s natural resources and diverse habitats, by disseminating information, monitoring the state of the ecosystem and encouraging co-operative research, conservation and other activities. BoFEP welcomes all partners who share the vision of a healthy, diverse, productive Bay of Fundy, be they individuals, community groups, First Nation groups, resource harvesters, scientists, resource managers, coastal zone planners, businesses, government agencies, industries or academic institutions. By sharing our knowledge and coordinating our individual efforts we can ensure that present and future generations will be able to benefit from Fundy’s rich and varied bounty and continue to appreciate its awesome beauty and diversity.

To learn more about BoFEP, visit: <http://www.bofep.org>

Huntsman Marine Science Centre

The Huntsman Marine Science Centre is a membership driven non-profit institution founded in 1969 and operated by a consortium of university, government and private industry members dedicated to marine science and education. The organization is committed to the advancement of marine sciences through basic and applied research, the delivery of a superior educational experience, and the provision of technical solutions for public and private partners.

To learn more about Huntsman, visit: <http://www.huntsmanmarine.ca>

Acadia Centre for Estuarine Research

The primary objective of the Acadia Centre for Estuarine Research is to focus research attention on the estuaries and nearshore coastal waters of Eastern Canada, with emphasis on the estuarine systems of the Bay of Fundy and the hydrographically-related Gulf of Maine and Georges Bank. The Centre was established in September 1985 with a grant from the Centres of Specialization Fund, administered by the Secretary of the State of Canada. Space and additional funds were provided by Acadia University. The Centre actively encourages cooperative, multidisciplinary research programmes that involve scientists and students from regional, national and international institutions.

To learn more about ACER, visit: <http://ace.acadiau.ca/science/cer/home.htm>

Gulf of Maine Council on the Marine Environment (GOMCME)

The Gulf of Maine Council on the Marine Environment is a United States-Canadian partnership of government and non-government organizations working to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations. The governors and premiers of the five Gulf jurisdictions—Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia—created the Council in 1989 as a regional forum to exchange information and engage in long-term planning. The Council organizes conferences and workshops; offers grants and recognition awards; conducts environmental monitoring; provides science translation to management; raises public awareness about the Gulf; and connects people, organizations, and information. The Councilors are leaders of state, provincial, and federal agencies, non-government organizations, and the private sector. With no central office, the Council is administered through an annual Secretariat that rotates among the jurisdictions.

BoFEP and GOMCME are now formally linked through an agreement (2004–2007) that promotes shared goals and objectives, and common projects in the Gulf of Maine.

To learn more about GPAC visit: <http://www.gulfofmaine.org>

Environment Canada

Environment Canada is responsible for preserving and enhancing the quality of the natural environment, including water, air and soil quality; conserving Canada's renewable resources, including migratory birds and other non-domestic flora and fauna; conserving and protecting Canada's water resources; carrying out meteorology; enforcing the rules made by the Canada-United States International Joint Commission relating to boundary waters; and coordinating environmental policies and programs for the federal government. Environment Canada seeks to make sustainable development a reality in Canada by helping Canadians live and prosper in an environment that needs to be respected, protected and conserved. With approximately 4,700 employees and a more than half billion dollar budget, Environment Canada works in communities across Canada and with thousands of partners in every province and territory and around the globe.

To learn more about EC's programs visit: <http://www.ec.gc.ca/envhome.html>

Keynote Addresses

PHYSICAL ENVIRONMENTAL VARIABILITY IN THE BAY OF FUNDY - GULF OF MAINE AND ITS RELEVANCE TO ENVIRONMENTAL MANAGEMENT

Fred H. Page

Biological Station, Fisheries and Oceans Canada, St. Andrews, NB (pagef@mar.dfo-mpo.gc.ca **)**

Introduction

The Bay of Fundy and Gulf of Maine today consists of a variety of physical and chemical features that provide habitat for a highly diverse suite of biological components. The region is bounded largely by the coastline of the New England states of the United States of America and the Canadian provinces of New Brunswick and Nova Scotia on the west, north and east and the Atlantic Ocean on the south. Freshwater enters the region through several significant rivers and from the Scotian Shelf on the east. The most prominent and unique physical characteristic is the high tidal range, especially in the Bay of Fundy.

This diverse physical (and chemical) habitat is occupied by a diverse and productive suite of biological populations, species, communities which combine with the physical features to form many ecosystem types.

Many of the physical and biological components of the region are utilized by humans. Some components, such as fish and shellfish are extracted through fishing activities. Other components are utilized for their beauty through ecotourism, the tides are looked upon for as sources for generating electrical energy, and some of the gravels are viewed as sources for extraction. The waters are indirectly influenced by the by-products of human inhabitation along the edges of the Gulf of Maine-Bay of Fundy area, especially in the areas where cities such as Boston, Portland and Saint John have been established and grown over the past several hundred years.

The management challenge is to achieve a sustainable balance with the evolving natural ecosystem and human needs to develop socially and economically. This challenge is further complicated by the fact that the rate of change in natural systems and human society and economics is accelerating. The present physical situation has evolved over the past ten to twenty thousand years after the last glaciations in the area (AGS 2001) but global warming threatens to induce significant change over the next hundred years. Native peoples occupied the region for thousands of years, with the presence of Europeans only being prominent in the past four hundred years. Many of the people now living along the coast of the Gulf of Maine and Bay of Fundy have grandparents who were born in the late 1800s when cities such as Saint John, New Brunswick, were much smaller in population and area than they are today. From my family history in the Saint John area over the past two hundred (plus) years, we know that Saint John and the surrounding communities have expanded from their beginnings on the shores of the Saint John Harbour to the shores of the Kennebecassis River, the Grand Bay area of the Saint John River, and beyond. During my own life, coastal erosion and industrial development have removed land that once supported our summer cottage along the Lorneville area of the northwestern Bay of Fundy.

The Gulf of Maine and Bay of Fundy will continue to change physically and biologically and the human presence will need to adjust to these changes – hopefully in a way that minimizes disruption of a negative character. As mentioned previously, the rate of these changes and adjustments will be faster than in the past millennia due to global climate change and worldwide, human population dynamics. Hence, the management challenge will be to develop more knowledge and awareness of the changes that are likely to occur and develop knowledge, policies and practices concerning what can be done to smooth the inevitable adjustment to the realities of change. Hopefully, the human population associated with the Gulf of Maine and Bay of Fundy will be able to adjust in a somewhat orderly fashion so many more generations of individuals can enjoy the wealth and beauty that the Gulf of Maine and Bay of Fundy have to offer.

Environmental Monitoring

The Gulf of Maine and Bay of Fundy region is one of the best studied marine areas in the world. Hence, it is a testing ground for how to develop, maintain and utilize the marine environmental monitoring, prediction and socio-economic management schemes that will be needed by the future generations of humans associated with the region. Early versions of environmental monitoring and prediction capabilities are now operational in the region and hopefully these will continue to be developed and improved over the decades to come. However, there is still much work to be done, especially in terms of developing similar capabilities for the biological aspects of the environment and for learning how to meaningfully incorporate the physical and biological knowledge into the various levels of social and economic decision making needed to guide people in their adjustment to the changing environment in which they live.

Observations on the physical, chemical and biological aspects of the marine environment in the Gulf of Maine and Bay of Fundy began over one hundred years ago, and perhaps even a few thousand years ago. Systematic observations that are routinely recorded and archived only began in earnest at the beginning of the last century and it has only been in the past decade or so that aspects of these programs have been modernized to include unmanned and telemetered arrays of observational sensors. Regional nowcasting (near real time forecasts) programs were only implemented in the late 1990s and early 2000s, less than a decade ago, and longer term forecasting is still in its infancy. Nevertheless, the Gulf of Maine and Bay of Fundy community is now able to receive observational and model-based nowcast information on an almost continuous basis through the Internet. There are two main dissemination points for this information. One is a Canadian-based source and the other is an American-based source. The Canadian source is the Marine Environmental Data Service (MEDS) Web site (http://www.meds-sdmm.dfo.mpo.gc.ca) and the American source is the Gulf of Maine Ocean Observing System (GoMOOS) Web site (http://www.gomoos.org).

These approaches are part of a growing global-scale ocean observing and modelling approach that is being developed. The approach consists of a coordinated suite of observational, data management and numerical modelling programs (Figure 1). The programs cover a range of spatial scales from truly global perspectives to regional and local scales. The Gulf of Maine and Bay of Fundy are an example of a regional and local scale implementation of this approach.

The MEDS Web site contains information on atmospheric and ocean conditions. For example, it contains data on wind velocities at several Canadian atmospheric monitoring stations including Saint John, New Brunswick, in the Bay of Fundy and Yarmouth, Nova Scotia, on the eastern Gulf of Maine; freshwater runoff from the Saint John and St. Lawrence Rivers; sea level near Saint John, New Brunswick, and Yarmouth, Nova Scotia; and air temperatures at Saint John, New Brunswick. The site also contains oceanographic data and data products collected as part of the Fisheries and Oceans Canada, Atlantic Zonal Monitoring Program (DFO AZMP). This data includes surface water temperature monitored in the mouth of the Bay of Fundy at the Biological Station wharf in St. Andrews, New Brunswick; water temperature and salinity, water nutrient and dissolved oxygen concentration, and lower trophic level biomass indicators (phytoplankton and zooplankton) at the Prince 5 oceanographic monitoring station located off Campobello Island, New Brunswick in 90 metres of water at the mouth of the Bay of Fundy; and remotely-sensed maps of sea surface temperature and chlorophyll concentration. The inflow into the Gulf of Maine is monitored along seasonally occupied hydrographic transects running across the continental shelf from Cape Sable, Nova Scotia, to Browns Bank and offshore of Halifax, Nova Scotia (Figure 2). The input is also monitored at a fixed station (Station 2) located off Halifax.

Figure 1. Schematic illustration of the generalized components of an operational oceanographic monitoring and prediction approach that is being developed in several parts of the world, including the Gulf of Maine and Bay of Fundy.

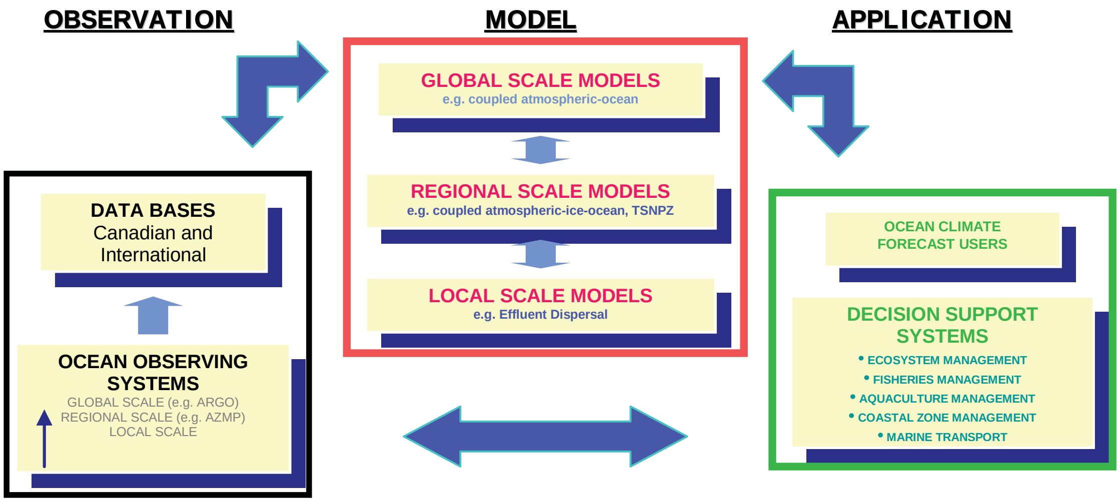


Figure 2. Canadian Atlantic Zonal Monitoring Program (AZMP) oceanographic data monitoring locations whose data is available on the web from the Canadian Marine Environmental Data Service (MEDS) Web site. The transects are occupied seasonally and the fixed stations are occupied throughout the year on a monthly or higher frequency basis. This figure was downloaded from the MEDS Web site.

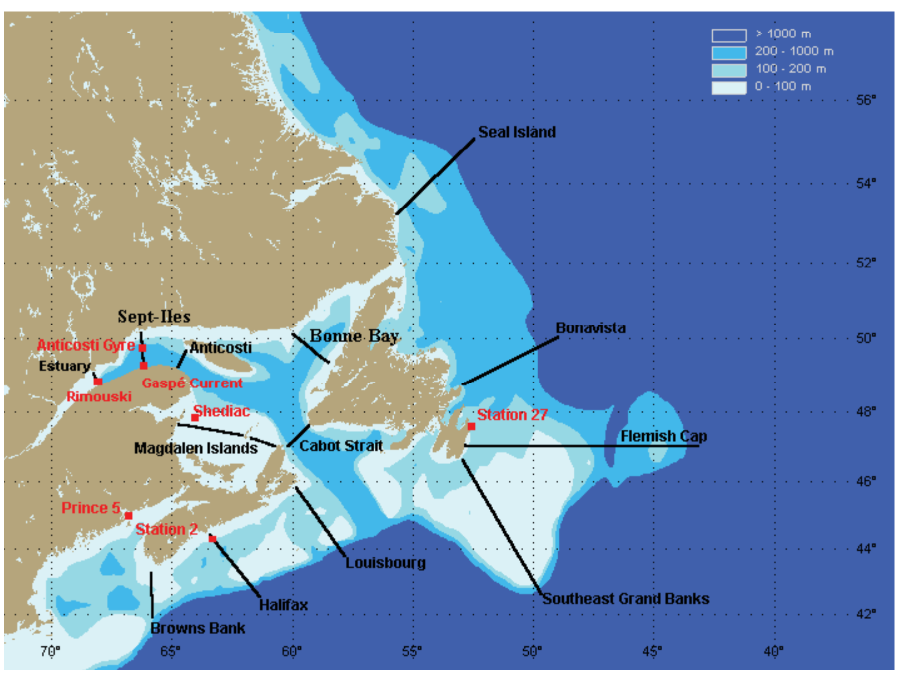
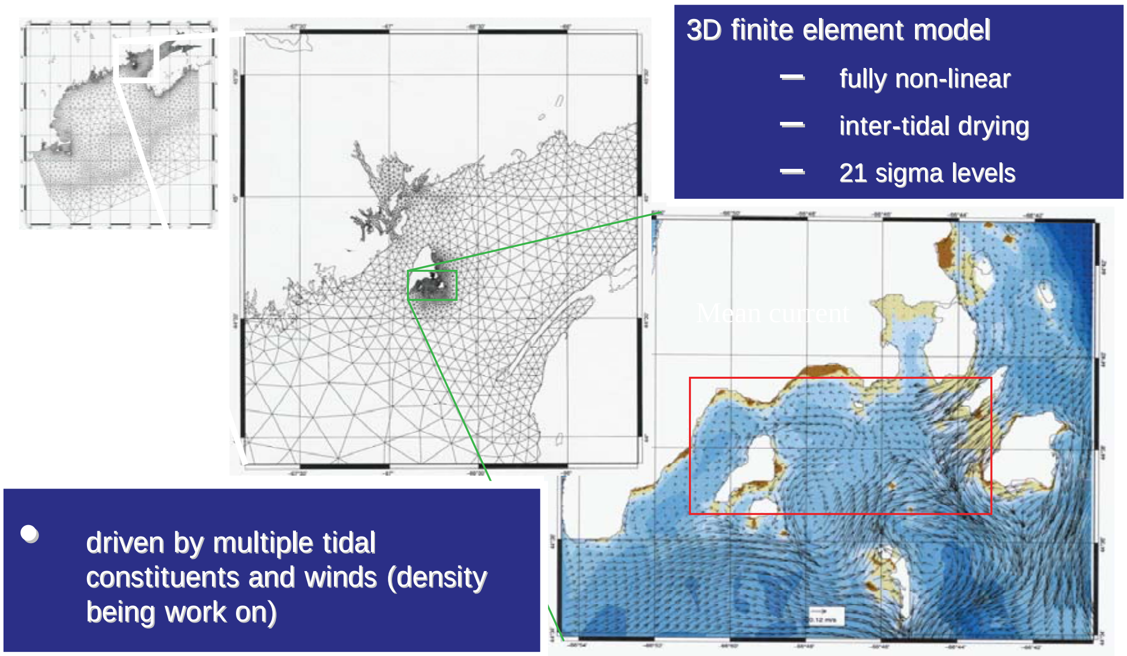


Figure 3. An example of a local-scale water circulation model that has been developed for the southwest New Brunswick area of the Bay of Fundy. The model is a modification of the irregular grid finite element model (QUODDY_dry) developed by D. Greenberg et al. (2005).



The observational information is also helping to develop regional and local-scale water circulation models. An example is the three dimension, finite element tidal model that has been developed for the inshore areas of the southwestern Bay of Fundy area (Figure 3).

The GoMOOS Web site contains information on wind velocities from several United States supported meteorological and oceanographic buoys, as well as information on water and air temperatures, salinities, oxygen concentrations, wave heights and water currents measured at the buoy locations (Figure 4). The site also provides maps of CODAR estimated surface water currents (Figure 5), maps of remotely sensed sea surface temperature (Figure 6) and numerical computer model predictions of surface currents, sea surface temperature and wave heights.

Some of the Canadian and American data sets span many decades. For example, water temperatures have been recorded since the early 1900s at the mouth of the Bay of Fundy, at the St. Andrews Biological Station and at the Prince 5 monitoring station and at Boothbay Harbor along the southern Maine coastline of the Gulf of Maine. These records indicate that water temperatures in the region have fluctuated by several degrees Celsius over the past 50-100 years and that the fluctuations occur on time scales of years to decades. The data do not indicate strong long-term warming trends but water temperatures in recent years are part of a recent warming trend that began around 1990. Interestingly, some recent global climate change modelling has suggested that the region's marine waters may not warm by more than a degree or so (Chmura, pers. comm.)

Figure 4. United States meteorological and oceanographic data monitoring locations in the Gulf of Maine where data are available on the Web from the Gulf of Maine Ocean Observing System Web site. The buoys are occupied throughout the year. The figure was downloaded from the GOMOOS Web site.

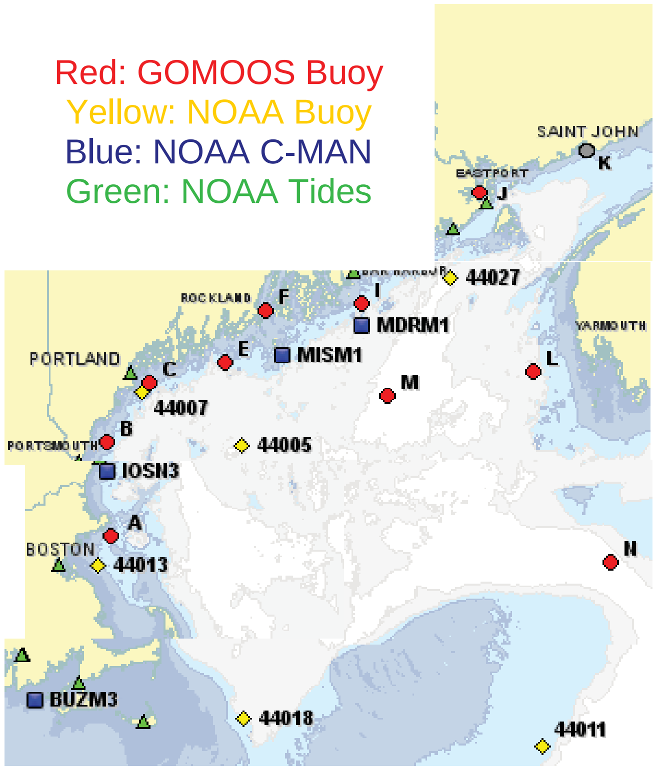


Figure 5. Example map of surface water currents as measured by the CODAR system installed around the Gulf of Maine. The figure was downloaded from the GOMOOS Web site.

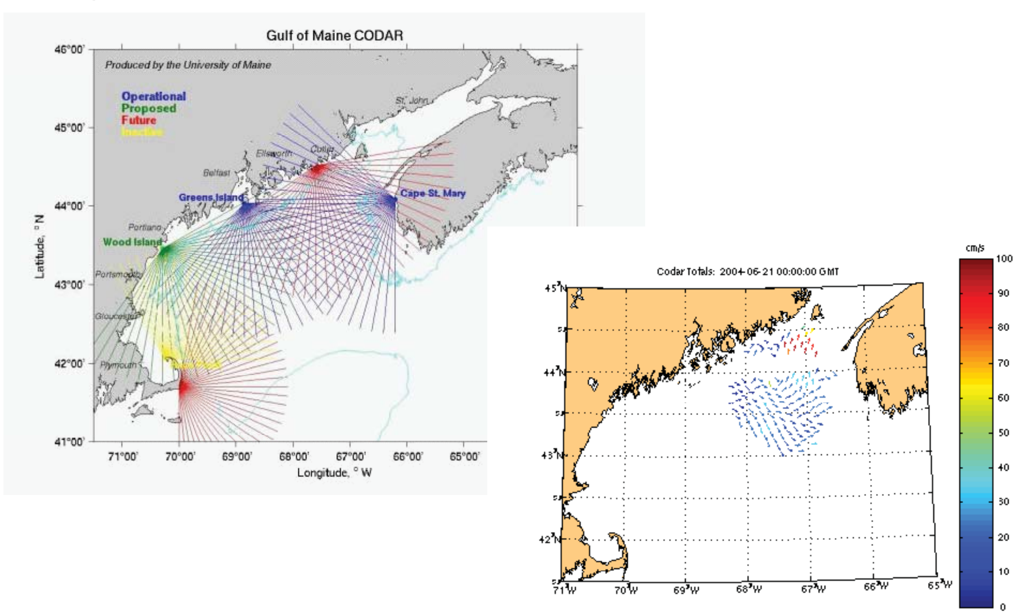
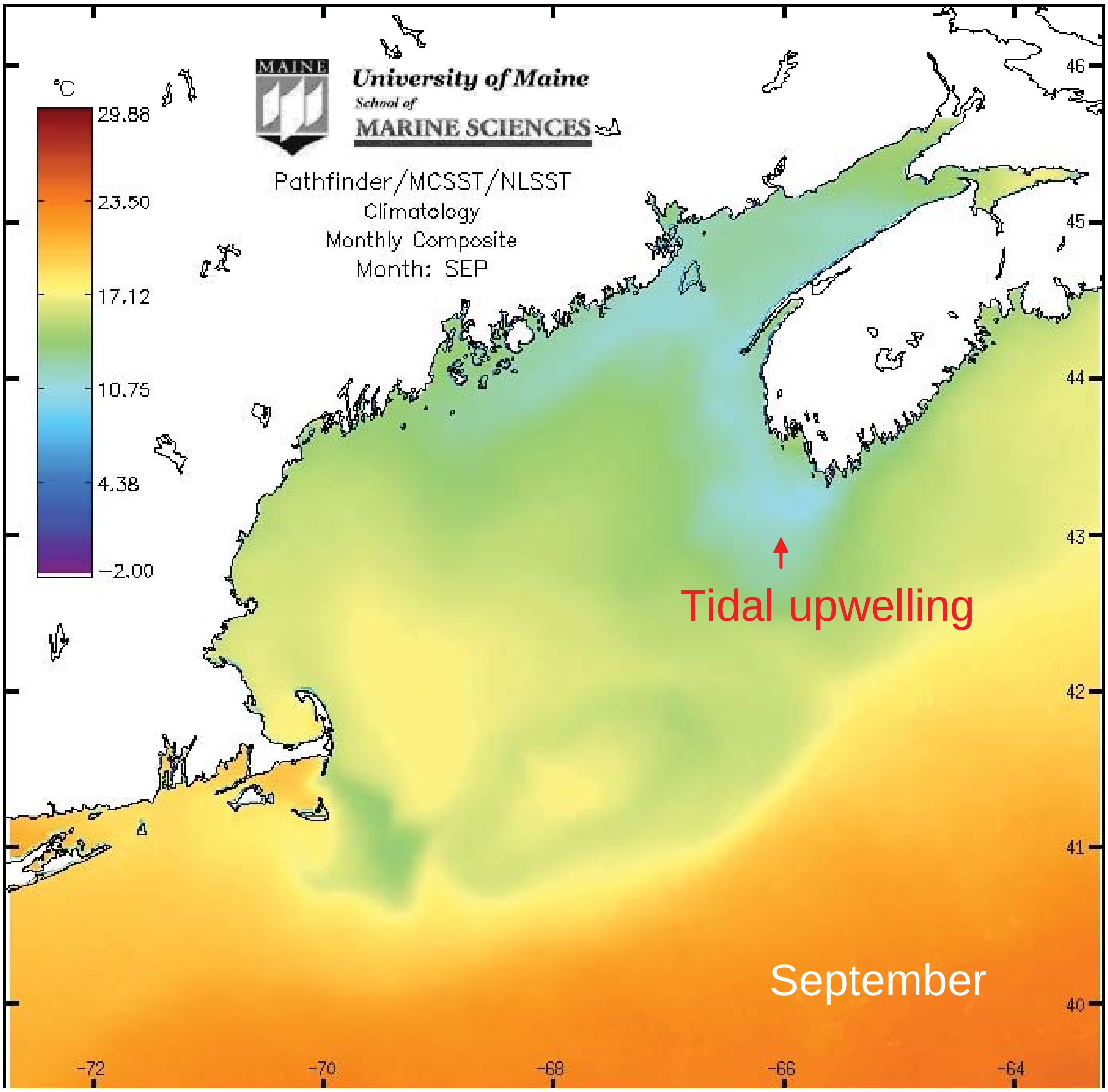


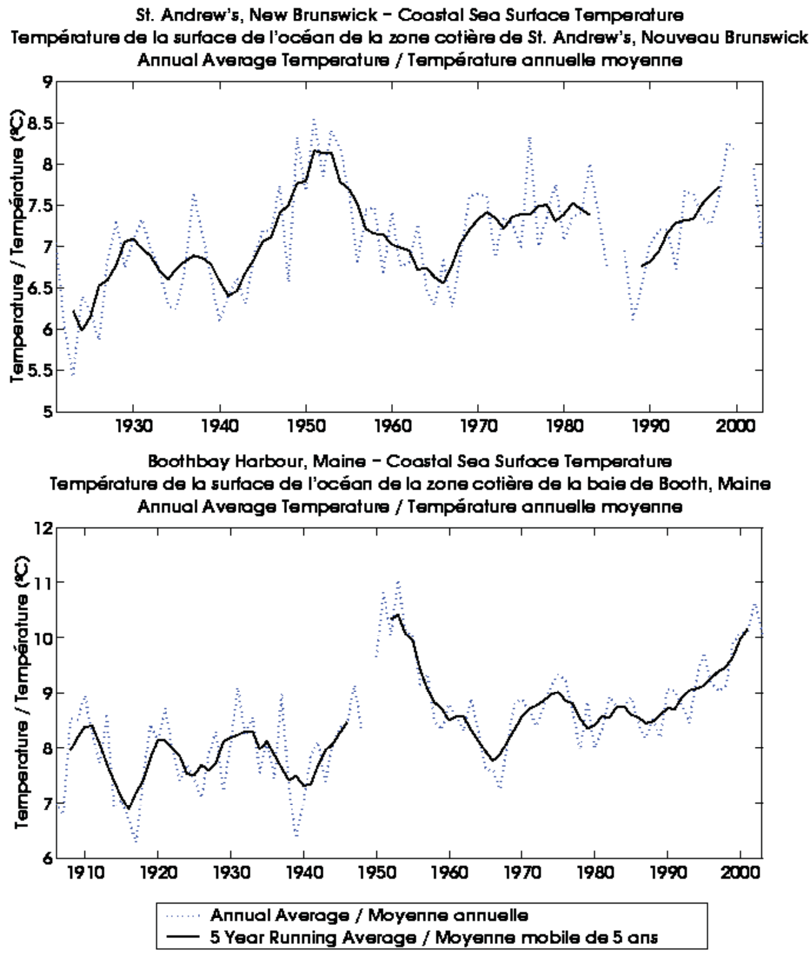
Figure 6. Example of a monthly composite map of sea surface temperature climatology derived from satellite data. The map was downloaded from the GOMOOS Web site.



Challenge to Management

The above types of environmental monitoring and modelling capabilities are beginning to be utilized more and more for generating information of use to decision-making processes in society. Perhaps the most familiar example to society is that of coastal tide prediction. Analyses of sea level observations have enabled predictions of tidal heights to be made on a routine basis for decades. These predictions are still being made and are being improved by models which enhance the spatial resolution of these predictions. There are many other examples, a few of which are mentioned below. Storm surge predictions have also been available for many years and recently there are efforts to institute tsunami warnings. Knowledge of sea surface circulation has also been used in estimations of the spread of oil spills for many years and the occasional search and rescue effort (e.g., in southwestern New Brunswick, R. Losier, pers. comm.).

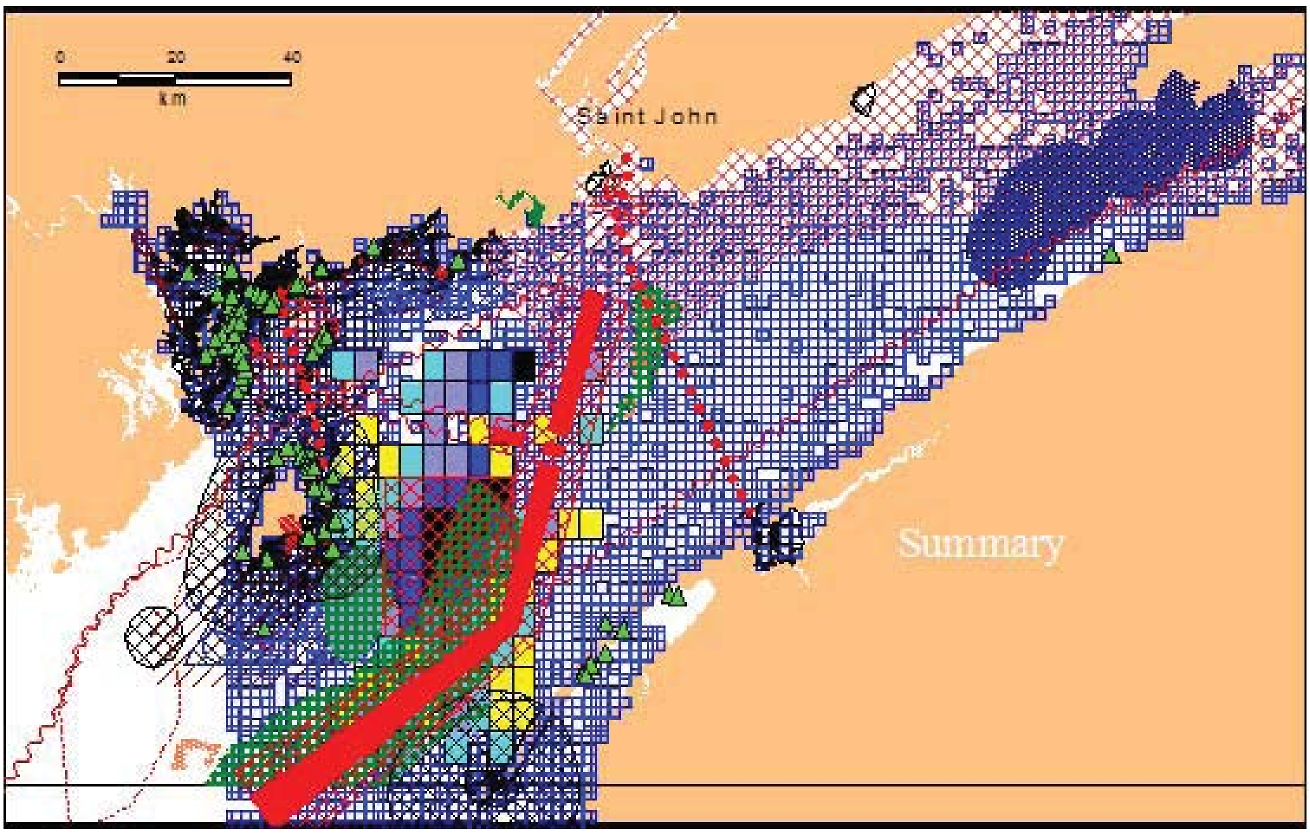
Figure 7. Coastal sea surface temperatures recorded at the St. Andrews Biological Station wharf and in Boothbay Harbor, Maine. Figure downloaded from the MEDS Web site.



Some less well known applications are those being utilized and developed within the science community in relation to more biologically oriented processes and activities such as fisheries, plankton blooms and aquaculture. These applications began about a decade ago with the results from regional scale models of water circulation being applied to fisheries issues such as the influence of water circulation on the distribution of the early life stages of cod, haddock, scallop on Georges Bank, and lobster in the northern Gulf of Maine (Werner et al. 1993; Page et al. 1999; Tremblay et al. 1994). In recent years the approach has been applied to issues of harmful algal bloom transport in the northern Gulf of Maine. Local scale models have been developed and applied to aquaculture management issues such as the spread of disease between finfish aquaculture farms in the mouth of the Bay of Fundy (Page et al. 2004, 2005; Chang et al. 2005a).

The physical and biological applications are also beginning to be combined with information on the spatial and temporal distributions of habitat types, species distributions and human activities utilizing geographic information system software to display and analyze overlaps in the various spatial and temporal domains. This approach is gaining wider acceptance and is beginning to be utilized in marine planning and management processes (J. M. Crocker, DFO Maritimes, pers. comm.). An example of an early step in this direction in the Bay of Fundy is that by Chang et al. (2005b). In this work the authors amalgamate environmental data with information on fish catch, shipping lanes, the distribution of the spawning areas of some major commercial species, and the distribution of critical habitat for the endangered Right Whale and inner Bay of Fundy salmon species (Figure 8). This work was done as part of a process to explore the development potential of offshore aquaculture in the Bay of Fundy. The approach and information may also be of interest to the Marine Resource Planning Program that is focusing on the southwest New Brunswick area of the Bay of Fundy.

Figure 8. Composite map of fishing activity, some fish spawning areas, navigation channels and sensitive habitats for the Bay of Fundy (Chang et al. pers. comm.).



Summary

The Gulf of Maine and Bay of Fundy consist of a dynamic and diversified physical and biological marine environment that has undergone large changes in the past on time scales of thousands of years and is likely to undergo changes of significance to social and economic regimes of the region in the next few hundred years. Observational monitoring and numerical prediction capabilities for physical aspects of the regions marine environment are being actively implemented in the region and these will hopefully continue to be supported and upgraded. Much more effort is needed to develop similar capabilities for the biological state of the region and to develop mechanisms that enable this information to be incorporated into the socio-economic and perhaps cultural routines of the societies inhabiting and utilizing the region. Unlike a hundred years ago, we now have the beginnings of a comprehensive monitoring, mapping and prediction system in the Gulf of Maine and Bay of Fundy and can begin to see how these can be improved and utilized. As the information and models become more widely understood and available, and the benefits and cost effectiveness of having the information are more widely recognized, more linkages to decision making will presumably be made. The management challenge is, therefore, to maintain the momentum in developing these sources of information and to be willing to routinely and wisely use the information and knowledge generated to help smooth and wisely direct the continued evolution of the region's human presence.

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HOMAGE TO PENELOPE: UNRAVELLING THE ECOLOGY OF THE BAY OF FUNDY SYSTEM

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Muse, tell us of these matters.
Homer, *The Odyssey*, Book 1 Line 14[1]

Introduction

The Bay of Fundy has been the subject of scientific investigations for over a century, yet it remains almost as much of a mystery as ever. One of the original reasons for creating BoFEP was the recognized need not only to understand the ecosystems of the Bay of Fundy, but to ensure that the community of the Bay and its watershed also appreciated the nature and significance of those ecosystems. To that end, the series of Bay of Fundy workshops, of which this is the 7th, have been held to review the state of our knowledge, and to pass that knowledge on. What is surprising—and somewhat disappointing—is the realization that we have constantly to revise our descriptions, hypotheses and models to reflect the reality of new knowledge. That, in itself, is not new—science progresses that way—however, the extent to which we have to revise our concepts seems to be far greater than in other ecosystems. Sometimes these scientific myths take root and remain in our minds in spite of contrary evidence; at others, we have to abandon them almost as soon as they are formed. The Bay of Fundy thus seems much like Homer's Penelope: constantly unraveling at night what she weaves during the day.

An analogy between our work on the Bay and the Homeric tradition may seem a little fanciful, but, interestingly, in science as in life, once an analogy takes hold it is hard to shake. In *The Odyssey*, Penelope, the wife of Odysseus and mother of Telemachus, is seen as a symbol of constancy, purity and intelligence. With Odysseus absent and unheard-of for ten years, she is besieged by suitors each intent upon marrying her and acquiring the wealth he left behind. To forestall the decision, Penelope agrees to make a choice among the suitors when she has completed weaving a shroud for her aged father-in-law; but what she weaves during the day, she undoes each night, constantly delaying a resolution (Figure 1). Meanwhile the suitors live at her expense, consuming her resources.

So what, you may ask, has this myth to do with the Bay of Fundy? Review of research on the system over the last century indicates that our scientific knowledge has changed quite dramatically, particularly with regard to the Bay of Fundy. To some extent this is a function of the limited, episodic efforts applied during the century to investigations of the Bay; in contrast, research on the Gulf of Maine and Georges Bank portions of the system has been consistent and extensive, leading to a generalized understanding of the oceanographic features that yield the high productivity of the banks, and the relatively low productivity of the gyre of the central Gulf (Apollonio 1979; Backus and Bourne 1987; Conklin 1995).

[1] Quotations from *The Odyssey* derived from the translation by Allen Mandelbaum.

Figure 1. "Penelope and the Suitors." Oil on canvas. 1912 by J. W. Waterhouse. Original is in the City of Aberdeen Gallery and Museums Collection, Aberdeen, Scotland. The image is obtained from: www.johnwilliamwaterhouse.com/images/content/waterhouse/clip/47.jpg.

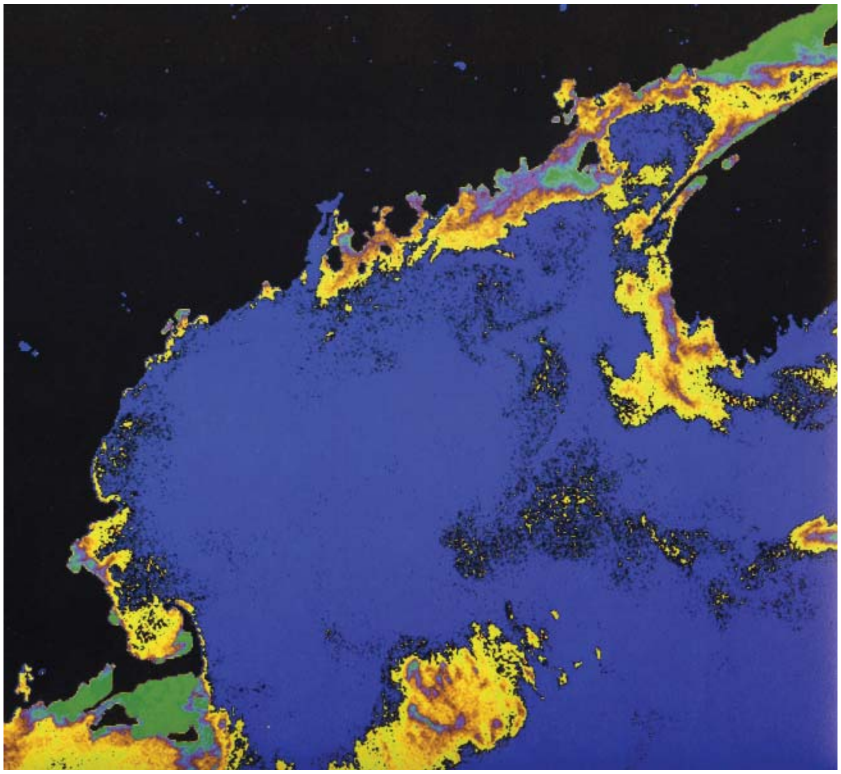
In the Bay of Fundy, research efforts have been associated with early fisheries investigations (1898–1911), and then with a succession of studies stimulated by proposals to develop tidal power in the late 1920s, 1940s and 1970s (Huntsman 1938, 1952; Daborn 1976; Johnstone 1977; Gordon and Dadswell 1984; Percy et al. 1997). These have built a basic recognition that the Bay constitutes a unique ecosystem; it has some areas of high biological production, and is biologically connected, through the movements of fish, birds and marine mammals, to the Arctic, the Caribbean, South America, and indeed much of the North Atlantic. However, our understanding of the productive processes at work, and the persistence of important populations seems to be constantly in flux: we see the loom and the material, but the weave keeps changing. Below are a few examples of this continuing reassessment.

The Loom

The basic features of the Bay of Fundy ecosystem have been well described in the successive proceedings of BoFEP conferences, particularly those in 1996 and 2004 (Percy et al. 1997, 2005.) There are three important unities that tie the regions of the Bay of Fundy together and link them to the Gulf of Maine and more distant ecosystems: the tides and circulation pattern of the Bay; the migrations of animals; and, regrettably, the long range transportation of particulates and contaminants from industrial regions far removed. In spite of these shared properties, we recognize three biologically different regions in the Bay: the outer Bay beyond the Digby-Saint John transect; the inner Bay between that transect and Cape D'Or; and the highly variable bays and basins—Passamaquoddy, Shepody, Cumberland, Minas and Annapolis—at the sides and head of the Bay. The ecological systems of these regions are very different.

In the outer Bay, tidal upwelling at the mouth of the Bay produces a region of high productivity offshore of western Nova Scotia. These waters are driven into the Bay primarily along the Nova Scotia shore (Figure 2) as a result of the counterclockwise circulation in the main Bay caused by Coriolis' Force and the outflow of the Saint John River (Greenberg et al. 1997). Although the tide causes extensive upwelling, recirculation of nutrients and therefore high phytoplankton production at the mouth of the Bay, the circulation pattern results in formation of a

Figure 2. Satellite image of the Gulf of Maine and Bay of Fundy, showing distribution and concentrations of chlorophyll (from Conklin 1995).



gyre in the central part of the outer Bay (Garrett et al. 1978). As a result, the water column here becomes stratified in spring and summer seasons, leading to surface waters in which nutrients, particulates and primary production are all low. This is apparent in Figure 2, which is derived from a satellite image enhanced to reflect chlorophyll concentrations (Conklin 1995). This outer region also has abundant shoreline macrophytes, especially rockweed (*Ascophyllum nodosum*), contributing to the overall productivity. Portions of the outer Bay, therefore, are good feeding grounds for fish, birds and mammals, including filter-feeding Atlantic right whales.

As tidal waters progress further into the Bay, chlorophyll levels decrease and seaweeds become steadily less abundant. The waters of the inner Bay therefore appear less productive, although stocks of benthic fauna, especially scallops (*Placopecten magellanicus*) and the horse mussel (*Modiolus modiolus*), may be locally extremely abundant (Wildish et al. 1992). In this part of the system, the water column is almost always vertically mixed, with the result that benthic filter-feeding communities have access to the whole water mass over time (Daborn 1986).

The innermost basins, however, are radically different: with extreme tides and friable shorelines, the waters are turbid and generally devoid of phytoplankton. Around the periphery of these basins, is a fringe of very productive salt marsh which, although a small remnant of what was there before European settlement, i.e. 1604, yields considerable organic production for the system (Gordon et al. 1985; Daborn et al. 2002). Extensive intertidal flats appear more or less lifeless to the casual observer, although in reality they may be extremely productive because of microscopic diatoms (Hargrave et al. 1983; Daborn et al. 1991). Vast numbers of mostly inconspicuous invertebrates (crustaceans such as *Corophium*, polychaetes, clams and snails) form an extensive food store for similarly large numbers of visiting birds and fish. These systems, however, are physically stressed—the substrate and salt marshes by ice in winter, and the water column by tidal turbulence and strong currents; it is as if the intertidal 'shroud' that develops each summer is ripped away during the winter months, resetting the successional process each year. These regional differences led Gordon and Dadswell (1984) to describe the Bay of Fundy as a highly diverse ecosystem with a production "pump" at each end: one based upon seaweeds and phytoplankton, and the other upon benthic diatoms and salt marshes. For obvious reasons, the biophysical processes that underlie these different ecologies have been the subject of much research in the last half century.

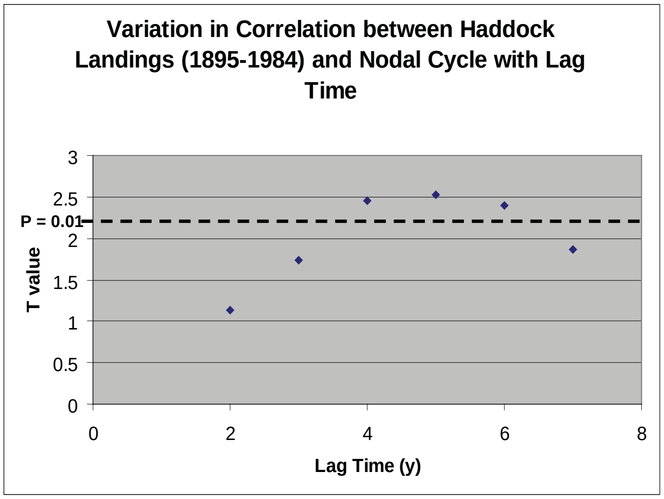
Warp and Weft - 1

Early research about the outer Bay was focused mostly on the important commercial fisheries, particularly herring, hake, haddock and pollock. The relative paucity of cod was attributed by Huntsman (1918) to the strong vertical mixing of the water column resulting from tidal movements, which eliminated, in his view, the cold-water fauna such as found in deep waters of the Gulf of St. Lawrence. It is difficult to reconcile this interpretation with early descriptions in the writings of Lescarbot and Perly of the enormous abundance and fat conditions of cod (MacLeod 2005). Subsequent work associated with the International Passamaquoddy Investigations of 1931–1933 focused strongly upon the ecology of herring (Huntsman 1938), and identified an important inconsistency: the regions of highest abundance of juvenile herring (the islands at the entrance to Passamaquoddy Bay) were generally largely devoid of plankton, leading Graham (1936) to conclude that high fish productivity there was sustained by the import of food from the Gulf of Maine. Since herring were not thought to spawn in the Bay, being transported into the Bay themselves, the conclusion was that the role of the tide was primarily to concentrate both advected fish and their food in places where they were free from predators and competition. This led to the surprising assessment that the Bay of Fundy per se was not biologically productive, and that the "local abundance of fish…is to a considerable extent attributable merely to the transport and concentration of fish by the circulation of water" (Huntsman 1952: 37). Subsequently, the "larval retention hypothesis" formed the basis of many investigations conducted into the 1970s (e.g., Iles 1971, 1975a, b).

The Unraveling – 1

The notion that the Bay was merely a concentrator of fish, as a result of tidal movements, no doubt would have appeared odd to the fishermen of the upper Bay if they had been readers of the *Transactions of the Royal Society*. Furthermore, it did not recognize the comprehensive way in which tidal movements affect most ecologically important features of Fundy water, from salinity to temperature and turbidity. In spite of extensive records of temperature and fish landings, it was not until Loder and Garrett (1978) examined the long-term data on temperature, finding a strong negative correlation between sea surface temperature and the 18.6 year nodal cycle, that the potential significance of long-term oscillations in tidal range were appreciated. Subsequently, Cabilio et al. (1987) discovered that there were highly significant correlations between fish landings over almost a century around the Gulf of Maine and Bay of Fundy and the nodal cycle of the tides. Positive correlations were found with northern species such as cod, haddock, alewife and herring (as 'sardines'), and a negative correlation with the warm water menhaden. The statistical value (T) and the significance (P) of the correlation vary as the data on landings are offset relative to the nodal cycle, with the highest correlations occurring for a lag of years that corresponds to the time between hatching and recruitment into the fishery (Figure 3). (It is not surprising that a recognition of these long-term cycles in fisheries data was not part of Huntsman's 1952 account: although sufficient data existed, no one thought to 'mine' them at that time. Furthermore, Huntsman was apparently not a fan of statistical inference, preferring to develop concepts from the appearance of the data.)

Figure 3. Effect of lag time on correlation between haddock landings and the 18.6 year cycle of the tides (after Cabilio et al. 1987).



The implication of these results is that conditions associated with the highest tides in the multi-year cycle are relatively more favourable to some of these species. Whether the effect is through decreased surface temperatures during peak years, as indicated by Loder and Garrett (1978), or increased primary production at that time, apparently has not been determined.

With resurgence of interest in tidal power in the 1970s (cf. The Suitors below), attention moved to the upper Bay. Huntsman's Flavelle Lecture to the Royal Society of Canada (Huntsman 1952) had provided the first account of the ecology of the Bay of Fundy as a whole, and established the expectation that the upper basins were even less productive than the outer Bay. Landings of fish (per unit area) in Minas Basin and Chignecto Bay were only a fraction of those further out. (The inherent limitations of basing estimates of stock size on fish catch data continue to plague fisheries biologists to this day!) Curiously, Huntsman concluded that conditions for phytoplankton growth improved in the upper basins because the decreasing depth meant that phytoplankton cells would not spend much time out of the light. Since it does not appear that there were any phytoplankton studies in those areas at that time, and suspended sediment concentrations greatly exceed those in the main Bay, this is certainly an odd conclusion.

A very different picture was developed as a result of Dadswell's work on shad in Cumberland and Minas Basins. Far from being a biological desert, the upper basins and bays support considerable numbers and variety of fish during the summer months (Dadswell et al. 1984; Dadswell and Rulifson 1994). Many of these are migratory species that move into the upper Bay on feeding migrations, moving (not drifting) with the tides and circulation inward along the Nova Scotia shore to Minas Basin, Chignecto and Cumberland, before leaving along the New Brunswick shore north of Grand Manan. Dadswell suggests that similar migratory paths apply to other species that have not been as well studied. If the upper Bay is so unproductive, why would they do it?

Preliminary zooplankton collections by Jermolajev (1958) in the early 1950s in the Shubenacadie Estuary indicated that there were in fact large concentrations of microcrustacea there, and that their numbers increased as the turbidity got higher. In conditions where photic zone depth was to be measured in centimetres or millimetres rather than metres, and from which phytoplankton are almost totally absent, these results obviously beg the question of the nature of the food web and its support. It is clearly a heterotrophic system, dependent upon microbial processing of organic matter derived from marshes, upstream sources, or the epipelic diatoms of the intertidal zone (Hargrave et al. 1983; Prouse et al. 1984; Brylinsky and Daborn 1987). Stomach analyses on fish have often provided equivocal answers about the value of this supposed feeding migration to the fish, but evidence from body condition as they leave the Bay seems to support the idea that the upper Bay has much more to offer than it seemed. Apparently this weave is a more subtle pattern than previously thought.

Warp and Weft - 2

Early notions about the low productivity of the upper basins and bays thus belied two sets of observations: the presence of large numbers of migratory shorebirds, which everyone could see, and the discovered presence of large migratory fish populations, which previously were known primarily to local fishers. A comprehensive, multi-institutional and multi-disciplinary programme of study, coordinated by the Fundy Environmental Studies Committee from 1977 to 1984, included the first extensive surveys of the intertidal zone of Minas and Cumberland Basins (Gordon and Dadswell 1984). The purpose was two-fold: to understand the dynamics of sediments in the upper Bay where tidal power barrages were being considered, and to inventory the fauna. As it became apparent that these intertidal systems were critical to the support of migratory birds and fish, the assumption of low productivity had to be abandoned. It became evident that a major consideration was the formation, presence and movements of ice during the winter months (e.g., Gordon and Desplanque 1983). In most years, surface sediments that have built up during the summer and fall on the intertidal zone are completely reworked and often scoured out by ice that freezes into the sediments at low tide, and is then broken up, piled up and moved around by the rising tide. This is a Penelope-like reworking of the sedimentary fabric that resets the successional clock each year. As with other physically-disturbed systems, the secondary succession process is often characterized by low biological diversity, but high production.

Understanding the factors controlling sediment dynamics in the summer time was an essential requirement for modeling the effects of tidal power development, but existing sediment models did not adequately capture the behaviour of the fine, cohesive sediments found in the upper Bay of Fundy (Amos 1984). A principal problem was the apparent change in sediment properties when material was removed to a laboratory for testing. To address that problem, a series of studies based on measurements of properties *in situ*, and including consideration of biological factors, have been carried out. In the first study, Amos et al. (1988) confidently reported that a significant rise in the shear strength of intertidal sediments during mid-summer was associated with drying effects of the surface mud when low tide coincided with mid-day, and thus was a function of sub-aerial exposure. Some inconsistent results arising from a set of poisoning experiments, however, and the relatively insensitive techniques available for measuring shear strength *in situ*, led to a more comprehensive study of the same tidal flat in 1989. The LISP project (for *Littoral Investigation of Sediment Properties*) incorporated a wide range of studies based on new technologies (Daborn et al. 1991). Once again, we confidently reported our results: while intertidal drying was important, the primary change in shear strength in mid-summer (which was clearly real) was associated with the arrival of large numbers of shorebirds from the Arctic in mid-July (Daborn et al. 1993). In a "cascading food chain effect," predation by shorebirds reduced the numbers of the dominant invertebrate grazer, *Corophium volutator*, enabling benthic diatoms to bloom and increase the cohesiveness of the sediments by their exudates. This was not a Penelope-like reworking of the natural environment: the sediment features and fauna were essentially the same in 1989 as in 1985. The change in model resulted from more suitable and comprehensive experiments and better technology; it was the normal iterative process of science.

The Unraveling – 2

But some of that confidence has evaporated. A careful exclosure-based study on the role of birds, invertebrates and sediment properties on a nearby mudflat produced, instead, a model that identified interspecific competition between the mud snail, *Ilyanassa obsoleta*, and *Corophium* as a driving force in controlling sediment dynamics (Hamilton and Diamond 2000; Hamilton et al. 2006). At first this seemed to be another of the iterative changes in scientific models resulting from selection of a different intertidal location with a different suite of inhabitants; however it has become apparent that significant changes have taken place in the intertidal zones of the upper Bay since the 1970s and 1980s (Shepherd et al. 1995). *Corophium* numbers appear to be much lower in many places than previously recorded; sediments appear to have higher water content; and the migratory shorebird populations appear to have declined significantly. In many mudflats, the mud snail is now a very conspicuous member of the fauna, for reasons that are unclear. This all tends to suggest that Penelope has once again reworked the fabric of the intertidal zone throughout much of the upper Bay, for reasons that are not understood. Are these changes part of periodic long-term oscillations in biophysical dynamics? Are they the consequence of human actions such as barrage construction? Are they caused by the disturbance associated with worm harvesting? Until these questions are resolved, we can have little confidence that we understand the ecosystem adequately, and therefore less security in dealing with the challenges presented by the latest proposals for tidal power development.

The Suitors

Much of what we have learned about the Bay of Fundy has been derived because of proposals to exploit the abundant resources of the Bay. The Bay's suitors are numerous: they include the fishers, both individual and corporate, whose competitive nature and focus on efficiency (e.g., maximizing catch per unit of effort) have collectively led to significant reductions of stock sizes for many of the species that were apparently here prior to European settlement. Fundy stocks of Atlantic salmon are endangered; and cod, halibut, haddock and flounder stocks are pale shadows of their former size; purse seines and pair trawls have swept up most of the herring that was the signature species in the outer Bay a century ago. But Penelope has more than one pattern: if not groundfish and herring, then dogfish and skate will do: although data seem to be scarce, it seems that fish biomass is not greatly different now from a century ago. However, the dominant species are different. Lobster and scallop fisheries appear to be doing well, perhaps in the former case because of the absence of an important predator such as cod.

Other suitors focus on energy resources: the successive proponents for tidal power development that stimulated research in the 1920s, 1930s and 1970s, which gave us, on the one hand, a much better understanding of the natural history of the Bay, and on the other, serious concerns for the long-term and long-distance effects of energy extraction. Other energy proposals include the development of refineries and LNG terminals, which, although based upon energy extraction elsewhere, require increased transportation of materials into the Bay, raising concerns about pollution and collisions with endangered Atlantic right whales. The list of suitors continues: basalt and aggregate miners, tourism developers, and transportation engineers, for example.

Like the suitors in my analogy, proponents of exploitation are rarely seen as benign, but rather as driven by ambition and self interest. Nonetheless, without these proposals we would probably know very little about this extraordinary ecosystem. The fact that we still have major questions about how the system works indicates that once again we need a major collaborative effort like that of the 1930s and 1970s to satisfy both the needs of science and management. For this reason, perhaps we should embrace the various proposals for converting the Fundy region into an 'energy hub' of eastern North America: new approaches to development of tidal power, for example, and new energy-processing terminals. The new technologies for tidal power generation are very different from those considered in the 1930s and 1970s, and some of the former environmental concerns appear to be less valid. It is necessary to examine the new approaches on their own terms. We may not, in the end, find these acceptable, but in pursuing their consideration, we should end up knowing much more about what the Bay offers, and what we need to protect. I see that as a major challenge and contribution that should be made by BoFEP in the next few years.

As has been well said:

> We shall not cease from exploration
> And the end of all our exploring
> Will be to arrive where we started
> And know the place for the first time.
>
> T. S. Eliot. 1942. *Four Quartets: Little Gidding*

It is natural, when an analogy has been drawn out (too much?) to expect to identify the actors in both the analogy and the model. Hopefully, the character of the faithful and resourceful Penelope is obvious, and a list of some of the suitors is above. Who then is Telemachus, the son who sees his life and livelihood threatened, but who comes to maturity by dealing with the suitors (Figure 4)? That seems an appropriate role for BoFEP. But then who is Ulysseus? It seems the obvious candidate is Glooscap—the long-absent god of the Mi'kmaq, whose seat is on Blomidon, who traveled all over the world, caused the alternation of summer and winter, and whose dealings with beaver and whale gave Fundy its tides. While we wait for his return, we need to take on the spirit of Penelope and Telemachus: apply intelligence, understanding and the precautionary principle in assessing proposals for further exploitation of the Bay and its resources. (In private conversations, I might tell who fits the role of Argos.)

Figure 4. "Ulysseus and Telemachus Massacre Penelope's Suitors." Oil on canvas by Louis-Vincent-Léon Pallière (1787-1820) (from *Art Times Journal* at www.arttimesjournal.com/art/reviews/Dec05/dec05reviews.html).

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FACING THE CHALLENGES IN ENVIRONMENTAL MANAGEMENT: A TWELVE THOUSAND YEAR PERSPECTIVE

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The title is meant to emphasize the existence of the Passamaquoddy in their territory for a period in excess of twelve thousand years (Bourque 2001) by archeological records. This indicates that they were managers of their territory for approximately eleven thousand, seven hundred of those years (all but the past few hundred years) using trial and error to fine tune this existence.

The original concept is to present a session different from most “Native” presentations in both content and format. The “awareness” portion is imbedded in the first speaker’s words of a culture consisting of much of what they have heard or read over the years but never from one who lives and pays respect to that culture, every day of his life.

A brief introduction of the format of the presentation and the first speaker will prepare the audience for a Native perspective on the past, present and future of the relationship between the cultures and the Bay. The key to understanding the presentation will be in understanding the presenter himself. gkisedtanamoogk is a Mashpee of the Wampanoag Tribes, a brother to the Passamaquoddy and the Wabanaki confederacy. Recently a member of the Esgenoopetitj (*Burnt Church) community, the home of his wife and family, he is presently teaching at the University of Maine in Orono, Maine.

Part 1 (the past)

“i paint my face to honor You.”

These incredible words will begin the relationship between gkisedtanamoogk and his audience. To address the worst fears of the other culture, taught to believe that this must be “war paint” that they were seeing; this will pave the path to the understanding that is needed for those in the room to hear his words in the context in which they were meant to be heard. As he spoke of the universe in terms of his relations (Grandmother Moon, Father Sky, and Mother Earth), the respect in his voice would translate into a respect for the planet and all its creatures. His description of every tree and rock as having life; tells us that our planet has feelings deserving of said respect; if we are not to hurt “our Mother”. Here is a view we might accept as we seek different ways to protect the Bay from further harm; that is, if we are to indeed, to manage it wisely.

His discussion of a glass of water as a key element of life (“one that touches everything, for without it our bodies are but dust”) easily relates to the waters in the Bay. “Water has its own spirit, its own life: we sing honor songs to it and it remains an important part of our ceremonies. It is our women who speak of water in our ceremonies (the highest honor), i have seen snakes and bees and ants drink water, even rocks absorb water for these have been known to explode in our sweat lodges”.

A further discussion of “Grandmother Moon” would remind us of the tides in the Bay. “Father Sky and Grandfather Sun” remind us of the air we breathe, and the heat and light that supplies such an abundance of nutrient to the waters of the Bay. His use of legends and stories would be teachings of the land and the waters of our territory. The stories of battles between the “giant beaver” and Glooscap would often describe the history of environmental changes to the land. The air we breathe and the sun that warms us and nurtures our plants are sacred to our People for what they give to our Mother.

By bringing his stories back to the Sacred, he kept reminding us that everything about this world is precious and any management scheme should take this into account. These are the values Natives used in preserving the “garden of Eden” known as Turtle Island before “discovery”. This was how the caretakers of our Mother saw their role, not as managers, but as those who would protect the management scheme already in place. We were users, perhaps, yet worshipers of the true manager of our environment, believing that mankind would make a poor replacement for a creator who looks after all things.

The presentation had a spiritual aspect in that the content was from one who lives everyday, this life he has shared with others. By asking those in the room not to clap, gkisedtanamoogk left the clear message that this was not a show for the purpose of entertainment; but a view of the “Sacred” as lived by an Indian!

The capital letters indicate how i interpret Wabanaki Worldview. That being, to show and give Respect to and Honour for the ones i speak to. The lower case references to my Self indicate that my Path of Life is not complete and that i make no pretensions about my status and state of Being with the Sacred. Simply put, i place my Self last before all Others as a small token of humility and gratitude for the Life i’m given and the opportunity to do something with this Gift.…

gk

Part 2 (the present)

The second speaker would concentrate on today’s management of the Bay as seen through Native eyes. To contrast the “past” presentation, power point would be used to bring the audience back to the present, where one is expected to use visual effects. The previous speaker required that we see with our minds; this is the power of oral history. There is no limit where you might go with your mind yet there are limits to visual effects. Still there is knowledge to be transferred and using today’s tools and technology is a necessary prerequisite to understanding this in a context familiar in today’s world.

The “Passamaquoddy Story” about the porpoise hunter and the reporter is presented in written format, yet tells a “Native story”. The point that needed to be made was how management changed from harvesting what was needed; to the creation of industry. The new occupants of our territory sacrificed living in harmony with their surroundings as a means of survival, in exchange for exploitation for profit.

The trial and error used by our ancestors may have cost them their lives; but today’s trial and error has resulted in the extinction of numerous other species at an alarming rate! This begs the question: “Are we really better managers today than those who were here before us?” To answer this we need only view the past; however, not only within our territory but throughout the world (after all, we are told this is now a global economy and the issues are now global as well). The speaker uses the opportunity to draw from the 2005 Massey Lecture series “A Short History of Civilization” by Ronald Wright. If poor management has destroyed civilizations for thousands of years, why is it still practiced today? Why have we not learned the lessons?

Making the point that something is missing as to proper management of the Bay, requires clarification of definitions which appear to encompass all that is necessary to complete this mandate; the misinterpretation of which can lead to disastrous consequences for a number of species on this planet (the “error” in “trial and error”). Deliberate use of words such as “sustainable” while omitting words such as “protect” (that which is missing); adds to the confusion of just what “proper management” of the Bay might actually mean! Where are the science, research, universities, and groups such as BoFEP, in the equation; are they properly funded and consulted on the all important management issue, or are they simply “missing”? Is appropriate weight being given to the advice from local fishermen, or are they too “missing”? Where have the Natives been consulted on their traditional knowledge and expertise which for the past few hundred years certainly has been “missing”?

In summary, the “present” state of management needs to be improved. It is important to understand that improvement does not always mean moving ahead, sometimes it is necessary to take a step back and analyze the situation before proceeding into the unknown. In today’s world where we sacrifice so much for speed, it is often difficult to convince others to proceed with caution. We’ve always been taught that speed kills, yet once again, we ignore our own words. Here is a major divergence of culture in the way Natives see time (circular) as opposed to the way modern society would (linear). In a linear world we concentrate on getting from point “A” to point “B” as quickly as possible, regardless of the resources required (often wasted) with little or no concern for what we might leave behind. In the Native’s circular world, we understand that it is important to leave things as we found them for we will come full circle at some point in time. Here is the conscience missing from today’s society as we often careen out of control knowing that a crash is imminent. Poor management, maybe; the good news is that we have not crashed yet.

Part 3 (the future)

Since we have yet to crash, it would seem that we still have a chance to do something about it. We will need to abandon some of the arrogance with which we manage; for believing that we have all the answers can make us blind to certain things that are happening around us. It is important to acknowledge the value of every rock and stone, every creature that flies, walks, swims, or slithers throughout this world as occupying an important niche in space and time; if we are to continue enjoying the planet we live on. What management scheme would boast the loss of the wild Atlantic Salmon, or allowing the Right Whale to teeter on the brink of extinction? If we are to prevent this from happening into the future; we will need to reassess our values. We will need to manage with integrity and a knowledge and understanding of how in the past these creatures were worshipped as precious members of a “global” society that included all things. Perhaps the Native ways of living in harmony with all, treating everything as sacred, and loving the planet as our mother might not seem like such a strange concept after all. Perhaps all we truly need is a better understanding of each other and what it is all about….

Remember: i paint my face to honor You.

Hugh M. Akagi (chief of Passamaquoddy Peoples)

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Session One

BIODIVERSITY AND ECOLOGY: DISCOVERY CORRIDOR INITIATIVE

Chairs: Peter Lawton, Department of Fisheries and Oceans, Biological Station, St. Andrews, New Brunswick

and

Thierry Chopin, University of New Brunswick, Saint John, New Brunswick

THE GULF OF MAINE DISCOVERY CORRIDOR INITIATIVE

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Three Oceans of Biodiversity, a report outlining a five year (2004–2009) national strategy for enhancing marine biodiversity research in Canada, recommended the establishment of Discovery Corridors as a means of focusing regional research efforts. Corridors would logically cover a variety of seascapes, and contain a range of depths, productivities, human activities, or other ecologically relevant variables. The notion of Discovery captures not only new species and distributions, but new approaches and understanding of ecosystem functioning. The Centre for Marine Biodiversity (CMB; http://www.marinebiodiversity.ca) launched the Gulf of Maine Discovery Corridor Initiative in 2004.

An additional component of this program is the development of opportunities for non-scientists and educators to experience and interpret marine research from their own perspective, both by participating in the research cruises and by building interpretive programs in their own disciplines. In this presentation, I provide an overview of the development of the corridor project to date and rationale for the initial deepwater and offshore focus of research planning. The first discovery cruise took place in June 2005, from which preliminary results will be presented in other, more specific presentations. A July 2006 follow-up cruise, involving scientists from DFO, Dalhousie University, Memorial University and Natural Resources Canada, used ROPOS (http://www.ropos.com), a remotely operated vehicle used for deepwater research, to explore the outer portions of the Gulf of Maine corridor to depths of 2,500 metres.

BENTHIC COMMUNITIES IN THE DISCOVERY CORRIDOR – PRELIMINARY RESULTS FROM THE 2005 DISCOVERY CRUISE

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Higher resolution video and photographic imagery of habitat and epibenthic organisms were collected using Campod, from previously unexplored regions of Jordan Basin, Crowell Basin, the Northeast Channel and the flank of Georges Bank, all within the Discovery Corridor in 2005. Campod is a light-weight instrumented tripod equipped with two digital video cameras (oblique and downward looking), quartz halogen lights, a 35-mm digital still camera and high speed flashes. It reaches a depth of 500 metres. Campod photos can resolve features down to few millimetres (i.e., tubes and burrows). Imagery was recorded from 62 drift stations (average depth 240 metres, range 140-520 metres). 1,510 Campod photographs were analyzed for species presence/absence. Twenty-eight 2-hour videos of both oblique and vertical views were analyzed in 30 second segments for species presence/absence using ClassAct Mapper, except for corals, where abundance was documented so coral distribution could be mapped. Georeferencing video and photos allowed us to go back to specific areas in 2006 for further video footage and sample collection. One objective for the 2006 Discovery cruise with ROPOS was to get actual samples and verify findings as it is difficult to identify some species from photos and video alone. Another objective was to look at the differences between the limited bottom fishery and restricted bottom fishery in the Northeast Channel Coral Conservation Area. Extensive video footage of the Coral Conservation Area was recorded in 2006 for further analysis of coral distribution in the area.

Approximately 200 different species were observed in the 2005 photos and approximately 80 of these have yet to be identified. Species identification is an ongoing work in progress. Some species observed in the 2005 photos have not been observed in the Discovery Corridor area since the late 19th-early 20th century. Since the 2006 Discovery Corridor cruise, new species records have been identified and new ecological information has been discovered. For example, brittle star (*Ophiocantha abyssicola*) beds in the Northeast Channel, locally abundant stalked bryozoans (*Kinetoskias smitti*), stalked sponges (*Stylocordyla* sp., *Hyalonema* sp.), and a first confirmed record of the deep-sea Gorgonian coral, *Primnoa resedaeformis*, for Jordan Basin were observed. Another discovery in 2005 was the Rock Garden, a large, highly productive area of exposed rock with a diverse benthic community of sponges, anemones, and other invertebrates, in Jordan Basin. The Rock Garden boundaries were mapped and extensive video footage was collected on the 2006 cruise.

Currently, the 2006 Discovery cruise ROPOS video footage is being analyzed for coral distribution and identification and collected species samples are being identified in order to resolve species identifications from the 2005 cruise.

BIODIVERSITY OF MACROINVERTEBRATE COMMUNITIES WITHIN DEEP WATER SOFT SEDIMENTS OF THE GULF OF MAINE'S JORDAN BASIN

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Aiming to fill a knowledge gap, this study investigates the benthic invertebrate community structure within the deep water soft sediments of the Gulf of Maine's Jordan Basin, as part of the Discovery Corridor initiative of the Centre for Marine Biodiversity. The Discovery Corridor is a swath of ocean covering a wide range of marine habitats from intertidal zones of the Fundy Isles Region to the abyssal plains of the Gulf of Maine. A 0.5m^2 video grab was used in 2005 to collect samples from three sites at 200-220 metres depth within the Basin, with three replicate grabs taken per site. Sediment sub-samples were also taken. Specimens are currently being identified, enumerated, and curated at the Atlantic Reference Centre, Huntsman Marine Science Centre.

The community structure is being analyzed using various univariate indices, as well as bivariate and multivariate techniques. Possible correlations of physical and biological parameters are being investigated. The anticipated results and significance of this study are to: characterize the benthos found in the soft bottom sediment of the deeper waters of Jordan Basin; evaluate the level of biodiversity found within these sites; contribute to the overall species list for the Gulf of Maine; discover animal range extensions, and possibly discover new species.

BENTHIC BIODIVERSITY IN SOUTHWEST NEW BRUNSWICK, BAY OF FUNDY: EXAMINATION OF RELATIONSHIPS BETWEEN FACTORS AND SPECIES

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Using existing and new numeric data, this study explores species assemblages and the factors that characterize their habitat, followed by exploration of factors that help explain the levels of species richness. Statistical analyses showed a significant difference between the species assemblages found in the different regions studied, and species richness patterns were in part explained by physiological disturbance and geomorphology. Additionally, we found that there is a higher than average potential of finding elevated species richness in the West Isles archipelago, an area exhibiting a smaller range and lower variability of salinity and temperature. Conservation of biodiversity can be an effective tool in managing marine areas, and species assemblages and richness are considered useful surrogates for protection of the marine processes that support them. In areas of decreased environmental variability where species-limiting physiological stress is not as prevalent, other factors such as suitable habitat become more limiting, and it is these areas where all factors combine to accommodate a larger number of species that are more likely to be important in the conservation of biodiversity in coastal areas. A framework that reasonably predicts where species richness may be found, based on these relationships, could prove useful in identifying and assessing priority areas for management. Results of the study are reviewed with respect to evaluating areas for their ecological and biological significance as related to biodiversity.

ECOLOGY OF PASSIVE POCKMARKS IN PASSAMAQUODDY BAY

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Pockmarks are universal features of soft sediments of the continental shelf and slope and represent one of the most common forms, at least on a geological timescale, of physical disturbance to the sediment and its biotic community. Visible video-surveyed megafauna was contagiously and sparsely distributed and included the five armed starfish, *Asterias rubens*, the sea cucumber, *Cucumaria frondosa,* and an un-identified colonial hydroid or bryozoan. In addition there were occasional discreet white patches of filamentous sulphur bacteria (*Beggiatoa* sp.) at the sediment-water interface. Macro-infauna was sampled with a 0.1m^2 precisely positioned grab and 101 grab samples were obtained. Analysis of macrofaunal community structure showed consistent significant differences between the inside and outside of pockmarks, including lower benthic diversity on the inside. Macroinfaunal species/abundance patterns within pockmarks were best explained by island biogeographic theory, rather than temporal patterns possibly linked to pockmark age. Trophic analysis of all 139 species of macroinfauna and three species of megafauna identified in this study suggest that the macrobenthic community was predominantly heterotrophic. Only two species of infaunal clams, *Thyasira flexuosa* and *Solemya* sp., and the bacterium, *Beggiatoa* sp., which are perhaps relicts, suggest a more intense chemosynthetic past.

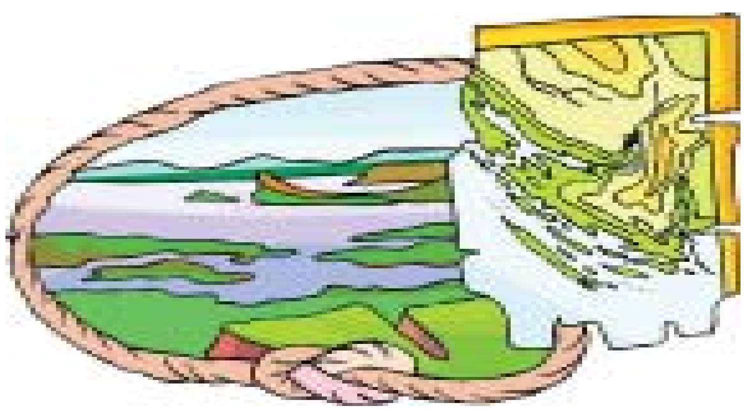
Session Two

ENVIRONMENTAL ISSUES

Chairs: Jane Tims, New Brunswick Department of the Environment, Fredericton, New Brunswick

and

Peter Wells, Environment Canada, Dartmouth, Nova Scotia, and Dalhousie University, Halifax, Nova Scotia



ENHANCING INFORMATION AND KNOWLEDGE OF THE BAY OF FUNDY

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Like many organizations and agencies, the wardens of the Bay of Fundy and Gulf of Maine are faced with an ever increasing volume of information and data that needs to be sifted through when making decisions about the care and management of the Bay and Gulf. The challenge has been in finding the information and/or data that is needed at the point of making a decision. This problem is exacerbated when one examines the range of "wardens"—from policy makers to citizens and scientists, and the range of possible sources and resources. This problem is not novel to this group, but extends to many other environments. A recent survey of 1,000 managers in Canada and the United States by Accenture Ltd. found that managers waste around two hours a day looking for information, and much of what they find is of little value to them. Too often, wrong or inappropriate information is retrieved from searches on the Web. Our goal is to rethink the current tools for providing access to information about the Bay of Fundy to emphasize information at the point of need.

Over the past few decades, access to information has evolved with changes in technologies from the traditional approach—using bibliographic databases—to extended systems that provide full text search engines, to augmented systems that provide even greater flexibility enabling search and browse capabilities. This range of systems is limited to the "bag of words" approach to accessing the content of documents. The next stage will be the enhanced system that not only provides enriched full text searching using text mining approaches, but also considers the contexts of use. Enabling the provision of information at the point of decision making is the goal.

An extended system is illustrated by the current Gulf of Maine Council on the Marine Environment (GOMC) Web site (www.gulfofmaine.org), with the list of knowledge-base topics, lists of papers and their PDFs, and the link to the search engine Google. An augmented system is the Web site maintained for the USA Chesapeake Bay Program (www.chesapeakebay.net), where, for example, one can browse through a range of environmental topics from habitats to bay pollutants to nutrients and toxic chemicals and view the full text. An *enhanced* system needs additional sophistication including the integration of environmental data with secondary source information to help solve real problems associated with real tasks that may be executed by a range of people from citizens to policy makers and scientists. The emphasis is on examining patterns from the data, and being receptive to the unexpected finding, while being focused on the contexts of use.

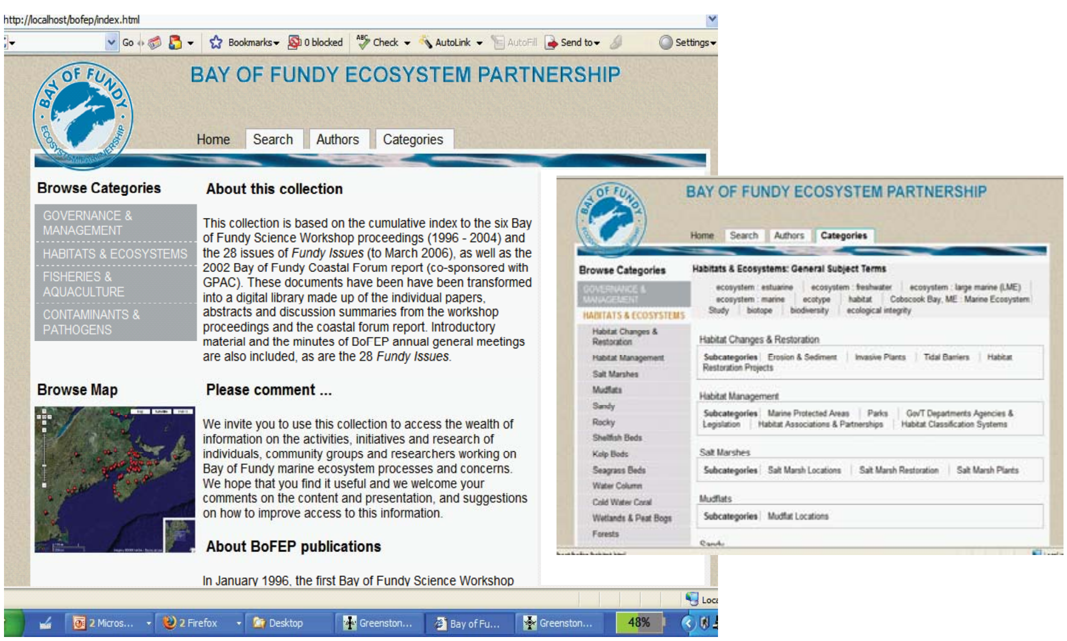
For the Bay of Fundy, we envisage connecting the user communities, very broadly defined, to the data sources, covering primary (the raw data) and secondary data (e.g., bibliographic or full text), and interfacing the data sources with the specific jobs or work tasks at hand, from exploration and fact finding to decision-making. Such an enhanced system, designed specifically for the Bay of Fundy user community, will have three functions: enabling multiple types of access to multiple forms of data and information; facilitating the link from raw data to analyses to formal and informal publications; and enabling drilling through the sea of data and information in response to many types of problems. Our biggest challenge, of course, will be to find an inspired donor to fund this ground-breaking study and system!

Since summer 2006, we have been developing a prototype for the Bay of Fundy "information collaboratory" which is a starting point on the road to an enhanced system. Our prototype is built using the Greenstone open source software (www.greenstone.org) which indexes and enables access to the full text of documents in a variety of format such as *.doc*, *.pdf*, and *.htm*. Our prototype contains the BoFEP proceedings from 1996–2004, *Fundy Issues* to March 2006, and the Coastal Forum report of 2005. In addition, we extracted concepts from the Cumulative Index created by Rolston and Wells (2006) to create a novel browsing tool loosely based on the Chesapeake Bay program design.

This resource base, thus, has several access points including a typical search engine, the ability to browse by a multi-layered set of environmental concepts that are directly related to the Bay, and has included a special browser to examine documents in four key categories that are important in the management of the Bay: governance and management, habitats and ecosystems, fisheries and aquaculture, and contaminants and pathogens. Finally, a limited, but browseable map of the Bay of Fundy and Gulf of Maine provides spatial access to the content.

As illustrated in Figure 1, the system is much like the augmented system described earlier. A 'google' like search engine provides full access to the content of each document ,which can either be viewed as a Web document or downloaded as a PDF. The enriched browser enables multiple pathways to explore depending on the interest of the viewer as illustrated by the habitat example above. Because spatial location is intrinsic to the problem domain, articles may also be found by location, e.g., Victoria Beach, NS. At the moment this is accomplished by integrating the Google map tool.

Figure 1.



Ideally, the system will be interfaced with a geographic information system (GIS) and integrated with other systems such as GoMOOS (Gulf of Maine Ocean Observing System, see www.gomoos.org) to permit access to specific data on variables of interest, e.g., chlorophyll, at specific locations where automated instrument buoys have been collecting data for many years. This form of sophisticated interface will facilitate comparisons between real time measurements and values reported in the research literature. Eventually, we hope to add other types of information, such as names of experts on the topic and other formats including presentations, videos or documentaries. The range of possibilities is only limited by the imagination and available resources.

The prototype will be accessible from both the Dalhousie University Centre for Management Informatics (http://informatics.management.dal.ca) and the BoFEP (www.bofep.org) Web sites (and we are receptive to suggestions about the design and potential of the prototype). The prototype at the moment is in its infancy. Our long-term goal is to build an information and knowledge repository that will serve as a digital information collaboratory for the Bay of Fundy. It will be a decision making tool for use by communities of citizens, policy makers and researchers so that critical Fundy information is accessible and useful for day-to-day applications.

Acknowledgements

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PERSISTENT INDUSTRIAL MARINE DEBRIS: THE RELATIONSHIP BETWEEN MARINE DEBRIS AND COASTAL INDUSTRIAL ACTIVITIES IN CHARLOTTE COUNTY, NEW BRUNSWICK

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Waste material discarded or abandoned by coastal marine industrial enterprises will accumulate on beaches where it is aesthetically degrading and can pose a threat to wildlife. Accumulated persistent industrial marine debris (PIMD) affects coastal wetlands, marine species, and water quality. The primary objective of this study was to identify the types, amounts, sources, and effects of PIMD in the coastal waters and along the shores of Charlotte County, New Brunswick, and examine any relationship between the amount of debris found in the study area and the types and numbers of industrial operations nearby.

Field studies included an aerial survey of the region followed by preliminary site visits to evaluate the scope of the problem. Definitive site surveys in the spring and summer of 2001 provided data on the types and amounts of PIMD in areas close to coastal industrial activities, such as commercial fishing, aquaculture, and marine transport. The debris included plastics (particularly plastic bags and synthetic foams) and chemically treated materials, as well as wood and other wastes. Some locations also showed accumulations of wastes from specific sources.

Accumulations of debris were greatest in areas close to large numbers of industrial sites, particularly where the local topography trapped material carried in by the tides and wind-driven surface currents. Floating debris discharged from coastal industry sites is transported to adjacent shores by wind and wind-driven surface currents. Heavier items such as boats, cage parts, and tires may sink to the bottom. In some locations lightweight materials such as feedbags, salt bags, foam floats, and plastic containers were transported several metres inland by wind. There is a positive statistical correlation between coastal industry operations, and PIMD accumulating above the high water mark in each study area.

Environmental effects include navigational hazards, aesthetic degradation, and release of volatile hydrocarbons from burning plastic items and treated wood. Marine mammals also can become entangled in discarded nets, lines, or fishing gear. The main methods of waste disposal leading to the accumulation of PIMD on the beaches include simple discharge as well as unauthorized burial or incineration along shorelines. In some cases, large items such as net frames and old boats appear to be wilfully abandoned on the beach. Appropriate pollution prevention strategies that monitor industrial activities for compliance with waste management regulations and policies are recommended.

SEDIMENTATION IN THE GREATER BAY OF FUNDY: A RESEARCH AGENDA

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We convened a session on Sedimentation in the Greater Bay of Fundy during the 2006 Annual Conference of the Atlantic Geoscience Society, with the aim of defining a research agenda. Such an exercise has not been carried out for a long time and we deemed this a necessary task given a) global change implications, b) renewed interest in tidal power generation, and c) changing views on coastal zone management practices, all of which influence sedimentation patterns. We do not claim that this agenda is the final word, but think it necessary to discuss it with other groups of peers, as well as with the general public. The most important topics of the agenda were:

1. Map the entire Bay floor using multibeam bathymetry: pay special attention to mussel reefs and sand bedforms.
2. Establish a sediment budget: pay special attention to the different contributions of bedload, suspended load, organic and inorganic matter.
3. Improve understanding of sea level rise over the last 10,000 years.
4. Establish the proportions of organic and non-organic material in the sediment column, spatially and temporally.
5. Establish the timing of origin of the big sand waves on the bottom of the Bay.
6. Address bottom fishing and its effects on benthic communities and sediment erosion.
7. Establish a sediment monitoring system in the upper Bay before the Petitcodiac causeway is removed.
8. Quantify the role of winter ice as a source of sediment and of new vegetation.
9. Quantify the effects of increased wave activity on exposed marsh cliffs.
10. Compile detailed high-resolution LIDAR surveys of marshes and mudflats.
11. Integrate modern and historical bathymetric data with historical aerial photography and HR satellite imagery.
12. Expand monitoring of dredge spoil disposal sites, as at Saint John (NB), to other locations.

NEW BRUNSWICK'S COASTAL AREAS PROTECTION POLICY: MEETING CHALLENGES IN THE COASTAL FRINGE

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Abstract

Coastal areas are an important part of New Brunswick's identity. A number of factors, from human activity to changes in our global climate, have placed stresses on coastal areas, creating greater risk to public safety and infrastructure, affecting important agricultural lands, and threatening the biodiversity of plant and animal life which have sustained coastal regions for centuries.

The challenge of government is to ensure future viability of coastal areas in terms of economic and community growth through advances in environmental protection. To accomplish this, the New Brunswick Coastal Areas Protection Policy establishes minimum standards for the management and sustainable development of coastal lands. The policy aims to protect coastal features such as beaches, dunes, and coastal marshes, and to provide a level of protection to the built environment near these coastal features, while maintaining a commitment to manage the development of coastal areas provincially.

This paper discusses the factors influencing the policy and its objectives, particularly linking the objectives to climate change and protection of flora, fauna and human health and safety.

Introduction

In January of 2002, the New Brunswick Coastal Areas Protection Policy (CAPP) was formally introduced to the public. The Policy is considered a tool for managing development and activities on the coast, stretching from St. Stephen to Campbellton, a distance of approximately 5,500 kilometres. The province-wide policy has been implemented through existing government regulations and processes for the last four years. The intent is to develop a regulation under the New Brunswick *Clean Environment Act*.

The New Brunswick coast consists of a variety of coastal features and types including beaches, dunes, coastal marshes, rocky shores, cliffs and dyked lands. Each feature has unique qualities and characteristics, as well as differing development pressures.

Over the past 100 years, development on the coast of New Brunswick, especially residential and cottage development, has gradually increased and has been one of the factors in changing the coastline. The New Brunswick Coastal Areas Protection Policy was introduced as a tool to manage development pressures.

Coastal lands make up 30,719 hectares (ha) or 0.4 per cent of the provincial landmass. The coastal features within the coastal lands include:

- Coastal marshes -14,435 ha
- Dyked lands – 12,431 ha
- Dunes - 2,546 ha
- Beaches - 815 ha
- Rock platforms - 77 ha

The Development Pressure

Although coastal development currently remains relatively stable, at an annual rate of approximately 600 new lots or parcels per year, the proportion of coastal subdivisions, as a percentage of all subdivisions in the province, has increased 35 per cent over the period from 1990–1999:

- 87,830 new lots or parcels were created provincially, with an average of 8,783 new properties per year.
- 6,268 new coastal lots or parcels were created, with an average of 627 new coastal properties per year.

The majority of the coastal development activity between 2004 and 2006 that the Department has responded to has been in the Greater Moncton and Greater Bathurst areas. There appears to be less development pressure on the Bay of Fundy area, which may be attributable to the long stretches of rocky shore and lack of access roads along that coastline.

The Economic Importance of Our Coast

Economic activities in the New Brunswick coastal zone reflect a significant portion of the provincial economy, as shown by:

- 60% of our population lives within 50 kilometres of our coastlines.
- Coastal land-based and marine activities are valued at over $1 billion or 7% of GDP.
- Traditional inshore fisheries landings are valued at approx. $125 million.
- Approximately 70% of all tourism activity is related to the coast, valued at approx. $700 million.

Storm surge damage is also significant, reflecting the ongoing danger to people and their property and the need for mechanisms for protection. For example,

- 1976 Groundhog Day Gale - $7.25 million
- Red Head, East Saint John 1985 Escarpment Landslide - $230,000
- January 2000 - $2.0 million
- October 2000 - $2.5 million

Estimated additional costs - $1.0 million

The Ecological Value of the Coast

The New Brunswick coast is home to a variety of flora and fauna which are sensitive to change, such as the Gulf of St. Lawrence Aster and the Maritime Ringlet Butterfly, both of which make their home in coastal marshes.

Some of the sensitive and important fauna in New Brunswick's coastal area include Great Blue Heron, Piping Plover, sandpipers, many species of ducks and other shorebirds. Mary's Point, in the upper Bay of Fundy, for instance, is one of the major stop-over points for two to three million shorebirds on their southerly migration each year. Here they stock up on food, living on the mudflats, and linger to feed until they double their weight. This additional weight will sustain them for the remainder of their non-stop journey to Suriname, South America. Red-breasted Mergansers nest on dunes and storm flood events have been known to significantly reduce nesting success. The protection of the habitats—beaches, dunes and coastal marshes—is essential for the survival of these shorebirds and other fauna.

Coastal wetlands along the Bay of Fundy provide valuable habitat for a variety of flora and fauna. They also provide buffering to protect inland areas from storm surges, coastal flooding and erosion. Wetlands absorb the water and energy from waves, reducing the impact on inland properties. Wetlands also act as sponges, collecting and cleaning water. This water is then released to aquifers, providing a resource for flora, fauna and humans as potable water.

A large number of coastal wetlands along the Bay of Fundy had been converted to other uses in the past, so presently there are fewer than there once were. As a result of this, the ecological value of the remaining wetlands has increased dramatically. As the impact of climate change increases, the role and value of wetlands become even greater with the increase in frequency and intensity of storm surges. The variability in precipitation events and the possibility of drier climatic conditions will increase the role wetlands play in absorbing and holding valuable water resources. Overall, the wetlands on the Bay of Fundy are expected to play a vital role in protecting ecological functions along the coastline, as well as contributing to a continuance of the social and economic fabric of coastal communities.

Coastal Issues

The Coastal Areas Protection Policy was developed to address the specific issues of :

- coastal wetland loss
- water and sewage disposal
- erosion hazards and structures
- storm surges and coastal flooding
- loss of public access to the coast
- management of dyked lands
- compensation for losses due to erosion, flooding and storm surges

The Policy objectives to address the specific issues are:

- To reduce the likelihood of threats to personal safety by storm surges and to minimize the danger to personnel involved in emergency and rescue efforts during storm and/or flooding events.
- To minimize the contamination of water and wetlands from hazardous materials or other contaminants (e.g., the contents of heating fuel tanks, or septic tanks), as well as to minimize the intrusion of salt water into wells due to water table draw-down.
- To maintain the buffering capacity of coastal areas to protect inland areas from storm surges.
- To maintain flora and fauna, both for the role they play in traditional fisheries and eco-tourism, as well for their inherent value in maintaining the coastal ecosystem.
- To minimize public expenditures required to repair storm damage to public property such as roads, bridges, public buildings and so on, as well as to reduce the expenditures required to control erosion as a means of protecting human-made structures.

The Protection of Human Settlements and People

As mentioned above, a large percentage of the New Brunswick population lives either along the coast or within a short driving distance. Most of New Brunswick's cities such as Saint John, Moncton, Dieppe, Miramichi, Bathurst, and Campbellton are in coastal locations. As time passes, more and more people are looking to retire or live on the coast, as close to the ocean as possible. This results in development being placed in a dynamic environment where a single storm may change the entire dune or beach system within a few hours.

The potential for destruction and damage to human settlements, buildings and infrastructure is real and the threat increases as more people choose to live close to the ocean and as factors such as climate change continue to occur. Climate change may result in sea-level rise, increased and more intense storm surges, increased coastal flooding and increased coastal erosion. The threats to people and property are very real.

How CAPP Protects People and Property

The New Brunswick Coastal Areas Protection Policy was developed at a time when issues such as climate change, storm surges, coastal flooding, erosion and pollution were moving to the forefront. Research and science indicated coastal communities were under threat and the risks of living on the coast were serious. With that in mind, CAPP was designed so that risks can be reduced or eliminated (Table 1).

The Policy recognizes the importance of beaches, dunes, coastal marshes as buffers for storm surges, flooding and storm waves, and for the human development on the landward side of the coastal features. Therefore, these features are given the highest degree of protection from development. Behind the features, CAPP identifies a 30 metre buffer designed to maintain some space between the ocean, the sensitive features and human settlement. A standard 30 metre approach was taken for reasons of consistency and ease of understanding.

The Policy recognizes the rights of individual property owners to use their properties in some form, but limits the development and activities by placing terms and conditions on the development. There is a balance between the property rights of the owner and the value of the natural environment.

Developments which may be allowed to proceed in coastal areas are limited by location, the type of building and construction or design in order to reduce or limit the risk. These developments are subject to terms and conditions which, for example, recommend that the livable portion of homes are elevated a minimum of two metres above the higher high water large tide (this is the average highest tide over a 19-year period). This assists in reducing the impacts of storm waters on living space and protects property and people. Other conditions, such as set-backs from the coast or locating sewage and water systems at the back of lots, are all required to protect drinking water supplies and coastal features from pollution and salt water intrusion.

As more information becomes available regarding the potential impacts of erosion, storm surge and the potential for coastal flooding, this information is used in evaluating proposed projects and in many cases is used to convince developers and property owners to redesign and reconsider projects. Specifically, climate change is taken into consideration when a project is reviewed.

The Policy also addresses the potential costs of repairing public infrastructure due to storm surges, coastal flooding and erosion. The costs of repairing roads, sewage and water lines, sewage treatment plants and bridges are costs which are passed on to all tax payers of New Brunswick, whether they live on the coast or not. As more people live on the coast, more infrastructure is demanded. The costs for repairing this infrastructure can become enormous. Therefore, when a new project is proposed along the coast, the issue of associated infrastructure availability or requirements are brought forth to ensure that the project design takes into consideration the risk associated with the coastal location. The results have been the relocation and redesign of infrastructure to better suit or adapt to coastal conditions.

With the ongoing occurrence of storm surges and coastal flooding comes the task and its associated risks of rescuing individuals living on the coast. In the past, many homes have been built in precarious locations, which during the right weather conditions, can become suddenly inundated with flood waters. The local resources and emergency preparedness are taken into consideration when reviewing projects under the Policy. Tough questions are asked of local officials regarding their preparedness and ability to respond to emergency situations. As we have seen in other parts of North America, when conditions are right**,** there is the potential for real disaster in coastal areas. Local and regional officials must have the capacity to respond to these situations where, in many cases, human lives and property are at risk.

The aftermath of these situations is also reflected in the Policy. When an area becomes flooded or eroded away, private and even public septic systems are damaged, resulting in pollution from sewage. The Policy identifies terms and conditions to be placed on the location of wells and sewage systems in coastal areas, including the location of new community waste water treatment systems and lagoons. Upgrading of septic systems or wells is allowed under the Policy.

How CAPP Protects of Flora and Fauna

The protection of flora and fauna is an objective of the Policy. It is recognized that the coast is home to a host of sensitive and endangered species which are ecologically linked to our well-being and the well-being of our environment. The loss of beaches, dunes, coastal marshes, etc. results in the destruction of critical habitat and loss of biodiversity of our coastal areas. Therefore, the sensitive areas, such as beaches, dunes, coastal marshes, etc., are provided with protection under CAPP through set back requirements and conditions on location and types of building. For instance, boardwalks over marshes or dunes must not require excavation or modification to the coastal feature; the footprint and construction area is limited to a single corridor, no infilling is done, and pile or pole construction is used. These conditions reduce the development in these areas. Projects are reviewed thoroughly to determine if any endangered species, either flora or fauna, are present.

Conclusion

The recent New Brunswick Coastal Areas Protection Policy is a response to the realization that the coastal areas of New Brunswick are challenged with development pressures and are still at a stage where effective planning and management can make a difference. In protecting coastal features, the unique ecological attributes of the coast, as well as the people and their property, are protected.

Table 1. The policy response to issues under the New Brunswick Coastal Areas Protection Policy

CAPP Response to Issues			
Issue	**Policy Response 1**	**Policy Response 2**	**Policy Response 3**
Coastal wetland loss	30-meter buffer around coastal marshes	Construction requirements for boardwalks	
Water and sewage disposal	Water and sewage systems must be located on the portion of the lot furthest from the coastal feature		
Erosion hazards and structures	Must be located landward of the high water mark and no backfilling permitted	Maximum height of 2 meters above the elevation of the beach	Must be a sloped structure (max. 45 degree slope)
Storm surges and coastal flooding	Habitable portion of the structure must be at least two meters above the high water, large tide elevation	Multifamily dwellings, hotels and apartments are not considered for zone B	Construction must be 30 meters inland from the coastal feature
Loss of public access to the coast	Erosion control structures must not be below the high water mark	Boat launches do not extend seaward and boardwalks do not extend seaward	
Management of dyked lands	Allow dyked lands to revert to marshes by removing control structures	Continue agricultural practices on those dyked lands that have been consistently used for agriculture	

POPULATION DYNAMICS OF THE INTERTIDAL AMPHIPOD *Corophium volutator*: SPATIAL AND TEMPORAL VARIATION

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Within the context of this session on environmental issues, the title of our presentation could also be "At what spatial and temporal scales should one sample? A case study with *Corophium volutator.*"

Our study was initiated in 1999, within the context of an impact assessment of the planned opening of the Petitcodiac causeway on populations of *Corophium volutator* at the mouth of the Petitcodiac River. To be able to properly detect an impact, it is recommended that one uses a BACI sampling design; BACI stands for Before, After, Control and Impact (Green 1979). The simplest design consists of measuring a population variable at the potentially impacted site and at *one* control (reference) site, before a disturbance and after a disturbance. However, this leaves the potential for confounding of effects with site-specific differences, and limits the generality of results. In recent years, these designs have improved with the inclusion of *multiple* control sites ("Beyond BACI"; Underwood 1992). Sites naturally show different levels of variation, with some much higher than others. By incorporating multiple control sites in the impact assessment design, one can quantify natural variability and thus have a much more powerful design to *reliably* detect an impact. To optimize a sampling design, it is also important to know the scale at which variation occurs. For example, does the population variable under study vary on a large scale (such as between mudflats), on an intermediate scale (such as between one-kilometre long transects within mudflats), or on a small scale (such as between samples within transects)? The scale which shows the highest variation is that to which the highest sampling effort, to ensure adequate replication, should be allocated. In summary, assessing natural variability is important (1) to have the best possible impact assessment study, and (2) to optimize how one will sample populations.

The burrowing amphipod *Corophium volutator* is a dominant macroinvertebrate on the mudflats in the upper Bay of Fundy (Peer et al. 1986). It can reach densities of 50,000 or more individuals m^{-2}, and is a major food for fish and migratory shorebirds. Given this, its population dynamics provide an index for the ecological state of the Bay of Fundy. At present, we have collected large amounts of data on the population dynamics of *C. volutator* in the *before* period of the BACI design. The opening of the Petitcodiac causeway has not occurred yet (www.petitcodiac.com/index.htm#). However, our data set has proven very useful to answer questions about scale.

We examined two questions related to spatial scale. At what spatial scale do populations of *C. volutator* vary most? Which population variables show variation: density, proportion of juveniles (a measure of population structure), sex ratio or fecundity (number of eggs per female)? As well, we examined one question related to temporal scale: How much variation is there in density between years? We quantified density and population variables monthly over 1–2 years (1999-2001) at four mudflats: Daniels Flats and Grande Anse in Shepody Bay, Minudie in Cumberland Basin and Avonport Beach in Minas Basin (Barbeau and Grecian 2003; Hamilton et al. 2003). We assessed the amount of variation (variance components estimated using ANOVA, Searle et al. 1992) at three scales: at the level of samples (10-centimetre diameter cores), 900-metre long transects and sites (mudflats).

Total density of *C. volutator* peaked in mid-summer, and this correlated well with juvenile density. Most of the variation in density was between samples and between sites, accounting for 45 and 40 per cent of the random variation, respectively. There was relatively little variation (2%) in density between transects. Proportion of juveniles showed a strong interaction between month and site, accounting for 60 per cent of the random variation; one site (Avonport Beach) had a decrease in proportion of juveniles in winter that was more rapid than other sites. Essentially, juveniles at this site grew faster and became adults sooner that at other sites. Site and transect accounted for moderate amounts of the random variation in proportion of juveniles (25 and 14 per cent, respectively). The sex ratio was consistently female-biased throughout the year, and more of the random variation was between sites (74%) than between transects (14%). Fecundity (number of eggs per female) consistently increased with female size at all sites; however, fecundity was higher in June than in other months in the reproductive period.

In the analysis to assess variation between years, total density varied mostly between sites (43%) and samples (23%), as in the analyses mentioned above. Year and interactions involving year accounted for less than 14 per cent of the random variation.

In conclusion, random variation in population variables for *C. volutator* was greatest at the scale of mudflats and at the scale of samples. Variation was much less at the scale of transects. Variation between years was low; note, though, that we compared only two years. The implication of our work with regards to the ecology of *C. volutator* is that patchiness in the distribution of the amphipods within site is at the scale of samples (metres) and not at the scale of transects (hundreds of metres). Hence, sampling transects provide a good representation of general density of *C. volutator* on a mudflat, and there seems to be little need to have many transects. However, one needs many samples per transect, since variation is high between samples. With regard to impact assessment studies, the wide observed variation across mudflats demonstrates a clear need for multiple control (reference) sites to obtain a good measure of natural variation.

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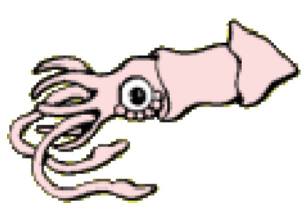
Session Three

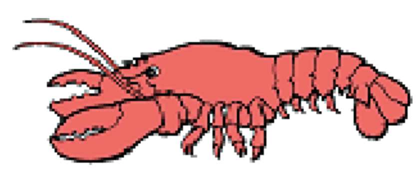
BIODIVERSITY AND ECOLOGY: REGIONAL INITIATIVES

Chairs: John Sowles, Maine Department of Marine Resources, West Boothbay Harbor, Maine

and

Kent Smedbol, Department of Fisheries and Oceans, Biological Station, St. Andrews, New Brunswick





Session Three Summary

John Sowles, Rapporteur

Five talks were given that varied in subject area and spatial coverage. Primary points and highlights of the discussions were as follows:

1. A lot of progress has been made regarding data and information organization and management, making the information available to managers.
2. In the Fundy region, we have a good critical mass of interest and commitment toward information exchange and sharing.
3. There appears to be a deliberate effort to make the work—whether monitoring/inventory or research—relevant to management's needs.
4. It also appears that there is increasing recognition that inventories and longer-term monitoring are critical to understanding ecological relationships, answering the "so-what i.e. what is the relevance?" question; establishing criteria and standards for designating special areas; and setting goals and measuring progress.
5. Regarding indicators, we seem to be on the way towards their development and prioritization, but that in most cases we have a long way to go for routine application. We know what is "unusual", but do we know what is "sensitive"? Research is needed in these areas.
6. Indicators may not only be a standard set of species, however. They may be conditions, biological communities, and ecological functions that may be universally applied.
7. It appears that there is institutional agreement over the need for collaboration and information sharing. Institutional turf i.e. competition, and politics (at least regarding this topic) are not limiting factors. Rather, the limiting factor is funding (sufficient, consistent, long term) to support surveys and studies.

Summary comment: We need to know what we have in order to know what to manage or what we stand to lose in the absence of appropriate management. Baseline studies, monitoring, and ecological studies are all needed as part of the overall "management package" to protect the habitats, unique species, living resources, and ecosystems of the Gulf of Maine and Bay of Fundy.

THE GULF OF MAINE CENSUS OF MARINE LIFE PROGRAM AND AN APPEAL FOR BAY OF FUNDY PARTICIPATION

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The Gulf of Maine (GoM) Area Program is one of the field programs of the global Census of Marine Life. The GoM Area defined for this study includes all of the Gulf of Maine proper, plus the Great South Channel, Georges Bank, the Western Scotian Shelf (to the Halifax Line), the neighboring continental slope and the western New England Seamounts. The objectives of the program are to increase exploration and awareness of the region's biodiversity, add to our knowledge of how this diversity is organized and what it contributes to ecosystem function, and develop strategies for incorporating this knowledge into ecosystem-based approaches to ocean area management. The program includes studies from the high intertidal to the abyssal plain. The scope of these goals and geography is obviously enormous and the program's success depends on involvement of the GoM's community of researchers, managers and other stakeholders. We will summarize the program's main approaches, activities, products and future plans, and seek to involve more information and ideas from the Bay of Fundy community.

ZOOGEOGRAPHY AND CHANGES IN MACROINVERTEBRATE COMMUNITY DIVERSITY OF ROCKY INTERTIDAL HABITATS ON THE MAINE COAST

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Abstract

Epibenthic macroinvertebrate communities were examined at six rocky intertidal locations along the Maine shore. Sampled locations were distributed across nearly the entire coast of Maine from Kittery to Perry (43º 5' 3" N, 70º 39' 30" W to 44º 58' 28" N, 67º 02' 04" W) and were situated roughly equidistant from each other. All field sites were registered Critical Invertebrate Areas designated with this status in the 1970s by the Maine State Planning Office Critical Areas Program (1970-1987). Sampling of epibenthic macroinvertebrates was conducted by recording species observed on the substratum surface and under rocks during a random walk through the intertidal zone. Intertidal areas ranged from 6 to 12 acres and both sampling time and frequency of rock flipping were accordingly proportionate. Numbers of species (S) decreased south to north from 71 to 42. A geographic trend in β-diversity was discovered. Specifically, species assemblages south of Penobscot Bay clustered together and were significantly different from communities sampled north of the bay which also formed a distinct cluster. Distinct clusters emerged also according to gross regional geographic scale (south versus north of Penobscot Bay) from 2- and 3-multidimensional ordination of the six sample sites. Change in diversity was measured with average taxonomic distinctness (AvTD) as a metric. The sampled species assemblage from each location was compared statistically to a historical master species list compiled nearly 30 years previous by the Maine Critical Areas Program. Intertidal epibenthic macroinvertebrate diversity has changed significantly according to AvTD at Sea Point and Bailey Island. Comparisons made with original site descriptions and photographs did not show any detectable disturbances that could account for changes in AvTD at the two southern-most locations. While the causes for the measured changes are probably multifaceted, a trend of increasing sea water temperature may be a clue.

Introduction

Most of the shoreline of the Gulf of Maine is formed by the 8,690 km coast of the state of Maine, not including the shores of the 3,500 islands that lie off the Maine coast. The complex convoluted shoreline is largely the result of glaciations that have occurred at least five times (Knott and Hoskins 1968). The last glaciation produced great changes in sea level which strongly influenced regional climate and the distribution of littoral invertebrates (Bousfield and Thomas 1975; Campbell 1986; Belknap et al. 1987). These were largely the result of changes in coastal oceanography which were linked to the Gulf of Maine, a semi-enclosed macrotidal sea which itself is influenced by both continental and marine factors (Hertzman 1992).

The coast of Maine is perhaps best known for its rocky intertidal zone, although marshes, mudflats, eel grass beds, and sandy beaches share this coastline to different extents. Sand beaches and salt marsh predominate in southern Maine and are present as pockets and fringes in northerly locations. As these habitats become less frequent in the north, the intertidal becomes rocky with mud and coarse grain flats (Kelley et al. 1989). The differential distribution of habitats is largely the result of geological history (Caldwell 1998).

The present distribution of shallow water invertebrates along the Gulf of Maine is mainly the result of coastal geology and sea water temperature. Zoogeographic patterns in β diversity of intertidal invertebrates along coastal Maine have been attributed to surface sea water temperatures (Bousfield and Laubitz 1972; Larsen 1985; Larsen and Doggett 1985; Watling 1979). These patterns persist apparently across various habitats with one exception, i.e., mudflats (Larsen and Doggett 1991). Causes for the regimes in sea water temperature recorded along the coast result from physical oceanography of the Gulf of Maine, with oceanic fronts and upwelling implicated as a cause (Larsen and Dogett 1985).

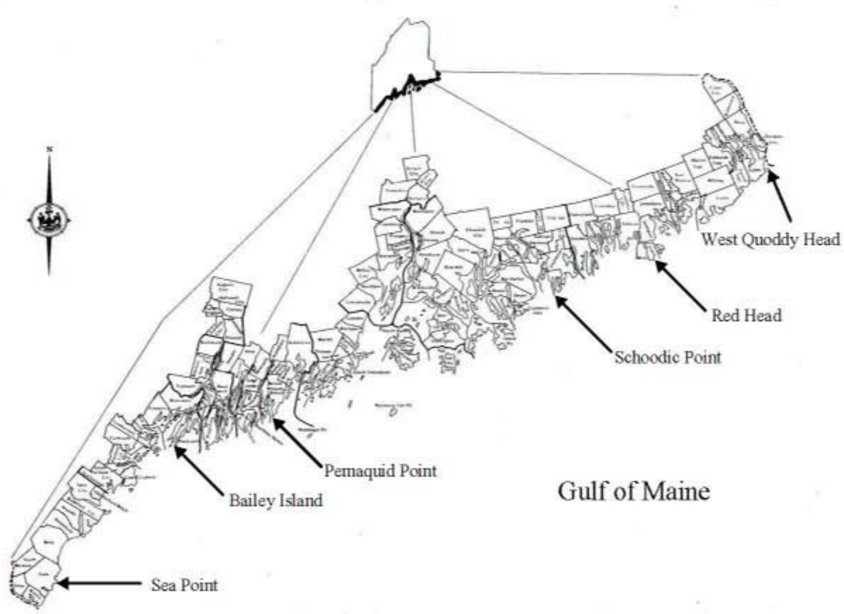
This study examined the intertidal distribution of macroinvertebrates along the coast of Maine by revisiting special areas where baselines were generated by the Maine State Planning Office Critical Areas Program (1970–1987). This program recognized the high diversity of intertidal communities by establishing Critical Invertebrate Areas distributed along the entire seaboard of Maine from Kittery to Cobscook Bay. Only rocky intertidal habitats were chosen for study. They were examined for zoogeographic patterns in β diversity (between habitat diversity) and changes in α diversity (local diversity).

Methods

Field Site Selection

Sample locations were chosen according to a preliminary study of 22 Critical Marine Invertebrate Areas conducted in the summer of 2004 (Trott, unpublished). Criteria used for selecting these field sites were similarity in habitats and well documented species assemblages with high species diversity. The distribution of field sites spanned nearly the entire Maine coastline making possible an examination of latitudinal trends in biodiversity (Figure 1). No sample locations were in the Penobscot Bay area since no Critical Marine Invertebrate Areas were established there. North and south of the bay, sampling locations were approximately equidistant from each other.

Figure 1. Map of coastal Maine showing locations of Critical Invertebrate Area sample sites



General Field Site Descriptions

Sea Point Marine Invertebrate Area. This exposed granite headland faces southeast and is bordered by sandy beaches. The high intertidal area is steep and banked with granite and igneous rock. Much of the mid-intertidal area of Sea Point is cobble with boulder (Figure 2A). There are pockets of gravel and sand. Bedrock outcrops are present in the low intertidal. Tide pools are scattered throughout the area. On a 0.64 ft (19 cm) tide, the intertidal area slopes approximately 1.4° away from mean high water to just beyond 747.5 ft (230 metres) (Figure 3). The first species list for this area is dated 1959.

Bailey Island Marine Invertebrate Area. This partially exposed, bedrock formation faces southwest and is part of a highly corrugated coastline. The intertidal contains areas of bedrock, boulder and cobble (Fig. 2B). The high intertidal is steep (60° - 80°). It grades into the lower intertidal that has a more gradual, 2.3° slope (Figure 3). Patches of gravel and sand are found between the finger-like projections of bedrock that create an irregular shape to the shore. Tide pools of various sizes and depths are located throughout the area but concentrated mostly in the eastern section. The species list is dated 1983.

Pemaquid Point Marine Invertebrate Area. This exposed bedrock headland projects seaward, south-south-east. The intertidal zone is narrow and nearly flat bedrock forming a shelf ending in deep open water (Figure 2C). Above it is a steep bedrock wall of approximately 90° that grades into the gradually, 2.4° sloping intertidal (Figure 3). Tide pools, few in number but large in size, are distributed mainly along the bedrock shelf. The species list is dated 1977.

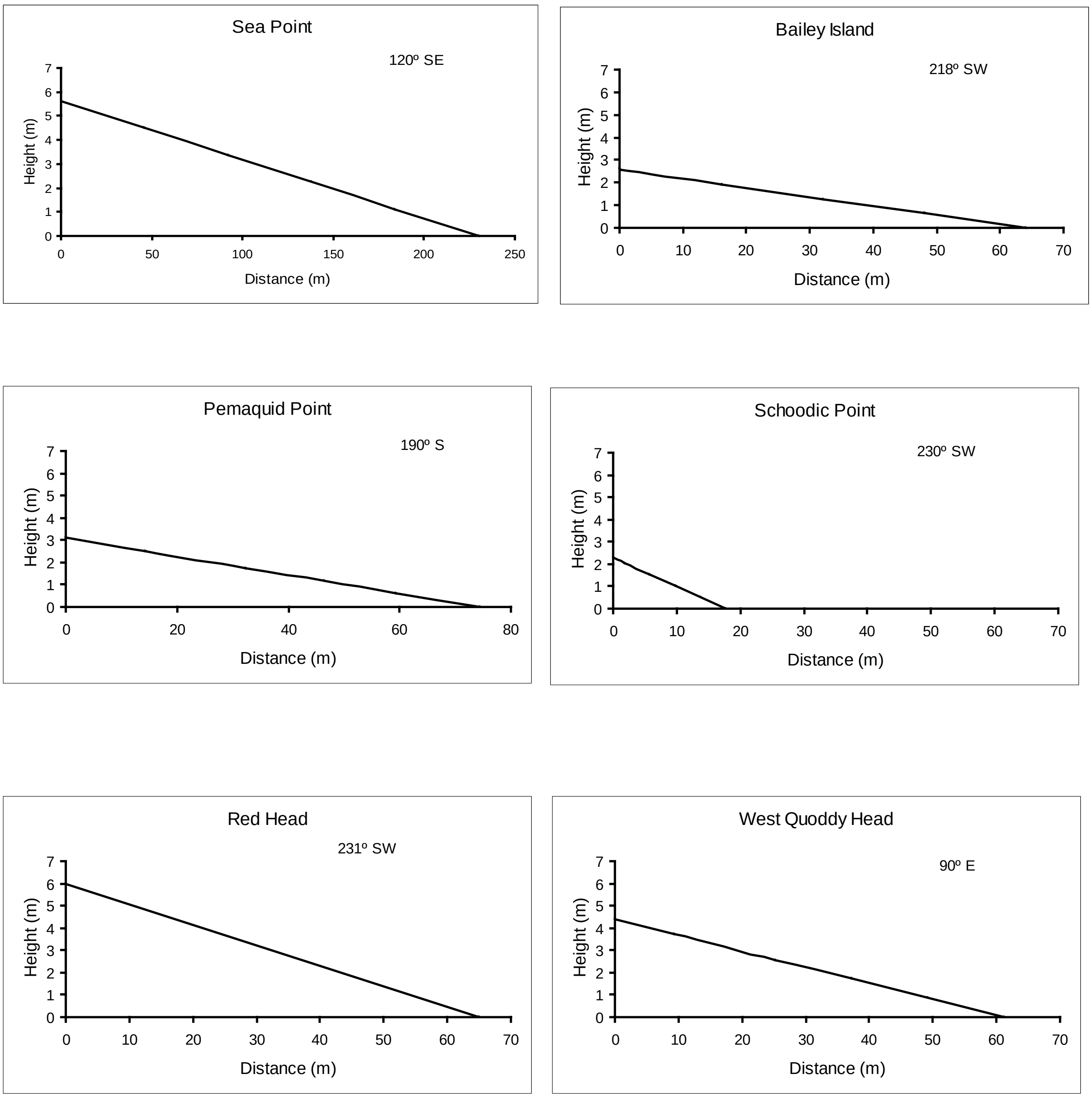
Schoodic Point Marine Invertebrate Area. This exposed pink granite headland is located on the western shore of the Schoodic Point peninsula. Most of the area has a granite escarpment cut by gullies making the topography complex in some places. While the ledge is the dominant feature, cobble and boulder prevail in some locations (Figure 2D). The escarpment is pitched at an angle of roughly 7° (Figure 3), although the slope is quite variable and can reach 90° on cliff faces. Numerous tide pools of various sizes are scattered throughout the high and low intertidal. The species list is dated 1977.

Red Head Marine Invertebrate Area. This exposed headland faces southwest and is primarily red granite. The head is formed by massive, very high and steep bluffs (Figure 2E). There are many deep grottos which are nearly inaccessible because of the steep, rockweed covered cliff faces that surround them. Wave surge can be extreme. Cobble and boulder are minor components of the substratum. The complex topography of the head is steep (Figure 3). Slopes range from 10 to 90° along this convoluted shoreline. The species list is dated 1977.

West Quoddy Head Invertebrate Area. This exposed, largely basalt headland faces east (Figure 2F). Steep, 75 ft (22.5 m) - 125 ft (37.5 m), irregular cliffs with 20° - 90° slopes border the intertidal zone. Cobble beaches lie at both the northern and southern boundaries of the area. Most of the intertidal zone is a mix of boulder, cobble and bedrock, although the latter predominates (Figure 2F). There are patches of gravel and sand. Numerous tide pools of various sizes are scattered throughout the high and low intertidal. The intertidal zone has a shallow 4° slope (Figure 3) and is influenced by 20 ft (6 m)tides.

Figure 2. Critical Invertebrate Area sample sites. A, Sea Point; B, Bailey Island; C, Pemaquid Point; D, Schoodic Point; E, Red Head; F, West Quoddy Head

Figure 3. Simple profiles of field locations indicating general slope of intertidal zone measured from high tide mark to low tide mark at a single position within each area. Note that distance scale differs for Sea Point. Seaward direction given in degrees.



Qualitative Faunal Evaluations for Taxonomic Distinctness

Faunal composition at all sites was documented by recording species of macroinvertebrates living on or near the substratum surface. Macroinvertebrates included animals ≥ 1mm. This is an operational definition based on the ability to identify animals of this size in the field. Intertidal areas were sampled continuously four hours each day along a random walk with random boulder turning. During sampling, the discovery of each new species encountered was recorded with a digital voice recorder. Organisms were identified to species either on site or if unknown, collected and identified later that day.

Sampling effort was proportional to the size of the critical area and lasted 3 to 9 days (Table 1). Day to day, start and end points of sample paths were recorded three ways: WASS GPS, landmarks, and photographs. Sampling effort differed from site evaluations of the Critical Areas Program which usually lasted one low tide (Peter Larsen, personal communication). Effects from differences in the spatial areas of each habitat type can be accommodated by spending proportionately similar sampling times in each of the different habitats (Somerfield, personal communication). The amount of time spent in each habitat was based on their estimated species richness. For example, more time was spent in mixed coarse and fine (cobble and/or gravel with sand/shell hash) habitats than sand, since the latter will not have boulders to turn over and few species of epifauna live on the sand surface.

Table 1. Description of field sites along coastal Maine by location, area, and sampling effort

Critical Invertebrate Area	Location	Heading	Area (acres)	* Days
Sea Point	N 43° 05' 03"; W 70° 39' 30"	120° SE	10	8
Baily Island	N 43° 43' 03"; W 70° 00' 16" N 43° 43' 15"; W 70° 00' 25"	218° SW	5.79	4
Pemaquid Point	N 45° 50' 15"; W 69° 30' 15" N 43° 50' 08"; W 69° 30' 27"	190° S	2.2	3
Schoodic Point	N 44° 21' 10"; W 68° 05' 26" N 44° 21' 09"; W 68° 04' 31"	230° SW	12.4	9
Red Head	N 44° 27' 05"; W 67° 34' 30" N 44° 27' 01"; W 67° 34' 53"	231° SW	3.27	4
West Quoddy Head	N 44° 48' 50"; W 66° 56' 55" N 44° 49' 17"; W 66° 57' 12"	90° E	7	4

*Field sites were sampled four hours each day

Data Analysis

Patterns in diversity related to latitude were investigated by comparing species assemblages at different sites using PRIMER 6 (Plymouth Routines in Multivariate Ecological Research) and its various subroutines. Two methods were used, the first examined similarity among sample sites by simple matching of species between locations with cluster analysis and multidimensional scaling. Another procedure developed by Izsak and Price (2001) was used to evaluate β-diversity, i.e., differences in diversity between sample sites. Their dissimilarity coefficient Γ+ (upper case Greek gamma) takes into account the taxonomic relatedness of species of the compared species assemblages. Among the types of patterns that can be revealed using this method are gradients in biodiversity across latitude, e.g., increasing or decreasing β-diversity with increasing latitude.

Changes in α diversity of species assemblages were evaluated with PRIMER 6 using a univariate approach. The species assemblage of each sample site was described with average taxonomic distinctness (AvTD) and variation in taxonomic distinction (VarTD). These two metrics describe diversity, i.e. AvTD, and evenness, i.e. VarTD, of species assemblages according to their taxonomic structure (Clarke and Warwick 1998a, b). Sites south of Penobscot Bay were treated separately from sites north of Penobscot Bay since these groups were found to form distinctly different assemblages. Two master species lists were assembled from species lists collected by the Critical Areas Program for sample sites north and south of Penobscot Bay. They were used to calculate expected taxonomic spread of these two sample groups by creating funnel graphs of predicted 95 per cent confidence intervals for predicted AvTDs. Change in α-diversity was evaluated by superimposing on the funnel graph values of actual AvTD calculated for each location from sample species lists. Species assemblages significantly different from their expected AvTD would have AvTD plots outside the 95 per cent probability of expected taxonomic spread. A similar method was used to calculate predicted taxonomic evenness with the two master species lists. They were used to calculate expected variation in taxonomic distinctness for locations north and south of Penobscot Bay by creating funnel graphs of predicted 95% confidence intervals for predicted VarTDs. Species assemblages significantly different from their expected VarTD had observed VarTD plots outside the 95% probability of expected taxonomic spread.

Results

Species Composition and Community Structure

More species were encountered at all locations during the present investigation than during original critical area evaluations except Sea Point and West Quoddy Head (Figures 4, 5). This difference held for higher taxa as well, excluding West Quoddy Head that differed by only one phylum, Platyhelminthes. There were trends in dominant phyla consistent among all sample sites. Molluscs dominated in number of species present at all locations, a feature consistent with the original critical area evaluations. Arthropods were the next most common taxon found both historically and in this study, except in the original site evaluations for Red Head and West Quoddy Head where there were more species of Annelida and Echinodermata, respectively. These two phyla were the next most frequently encountered taxa in this study followed by cnidarians. Poriferans, plathyhelminths, nemerteans, ectoprocts, and chordates comprised minor portions of species assemblages at all locations.

Species richness decreased from south to north, with the greatest numbers of species found at Sea Point where habitats were most heterogeneous, i.e. bedrock, boulder, cobble, gravel, and sand (Table 2). Average phylogenetic diversity (AvPD) increased and total phylogenetic diversity (PD) decreased south to north. No latitudinal trends were observed in either AvTD or VarTD.

Latitudinal Trends in Diversity

Similarity of species found among sample sites was related to their location (Figure 6A). When sample sites were compared by simple matching of species found, two significantly distinct clusters formed north and south of Penobscot Bay (Simprof Test; $P < 0.05$). The geographic pattern of species similarity among sample sites is preserved when species assemblages were examined with multidimensional scaling. MDS maps show

Figure 4. Community composition of sampled critical invertebrate areas south of Penobscot Bay. Each area is represented by data from the current study paired with those from area evaluations conducted by the Critical Area Program, ca. 1977. Numbers in parentheses indicate the number of species in each phylum. The total number of species found at each location is represented by S.

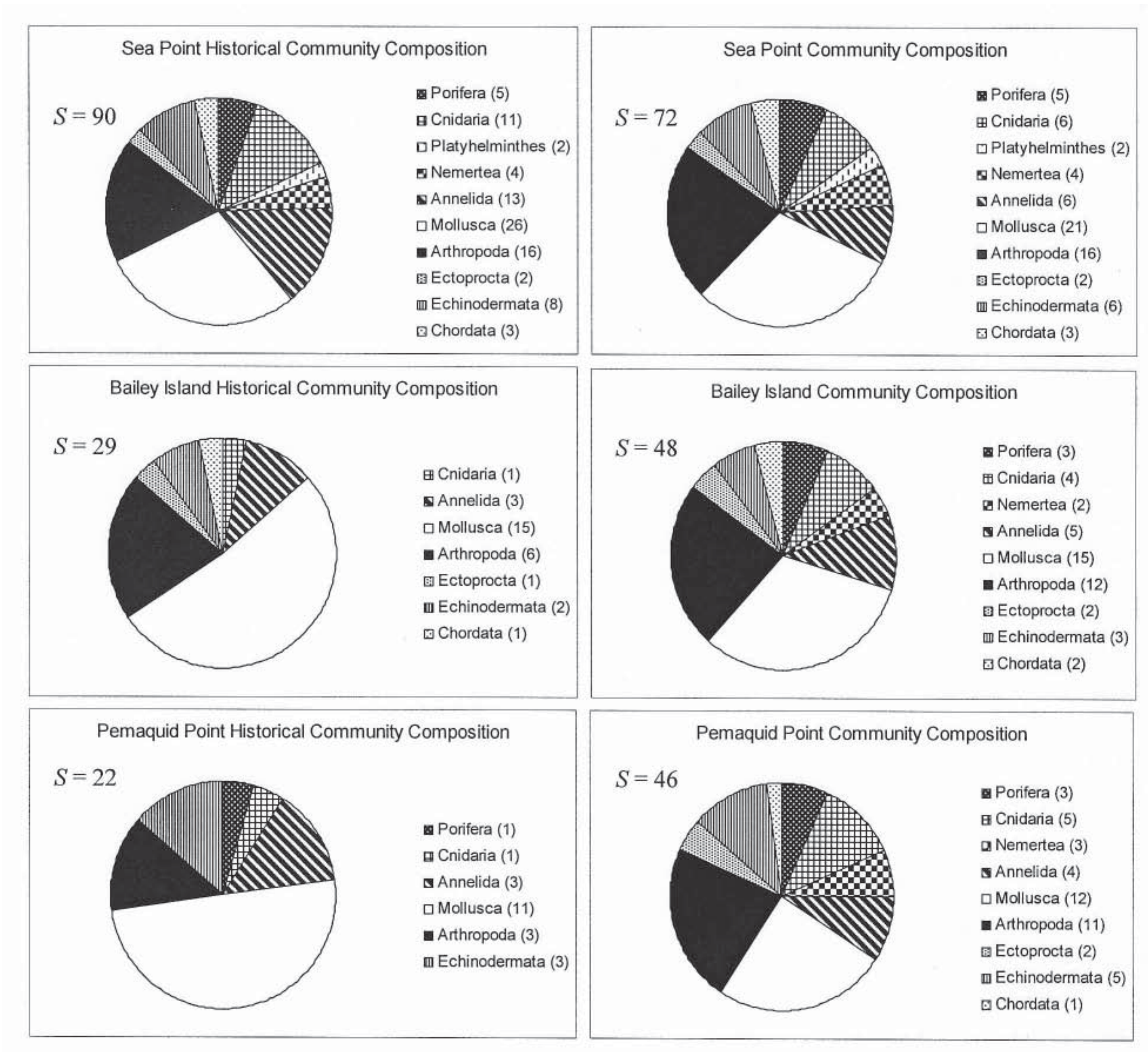


Figure 5. Community composition of sampled critical invertebrate areas north of Penobscot Bay. Each area is represented by data from the current study paired with those from area evaluations conducted by the Critical Area Program, ca. 1977. Numbers in parentheses indicate the number of species in each phylum. The total number of species found at each location is represented by S.

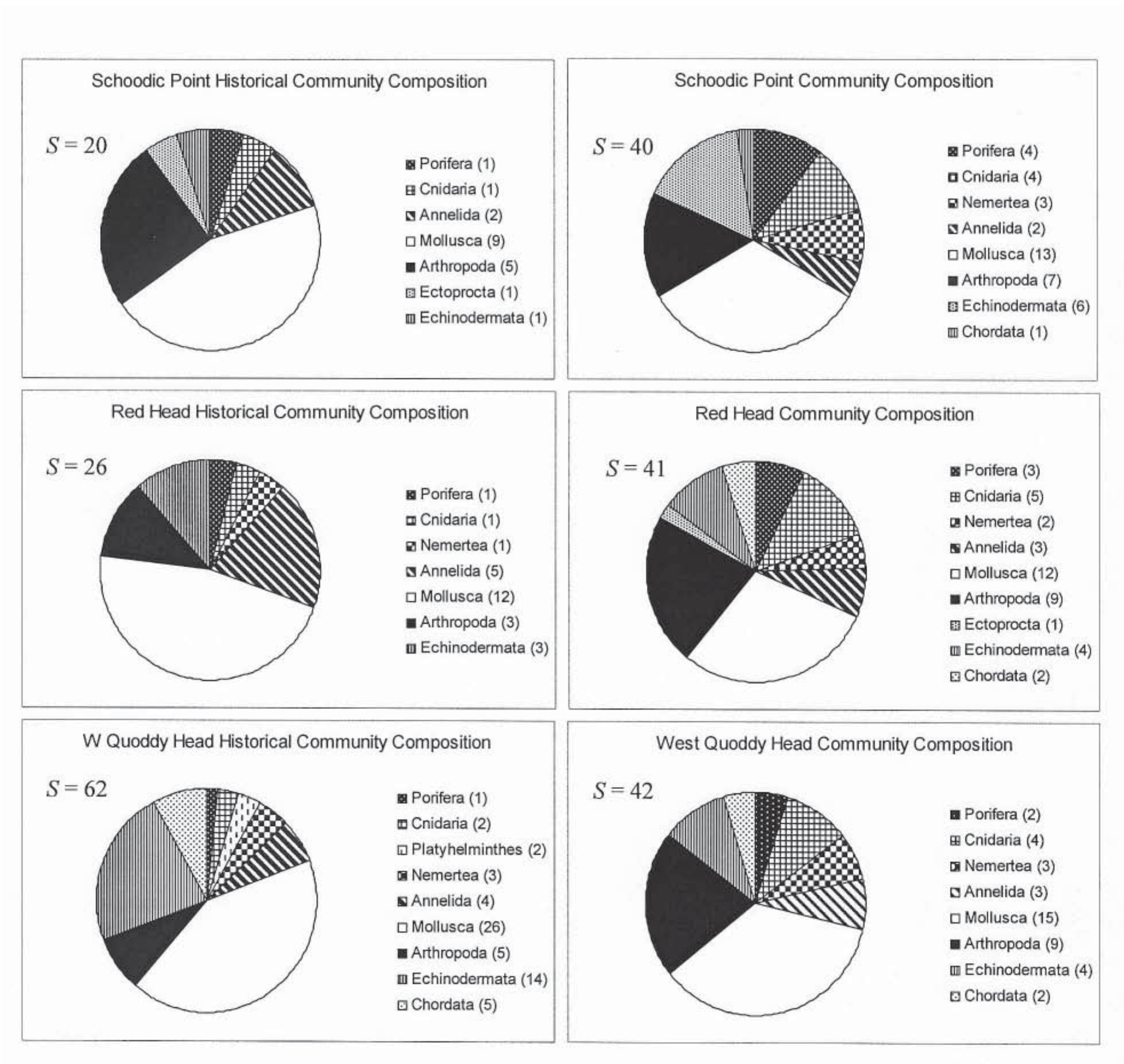


Figure 6. Dendrograms from cluster analysis of all six critical areas sampled based on (A) simple matching and (B) taxonomic dissimilarity (β-diversity). (A) Slice (dotted line) in is at 63 per cent similarity. Red dotted lines indicate clusters not significantly different from each other. Solid black lines indicate clusters significantly different from each other. (B) Slice (dotted line) is at 18 per cent dissimilarity. ▲ represents locations north of Penobscot Bay. ▼ represents locations south of Penobscot Bay.

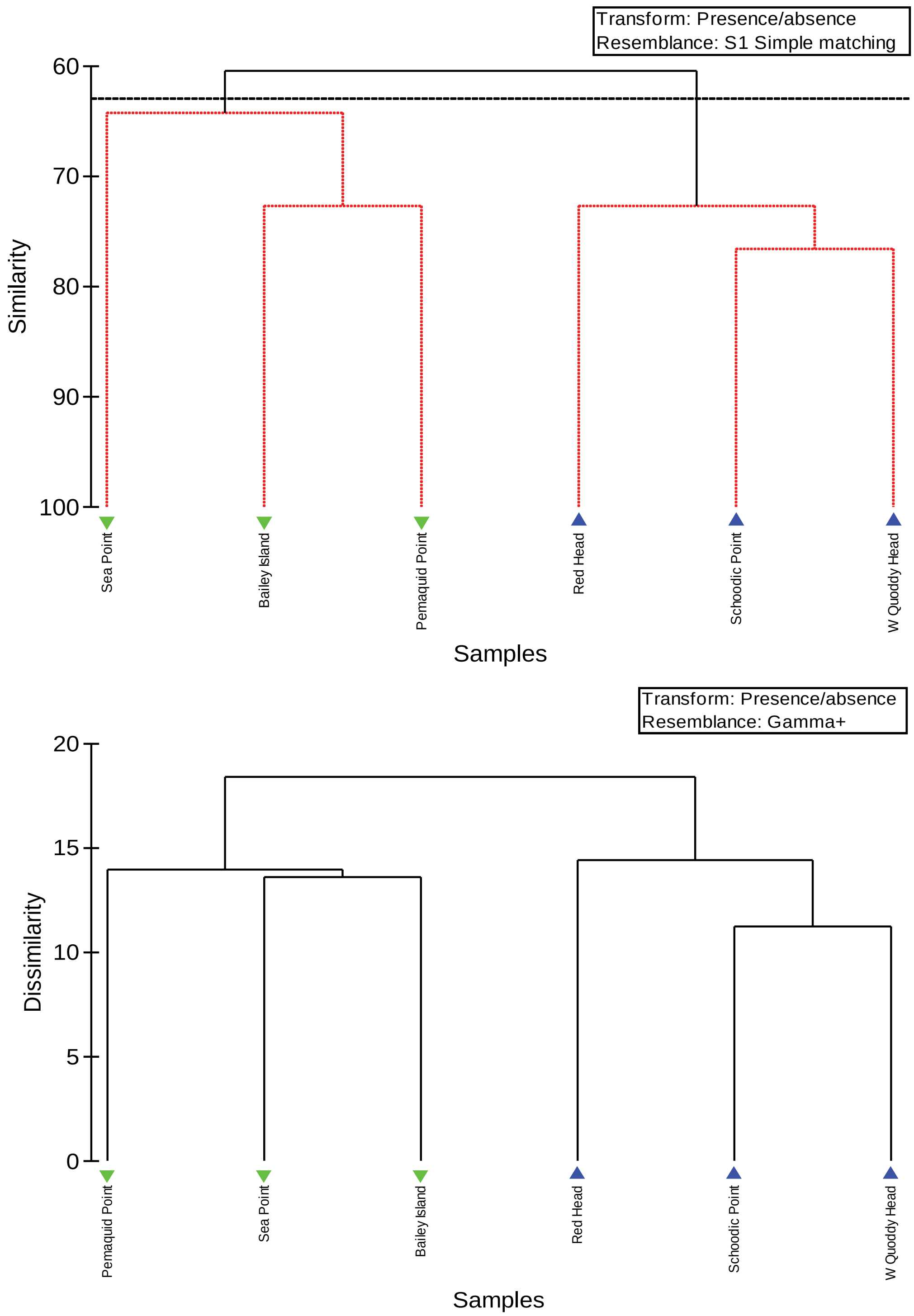


Table 2. Characterization of field sites located along Maine coast according to various indices of biodiversity

Critical Invertebrate Area	Diversity Index				
	S	**AvTD**	**VarTD**	**AvPD**	**PD**
Seal Point	72	91.8	396.1	39.7	2855.0
Bailey Island	48	91.1	423.4	45.5	2183.0
Pemaquid Point	46	92.3	376.7	46.7	2149.8
Schoodic Point	40	91.7	399.4	47.7	1909.7
Red Head	41	92.5	365.3	48.9	2003.2
West Quoddy Head	42	91.2	401.3	49.0	2058.0

significant structure amongst sample sites with Stress = 0 for 2-dimensional and 3-dimensional plots (Figures 7A, B). The separation of sample locations into two groups north and south of Penobscot Bay supports the idea that Penobscot Bay represents a faunal break point.

The taxonomic structure of communities sampled along the coast of Maine, measured as β-diversity, also differs north and south of Penobscot Bay. Taxonomic dissimilarity or β-diversity of intertidal communities revealed a clear clustering of locations south and north of Penobscot Bay (Figure 6B). A geographic pattern of dissimilarity among sample sites is evident from analysis of sample locations with multidimensional scaling. MDS maps show significant structure amongst sample site β-diversity with Stress = 0.01 for 2-dimensional and 3-dimensional plots (Figures 8A, B). Distinct groups of locations north and south of Penobscot Bay based on β-diversity parallel the groupings of similarity of shared species among sample locations.

Community Change

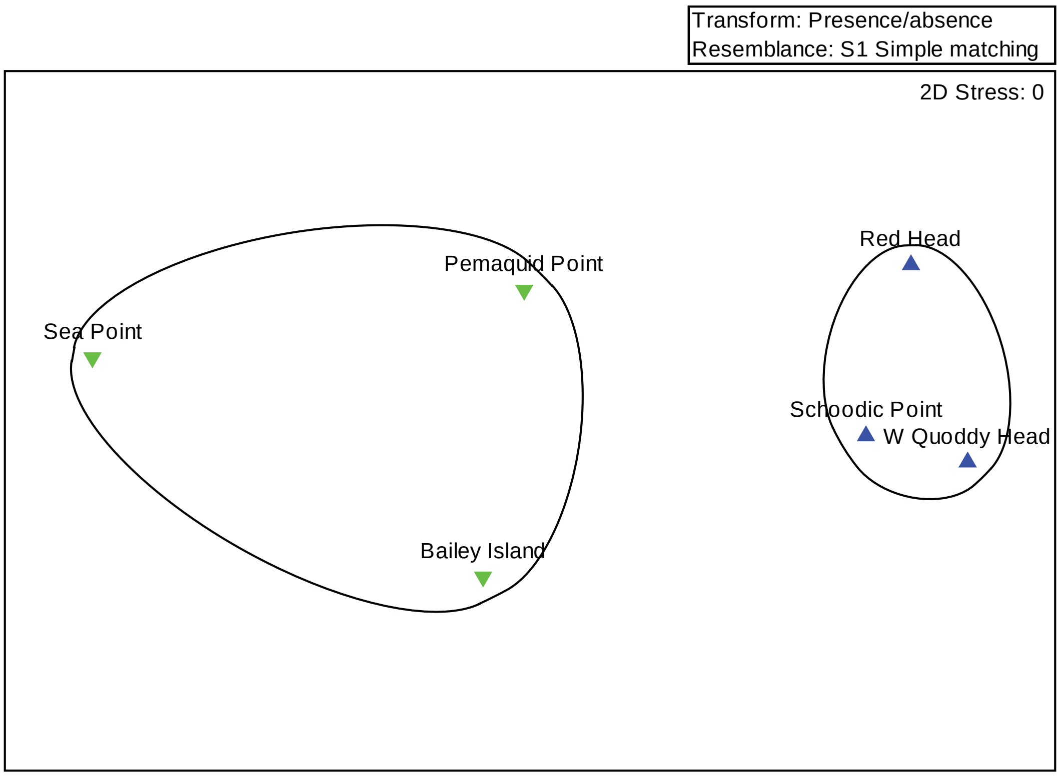
Changes in community structure were detected by superimposing measured values of average taxonomic distinctness (Table 2) for each location onto a funnel plot created from a historical species list. Significantly reduced taxonomic distinctness was measured at Sea Point and Bailey Island (Figure 9A). None of the species assemblages at sample locations north of Penobscot Bay had changed significantly (9B). This change in taxonomic structure of species assemblages represents a shift to assemblages with more closely related species, i.e., more belonging to fewer higher taxa. Variation in taxonomic diversity of species assemblages had not changed significantly (Figures 10A, B).

Discussion

Coastal Maine rocky intertidal communities sampled along the Sea Point to West Quoddy Head transect are dichotomous, separated at Penobscot Bay into two distinct, north and south species assemblages. Similar patterns in β diversity along the Maine coast were reported by previous investigators with temperature given as the principal cause (Bousfield and Laubitz 1972; Watling 1979; Larsen and Doggett 1990). Temperature is a determinant of the spatial distribution of species limited by their physiological ecology, specifically through thermal tolerances and reproductive requirements. Sea water temperature delineates the New England shore north of Cape Cod into two zoogeographic subregions (Bousfield and Laubitz 1972) or provinces (Watling 1979) with a faunistic break occurring in the vicinity of Penobscot Bay. Another division was described by Larsen and Doggett (1990) who reported sand beach macrofauna assemblages are separated by two sharp discontinuities resulting from

Figure 7. A. Two-dimensional ordination plot from multidimensional scaling analysis of the six critical areas sampled examining species similarity among locations. Slice shown in Figure 6 is superimposed upon plot (black line). B. Three-dimensional ordination plot from multidimensional scaling analysis of the six critical areas sampled examining species similarity among locations. ▼ represents sites south of Penobscot Bay. ▲ represents sites north of Penobscot Bay.

A



B

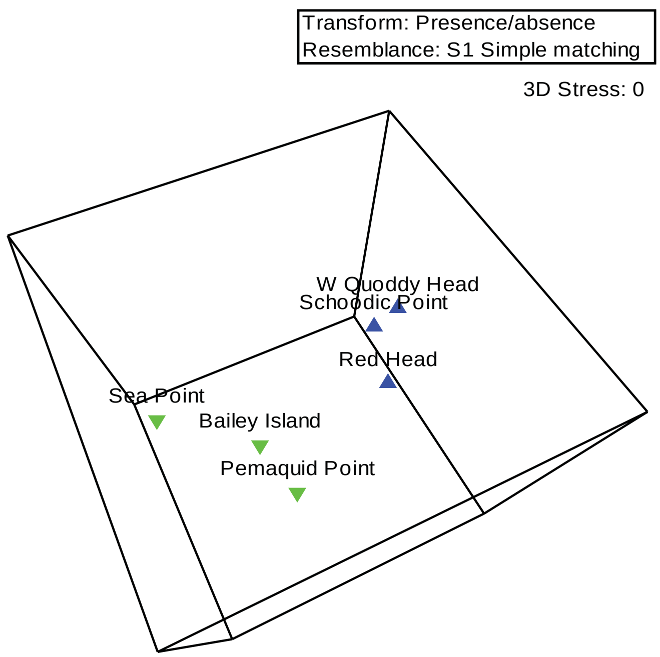
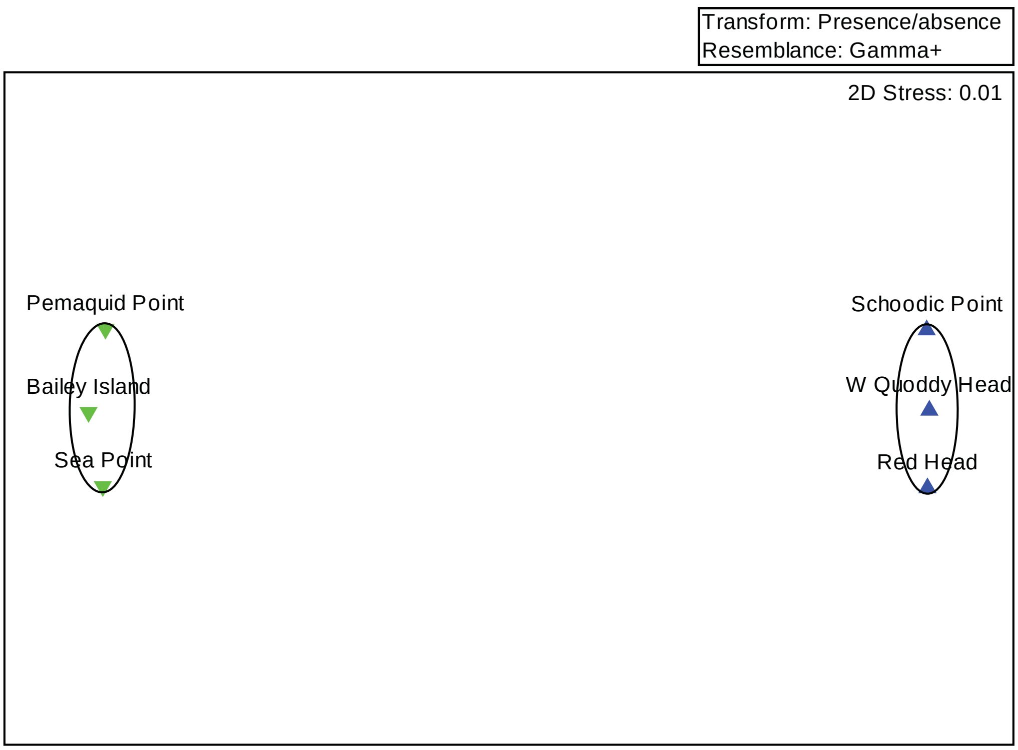


Figure 8. A. Two-dimensional ordination plot from multidimensional scaling analysis of taxonomic dissimilarity (β-diversity) among the six critical areas sampled. Slice shown in Figure 8 is superimposed upon plot (black line). B. Three-dimensional ordination plot from multidimensional scaling analysis of the six critical areas sampled examining taxonomic dissimilarity (β-diversity) among locations. ▼ represents sites south of Penobscot Bay. ▲ represents sites north of Penobscot Bay.

A



B

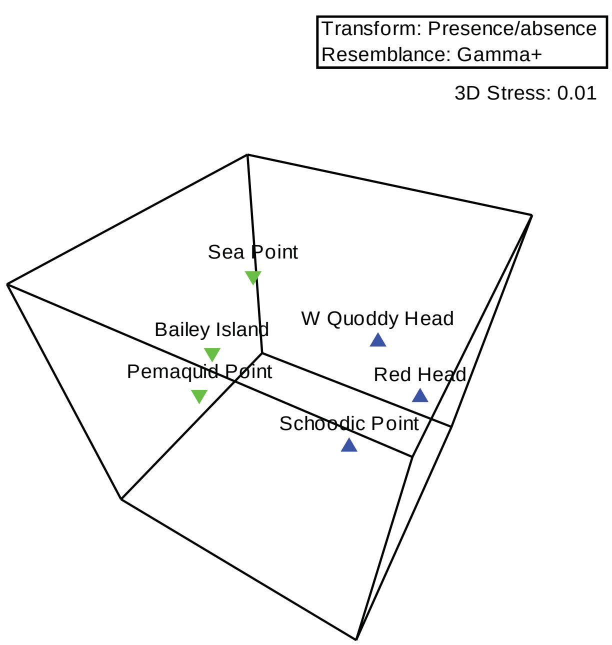


Figure 9. Average taxonomic distinctness (AvTD) for the locations south (A) and north (B) of Penobscot Bay plotted against their species list size. Lines forming the funnel represent the 95 per cent confidence intervals of AvTD simulated from historical species lists. The dotted line represents the average value of AvTD from the historical species lists.

A

B

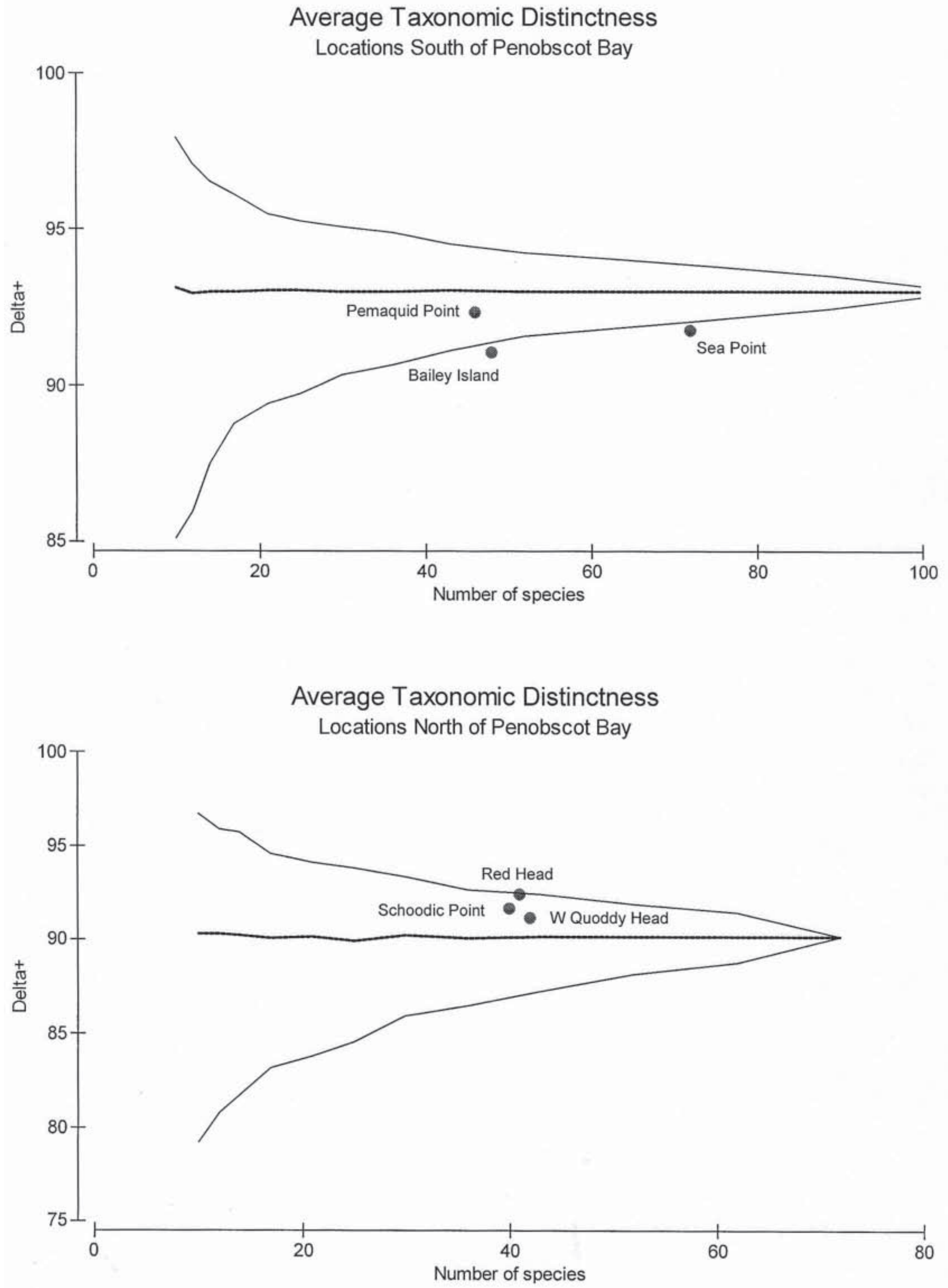
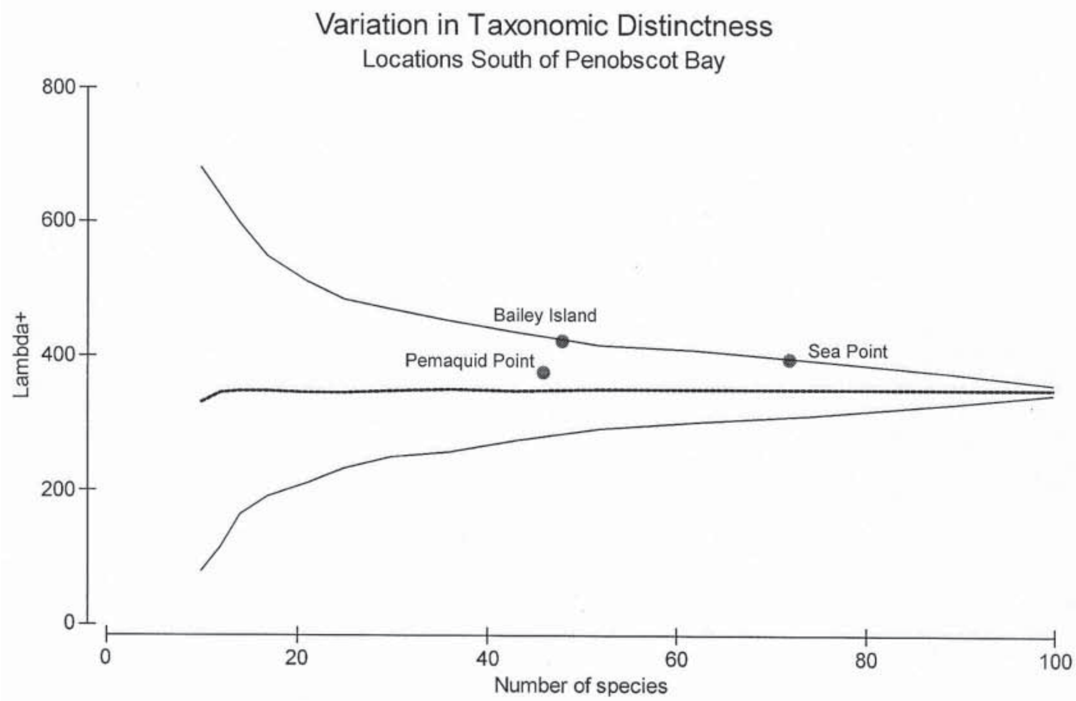
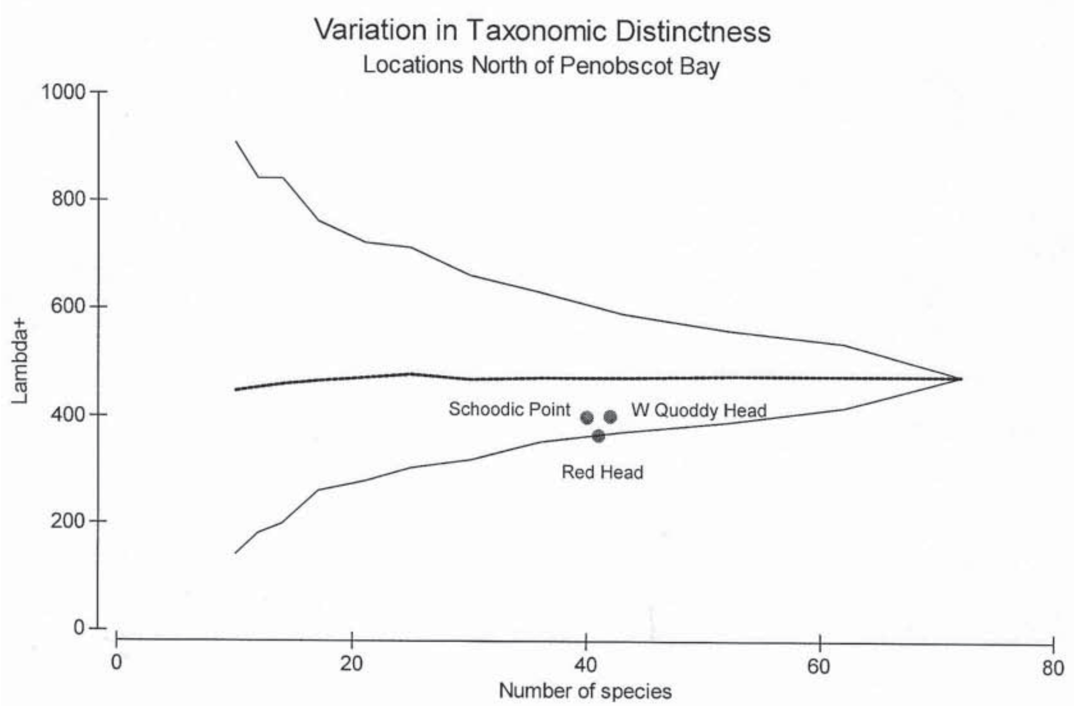


Figure 10. Variation in taxonomic distinctness (VarTD) for locations south (A) and north (B) of Penobscot Bay plotted against their species list size. Lines forming the funnel represent the 95 per cent confidence intervals of VarTD simulated form historical species lists. The dotted line represents the average value of VarTD from the historical species lists.

A



B



steep temperature gradients. These create a third faunistic group in the Penobscot Bay region delineated by southern and northern boundaries in the vicinity of the Sheepscot River and Mount Desert/Jonesport area, respectively (Larsen and Doggett 1990).

The zoogeographic dichotomy of coastal Maine rocky intertidal species assemblages coincides with the two principal branches of the Gulf of Maine Coastal Current (Lynch et al. 1997; Pettigrew et al. 2005). These are the Eastern Maine Coastal Current (EMCC) that flows along eastern Maine to Penobscot Bay where it is deflected to a variable degree offshore and the Western Maine Coastal Current (WMCC) that flows westward from Penobscot Bay to Massachusetts Bay. The extent of separation between these branches is variable; its strength dependent on how much of the EMCC veers offshore (Pettigrew et al. 2005). The two currents differ in temperature, speed and structure which contribute additionally to their distinctness, most defined in the spring and summer (Lynch et al. 1997). The EMCC is a colder, faster current well mixed out to 50 m depth while the WMCC is warmer, slow surface current consisting primarily of a trapped plume of fresh water flowing from the Kennebec River (Hetland and Signell 2005; Pettigrew et al. 2005).

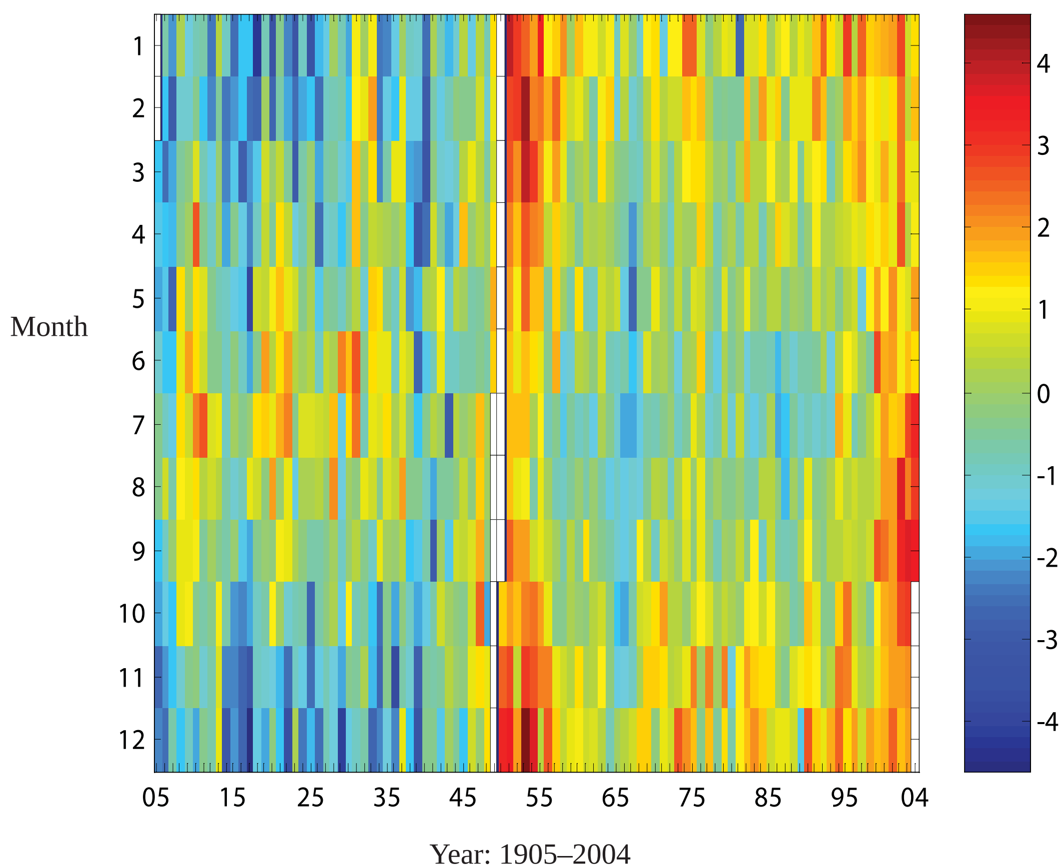
The region where the EMCC and WMCC diverge could represent a variable oceanographic barrier which, in addition to the speed, structure, and temperature differences of the currents, account for the faunistic break observed at Penobscot Bay. Geological differences between the eastern and western coastlines which influence habitat types also may reinforce the discontinuity (Caldwell 1998). Nearshore processes structuring communities of species that have life histories with larval dispersal are connected to offshore physical oceanography of the Gulf of Maine (Brooks and Townsend 1989). Transport of phytoplankton and larvae, and the resulting distribution of blooms and settlement along the coast of Maine, have been linked to the split between the EMCC and WMCC (Incze and Naime 2000; Townsend et al. 2005). Ultimately, the final transport of larvae to benthic habitats is strongly influenced by very nearshore coastal oceanography, and fronts created by nearshore flow patterns affect recruitment in the intertidal zone (Shanks et al. 2003; McCulloch and Shanks 2003). Because the strength of divergence between the two coastal currents is variable, the strength of an oceanographic barrier would vary likewise, and could account for the southern extension of some coldwater species as far south as Long Island and beyond (Bousfield and Laubitz 1972). In this region, patterns of distribution along the southern Maine coast must also be influenced by wind-driven coastal upwelling and its cooling affects on surface sea water temperature (Yentsch and Garfield 1981).

Differences in average and total phylogenetic diversity paralleled closely the number of species (S) found at each site (Table 2) and demonstrates how both of these metrics of diversity are dependent on S in their calculation. In contrast, average taxonomic distinctness was not related to differences in habitat or number of species. For example, the mostly bedrock Schoodic Point and boulder/cobble Sea Point are roughly similar in AvTD (Table 2). The independence of AvTD from S (Clarke and Warwick 1998a) is evident from comparing Schoodic Point and Sea Point (Table 2). The number of species found was very different yet these locations have roughly similar AvTD. Variation in taxonomic distinctness is also independent from sampling effort.

The causes of reduced average taxonomic distinctness at Sea Point and Bailey Island can be many and all are speculative. Anthropogenic disturbance can decrease species diversity, sometimes through salient affects. Sediment redistribution from harvesting commercial species has been implicated as the cause for a qualitative faunal shift from hard bottom to soft bottom species over a span of 30 years (Trott 2004). Environmental degradation decreases average taxonomic distinctness by creating communities with more closely related species (Clarke and Warwick 2001). For example, organic enrichment from salmon mariculture can result in decreased diversity with some closely related taxa, *Nucula proxima* and *N. delphinodonta*, increasing in abundance (Pohle et al. 2001). The possibility that anthropogenic disturbance could have caused the change at Sea Point and Bailey Island was investigated by comparing archived field evaluations and photographs with those made during this study. Neither of the critical areas appeared to have changed in a way that was noticeable. Natural disturbance from large storms and heavy sea ice could result in shifts of community composition and taxonomic distinctness. Since community structure is being compared across only two points in time separated by 28 years, identifying responsible disturbances is not possible.

Attributing a single cause for change in the taxonomic structure of the species assemblages may not be realistic, but temperature variability stands out for reasons previously discussed as a likely candidate that acted alone or in combination with other factors. Surface sea water temperatures at Boothbay Harbor, Maine recorded by the Department of Marine Resources have increased since 1952, particularly during the winter months (Figure 11). If this warming trend has occurred further south, community composition may have changed as cold water species were lost. While more species were found during the present study at most sample sites, greater sampling

Figure 11. Boothbay Harbor (43.84º N, 69.64º W) Monthly surface sea water temperature anomaly 1905 – 2004. Anomaly °C is the deviation from 20th century mean, 1905-1999. Data after September 2004 not plotted and other missing data (1950-51), both in white. Note the trends of warmer summers in first half of time-series, warm throughout the year in early 1950s and again beginning 2000. Then from the early 1970s to late 1990s, the warming trend was expressed mostly during winter months. (Figure courtesy of Lew Incze)



effort is the likely cause for greater species richness than evidence countering the temperature hypothesis for change in taxonomic distinctness. Community composition examined at taxonomic levels lower than phyla may better reveal changes caused by a warming trend. Only one cold water species in the echinoderm genus *Psolus* was documented in 1959 at Sea Point but not in 1960, 1962, 1964, 1971–73, and the present study. Since no other documented cold water species are absent from either Sea Point or Bailey Island assemblages, the idea that warming temperatures restructured taxonomic relationships of intertidal species is speculative.

General Conclusions

1. A faunistic break occurs in the vicinity of Penobscot Bay, creating a zoogeographic dichotomy with southern intertidal communities significantly different from those to the north. This conclusion is supported both by similarities of species composition and taxonomic dissimilarity.
2. Diversity measured as average taxonomic distinctness, a measure of diversity based on the structure of the classification of species in a community, was determined for six intertidal locations distributed across the length of the Maine coast.
3. Average taxonomic distinctness at Sea Point and Bailey Island has changed significantly from baselines established approximately 30 years ago.
4. Variation in taxonomic distinctness, a metric for the taxonomic evenness of a community, has not changed significantly for all locations from baselines established approximately 30 years ago.
5. The causes for changes in diversity are probably multifaceted, interactive, biotic and abiotic factors, making a simple overarching explanation unlikely. However, warming sea water temperature could be one cause which acting alone or in combination with others influenced a change in species assemblages at the two most southern Maine sample sites.

Acknowledgements

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RE-EVALUATION OF SIGNIFICANT AREAS IDENTIFIED IN THE BAY OF FUNDY: NEW CRITERIA, DIFFERENT PICTURE?

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Previously, information gathered from the scientific literature, or from experts and community members, identified a subset of marine and coastal areas reviewed for the Bay of Fundy as sensitive. The criteria used included those for the selection of marine protected areas (Canada's *Oceans Act*) and those used for protecting and managing marine resources (International Union for the Conservation of Nature), as well as additional ecological criteria. Many of the areas reviewed had direct references to suggest their sensitivity to disturbance, their ecological importance, their species-specific importance, their high biodiversity, or the reference specifically called for its protection.

An Ecosystem Overview and Assessment Report (EOAR) for the Bay of Fundy fulfills a portion of the first step in the Integrated Management process, and one of its main purposes is to identify areas that warrant further attention within the IM planning, key areas for further study, management intervention, or protection. The EOAR should include, among others, areas that have special characteristics because of their ecological significance, existing conservation areas, and areas that should not be jeopardized. For this, the Department of Fisheries and Oceans has recently developed criteria for Ecologically and Biologically Significant Areas (EBSAs) that provide a defined and potentially quantifiable method for assessment of areas.

Several criteria for identifying EBSAs overlap with those previously used in assessment of areas in the Bay of Fundy, while others are not part of that assessment. This paper compares the previous evaluation of areas with that of the new EBSA criteria, and identifies the next steps required to fulfill their assessment as part of an Ecosystem Overview and Assessment Report for the Bay of Fundy.

INTERNAL WAVES MEDIATE TROPHIC RELATIONSHIPS AND BIODIVERSITY ON A SMALL OFFSHORE BANK

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In July 2005 we used airplane surveys to identify and assess populations of upper trophic level predators, and a small research vessel to investigate predator behaviors and concurrent oceanographic conditions and prey distributions at a small offshore bank, Platts Bank, in the southwestern Gulf of Maine. In this talk we focus on the relationship between the feeding of humpback whales (*Megaptera novaeangliae*); their primary prey during this period, the euphausiid *Meganyctiphanes norvegica*; and hydrodynamic processes that appear to be responsible for small to medium-scale patchiness of the euphausiids. The distribution of feeding humpbacks on the bank is highly localized and regular and is focused on two crests of similar depth but different morphometry. On the northern crest of the bank, euphausiid swarms appear to be associated with the internal wave field, which is either impinging on or is generated by the steeply shoaling bathymetry of the crest. Dense surface patches of euphausiids give rise to bursts of intense feeding activity by whales and herring (*Clupea harengus*). On the southern crest, less than seven kilometers away, shallow but subsurface feeding seems to predominate. We discuss the coupling of physical and biological processes that result in these different, locally intense and diverse trophic interactions and the role of small banks in the populations of migrating predators in the Gulf of Maine.

AN INITIATIVE TO DNA BARCODE FISHES OF THE CANADIAN ATLANTIC

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Because of their high diversity and profound changes in appearance during development, fish identification in the laboratory is not an easy task. Outside the lab there are socially relevant identification questions concerning market substitution and quota management of commercial fisheries. An alternative to traditional morphological identification is DNA barcoding, a technique that uses a short gene sequence from a standardized region of the genome as a diagnostic "biomarker", or barcode, for species. The Consortium for the Barcode of Life is an international initiative devoted to developing and coordinating DNA barcoding as a global standard in taxonomy. The Canadian Centre for DNA Barcoding (located at the University of Guelph) is a consortium member leading Canadian contributions to the initiative. One such contribution is the FISH-BOL program which is gathering barcodes for all the world's fishes, with an emphasis on the 15,000 marine species. Under this program the Dalhousie Gene Probe Laboratory, the Bedford Institute of Oceanography, and the Huntsman Marine Science Centre are collaborating in a five year project to barcode the approximately 880 species of Canadian Atlantic fishes. This project will develop key recommendations regarding data policy and standards for molecular data for the national DFO Management Policy for Scientific Data.

Session Four

CLIMATE CHANGE AND ADAPTATION

Chairs: Gary Lines, Environment Canada, Dartmouth, Nova Scotia

and

Kim Hughes, New Brunswick Department of the Environment, Fredericton, New Brunswick

Session Four Summary

Gary Lines and Kim Hughes, Rapporteurs

Highlights from the papers presented in this session are as follows:

1. Charles O'Reilly talked about the Atlantic Storm Surge and Tsunami Warning System. He described the natural coastal hazard warning system that is in place for the east coast:

   a) There is a very low probability of a tsunami event on the east coast (though it has occurred before such as on the Burin Peninsula in 1929); it is more likely that a seismic event will lead to a rise in sea level and a storm surge.

   b) There is value in better ocean mapping.

   c) The time to event is critical—how does notification occur?

   d) Which shoreline do you protect?

   e) Are you ready—there should be disaster plans for coastal communities (NOAA has a certification program).

   f) The sea level variable (i.e. climate change effects) affects the model predicting surges.

2. Points raised on development of a real-time water level (RTWL) system for Atlantic Canada, include:

   a) There is a need for sensors and gauges.

   b) There is a tidal model and a storm surge model, but who uses the information output from these?

   c) Tide gauges, and long-term tsunami and storm surge early detection, are very important.

   d) Tidal predictions (and tide tables) require "truthing"—what is the level that predictions are based upon?

3. Two papers were presented on climate change in the Gulf of Maine region (GOM). The following points were made:

   a) There is representation of local effects, often driven by local interests.

   b) In the region, the average winter temperature has increased by 2.4^{o}C between 1900–2000, mostly over the past 30 years (1970–2000, based on data comparing Boston to Halifax, and Philadelphia to Boston). Annual precipitation has increased two per cent globally but 12 per cent in the GOM region. There are examples of extreme precipitation.

   c) Snowfall has generally decreased since 1970; snow on the ground (length of time) has declined. Spring runoff is earlier, ice thaws earlier, and sea level has risen approximately 30 centimetres in the past 100 years.

   d) What are the climate data saying? The October 2005 C-CIARN workshop report and two reports released at the fall 2006 GOMC meetings (see www.gulfofmainecouncil.org) discuss this.

   e) For water management issues such as source water protection and knowledge of local climate, the focus is on First Nations and their needs in the region.

4. The session concluded with a discussion on sea surface temperature changes and biogeographic ranges of commercial marine species.

ATLANTIC STORM SURGE AND TSUNAMI WARNING SYSTEM

Charles T. O'Reilly[1], Phillip N. MacAulay[1] and George S. Parkes[2]

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Storm surges and tsunamis are serious issues for coastal zones. Real-time forecasting and alert systems can prevent loss of life and mitigate the damage caused by these hazards. Canada and the United States have recently undertaken interim measures to develop an enhanced capacity for early warning of surges and tsunamis in the Atlantic. Part of this effort includes dissemination of high frequency sampled and polled water levels in real-time.

Tsunami forecasting is initiated through monitoring seismic events. It also requires a priori modeling of tsunami propagation. However, for confirmation of earliest arrivals and amplitude estimation at anticipated arrival sites, decision makers must have immediate access to real-time data. In Atlantic Canada, corroboration of projected extreme water levels is now available through the Permanent Water Level Network.

Future development of coastal management practices, risk reduction measures and design of mitigation strategies require geo-scientific and climatological knowledge in order to better estimate flood probabilities under changing rates of sea-level rise and, in the case of storm surges, the possible effects of a warming climate. Furthermore, they require adequate understanding of vertical land/sea datums and realistic mapping of hazard zones. Determination of the potential for coastal flooding in areas of high vulnerability is a key element of any alert system.

The coastline can no longer be considered as a line on paper, but should be understood as a 3-D landform subject to physical processes. Airborne laser altimetry allows the development of high-resolution digital elevation models of low-lying, flood-prone terrain to support risk reduction and hazard mitigation.

DEVELOPING A REAL-TIME WATER LEVEL (RTWL) SYSTEM FOR ATLANTIC CANADA

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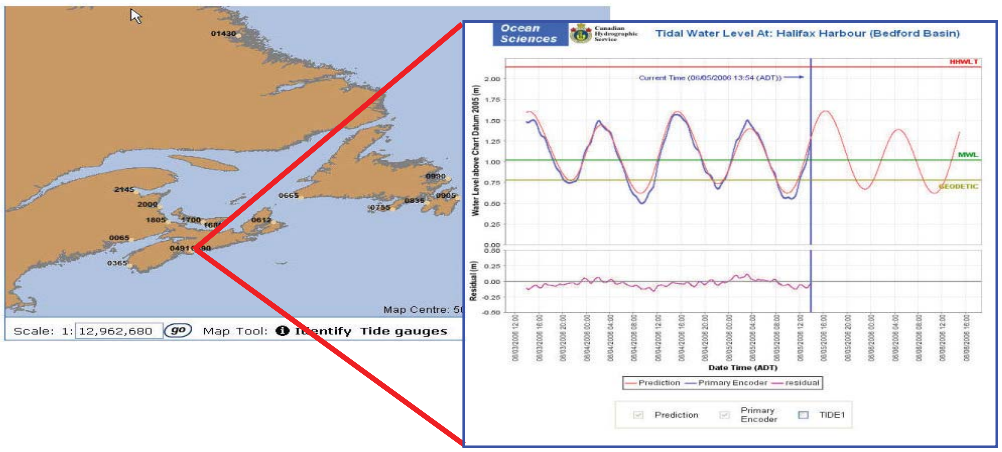


In Canada, the Canadian Hydrographic Service (CHS) is responsible for the collection of water level data and the publication of water level predictions. Shipping and navigation interests have long been well served by these basic CHS water level activities. However, over recent years it has become increasingly clear that water level observations, predictions and "now" forecasting can and will serve a wider clientele. In response, CHS has initiated a set of regional Permanent Water Level Network (PWLN) revitalization programs. This article outlines CHS Atlantic's efforts to update its systems and activities to provide the appropriate level of services now expected by both existing and new water level interests. Particular attention will be given to the recent developments of CHS Atlantic's data acquisition, management and dissemination systems that were required in order to provide timely water level data to the new Interim Atlantic Tsunami / Storm Surge Warning System.

The Atlantic PWLN Network

CHS Atlantic's PWLN consists of 16 operational tide gauge stations (Figure 1). Three sites have been designated as long-term sea level stations of the Global Sea Level Observing System (GLOSS) and six have been designated as storm surge stations (based on the frequency and severity of storm surges). Most recently, six others have been assigned duty as tsunami warning stations because the combination of their locations and the bathymetry of the continental shelf conspire to make them first strike points for tsunamis propagating into Atlantic Canadian waters from various deep water directions.

Prior to CHS Atlantic's recent revitalization program, each station in the PWLN consisted of: i) a gauge hut (or box shelter for those stations with only temporary status); ii) a connection to line power plus battery backup; iii) a local telephone connection; iv) one or more stilling wells; v) a reference tape drop; vi) a Sutron 8210 data-logger; vii) a primary water level sensor (rotary encoder with float and pulley); and viii) a backup pressure or bubbler sensor (see Figure 2).

Until recently, water level data was acquired and logged every 15 minutes at each site and all stations were polled once a day for their data via modem by the Marine Environmental Data Service (MEDS). In this system, MEDS also conducted primary quality control and provided the majority of water level data to interested clients. It was also possible for anyone with a modem to download data directly from any of the tide gauge stations. If and when problems with water level data arose, CHS tidal personnel were contacted and would troubleshoot the affected gauge(s), and if necessary, dispatch a repair team at the earliest feasible opportunity. They would also, as part of normal CHS activities, and often upon ad-hoc demand, independently provide quality assurance of water level data.

In the past, delays of hours, days or even weeks between the collection and dissemination of water level data frequently occurred. These delays were acceptable for basic tidal analysis, traditional hydrographic survey work and for long-term sea level monitoring purposes. However, new water level missions pertaining to storm surge, tsunami warning systems and harbour clearances, require more timely data collection, primary quality control and data dissemination. In other words, these applications require quality assured data available in 'real-time', i.e. within the last few minutes. For example, to meet the needs of the new Interim Atlantic Tsunami Warning System, CHS Atlantic must be able to collect, quality-assure and deliver accurate water level data within 10 minutes of the present. In addition, this data must be available to geographically distant emergency measures organizations, such as Environment Canada's Atlantic Storm Prediction Center (ASPC) and the Alaska Tsunami Warning Center (ATWC) in Palmer, Alaska.

Figure 1. CHS Atlantic's PWLN

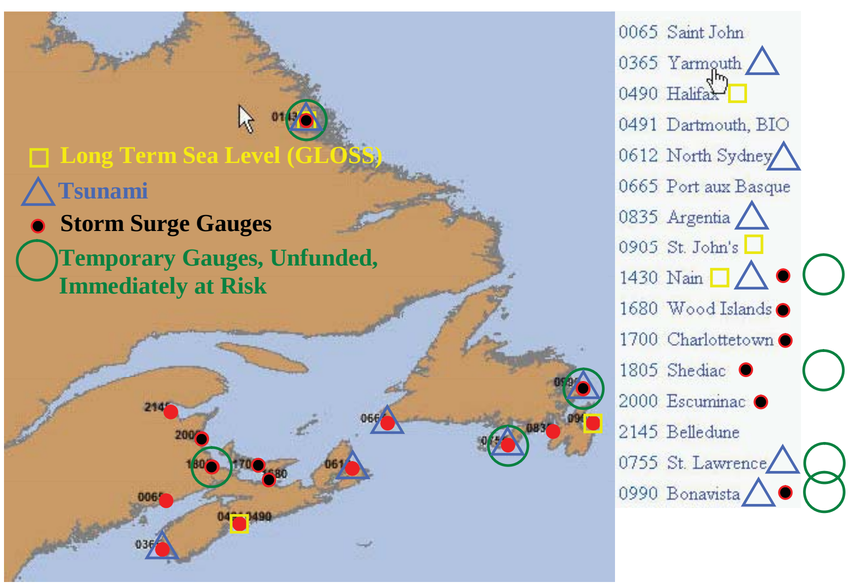
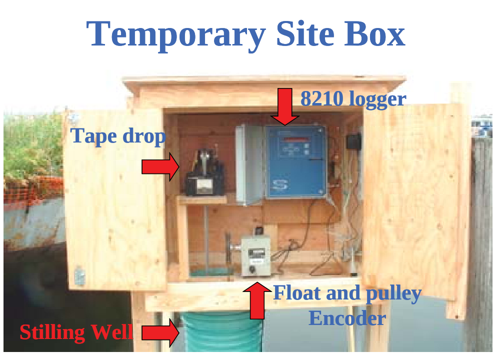


Figure 2. Temporary and permanent gauge stations



Examples of Contemporary Real-time Water Level Systems

In the Atlantic Region, a minimal system for delivery of real-time water levels to single users had long been available from some gauges based on a "talking tide gauge." The client would phone up the gauge and receive the latest water level observation and perhaps, some recent water level statistics. However, this system only provided a verbal 'now' measurement and only one user could access any one gauge at a time. Quebec's more capable telephone SERVOX system is similar in concept, except that it is based on centralized data collection and a computer controlled database attached to multiple call-in phone lines. But again, data content is limited. Refer: (http://www.waterlevels.gc.ca/english/WaterLevelsAtYourFingerTips.shtml).

Quebec's SINECO system is an example of a more sophisticated strategy (http://tides-marees.gc.ca/english/DataAvailable.shtml). SINECO provides quality assured, real-time water level observation time-series at multiple water level stations simultaneously. It also compares these observations with water level predictions and with forecasts generated using a numerical hydrodynamic model of the St. Lawrence estuary. Although a very capable system, in its current configuration, SINECO is not easily transportable as it was developed as a cost-recovery solution designed to serve shipping and navigation interests and requires proprietary licensed software at the user end. However, in recent months, 15 minute real-time water level data has been made publicly available from Quebec's water level gauges on the St. Lawrence through the DFO Tides, Currents and Water Levels Web site. Refer: http://www.waterlevels.gc.ca/english/Canada.shtml).

Similarly, the CHS Central and Arctic Region Web site http://biachss.car.dfo-mpo.gc.ca/danp/gs_selection_e.html, and the CHS Pacific Region Web site http://www-sci.pac.dfo-mpo.gc.ca/charts/Tides/OWL/OWL_e.htm provide free Internet-based water level data access. However, neither of the last two systems at present provides real-time water level data.

Other nations have developed (or are developing) free Internet-based applications that provide real-time or near real-time water level data. For example, the United States has the National Oceanographic and Atmospheric Administration's (NOAA) Tides and Currents Web site http://tidesandcurrents.noaa.gov/ and its associated Physical Oceanographic Real-Time System (PORTS Web site http://tidesandcurrents.noaa.gov/ports.html. The UK has developed Internet access to water level data through the National Tidal and Sea Level Facility (NTSLF) Web site http://www.pol.ac.uk/ntslf/networks.html. In Europe similar services are available through the European Sea Level Service (ESEAS) Web site http://www.eseas.org/products/?page=real_time_data and the Monitoring

Network System for Systematic Sea Level Measurements in the Mediterranean and Black Sea (MedGLOSS) Web site http://medgloss.ocean.org.il/.

Although there were many example systems available to provide guidance, the challenge for CHS Atlantic was not only to develop its own real-time system, but to do so in just several months. This required, at least initially, making use of as much existing infrastructure as possible.

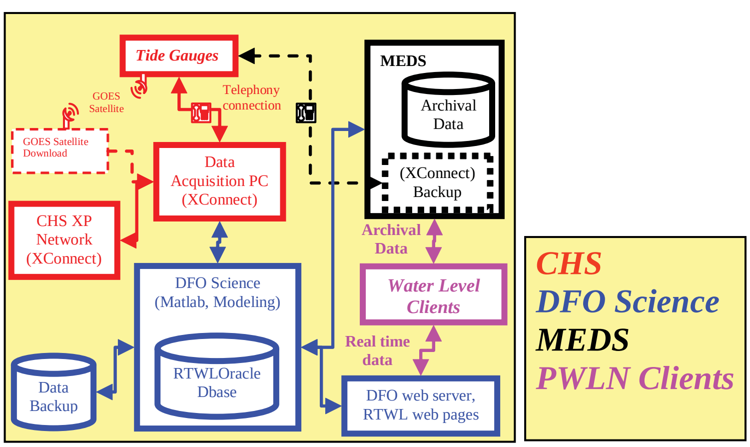
CHS Atlantic's Real-Time Water Level Solution

Figure 3 shows a schematic of the basic elements of CHS Atlantic's Real Time Water Level (RTWL) solution. The system is inter-departmental and collaborative and has made use of existing Department of Fisheries and Oceans (DFO) infrastructure in both CHS and Ocean Sciences Atlantic as much as possible. In the figure, red identifies new and pre-existing CHS Atlantic elements, blue pre-existing DFO systems, and black pre-existing and future potential elements (dotted) at MEDS.

CHS Atlantic chose to use Sutron's XConnect software for initial data acquisition because it was a commercial turn-key system and it possessed all the necessary data acquisition and basic data management requirements. Most importantly it could be quickly interfaced to all of CHS Atlantic's existing Sutron 8210 tide gauge equipment. In the Atlantic RTWL solution, once data is acquired and downloaded from the gauges using XConnect, it is immediately piped to a RTWL database attached to DFO Science's Oracle database sever.

Although the XConnect software has quality control and Web-based data presentation modules, CHS Atlantic has chosen not to employ them. Access to the real-time water level data is instead provided through password protected Web pages on Bluefin, an Atlantic DFO Science Web server. Gauge stations are selected using an Environmental Systems Research Institute (ESRI) Map interface (see this document's preliminary figure) and data is displayed using in-house written SQL and Java routines (by Kohila Thana, DFO Science Informatics). In this way, CHS Atlantic has more comprehensive and flexible control over how water level data and value added content is presented.

Figure 3. CHS Atlantic's RTWL solution



At present the RTWL Web pages have only been made available to selected emergency measures water level clients. However, some form of public free access to Atlantic RTWL data is planned. As previously indicated, a system providing 15 minute observations already exists for the Quebec water level stations. Nonetheless, water level clients should expect to continue to obtain the bulk of their archival data from MEDS.

Under the new system, only CHS Atlantic has direct access to its tide gauge stations, which are all password protected. Unfortunately, the new Atlantic system presently has no data acquisition redundancy, although a backup capacity is contemplated at MEDS (Figure 3, dotted in black).

To meet the needs of the Interim Atlantic Tsunami Warning System, water levels at PWLN stations are now measured every 10 seconds, averaged and logged every 1 minute, and new data is uploaded to the RTWL database, and available to the Web pages every 10 minutes. Thus, 1 minute water level data is now available on the Web, up-to-date and on average, to within 5 minutes of the present.

Web Page Presentation of Atlantic RTWL data

Figures 4 shows RTWL data from the gauge station at Halifax as presented (following tide gauge station selection via the ESRI map interface) by the RTWL emergency measures Web pages. Data from the primary encoder is compared to water level predictions in the top panel. Below is the residual i.e. observations-predictions. The vertical blue line in both panels shows the time the data was requested i.e. the present time. Two tidal datums, Higher High Water Large Tide (HHWLT) and Mean Water Level (MWL), and a GEODETIC reference are included in the upper panel. HHWLT is loosely representative of the flood level threshold.

At the user's discretion, data from additional sensors may be added to the graphs using the dialog box below the legend i.e. selection of TIDE1. In addition, the user may also opt to: i) alter the time range of data displayed from up to 2 months into the past to up to 1 month into the future; ii) change the time zone for data display; or iii) download data and predictions in either 1, 5, 15 or 60 minute interval formats.

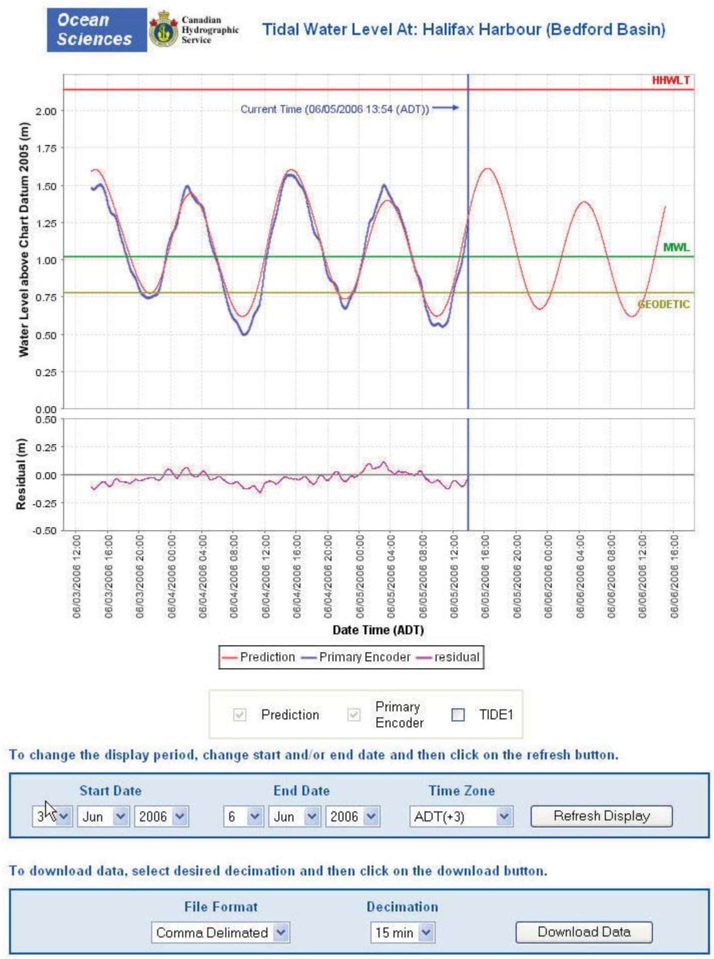
Revitalization of Atlantic PWLN Infrastructure

As part of its water level revitalization program, CHS Atlantic is in the process of installing a full compliment of: i) new Sutron Xpert dataloggers to replace the existing aging 8210s, and ii) new Sutron rapid sampling bubbler sensors to act as the secondary sensors at each gauge site. It is also testing new Esterline 550 pressure sensors. When installation is complete, each PWLN station will have an Xpert datalogger and three independent water level sensors: an encoder float and pulley, a bubbler, and a pressure sensor.

The new 550 pressure sensors are noteworthy because they simultaneously output data and log it internally. They also have onboard battery backup power available in the case of data acquisition system power failure. These units have been installed in their own small protective wells (with minimal stilling) at tsunami designated stations (see Figure 1). Because all gauge huts and boxes are located within a few metres of HHWLT, a tsunami or storm surge of appreciable size can flood them. This could result in either failure of the primary encoder and secondary bubbler, and/or failure of the station's datalogger. In such an event the 550 pressure sensors should still continue to log internally. Thus, assuming the physical structure to which the hut is attached survives, and the pressure sensor can be recovered, a record of the event may still be available.

CHS Atlantic has also acquired Sutron Satlink Geostationary Operational Environmental Satellites (GOES) hardware. These units are intended to be used as backup communications systems at storm surge and tsunami warning gauge stations. However, their installation awaits the necessary funding and the appropriate permission from the NOAA, GOES DCS authorities for the required data transmission cycle. For the GOES systems to be functional in a real-time emergency measures sense, a ten minute GOES report timing permission is necessary.

Figure 4. RTWL Observations from Halifax



New Atlantic RTWL System Initiatives

Two interrelated projects to incorporate Real Time Quality Control (RTQC) and model generated water level forecasts into CHS Atlantic's RTWL solution are also underway. Both should be implemented in the spring of 2007. Automated 24/7 RTQC is necessary to provide both RTWL clients and CHS personnel with a measure of primary data quality assurance. Incorporation of water level forecasts into the Atlantic RTWL system will provide water level clients with some warning of upcoming, weather generated, water level variability, and will provide an opportunity for increased measures of quality assurance.

Atlantic's RTQC will include: i) initial data cleaning and removal of data spikes; ii) inter-comparison of data streams from all three sensors; iii) comparison of water level data with predictions; iv) comparison of water level data with water level forecasts derived from the meteorologically driven shelf-scale Dalcoast II model, through an arrangement with Dr. Keith Thompson, Dalhousie University, Department of Oceanography (Web sites http://www.phys.ocean.dal.ca/people/po/Thompson/Thompson_Keith.html, http://www.phys.ocean.dal.ca/~dalcoast/Dalcoast1/exper/index.html); and potentially v) tsunami detection algorithms.

As indicated earlier, the XConnect software does have some quality assurance capability. However, to permit greater flexibility and to employ a wide range of real-time, time-series analysis techniques, CHS Atlantic has linked the RTWL database to the technical computing software MATLAB using MATLAB's database toolbox. MATLAB is commonly used in engineering and scientific institutions and was already available to CHS Atlantic via DFO Science at the Bedford Institute of Oceanography.

A Proposed RTWL System Enhancement

Tsunami warnings are initiated based on seismic activity, but only direct observations of the wave itself confirms the existence and magnitude of a tsunami. The Atlantic RTWL solution is unfortunately limited from a tsunami warning perspective. It will only provide observational based warning/verification on a sacrificial basis. That is, the first tsunami land arrival site is sacrificed for the benefit of the rest. Under this system, little useful warning can be achieved for nearby areas. If the wave is large enough to take down the first landfall station, then no wave amplitude information will be available for assessment of the likely impact at future landfall locations. Finally, because the wave has already reached land, little opportunity for impact assessment prior to wave landfall at other locations can be achieved, including the socio-economic benefits that might be available from the ability to 'stand down' or reduce warning levels based on the observation that an approaching wave is of limited amplitude.

To address these limitations, CHS Atlantic proposes an offshore observation-based early tsunami detection and warning solution based on installation of downward looking radar water level gauges situated on the production platforms at both the Sable Island and Hibernia oil and gas fields (Figure 5). Initial communications with Exxon-Mobil suggest they are amenable to the idea.

Gauges at these locations would provide early detection/verification of wave amplitude at a minimum of 1-2 hours before landfall. Dr. Zhigang Zu at the Institut Maurice-Lamontagne (IML) has developed a prototype, Green's function based, numerical tsunami prediction methodology (publication in prep) that, once given the seismic source location and an observed wave amplitude time-series (in this case, data from Sable or Hibernia), can provide estimates within seconds of the resulting wave height time-series at any number of selected landfall sites. CHS Atlantic regards Dr. Zu's methods, combined with offshore observations, as a significant improvement on the existing role played in the Interim Atlantic Tsunami Warning System by the present RTWL solution.

Figure 6 shows storm surges caused by a winter storm at Shediac, New Brunswick, and St. Lawrence, Newfoundland, in early February 2006. The graphs show that the 1+ metre surge at Shediac and the near one metre surge at St. Lawrence, both raised water levels significantly above the local HHWLT datums. Local flooding is likely to have occurred. It is the combination of the storm surge and a high spring tide that most often results in flooding, particularly in regions with low tidal ranges.

Figure 5. Proposed offshore early warning gauge sites

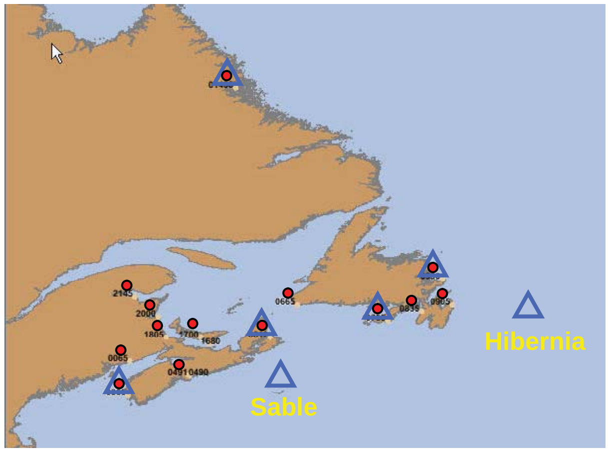


Figure 6. Storm surges at Shediac, NB, and St. Lawrence, NL, February 1, 2006 (15 min. sampling)

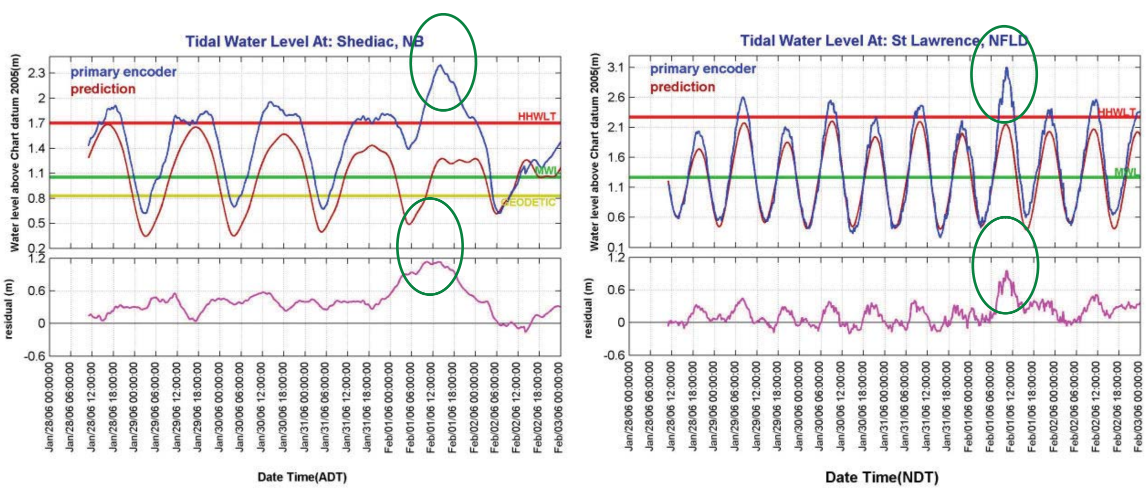
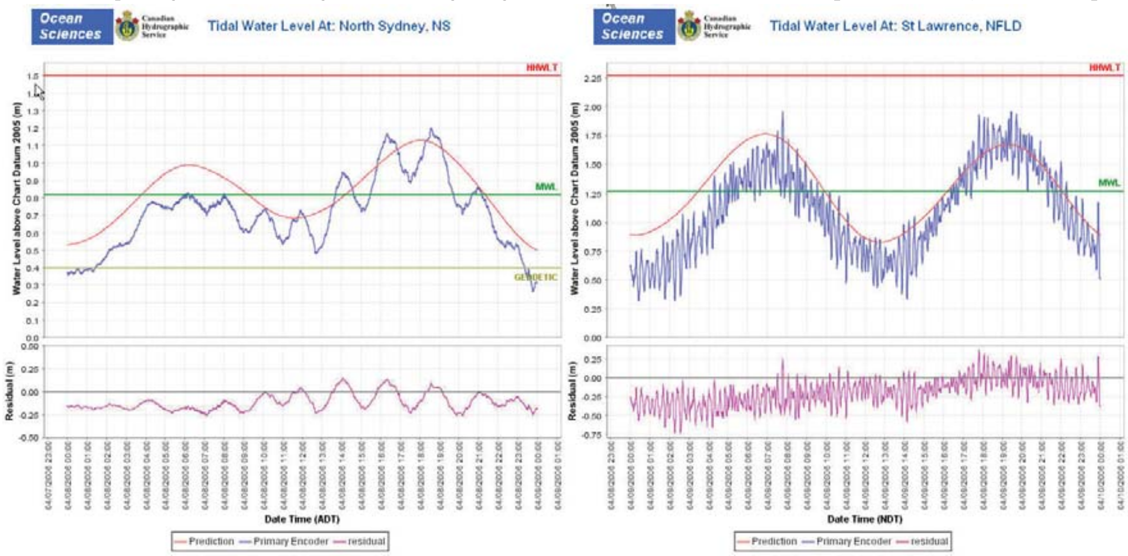


Figure 7. Low frequency wave activity at North Sydney, NS, and St Lawrence, NL, April 8, 2006 (1 min. sampling)



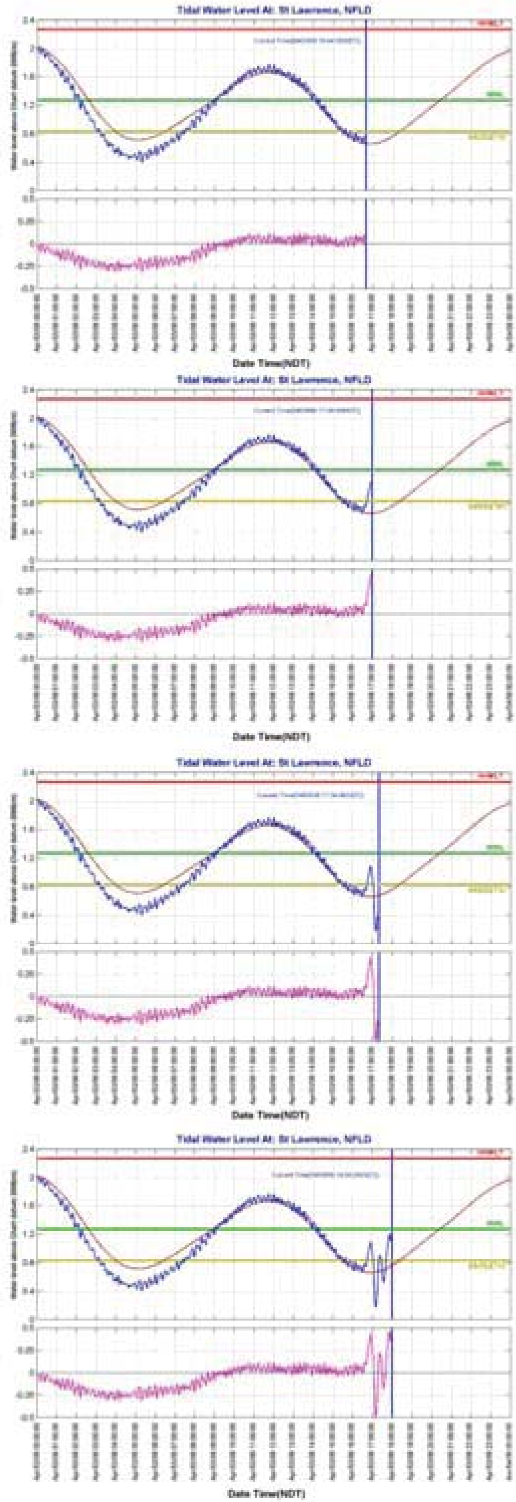
The RTWL System in Action

The implications of the increase in temporal resolution realized by the switch from 15 to 1 minute sampling are clearly shown in the right panel of Figure 7 when compared with the right panel of Figure 6 (both show data from St. Lawrence, NFLD). Low frequency (infra-gravity) wave activity is clearly present in the 1 minute data of Figure 7, but similar activity is under-resolved in the 15 minute data of Figure 6. St. Lawrence often displays strong seiches at near 17 minute periods, a fact that was not apparent in earlier 15 minute data sets. Many Atlantic harbours display similar behavior. The left panel of Figure 7 shows North Sydney's seiche at about 2+ hour period. Both observations of seiches agree well with theory based on harbour dimensions and average depths. During stormy conditions with strong infra-gravity forcing, seiche amplitudes (peak to peak) have been observed to reach nearly 1 metre. In some cases, these seiches, like storm surges, combined with high tide have resulted in local flooding. An implication for tsunami warning emergency measures personnel is that during stormy conditions, they must be able to distinguish between a seiche and the arrival of a tsunami of similar amplitude.

Figure 8 presents a time-series of images simulating the arrival of a 0.5 m amplitude tsunami at St. Lawrence, NL. The first 6 images (left to right then down) are presented with 10 minute spacing (recall that 10 minutes is the new station upload period). The last 2 images show wave arrival over the following 2 hrs. This is how emergency measures decision makers will be presented with observations of a tsunami arrival through time. The incoming waveform (a scaled-down version of a simulated wave from the 1929 Burin Tsunami, courtesy of Zhigang Zu) has about a 30 minute period. Clearly, 15 minute sampling would have significantly under-resolved the wave and might result in an additional time delay of 10 to 20 minutes before the wave could be properly identified.

A 0.5 metre tsunami at St. Lawrence could be problematic, particularly at high tide, but would be unlikely to cause catastrophic damage. However, wave amplitudes at other coastal locations could be significantly greater, particularly if the tsunami was not a local event, but had propagated in from deep water. What Figure 8 demonstrates is that a delay of at least 20-30 minutes is likely following the initial arrival of the wave front before identification and a preliminary estimate of initial wave height could be made. This shows that land based detection is unlikely to provide appreciable warning for locations along the adjacent coastline.

Figure 8. Simulation of a 0.5 m tsunami arriving at St Lawrence. The top 6 panels show how the event would appear to emergency measures personnel at ASPC and ATWC tracking its arrival, given the system's 10 minute data upload cycle (10 min. elapsed time between panels). Bottom panels present wave arrival over the following 2 hrs.



Conclusion

CHS Atlantic's Real-Time Water Level (RTWL) system is a work in progress. Much remains to be done. Implementation of Real-Time Quality Control (RTQC) and incorporation of water level forecasts incorporating weather forcing effects is underway and the results should be available in the spring of 2007. Access to Geostationary Operational Environmental Satellites (GOES) transmission windows and deployment of the GOES hardware are still pressing issues. However, RTWL access is now a reality in Atlantic Canada and CHS Atlantic has come a long way in a short time towards achieving its Permanent Water Level Network (PWLN) revitalization goals.

Acknowledgments

We would like to thank many individuals who have played significant roles in development of the RTWL system—a truly collaborative effort. Particular thanks go to Dr. Savi Narayanan for direction, and for assisting with the necessary funding. To Richard MacDougall and Douglas Bancroft for their direction, to John Loder for expertise and advice on tsunami warning gauge locations, to John O'Neill and Kohila Thana for system and Web design, to Douglas Gregory and Richard Eisner for providing the Web infrastructure necessary for quick development of the RTWL Web pages, to Mike Ruxton, Craig Wright, Larry Norton and Mark McCracken for Geomatics IT assistance, to Dave Blaney, Chris Coolen and Fred Carmichael for extensive field work, and to other CHS personnel who have at times provided assistance and advice.

CLIMATE CHANGE INDICATORS FOR THE GULF OF MAINE

Cameron Wake[1], Elizabeth Burakowski[1], Kyle McKenzie[2], Gary Lines[2], Thomas Huntington[3], and Bill Burtis[4]

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Ecosystem and resource management has become much more complex since managers have identified the need to incorporate information concerning climate change into their decision-making processes. To aid in understanding the potential impacts of climate change on ecosystems and resources, indicators of climate change are being identified and developed.

This ‘indicator’ approach to monitoring climate change offers several advantages over more traditional approaches that only examine temperature and precipitation data:

- it offers a better sense of how global and regional climate models differ from local experiences;
- it focuses on impacts on natural processes and ecosystems (environmental change) rather than just temperature (climate change);
- people don’t notice slight changes in averages, but they do notice effects like crops ready for harvest earlier, tourists arriving earlier and staying later, and lakes freezing later and thawing earlier; and
- it is a good way of illustrating differences between short-term variation and long-term trends.

The authors, along with staff working on both sides of the Canada-U.S. border, have defined a geographical region spanning that border, with the Gulf of Maine at its heart (Figure 1). This ‘cross border region’ (CBR) was established in order to understand adjacent trends that may affect the Gulf of Maine (e.g., movement of invasive species, land-based activities, changes in land drainage, and changes in ocean circulation).

Figure 1. The northeastern United States and Canadian Maritime Provinces that make up the cross-border region (CBR) that is the focus of this report.

Approximately a dozen environmental indicators, for which phenological historical data were available, were chosen and analysed. The list includes common climate variables such as temperature and precipitation change but also indicators important to the marine environment such as sea surface temperature and sea level rise. Table 1 summarizes the indicator findings.

Table 1. Summary of indicator findings for the cross border region (CBR)

Indicator	Data Period	Finding
Average annual temperature	1900–2002	increased 0.8 ºC
Average winter temperature	1900–2002 1970–2002	increased 1.4 ºC increased 2.4 ºC
Average annual precipitation	1900–2002	increased 12%
Number of extreme precipitation events	1949–2002	increased > 10% (36 stations) decreased > 10% (8 stations)
Snowfall amount	1970–2002	decreased in northern CBR
Snow to precipitation ratio	1949–2000	decreased in New England
Days with snow on ground	1970–2002	decreased
Timing of high spring flow	(1909–1964)–2003	1–2 weeks earlier in northern CBR (most change since 1970)
River ice duration	1936–2000	decreased 20 days (mostly since 1960)
River ice out	1936–2000	11 days earlier
Lake ice out	1925–2005	4–5 days earlier in New England
Growing season	1970–2002	increased (49 stations) decreased (20 stations)
Sea level	1856–2003	increased 400 mm
Sea surface temperature	1900–2002 1970–2002	increased 0.61 ºC increased 0.21 ºC

In general, the indicator findings were consistent with observed changes in temperature and precipitation over the period and with what one would expect from a warming climate. In particular, the final three decades of data tended to show the strongest indications of a warming climate. This is consistent with an observed global warming trend that started in the 1970s and continues to this day and is likely a result of increasing greenhouse gas concentration in the atmosphere. Perhaps most importantly, it demonstrates that the cross border region is sensitive to climate change in many ways. Therefore these indicators should continue to be monitored and their sensitivity taken into account by ecosystem and resource managers.

This first indicators report (Wake et al. 2006) is intended as a baseline, setting out the current state of understanding and the most commonly used data for understanding climate changes in the Gulf of Maine watershed and region. It is anticipated that further climate change indicators work will be carried out by the Gulf of Maine Council's Climate Change Network (CCN) and Ecosystem Indicator Partnership (ESIP). The full report is available for download at http://www.gulfofmaine.org/council/ publications/.

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ATLANTIC WATER RESOURCES AND CLIMATE CHANGE

C-CIARN Atlantic*

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This presentation is a summary of the results of the sixth workshop by the Canadian-Climate Impacts and Adaptation Research Network (C-CIARN) Atlantic Region held in October 2005 in conjunction with the Atlantic First Nation Environmental Network (AFNEN). The information in this presentation can be found on the C-CIARN Atlantic Web site at http://atlantic.c-ciarn.ca under the Workshop 6 heading in the workshop report. The workshop report includes brief summaries of the climate change impacts presentations, as well as the results of participants' activities. This workshop focused on increasing awareness of and adaptation to climate change impacts in First Nations communities. Its second objective was to increase the networking of those working on climate change adaptation within the academic, non-governmental organization, private and government circles with the First Nations of the region. The overall objective was to increase the adaptive capacity of the First Nations communities in the region, specifically in regards to their fresh water systems. It was determined in the Canadian Perspective document on climate change in Canada that most impacts affect water, thereby further aggravating current water problems, and hence it is a priority issue (Lemmen and Warren 2004). Climate studies also indicate that dependence on groundwater especially in rural areas makes water management systems more vulnerable to climate changes (De Loë 2003). As such many First Nations communities have an increased vulnerability to climate change. Water also falls under both provincial and federal jurisdiction, making the issue of managing our activities on this resource complicated. For First Nations communities, which are isolated in small "federal jurisdiction" pockets through out "provincial" land, finding solutions to water issues requires much communication, collaboration and leadership. This creates a complicated scenario when climate impacts and adaptation are added to the mix.

Aboriginal peoples in Canada are roughly 3.3 per cent of our population and their numbers are increasing. Focusing a workshop specifically for First Nations was timely because an increasing population means an increase in demand for water, land and resources. It also means that on a social, political, cultural and economical sphere, this population will not only have needs that must be satisfied but also has a huge role to play in forming the country's future. For First Nations, water is already a priority issue, with still approximately three-quarters of reserves having still at risk or unsafe drinking water (Auditor General Report 2005). It is also important to realise the non-drinking aspects related to water and their importance to our society. Finally, climate change research has shown that indigenous peoples, though traditionally the most adaptable to their environment and its changes, are today one of the most vulnerable populations to climate changes because of social, political and economic restrictions (Lemmen 2004; Verheyen 2003).

* This program was closed by the federal government in 2006.

As such, climate change impacts to freshwater sources (surface and ground), its effects on aquatic life, water quality and quantity, were brought forth and discussed at the workshop. Human health risks related to drinking water and climate change impacts, such as increase heavy precipitation, were also presented. Moreover, examples of some work being done in the region on climate change and water sources in First Nations communities were also presented. Activities were held on both days of the workshop for participants to share their views and experiences regarding the vulnerabilities of their water sources and their concerns regarding climate change. The last activity gave participants the opportunity to identify barriers to adaptation, and to brainstorm on possible solutions, information and resources needed for them to increase their adaptive capacity. The activities at the workshop and the workshop setting permitted the sharing of knowledge and concerns between First Nations and non-First Nations participants, and focused on bringing the social, political, economical, cultural and environmental dimensions of climate adaptation for First Nations in the region to the discussions. This workshop was not consultation with First Nations, and the results from it should not be considered as such. The results of this workshop can be found in the report at http://atlantic.c-ciarn.ca under the Workshop 6 heading.

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SEA SURFACE TEMPERATURE CHANGES AND BIOGEOGRAPHIC RANGES OF COMMERCIAL MARINE SPECIES

Gail L. Chmura[1], Lou Van Guelpen[2], Gerhard W. Pohle[2], Sarah A. Vereault[1], and Elizabeth A. Flanary[1]

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We examined the changes in February and August sea surface temperatures (SSTs) projected with greenhouse warming, using output from an ensemble of four Atmosphere-Ocean General Circulation Models (AOGCMs) for the period when average global air temperatures are expected to increase by 4°C. Although we applied two commonly used climate warming scenarios (A2 and B2), we found that differences in the magnitude of SST changes between the two scenarios were less than differences among models. We used projected SSTs to predict changes in biogeographic distributions of over 30 marine species important to commercial harvests.

These included an important copepod prey, various shellfish, finfish, introduced and invasive species, as well as harvested seaweeds. For each species, the "thermal niche" or "bioclimate envelope" was determined from its geographical distribution (water depths and range in latitude) with respect to satellite-derived (AVHRR) data on sea surface temperatures. Here we present a summary of results and input from a stakeholder workshop held earlier this week (October 2006). In the northwest Atlantic, many species may experience some loss in the southernmost part of their range, near Cape Hatteras. For instance, SSTs will be limiting for the pelagic larvae of the Atlantic deep-sea scallop (*Placopecten magellanicus*), limiting future harvests in the south. Although we have not addressed impacts on populations, changes in populations would be expected in areas adjacent to regions of extirpation.

For some species, a change in biogeographic range is expected within Canadian waters. This includes the invasive Asian shore crab (*Hemigrapsus sanguineus*), which is presently spreading northward into New England. Assuming that range expansion is primarily temperature limited, warmer winter ocean temperatures predict its expansion along the shore of most of the Canadian Atlantic. As it expands its range, it is likely to prey on native clams and mussels, endangering these harvests. Higher summer ocean water temperatures in the Gulf of St. Lawrence will also limit the marine phase of the Atlantic salmon (*Salmo salar*) life cycle, causing further decline in populations.

Session Five

SALT MARSHES: PHYSICAL ENVIRONMENT

Chairs: Gail Chmura, McGill University, Montreal, Quebec

and

Elisabeth Kosters,
Elisabeth Kosters Consultancy, Wolfville, Nova Scotia

Sessions Five and Seven Summary

Several questions and points were posed during discussions of papers in the two sessions:

1. How do we get or can we get appropriate reference sites to monitor the restoration success?
2. Do we have enough information and knowledge to target parameters i.e. design monitoring? Which ecosystem functions are we concerned with?
3. How do we get funding for monitoring success? Note that there are funds for restorations.
4. Monitoring of ecosystem functions of salt marshes – there is limited analysis of change of distribution and extent of marshes over time in the Bay of Fundy.
5. There is limited information on salt marsh accretion rates in Atlantic Canada, and concern about the misapplication of Bay of Fundy data and results to the region as a whole. We may be a victim of our successful research in the Bay of Fundy, as the other "spatial" children in the family may be being neglected, e.g., marshes along the Northumberland Strait.
6. There is a lack of enunciated SLR (sea level rise) adaptation strategies.
7. What is the potential benefit of dedicated staff/program for salt marsh restoration, compared to the use of scattered temporal pools of money. For example, there are too few people overseeing the sites during and after restoration, and too few people for a strategic approach for restoration.

METHANE ACCUMULATION IN SEDIMENTS OF A NORTHERN SALT MARSH, MUSQUASH ESTUARY, NEW BRUNSWICK

Angela M. Pitcher, Jeff Ollerhead, and Douglas C. Campbell

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The molar effluxes of the greenhouse gases carbon dioxide and methane were measured from a fresh water impoundment, a former dyke land, and natural salt marsh in the Musquash Estuary, New Brunswick, latitude 45° 11′ 20″, longitude 66° 20′ 16″, to quantify and compare the greenhouse gas emissions from these contrasting sites, within the context of a salt marsh restoration project. Dark, static, chamber incubations were performed at each site in July, 2005, with methane and carbon dioxide measured from headspace samples using gas chromatography. Upon insertion of the chamber into the marsh sediment, we detected immediate, large releases of methane from the salt marsh that did not recur upon ventilation and immediate, careful re-insertion of chamber into the same patch. Such bursts were not observed in the fresh or restored sites, showing that large, easily perturbed, sub-surface pools of methane exist in this salt marsh.

The restored dyke land resembled the fresh water marsh with respect to gas burst and efflux rate patterns, supporting recent evidence for lag times between re-inundation and the response of vegetation and microbial communities. Transient release of carbon dioxide was also highest for the salt marsh, but the restored site did show some evidence of this phenomenon. Sustained net molar efflux of carbon dioxide was always higher than methane, however, methane contributed significantly more to the net release of greenhouse gas equivalents from the sediment. The high methane release from the salt marsh sediment renders it a net greenhouse gas source in this estuary. Within a management context, it is important to consider the possible climate change impacts of restorations of dyked lands to salt marsh function.

SPATIAL AND ENVIRONMENTAL VARIABILITY OF POOLS ON A NATURAL AND A RECOVERING SALT MARSH IN THE BAY OF FUNDY

Paula E. Noël and Gail L. Chmura

Department of Geography and Global Environmental and Climate Change Centre, McGill University, Montreal, QC (paula.noel@mail.mcgill.ca; gail.chmura@mcgill.ca)

Permanent pools of water on the surface of a salt marsh serve as habitat and feeding areas for invertebrates, fish and birds. Despite their ecological importance there is little baseline information on the spatial distribution and controls on the environment of salt marsh pools. Differential GPS was used to map salt marsh pools in order to examine and compare the spatial coverage and distribution of pool habitat in a "natural" salt marsh at Dipper Harbour, New Brunswick, and Saints Rest Marsh, New Brunswick—a marsh which was formerly ditched and dyked but has been recovering since an unmanaged dyke breach approximately 50 years ago. Pools were found to represent a substantial portion of the marsh habitat in the recovering marsh, comprising 13 per cent of the total marsh area, but 4.8 per cent in the natural marsh. Observations indicate ice may be an important mechanism of pool formation and growth in these marshes. Pools at different elevations were selected at each marsh to monitor variability in temperature and salinity over one year. Water temperature ranged from freezing (-1.97°C) to a maximum of 36.1°C with ice covering pools for up to one month in the winter. Salinity of the pools ranged from near freshwater (4 ‰) to hypersaline (41‰). Environmental variability was mainly driven by climatic conditions with temperature and salinity becoming more stable with increased tidal flooding.

MOVING FROM IDEAS TO ACTION: ARE CURRENT POLICIES PROMOTING SALT MARSH RESTORATION IN THE BAY OF FUNDY?

Jennifer Graham

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This paper is about how current federal and provincial policies influence efforts towards salt marsh restoration in the region, with a particular focus on experiences in the Bay of Fundy. It covers some of the ongoing salt marsh restoration projects in the region and introduces the key federal and provincial legislation and policies that drive these efforts. The paper then presents some thoughts about the opportunities and risks of compensation-driven restoration projects, and discusses the importance and need for community-driven, pro-active restoration projects. It concludes with some observations on the effect of current policies on salt marsh restoration in the Maritimes.

The growing regional interest in salt marsh restoration is leading to the development of a body of knowledge about the functions and values of salt marshes in the Maritimes, particularly in the Bay of Fundy. The Ecology Action Centre (EAC) is a Halifax-based environmental organization that has been promoting salt marsh restoration since 1999, inspired by New England experience; they decided to initiate a pilot project in the Bay of Fundy. In December 2005, the Nova Scotia Department of Transportation and Public Works replaced a tidally restricted culvert at Cheverie Creek, Hants County, with a much larger culvert, thereby restoring a more natural tidal regime to the marsh system. Many other organizations and groups also worked to identify restoration opportunities and build support for restoration in other parts of New Brunswick and Nova Scotia. In light of these experiences, it is useful to look back and review the policies and legislation that enable salt marsh restoration. Many local groups want to be actively involved in salt marsh restoration, yet they do not understand what policy and regulatory mechanisms support moving from ideas to action.

This paper is a result of a small research project undertaken by the Ecology Action Centre in August 2006 to explore the mechanisms that trigger restoration and identify opportunities for restoration within current policies and regulations. It is based on a review of the existing restoration case studies in the region to better understand how stakeholders built regulatory support and financing for the projects. The paper summarizes existing federal and provincial polices that have been used to support salt marsh restoration (*Fisheries Act*, Federal Wetlands Conservation Policy, Nova Scotia Environment Act and Wetlands Designation Policy, New Brunswick Wetlands Conservation Policy). Federally, the Policy on Wetlands Conservation is dedicated to the protection of wetlands including salt marshes. The policy recommends a “no-net loss” approach for wetlands values and functions. A mitigative sequence (avoid, mitigate, compensate) outlines how any undertaking that will likely impact wetlands is treated under this policy. The Federal Wetlands Policy considers cumulative impact and loss of wetlands. Both Nova Scotia and New Brunswick provincial wetlands policies operate similarly, with an emphasis on implementing a mitigative sequence and varying degrees of commitment to no-net loss. Compensation projects, such as salt marsh restoration, should be a last resort under federal and provincial wetlands policies since the emphasis should be on avoiding damage in the first place.

In Nova Scotia, however, most salt marsh restoration projects have been triggered under the *Fisheries Act* rather than federal or provincial wetlands legislation. Section 35 of the *Fisheries Act* strives for no-net-loss of habitat and prohibits a Harmful Alteration Destruction or Disruption of Fish Habitat (HADD). Similar to the wetlands policies, the *Fisheries Act* follows a mitigative sequence, which emphasizes avoiding and minimizing damage. Salt marsh restoration projects occur under this act as compensation for damage to fish habitat (wetlands) or obstruction of fish passage. Unlike the wetlands policy, the *Fisheries Act* does not explicitly take into account cumulative loss of habitat.

In reviewing salt marsh restoration case studies to date, a requirement of no-net loss and a mitigative sequence seem to be required in order to create conditions for compensation projects to occur. Compensation requirement trigger funds for restoration projects and post-restoration monitoring. Provincial legislation and federal wetlands legislation seem to be used to support salt marsh restoration projects in New Brunswick more than in Nova Scotia at this time. It remains to be seen whether other policies such as the *Species at Risk Act*, or the North American Waterfowl Management Agreements, can also stimulate restoration.

The trend towards compensation-driven restoration projects creates some opportunities and challenges. On the plus side, regulatory agencies are now "on board" and more proactive in identifying potential restoration projects. They are also committed to supporting post-restoration monitoring. Recent memorandums of understanding (MOU) between provincial and federal fisheries departments are now speeding up the restoration process through more direct links between damage to fish habitat and restoration. On the other hand, compensation projects raise some questions about accountability and transparency: Who is tracking and assessing how well the mitigative sequence is followed? What is the scientific basis for current compensation ratios of 3:1?

There are also questions about how to keep communities involved in salt marsh restoration projects. Replacing highways culverts and opening up dykes are large-scale projects. So far in the Maritimes, there have been very few small-scale or enhancement projects, i.e creating marsh ponds that might be suitable for hands-on work by local community groups. At the same time, many funding agencies only fund actual restoration work, and some will not support compensation-driven projects. Furthermore, even very small community-based restoration projects can trigger onerous permitting bureaucracy.

Community involvement in salt marsh restoration could be facilitated through smaller scale enhancement projects, and by generating public pressure for restoration at key sites. Communities can also partner with federal and provincial departments, private groups, and private land owners. It would also help to identify funding sources that support pro-active restoration.

This paper concludes that current policies can be used to support salt marsh restoration, but will not actively promote it. The current policy environment could be strengthened by identifying and ensuring protection for significant and severely degraded wetlands habitat and fish habitat. Other jurisdictions could follow New Brunswick's example and commit to no further loss of Bay of Fundy salt marshes. Current policies will only protect salt marshes if there is a strict enforcement of the mitigative sequence and the restoration of significant habitats is prioritized. A pro-active salt marsh restoration policy is needed for restoration in areas of significant habitat loss. Monitoring and enforcement are the biggest concerns with the current approach. Public involvement can drive restoration and also monitor its effectiveness.

The paper closes with some key questions, including: How do we achieve a balance of compensation driven restoration and pro-active restoration projects? What mechanisms can ensure restoration of significant or threatened wetlands? How can we streamline process and maintain an ability to monitor and enforce regulations? What are the mechanisms for monitoring and reviewing the effectiveness of the process? How can community-driven projects complement compensation projects?

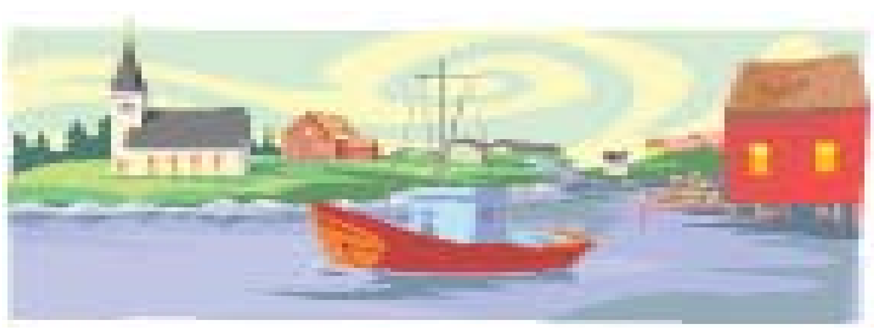
Session Six

RESOURCE MANAGEMENT

Chairs: Maria Recchia, Fundy North Fisherman's Association, St. Andrews, New Brunswick

and

Seth Barker, Maine Department of Marine Resources, West Boothbay Harbor, Maine



Session Six Summary

Maria Recchia and Seth Barker, Rapporteurs

A number of points and questions were recorded from this session:

1. Are we doing enough work on trans-border management issues at the local/regional level, such as in Passamaquoddy Bay?
2. Marine ecosystems are complex. Are we up to the job of marine resource management?
3. There is mention of indicators but of what?
4. Presenters have told us that we need to conduct massive data mining and data generation, yet we need simple tools to present the data and information to decision makers.
5. It seems very important to get the right people to the discussion table.
6. The multi-stakeholder processes that are in place are most often advisory, not processes aimed at, and involving, the decision-making bodies.

EFFICIENT AND EFFECTIVE TRANSBOUNDARY GOVERNANCE? A WORKING EXAMPLE IN THE SHARED WATERS OF THE BAY OF FUNDY/GULF OF MAINE

Maxine C. Westhead

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The Gulf of Maine is a semi-enclosed sea bounded to the south and east by tall underwater banks that rise up to form a barrier to the North Atlantic. The western and northern coastlines of the Gulf are shared by the United States (Massachusetts, New Hampshire, and Maine), and Canada (New Brunswick and Nova Scotia). The area is rich in commercial species of groundfish, large and small pelagics, and invertebrates.

Canada and the US have been developing a transboundary management relationship in the Gulf of Maine since the offshore boundary known as the Hague Line was declared by the International Court of Justice in1984. A unique governance mechanism has evolved. This structure is atypical in that it is bound by no memorandum of understanding, treaty, or formal organization. The result is a mechanism that is flexible, adaptable, transparent, and growing to include broader oceans issues other than fish and fisheries management.

Most recently, DFO's shift towards ecosystem-based management through Canada's *Oceans Act* and Oceans Action Plan has expanded the focus and breadth of Canada's relationship with the United States in the region. We are now required to pay more attention to the broader ecosystem effects of human activities, as well as their potential cumulative impacts, than we have in the past.

This presentation describes the unique regional governance mechanism in the Gulf of Maine and provides an overview of recent progress in formalizing this structure and the resulting implementation of a portion of Canada's Oceans Action Plan.

DEVELOPMENT OF A NUTRIENT GUIDANCE FRAMEWORK FOR NEARSHORE CANADIAN WATERS

Mike Brylinsky

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Eutrophication of coastal waters is a severe problem in many areas of the world. Although it is less of a problem within Canada than within other developed nations, some areas of Canada, most notably Prince Edward Island, have been experiencing the consequences of estuarine nutrient over-enrichment for several decades. As a result, Environment Canada, in partnership with the Canadian Council of Ministers of the Environment, is in the process of developing a nutrient guideline framework that can be used to set criteria for determining threshhold levels of nutrient concentrations in nearshore Canadian waters. The development of this framework, and the problems associated with its development, are presented.

COMMUNITY-BASED RESOURCE MANAGEMENT: PROMOTING ECOLOGICAL HEALTH AND LASTING LIVELIHOODS IN THE ANNAPOLIS BASIN

Denise Sullivan

Clean Annapolis River Project, Annapolis Royal, NS (carp@annapolisriver.ca)

The intertidal zones of Nova Scotia's Annapolis Basin have a potentially very productive and lucrative soft-shell clam (*Mya arenaria*) industry. Historically, the area consistently produced over 30 per cent of all the soft-shell clam landings in the Scotia-Fundy region. Since the late 1970s, however, several factors have contributed to the decline in clam populations as well as the increasing closure of harvesting areas. The contributing factors include environmental and biological as well as managerial factors.

In early 2006, the multi-stakeholder Annapolis Watershed Resource Committee was created to address local concerns on the ecological health and sustainability of the soft-shell clam resource. Under the direction of this committee, a water quality monitoring program was initiated in an important shellfish growing area, closed due to bacterial contamination. A stock assessment and economic valuation study was conducted to evaluate the state of the stocks, as well as their value under current and alternative management scenarios.

REVIEW OF THE MANAGEMENT OF ROCKWEED (*Ascophyllum nodosum*) HARVESTING IN NEW BRUNSWICK AFTER A DECADE OF ITS INITIATION

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Introduction

During the late 1980s, there was an increase in the international demand for products such as kelp meal and fertilizers, causing the harvest of rockweed (*Ascophyllum nodosum*) to reach its maximum sustainable level in the traditionally harvesting areas of Nova Scotia. This factor sparked an interest to expand the harvest to the unexploited resource of southern New Brunswick. As no legislative structure for marine plants management was in place in the province, a memorandum of understanding (MOU) was signed between the federal Department of Fisheries and Oceans (DFO) and the provincial Department of Fisheries and Aquaculture (DFA). This agreement set the terms for shared management of the rockweed resource following the same regulatory principles as in the federal *Atlantic Marine Plants Act* and the Nova Scotia *Seaplants Harvesting Act*.

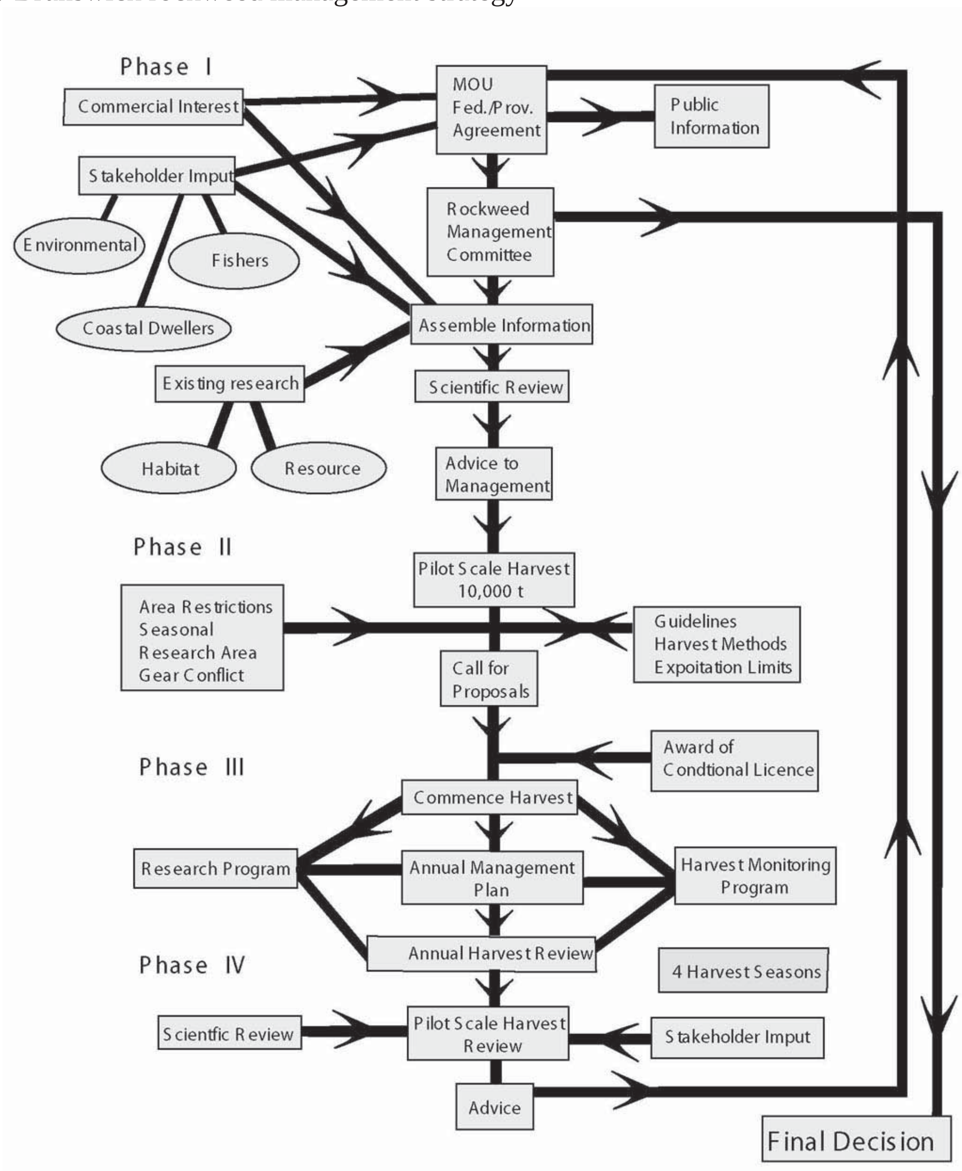
Despite the economic benefits associated with the rockweed harvest, the opening of the fishery was delayed in New Brunswick. Although seaweed harvesting was a traditional fishery activity in Prince Edward Island and Nova Scotia, this activity was new to southern New Brunswick. As well, the credibility of the Department of Fisheries and Oceans was under question in those years due to the collapse of the groundfish fisheries in Atlantic Canada. Therefore, conservation groups highlighted stakeholders concerns regarding rockweed harvest in New Brunswick. These concerns included the long and short-term sustainability of harvesting, as well as the cumulative impact of harvesting on the larger Bay of Fundy ecosystem, particularly on existing fisheries (Sharp et al. 1999; Ugarte and Sharp 2001). *Ascophyllum* has an important role in the Fundy ecosystem as it provides habitat for the prey of some waterfowl (Hamilton 2001). Also, at least 22 species of fish (seven of commercial importance) are known to be associated with *Ascophyllum* in parts of their life cycle (Rangeley 1994; Rangeley and Kramer 1995). During the late 1990s, the *Oceans Act* also came into effect, expanding the management structure for resources such as kelps or rockweed. As these seaweeds are considered habitat, they could no longer be managed under the single species, maximum sustainable yield concept.

A New Approach to Seaweed Management

Managers, cognizant of the need to have a precautionary approach, designed a five-year management strategy to develop the fishery in a sustainable way while protecting the ecosystem. In order to achieve these goals, four phases were established in this management strategy (Figure 1; also see Ugarte and Sharp 2001 for details).

In Phase I, a Rockweed Management Committee was formed to review management plans, monitoring, assessment, and environmental data and develop a guideline for licence applicants (Figure 1). It consisted of a core of DFA and DFO managers and scientists. This core advised a second level committee of two, the Deputy Minister of Fisheries and the Regional Director General of DFO. Also during this phase, European and regional studies provided the biological information to establish a scientific baseline for this plan. Standing crop estimates and productivity measures were utilized to establish annual quotas. The resource was divided in three major harvesting areas (Figure 2). Each one of these areas was subdivided into sectors, the smallest management units of the system (Figure 2). Total standing stock of *A. nodosum* in southern New Brunswick was estimated at 153,053 tonnes (CAFSAC 1992).

Figure 1: New Brunswick rockweed management strategy



Following a formal DFO peer review of the relevant databases, a pilot harvest was recommended (CAFSAC 1992). Significant knowledge gaps, however, were identified, especially in relation with the impact of the harvest on the habitat and associated species. Thus, a monitoring and research program was recommended with the pilot harvest. Study sites were set aside to provide undisturbed areas for research. Also, closed areas were established to protect wildfowl and prevent gear conflict. Stakeholder input was solicited at public meetings and stakeholders were provided with information on the decision to harvest and answers to questions regarding the development of the resource.

In the second phase (Figure 1), managers set a pilot harvest quota of 10,000 tonnes (seven per cent of the estimated standing crop) as a precautionary approach to management. Maximum exploitation rate, cutting height, gear restrictions, and protected areas were management measures within the precautionary pilot harvest plan. Companies, individuals, or associations who were interested in harvesting rockweed were asked to submit a proposal. After reviewing the proposals, the Rockweed Management Committee recommended that one company (Acadian Seaplants Limited) be awarded an exclusive license to all three rockweed harvesting areas. This decision was based on the conclusion that this company was the only proponent who successfully met the conservation and development criteria.

The third phase of the management process began in 1995, with the commencement of the pilot-scale harvest (Figure 1) and five years after the MOU was signed. In this phase the company was required to submit a new management plan for the harvest of rockweed at the beginning of each year. This management plan was to include the projected annual harvest by sector. At the end of each year, the company was to provide the government with vital statistics on the resource, including records of monthly purchases from harvesters, price paid, location, and harvest dates. The Rockweed Management Committee conducted three reviews of the company's performance at pre-season, mid-season and post-season meetings. The reviews were designed to investigate problems with harvesting strategies and ensure that the company was fulfilling its obligations. Finally, an independent third party was to be hired by the company to audit the recorded landings of rockweed. This review process was designed to ensure that the company complied with the yearly management strategy and the overall strategy of harvesting the resource.

During phase three, a multifaceted approach was taken to carry out the monitoring and research program. This program focused on the effect of the harvest on three major components: rockweed biology, the habitat, and associated fauna. Research was carried out by company, DFO, DFA, university and non-governmental organization (NGO) scientists. The degree of shoot removal and effect of the harvest on population structure, growth and mortality were addressed by the licensee. DFO habitat studies focused on the invertebrate fauna of the canopy and primary space. University research workers examined food linkages to wildfowl and fish use of intertidal zones, as well as nutrient variation on harvested and non-harvested plants. DFA personnel monitored invertebrate by-catch and clump mortality associated with rockweed landings for sector and seasonal variability.

Although there was an extensive detailed management plan for the pilot harvest, the provisions of this plan were not immutable. New information was anticipated annually and changes in aspects of exploitation levels, seasonal effort, distribution of the effort, and harvest technology could be integrated into the plan each year. Data inputs were derived from all sources, harvesters, researchers, stakeholders and the licensed company.

Phase IV marked the end of the pilot harvest and the final review of the information gathered during the research and monitoring plan, as well as the general performance of the company (Figure 1). The pilot harvest finished in October 1998 and in April 1999 a formal peer review committee, Regional Assessment Process (RAP), analyzed the information gathered during the three-year pilot harvest. Although it was agreed that the harvest impact on the habitat architecture was minimal and of short duration (Sharp et al. 1999; Ugarte et al. 2006), it was advised to continue the harvest, maintaining a precautionary approach (17 per cent exploitation rate) in light of other knowledge gaps (Ugarte and Sharp 2001). A further more general review of the same research was completed by the Global Program of Action Coalition for the Gulf of Maine (GPAC) under the theme of management in the face of scientific uncertainty with the conclusion that the existing management strategy was successfully managing the resource (Rangeley and Davies 2000).

Current Situation

Restricted Areas

Study areas and other exclusion areas are still an integral part of the harvest plan in southern New Brunswick, but there have been some changes in their original geographic location. Several study areas have been opened to the harvest as no scientific activity was carried out on them or no direct impact of the harvest was shown on the targeted species being studied. Exclusion areas such as the Cheney and Cows Passages in Grand Manan, originally closed to avoid conflicts between the dulse (*Palmaria palmata*) and the rockweed harvests, was also opened. At the same time, and with the company's agreement, new restricted areas have been created in previously harvested sectors as requested by local scientists (e.g., Green Point in Letete, Dead Man's Harbour and Harrington Cove in Grand Manan), scientific institutions (e.g., Three Island in Grand Manan, requested by Bowdoin College) and conservation groups (e.g., Dicks Island in Passamaquoddy Bay, requested by the Nature Trust of New Brunswick Inc.). Some of these areas have been designated as long-term reference areas or exclusion areas. The former are designated to be permanently closed to the harvest, and the later could be opened at one point in time. Especially managed areas, designated to protect waterfowl during breeding periods, have remained unchanged in both number and location. They are open to the harvest after July 1st. Also, a marine protected area has been created in Musquash Harbour and, although several traditional fisheries are allowed to continue here, that harvest of rockweed has been excluded. Finally, and as demanded by national security, a restricted area was also created around the Point Lepreau Generation Station. The location, area covered, and resource protected in these restricted areas are detailed in Table 1. Special rockweed management areas (SRMA) to protect waterfowl and gear conflict areas (around herring weirs) have remained unchanged since the beginning of the harvest. They are not included in Table 1, as the resource in SRMAs can be accessed after July 1st and at certain times of the day around the weirs (see Ugarte and Sharp, 2001 for details).

Table 1. Total biomass and area covered by rockweed in restricted areas to rockweed harvest in southern NB

Location	**Total Area** (ha)	**Total Biomass** (tonnes)	**Status**
Lorneville Harbour	18.1	870	Exclusion area
Musquash Harbour	20.8	1,176	Marine protected area
Goosberry Cove	2.6	242	Exclusion area
Point Lepreau Generation Station	25.1	2,274	Exclusion area
Maces Bay South	3.8	331	Study site
Maces Bay Ledges	62.6	4,910	Long-term reference area
Maces Bay North	1.8	126	Study site
Boyle's Cove Site	0	0	Exclusion area
Deadman's Harbour	4.6	398	Long-term reference area
Wallace Cove	0.5	70	Exclusion area
Green's Point	1.9	167	Study site
Barnes, Simpson & Mowat Is.	50.1	4,188	Long-term reference area
Dicks Island	4.0	418	Exclusion area
Castalia Marsh (G. Manan)	3.9	490	Study site
Three Islands (G. Manan)	52.8	6,761	Exclusion area
Harrington Cove (G. Manan)	0.5	35	Study site
Total	253.1	22,456	

The Harvest

Since the pilot harvest, the assessment of the rockweed resource has improved substantially. A detailed database with biological data has been created for 632 rockweed beds distributed in 87 harvesting sectors in New Brunswick. As the provisions of the management plan are not immutable, changes have been made since 1999. For example, resource allocation between harvesting areas has been modified based on a re-assessment of the resource base from the perspective of accessibility and economics provided by the company. According to the new data, the total biomass of rockweed in New Brunswick is 156,410 tonnes, with 131,673 tonnes in the leased harvesting areas. Following the current regulation that allows a 17 per cent exploitation rate, this could in theory translate into 22,384 tonnes of annual harvest from the leased resource. However, geographical restrictions such as wave exposed areas and areas with high intertidal slope severely restrict the access to the total biomass. Although a commercial biomass exist in these areas, these factors pose a high risk to the harvesters when utilizing the current allowable gear. In high slope areas, the floating canopy is not wide enough (Figure 3) to achieve the minimum biomass (or minimum catch-per-unit effort) that compensates for the energy and resources invested by the harvester. Therefore, the total accessible biomass to the harvest is only around 76,583 tonnes, with a potential annual maximum of approximately 13,019 tonnes (Table 2). Regular re-assessments are able to take into account changing annual levels of productivity, plant mortality due to impacts of storm events, and ice damage to integrate into annual harvesting plans.

Figure 2. New Brunswick rockweed harvesting areas

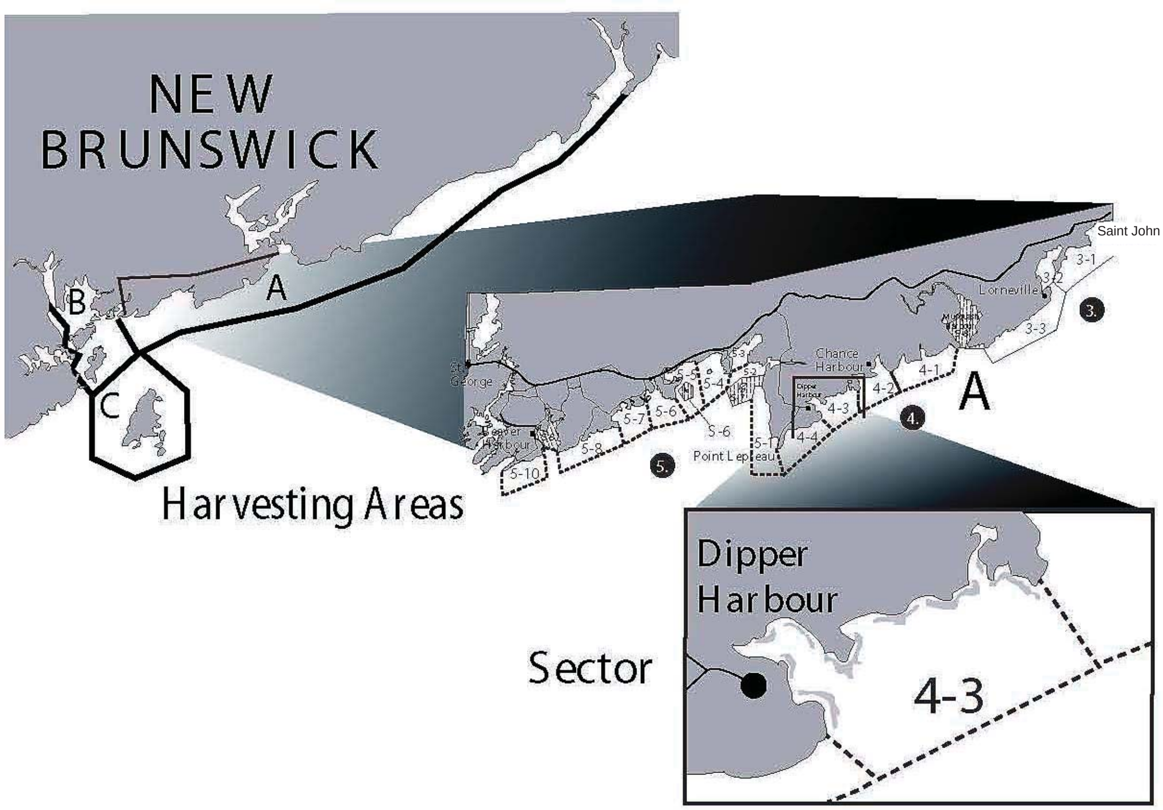


Figure 3. Slope area and harvest

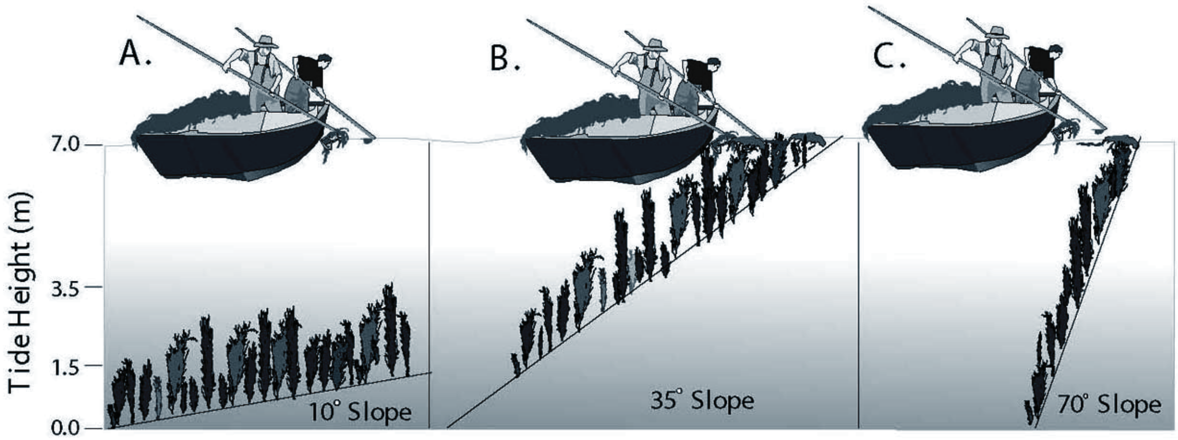


Table 2. Rockweed harvesting areas of southern New Brunswick and information on total, accessible and anuual biomass available to the industry

Harvesting Area	Total Biomass (tonnes)	Total Harvestable Biomass (tonnes)	Annual Harvest (17% ER) (tonnes)
A	31,820	4,491	763
B	71,343	50,922	8,657
C	28,510	21,170	3,599
Total	131,673	76,583	13,019

Since 1995, when the first 750 tonnes were harvested, the harvest of rockweed increased steadily to a peak of 11,803 tonnes in 2004 (Figure 4) with 72 harvesters participating in this fishery. The harvest has been consolidated; it is well accepted by the local community and is now considered a mature operation. New landing infrastructure and technology have been developed by the company to access and facilitate the harvest in remote sectors. As well, all of the harvested material is processed locally into value-added and organically certified products and exported directly to more than 60 countries. However, during the last two years, the landings have declined (Figure 4) due to a new phenomenon common to all industries requiring hand labour in the Maritimes; the migration of workers to western Canada for better paid jobs. Between 2005 and 2006, the company lost ten of the best harvesters to Alberta and, although these numbers seem low, they had harvested almost 30 per cent of the annual quota in New Brunswick. Experienced harvesters are very difficult to replace as harvesting is more a technique than muscles and they need to become knowledgeable of areas with rapid current and high tide variation. These techniques and experience require a few years to develop (Figure 5).

Figure 4: Landings of rockweed (*Ascophyllum nodosum*) in southern New Brunswick

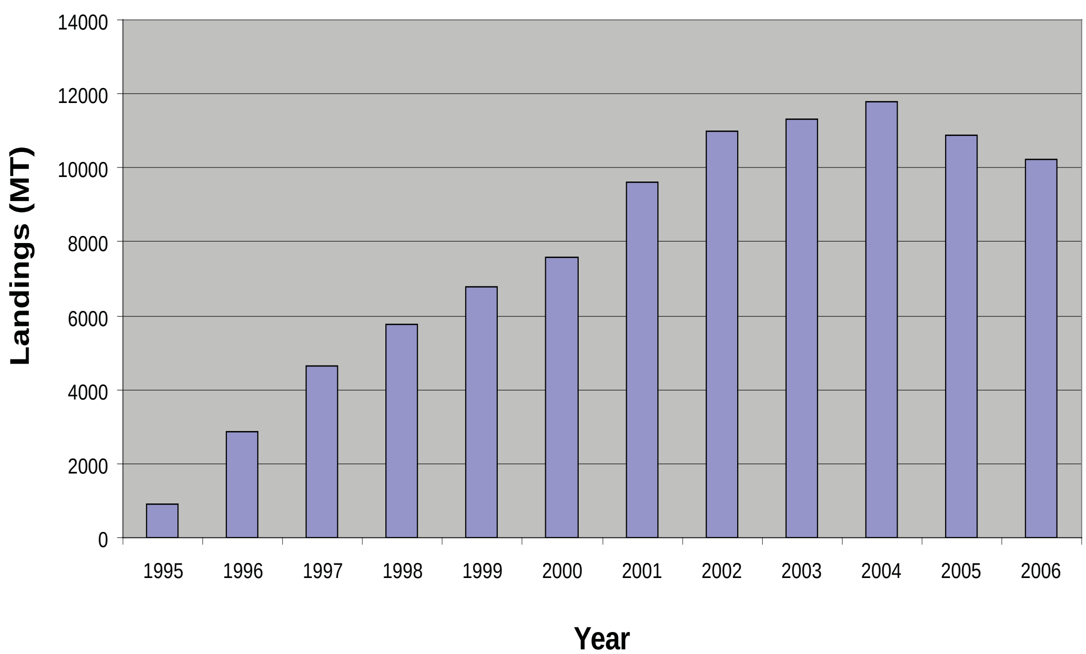
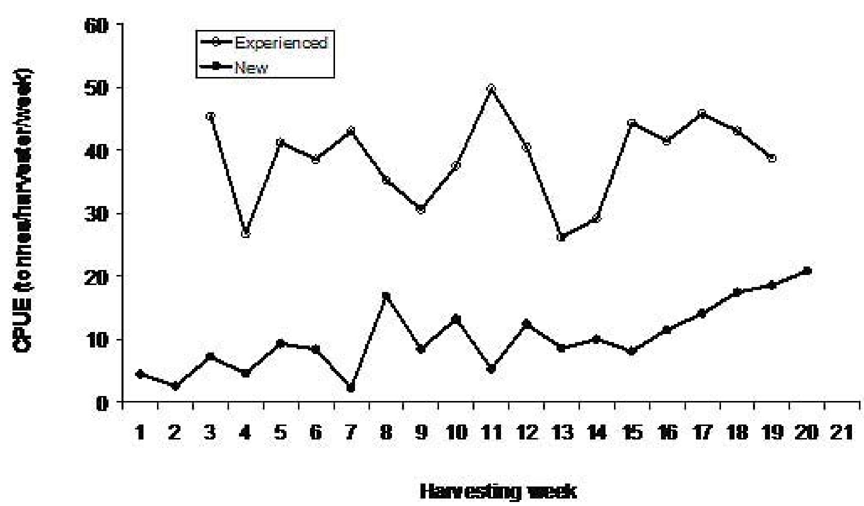


Figure 5: Effect of harvester's experience in the CPUE of rockweed (information obtained during the 2004 harvest season)



Discussion

New fisheries development, like the rockweed in New Brunswick, can be a highly controversial issue today in Canada. Established fishermen feel overwhelmed by increasingly restrictive license conditions on traditional fisheries and do not want any new activities in their area. Most arguments against the opening of a fishery point to the lack of knowledge of the resource, the risk to other commercial species, and the potential impact of the gear on the surrounding habitat. In the case of rockweed, there was a history of more than 30 years of harvest in the neighboring province of Nova Scotia that showed the sustainability of the resource in the region. However, conservation groups considered these facts inadequate. Some local scientists argued that the uniqueness of southern New Brunswick reduced the relevancy of this data (Rangeley 1991). The uncertainty of the long-term impact of the harvest on the ecosystem as expressed in the CAFSAC (1992) document increased these concerns (Ugarte and Sharp 2001; Sharp et al. 2006).

The possibility of gathering all of the ecological information suggested as knowledge gaps in the CAFSAC document (CAFSAC 1992) is very unrealistic for any marine resource in the world. Since there is no fishery where all the necessary biological information is available to develop a zero risk management plan, the recommendation is to apply a precautionary approach. The low exploitation rate, study areas and special rockweed management areas established in the New Brunswick management plan are components of the precautionary approach and general conservation principles. The goal is to either make no significant changes in habitat structure or to keep impacts short term and within limits that could be mitigated. To reach this goal, the management plan controls cutting height, incidence of cut shoots, holdfast removal, number of clumps cut in a stand and the patchiness of the harvest. In the case of rockweed, risks are minimized since structural changes in the habitat are short lived as the reduction in standing crop is compensated by the overall production during the summer months, and the time of active harvest (Sharp et al. 1999; Ugarte et al. 2006). Consequently, the probability of habitat loses is minimal.

The responsiveness of the rockweed management plan to annual assessments and the regular integration of new information into the management strategies provide a flexible and adaptive approach to utilizing this resource in the face of uncertainties. The rockweed management model of New Brunswick is slowly becoming known worldwide; some aspects of the plan are starting to be implemented in Maine, USA. Also the government of Chile has expressed interest in applying the “Canadian Model” to the development of the harvest of *Macrocystis pyrifera* in the southern part of that country. The Chilean coast is one of the world largest reservoirs of kelp, located in a pristine and ecologically sensitive area in South America. Therefore, this is an ideal opportunity to implement a program similar to the harvest of rockweed in Canada where, for the first time, management regulations would be in place before the harvest started.

Although some challenges such as accessibility to the available resource and shortage of labour are hindering the harvest of rockweed in southern New Brunswick, there is confidence that adequate technological innovation could help to solve this problem. As per the current harvest tool, any new harvest technology will have to demonstrate that the integrity of the habitat is maintained before being used in a large-scale harvest in southern New Brunswick.

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LOBSTER HABITAT EVALUATION: INTEGRATING MARINE ECOLOGICAL AND MARINE GEOMATICS APPROACHES IN SUPPORT OF INTEGRATED COASTAL ZONE DECISION MAKING

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While there is a considerable historical literature on lobster distribution and movement in the Bay of Fundy, as well as ongoing monitoring and assessment of the regional fishery, the increasing pace of development in the coastal zone requires an enhanced capability to provide assessment of habitat-related impacts on sensitive lobster habitat at a range of spatial and temporal scales.

Using geographic information system and relational database software, we have consolidated linkages to the available historical data on lobster distribution and coastal habitat structure, and have implemented new field survey approaches for coastal habitat evaluation. These diving, trap, and video-based approaches can each take advantage of seabed mapping technology (e.g., multi-beam and side-scan sonar) for survey design and interpretation. Several project examples, where these integrated approaches have been applied, are discussed.

Session Seven

SALT MARSHES: BIOLOGICAL ENVIRONMENT AND RESTORATION

Chairs: Lee Swanson, New Brunswick Department of the Environment, Fredericton, New Brunswick

and

Al Hanson, Environment Canada, Sackville, New Brunswick

Sessions Five and Seven Summary

Several questions and points were posed during discussions of papers in the two sessions:

1. How do we get or can we get appropriate reference sites to monitor the restoration success?
2. Do we have enough information and knowledge to target parameters i.e. design monitoring? Which ecosystem functions are we concerned with?
3. How do we get funding for monitoring success? Note that there are funds for restorations.
4. Monitoring of ecosystem functions of salt marshes – there is limited analysis of change of distribution and extent of marshes over time in the Bay of Fundy.
5. There is limited information on salt marsh accretion rates in Atlantic Canada, and concern about the misapplication of Bay of Fundy data and results to the region as a whole. We may be a victim of our successful research in the Bay of Fundy, as the other "spatial" children in the family may be being neglected, e.g., marshes along the Northumberland Strait.
6. There is a lack of enunciated SLR (sea level rise) adaptation strategies.
7. What is the potential benefit of dedicated staff/program for salt marsh restoration, compared to the use of scattered temporal pools of money. For example, there are too few people overseeing the sites during and after restoration, and too few people for a strategic approach for restoration.

SALT MARSH RESTORATION AS AN ADAPTATION STRATEGY TO FUTURE CLIMATE CHANGE AND SEA LEVEL RISE IN THE BAY OF FUNDY, CANADA

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The climate in Maritime Canada is changing and sea level is rising at 0.3-0.4 m/century. Of concern is that this rate of sea level rise may double by the end of this century. Large tracts of land in this region are presently protected from salt water inundation by dykes. As our environment changes, there will be two options for society to consider: (i) adapt by raising and reinforcing the dykes or (ii) adapt by restoring dyked lands to salt marsh. Raising and reinforcing dykes will become progressively more expensive as time goes on and dykes cannot self-adapt to ongoing changes in climate and sea level as salt marshes can.

Salt marshes around the Bay of Fundy exist in a unique environment. The Bay is macrotidal, has a relatively high suspended sediment concentration within the water column, and its marshes are subject to the effects of ice and snow. Thus, available scientific literature on salt marsh restoration, which primarily describes projects in more temperate parts of the world, is typically of limited utility with respect to understanding the steps necessary to restore a Fundy salt marsh.

The objective of this presentation is to evaluate the technical and socio-economic feasibility of converting dyked lands to salt marsh in Maritime Canada as an adaptation strategy to future climate change and sea level rise. The goal is to explore whether salt marsh restoration is a viable method of adapting to changing environmental conditions and, even more importantly, to determine under what conditions stakeholders will be prepared to adopt this method of adaptation.

SALT MARSH SPECIES ZONATION IN THE MINAS AND CUMBERLAND BASINS: USING LIDAR TO EXAMINE SALT MARSH VEGETATION

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High-resolution LiDAR (Light Detection and Ranging) data were collected in May 2003 and May 2006 for salt marshes near the Cornwallis Estuary, Nova Scotia, and Fort Beausejour, New Brunswick, respectively. The data were used to develop digital elevation models (DEM) of the two sites with a resolution of 1 metre and a vertical precision of +/- 15 and +/- 30 cm depending on the system used. Aerial photographs were also obtained, orthorectified and mosaicked. These basins have a high tidal range which, at low tide, allowed a large portion of the inter-tidal zone to be surveyed, including tidal flats and salt marshes.

Salt marsh vegetation species live within specific elevation ranges due to their dependence upon the frequency and duration of tidal inundation and flooding. Four salt marsh vegetation "zones" were determined through field visits to the Cornwallis study area throughout spring and summer 2006. Vegetation zones were then digitized from the aerial photographs to create a geographic information system (GIS) database and species maps. The mean, minimum, maximum and standard deviation of the elevation of each zone type was determined through ArcGIS tools and was used to calculate zone "limits". As defined by Olsen et al. (2005), a zone limit equals mean elevation +/- 1 standard deviation. Using the determined limits, the DEM was then reclassified in other areas of existing salt marsh, essentially "predicting" species zonation.

Sixty-four, 1-metre vegetation plots were surveyed by the estuarine ecology students at Acadia University in Sept 2006. They recorded the global positioning system (GPS) position of the plots and information on occurrence and vegetation height of each species (Figure 1). These plots, along with other field points, were used to validate the digitized zones as well as the reclassified zones. Through visual inspection the digitized zones corresponded extremely well to the validation plots (98 per cent plots correct), confirming that the digitized zones closely represent the actual vegetation. The plots also corresponded well to the reclassified zones, although there was higher error (85 per cent of plots correct). In order to compare the accuracy of the reclassification with the digitized zones, accuracy assessments and Kappa Index of Agreement coefficients were calculated for each zone to determine the accuracy and degree of "agreement" between the two datasets. Instead of working on a plot basis, these tests work on a pixel-by-pixel basis allowing the entire study area to be assessed. These determined varying accuracy for each of the reclassified zones (kappa coefficient = 0.76 for young marsh; 0.73 for low marsh; 0.91 for mid-marsh).

Differences in tidal range, tidal amplitude and other environmental factors affect the exact elevation ranges at which salt marsh vegetation zones occur at different locations (Dawson et al. 1999). To test the usefulness of the Cornwallis dataset in predicting marsh vegetation in other areas, the vegetation limits were applied to the digital elevation model for the Beausejour Marsh study area. They produced surprisingly accurate results despite the difference in tidal amplitude. Seventy-five field validation plots were conducted, of which 92 per cent corresponded correctly to the reclassified marsh zones, inferring that the differences in site characteristics between these two sites are not great enough to affect the elevation range that each vegetation zone occurs within (Figure 2). Interestingly, some areas where no vegetation existed (mudflats) were predicted to have vegetation, suggesting that some factor other than elevation could be deterring vegetation growth.

Figure 1. Validation plots surveyed by Acadia University students (2006). Data on species and vegetation height are overlain on digitized vegetation zones and airphotos (Airphoto source: Service Nova Scotia).

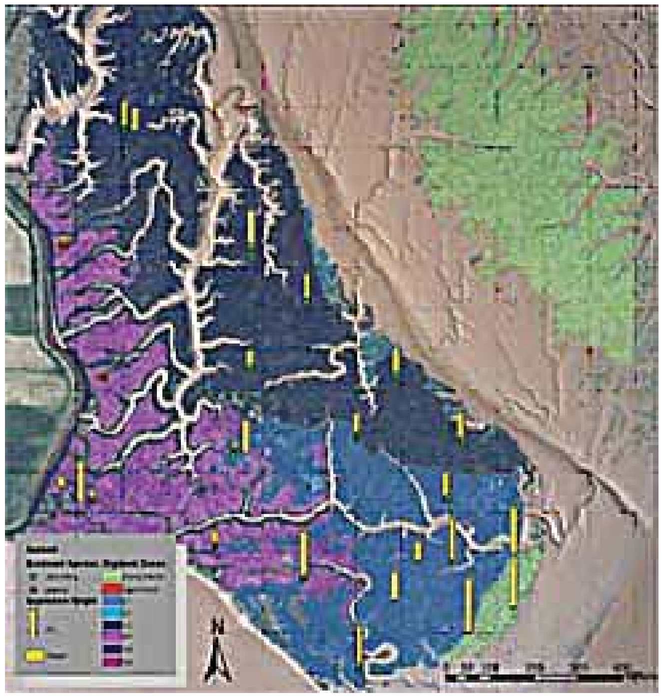
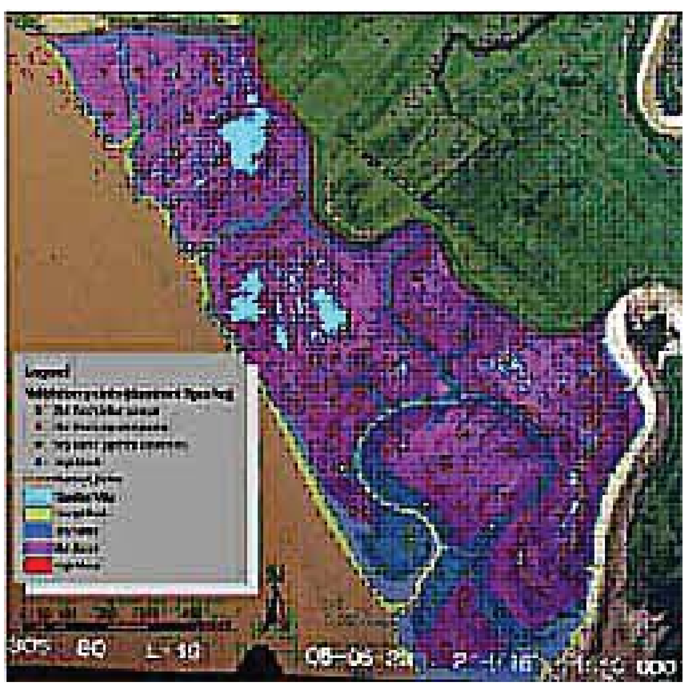


Figure 2. Beausejour salt marsh reclassified based on marsh zone, overlain with validation plots (Airphoto source: Nova Scotia Geomatics Centre).



These vegetation zone limits can be used to predict salt marsh vegetation in areas where salt marsh vegetation does not currently exist (i.e. where barriers have been erected such as dykes). If tidal flooding is restored to the area, then salt marsh vegetation should reform. One study found that the elevation of the land behind the barrier is the most important factor in the successful restoration of salt marshes (Blott and Pye 2004).

LiDAR digital elevation models prove to be extremely useful in decision making for salt marsh restoration. Figure 3 demonstrates how DEMs can be used to assess the effect of dyke removal or relocation.

Figure 3. Beausejour marsh site: A) original DEM; B) altered DEM which allows tidal inundation, and C) reclassified DEM showing predicted marsh zones if tidal inundation was restored.

a b c

The vegetation limits determined for the Cornwallis site appeared to accurately predict vegetation at the Beausejour site. Similar methods will be used to determine the specific salt marsh vegetation zones for this site. Different restoration scenarios can then be modeled, taking into consideration hydrological and geomorphological features of this site.

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VEGETATION DISTRIBUTION AT JOHN LUSBY, A RECOVERING SALT MARSH IN THE CUMBERLAND BASIN

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Abstract

Restoration of Fundy salt marshes is sometimes required by federal and provincial agencies as compensation for the unavoidable loss of wetlands. To understand the potential outcomes of restoration, it is useful to examine marshes that have already experienced a period of recovery. By comparing conditions at marshes recovering for different periods, we can define trajectories—rates of change and outcomes likely for marshes targeted for restoration.

One of the recovering marshes we are studying is John Lusby Wildlife Refuge, Nova Scotia, at the head of Cumberland Basin. John Lusby was dyked and maintained for agricultural use for approximately 250 years, until neglect led to dyke breaching and a return of tidal flooding in the 1940s. With a contiguous area of 600 hectares, John Lusby is now the largest marsh on the Bay of Fundy.

In this presentation we report on the vegetation of John Lusby Marsh. Vegetation assemblages and their elevations were mapped using a differential global positioning system and data was transformed to a layer within a geographic information system (GIS) that contains data from previous research on the marsh's hydrology and geomorphology. We use the GIS to establish empirical relationships between vegetation and geomorphic characteristics that are considered predictors of plant distribution: elevation and proximity to features such as channels, the bay edge, and the terrestrial boundary – providing the first model of a recovered marsh in the Bay of Fundy.

Introduction

Since the 17th century, the Bay of Fundy has seen up to 85 per cent of its salt marshes converted to agricultural dykelands (Ganong 1903). Recently, however, there has been a growing interest in the restoration of Fundy salt marshes through the breaching of tidal barriers (Harvey 2000). The vegetation cover and zonation in a recovering marsh, one that has never been actively restored, can serve as an analog for long-term restoration efforts (Crooks et al. 2002; Williams and Orr 2002).

Marsh vegetation zonation is driven by hydrological conditions such as tidal inundation, soil drainage, and soil salinity. Studies have found that these factors in turn are influenced by elevation and proximity to features such as channels, the bay edge, and the terrestrial boundary (Gordon et al. 1985; Sanderson et al. 2000; Morris et al. 2005; Olsen et al. 2005).

This study follows the M. Sc. research of Byers (in review) by providing a more detailed look at the vegetation of the John Lusby Wildlife Sanctuary, a recovering Fundy salt marsh in Nova Scotia. By empirically determining the relationship between vegetation and its determining geomorphic characteristics, we can provide insight into the necessary components for marsh recovery.

Study Area

This study focuses on the John Lusby Wildlife Sanctuary, Nova Scotia, which is under the management of the Canadian Wildlife Service, Environment Canada. The marsh is situated at the head of the Cumberland Basin on the northern side of the Bay of Fundy, from the LaPlanche River to Amherst Point (Figure 1). The basin has a watershed size of approximately 1900 km^2 with six small rivers draining into it (Gordon et al. 1985).

John Lusby had been converted to agricultural land through earthen dykes, tide gates (locally termed 'aboiteaux'), and ditches in the 17th century by Acadian settlers (Ganong 1903). The marsh was breached in 1947 by storm surge (Graf 2004) and no subsequent effort was made to restore dykes. John Lusby is therefore classified as a recovering salt marsh, locally referred to as "gone out to sea".

With a contiguous area of 600 hectares, John Lusby is now the largest marsh on the Bay of Fundy and is managed by the Canadian Wildlife Service. The marsh has an average tidal range of 11 metres (Gordon et al. 1985) and a Mean High Water (MHW) of 5.4 metres and a Higher High Water (HHW) of 7.9 metres a.s.l. (calculated by Byers, in review). The bayward edge of the marsh is characterized by a cliff edge with a 1–2 metres height. Thus lower marsh elevations are not found at the bayward edge, but around channels and creeks. In the southern section of the study area there is still a remnant dyke, shown in Figure 2 in maroon.

The low marsh at Lusby, near channels and creeks, is dominated by the cordgrass *Spartina alterniflora*, while the high marsh is dominated by the grasses *Spartina patens* and *Puccinellia maritima*. Higher elevations within the marsh are dominated by *Hordeum jubatum*, *Hordeum vulgare*, and *Spartina pectinata*.

Vegetation Mapping

Mapping of John Lusby vegetation was conducted in July 2006 to coincide with peak blossoming for accuracy of identification. The study was done within the bounds of previous studies of channel geomorphology and marsh hydrology (Figure 2; Chmura and Macdonald 2006; Byers, in review).

Figure 1. The John Lusby Wildlife Sanctuary, located on the Cumberland Basin at the northern head of Fundy, near Amherst, Nova Scotia. Modified from Connor et al. (2001)

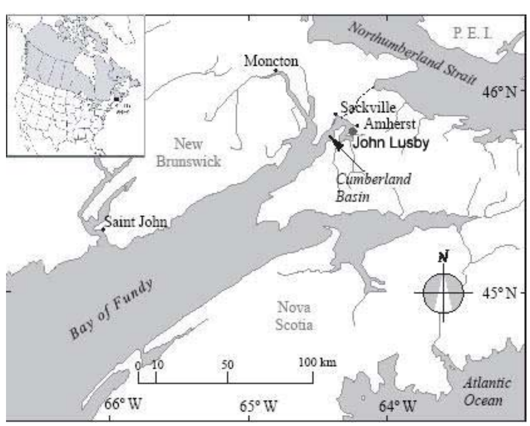


Figure 2: The John Lusby Wildlife Sanctuary as seen from an aerial photograph in June 2005 (Nova Scotia Geomatics Centre). The study area is outlined in orange, channel data is outlined in blue, and the remnants of the old dyke are in maroon.

To characterize the marsh platform, two approaches were taken. On a broad scale, the area of interest was subdivided based on visual estimates of cover. For this study, the species that had both the highest percent cover and was > than 30 per cent was considered dominant. In situations where there is no single dominant species, the group is labeled by the types of species it contains (e.g., 'Mixed Forbs'). The minimum size for a group was determined to be 5 metres on at least one axis, and within each group the abundance (per cent cover) of each present species was noted. An exception was made with *Juncus gerardi,* as it always appeared in homogenous patches and was thus considered noteworthy. Agglomerative cluster analysis using Ward's algorithm based on Euclidean distances was performed using the Community Analysis Package v. 2.1 (Pisces Conservation Ltd., UK 2003) to put all the designated groups into units of similarity based on percent cover. This method is based on minimum variance, which means smaller percentage species will have greater weight.

Further characterization was done through 60 cm x 60 cm quadrats (n=298), spaced at 5 metre intervals along transects (n=50) oriented both perpendicular and parallel to the bayward edge and channels throughout the study area. Abundance was noted for each species present within the quadrat.

Two base points were gathered using a Carrier Phase Trimble 4700 differential global positioning system (DGPS) with a post-processing kinematic survey method (±3-5 cm horizontal and vertical precision). Coordinates were tied to the Nova Scotia survey control network through a local benchmark (monument NS#215056) and transformed to the International Terrestrial Reference Frame (ITRF 2000). The corrected survey points were then imported into ArcMap 9.1 (ESRI, Redlands, CA) geographic information system (GIS) and transformed to the Canadian Spatial Reference System, NAD 83 (CSRS98), and projected as UTM zone 20N. Elevation was then transformed from the NAD 83 ellipsoidal value to CGVD28 orthometric height (height above mean sea level) using the GPS·H 2.1 Geoid Height Transformation Program (Natural Resources Canada 2005).

The coordinates of quadrat points and vegetation groups were taken relative to the two base points using a Sokia Set 3000 Total Station (vertical and horizontal precision of ±3 arc seconds). Data was then imported into ArcMap. In ArcMap aerial photos and tidal channel shapefiles (Chmura and MacDonald 2006) were used to determine distance to the bayward edge and distance to nearest tidal channel.

Statistical Analyses

We analyzed data by detrended correspondence analysis (DCA), performed using CANOCO (Biometris, The Netherlands, 2006). To explain the variability between samples, vegetation data along with landscape data were analyzed under constrained direct ordination in the form of canonical correspondence analysis (CCA) in CANOCO. Only landscape variables that had probability values less than the Bonferroni adjustment ($ά < 0.05$) were included in the model. Unimodal methods were employed since the samples were heterogeneous (i.e. the longest gradient from DCA was greater than 4) (Leps and Smilauer 2003). Hill's scaling was used and scaling was focused on inter-species distances. Monte Carlo permutation tests with 1000 permutations were then used to test the significance of this model. Regression analyses on other variables were performed using SPSS 13.0 for Windows.

Results

Vegetation Zone Characteristics

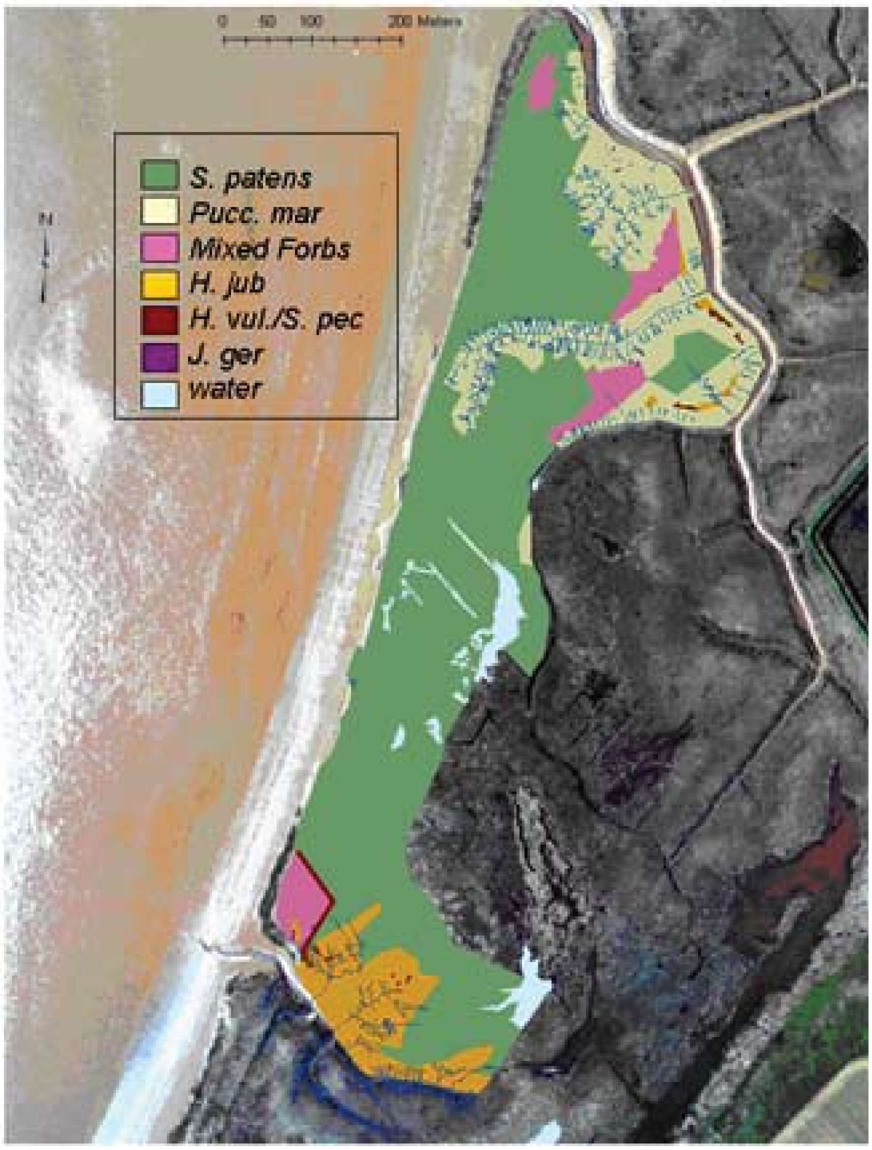
We mapped vegetation into five broad units: (1) *S. patens* dominant, (2) *Puccinellia maritima* dominant, (3) *H. jubatum* dominant, (4) *H. vulgare/ S. pectinata* dominant, and a group that has a mixture of different grasses and forbs such as *Solidago sempervirens, Limonium nashii, Glaux maritima,* and *Triglochin maritima* (5) (Figure 3). This map also shows patches of *Juncus gerardi*. Elevation, distance from the bayward edge, and distance from primary channels vary among the plant units (Figures 4 a, b).

Unit 1 (*S.* patens) encompasses much of the marsh, seen in green in Figure 3, and is fairly homogenous, with *S. patens* occupying greater than 90% of the cover, with several patches of *Triglochin maritima*. This also includes several wet patches dominated by *S. alterniflora.* These patches have a mean elevation of 6.19 m ±0.11 m), which is 0.32 metres below the mean elevation for this unit, and waterlogged soils were evident.

Unit 1 is present along all of the bayward edge, however it is not found by the side of any channels, with the exception of the head of the channel at the northernmost extent of the study site (Fig. 3). The zone has the second lowest mean elevation (6.51m ± 0.1; Figure 4a). The minimum distance from bayward edge ranges from 0 to 243 metres and averages 35 metres, with a SD of 85 m (Figure 4b). The distance from channels ranges between 0 and 32 metres, averaging 16 m ± 15 (Figure 4b).

Unit 2, dominated by *Puccinellia maritima,* is located alongside channels, generally in the northern section of the study area (though the species is present throughout; Figure 3). In this unit *S. alterniflora* borders channels, and an average elevation of 5.7 metres marks a transition to dominance (80 per cent) cover by *Puccinellia maritima.* Unit 2 has the lowest mean elevation (6.48 metres), but it has the largest range (0.95 m; Figure 4a). Its distance from the bayward edge varies considerably, with a range of 130 metres and averaging 85 m ±4. Distance from a channel however, never exceeds 14 metres and averages 8 m ±4 (Figure 4b).

Figure 3: Vegetation units for study area created in ArcMap with an aerial photograph background from June 2005 (Natural Resources Canada). Channels (in dark blue) are lined with *S. alterniflora*.

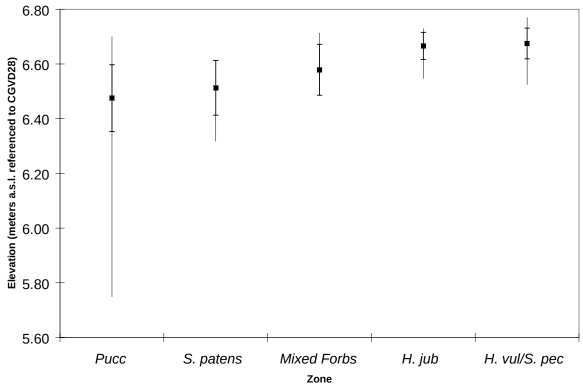


Unit 3 (*Hordeum jubatum* dominated) occurred as small clusters in the northern section of the marsh, but surrounds channels in the southern section of the study area, which is generally 10 centimetres higher than the northern section (Figure 3). This unit also includes a band of *S. alterniflora* that occupies the areas surrounding the creeks, while *Puccinellia maritima* and *H. jubatum* occupy areas further from the creeks at higher elevations.

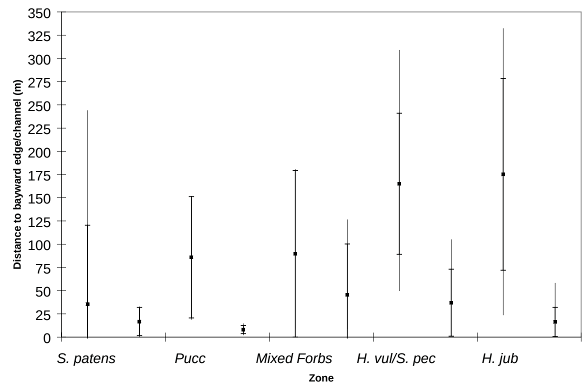
This unit has the second highest mean elevation (6.67 m ±0.05), though its range is smaller than the two zones at lower elevations (Figure 4a). *H. jubatum* is located ≥ 24 metres from the bayward edge, and can be as far as 332 metres, with a mean minimum distance of 175 m ±103.

Figure 4a: Mean elevation of the five plant zones where the black line represents the entire elevation range and the tick marks represent one standard deviation from the mean.
4b*:* Distance (m) from the bayward edge and the primary channel for the five vegetation zones. The black line represents the range while tick marks are one standard deviation from the mean.

a



b



Unit 4 occupies the highest marsh elevation. It occurs in distinct patches of 90 per cent cover of *H. vulgare* or *S. pectinata* (Figure 3). The unit is surrounded by either unit 1 or unit 2. The mean elevation is 6.67 ±0.06 metres, while the mean distance from the bayward edge is 165 metres and the mean distance from a channel is 37 metres, both with very large ranges (Figures 4a, b).

Unit 5 is either surrounded by unit 1 or unit 2, except for one surrounded by the old dyke (Figure 3). The dominant species in the unit, *S. patens*, only composes 42 per cent and there is a concentration of forbs such as *Solidago sempervirens* and *Limonium nashii*. These areas also occupy a higher elevation range than *S. patens* and *Puccinellia*, with a mean of 6.58 m ± 0.09 (Figure 4a).

Statistical Analysis of Vegetation Zone Data

The relationship of vegetation cover and landscape variables was then examined through CCA. Table 1 lists the variables used and their corresponding eigenvalue (λ) and probability (p) values. The relationship between landscape variable axes and vegetation is represented by cosign of the angle between them. Therefore landscape variables (arrows in biplot, Figure 5) are positively correlated with a plant species or landscape variable if the species/variable is in the same direction as the arrow, have no effect if they are perpendicular to each other, and are negatively correlated if they point in opposite directions to each other (Leps and Smilauer 2003). Longer arrows represent stronger correlations. In this model the minimum distance from bayward edge has the most influence, followed by mean elevation and minimum distance from a channel, all of which are significant.

Transect Data Analyses

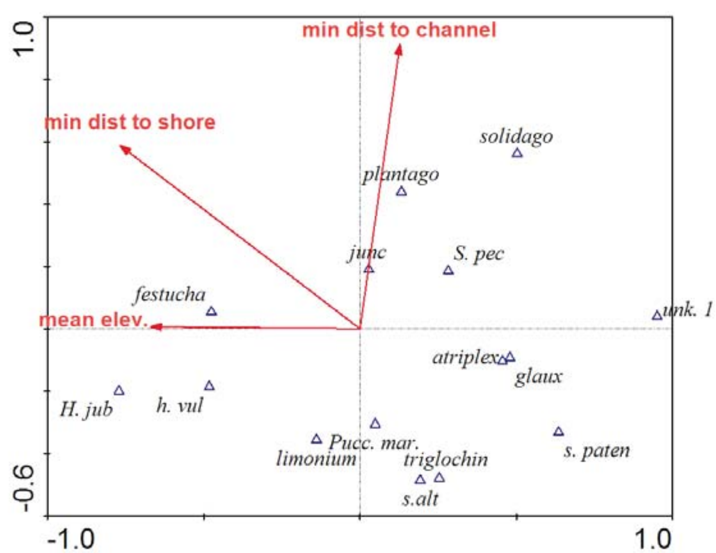
Quadrat data confirms the elevation hierarchy determined through unit mapping (Figure 6). *S. alterniflora* occupies the lowest areas, while the grasses *S. patens* and *Puccinellia maritima* are lower than forbs, and *H. jubatum* and *H. vulgare* occupy the highest elevations. The only exception is *S. pectinata*, which occupies a mean elevation lower than most forbs, whereas inuts containing this species occupied the higher elevation ranges. However, this species has a large range (1.58 metres) and was often found at higher elevations.

The importance of elevation relative to species cover was evaluated in CANOCO through CCA. Elevation explains 31 per cent of the total variance (p = 0.002), as opposed to 14 per cent derived from analysis of the larger scale map units. This is expected since the group data may not give a reasonable estimate of elevation, as the majority of points were taken at the edge of the zones.

Table 1. Statistical results of CCA ordination on vegetation cover in groups

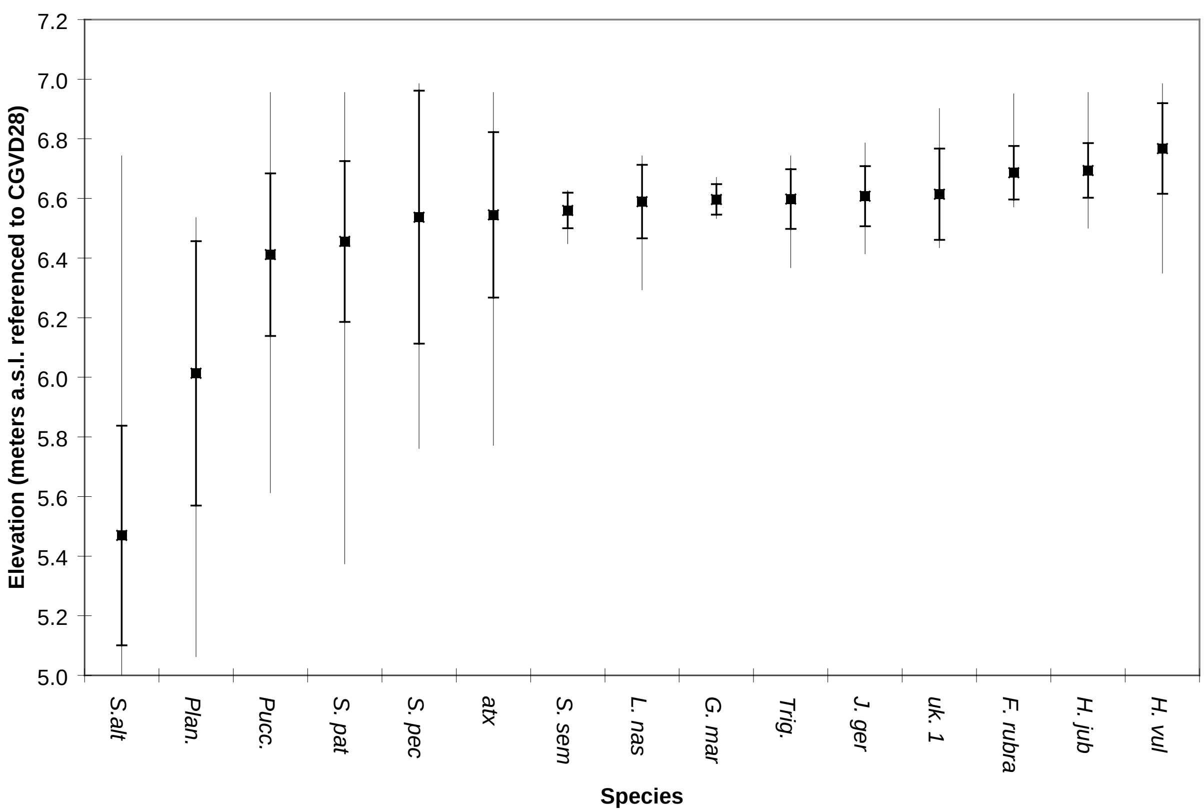
Variable	Var.N	Eigenvalue	P
Min to bayward edge	1.00	0.27	0.002
Min to channel	2.00	0.17	0.002
Mean elevation	3.00	0.14	0.006

Figure 5. Ordination biplot of landscape and species data from CCA ordination of groups' vegetation cover.



(*plantago= Plantago maritime; solidago = Solidago sempervirens; junc = Juncus gerardi; S. pec = Spartina pectinata; festuca = Festuca rubra; H. jub. = Hordeum jubatum; H. vul = Hordeum vulgare; limonium = Limonium nashii; Pucc. mar. = Puccinellia maritima; triglochin = Triglochin maritima; s. alt = Spartina alterniflora; atriplex = Atriplex patula; glaux = Glaux maritima; s. paten = Spartina patens; unk. 1 = Unknown species 1).*

Figure 6: Elevation (m) for all species found in quadrats. The black line represents the range and tick marks are one standard deviation from the mean.



(S. alt = Spartina alterniflora; Plan. = Plantago maritime; Pucc. = Puccinellia maritima; S. pat = Spartina patens; S. pec = Spartina pectinata; atx = Atriplex patula; S. sem = Solidago sempervirens; L. nas = Limonium nashii; G. mar = Glaux maritima; Trig. = Triglochin maritima; J. ger = Juncus gerardi; uk. 1= unknown species 1; F. rubra = Festuca rubra, H. jub = Hordeum jubatum; H. vul = Hordeum vulgare)

Conclusion

Initial results indicate that elevation, while a useful surrogate and statistically significant, cannot explain all plant zonation in the marsh. The distance from the bayward edge and distance from channels are both also statistically significant. This implies that the size of the marsh is important when predicting vegetation growth. To better get an understanding of how these findings will impact targets of restoration, it will be necessary to conduct a similar analysis on an undyked marsh of similar proportions on the head of Fundy.

Acknowledgements

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EFFECTS OF NUTRIENT ENRICHMENT ON FUNDY SALT MARSH VEGETATION

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Global use of inorganic fertilizers and fossil fuel combustion are causing an increase in deposition of atmospheric nitrogen and coastal development further adds to nutrient loads in local waters. What impact could this have on Fundy marshes? In New England increasing nutrient supply to salt marshes has been shown to reduce competition among marsh dominants and shift vegetation zones of tidal salt marshes. A fertilization experiment has been ongoing at Dipper Harbour, New Brunswick, to determine if Fundy marsh vegetation is also nutrient limited. This presentation reports on results of the first two years of an experiment in which fertilizer was added to plots of mixed vegetation straddling the transition between low marsh *Spartina alterniflora* and high marsh *Spartina patens*. Unique to Canadian marshes is the common dominance *Plantago maritima* in the middle marsh, and experimental plots included the transitions of this species with *S. alterniflora* and *S. patens*. For all species, growth in fertilized plots was more robust than in control plots, but height of *S. alterniflora* and *S. patens* in fertilized single species plots was greater than in mixed species plots where there was inter-specific competition. Interestingly, *Plantago* seemed to grow better in fertilized plots where it was in competition with grasses, than in plots comprised primarily of *Plantago* and other forbs. These preliminary results indicate that the *Spartina* grasses of Fundy marshes are nutrient-limited, but competition for nutrients may not be the driver for existence of the middle marsh *Plantago* zone.

AN EVALUATION OF THE ECOLOGICAL RESPONSES ASSOCIATED WITH THE SALT MARSH RESTORATION PROJECT IN MUSQUASH, NEW BRUNSWICK, CANADA

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Construction of dykes and subsequent draining of wetland has resulted in the conversion of 65% of the Upper Bay of Fundy salt marshes to agriculture. Recently, there has been increasing interest to promote the restoration of these lost systems. As salt marsh restoration activities increase, a better understanding of physical and biological processes and anticipated outcomes have become imperative. With the introduction of full tidal influence to the 38-acre property complete, Musquash Marsh was an ideal location to address some of these knowledge gaps. Ducks Unlimited Canada and Mount Allison University developed a salt marsh evaluation program to assess changes in geomorphology, vegetation and the animal community. Two adjacent salt marsh segments served as reference sites. Changes in surface elevation were monitored through marker horizons, placed in the marsh before the restoration, using differential global positioning systems (GPS). Changes to marsh hydrology, measured by low-level aerial photographs and differential GPS surveys of channel cross-sections, and the depth of tidal inundation, were measured using a water level recorder. Vegetation surveys were conducted to assess changes in vegetation height, density, and species composition. The avian community response to the restoration was evaluated. In addition, invertebrate surveys assessed the food availability in the restored salt marsh. Preliminary results of these variables were discussed.

Session Eight

GULF OF MAINE AND BAY OF FUNDY MAPPING: INTEGRATION OF BIOLOGICAL INFORMATION INTO SEAFLOOR MAPPING

Chairs: Brian Todd, Geological Survey of Canada, Dartmouth, Nova Scotia

and

Kate Killerlain Morrison, Massachusetts Office of Coastal Zone Management, Boston, Massachusetts

Session Eight Summary

Brian Todd and Kate Killerain Morrison, Rapporteurs

The following points and recommendations, in no particular order, were made during the talks and discussions:

1. Backscatter (from the bottom) can give a wrong impression because it is so surficial.
2. Minimum standard may need to be higher than was presented in Tyrrell's presentation for transition areas.
3. Minimum mapping units may be identified for different areas–nearshore/offshore, etc.
4. Habitat map should be answering a particular set of questions–with different scales, it is difficult to have "a habitat map".
5. GOMMI advocates benthic habitat mapping for planning purposes–not one size fits all.
6. Possibility of third party using the maps for a different purpose. Government maps need to be cognizant of accuracy to avoid liability. Disassociate the theme from the base map, so can claim expertise in the theme only.
7. Need to map errors/uncertainty as well, if you cannot clean them up prior to publication. The user community needs to see a mosaic. Need to also remember that "errors" have errors.
8. Isn't a habitat map the same as sum of species maps?
9. Movement of material? Effects of fishing? These are different thematic maps for planning–build around assessment of impacts.
10. Are we going beyond the initial design/utility of the seafloor maps? We lack the synoptic view- what are the general characteristics of the offshore environment, and what is their ecosystem function? Habitat maps would help us get there, but habitat maps would not be used as much as general surficial ones.
11. Should we spend time thinking about habitat maps, or the correct use of the surficial sediment maps?
12. Need to challenge this: conduct a cost/benefit analysis. As a community of biologists, is this how we would like to move forward? Perhaps we need to rethink GOMMI's original goal of creating habitat maps as a fourth product.

THE GULF OF MAINE MAPPING INITIATIVE: A REGIONAL COLLABORATIVE EFFORT

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Detailed maps of the seafloor are critical tools to help implement ecosystem-based management of marine resources. The Gulf of Maine Mapping Initiative (GOMMI) is a partnership of governmental and non-governmental organizations in the United States and Canada, whose mission is to map the entire Gulf of Maine basin. GOMMI's strategy is to facilitate communication and collaboration within the mapping community, coordinate ongoing mapping efforts, facilitate new projects in priority areas, and make maps and data widely available to users and stakeholders.

The emergence of advanced acoustic technologies coupled with groundtruthing (video and photographic imagery, and geological and biological sampling) now allows researchers to rapidly survey large areas of the seafloor and produce high-resolution maps. GOMMI's goal is to produce four map products: seafloor topography and backscatter maps based on acoustic surveys; and interpretive surficial geologic and benthic habitat maps that incorporate biological and geological groundtruth information.

GOMMI's approach is to simultaneously address the needs of coastal and offshore stakeholders by mapping prioritized areas in both regions. At recent GOMMI workshops involving scientists, managers, and stakeholders, participants identified priority areas for 2006–2008 as the Bay of Fundy, Casco Bay, Platts Bank, Cashes Ledge, and northern Georges Bank.

Comprehensive seafloor mapping of the Gulf of Maine is an ambitious undertaking. Success will require creative collaborations between researchers and managers representing government, academia, and the private sector. A collaborative approach, embraced by GOMMI, will help build the base of knowledge required to effectively manage marine resources within the region.

MULTIBEAM SONAR MAPPING OF THE BAY OF FUNDY SEA FLOOR

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Mapping of selected areas of the sea floor of the Bay of Fundy using multibeam sonar has been underway since 1992. This large-scale (small area) mapping investigated local geology, biology and oceanography. Large sediment bedforms were discovered in Minas Channel, mussel bioherms were imaged near Ile Haute, extensive areas of pockmarks were revealed in Passamaquoddy Bay and repetitive surveys of offshore disposal sites near Saint John mapped sediment dispersal pathways. The demand for small-scale (large area) mapping, coupled with technological advances in survey systems, culminated in 2006 with the launch of a new, three-year regional sea survey to map the Bay of Fundy sea floor from the approaches in the southwest to the inner bay in the northeast.

This new mapping is a national priority under the Oceans Action Plan announced in the 2005 federal budget. The work is led by Natural Resources Canada in partnership with the Canadian Hydrographic Service and Canadian universities. The resulting 1:50 000 scale maps will be released as part of the new NRCan national marine map series and will include sheets of sea floor topography, backscatter strength, and surficial geology. In selected coastal regions around the bay, the marriage of airborne topographic and bathymetric survey data with ship-borne data will provide a seamless digital elevation model across the intertidal zone. The Bay of Fundy maps will be the crucial scientific underpinning for integrated ocean management.

USING BOTTOM TYPE AND WATER DEPTH INFORMATION TO PREDICT BYCATCH SPECIES IN A SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) FISHERY

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The sea scallop (*Placopecten magellanicus*) fishery in Southwest Nova Scotia's Scallop Fishing Area 29 has had full monitoring in terms of annual surveys, observer coverage, catch sampling, and satellite monitoring systems since it began in 2001. A three-year joint project involving the scalloping fleet, Natural Resources Canada, and Department of Fisheries and Oceans Canada was launched in 2002; all parties helped fund multibeam sonar acoustic mapping of the sea floor and associated scientific work. High-resolution maps of bathymetry, acoustic backscatter and surficial geology have been produced. In addition, benthic data were collected using photographic and video equipment to analyze the distribution of benthic assemblages in relation to bottom type.

This scallop fishery occurs in the richest lobster (*Homarus americanus*) grounds in Canada (Lobster Fishing Area 34). Fishery observer coverage was implemented to measure lobster bycatch. Other fish and invertebrate species were also recorded by observers. We fitted a multinomial generalized linear model to these observer data to predict the probability of a particular species, or groups of species, occurring as bycatch in the scallop fishery as a function of bottom type, fishing area, and water depth. These predictions were compared with the distribution of species assemblages identified by photo and video records. This model shows promise for evaluating impacts of the scallop fishery on species biodiversity in an area. It is expected that adjustments to the scallop fishery resulting from this study will improve scallop catches, minimize gear losses, and greatly reduce bycatch and damage to epibenthic communities.

GOMMI'S APPROACH TO GROUNDTRUTH SURVEYS, DATA ANALYSIS, AND INTERPOLATION FOR BENTHIC HABITAT MAPPING

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The Gulf of Maine Mapping Initiative (GOMMI) aims to obtain benthic habitat maps for the entire Gulf of Maine to provide a geospatial framework for marine resource management. To maximize the value of regional seafloor maps, groundtruthing survey designs should meet or exceed minimum standards. Here we present a draft plan for an upcoming survey to generate a discussion within the mapping community on groundtruthing protocols and standards.

In 2000, a 72 square kilometre area (east of Cape Elizabeth and southeast of Peaks Island), representing approximately 17 per cent of the seafloor of Casco Bay, Maine, was surveyed with high-resolution multibeam sonar. The resulting backscatter and bathymetry maps have been made available to GOMMI and will be used to plan a 2007 groundtruthing survey. The study area will be stratified according to backscatter signatures and depth. Within each distinct stratum, sampling stations will be located randomly with a minimum of one sampling station per square kilometre. Benthic sampling will include grab samples for biological and geological analysis, as well as still photos taken with a sediment profile imaging (SPI) camera. Water depth, sediment grain size, species composition and density will be used to classify the benthic habitat type at each station. Interpolation of the point groundtruthing data into polygons of distinct habitat types will be accomplished using spatial analysis. Digital maps and data will be disseminated to coastal managers and community stakeholders via GOMMI's Web site.

A discussion of recommendations for standardizing GOMMI groundtruth survey design and data analysis will follow this presentation.

Session Nine

MONITORING AND MANAGEMENT: COMMUNITY-BASED PROGRAMS

Chairs: Stephen Hawboldt, Clean Annapolis River Project, Annapolis Royal, Nova Scotia

and

Patricia Nash, Quebec-Labrador Foundation, Lourdes-de-Blanc Sablon, Quebec

Session Summary

Patricia Nash, Rapporteur

A number of questions were raised during discussions, useful for the final "moving forward" session:

1. How can there be better collaboration between the community and government/academic researchers?
2. Where can the fishing community play a role in providing information on long-term trends or changes that they observe?
3. How can community groups better network and share information on their initiatives?
4. How can we prevent similar programs from advancing, without any connection or identified lead i.e. to reduce unnecessary duplication?
5. Why isn't private industry a partner in information collection? For example, private industry collects near-shore habitat data for 2,000 km of their license – is this information not useful? (*Ed.* – this refers to the fishing industry).
6. To improve effectiveness and efficiency, would it not make sense to include all interests when collecting mapping data?
7. Why does the fishing industry feel that the scientific community does not respect their input?

SHOULD RESEARCH ON THE MARINE ENVIRONMENT USE THE TRADITIONAL KNOWLEDGE OF THE FISHING COMMUNITIES?

Kemp L. Stanton[1], Robert W. Morsches[2] and Ashraf Mahtab[3]

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Abstract

The marine research financed by the government and industry has improved the efficiency of fishing, but it ended up as a detriment to the ecosystems of the oceans. The recent research that focuses on specific species, although interesting and necessary, is of limited use unless it is integrated into an overall ecosystem approach that uses the traditional knowledge of the fishing communities. The traditional knowledge may not have produced award-winning papers, but, in many cases, this knowledge is more relevant and practical than the results of an isolated laboratory test. For example, dragging in the early stages of the fishing industry could only be done on a very smooth bottom of the ocean. However, with the research-improved technology, which resulted in the use of “rock hopper nets”, it became possible to drag the previously undisturbed areas. This was a mistake. The fishing communities knew that there were few stable habitats left for regeneration of the marine ecosystem. There are instances where weak or unsubstantiated data are inputted to computer models for predicting the future events in the oceans. With the passage of time, these models become generally acceptable and harder to modify, but their results become increasingly distorted. We believe that for the scientific community to remain relevant, it should be willing to accept the idea that there is great value to be gained by researching and using the knowledge and wisdom of our fishing communities.

Introduction

Scientists do not have “baseline data” or knowledge of the marine surroundings and conditions, but *traditional knowledge* does have the facts and information that go back 150 years. Even now, researchers are focused on a narrow view of species over a small area of ever-changing ecological systems. On the other hand, mariners (fishermen and tourism operators) are focused on the entire system of marine life (see Figure 1). The following sections of this paper deal with the traditional insights into marine life and the approach for its use in managing the marine environment. The subjects that are not addressed here include the progressively increasing impacts of noise, shock waves and light.

Insights Into Marine Life

Creatures like whales, pollock, and cod are known to feed off krill and herring; their excrement provides feed for the creatures at the bottom (see Figure 2). As much as 70 to 80 per cent of the biomass in areas of sand and mud bottoms may well consist of worms, crustaceans, shrimp, and other creatures that we refer to as “sand fleas”, which at times seem to disappear into the bottom. The sand fleas provide food for some creatures and feed on some others (see Figures 2 and 3). If the cod, pollock, and other large predators have been removed, their excrement is no longer available to enrich the feed of the creatures at the bottom. This affects the entire food chain.

Figure 1. Scientific versus traditional views of marine life

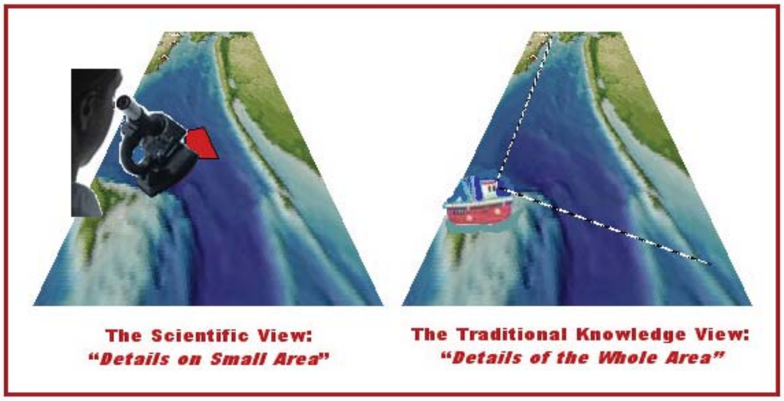


Figure 2. Marine life and food chain

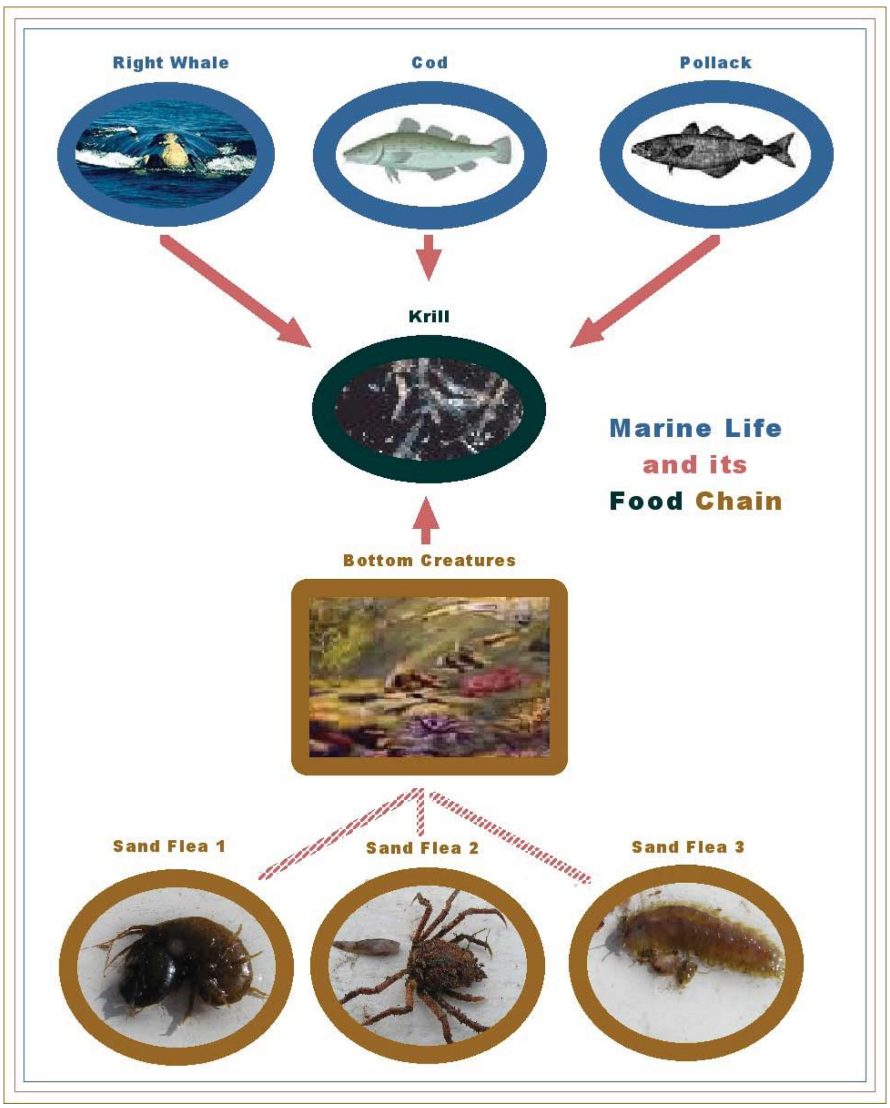


Figure 3. Changes to marine life food chain

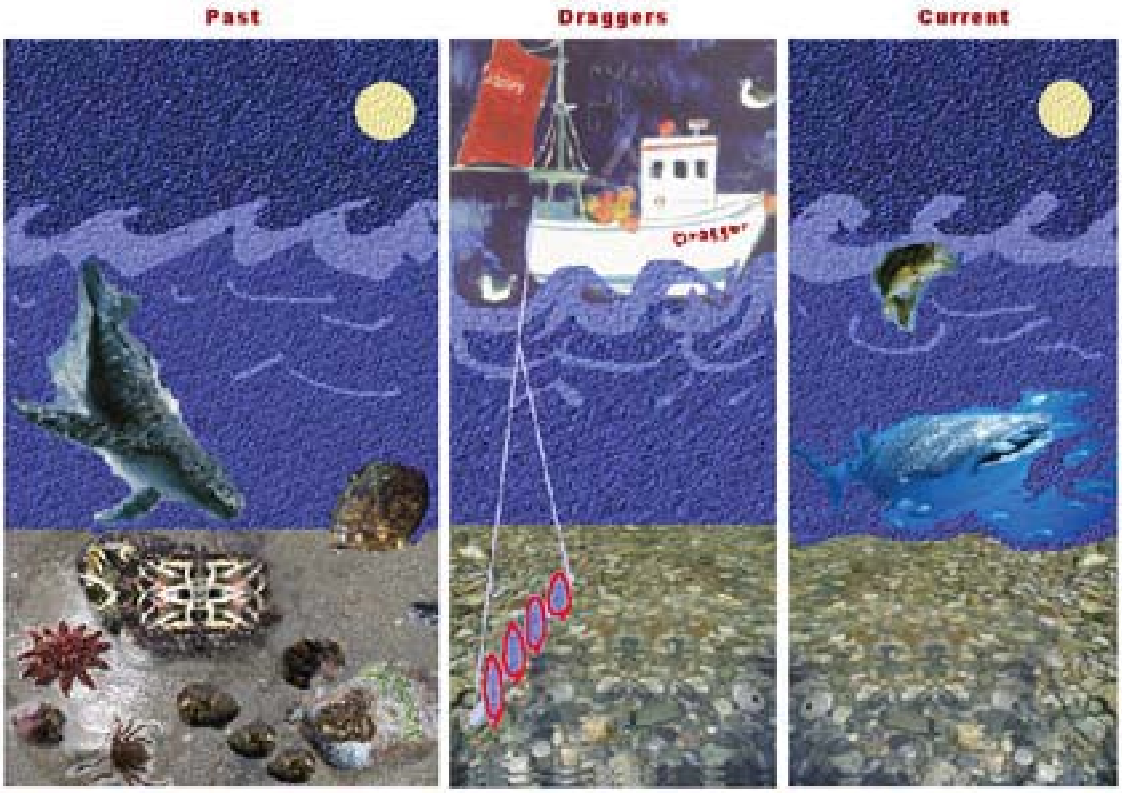


Figure 4. Example of weir fishing in the Bay of Fundy

The effects of the destruction and changes that have taken place on the bottom of the Bay of Fundy over the past 40 to 50 years have been observed inside the stomachs of the fish we have been catching. When we clean up the boat, we no longer find meat rocks (anemones). We also suspect that the destruction of mussel beds on ridges in the Bay of Fundy may also result in increasing the number of soft-shelled lobsters.

Research that is done often relies on data gathered through the use of draggers and seiners, because the process is easy and comfortable. But the gear and technology changes used today are significantly different from those used 30 to 40 years ago; the resulting information is misleading. Comparing the results from a hand-line or weir fishery may be more informative (see Figure 4).

Lobstering is being gradually pushed to the limit and beyond by the failure of regulators to acknowledge and act on the huge increases in the lobstering effort. Before imposition of the regulated trap limits, almost all boats fished 200 or fewer traps, the regulated limit is now 400, but many boats fish 600 to 1,000 traps. The season was increased by 26 days by allowing Sunday fishing. Traps have grown much larger; boats are now four to five times as large (see Figure 5); and they fish day and night. The use of trawls with multiple traps offshore has also increased the fishing effort and the fishing area. However, the increase in the yield is not in proportion to the increase in effort and area.

The fishermen who fish by the rules and regulations see that those who violate the regulations are usually rewarded for their actions. "Grandfathering-in" of multiple licenses and calling a 50-foot boat a 45-foot boat are avenues for overfishing. Few of the fishermen who use boats for fishing 600 to 1,000 traps are ever charged or convicted.

The data are inputted to the computer models, and even too much of the written research, is derived from lies, half-truths, and misconceptions. The conclusions derived from these models and expressed in the research papers are useless, especially for developing the fishing regulations. In other words, "Garbage in, Garbage out." Fishermen have contributed to this by providing misinformation because of self-interest or their dislike for the arrogant attitude of researchers and regulators. Many times the fishermen have tried to provide insights and information only to be told that the "office jockey" knows the oceans better.

Figure 5. Comparison of older and newer lobster boats

Approaches For Using Traditional Knowledge

Mutual Trust and Respect

Trust and respect cannot be built between and among researchers, fishermen, and environmentalists until each group realizes that people who do not belong to any of these groups make most of the decisions. As long as researchers, true fishermen, and responsible environmentalists work separately and fight among themselves, there is no effective opposition to the bureaucrats and corporate interests whose decisions and deceptions have brought us into the mess we now find ourselves experiencing. Ministers of Fisheries and Environment come and go like "*cold showers*", but the same bureaucrats stay around like "*cancer*", eating away at the ocean's ability to sustain itself. Together, recognizing each other's strengths and weaknesses, we could at least bring honesty, common sense, and real science to the public's attention and maybe get new and different civil servants without corporate interests.

Examples of the Use of Traditional Knowledge

Use of Prior Information

Traditional knowledge could be used to help researchers and scientists to examine prior information and conclusions to locate and correct the many errors and omissions. If there is a commitment to use the precautionary principle and ecosystem approach, we believe that the use of fishermen's expertise and approach is indispensable. If this approach is not intended to be used, and is considered just propaganda, then tell the fishing communities now.

- When ports are opened or changed, causeways, bridges, or terminals are built, and seismic testing or oil drilling are done; the fishermen in the area must be consulted and their ideas and information must be taken into account seriously and considered as valid or important as the information gathered from any other source. This approach could have prevented much of the damage at Fox Harbour, the Strait of Canso, and Northumberland Strait. A lack of attention to the traditional knowledge has also caused the decline in the snow crab off Cape Breton.
- There needs to be proper recognition of the fact that moving vast quantities of sand and gravel from the bottom of the ocean causes a devastating effect on the ecosystem over a very large area. Sand is an extremely productive habitat in spite of what many researchers think. Sand, gravel, and even boulders can be moved by the prop-wash from ships in shallow water. Churning or "scouring" of water and seabed causes conflict with lobster traps. The turbulence from ship-props churning the water, when leaving a terminal, disturbs the siltation from the churning site to the coastline, displacing tons of material (sand, seabed fauna, etc.). This is an extremely serious event, especially if it happens with consistent frequency over a period of time (see Figure 6).

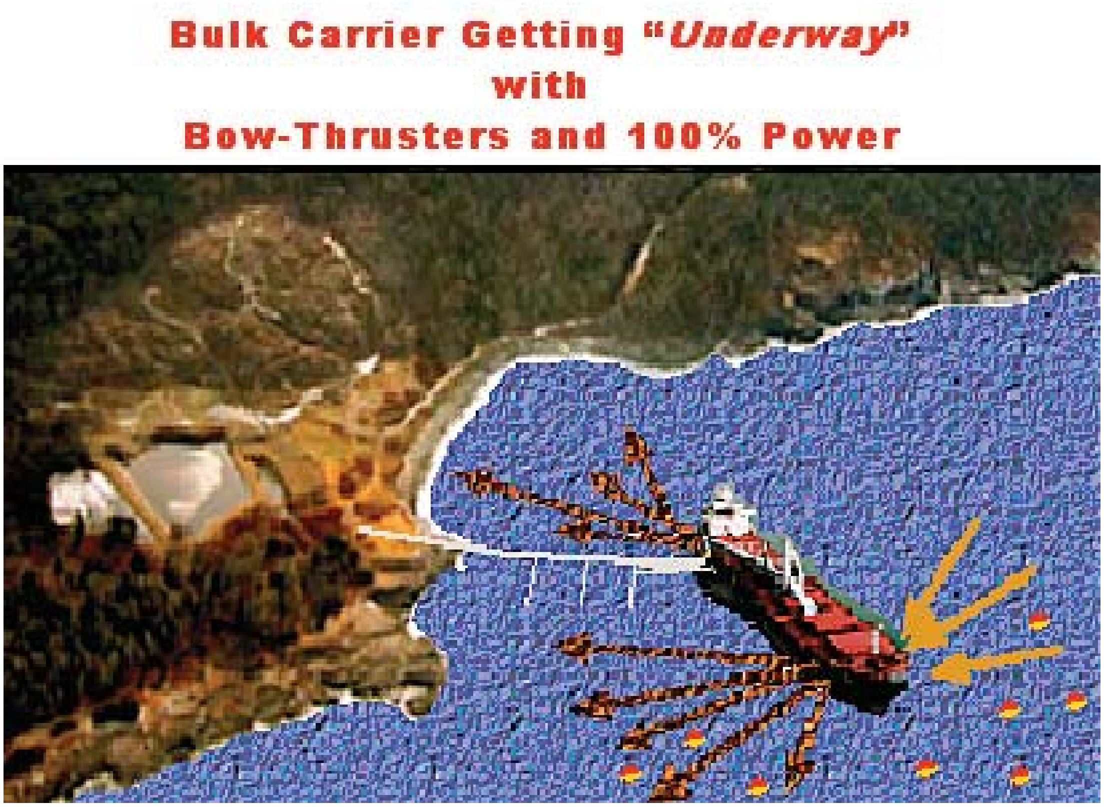
Filling-in the Gaps in the Knowledge

Traditional knowledge, when used in the proper way, can provide a means of filling in the gaps in the information about what was normal for an ecosystem and its parts for as long as 70 years ago. For periods over 70 years, the traditional knowledge is derived from the history that is passed on by word-of-mouth.

- Fishermen can remember and tell about the changes to the marine bottom and the species: their spawning patterns, distribution, and abundance. There is also the ability to catch fish by the traditional methods, like hook and line. The ability to catch fish by dragging has a lot to do with the type of gear and horsepower. "Hand-lining" and "long-lining" had more to do with the abundance of fish.

- Weirs can provide a very accurate picture of the abundance of and the decline in species close to the shoreline over a long period of time.

Figure 6: Disturbance of marine environment by bulk carrier



Conclusion and Recommendation

Most subjects in marine research are presently analyzed by focusing on small and isolated samples. In order to make the research comprehensive, the entire ecosystem needs to be addressed over a long period of time. Many fishermen have fished the waters over long periods of time. They have the traditional knowledge, which can and should be used as input to scientific research that will produce credible and useful results.

Editors' note: This paper is a statement of opinion of the authors.

MARINE HABITAT MANAGEMENT---OPTIONS FOR CONSERVATION PARTNERSHIPS

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Abstract

The Gulf of Maine Council on the Marine Environment's Habitat Conservation Subcommittee has been focused on developing the pieces needed for an overall marine habitat conservation strategy for the Gulf of Maine region. The process involves improving the understanding of habitat types and their ecological relationships, activities impacting these habitats, and the state of science related to management options for addressing the impacts on marine habitats.

So far the sub-committee has assembled an inventory, *Tools for Habitat Conservation in the Gulf of Maine,* intended to provide a review of all of the known, long-term and regional habitat conservation activities taking place in the Gulf of Maine at the time that the study was published. In the winter of 2005, the sub-committee released the *Gulf of Maine Marine Habitat Primer.* This provides an overview of marine habitat characteristics, ecological functions, economic and recreational values and management considerations, intended for anyone interested in the region's coastal and offshore habitats. The sub-committee also compiled a *Catalogue of Ecosystem Management, Impact Assessment and Mapping Initiatives for the Gulf of Maine*, giving a "snapshot" of projects which have been, or are being carried out in the Gulf of Maine area. This was a preparatory document to a workshop held by the sub-committee in the fall of 2005 where sixty-two participants worked in small groups to define and prioritize human impacts to six habitat types (rocky, sandy, muddy, seagrass, kelp, shellfish beds/reefs) and identify ecosystem-based management strategies to address human impacts on a regional scale.

The Marine Habitats in the Gulf of Maine: Assessing Human Impacts and Developing Management Strategies Workshop Proceedings identifies the following categories of management options:

- Focusing management
    - Ecosystem-based management
    - Addressing cumulative impacts
    - Addressing non-point source pollution
    - Addressing fisheries issues
- Informing Management
    - Mapping needs
    - Research needs
- Improving Stewardship
    - Stakeholder and local involvement
    - Messages for the public

This paper will discuss the options that have been further explored, how they can be utilized by the Gulf of Maine community, and the resources or additional research required to optimize their conservation potential.

Introduction

The Gulf of Maine Council on the Marine Environment's Habitat Conservation Subcommittee (HCSC) was created to focus on activities that assist in maintaining the integrity of coastal zone ecosystems from the landward extent of the coastal watersheds to the further marine boundaries of the Gulf of Maine. It is seen as the focal point for Gulf-wide coastal zone habitat conservation initiatives pursued by the Gulf of Maine Council's state, provincial and federal jurisdictions. The committee's goals are to:

1. Serve as a forum for sharing habitat conservation information and methods;
2. Identify guidelines and models for conservation;
3. Identify and promote conservation activities in identified habitats or habitats that have been restored;
4. Identify research needs in relation to coastal zone conservation;
5. Coordinate activities with other GOMC subcommittees.

Membership of the sub-committee includes representatives from each jurisdiction within the Gulf of Maine and from federal, state and provincial agencies as well as scientists, non-government organizations (NGOs such as Audubon, Ocean Conservancy, The Nature Conservancy) and academics.

While the sub-committee is mandated to work in a large area, the entire Gulf of Maine, including its coastal and watershed components, it has chosen to concentrate on pulling together the knowledge about nearshore marine habitats. The HCSC focus is to design pieces so that management decisions and activities respect the ecological characteristics and constraints of the nearshore habitats.

Background

In February of 2005, the sub-committee released the *Gulf of Maine Marine Habitat Primer*. This document describes selected nearshore habitats and was designed as a tool to assist managers and the public to better understand those habitats, their ecological function, economic and recreational values, and management considerations.

The Primer set the stage for a workshop in the fall of 2005 that the subcommittee sponsored in partnership with The Nature Conservancy. The subcommittee's intent for the workshop was to assess human impacts on habitats and to develop management strategies. The Nature Conservancy used the workshop as a step toward developing a key ecological attributes framework for the marine environment.

Sixty-two people participated in this workshop and they represented the type of partnership that HCSC encourages and needs in order to get its work done. Participants included people with a range of interests. They came from the fishing communities, NGOs, government and research institutions.

The management options identified at the workshop fall into the categories of focusing management, improving stewardship and informing management. Activities were identified under each of these categories.

Under "focusing management" the following activities were recommended:

- Transition to ecosystem-based management
- Address cumulative impacts
- Address non-point sources of pollution

- Address fisheries issues

Under “improving stewardship”, the activities recommended included:
- Increasing stakeholder and local involvement
- Developing effective messages for the public

Under “informing management”, recommendations were:
- Develop and improve maps
- Fill research gaps

Context for Moving On

The new Gulf of Maine Action Plan 2007–2012 has provided the opportunity to incorporate some of these recommendations that will be implemented by a host of players in the Gulf of Maine. Not all of the activities related to the workshop recommendations are part of the agenda of the Habitat Conservation Subcommittee, however, and will not be acted upon by HCSC.

Under focusing management, recommendations from the workshop are incorporated into the action plan as:

- Develop a framework for ecosystem characterization that integrates existing chemical, physical and biological knowledge as well as human use activities.

This is an activity that the HCS does not feel is within its mandate since it involves the larger ecosystem perspective rather than the habitat component only. The subcommittee recognizes that habitat must be an integral part of ecosystem management and is prepared to partner with the lead on this activity.

- Deal with cumulative impacts within the context of ecosystem-based management.

This translates in the action plan to: “Document scientific thresholds and metrics for maintaining nearshore coastal and marine habitat integrity”. This is an activity that the HCS is eager to undertake. It is part of the continuum of pulling knowledge together, publication of the Primer being the first piece, the workshop the second, classification being the next and now, with this project, the subcommittee hopes to identify the point at which the habitat integrity fulcrum sways.

Under “improving stewardship”, recommendations from the workshop are incorporated into the action plan as:

- Complete documentation (e.g., identify habitats and associated species) of existing coastal/marine managed areas in the Gulf of Maine.

The subcommittee recognizes that there may be gaps in the documentation of managed areas on the Canadian side of the border. We also recognize that any Ecosystem Overview Assessment Report (EOAR) of the Bay of Fundy/Gulf of Maine should include this information. We are prepared to take the lead in developing this information and anticipate its need for the EOAR.

- Synthesize and display existing regional monitoring data on salt marsh and seagrass habitat indicators.

  This project is being worked on by the Habitat Monitoring Subcommittee.

- Identify most significant conflicting policies and programs that are impeding an ecosystem-based approach and the effects of these conflicts include an evaluation of the cumulative effect that these programs and policies have on ecosystem services. Suggest ways to reconcile these conflicts and offer a vision for the Gulf of Maine that builds on current statutes.

  This activity will result in a workshop planned for March of 2007.

- Complete the development of Human Use Atlas that documents and assesses uses in the marine environment.

  HCSC is interested in doing this but perhaps not in year one or two of the new action plan.

- Support and enable existing programs that are implementing elements of an ecosystem-based approach through professional development, agreements, and capacity building (e.g., technical assistance, workshops, training, matching funds, etc.).

  This will be taken on by Environment Canada and the Environmental Protection Agency.

Under "informing management, recommendations from the workshop are incorporated into the action plan as;

- Facilitate communication about sub-tidal habitat classification methodologies in the GOM and work toward a consistent approach.

This is the primary project that HCSC will put efforts toward in the next few years. The subcommittee recognizes that there is considerable work being done in the Gulf of Maine and its adjoining areas on marine habitat classification.

- Support the mapping of priority areas (e.g., Cashes Ledge, Platts Bank, Casco Bay, northern Georges Bank) identified in the Gulf of Maine Mapping Initiative 2-year work plan.

  This activity is being taken on by the Gulf of Maine Mapping Initiative.

- Develop, track and report on habitat integrity indicators at multiple scales, including effects of climate change.

  The Ecosystem Indicators Project (ESIP) has been assigned this task.

- Establish and implement an integrated, hierarchical framework (e.g., broad-scale, rapid assessments, high resolution/intensive) for indicator-based monitoring of high priority coastal/marine habitats (e.g., seagrass, salt marsh, and nearshore sub-tidal soft bottom)

Although presently there has been no group assigned to this task, it may fit into the ESIP agenda along with one of the monitoring groups.

All subcommittees and working groups of the Gulf of Maine Council have identified their agenda for year one and two of the next action plan. For HCSC, that includes facilitating communication about habitat classification methodologies, completing documentation on existing coastal/marine managed areas, and documenting scientific thresholds for maintaining nearshore habitat integrity.

The HCSC priority is habitat classification methodologies and identifying the place where the subcommittee could be of most assistance in this field where progress and activity is progressing rapidly. It has turned out to be more of a challenge to find our niche in this task than the subcommittee had anticipated.

The Massachusetts Office of Coastal Zone Management conducted a feasibility study to identify classification methodologies that might be relevant to that state and now will pilot selected methodologies to determine applicability. A public discussion to explain the methodology and gain acceptance for one or the other of the types piloted will be part of the process.

In Canada an exercise is being undertaken for the Quoddy Region of the Bay of Fundy. In addition, Peter Auster, at the University of Connecticut with EPA funds, is developing a classification system to be utilized for Long Island Sound.

At this time, the HCSC hopes to take the work done by Massachusetts one step further by acting on two of the recommendations from the paper commissioned by that state. The subcommittee intends to identify the methodologies that are presently being developed in order to have up-to-date information on this expanding research activity and to identify the researchers pursuing the issue.

Next, the subcommittee will host a forum to bring the researchers together. Discussion among the researchers and developers of methodologies would be a way to: clearly identify the critical information requirements for classification; discuss lessons learned in applying the methods; obtain clarification and possibly consensus on the intent and usage of classification; and discuss how to use the methods most effectively for management.

HCSC vision is that ultimately, a methodology is agreed to by the Gulf of Maine community that gives us enough information about habitats and their structure that managers can answer questions related to the impact that an activity, project or group of projects will have on the integrity of the specific habitat systems. The method needs to be usable to managers and planners within governments, by local communities that do planning both in the marine environment and on land, and by groups involved in improving environmental quality.

Experience has shown that there is one guideline that should be followed as methodologies are developed: it should be simple and understandable and as inexpensive as possible while giving a level of accuracy and confidence to users for the question they need answering. Frequently methodologies require information that is not available and that may be costly or time consuming to obtain. It is important that the NGOs, technicians, researchers, and managers utilizing the method can clearly see how it is built and how it provides answers. The method will answer a specific but broad question and in doing so, does not exclude the use of other methods to answer different questions.

Creating Partnerships

It is important, particularly at this stage of Gulf of Maine Council history, where resources need to be effectively pooled to achieve progress, that partnerships be fostered and fully utilized. Given that HCSC is composed of volunteers who, because of interest or related work are participating, it is a challenge to make the essential link with partners. However, as we work on classification methodologies, partners naturally fall into place.

The Massachusetts CZM has an interest in the research and management discussion on criteria for an effective methodology as that state moves forward on classification pilot projects. It is supportive of ensuring that there is transferability between the work being done there and the larger Gulf of Maine area.

The Gulf of Maine Mapping Initiative (GOMMI) is doing some of the basic work required for habitat classification, such as multi-beam bathymetric data collection. That group is on board to partner with HCSC on the project. The forum may identify areas where it is critical that more multi-beam work be conducted.

The HCSC is fortunate to have members who are among those researchers or collectors of data that form the cornerstones of methodologies. For instance, Art MacKay did an extensive examination of assemblages in the Bay of Fundy. This work is incorporated into the approach being developed at the Biological Station in St. Andrews by Maria-Ines Buzeta, another subcommittee member, and others. The subcommittee has a Scientific Advisory Team, one member of which is Peter Auster. And there are others on the team doing work that feeds into classification methodologies.

Documenting scientific thresholds and metrics for maintaining nearshore coastal and marine habitat integrity has some natural partners within the Gulf of Maine Council working groups, including the following:

Contaminants Monitoring Committee
Ecosystem Indicator Partnership
Nutrients Task Force
Sewage Management Committee
Science Translation

The agencies or other organizations that have an interest in this topic include the Canadian National Program of Action (NPA), Environment Canada (EC) Environmental Protection Branch, Department of Fisheries and Oceans (DFO) and its research and habitat divisions, and the National Oceanic and Atmospheric Administration (NOAA).

As we work toward completing the documentation of the existing coastal and marine managed areas in the Gulf of Maine, we will be creating an information piece to help the public and managers have a better understanding of usage and management of marine areas including characteristics that may need to be protected. We will be partnering with fisheries and conservation agencies, DFO, NOAA and sanctuaries. This activity will provide an excellent chance to learn of each other's activities and build opportunities for future collaboration.

Conclusion

The Habitat Conservation Subcommittee has an interesting few years ahead. In the end, HCSC believes that three goals will have been achieved:

- The toolbox for effective ecosystem-based management of nearshore habitats will have been enlarged.
- There will be an increased understanding of nearshore habitats and their critical components.
- There will be increased communication and collaboration among agencies, researchers and others interested in nearshore marine habitats.

THE GULF OF MAINE INSTITUTE (GOMI)

John P. Terry

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Organization Mission

The Gulf of Maine Institute's mission is *to touch, move and inspire youth to be stewards of the Gulf of Maine and its watershed***.**

Background

The pressing social issue our current work addresses is environmental degradation. What can be more crucial to human survival and development than clean earth, air and water; and how we preserve and share these necessities? To whom is this more crucial than future generations? The Gulf of Maine Institute (GOMI), a six-year-old private international non-profit, addresses these questions by preparing today's youth to be tomorrow's stewards.

History

In six years we have moved GOMI from a fledgling idea to a real organization. We are now a remarkable bioregional network composed of reliable volunteer partners including university scientists, public schools teachers, environmental groups, concerned citizens and government officials. This partnership has 1) developed highly effective methods for training teams to think bioregionally and lead locally, 2) raised funds to conduct five residential summer community based initiative (CBI) workshops and additional funds for academic year/local projects, 3) recruited highly qualified, volunteer, science faculty for the five summer CBI workshops, 4) provided technical support to CBI teams; 5) trained and supported 19 CBI teams with a cascade effect of 4,000 people, and 6) established a Web site at www.gulfofmaineinstitute.org.

Organization

GOMI is organized into three distinct initiatives diagrammed in Figure 1 below. The Community Based Initiative represents the most developed initiative to date and it will be the focus of this discussion. Activities begun within the other two initiatives are briefly discussed below.

Teacher Training Initiative

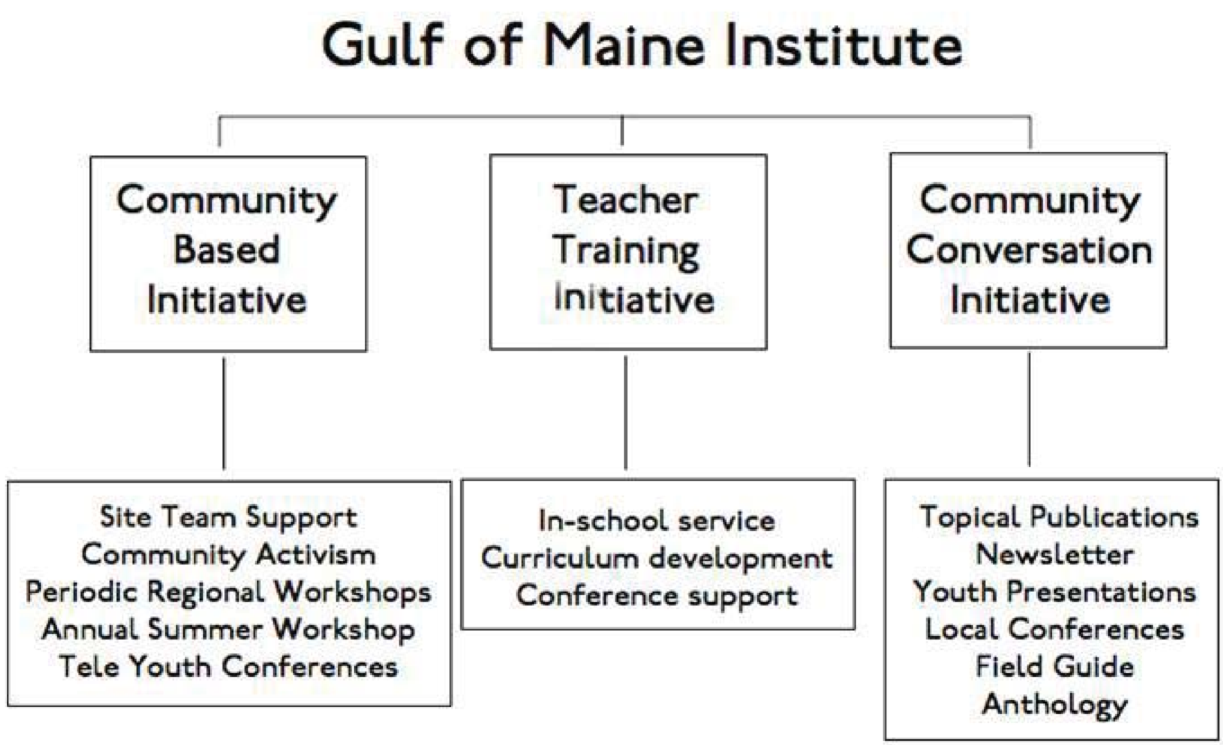
GOMI is collaborating with Tufts University, Medford, Massachusetts, and Acadia University, Wolfville, Nova Scotia, to develop activities that will provide research and community service opportunities for faculty, and university and GOMI students. A committee representing the three institutions has been formed to further define and pursue these initiatives. The same group is pursuing the development of a model, pre-service, teacher-training program employing GOMI's place-based approach. Additionally, Acadia University provided volunteer faculty for the summer 2006 workshop and is conducting a longitudinal study to assess long-term impacts. Tufts faculty members will join the summer 2007 CBI workshop.

Community Conversations Initiative

November 15, 2006 will mark the publication of our first newsletter, *GOMI Currents,* to be followed by volumes II and III on February 15 and June 15. Content will include articles and creative contributions from youth, notes from the editors, a calendar of events and special submissions. As the voice of GOMI youth and adult partnerships, *GOMI Currents* will reach audiences beyond our CBI teams and board of directors to include volunteers, summer faculty, local politicians, funders (potential and active) and other interested parties. Our long-term goal is to develop a comprehensive and broad-based publications menu.

Our first annual Gulf-wide conference is scheduled for the fall of 2008. Beyond highlighting the contributions of youth, the intention of the working conference is to bring together all GOMI teams past and current, along with governmental and non-governmental agencies, scientists and other interested parties, to present their work, share their concerns, and point to current and future stewardship needs of the Gulf of Maine and its watershed. The conference will result in an agenda for research and action.

Figure 1: Organization of the Gulf of Maine Institute



Overview of Programs Implemented within the Past Year

Approach

We address the issue of environmental degradation by training community based initiative teams of youth and mentoring adults from throughout the bi-national watershed. In preparing a cadre of leaders who will not "duck" the issues, GOMI buttresses youthful enthusiasm and sense of the possible with solid training in environmental sciences and civic engagement.

Our systems approach uses sensorial immersion in real life settings. Participants develop a deep and intuitive sense of interconnected natural ecological and human political systems, and learn how to manage them. The result is that youth become aware and active contributing citizens. GOMI participants are recruited via local environmental groups and school systems. Typically GOMI-CBI teams are high or middle school aged youth and include seven youth and three adult mentors.

CBI team participation requires a two-year commitment: two summer CBI workshops and two academic years. Each summer CBI workshop is a weeklong residential immersion in environmental science, team building and civic engagement. CBI teams learn: 1) the basis of scientific inquiry; 2) how their local efforts promote the health of the entire bioregion; 3) techniques for project planning, execution and presentation; 4) methods for presenting scientific findings and recommendations to civic groups; and 5) how to involve larger groups of citizens. During the academic year, GOMI supports the CBI teams as they bring their work back to their local community. The overview section below gives examples of how GOMI and its CBI teams accomplish local implementation.

After each summer workshop, GOMI's leaders evaluate the attainment of learning goals for participants and how the delivery of instruction could be improved. In this way, GOMI's staff and volunteers fine-tune their methods in meeting GOMI's goals and objectives.

The 2006 Summer Community Based Initiatives (CBI) Workshop

The CBI workshop, conducted in Cornwallis, Nova Scotia, brought together a newly formed team from Tantramar Wetlands Centre, Sackville, New Brunswick, plus representatives from four teams (Barrington High School, Barrington, Nova Scotia; Bear River Reservation, Bear River, Nova Scotia; St. Mary's Bay Resource Centre/Le Centre de ressources de la Baie Ste Marie, Claire, Nova Scotia; and Cocheco River Watershed Coalition, New Hampshire). Thirty-four youth and twenty-four adults participated in the summer workshop. As in previous years, teams developed their scientific, presentation and collaboration skills, learned about the larger bioregion and formed cross-jurisdictional bonds while working on local Nova Scotia and their home base projects. On the last day the youth had an opportunity to present their work to a select panel of interested professionals (including representatives from the local regional school board, both governmental and non-governmental agencies, elected officials and university representatives) from throughout Nova Scotia.

Each team developed a CBI plan to implement this fall and to continue throughout the academic year. Each initiative requires recruitment of other members, research and presentation of findings and/or recommendations back to the public. Representatives from all four newly-forming teams (Barrington, Bear River, St. Mary's Bay Resource Centre/Le Centre de resources de la Baie Ste Marie, and Cocheco River Watershed Coalition) are now actively engaged in GOMI activities in their communities and committed to send full teams to next summer's workshop. CBI plans include:

- Tantramar Wetlands Centre, New Brunswick – conduct migratory water fowl banding along the wetlands fly way during which all Mallard ducks will be tested for bird flu virus.
- Bear River Reservation, Nova Scotia – a First Nations study of traditional uses of the land, particularly the Mi'kmaq use, to be conducted by Shallon Jaundry, a Bear River environmental educator.
- Barrington, Nova Scotia – Piping Plover habitat restoration along Cape Sable Island, including dune restoration.
- St. Mary's Bay Resource Centre/Le Centre de ressources de la Baie Ste Marie – develop a Francophone component to GOMI throughout the French shore that will reach out to the Francophone community in New Brunswick.
- Salem, MA – salt marsh restoration and clean-up to include a public campaign called "Minding Your Business," to encourage dog owners to clean up after their dogs.
- Chelsea, MA – creation of a multiple use downtown recreation and social service centre and restoration of salt marsh signed nature trail.
- Newburyport, MA – continuation of salt marsh invasive species removal and public awareness campaign.
- Lowell, MA – fish habitat restoration and water quality testing along the Assabet and Concord rivers.
- Cocheco River Watershed Coalition, Dover, NH – fish habitat and water quality testing along the Cocheco.

Summer 2007 CBI Workshop

The 2007 workshop will be notable in that a team from Maine, and five teams from the Canadian Maritimes, including one First Nations team and a Francophone team, will join us. Thus we achieve our goal of representation from each political jurisdiction within the Gulf of Maine watershed and further our goal of diversity. The addition of the First Nations and Francophone teams adds new cultural diversity to our already ethnically diverse urban, suburban and rural mix of youth. The workshop will be conducted from the campus of the University of New Hampshire, Durham. The place-based experiential learning will occur in and on the waters and shores of the Cocheco River watershed and Great Bay, into which the Cocheco empties. The goals and objectives remain the same as previous years.

BoFEP Outreach

How can we assist BoFEP to fulfill its educational mission?

For more information on GOMI and its team, go to www.gulfofmaineinstitute.org.

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CANADA'S NATIONAL PROGRAMME OF ACTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT FROM LAND-BASED ACTIVITIES (NPA)— THE NATIONAL PROGRAMME OF ACTION ATLANTIC TEAM: FILLING THE GAPS IN ACTION ON LAND-BASED SOURCES OF MARINE POLLUTION

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Abstract

In Washington, 1995, world countries including Canada declared their commitment to protect and preserve the marine environment from the impact of land-based activities. Canada was the first country to implement a National Programme of Action for the Protection of the Marine Environment from Land-Based Activities (NPA) and hosted the first Intergovernmental Review of the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (IGR-1) in Montréal 2001. The second Intergovernmental Review (IGR-2) in October 2006 in Beijing, China, gave the NPA Atlantic Team an incentive to review progress to date and to plan for the future.

As one of four regional NPA teams in Canada, the NPA Atlantic Team has identified priorities that require attention in Atlantic Canada. One such priority, under nutrient enrichment, is seafood plant effluents, another, under habitat restoration and conservation, is contaminated dredge sediments. In both cases and for other priorities, progress has been made.

This presentation looks at the issues identified by the Atlantic team and why, actions taken, and highlights a project on information for municipalities on land-based activities that can impact the marine environment. Providing information on environmental best management practices to municipal planners is critical to bringing long-term changes at the local level. Although our projects focused on Atlantic Canada, the ideas and methods are transferable to other regions.

Introduction

In Washington, 1995, world countries including Canada declared their commitment to protect and preserve the marine environment from the impact of land-based activities. Governments adopted the United Nations Environment Programme's *Global Programme of Action for Protection of the Marine Environment from Land-Based Activities* (GPA). The GPA targets major threats to the health, productivity and biodiversity of marine and coastal environments resulting from human activities on land. It is a non-legally binding agreement, with its legal foundation provided in the 1982 *United Nations Convention on the Law of the Sea* (UNCLOS – Articles 207 and 213).

Canada, bordered by three oceans and with the longest coastline in the world, was the first country to implement a National Programme of Action and hosted the first Intergovernmental Review (IGR-1) of UNEP's GPA in Montréal in 2001. The second Intergovernmental Review (IGR-2) took place October 16–20, 2006, in Beijing, China. At IGR-2, 104 nations including Canada recommitted to implementing NPAs, and to improving coordination at all levels to deal with issues related to water resources and river basin management, coastal zone and coastal area management in an integrated manner.

Coastal communities and governments in the Atlantic region recognize the fact that there is a gap in the level of action at the land-coastal interface. The NPA is the embodiment of Canada's commitment to UNEP's GPA and is an international and domestic instrument that addresses the linkages among freshwater, coastal and marine environments. The NPA is the mechanism to fill this gap. The NPA looks at the "land component" of pollution entering the oceans, identifying and proposing actions to prevent or decrease the amount of pollution reaching our waterways, and eventually the oceans.

Priorities

The national NPA priorities are defined in the report called *Canada's National Programme of Action for the Protection of the Marine Environment from Land-Based Activities* (Environment Canada 2000). Sewage, persistent organic pollutants (POPs), shoreline construction and alteration, and wetland and salt marsh alteration were ranked as high priorities for action in Canada. As one of four regional NPA teams, the Atlantic team did participate in the priority setting exercise at the beginning of the NPA in Canada in 1996.

Following the release of the Canadian NPA in 2000, the Atlantic NPA team met on several occasions to define and agree upon a common strategic, progressive and results-oriented action plan. The plan was completed in 2002 during which time the Atlantic team identified nutrient enrichment, sewage and habitat destruction from land-based activities as their priorities for intervention. The team created working groups to deal with specific issues identified in the action plan.

The Atlantic team has produced two progress reports called: *Atlantic Team Status Report: Implementing Canada's National Programme of Action for the Protection of the Marine Environment from Land-Based Activities 2002–2004* (Bastien-Daigle et al. 2005) and *Implementing Canada's National Programme of Action for the Protection of the Marine Environment from Land-Based Activities: Second Atlantic Team Status Report 2004–2006* (Janowicz and Tremblay 2006).

Nutrient Enrichment: Seafood Processing Effluents

Our first priority issue was nutrient enrichment and it was tackled by an NPA working group dealing with seafood processing effluent and a New Brunswick (NB) seafood processing effluent working group. The NB working group is not under the auspices of NPA, but it is linked closely with the NPA group, with overlap of membership and a common objective.

In March 2004, a study commissioned by the Atlantic team entitled *Management of Wastes from Atlantic Seafood Processing Operations* (AMEC Earth & Environmental Ltd. 2003) was translated, printed and distributed. In May 2004, the NPA Seafood Processing Effluent working group (NPA-SPEWG) met and viewed four presentations: 1) Environment Canada's work on toxicity of seafood processing effluents, 2) the Dalhousie Research Chair's *Preliminary Assessment of Effluents Generated by Seafood Processors in the Atlantic Region*

(Walsh et al. 2004), 3) environmental effects monitoring at fish processing sites (Department of Fisheries and Oceans Canada), and 4) the New Brunswick Seafood Processing Effluent Working Group. Working group members continue to share information on all of these initiatives, as well as others, through regular conference calls and meetings.

Through the work of the NPA and NB Seafood Processing Effluent Working roups, the issues were raised to a national level. Work is now underway to advance our knowledge of this sector, and we plan to continue our involvement on the seafood processing effluent file.

We expect nutrient enrichment to continue to be a high priority in our next action plan for 2007–2011. And so, in addition to the seafood plants effluent work, the team will follow up on other aspects of this issue such as pursuing the offer to combine forces with the group that put together the "Ecological Implications of Nutrient Enrichment on Freshwater and Coastal Ecosystems" workshop in March 2005, in Summerside, PEI.

Sewage: On-site Sewage Systems and Microbial Source Tracking

Sewage was the second of the team's three priority issues. Sewage contributes to nutrient enrichment in the Atlantic coastal zone. We looked at it in the context of on-site sewage systems and microbial source tracking techniques.

Under the sewage action plan, an NPA On-Site Sewage Working Group (NPA-OSWG) was formed in early 2004. The working group began by reviewing work conducted on this topic. Specifically, a summary of recent workshops (e.g., Hinch et al. 2002; Joy et al. 2003) and recommendations from those workshops were compiled as a starting point.

The complexity and sensitivity of the issue has resulted in minimal advancement in the group's action plan. Discussion identified the need for public education and that in turn required economic information to identify the implications of inadequate on-site sewage systems to the local economy, for example, shellfish closures and reduced attraction to tourism, and to the environment (nearshore nitrification and implications for biodiversity, fisheries and shellfish resources and industries). Through 2004–2005, there have been changes in co-chairs of the NPA-OSWG due to operational requirements. One co-chair is now in place and the search for a second co-chair is on-going. In order to move forward, the working group will develop terms of reference (TOR) and an action plan to be reviewed and approved by the appropriate managers.

Also, under the sewage action plan, we are looking at methods for microbial source tracking. "Microbial Source Tracking (MST) refers to the approach or approaches intended to identify the fecal sources impacting a water system. Other terms that relate to MST are bacterial source tracking (when bacteria are the target), microbial source identification, and fecal source identification"(http://www.sourcemolecular.com/definitions/definitionmicrobialsourcetracking.htm). MST is a young applied science with many methods being developed and field-tested. It promises to be an invaluable tool for managers, particularly in watersheds subject to multiple uses.

Community groups and regulators working in Atlantic Canada have indicated that dealing with bacterial contamination is their highest priority in efforts to restore coastal and freshwater ecosystems. Sources of fecal contamination are widespread and affect drinking water, recreational waters, shellfish growing areas, the use of marine water in fish processing, and irrigation water quality throughout the region. While all sources are important, from a management perspective, knowing the source of contamination can help managers decide on the most beneficial response by directing limited resources where they can have the most significant impact.

The Atlantic NPA team involvement with MST started by sponsoring, along with Environment Canada (EC) and Acadia University, a workshop in April 2004, at Acadia University, Wolfville, Nova Scotia. The workshop, entitled *Microbial Source Tracking (MST): Towards Effective Identification of Fecal Pollution Sources,* brought together researchers in the field and potential end users of MST (Sullivan 2004). Experts from Canada and the United States shared their knowledge of this evolving scientific method of identifying sources of bacterial contamination. The workshop confirmed that there is considerable interest in assessing the merits of using MST tracking for environmental applications. The final workshop report was distributed to participants in March 2005. As a result of that workshop, a working group was established under the umbrella of the Atlantic NPA and has been working from an action plan to implement the recommendations from the workshop. At the conclusion of the workshop, the *Bacteroides-Prevotella* method was identified as a potentially good candidate to offer an inexpensive answer to the question of whether or not fecal contamination was of human or ruminant origin.

The Department of Fisheries and Oceans (DFO) Moncton lab and the EC Vancouver lab (Pacific Environmental Science Centre) are collaborating in transferring and validating the *Bacteroides-Prevotella* method to the East Coast. Funding was provided by EC Atlantic to the DFO Moncton lab to defray the costs of MST pilot projects.

Projects were carried out in 2004–2006 in Atlantic Canada at Newman Sounds, NL (with DFO NL); in Cardigan, PEI (with the Southeast Environmental Association (SEA)–Atlantic Coastal Action Program (ACAP) group and the EC shellfish section); in southwest New Brunswick (with Eastern Charlotte Waterways Inc. (ECW)–ACAP group and the EC shellfish section); at Thornes Cove, NS (with Clean Annapolis River Project (CARP)–ACAP group and Acadia University); and in Miramichi River, NB (with Miramichi River Environmental Assessment Committee (MREAC)–ACAP group and the EC shellfish section). Results varied greatly from solid MST results, to no results due to technical difficulties, to no MST results because of less than required fecal coliforms in the water samples.

Through the working group membership, we were kept informed of activities outside of Atlantic Canada such as a pilot project carried out in Iles de la Madeleine by the local Comité zone d'intervention prioritaire (ZIP) group and EC shellfish section, and of activities at the EC west coast laboratory.

The results of the pilot projects have highlighted some questions regarding differences between freshwater and saltwater results and level of fecal coliforms required to obtain consistent MST results. The group is carrying out further projects in 2006–2007 to attempt to answer some of these questions. A progress report entitled *Microbial Source Tracking Working Group (NPA-MSTWG) Progress Report 2004–2006* was written by the working group and summarizes the results of the various field projects, gives a lab update, reviews lessons learned and makes recommendations for next steps.

Habitat Conservation and Restoration

The focus of the third priority, habitat conservation and restoration, is the management of dredge material. Dredging is an activity conducted throughout the world, and is required for the sustainability of ports, including in Atlantic Canada. The NPA has had an opportunity to facilitate discussions. In June 2004, an EC sponsored and NPA supported workshop on technical issues related to the management of contaminated dredge material took place. A working group was formed under the umbrella of the NPA in 2005 to address the issue of dredging and the associated disposal of marine sediment, in an effort to balance environmental, social and economic concerns as well as to foster open communication among all organizations and stakeholders involved. It is composed of agencies with a direct involvement or interest in dredging. The objectives of the working group are to clearly describe the framework of regulations and policies currently governing the management of contaminated dredged material; to identify conflicts, constraints, inconsistencies, omissions within the framework; to recommend improvements to current dredged material management practices that could be implemented readily within the current regulatory and policy framework; to identify opportunities to harmonize and/or modify regulations and policies so as to ensure that, after considering environmental, social and economic factors, dredged materials are properly managed; to investigate development of a workshop(s) with responsible agencies to address alternate solutions to containment cells; and to act upon outcomes from the workshop including communicating the outcomes to the appropriate agencies and organizations so that change can occur.

The co-chairs have submitted a proposal for funds to the National Office of NPA to forward the group's agenda. The funds have been secured through Environment Canada and DFO Small Craft Harbours to conduct the investigative work with the assistance of a consultant and to produce a report on the first four objectives of the working group. This work is expected to be finalized early in 2007 and to lay the framework for a new coordinated approach to dredge material management in Atlantic Canada.

Land-use Planning

Our initial action plan has served us well from 2002 to the present, but it is time to renew our action plan and to look at where our future involvement is needed. Discussions have highlighted the need to try and involve land planners with the NPA Atlantic team. As a first step, a project proposal was developed to research some issues of potential interest with municipal planners.

Municipalities plan and manage land use activities in the coastal zone and adjacent watersheds, often with limited knowledge, capacity and resources to reduce impacts from land-based activities, such as marine pollution and habitat alteration. This is true especially in Atlantic Canada where many municipalities are small and rural, and have a limited capacity for watershed and coastal planning. A project to provide municipalities with much needed assistance and information resources in a one-window, coordinated approach was proposed.

This project will provide municipalities in Atlantic Canada with planning tools to address land-based activities that affect the coastal and marine environment, and sharing of these tools will occur via the Internet (e.g., the NPA Clearinghouse). A series of best management practices (BMPs) for land-based sources of marine pollution based on the NPA Atlantic team priorities (nutrient enrichment, sewage and habitat destruction) and in consultation with the responsible regulatory agencies will be researched. In 2005–2006, two projects were supported by funding from the NPA and team members. The issues researched were coastal erosion and salt marshes.

Each project's deliverables included an annotated bibliography of existing information and regulations relevant to Atlantic Canada, a fact sheet on the issue, and a gap analysis of the information/knowledge available on the issue. Although the projects focused on Atlantic Canada, the ideas and methods are transferable to other regions in Canada. We hope to continue to add to the fact sheet series. In preparation, the team has compiled a list of topics for best management practices for future use. The resulting factsheets and annotated bibliographies will become part of a series of fact sheets and other information available on the revamped NPA-PAN Web site (www.npa-pan.ca) to be re-launched in 2006.

Conclusion

In preparation for 2007 and beyond, during the summer of 2006, the NPA Atlantic team began discussing emerging issues and next steps for current activities. By the beginning of 2007, the Atlantic team will complete an action plan (2007–2011) for the next five years. It will need approval and support from the various levels of management in the various member agencies and jurisdictions. The team will then pursue its implementation.

The team hopes that by implementing the NPA at a local level and supporting action oriented projects, it will do its part to reduce the impacts of land-based activities to the marine environment.

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NEARSHORE MARINE MONITORING: THE RESULTS OF A NATIONAL WORKSHOP ON COORDINATION

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Summary of the EMAN Nearshore Marine Ecological Monitoring Workshop

A number of groups and communities engaged in monitoring in nearshore marine environments across Canada have expressed concern that the various monitoring activities lack coordination, accepted protocols and standards, and integration such as have benefited monitoring initiatives in terrestrial and freshwater environments. To address this concern, Environment Canada's Ecological Monitoring and Assessment Network (EMAN) Coordinating Office worked with Environment Canada across Canada, the Department of Fisheries and Oceans, Parks Canada and non-governmental organization (NGO) representatives to organize a national workshop on nearshore marine ecological monitoring.

Between 7–9 February 2006, over 170 representatives of community groups, NGOs, aboriginal groups, industry and other organizations from many coastal areas of Canada participated in a full agenda of invited presentations, plenary discussions, breakout sessions, and poster sessions at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. Objectives of the workshop were to:

- Improve communication among monitoring groups working on nearshore marine/estuarine ecosystems in the various coastal regions of Canada.
- Improve understanding among participants of various nearshore marine monitoring approaches, protocols and their strengths and limitations.
- Improve understanding among participants of the types of nearshore marine monitoring information that various decision-maker/coastal stewards are seeking.
- Facilitate development of frameworks, best practices, tools and resources to ensure that nearshore monitoring is responsive to clear goals, data are scientifically valid, and results are broadly accessible.
- Facilitate integration among community-based monitoring groups and scientists in the nearshore marine community.
- Develop consensus on a path forward to improve the coordination of nearshore marine monitoring and the comparability of information gathered.

Over twenty papers and 35 posters were presented, which described the information needs of decision makers at various scales, possible indicators that could be monitored, best practices, metadata management issues and lessons learned. Participants had the opportunity to discuss the types of nearshore information they needed and common challenges faced by coastal monitoring organizations in delivering such information in plenary and small group breakout sessions.

Recommendations were made to improve coordination of nearshore marine monitoring and the effectiveness of current monitoring programs in Canada by:

1. Publication of the 2006 EMAN workshop report (see Hazel et al. 2006).

2. Preparation of an inventory of ongoing nearshore monitoring programs in Canada.

3. Identification of data gaps for coastal monitoring data in Canada.

4. Development a suite of monitoring indicators and protocols of use in Canadian nearshore waters.

5. Formation of a National Steering Committee which could lead actions to improve the coordination of nearshore marine monitoring.

6. Development of a Canadian model for sustaining a coordinated nearshore monitoring network.

7. Provision of dedicated funding to enhance the monitoring efforts themselves and also the coordination and synthesis periodically of what is being done, what it is showing, and actions required.

8. Preparation of comprehensive water and sediment quality objectives and standards for the nearshore marine environment, under the Canadian Council of Ministers of the Environment (CCME).

Nearshore Monitoring in the Atlantic Region (Wells, from Hazel et al. 2006)

Two hundred and twenty-one survey requests/forms were sent across the region. In response, 45 surveys (~20%) describing monitoring programs circa 2005–2006 were received by the time of the February 2006 workshop – 21/88 from Nova Scotia; 18/94 from New Brunswick; 1/6 from Prince Edward Island; and 4/26 from Newfoundland and Labrador. The replies came from government (22), community groups (14); industry (2); university (8); and others (1). Hence, the survey to February 2006, reported at the workshop, is not yet completed. There are an unknown number of other ongoing programs.

Government programs include those conducted by Fisheries and Oceans Canada (DFO), Environment Canada (EC), the Canadian Food Inspection Agency (CFIA), and Parks Canada, and those of various provincial agencies.

Programs under DFO include: Atlantic Zonal Monitoring Program (AZMP); the Gulf of Maine Ocean Observing System (GoMOOS), with various partners; tidal monitoring by the Canadian Hydrographic Service; monitoring phytoplankton, i.e. the harmful algal bloom program; rockweed monitoring; organochlorine chemical monitoring; benthic macrofaunal change monitoring associated with aquaculture; and faunal monitoring within the DFO marine protected areas program.

The economically vital and long-standing (since 1948) Canadian Shellfish Sanitation Program is conducted jointly by DFO, EC and CFIA. EC monitors fecal coliform in overlay waters of shellfish harvesting areas in support of this program and CFIA monitors biotoxins in shellfish. DFO opens and closes areas based on recommendations from EC and CFIA.

Environment Canada's other monitoring programs include: chemical contaminants disposal at sea site monitoring; participation in the Gulfwatch mussel watch program in the Gulf of Maine and Bay of Fundy (see www.gulfofmainecouncil.org); studies under the National Program of Action, especially for the effects of fish processing plant effluents; national ambient air quality monitoring; and at least 13 wildlife conservation monitoring programs under the Canadian Wildlife Service.

Parks Canada's Atlantic Coastal Monitoring Programs are particularly numerous at the seven Atlantic national parks. Provincially, Newfoundland and Labrador conducts at least five programs of nearshore monitoring. Data on other provincial programs is as yet incomplete in this survey.

At least seven community-led monitoring programs or sets of programs are also being conducted, e.g., such as those through ACAP (Atlantic Coastal Action Program). Also of note are multi-partner programs such as those being conducted on Sable Island, NS, monitoring weather and climate, trace contaminants in air and water, vegetation, birds, oil on beached birds, plastics, and the population status of ponies and grey seals. Industry -led programs include Atlantic salmon monitoring, nearshore monitoring associated with the Sable Offshore Energy Project, and pulp and paper environmental effects monitoring. Finally, there are various university-led research-monitoring programs, such as those from McGill, Cape Breton and Dalhousie universities, with graduate training and community volunteer components.

The survey indicated that nearshore monitoring activity across the Atlantic Provinces is considerable, with a wide range of indicators being measured. However, knowledge and research can be spatially patchy and old/outdated in many areas, and the capacity for significant long-term monitoring is very limited. This database can be evaluated for the Bay of Fundy specifically, and built upon, so as to have both a good knowledge of what is being done, as well as having the opportunity to coordinate and enhance the current programs in a planned but opportunistic way for the longer term.

Acknowledgements

The talk at the BoFEP workshop was given by P. G.Wells. It was prepared by Marlene Doyle of EMAN, CCIW, Burlington, ON, and enhanced by Wells to cover activities in the Atlantic region, and Fundy in particular. Many people contributed the data and information for the original survey conducted in 2005–2006, and are thanked accordingly. The materials above were selected from the manuscript by Hazel et al. 2006, and adapted and revised slightly for the BoFEP workshop proceedings, with the permission of the EMAN office, Environment Canada, Burlington, ON.

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Session Ten

SEA BIRD ECOLOGY, PREY AND CONTAMINANTS

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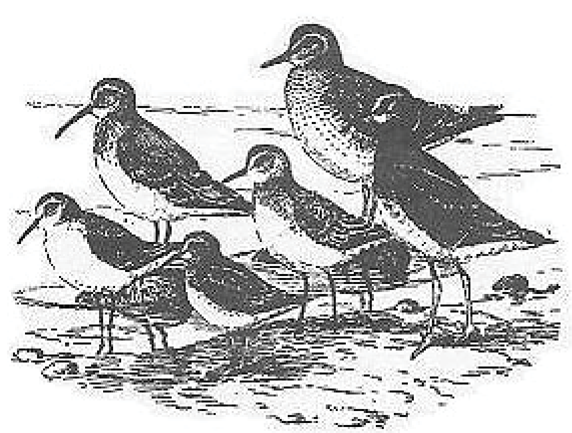

Session Ten Summary

Robert Ronconi and Peter Hicklin, Rapporteurs

This session highlighted the complexity of marine food webs in the Bay of Fundy. Food web complexity has always been recognized in recent decades; however, this session added new insight in two areas:

1. The dynamic nature of BoF food webs. Food webs can change in response to environmental change:
    a) Changing prey base on Machias Seal Island (Diamond)
    b) Flexible diets of seabirds (Bond)
    c) Variable foraging strategies of sandpipers (Ginn)
    d) Snail effects on *Corophium* (Drolet)
2. Birds as indicators and warning signs of environmental change in the Bay of Fundy
    a) Particular mudflats have shown changes in moisture content in recent years, potentially affecting prey base for sandpipers (Ginn)
    b) Unknown sources of mercury in sandpipers in the BoF (Dydik)
    c) Colony abandonment at Machias (Diamond)

CHANGES IN THE SEABIRD COMMUNITY OF MACHIAS SEAL ISLAND, 1995-2006

Antony W. Diamond

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The inherent complexity of marine ecosystems makes it difficult to track the biological significance of changes. We need to reduce the infinite number of variables it is possible to measure to a few easily-measured ones. Species at or near the top of food webs, such as seabirds, can integrate many changes into a few responses. Since 1995 we have monitored breeding success and diet of seabirds breeding on Machias Seal Island, New Brunswick, and tracking environmental variables such as air and sea-surface temperature, wind and visibility. Prior to 2001, all four of the regularly-monitored species (Atlantic Puffin *Fratercula arctica*, Razorbill *Alca torda*, Common and Arctic Terns *Sterna hirundo* and *S. paradisaea*) fed chiefly on O-group Atlantic herring, *Clupea harengus.* Thereafter herring declined in the seabird diets, which have become more varied and less predictable, including sand lance (one year only), various hake species, fourbeard rockling, *Enchelyopus cimbrius*, and euphausiid shrimp, *Meganyctiphanes norvegicus*. In many years chick growth declined and over the last few years puffin chicks have fledged later and in poorer condition. Virtual failure of breeding occurred in both tern species in 2004 and 2005. Meanwhile, three species have colonized the island: Laughing Gull, *Larus atricilla*, and Black Tern, *Chlidonias niger*, two or three pairs each, and over 100 pairs of Common Murre, *Uria aalge*. Teasing out the separate effects of environmental change and overfishing of herring on the complex responses of seabirds is our current challenge.

***** WINNNER STUDENT PAPER PRIZE*****

COMPARING ADULT AND CHICK DIET IN TWO ALCID SPECIES USING STABLE ISOTOPE ANALYSIS

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Introduction

Atlantic Puffins (*Fratercula arctica*) and Razorbills (*Alca torda*) are deep-water pursuit divers, often diving up to 25m in seek of prey, although Razorbills can dive deeper than puffins (Burger and Simpson 1986). Both species carry multiple items in the bill back to the young, which remain in their burrow being provisioned by the adult for up to 17 days in Razorbills (Hipfner and Chapdelaine 2002) and 42 days in puffins (Lowther et al. 2002).

When assessing the chicks' diet, all food that is delivered is assumed to be ingested, and all ingested food is assumed to be assimilated. The diet of adults is less known than that of chicks; most studies are of gut content analysis, which is greatly biased because of differential digestion and retention times of some prey items (Hilton et al. 2000). To our knowledge, no study in the region has examined both adult and chick diet of these species at the same site and in the same year.

Recent advances in the use of stable-carbon and stable-nitrogen isotopic ratios ($^{13}C/^{12}C$ and $^{15}N/^{14}N$ respectively) to reconstruct diet (e.g., Hedd and Montevecchi 2006) have provided a technique to assess the diet of birds over different time scales, and in a non-invasive manner. Stable-carbon isotope signatures provide information on the origin of the prey as inshore, terrestrial, or offshore. Stable-nitrogen signatures indicate the trophic level, as the ratio of the heavier isotope is enriched at 3 parts per thousand (3‰) per trophic level (DeNiro and Epstein 1981). Sampling whole blood provides isotopic ratios that are indicative of the diet in the previous 10–14 days (Hobson and Clark 1993).

Using a combination of observational monitoring of chick diet, and stable isotope analysis, we examined the difference between adult and chick diet of puffins and Razorbills during the 2005 breeding season on Machias Seal Island, NB.

Methods

Study Site

The Bay of Fundy is home to four nesting members of the auk family (Aves: Alcidae) – Atlantic Puffin, Razorbill, Common Murre (*Uria aalge*) and Black Guillemot (*Cepphus grylle*) (Ronconi and Wong 2003; Bond et al. 2006). Of these, three (puffins, murres and Razorbills) nest on Machias Seal Island, New Brunswick (MSI, 44° 30' N, 67° 06' W), a small (9.5 hectare) treeless island at the mouth of the Bay of Fundy. The puffin and Razorbill populations have been subjects of a long-term study since 1995 by the Atlantic Cooperative Wildlife

Ecology Research Network (ACWERN) at the University of New Brunswick (Diamond and Devlin 2003). MSI is home to approximately 2,800 breeding pairs of puffins (Diamond and Robinson 2000) and 550 breeding pairs of Razorbills (Grecian 2005).

Chick Provisioning Observations

Chick provisioning observations were made during three-hour periods throughout the chick-rearing period, and totalled 133 hours for puffins and 58 hours for Razorbills. Three observers rotated through four observation blinds for each species, to minimize any observer effects. Observation areas were approximately 10 m x 10 m, and included between 8–10 active burrows. Items brought to the chick by adults, carried perpendicular to the bill, were identified to the lowest taxon possible, and their length estimated in relation to the mean length of the bill of adults of the species.

Sample Collection & Analysis

Individuals were captured in burrows late in the breeding season, and blood was taken from the brachial vein using a 25G needle and capillary tubes, and stored in 10 ml glass vials. Samples were frozen in the field and transported to the Stable Isotopes in Nature Laboratory (SINLAB) at the University of New Brunswick in Fredericton.

Prey items dropped in the colony, or regurgitated by individuals during handling, were analysed for stable isotopes. Samples were collected opportunistically throughout the breeding season, and frozen in the field. Samples were freeze-dried for 48 hours in a Virtis Bench-top freeze dryer. Prey items had lipids extracted using a modification of the Bligh and Dyer (1959) method and 0.2 mg was loaded into 5 mm x 8 mm tin capsules. Capsules were combusted in a Carlo Erba NC2500 elemental analyzer, with resultant gases delivered via continuous flow to a Finnigan Mat Delta XP mass spectrometer. Isotopic ratios are measured in parts per thousand (‰) and expressed in δ notation such that:

$$\delta X = \left(\frac{R_{sample}}{R_{std}} - 1 \right) \times 1000 \qquad \text{(Equation 1)}$$

where X is either ^{13}C or ^{15}N, and R is the corresponding ratio of $^{13}C/^{12}C$ or $^{15}N/^{14}N$. Sample ratios are compared to international standards for carbon (Peedee Belemnite Carbonate, PDB) and nitrogen atmospheric N_2 (AIR).

Results

In 2005, chick diet was quite different between the two species. Razorbills (n = 449 identified prey) fed largely on Atlantic Herring (*Clupea harengus*, 36.1%) and hake/rockling (*Urophycis tenuis*, *Merluccius bilinearis* or *Enchelyopus cimbrius*, 36.7%, which are indistinguishable in our field context). Other prey items included young-of-the-year (YOY) herring, hake and sand lance (*Ammodytes* spp.) at 20.0% combined, and 2.7% euphausiids (*Meganyctiphanes norvegica*).

Puffins (n = 2417) fed on a much higher proportion of euphausiids (44.2%), and YOY fish (29.0%), with smaller amounts of hake (21.5%) and virtually no herring (1.4%). This reflects a steady decline in the amount of herring, and an increasing amount of euphausiids, in puffin diets over recent years (Bond et al. 2006).

Stable isotope ratios (mean ± SD) for Razorbill adults (n = 10) were -19.94 ± 0.32 for carbon, and 11.64 ± 0.41 for nitrogen. Chick diet (n = 10) was not statistically different for carbon (-20.09 ± 0.18, t_{19} = 1.40, p < 0.2), or nitrogen (11.40 ± 0.42, t_{19} = 1.24, p<0.3) isotopic signatures.

Puffin adult (n = 10) and chick (n = 9) diets were similar in both carbon (-20.93 ± 0.13, t_{18} = 1.61, p < 0.1) and nitrogen (10.91 ± 0.09, t_{18} = 0.35, p < 0.8). The chick diets in each species were also significantly different (C: t_{18} = -10.47, p< 0.0001; N: t_{18} = -3.36, p < 0.005).

Adult puffins had significantly lower stable-carbon (-20.78 ± 0.25, t_{19} = -7.35, p < 0.0001) and stable-nitrogen ratios (10.97 ± 0.51, t_{19} = -3.96, p < 0.005) than adult Razorbills.

Isotopic signatures (number of samples, carbon, nitrogen) for euphausiids (n = 8; -20.57 ± 0.37, 8.76 ± 0.39), hake (n = 8; -19.93 ± 0.42, 10.15 ± 0.62), herring (n = 2; -20.76, 11.06) and YOY fish (n = 2; -20.45, 9.30) were also determined.

Discussion

Puffin and Razorbill diets were isotopically different, which is consistent with the differences in provisioning data observed in 2005. Adult and chick diets were the same in both species, which is an important finding considering the present challenges and decreased productivity observed in the seabirds on Machias Seal Island. This shows that adults are not compensating for the difficulty of finding quality prey by feeding at a higher trophic level themselves. The low nitrogen in puffins in 2005 is directly indicative of their poor diet of euphausiids, especially considering that their nitrogen signature is similar to that of herring, their highest quality prey.

Acknowledgements

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MERCURY LEVELS IN MIGRATING SEMIPALMATED SANDPIPERS, *CALIDRIS PUSILLA* (L.), ON STAGING GROUNDS IN THE BAY OF FUNDY

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Samples of liver and pectoral muscle tissue from 20 adult Semipalmated Sandpipers, *Calidris pusilla* (L.), collected at Dorchester Cape, New Brunsick, on the Bay of Fundy, were analyzed for mercury. We show that the burrowing amphipod *Corophium volutator* (Pallas) is an important source of organic mercury for foraging shorebirds during their 10–12 day midsummer stay in the Bay of Fundy prior to departing for wintering areas in South America. Since females arrive on the staging grounds before males, females would have consumed more *C. volutator* than males sampled at the same time and, as a consequence, should have higher mercury concentrations. In both male and female sandpipers, mercury concentrations were significantly higher in liver tissue than in muscle, but contrary to expectations, the lighter males had significantly higher mercury concentrations in liver and pectoral muscle tissue than females. There was no correlation between weight and mercury concentrations for either sex. It is not clear why the heavier females, which would have been on the staging grounds for a longer period of time and should have accumulated more mercury from feeding on contaminated *C. volutator,* actually had lower mercury levels than the lighter and more recently arrived males. Possible explanations for the results include gender differences in diet, condition, exposure and means of depuration of mercury.

USE OF ALTERNATE FORAGING STRATEGIES AND FOOD RESOURCES BY SEMIPALMATED SANDPIPERS (*CALIDRIS PUSILLA*) ON MUDFALTS IN THE UPPER BAY OF FUNDY

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The Semipalmated Sandpiper (*Calidris pusilla*) is a small scolopacid shorebird that breeds in the spring in the Canadian and Alaskan arctic and winters in South America. The distance between these two seasonal locales necessitates very long migratory routes in both spring and fall. Of particular interest is the use of critical staging habitats by this species in the upper Bay of Fundy, the one and only stop on their southward journey during fall migration. It is estimated that approximately 70% of the world's population of Semipalmated Sandpipers use upper Bay of Fundy mudflats to feed in order to gain appropriate energy reserves to sustain their long flight over open water (Hicklin 1987). During their approximate two week stay, these shorebirds feed on an assortment of invertebrate prey, among them the amphipod *Corophium volutator*, a species that can attain high densities on mudflats. In recent years, habitat use by sandpipers in this region has changed; some mudflats that were historically frequented by many birds now support very few (Hamilton et al. 2003). At one site in particular, the Grande Anse mudflat at Johnson's Mills on the Dorchester Peninsula, the observed decline in bird abundance may have been precipitated by crashes in *C. volutator* densities and changes in water content and sediment composition (Shepherd et al. 1995).

In 2005, a novel foraging behaviour was observed among the few birds still feeding at Grande Anse (Sprague 2005). This behaviour, which we have tentatively termed "slurping", involves maintaining contact of the bill with the sediment while slowly walking over the mud. Elner et al. (2005) observed a similar behaviour in Western Sandpipers (*Calidris mauri*) and concluded that it might be used to ingest benthic microalgae and its associated polysaccharide matrix (hereafter referred to as biofilm).

It has been traditionally thought that sandpipers in the Bay of Fundy depend primarily on *C. volutator* for food. However, recent changes in habitat use and foraging behaviour at some sites raise questions concerning Semipalmated Sandpipers' ability to exploit other food items when either preferred prey are absent or other possible food items are available in high densities. Given this, we are examining the extent to which sandpipers "slurp" during their stay, and whether this behaviour is used to feed on biofilm as described for Western Sandpipers. If sandpipers are exploiting biofilm, we predict that we should see a relationship between chlorophyll (Chl *a*) concentrations in the sediment (a good index of diatom abundance) and proportion of time spent "slurping".

During summer 2006 we studied foraging behaviour of Semipalmated Sandpipers at four sites in the upper Bay of Fundy: Grande Anse (Johnson's Mills), Daniel's Flat, and Mary's Point in Shepody Bay, and Peck's Cove, in Cumberland Basin. At each site, we recorded foraging behaviour using video cameras set on tripods. Most observations were made following the receding tide, as this is when birds congregate and forage most intensely. Filming area varied from 2 m x 2 m to 5 m x 5 m, depending on location and proximity to the birds. To estimate diatom and invertebrate abundance, core samples (two each for Chl *a* and invertebrates) were taken from within each quadrat. For diatoms, we used 10 cc syringes with the tops cut off to sample the top 2 to 3 mm of the sediment. Chlorophyll was later extracted from the sediment and concentration assessed using spectrophotometry. We collected cores for invertebrate abundance using PVC tubing (diameter 5.5 cm) inserted into the mud to the bottom of the aerobic layer. Invertebrates were later identified, counted, measured, and weighed. Statistical analyses were accomplished using SPSS.

Results showed no significant differences among sites in densities of birds foraging in our plots (ANOVA $p=0.24$, $n=4$-6), so differences in behaviour cannot be attributed to forager density. Proportion of time pecking was significantly lower at Grande Anse than at the other sites (ANOVA $p<0.0001$). This was associated with a rise in “slurping”, which could not be statistically analysed because it was completely absent at most sites. Birds at Grande Anse spent over 50 per cent of their time “slurping”, whereas pecking took up approximately 20 per cent. Conversely, at other sites, pecking took up 75 to 95 per cent of foraging time. When abundance of *C. volutator* was controlled statistically, differences among sites in time spent pecking persisted (ANCOVA $p<0.0001$). This is significant because it rules out a decline in *C. volutator* abundance as a possible cause for the change in foraging behaviour seen at Grande Anse. Chl *a* concentration showed no significant difference among sites (ANOVA $p=0.72$), suggesting that “slurping” is not driven by a high abundance of biofilm. The only significant difference among sites was in the density of ostracods, which were much more abundant at Grande Anse than at other sites (ANOVA $p<0.0001$). Further, within Grande Anse, there is a strong positive non-linear relationship between proportion of time spent “slurping” and ostracod density ($p=0.37$, $r^2=0.70$).

These results suggest that foraging behaviour of Semipalmated Sandpipers may be fairly plastic in response to a super abundant resource coupled with declines in a preferred prey. These are preliminary results representing small sample sizes, and additional work needs to be done to verify our findings. Dietary studies are also underway in an effort to determine the extent to which sandpipers use this “new” resource. However, our findings, coupled with previous movement studies (Sprague 2005), suggest that sandpipers are far more flexible in behaviour and habitat use than previously thought. This has implications in terms of our ability to predict responses of shorebirds to habitat change, and will contribute to our knowledge of mudflat community dynamics, which is important to future efforts to conserve this habitat.

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***** SECOND PLACE STUDENT PAPER PRIZE*****

EFFECT OF DENSITY OF THE GASTROPOD *ILYANASSA OBSOLETA* ON DISTRIBUTION AND MOVEMENT OF THE AMPHIPOD *COROPHIUM VOLUTATOR*

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We performed a field experiment investigating the effect of density of the gastropod *Ilyanassa obsoleta* on the density and distribution patterns of the amphipod *Corophium volutator* on the mudflat of Peck's Cove (Cumberland Basin, upper Bay of Fundy). We manipulated density of *I. obsoleta* in cages (1 x 1 m) to have a control, low and high density treatment, corresponding to 0, 100 and 300 snails m^{-2}, respectively. Density of *C. volutator* was lower at high density of snails than in the control or low density treatments. Density of snails also influenced spatial distribution patterns of *C. volutator* in the enclosures. Increasing density of snails induced a gradual increase in patchiness of *C. volutator* population (measured using Morisita's indices). We are currently investigating the effect of snail density on movement patterns of *C. volutator*. Preliminary results suggest an increase in emigration and a decrease in immigration of amphipods with increasing density of snails. The influence of snail density on movement of *C. volutator* may explain the changes in amphipod density observed in the field.

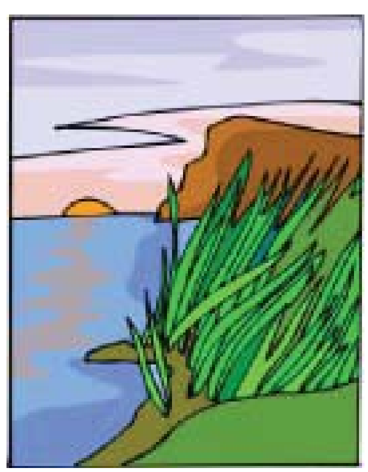
Session Eleven

MONITORING AND MANAGEMENT: ECOSYSTEM APPROACHES

Chairs: Robert Stephenson, Fisheries and Oceans Canada, Biological Station, St. Andrews, New Brunswick

and

Stratis Gavaris, Fisheries and Oceans Canada, Biological Station, St. Andrews, New Brunswick



SCIENCE FOR ECOSYSTEM-BASED FISHERIES MANAGEMENT IN THE BAY OF FUNDY

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Fisheries and Oceans Canada views the ecosystem approach as the management of human activities to ensure that marine ecosystems, their structure (e.g., biological diversity), function (e.g., productivity) and overall environmental quality (e.g., water and habitat quality) are not compromised and are maintained at appropriate temporal and spatial scales. It means understanding how human activities impact the ecosystem. It also means understanding how the ecosystem affects those activities.

For most of the 20th century, fisheries science focused on strategies to maintain productivity of the harvested resources, focusing largely on controlling exploitation and defining management units that reflected stock structure. The ecosystem approach introduces two changes. The first change is that for each managed activity, we have expanded the scope of conservation considerations to include aspects of biodiversity and habitat. A suite of strategies was developed under the three conservation objectives (Table 1). The aim was to make this list of strategies parsimonious, keeping it simple and manageable, while being comprehensive. This list may be revised as we gain experience. The suite of strategies embraces emerging ecosystem concerns but puts them in the proper context using a comprehensive framework that recognizes and keeps important "conventional" fisheries management considerations. The second change is that, for each strategy, we are now concerned with cumulative effects across activities in a managed area. The conservation strategies and the managed activities define the two fundamental dimensions of the ecosystem approach.

Management planning can be thought of as a hierarchical process that translates objectives into strategies (the what) and specifies tactical management measures to implement the strategies (the how). Indicators play a key role linking the objective, strategy and tactical management measure. Science supports two types of management decisions that reflect the two aspects of the ecosystem approach, a) human impact on the ecosystem: decisions on the 'level' of a tactical management measure, and b) how the ecosystem influences how we should manage: decisions on a suitable reference to signal when an unacceptable condition results. Science activities support development of practical and measurable strategy indicators or their proxies, establishment of suitable indicator reference points, and formulation of advice on consequences of alternative tactical management measures to the strategy indicators with respect to a reference.

The broader scope of conservation strategies and attention to wider range of managed activities places great demands for science support. A practical approach involves application of triage, with evaluation in the first steps done using rapid assessment tools that err on the side of caution. If risk is determined, the choices are to manage the risk or to conduct more involved and expensive evaluations to better define management options and associated risk.

For fisheries, the important impacts are the direct deaths associated with the harvest, the deaths from unintentional catch and the physical disturbance caused by the gear. To make the Ecosystem Approach operational we need to control exploitation, manage discards and incidental mortality, and limit benthic impact. Science aims to provide advice in support of tactical management decisions for controlling exploitation by incorporating uncertainty about the indicator and making harvest strategies compliant with the precautionary approach. More attention is being given to discard mortality of both harvested species and non-harvested species, paying particularly attention to species at risk. Effective management of habitat impacts will require classification of habitat, understanding of the impacts by different fishing activities on the various habitats, and quantification of the bottom area affected by the fishing activities.

To support the ecosystem approach, fisheries science should be active in four areas:

Productivity

- Support establishment/refinement of F* and B* reference points for the harvest strategy using fishery production analyses
- Evaluate fishery monitoring of discards for harvested species
- Consider impacts of discards on the F indicator and associated reference points
- Determine consequences of alternative catch quotas for F relative to F reference

Biodiversity

- Evaluate fishery monitoring of discards for non-harvested species
- Develop mortality indicators from discards for non-harvested species and support establishment of reference points using population dynamics analyses
- Determine consequences of alternative area/season closures and gear specifications to incidental fishery induced mortality relative to reference

Habitat

- Evaluate fishery monitoring for quantification of area fished
- Develop indicators of area disturbed and support establishment of reference points for unacceptable disturbance using seascape characteristics
- Determine consequences of alternative zoning management measures to amount of area disturbed relative to reference

Integrative

- Develop methodologies for addressing the interactions across the broader scope of conservation strategies
- Develop methodologies to address the cumulative effects across all managed activities

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* F – fishing mortality; B – biomass change

Table 1. The conservation strategies and the managed activities define the two fundamental dimensions of the ecosystem-based fisheries management approach

Conservation Strategies (*Indicator*)		**Managed Activities**			
		Groundfish fishery	**Herring fishery**	**Salmon aquaculture**	**Etc.**
Productivity					
Population productivity	Keep *fishing mortality* moderate				
	Promote positive *biomass change* when biomass is low				
	Manage *discarded catch* for all harvested species				
	Allow sufficient *spawning biomass* to escape exploitation				
	Target *per cent size/age/sex* of capture to avoid wastage				
	Limit disturbing *activity in spawning areas/seasons*				
Primary productivity	Control alteration of *nutrient concentrations* affecting primary production at the base of the food chain by algae				
Biodiversity					
Species diversity	Control *incidental mortality* for all non-harvested species				
Population diversity	Distribute population *component mortality* in relation to component biomass				
Habitat					
	Manage *area disturbed* of bottom habitat types				
	Limit *amounts of contaminants, toxins and waste* introduced in habitat				

GOVERNANCE IMPLICATIONS OF MULTI-STAKEHOLDER UNDERSTANDING OF ECOSYSTEM-BASED MANAGEMENT IN THE GULF OF MAINE

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Ecosystem-based management (EBM) for marine systems has been supported by ocean policy review panels in the United States and is being put into practice through the *Oceans Act* in Canada. Its appeal emerges from a recognized need to incorporate effects of environmental dynamics, ecological interactions, human activities, and socio-economic trends into an integrated management process. While there is strong high-level support for EBM, an understanding of what it means in practice to stakeholders and what they expect from its implementation remains elusive.

Interviews with representatives of multiple stakeholder groups with interests in fisheries and aquaculture in the Gulf of Maine region were conducted to identify (1) the benefits and challenges that they associate with EBM, (2) their characterization of what EBM entails and encompasses, and (3) their perceived importance of specific governance features for supporting EBM. Results of these interviews capture diverse perspectives on EBM in the Gulf of Maine. Developing governance approaches for EBM that reflect these stakeholder perspectives remains a challenge, but lessons can be derived from experiences with EBM in other marine and aquatic settings. A review and synthesis of governance approaches for EBM, coupled with regional interview results, suggest that EBM in the Gulf of Maine should incorporate interdisciplinary science, cross-agency and cross-sectoral coordination, and meaningful stakeholder involvement in priority-setting.

DEVELOPING AN ECOSYSTEM FRAMEWORK FOR THE MANAGEMENT OF THE MUSQUASH MARINE PROTECTED AREA

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Musquash, New Brunswick, has been declared an “area of interest,” the first step towards marine protected area (MPA) designation. The Department of Fisheries and Oceans has identified a need for the development of an ecosystem framework as a core element in the management plan for the area. Such a framework establishes physical, chemical, and biological habitat parameters for the assemblage of species using a defined physical area. It assists in setting the boundary or trigger levels for each parameter in order to establish ideal and recoverable ranges, which must be maintained in order to protect or restore various ecological relationships. By maintaining and restoring these relationships, the broad ecosystem objectives for the MPA will be achieved, including maintaining species diversity, maintaining ecological integrity and protecting habitat. To operationalize these broad objectives, sub-objectives, strategies and reference points are proposed. The progress in the development of this framework will be presented and details of the proposed operational strategies and objectives will be discussed.

GULF OF MAINE ECOSYSTEM INDICATORS PARTNERSHIP (ESIP) AND A STRATEGY FOR REGIONAL STATE OF THE ENVIRONMENT REPORTING

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Ecosystem indicators track changes in environmental, cultural, and economic interests, and when coupled with state of the environment (SOE) reports, draw attention to challenges and benefits created by ecosystem conditions. ESIP, the Gulf of Maine Ecosystem Indicator Partnership, is an emerging regional ecosystem indicators and reporting program for the Gulf of Maine/Bay of Fundy. While many indicator and reporting efforts exist within and around the Gulf of Maine, a gulf-wide program is currently lacking. As a program of the Gulf of Maine Council on the Marine Environment (GOMC) and its partners, ESIP is a science-based initiative to leverage existing monitoring infrastructure into a comprehensive reporting system for regional decision-makers.

Our approach is identified in a strategy document that outlines the guiding principles, fundamental approach, and organizational structure for ESIP. At its core, the program recognizes the importance of partnering with existing groups to build on and enhance regional capacity. Recognizing that a complete and sustainable program to track ecological integrity will require years to build, the plan calls for gradual development of steps that serve as building blocks for later phases. The plan includes 1) harmonizing and building on existing efforts, 2) creating regional indicators, 3) developing a data management infrastructure, 4) producing SOE reports, 5) building and sustaining partnerships, 6) conducting effective outreach and 7) securing multi-partner sustained funding. Initial indicator work is focused on six issues managers deemed most important in a 2004 survey—coastal development, contaminants and pathogens, fisheries and aquaculture, eutrophication, aquatic habitat, and climate change.

ECOSYSTEM-BASED MANAGEMENT AND AT-SEA SPECIES IDENTIFICATIONS–PANDORA'S BOX

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The inability to obtain reliable field identifications of species on research and industry surveys of marine organisms is increasingly being recognized as the weakest link in the move to ecosystem-based management. In addition to the retirement of experienced samplers, contributing factors to this trend are the introduction of more demanding sampling protocols coupled with a greater variety of species resulting from more sensitive trawls and extension of survey areas into deeper depths. In this presentation we characterize the scope of this problem for commercial and non-commercial vertebrate and invertebrate species encountered in various industry and research trawl surveys being conducted off North America's northeast coast. Remedial measures currently being attempted on the various surveys are evaluated, and protocols for improving field identifications are recommended. The benefits from this study are expected to be two-fold: first, to provide much needed metadata for end-users to better understand limitations of the resulting data bases, and second, to provide an informed basis for decision making regarding the implementation of new and improved species identification techniques.

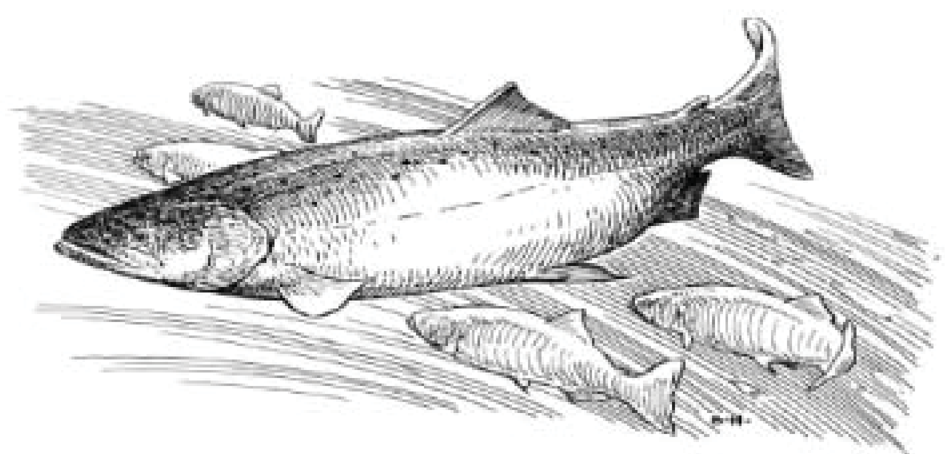
Session Twelve

NEARSHORE FISH ECOLOGY AND INTERACTIONS

Chairs: David Methven, University of New Brunswick, Saint John, New Brunswick

and

Fred Whoriskey, Atlantic Salmon Federation, St. Andrews, New Brunswick



SONIC TRACKING OF EXPERIMENTALLY RELEASED FARMED ATLANTIC SALMON (*SALMO SALAR*) IN THE COBSCOOK BAY REGION, MAINE

Fred G. Whoriskey, Paul Brooking, Gino Doucette, Steve Tinker and Jonathan W. Carr

Atlantic Salmon Federation, St. Andrews, NB (asfres@nbnet.nb.ca)

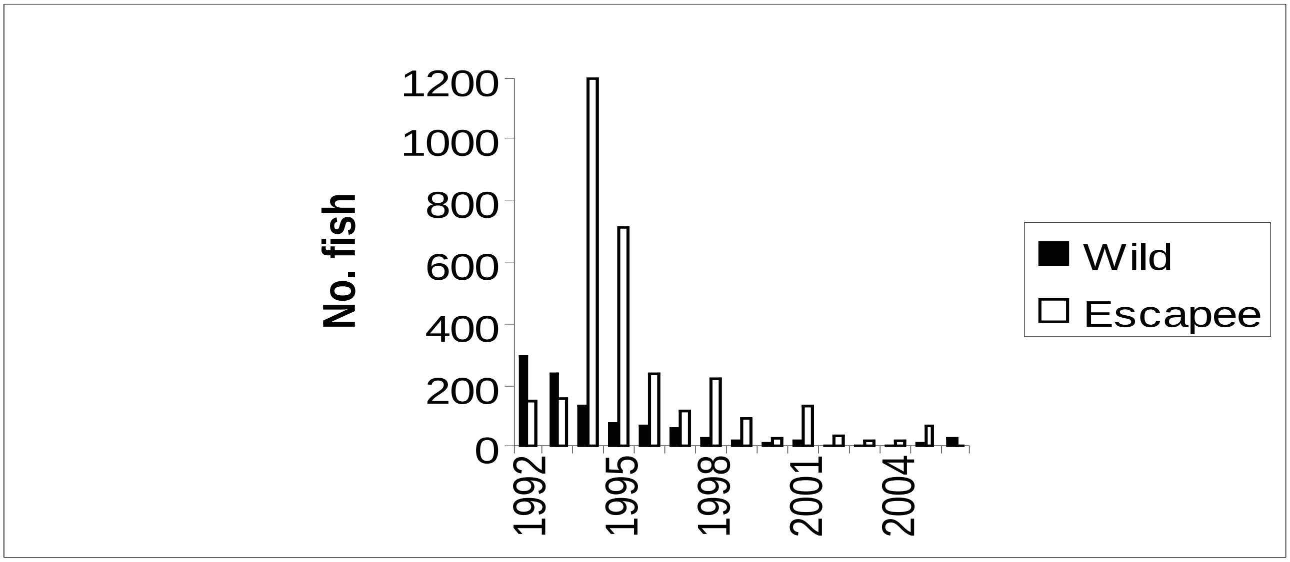
Introduction

The escape of salmon from sea cage sites and their subsequent potential for genetic introgression with wild Atlantic salmon populations is a conservation concern. Research has shown that juveniles from pure farm X farm crosses and from hybrids of farm X wild salmon are less fit in the wild than offspring resulting from pure wild fish crosses. Juvenile salmon of wholly or partially of farm-origin fish in a river can displace wild juveniles, and potentially contribute to an extinction vortex for river-specific wild salmon populations (Fleming et al. 2000, McGinnity et al. 2003). Escaped salmon have posed a serious threat in some rivers (e.g., Carr et al. 1997). The maladaptiveness of the farm-origin fish probably results from two processes. The first is the breakdown of river-specific genetic adaptations in wild populations because farmed stock is from a limited pool of rivers. For example, in New Brunswick it originates from a single river system (the Saint John River, New Brunswick. Glebe 1998). The second is the result of changes wrought in the farmed fish by domestication selection to adapt fish for life in cages instead of in the wild (e.g., Friars et al. 1997).

Farmed fish must survive from their moment of escape until the spawning season, and find a spawning river, in order to have a chance to genetically introgress with wild populations. We know little of the movements and survival of farmed salmon following escape events. Sonic telemetry has been successfully used to follow movements of experimentally released farmed steelhead trout in Newfoundland (Bridger et al. 2001). Here we report on the use of sonic telemetry to document movements and survival to the spawning season of experimentally released farmed Atlantic salmon in Cobscook Bay, Maine. The primary zone of salmon farming in East Coast North America is located in the Cobscook Bay region and the contiguous Quoddy region of New Brunswick. These areas are subjected to large tidal variation and have fast tidal currents. Our objectives were to:

- Report on time trends in escaped farmed salmon entering the Magaguadavic River in the Quoddy region of New Brunswick. This site serves as an indicator river for the numbers of escaped farmed salmon and wild salmon annually entering rivers in this region.
- Document the time it took for the escaped farmed salmon to disperse away from their cage site in the coastal zone to offshore areas of the Bay of Fundy.
- Track the directions and rates of any movements that the fish exhibit, and correlate them with tidal currents and other environmental cues.
- Determine rates of mortality of the escaped fish in the coastal zone.
- Document the degree to which escapees from the release site crossed the international border into Canadian waters.
- Determine if any fish moved to rivers in the region at spawning time.

Figure 1. Numbers of wild and escaped farm salmon captured annually in the fish ladder of the Magaguadavic River, New Brunswick, since 1992.



Methods

Descriptions of the methods used and of the study site can be found in Whoriskey et al. (2006). Briefly, counts of wild and farmed fish were obtained in the Magaguadavic River in a fish ladder which all fish must use to ascend from the head of tide into the river system. A hydroelectric dam constructed at the head of tide blocks upstream migration for the fish, hence the fish ladder.

Sonic telemetry was carried out using equipment from Vemco (now Amirix). Tags were surgically implanted in the fish and have proved to have a life expectancy exceeding 3.5 years in some cases. Receiver units were placed in strategic channels among the islands and bays in the study area, and within 40 Atlantic salmon rivers entering into the Bay of Fundy during the spawning season of the year of fish release. In addition, selected receivers were maintained in the coastal zone, and within the Magaguadavic River system for 20 months after the release of the tagged fish, which covered the second spawning season after the experiment started. Fish from the sea cage site used in the experiment originated from a hatchery on the Magaguadavic River system. If the farmed salmon showed any homing tendency (e.g., Whoriskey and Carr 2001), it presumably would have been to this river.

Results

Numbers of escaped farmed salmon entering the Magaguadavic River have been trending downward since 1994 (Fig. 1). In the sonic telemetry work, farmed salmon (N = 273) were surgically implanted with sonic tags (pingers), and experimentally "escaped" from their cage site during winter 2003 and spring 2004. Experimental releases occurred during either the day or night, on rising and falling tides.

In both seasons, escapees generally dispersed rapidly away from their cage sites. Heavy seal predation apparently rapidly killed many escapees in spring, but not winter. Course tracks of the fish indicate a combination of active swimming and drift with prevailing tidal currents. Movements carried most of the fish out of Maine and into Canadian waters. None of the escapees were detected entering rivers in the region during the spawning season where they could interact with the spawning of severely depressed (and in some cases officially endangered) wild populations of Atlantic salmon, although some escapees entered the estuaries of rivers outside of the spawning season. One individual was tracked for 180 days, and moved extensively within the region.

Conclusions

Improvements in containment (both technological and in operating procedures) have reduced the number of escapees available to enter the rivers in the Quoddy region. Rapid dispersal of the fish away from the cage sites precludes any effective recapture program. However, heavy predation by seals can rapidly reduce the numbers of escapees present, and we have no evidence of the survival of any of these fish to spawning. Thus the genetic threat from escaped farmed salmon towards wild salmon in this region has been greatly reduced over time. The documented movements of escaped fish from United States to Canadian waters (and presumably the reverse could occur for escapes from Canadian farms) argues for a coordinated international approach to managing the environmental impacts of the industry.

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SONIC TRACKING OF WILD COD, *Gadus morhua*, IN AN INSHORE REGION OF THE BAY OF FUNDY: A CONTRIBUTION TO UNDERSTANDING THE IMPACTS OF COD FARMING FOR WILD COD AND ENDANGERED SALMON POPULATIONS

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Sea cage trials to farm Atlantic cod have begun in the Bay of Fundy region. We fitted inshore wild cod (n=10) captured in the Quoddy region with sonic tags during the late summer of 2004 to provide data on their temporal and spatial residency and habitat usage, with a view to assessing the potential for interaction between escaped farmed cod and wild cod and other fish species, particularly Atlantic salmon.

The majority of the tagged cod remained within a restricted corridor in the inshore zone, occupying deep water (75-130 metres) within several kilometres of the release point and undertaking local movements. Three cod undertook more extensive movements, with one fish emigrating offshore from the study area and two fish moving up to 14 km away from the release point before returning, 52-54 hours later, to the area in which the other cod had assembled. The mean residence time in the inshore zone was 55 days. In the late fall there was a staggered pattern of departure from the coastal zone, although one fish over-wintered in Passamaquoddy Bay. Three of the nine cod that migrated offshore in the fall of 2004 returned within a three week period in May 2005 after a mean absence of 172 days and reoccupied the inshore region inhabited the previous year. These cod left the region again after a mean spring and summer residence of 120 days.

The presence of some of the tagged cod in the principal migration corridor for wild salmon smolts during the period of their migration suggests that escapes from cod farms could result in increased predation on salmon smolts from endangered populations.

THE ESCAPE OF JUVENILE FARMED ATLANTIC SALMON FROM HATCHERIES INTO FRESHWATER STREAMS IN NEW BRUNSWICK, CANADA

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The escape of juvenile Atlantic salmon from freshwater hatcheries supplying the salmon farming industry is a route for interactions between wild and farmed fish; however, the scale of this problem has not been substantially examined. We monitored temporal trends in abundance of escaped juvenile farmed salmon in the Magaguadavic River and Chamcook Stream over several years. In addition, we assessed more than 90 per cent of the commercial hatcheries located adjacent to freshwater streams in New Brunswick and which were producing salmon smolts in 2004. Escaped juvenile fish were recorded in 75 per cent of the streams electrofished close to hatcheries. Numbers varied per site and among years. However, escaped juvenile salmon were found every year at sites near hatcheries in the Magaguadavic River and Chamcook Stream. In the Magaguadavic River, juvenile escapees outnumbered wild salmon parr in most years. These results highlight the need for the implementation of a containment strategy for freshwater hatcheries to reduce escapes.

The use of European Atlantic salmon strains for commercial culture by the salmon farming industry has never been permitted in Nova Scotia and New Brunswick, Canada and has been prohibited in Maine, USA since 2003. Despite this, varying levels of European ancestry were detected in escaped farmed salmon obtained from the Magaguadavic River and Chamcook Stream, New Brunswick. Of the 53 escaped farm smolts from the Magaguadavic River and 17 escaped hatchery parr from Chamcook Stream analyzed, a single European type allele was observed at a single locus in two escaped farmed smolts from the Magaguadavic River, and two escaped hatchery parr from the Chamcook Stream. These results highlight the need for better containment strategies for freshwater hatcheries and genetic screening programs for farmed salmon broodstock to minimize the likelihood of introgression of non-local genetic material into severely depressed wild Atlantic salmon populations in the Bay of Fundy region.

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O'Reilly, P. T., J. W. Carr, F. G. Whoriskey, and E. Verspoor. 2006. Detection of European ancestry in escaped farmed Atlantic salmon obtained from the Magaguadavic River and Chamcook Stream, New Brunswick, Canada. ICES Journal of Marine Science 63: 1256–1262.

Editor's note: The abstracts were previously published in the papers noted above.

SEASONAL AND REGIONAL VARIATION IN SPECIES COMPOSITION AND ABUNDANCE OF NEARSHORE FISHES IN THE SOUTHWESTERN BAY OF FUNDY

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Estuaries and associated nearshore coastal waters are regions of high productivity that serve as nursery grounds and as migration corridors for anadromous species spawning in freshwaters. Our research examined how the scale and structure of the nearshore fish assemblages varies 1) seasonally, by sampling six sites every two weeks throughout the year and 2) regionally, by sampling 16 sites throughout the southwest Bay of Fundy over one week. Eighteen species were collected throughout the year, with just seven species comprising greater than 95% of the total catch. Species richness and abundance were correlated with water temperature, there being distinct warm and cold water assemblages present. Species richness and abundance were highest on more structurally complex substrates. The nearshore fish assemblage was typical of coastal regions elsewhere in Atlantic Canada being dominated by a few species (*Menidia menidia* (53.95%), *Osmerus mordax*, (18.70%), *Clupea harengus*, (9.25%), *Pseudopleuronectes americanus*, (3.86%), *Microgadus tomcod*, (3.86%), *Myoxocephalus scorpius*, (3.30%), and *Gasterosteus wheatlandi*, (3.26%)) and consisted mostly of juvenile fishes. The dynamic nature of this nearshore region of the Bay of Fundy, dominance by juveniles and lack of residency among many of its inhabitants limits the number of suitable species that can serve as sentinel indicators of environmental health.

Final Session

CHALLENGES IN ENVIRONMENTAL MANAGEMENT OF THE BAY OF FUNDY– MOVING FORWARD

Chairs: Maxine Westhead, Department of Fisheries and Oceans, Dartmouth, Nova Scotia,

Peter Wells, Environment Canada, Dartmouth, Nova Scotia and Dalhousie University, Halifax, Nova Scotia

Challenges in Environmental Management of the Bay of Fundy– Moving Forward

1320-1325 Student Award Presentations (Jon Percy)
1325-1330 Introduction to this session (Peter Wells).
1330-1350 Presentation – regional ecosystem governance (John Coon).
1350-1430 Panel discussion, with 5 min. per panelist. (the panelists).
1430-1500 Open Discussion/Questions (Maxine Westhead, Peter Wells)
1500 Closing Remarks (Gerhard Pohle)

Student Paper and Poster Awards Presented at the 7th Bay of Fundy Science Workshop

First Place Oral Presentation

Alexander Bond (University of New Brunswick, Fredericton, NB) [Supervisor: Antony Diamond]
Comparing adult and chick diet in two Alcid species using stable isotopes

Second Place Oral Presentation

David Drolet (University of New Brunswick, Fredericton, NB) [Supervisor: Myriam Barbeau]
Effect of density of the gastropod *Ilyanassa obsoleta* on distribution and movement of the amphipod *Corophium volutator*

First Place Poster

Koreen Millard (Nova Scotia Community College, Lawrencetown, NS, and Acadia University, Wolfville, NS) [Supervisor: Timothy Webster]
High-resolution LIDAR elevation data of inter-tidal areas: A potential tool for examining salt marsh vegetation communities

Second Place Poster

Shannon O'Connor (Acadia University, Wolfville, NS) [Supervisor: John Roff]
The Atlantic Coastal Zone: All the little fishes

Introduction to the Session

Peter Wells

The theme of this workshop has been "*Challenges in Environmental Management in the Bay of Fundy and Gulf of Maine*", with a focus on the Bay of Fundy. This theme was chosen because of the belief that much more needs to be accomplished before human activities around the bay, its inlets, estuaries, and its watersheds, including activities utilizing the bay's natural resources, are being managed demonstrably in a sustainable and integrated manner. That is to say, that we (i.e. Fundy and GOM citizens, communities and industries) have truly entered an era of practicing integrated coastal management (ICM), including integrated environmental management, ecosystem-based management (EBM), and ecosystem-based fisheries management, in the Bay of Fundy and Gulf of Maine (GOM) region. It is clearly time to move collectively from all the planning, talking and writing, to the practice!

To give context to the new challenges, it is crucial to recall that we are the current keepers of a highly changed marine ecosystem, one impacted in many ways since European settlement four hundred years ago (e.g., Lotze et al. 2004; Pesch and Wells 2004; Worm et al. 2006; Clover 2006; among many others). Unfortunately, too many environmental issues in the Bay of Fundy, from LNG (liquified natural gas) transport and aquaculture impacts, to potential onshore and offshore mining and the cumulative impacts of trawling, are being considered separately, as if they operate in isolation from one another. There must also be due consideration of the whole marine ecosystem, its interconnections with the land and freshwater systems, its long term health, and the implications of a continually degraded coastal and terrestrial ecosystem to the economies and sustainability of coastal communities.

Such comprehensive management, both of the environment and its living and non-living resources, is not a simple task, as shown by the recent efforts on ecosystem-based management (EBM) of living resources (in particular, see papers above in Session 11). Comprehensive environmental and resource management has a number of requirements (a preliminary check list):

1. Understanding the issues and their importance (e.g., climate change is occurring and will impact the Gulf of Maine, hence it is time to truly recognize the seriousness of the future challenges);
2. Having effective and objective forums for the dissemination of information and debate;
3. Ensuring that critical information sharing is taking place in a timely fashion;
4. Ensuring that we have practical ecosystem-based objectives, and guidelines of other sorts, recognizing the so-called shifting baseline syndrome;
5. Ensuring that we know how to practice EBM and ICM institutionally, and that we have genuine cooperation between institutions and responsible bureaucracies;
6. Ensuring that we have effective and active legislation in place at all levels of government to guide the practice; and
7. Ensuring that the process is driven by genuine goodwill and a desire to manage the bay and its resources and ecosystems in a sustainable manner over the longer term.

Comprehensive management also requires that we have mechanisms in place such as long-term monitoring of critical environmental indicators, and periodic state of the marine environment reports, to mark our progress, shortfalls, and next steps. In an era of accelerated change in our coastal ecosystems, driven by climate change and intensive resource use, the importance of succeeding at comprehensive environmental management and EBM of the Bay of Fundy and greater Gulf of Maine cannot be overstated.

In this session, we will hear from practitioners involved in aspects of coastal management, as to how they are addressing the challenges and proceeding with greater effectiveness and commitment. Afterwards, we hear the responses of workshop participants in the audience to the many challenges of environmental management, and how we should be moving forward.

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CAN WE GET THERE FROM HERE? TOWARD AN INTEGRATED ECOSYSTEM APPROACH TO GOVERNANCE IN THE GULF OF MAINE REGION

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Abstract

Decades, even centuries, of resource extraction and exploitation by humans have taken a toll on the Gulf of Maine. Traditional sector-by-sector governance has failed to stem the recent trend toward environmental degradation in the Bay of Fundy/Gulf of Maine region. Population growth trends and environmental threats show no sign of abating. The Gulf of Maine Council and others have joined in the chorus calling for a broader, more holistic ecosystem approach to the governance of the human activities that impact the coastal oceans. Using real-world lessons learned from the ecosystem-based efforts in the Great Lakes Basin and other binational governance models, this paper explores the methods being employed to examine whether the existing governance regime of the Bay of Fundy/Gulf of Maine region has the capacity to implement an adaptable ecosystem approach to restore and sustain, over time, the integrity of the ecosystem, including the functions upon which the humans in the ecosystem rely.

Purpose

In a world where coastal natural resources are under increasing pressure, ecosystem-based management regimes are gaining currency as an approach to the management of human activities that threaten the coastal margin. Despite the gaining popularity of various iterations of ecosystem-based decision making attempts, in many cases there is little sign that stresses on the coastal regions are abating. In many cases, the problems impacting critical coastal and aquatic habitats may be getting worse. Given the increasing adoption of ecosystem-based approaches to resource management in both watersheds and coastal marine areas, why do many stresses and threats to ecosystem integrity of these systems still persist, or in some cases, appear to be increasing? Why, for example, in the Gulf of Maine where the Gulf of Maine Council's mission statement now urges an ecosystem-based approach to decisions about resources, does the system exhibit increasing signs of stress? What lessons can be learned from other regions where ecosystem approaches to resource management are underway?

The purpose of our investigation is to examine whether the existing governance regime of the Gulf of Maine has the capacity to implement an integrated, adaptable ecosystem approach to restore and sustain, over time, the integrity of the respective ecosystems, including the functions upon which the humans in the ecosystem rely. For instance, what are the current goals of the governance system (units and subunits) in relation to the human uses of and anthropogenic threats to the ecosystem in the Gulf of Maine and how do these differ or resemble those of similar ecosystem restoration projects? What are the barriers that may prevent the current governance regime in the Gulf of Maine and comparable ecosystem restoration areas from managing the marine and coastal resources in the region in a sustainable manner? What measures have been adopted in comparable restoration efforts to modify and improve the governance and management regime so that the critical functions of the ecosystem can be preserved or enhanced, while at the same time enabling competing interests to be harmonized in a fair and equitable manner? How can relevant innovations be incorporated in the Gulf of Maine governance system, if at all? How can the policies, priorities, and actions of local, state, provincial and federal entities be integrated to assure a sustainable approach to the management, use and development of coastal ocean resources across political boundaries?

Background

The need to manage the human activities that contribute to the degradation of vital coastal ecosystems in a sustainable manner has never been more apparent. The pressure on coastal and ocean resources has increased relentlessly. While federal and related state and provincial environmental laws and regulations enacted in the 1970s have had an undeniable positive impact in the form of cleaner air, lakes, and rivers, locally and regionally rapid population growth, coastal development, and increasing user conflicts have degraded natural resources and led to declines in both ecological integrity and general productivity (Ullsten 2003). The coastal areas that provide essential habitats for a significant portion of commercially valuable marine species are reeling from the effects of habitat loss, pollution, and overfishing that have reduced populations of coastal fish and other species to historically low levels of abundance and diversity (VanderZwaag 1995; Sutinen et al. 2000). Further, larger coastal human populations lead invariably to needs for larger sewage treatment facilities, expanded solid waste landfills, increased recreational use, and other environmental pressures (Cicin-Sain and Knecht 1998). As the Joint Ocean Commission Initiative in the United States recently observed: “At the dawn of the 21st century, it is clear that these invaluable and life-sustaining assets are vulnerable to the activities of humans. Our failure to properly manage the human activities that adversely affect our oceans and coasts is compromising the health of these systems and diminishing our ability to fully realize their potential” (JOCI 2006: 47).

Certainly the overall picture is bleak. Yet stressed, degraded and overpopulated coastal areas still provide critical ecosystem services, including fish and shellfish for market, coastal transportation, tourism, pollutant detoxification, oil and gas potential and a wealth of other benefits. Despite the frail condition of the coastal ecosystems, and though sadly in need of relief, the reality is that humans continue to flock to the coasts to live, work and play, adding to the countless stresses already in existence. Diversity and resilience are undoubtedly eroding ecosystem functions and are likely accelerating at a global scale, with potentially catastrophic social consequences if current trends are not significantly mitigated or even reversed (Worm et al. 2006). Despite the added stresses, however, coastal ocean resources are capable of being used in a sustainable fashion and resource overexploitation is not the inevitable consequence of increasing human population and resulting environmental pressures (Rosenberg et al. 1993).

Nearly all of the human activities that pose threats to the Gulf of Maine ecosystem, including pollution, coastal development, and overfishing, are still managed, some more intensely than others, on a traditional medium-specific sector-by-sector basis (JOCI 2006). Current laws reflect the traditional tendency of government agencies and departments charged with responsibilities for natural resources and coastal ocean activities to be limited to regulation of some particular type of activity such as logging or fishing. Thus management focus has historically been narrow or sectoral and typically concerned with increasing production of desired commodities (Juda 2003). It is, however, “…understood that the collective result of these individual jurisdictional efforts is not enough to ensure the long-term sustainability of the entire Gulf of Maine region” (Hildebrand et al. 2002). Clearly “… the Gulf of Maine is at a critical juncture, with new management approaches needed to protect its valuable ecosystems for generations to come” (Pesch and Wells 2004).

Ecosystem-Based Governance

While a trend toward a broader, more holistic ecosystem approach to environmental management of the coastal marine regions has been the pronounced response to the perceived failure of traditional sector-based management (Haskell 1992; FAO 1995a; Costanza 1998; EPAP 1999; Juda 1999; Sherman and Duda 1999; Costanza et al. 2001; Macpherson 2001; Sherman and Duda 2001; Link 2002; US Commission on Ocean Policy 2002), considerable thought must be given to how such an ecosystem-based approach could effectively be implemented in the Bay of Fundy/Gulf of Maine region.

Implementation of ecosystem-based initiatives is still relatively rare. There are disagreements among the experts over the meaning of ecosystem-based management, and definitions are commonly used are often are confined to one component of a larger ecosystem (Costanza et al. 2001; COMPASS 2005). While no attempt to identify or recite the varied definitions and descriptions is attempted herein, there is substantial consensus on many of the key principles for the effective integrated and ecosystem-based management of our coastal regions as summarized in Table 1. One common characteristic that emerges from the literature, for instance, is that management decisions must recognize that humans are an integral part of the ecosystem; thus management decisions should be made based primarily upon the health and integrity of the ecosystems. The notion of intergenerational equity is also a strong influence upon ecosystem decision making: the future health of the ecosystem has value. In addition it is clear that ecosystem borders differ spatially from political borders. Further, there is a need for reliable science and information, adaptable governance that can monitor the science and act upon it, and decision makers who deal with scientific uncertainty by using a precautionary approach to management. Finally significant participatory democracy must be integrated into the social and decision processes including but not limited to significant roles in the gathering of information, decision making and program evaluation (Holling et al. 2002).

Clearly the transition from traditional natural resource sector-by-sector management to the broader, more holistic and integrated ecosystem-based approach is no easy task. There is an inextricable link between prescribed policy and the institutional arrangements and processes that fulfill and implement the policies. Institutions and agencies do not merely stand down for new policies formulated by legislatures or other law-making bodies, for the institution itself "…provides an environment in which policies can be devised, altered, interpreted, advocated, ignored, or otherwise transformed"(Donahue 1988).

Table 1. Key principles for the effective integrated and ecosystem-based management of our coastal regions

Criteria	Definition	Indicators
Governance must recognize that humans are a part of the system	Integrated ecosystem-based management must focus on the natural processes necessary to sustain ecosystem structure and function while recognizing the need for human and institutional involvement at every level of the ecosystem (Sutinen et al. 2000; Becker 1996).	The goal of sustaining the integrity and health of natural systems is a characteristic of an ecosystem management government regime. Focus should not be on particular levels of output (e.g., total allowable fish catch) when it is the capacity of the ecosystem that determines whether output levels are consistent with the sustainability of the system; sustainability is primary goal.

Adaptable and accountable ecosystem governance	Adaptable and accountable ecosystem. Governance must have led or joint institution able to adapt to new information and understanding (Christensen et al. 1996; Becker 1996). They must, therefore, have the authority and means to carry out systematic scientific research to understand system response and status, to track compliance with policy goals and objectives, as well as to make necessary changes when necessary.	Overarching agency, commission, or other political body or effective formal/informal affiliation of governance institutions with ability to monitor local and regional ecosystem in holistic fashion, process information, detect problems, and fashion solutions with input from working groups comprised of multidisciplinary working groups. Agreement, treaty, protocol or other arrangement giving governance its authority and defines boundaries in accordance with ecosystem boundaries, not political. Effective conflict resolution mechanism present.
Problems are accurately specified	A primary factor for successful policy implementation is that the nature of the policy problem must be accurately specified so its solution can be appropriately designed.	Formal and informal methods for intelligence from local and regional sources able to identify developing problems and prevention; incentives built-in, public input encouraged.
Clear policy goals with broad public input	Clear, unambiguous, and measurable policy goals and objectives that have been determined with significant input from scientists, regulators, and the regulated community	Goals and objectives to restore, protect, maintain ecosystem integrity; goals that have measurable indicators; mechanisms for public input into goal definition.
Ecological boundaries, not political	Approach is applied within a geographic framework determined primarily by ecological, not political, boundaries. Thus the process must overcome the fragmentation inherent in both the sectoral management approach and the splits in jurisdiction among levels of government at the land-water interface to get at all sources and impacts (Becker 1996).	Presence of treaties, protocols, agreements, partnerships that open pathways for cooperation between agencies and scientists of different jurisdictions and agencies to cooperate toward a common goal of ecosystem restoration and maintenance; informal arrangements; actual cooperation.
Degree of integrated coastal management (ICM) integration	This criterion may best be demonstrated by those regions that have implemented integration and coordination of institutional functions and responsibilities in a variety of directions (Cicin-Sain and Knecht 1998).	Intersectoral, intergovernmental, spatial, science-management, and international integration; agreements or other arrangements allowing communication and cooperation between levels and participants in restoration efforts. Reliable intelligence from science and public at all levels.
Precautionary approach	A precautionary decision-making approach must be used in order to account for the great degree of uncertainty inherent in complex natural resource issues (Sherman 1994, 1996; Sutinen et al. 2000; Costanza et al. 2001; VanderZwaag et al. 2002).	When uncertainty exists about the impact of a particular action, structure and regulations require regulators to balance the risk of harm against the socioeconomic impact of the activity to society and err on the side of conservation.
Public participation	Opportunity for meaningful participation and input of a broad segment of the regulated population in decision-making processes (Becker 1993; Pauly and Maclean 2003).	A process/plan is in place to educate the public and keep them informed of progress toward goals; formal mechanisms available for public to offer input and formal intervention.

A method that can be used to determine whether a given governance regime is making strides toward the implementation of an ecosystem-based approach to governance is clearly needed. How does one examine a region and determine if ecosystem-based management principles are being implemented and, if so, how and with what results?

Methods

In order to assess the governance regime in the Gulf of Maine region and assess the extent to which it has the capacity to implement a broader, more holistic, ecosystem approach to the management of human activities that impact the environment, we will use comparative case study methodology using the analytical framework provided by the policy sciences.

After examining a variety of initiatives that claim to take an ecosystem approach for our comparative case, the authors elected to examine the governance regime in place in the Great Lakes Basin under the Great Lakes Water Quality Agreement (GLWQA) and the Great Lakes Fisheries Commission (GLFC). This choice was made because many of the challenges to meaningful policy development in the Great Lakes parallel those present in the Gulf of Maine. The primary threats to the health of the ecosystem in the Gulf of Maine appear to be posed by overharvesting, pollution, shoreland development, habitat destruction, and global climate change (Steneck 2001; Clark 2002; Pesch and Wells 2004; Steneck et al. 2004). These threats are largely paralleled in the Great Lakes Basin (Dempsey 2004; Botts and Muldoon 2005; Becker 1996). Further, governance in both systems is challenged by the fragmented and often confusing array of local, state, provincial, and federal regulatory bodies that frequently form bureaucratic barriers to integrated and holistic management of the activities that threaten the health of their respective ecosystem (Pesch and Wells 2004; Botts and Muldoon 2005). The governance regime in the Great Lakes Basin also provides interesting insights into ecosystem-based initiatives because a basin-wide ecosystem approach to management has been mandated under the GLWQA and the GLFC since the 1970s.

There is, however, a need for a framework capable of systematically assessing the social and decision processes that have been employed in the selected regimes in order to begin to understand the lessons learned from the more veteran ecosystem-based regime in the Great Lakes Basin and consider the extent to which successful initiatives can be adapted in the Gulf of Maine. The framework chosen for this examination is provided by the policy sciences analytical framework (Clark 2002; Lasswell 1971).

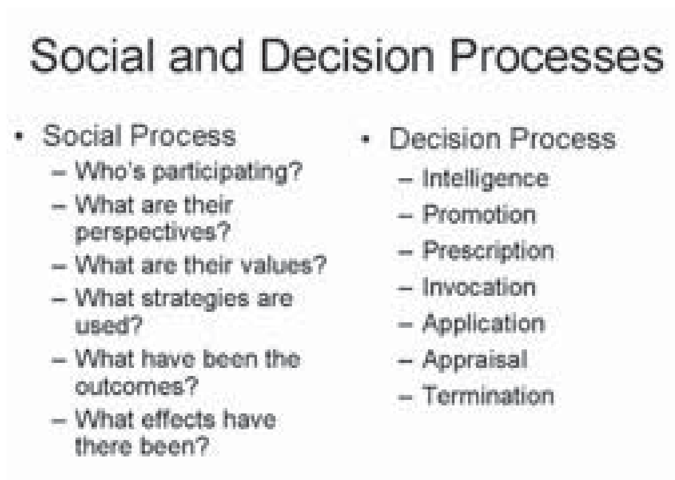
The analytical framework provided by the policy sciences recognizes that we need to ask questions of a significant array of participants and actors in a governance regime. We must recognize that resource problems are not simply environmental problems: They are human problems that have been created at many times and in many places, under a variety of political, social, and economic systems (Ludwig et al. 1993). From a policy sciences perspective, “the ongoing interaction of people in their efforts to achieve what they value is the foundation of all policy, including that of natural resources. Public policy making is a never-ending process whereby people attempt to clarify and secure their common interests. Management is the actual manipulation of people and resources through programs” (Clark and Willard 2000).

Thus the goal of the policy sciences is to clarify and secure the common interests. *Common interests* are those that are widely shared within a community and demanded on behalf of the whole community. This should be contrasted with *special interests* that benefit only part of a community as the expense of the rest of the community (Clark 2002). Generally a policy process serves common interests if:

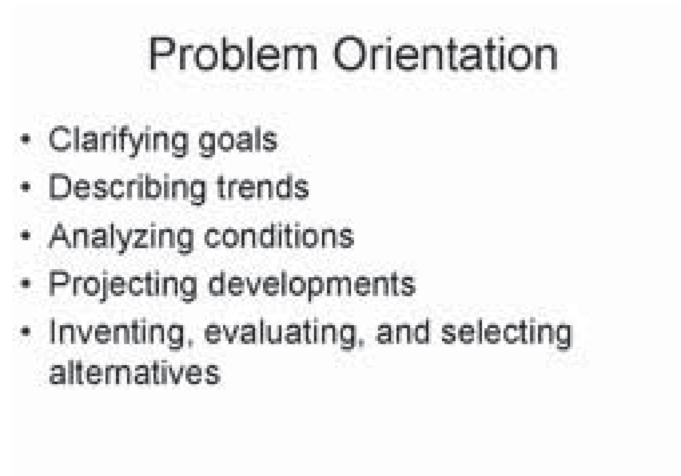
- It is inclusive and open to broad participation.
- It meets the valid expectations of participants.
- As implemented, or tested, it is responsive and adaptable in achieving the goals as the context changes, i.e. it is adaptive (Lasswell 1971; Brewer and deLeon 1983; Clark 2002).

The public policy method uses a framework of three principal dimensions: social process mapping, decision process mapping and problem orientation. These dimensions provide a flexible but "stable frame of reference" that allows analysts to look beyond technical particulars to see the functional relationships that are present. Thus, rather than ask agency and department heads whether they are employing an ecosystem-based management approach to the issues presented within their jurisdictions, the policy sciences analytical framework as used in this study provides means to empirically verify the situation by reviewing the literature and primary documents, observing participants behavior, and asking questions designed to explore the social process, decision process and problem orientation practices utilized by government and other institutions as well as stakeholders to determine the extent to which the components of an overall ecosystem-based governance regime are in place (Lasswell 1971; Brewer and deLeon 1983; Clark 2002).

Social process analysis examines the particular social contexts in which problems are embedded. A set of conceptual categories are used to describe or map any social process relevant to the problem situation. The categories include participants (who are they?), their particular perspectives, and their values or assets. Participants use whatever values they have ("assets" or "base values") and use various strategies to achieve desired outcomes that have effects. Values, both what people strive for and the assets that are used to acquire more of them, are created and exchanged (shaped or shared) through social interactions to gain more values. There are eight values we deal with: power, wealth, enlightenment, skill, well-being, affection, respect, and rectitude. Social and decision processes have outcomes and effects that may be characterized as indulgent or deprivational in terms of whether values are gained or lost for participants. Key to this analysis is the fundamental view that in all human interactions, people tend to act in ways they perceive will leave them better off than if they had acted otherwise (Lasswell 1971). With respect to ecosystem-based governance, social process mapping plays an important role in determining the degree of involvement of the public in all stages of the governance process, the values of the participants that drive the political and institutional framework in the respective, and helps to identify the social participation gaps that need to be filled in order to make governance more broadly representative of common interests.



An examination of the decision process practiced in a given ecosystem governance regime requires mapping the seven interlinked functions of intelligence, promotion, prescription, invocation, application, termination, and appraisal. This systematic analysis can turn up flaws in the decision process that cause restoration plans to fail. By knowing how a decision process works, or doesn't work, participants can maintain good practices or correct a poorly functioning one. A decision process can be a way of reconciling or at least productively managing competing interests and policies through politics. Politics will always be with us because people seek different policies that reflect their particular, or "special", interests. In many cases, however, as in sustainability management, people must reconcile interest differences to clarify and secure their common interest. Investigation should reveal who establishes what the common interests are or should be. In terms of ecosystem-based governance, trends can be determined that might indicate whether intelligence data is reliable and linked to the appropriate scales within an ecosystem, whether such intelligence is being communicated to policy makers in a meaningful manner and, ultimately, whether a structure exists that allows for decision makers to react to intelligence in an adaptive fashion. Note that ecosystem-based governance requires a decision process that is open and transparent, not slanted toward special interests and power (Clark 2002).



Finally, problem orientation is a strategy to address problems and invent solutions. It requires goal clarification. So in terms of ecosystem conservation/restoration, the question might be what should a sustainable, viable, functioning, resilient ecosystem look like? These questions need to be answered by the community only after considering the problem's context or social and decision process. If these questions have been answered and policy determined, who were the participants? What was the process? Were common interests defined or did special interests influence the process? Social process inquiry sneaks in here so that process, participants, their values and interests, and other factors can be evaluated to determine whether the approach used to define the problems or propose the goals was in some way flawed. Further, trends must be described with ample input from the natural sciences. Are conditions trending toward the goals established by the community? If not, there is a problem and alternatives need to be considered. Conditions need to be analyzed to determine the reason(s) for the environmental breakdowns and developments need to be projected, including the likely outcome if no action is taken (Clark 2002).

Policy Sciences and the Great Lakes Basin

A comparison of the selected governance and restoration initiatives in the Great Lakes Basin and the Gulf of Maine region using a policy sciences analytic framework as a guide is under way. It is hoped that it will reveal formal or informal factors which tend to facilitate or hinder progress in the design and implementation of ecosystem-based and integrated coastal management in real world projects. Empirical data is being obtained via targeted surveys and follow-up interviews to shed light on the challenges and benefits of such an approach. While no conclusions can be drawn at this time about the role played by ecosystem-based governance in the successes or failures of efforts in either the Great Lakes Basin or the Gulf of Maine, there are some patterns or stories that may be highlighted at this point.

Nearly 30 focused interviews have been conducted of individuals identified as having knowledge relevant to the governance system in place over time in the Great Lakes Basin. In addition, primary documents and secondary sources and literature pertaining to conditions, trends, and governance under the GLWQA and GLFC have been reviewed. The pattern that has emerged for the Great Lakes story can be described in brief.

During the 18th and 19th centuries, the Great Lakes Basin was widely exploited for its natural resources, including forest products and fisheries. Laws relating to the control of human activities that impacted the Great Lakes ecosystem were fragmented between the US and Canada and their respective states, provinces and local governments. The Boundary Waters Treaty of 1909 between Canada and the US created the International Joint Commission (IJC) mostly to mediate water quantity related border disputes between the countries, but also was given a role to investigate pollution issues between the two countries. Overfishing and pollution continued unabated into the 1960s, culminating in the public eye with the famous burning of the Cuyahoga River in Cleveland, the declaration of Lake Erie as “dead,” Love Canal, and other similar crises (Dworsky 1988; Dempsey 2004).

An angry and determined public, acting through a rapidly expanding list of citizens’ organizations that had emerged to combat pollution, drove additional reform measure. The IJC, acting on a reference, instructed both countries to take action on water pollution issues in the Great Lakes. The initial 1972 Agreement between the United States and Canada was negotiated. It was essentially a water pollution agreement but, with increasing environmental degradation and active citizen involvement, the agreement was ultimately amended in 1978 with the declared purpose to “… to restore and maintain the chemical, physical and biological integrity …of the waters of the Great Lakes Basin Ecosystem.” The ecosystem was defined as “the interacting components of air, land, water and living organisms, including humans.” Further evidence of the fact that the 1978 agreements had morphed into the restoration of ecological integrity as the major goal, not just improved water chemistry through pollution control can be found in the definition of the Great Lakes system as all of “… the streams, rivers, lakes and other bodies of water that are within the drainage basin” (Becker 1993; GLWQA 1987).

Fisheries in the Great Lakes, including a once-significant commercial fishery, had also seen a complete collapse caused by the invasion of lamprey eels and pollution. In the 1950s, lake trout populations had been reduced to 99% of their 1930s levels. This drove the ultimate formation of the Great Lakes Fishery Commission by convention between Canada and the U.S. in 1956. Its charter recognized the value of “joint and coordinated efforts’ to address fisheries conservation (Dempsey 2004). While the job of the GLFC was initially to formulate a plan to combat the invasive lampreys, by the 1980s the Commissioners from both sides of the border, and their staffs, had cultivated and begun to practice a protective ecosystem policy by working closely with the IJC and its related Water Quality Board and Science Advisory Board. They often reviewed land use and pollution impacts on fish, but stopped short of challenging the use and release of contaminating chemicals on the fisheries or the people who consumed them (Dempsey 2004)

The governance system under the IJC from 1978 until the early 1990s allowed for a social process that included a wide variety of actors, including government agencies, non-governmental organizations (NGOs), and related institutions. In 1979 the IJC established a standing committee to assist in providing the public information service called for in the 1978 agreement (GLWQA 1987) The basic concept was that citizens have rights to participate in IJC activities and should be encouraged to do so. The policy stressed that information should be provided while studies and activities are being carried out, not just after decisions were already made. The aim was to increase the IJC’s credibility by taking public opinion into account. Its 1980 public information policy included guidelines for the IJC annual meetings (later biennial), calling them “the most important public information event of the year” (Botts and Muldoon 2005). The “Camelot” years of the 1970s through the mid-1990s, marked by open and transparent decision making with significant public input at all levels, integrated governance task forces and overlapping advisory boards, had an impact. The 1978 GLWQA recognized the link between land-based activities and water quality (GLWQA 1987), explicitly acknowledging the role of non-point source pollution. It adopted the ecosystem approach, basin-wide (GLWQA 1987). A ban on the use of phosphates in the basin was passed over industry objection and a zero tolerance approach to persistent pollutants was adopted.

This era also opened up a variety of routes for citizen input and participation. In addition to the biennial meetings, the IJC's Great Lakes Regional Office in Windsor, Ontario, provided a much-needed public information center. Many of the NGOs extant in the basin united under one binational banner in 1982 via the formation of Great Lakes United—a binational coalition of more than one hundred NGOs, labor unions, conservation organizations, outdoor groups, colleges, and others. Its 1986 report *Unfulfilled Promises* was drafted after 19 citizen meetings around the basin attended by more than 1,200 people. In 1991, the GLU spearheaded the attendance of some 2,000 people at the IJC's biennial meeting in Windsor, Ontario. Other groups performed other much-needed functions. Great Lakes Tomorrow was an organization headquartered in Hiram, Ohio, that took education about the ecosystem-related decisions "on the road" to communities around the Great Lakes Basin (Becker 1993). The Great Lakes Cities Initiative involved cities on both sides of the border in Great Lakes environmental decisions.

The good times, however, did not last in the Great Lakes governance scheme. Through resource and budget reductions by both federal governments, the down-sizing of the Windsor office, and increasing efforts by federal agencies on both sides to accomplish through closed-door negotiations what had once been discussed at open meetings, the spirit of community that dominated the GLWQB/GLFC process gradually has been lost. Sadly, the Great Lakes ecosystem is once again under threat from various anthropogenic threats, including shoreland development and pollution (Dempsey 2004). Citizens are largely out of the information loop, hoping for aid from governments unwilling to fund a clean-up (Bay City Times 2006).

Implications for the Bay of Fundy/Gulf of Maine

This study has focused to date far more on an exploration of the governance regime encompassed under the GLWQA and the GLFC. Efforts to map the extent of "ecosystem-based governance" in the Bay of Fundy/Gulf of Maine region are in the early stages. Research and field interviews of interested actors in the Great Lakes Basin give rise to general questions about the capacity of the governance regime in the Bay of Fundy/Gulf of Maine region. We will briefly raise these questions in the context provided by the policy sciences analytical framework.

In an ecosystem-based governance regime, it is expected that the social process would include a broad range of participants and stakeholders. The values that would drive the process would be those of well-being and enlightenment rather than power and wealth. It would also be expected that strategies for the distribution of values would revolve around negotiation and idea-sharing, rather than litigation/confrontation. The outcome of such a process would possibly lead to a more community-wide effort to work together in issue-based task forces designed to tackle current problems as well as to anticipate future issues. The social process in the Bay of Fundy/Gulf of Maine region, however, seems to be at odds with these ideal expectations. At first blush there seems to be very little substantive citizen involvement at any level of the governance process. While values of the principal actors are unknown at this juncture, the strategy used relatively frequently to resolve conflict is litigation rather than diplomacy or engagement. There seems to be little chance that a spirit of cooperation and community could move the governance system down the path to ecosystem-based governance without active involvement and support of the public.

The decision process in the region seems to be in worse shape than the social process. While ecosystem-based governance would generally require scale-matched intelligence, integration, feedback mechanisms, and the ability to react adaptively to developing problems of the pertinent government agencies on issues of importance to the system, it is not clear that any of those are present in the Bay of Fundy/Gulf of Maine region. It is simply not known whether intelligence data are reliable and linked to the appropriate scales within an ecosystem, whether such intelligence is being communicated to policy makers in a meaningful manner and, ultimately, whether a structure exists that allows for decision makers to react to intelligence in an integrative and adaptive fashion. No overarching institution or agreement is in place that would enable adaptive change in the event that problems develop. It is also a struggle to find integration when representatives with primary responsibility for the development of fisheries management plans fail to attend or contribute to meetings of the Gulf of Maine Council on the Marine Environment and *vice versa*.

Finally, goal orientation is a process that is difficult to assess unless the decision and social processes are understood. While it is certainly premature to delve too deeply into analysis at this point, it is troubling that there seems to be nothing written that would indicate what goals the community wants for the ecosystem. With intelligence of some, but not all, of the threats confronting the ecosystem, it is also difficult to understand the nature of the ecological trends that might shed light on ecosystem health. In other words, at this stage of our investigation, there are far more questions than answers.

Conclusion

There simply has not been enough research and field work done to date to determine whether the institutions in the Bay of Fundy/Gulf of Maine have the capacity to implement an ecosystem-based governance regime. The point of this article, however, has been to demonstrate that the use of comparative case study methods with a policy sciences analytical framework may provide a functional, qualitative way to assess existing governance regimes. The paper also suggests modifications in governance that could help provide a more holistic and adaptive ecosystem-based approach to the management of those human activities that impact the environment—from all directions.

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THE PANEL DISCUSSION— CHALLENGES FACING ENVIRONMENTAL MANAGEMENT

Maxine Westhead and Peter Wells, Moderators

A distinguished panel was brought together for commentary on the workshop theme. The focus was on the challenges that face environmental management in the region, how to overcome the challenges, and identifying the next steps that we should be taking as a Fundy and Gulf of Maine community. Workshop participants were encouraged to form their own questions and to come prepared for a vigorous and constructive debate with the panelists.

Sample questions provided to all participants were:

1. What are the current challenges to achieve better management of the Bay of Fundy? How well understood are they?
2. What are the future issues in achieving the goal of sustainable management of the Bay and Gulf?
3. How can we prepare for the future issues?
4. What are the impediments to the management of (programs in) the Bay of Fundy?
5. What is the status of progress addressing them?
6. On indicators and indices, for reporting on the health of the bay – do we have what we need? Consider the science and its application – how can we reduce the lag time, from research to development and application?
7. How can we move forward with ICM in the Bay of Fundy and Gulf of Maine?
8. How can we work with other groups more effectively to address these challenges?
9. How can we fund the above ideas and suggested work?

The panelists were (in order of speaking):

Larry Hildebrand, Environment Canada, Dartmouth, NS.
Kate Killerlain-Morrison, Massachusetts Office of Coastal Zone management.
Rob Stephenson, St. Andrews Biological Station.
Fred Whoriskey, Atlantic Salmon Federation and HMSC.
Maria Recchia, Centre for Community Based Management, St. Andrews, NB.
John Coon, University of New Hampshire, Durham, NH.

The panelists made the following points (in summary, from notes of MW and PW):

Larry Hildebrand (LH): There are lots of organizations in the Bay of Fundy area, thus we have the groundswell of momentum to move forward. Expectations are high and people want to be involved. The question is 'are we investing money and effort wisely and efficiently?' Are we being cost-effective? Is the portfolio too diverse? To me, it's quite simple – the key questions that indicators address are 1. What do the scientific and monitoring data tell us? and 2. What should we do about it? Larry listed several activities going on in the BoF/GoM (GoMC, NEG/ECP, etc.) and stated that they must connect – something like the GoMC/BoFEP agreement is needed to provide structure. There should be linkages to broader levels and initiatives of government , such as the Oceans Agenda.

Kate Killerlain-Morrison (KKM): This is a Massachusetts (MA) perspective, where we have state jurisdiction of the coastline out to 5 km. The U.S. has something called consistency jurisdiction which helps deal with offshore issues such as wind farms , LNG, etc. A key question is—how much information is needed to make the appropriate decision(s)? We are currently creating a comprehensive management plan for MA waters, and they are classifying sea floor, water column, and air space. Through the Gulf of Maine Council there is great information exchange. We need to make proponents of developments consider the impacts and cumulative impacts of their projects. In this context, The Nature Conservancy is looking at submerged lands leasing. There is also a need for market-based incentives or eco-labelling. No single agency can do ecosystem-based management (EBM) alone, hence a CA/US professional exchange program is suggested.

Rob Stephenson (RS): Globally there is a move towards EBM. In general, the words are there, but we need to move the words into action and make the concept operational – need case studies and proof of concept. There is a complexity of structure in the BoF/GoM that is worrying, as well as the complexity of regulatory processes and the proliferation of meetings. This complexity may be our undoing. We need an overarching structure for EBM and clear leadership to make it happen. We will never completely understand the ecosystem and we need to get on with it and focus on EBM, which includes filtering and discriminating the real issues, and identifying what is relevant for the decisions that need to be made.

Fred Whoriskey (FW): We need to manage people’s fear, not their activities. Scientific information takes away the fear. We need to brief and inform politicians much better, so that they make decisions based on information. The Atlantic Salmon is “not a canary, but a fragile turkey”. We need long-term monitoring programs with such indicators, to “take the fear away”.

Maria Recchia (MR): I am the “radical person” on the panel. BoFEP is excellent at what it does – information generation, sharing and education – but perhaps it needs a bit of soft activism. We need to beconducting ecosystem management now. There is an information need, and a need for “wisdom holders/knowledge holders. The scientists should be the resource managers and make the decisions, hence moving the science more directly to the decision makers. At present, EBM is very traditional and the scientists and the various publics have only an advisory role – we need something more substantial and effective than this.

John Coon (JC) – there is a problem of fragmentation in EBM. The government needs to give more power to the people. Note the lessons learned with the spotted owl issue (in the US). Perhaps we should give BoFEP subpoena power!!

DISCUSSION FROM THE FLOOR

Moderated by Peter Wells and Maxine Westhead

The panel questions were followed by discussion from/with the audience. This record will feed into the themes and sessions for future workshops, and new work addressing the challenges, hopefully involving everyone who attended the workshop!

Peter Lawton (PL): We are all taxed with meetings. With the current procedures in place, there is too much process to handle. Bring the process back to a single system and aggregate the non-government players.

MR: Agreed there are too many meetings. If fishermen had the job of making decisions at these meetings, they would go to every one. If in an advisory role only, they won't go.

RS: Need effective co-management and fewer structures. But we use the existing structures for discussion and decisions.

Graham Daborn (GD): There are two different types of groups in the BoF/GoM – mandated groups like the GoMC and bottom-up groups like BoFEP, that focus on issues. Many groups are unwilling to bow to an over-arching coordinating body, they wish to hold onto their area of concern, but we desperately need such a body for the Bay of Fundy – the questions are – what is the best body or group for the Bay of Fundy? And how do we achieve it?

MR: It is interesting to note that in BoFEP, the scientific, knowledge based working groups have kept going, whereas the others dealing with broader mandates and roles have declined in activity.

Peter Wells (PGW): How can we improve the role of BoFEP in this regard?

FW: The Atlantic Salmon Federation focuses on the rivers and local area management. We have to get serious about the natural resources, and get a civic response to protecting and conserving the whole ecosystem.

LH: ACAP groups, which are community based, take the lead and control the direction and focus of their work. Then there are groups such as GOMC, which is government based. There is a power difference between such groups. A balance is required for inclusiveness and capacity across groups. How do we achieve this?.

FW: We generate inaction with too many groups and too many small/local issues. We need to decide where the best investment lies. We also need synthesis (?).

PGW: How about producing an annual synthesis report—issues, conditions, action, needs—for the Bay of Fundy? If there is agreement about this, we need to know why it is being done, how to fund it, and how it will be used for better EBM.

MR: In regard to BoFEP, do what we do well and remain as we are; the whole Fundy community is not involved enough but this may not be critical to what we do.

FP (Fred Page): There are so many groups operating on different scales, but we are losing the focus on and importance of particular issues. We have to focus on a few things. We need a synthesis. An annual status of the bay report may be needed. But how important is this information? Are we using it? Who cares? People are not saying!!

JC: "unrecorded comment by scribes…another Einstein moment in time lost forever…"

FP: Regarding reports, should they be annual? Does the community know about the many annual fisheries reports? We need short, bulleted, balanced overview reports. The reports should lead to action, advice, more action, with public buy-in.

RS: Let's get on with the job of the EOA/audit, against the backdrop of EBM. Get on and do it!

FP: We need to convince the public that higher level concerns are important (e.g., shooting merganser ducks versus maintaining a high quality salmon river; the Yellowstone Park example of maintaining its forest ecosystems and wildlife by using fire as a natural disturbance).

JP (Jon Percy): BoFEP's approach is not so much as an umbrella as an octopus, with many tentacles; its purpose is to link, not oversee. There is a fine line often between the science and the issues, putting us into a quandary at times. However, we do advocate "the health and sustainability of the Bay of Fundy and its watersheds".

PL: We really need to make more efficient progress on the Bay's issues. Right now, there are too many meetings for discussion, and scientists are involved, but this detracts from the work itself.

MR: Can we put the word out of the scientists working more closely with the fishermen, on issues? A lot of little steps will result in BoFEP being the octopus, as above.

LH: There may be over-governance in the Bay of Fundy and Gulf of Maine. We are fortunate in this region with organizations. For each group, determine your place in the system, define your roles, and do well at what you are good at.

Closing Remarks of the Workshop Chair, Dr. Gerhard Pohle, HMSC

The 7th Workshop formally ends now. Many thanks for your valued participation in the workshop, and particularly for staying for this afternoon's most valuable and stimulating session. Our challenge now is "to move on with the job"! We hope to see you all at the next BoFEP Bay of Fundy Science Workshop, to be held at Acadia University in Wolfville, NS, in October 2008. I wish everyone a safe trip home.

POSTER SESSION

A. BIOLOGY, ECOLOGY AND HABITAT PROTECTION/RESTORATION

HANDING OVER THE REINS: CHEVERIE CREEK SALT MARSH RESTORATION PROJECT AS AN EVOLVING MODEL OF COMMUNITY-BASED RESTORATION

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Cheverie Creek in Hants County, Nova Scotia, has won regional and national recognition as one of the first salt marsh restoration projects in Nova Scotia. Much of its success can be attributed to the close collaboration between the Ecology Action Centre (EAC–the organization that initiated the project), local community groups, and responsible regulatory agencies such as Nova Scotia Department of Transportation and Public Works (NS-DOTPW) and Department of Fisheries and Oceans Canada (DFO).

By showing how responsibility for project activities shifted over time, this poster illustrates the gradual transfer of project ownership from the EAC to community partners At the beginning of the process, EAC took the lead in education and outreach, date collection, and communication with regulatory agencies and the municipalities. Over time, this relationship has changed so that now local community groups, and the municipality are leading education, outreach and interpretative activities and the EAC plays a supporting role as needed. This project demonstrates how a community-based project can evolve as local ownership increases.

TO SETTLE AND SURVIVE: RECRUITMENT OF JUVENILE GREEN SEA URCHINS, *Strongylocentrotus droebachiensis*, IN BOCABEC COVE, BAY OF FUNDY

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Settlement and early post-settlement mortality can affect patterns of recruitment and influence the population dynamics of green sea urchins, *Strongylocentrotus droebachiensis*. In Bocabec Cove, Bay of Fundy, the patterns of settlement and recruitment of green sea urchins, *Strongylocentrotus droebachiensis* were examined at three rocky subtidal sites in 2004 and 2005. Settlement was measured using Astroturf collectors and was found to vary temporally and spatially. The abundance of settlers was consistent across sites in 2004, but in 2005 there were significantly more settlers at site 3 in mid July than at any other site or date in either year. Recruitment was quantified in late fall by counting and measuring juveniles <10 mm in test diameter. Regressions showed that recruitment patterns were not predicted by settlement patterns ($r^2 = 0.048$, $p = 0.7$), indicating that early post-settlement processes were occurring in these populations. Early post-settlement mortality due to predation was examined in both the laboratory and the field.

It was found that in the laboratory, rock crabs, *Cancer irroratus*, consumed more juvenile sea urchins than did sea stars, *Asterias vulgaris*. In the same experiment, substrata (cobble vs. sand) and density of sea urchins were not shown to be significant factors affecting the number of juvenile sea urchins consumed by these predators. A caging experiment in the field showed that predation was not likely the cause of the decline of the number of juvenile sea urchins <10 mm in the cages. It appears that early post-settlement events are important for setting up patterns of recruitment, although which processes are affecting the populations remain unclear.

***** SECOND PLACE STUDENT POSTER PRIZE*****

THE ATLANTIC COASTAL ZONE: ALL THE LITTLE FISHES

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Despite recent legislation from federal agencies to enable marine conservation, no coordinated national or regional plan has been formally adopted to develop national networks of marine protected areas (MPAs). Most studies undertaken in this field have concentrated on offshore waters – typically greater than thirty metres in depth. As such, very little work has been done to define representative or distinctive sites within the inshore zone. This project attempts to define relationships between the distribution of larval and juvenile fish, with topographic and geomorphological features in the coastal zone.

The intent is to derive a classification of inshore waters based on easily measured and mapped features, from which candidate protected areas can be selected. Questions being considered include: 1) Can we define areas with greater abundance or diversity of fish from topographic features? 2) How many areas of different habitat types do we need to protect? and 3) How large of an area do we need? To date, numerous habitat types have been surveyed around the coast of mainland Nova Scotia for juvenile and larval fish. Preliminary analysis depicts an increase in species number with decreasing substrate particle size (e.g., from boulder to mud substrate types). As well, the number of fish species increases northwards along the Atlantic coast of Nova Scotia. This study will contribute to information leading to the environmentally defensible selection of both priority and representative areas for MPAs.

DIET AND MOVEMENTS OF GREATER SHEARWATERS (*PUFFINUS GRAVIS*) AROUND GRAND MANAN ISLAND, NEW BRUNSWICK

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Tidally-mediated currents in the Bay of Fundy create areas of localized upwelling which may concentrate prey for a variety of marine organisms. At the north end of Grand Manan Island, the Long Eddy island wake is a tidal upwelling area used extensively by seabirds and marine mammals on the flood tide. In 2005, we captured 46 Greater Shearwaters (*Puffinus gravis*) foraging in the Long Eddy wake and collected 41 feather and 32 blood samples for dietary analysis using stable isotope and fatty acid analyses. Isotope analysis of blood samples reflects the average diet over the past few weeks. Comparisons of blood isotopic signatures with those from collected potential prey (12 krill and 14 herring) showed that most birds were feeding on herring but some individuals were specializing on krill. Fatty acid analysis, however, which reflects the most recent diet (hours or days), strongly suggested that shearwaters feeding at the Long Eddy were consuming krill. In 2006, we continued the dietary study and launched a pilot study tracking the movements of up to six shearwaters using satellite telemetry. Tags were deployed on shearwaters captured around Grand Manan and a preliminary analysis of the movements of these birds are presented. Combining dietary analysis with tracking studies may be a useful method for identifying critical foraging habitats of shearwaters, other seabirds, and marine mammals in the Bay of Fundy.

ANNAPOLIS RIVER WATERSHED PESTICIDE INVENTORY AND RISK RANKING PROJECT

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In response to local public concern over pesticide usage, Clean Annapolis River Project (CARP) conducted the first inventory of pesticide use in the Annapolis River watershed. By utilizing different methods of data collection such as interviews, surveys and consulting pesticide vendor sales data, the inventory identified 65 different active ingredients used across seven sectors in the watershed. The total pesticide usage was estimated to be approximately 55,400 kg in 2004. To further analyze the data, CARP utilized the methodology developed by Allison Dunn of Environment Canada to rank the pesticides based on their environmental risk.

The methodology incorporated uniquely weighted environmental, human and exposure effects specific to each active ingredient. A list of active ingredients was produced displaying the risk ranking for each with preliminary results indicating that Chlorothalonil was the highest ranked active ingredient in the watershed. The results of this study create a baseline for future reference as well as confirm that the methodology developed by Dunn can be successfully applied to different areas to produce site-specific risk rankings. The inventory and risk ranking serve to allow an informed discussion between members of the public, pesticide applicators and regulators on appropriate pesticide uses.

B. CLIMATE CHANGE

ATLANTIC COMMUNITIES AND CLIMATE CHANGE

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Atlantic Canadian communities, whether they're large cities or small rural centers, are going to feel the effects of a changing climate. Bridges, roads, and railways could be submerged by rising sea-level or washed out more frequently by storms. Coastal erosion will result in property loss and the need to relocate or abandon costly infrastructure and buildings. More frequent and severe weather events, such as ice, rain and wind storms, could result in power outages and disrupted municipal services. Municipalities have control over much of the infrastructure that may be impacted, and as such must incorporate climate change considerations into their decision-making processes, such as through modifications to municipal planning strategies and zoning by-laws.

Emergency preparedness planning and protection of critical infrastructure need to take climate change into consideration, as the likelihood of being impacted by an extreme weather event will increase as our climate changes. Adaptation strategies for resource-based communities could include diversifying the local economy away from dependence on natural resources and refocusing on natural resources that are more likely to flourish as the climate changes. Communities that draw their identity from their natural surroundings, such as the landscape or another natural resource, may find adaptation more difficult. Two Atlantic Canadian coastal communities, Saint John, NB, and Annapolis Royal, NS, have already taken steps to identify their vulnerability to climate change induced sea level rise and storm surges.

ATLANTIC FORESTS AND CLIMATE CHANGE

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Forests cover a large proportion of Atlantic Canada. People and wildlife alike depend on a thriving forest for their well-being. Climate is a key determinant of the health of forests, as well as what types of forest are present. The natural precipitation, winds, and temperature of a forest determine which trees will compose the forest and what organisms succeed. Scientists are predicting that as the global climate changes, average annual temperatures in Atlantic Canada will increase. Also, while total average precipitation will remain stable, rain and snowfall will depart from the seasonal patterns that Atlantic Canadians have grown used to. As a result of changes in temperature, the type and the health of forest in an area can also be expected to change. The effect of a changing climate on natural patterns of forest disturbance is poorly understood in Atlantic Canada but creates the biggest cause for concern. The major threats to forest health (insect infestations, damage from high winds, and forest fires) are all highly dependent on climate. Some strategies that may have potential to reduce the adverse effects of climate change on Atlantic Canada forests include: anticipatory planting, breeding to increase drought resistance, planting to increase species richness, integrated pest management, maintaining biodiversity in forest stands (i.e. avoiding plantations of a single species), and managing for uneven-aged stands.

ATLANTIC WATER RESOURCES AND CLIMATE CHANGE

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Future climate change in the Atlantic Provinces may result in changes to the water regime such as more heavy precipitation, longer periods of drought, changes in stream flow, salt water intrusion of coastal freshwater aquifers, and reduction in volume and length of snow cover. Human communities and natural ecosystems that depend on reliable supplies of fresh water may be impacted by a changing climate. Systems and communities with less capacity to adapt, including many First Nations communities, will be most vulnerable to these impacts. This poster presents some of the findings of a workshop held with participants from many First Nations in the Atlantic Region, and co-hosted by the Atlantic Region of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN)* and the Atlantic First Nations Environmental Network, to explore the relationship between fresh water and climate change in Atlantic Canada.

**Editors' note*: C-CIARN was discontinued by the federal government in early 2006.

ATLANTIC STORM SURGE AND TSUNAMI WARNING SYSTEM

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Storm surges and tsunamis are serious issues for coastal zones. Real-time forecasting and alert systems can prevent loss of life and mitigate the damage caused by these hazards. Canada and the United States have recently undertaken interim measures to develop an enhanced capacity for early warning of surges and tsunamis in the Atlantic. Part of this effort includes dissemination of high frequency sampled and polled water levels in real-time.

Tsunami forecasting is initiated through monitoring seismic events. It also requires a priori modeling of tsunami propagation. However, for confirmation of earliest arrivals and amplitude estimation at anticipated arrival sites, decision makers must have immediate access to real-time data. In Atlantic Canada, corroboration of projected extreme water levels is now available through the Permanent Water Level Network.

Future development of coastal management practices, risk reduction measures and design of mitigation strategies require geo-scientific and climatological knowledge in order to better estimate flood probabilities under changing rates of sea-level rise and, in the case of storm surges, the possible effects of a warming climate. Furthermore, they require adequate understanding of vertical land/sea datums and realistic mapping of hazard zones. Determination of the potential for coastal flooding in areas of high vulnerability is a key element of any alert system.

The coastline can no longer be considered as a line on paper, but should be understood as a 3-D landform subject to physical processes. Airborne laser altimetry allows the development of high-resolution digital elevation models of low-lying, flood-prone terrain to support risk reduction and hazard mitigation.

LOCAL DOMAIN GLOBAL FORCING (LDGF) METHOD AND ITS APPLICATIONS IN THE PROBLEMS OF TSUNAMIS, STORM SURGES, AND OPEN WATER BOUNDARY CONDITIONS

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A new modelling method, the LDGF (Local Domain Global Forcing) method, is proposed, which permits simulations run only on a subset of grid points while still allowing for the effects of global forcing and global boundaries, hence the name of the method. The subset defining a local domain may consist of points of interest only, not necessarily adjacent to each other, such as locations of tide gauge or important coastal cities. The ratio of the number of the grid points in the local domains versus that in the global domain indicates the computational efficiency one can achieve with the LDGF method.

This is possible because of the superposition principle of linear dynamics. The LDGF method first calculates the Green's functions for the points of the local domain as the characteristic response to a unit forcing in any part of the global domain. The Green's functions must be calculated, once only, before running the model for a real event. The local response to a real global forcing will then be a linear combination of the pre-calculated Green's functions. Simulation at any points of interest can proceed alone without the simulations elsewhere because the decoupling has been handled by the Green's functions; parallel computations are thus ready for multiple local domains.

This modelling method will greatly facilitate the real-time simulations of a local effect driven by a global or ocean basin event, like tsunami or storm surges. With the LDGF method, specification of open boundary conditions is no longer necessary as far as the linear dynamics are concerned. The local solution is identical to the one obtained as if the simulation were run globally. Using the LDGF method can provide a non-linear model with the linear solution as the conditions at open boundaries, which should be placed at locations where the non-linearity is weak.

C. MONITORING

RESOLVING SCALES FOR DEVELOPING AND APPLYING ECOSYSTEM INDICATORS IN THE GULF OF MAINE

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Ecosystem indicators are being actively explored in many regions, including the Gulf of Maine, as an approach to track key ecological changes and to integrate broader ecological considerations into management decisions. Numerous potential indicators have been proposed to support ecosystem-based approaches to fisheries management; however, detailed investigations of appropriate taxonomic, temporal, and spatial scales at which indicators should be developed and applied have not been conducted. Analyses of mean trends, variability patterns, and correlation structures in the data offer powerful approaches for resolving appropriate indicator scales. When combined, these analyses convey the importance of looking beyond mean trends in the data. In addition to information available from the statistical properties of the data, current understandings of the ecosystem as well as the information needs and capacities of the management process will influence the choice of scales at which indicators are implemented. This presentation will draw upon example indicators compiled from Northeast Fisheries Science Center data sets of biological features, physical conditions, and human activities relevant to marine fisheries in the Gulf of Maine ecosystem. These examples will be used to derive conclusions about the scales at which indicators may prove most useful in supporting ecosystem-based fisheries management within this region.

DEVELOPMENT OF CHEMICAL INDICES OF COASTAL ZONE EUTROPHICATION

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This study will develop a working index of coastal zone eutrophication for the Atlantic coast of Nova Scotia. It should be applicable around the world. Measurements of nitrate, ammonia, phosphate, chlorophyll *a*, total nitrogen, and total phosphorous were taken at an extensive series of bays and estuaries along the Atlantic coast of Nova Scotia throughout the summer of 2006. Collected data will be displayed on a nitrogen: phosphorous phase space diagram that should clearly indicate the observed threshold between impacted and un-impacted coastal environments. The historical problem of temporal variability in nutrient levels due to phytoplankton activity will be accounted for using an amalgamation of the Redfield nutrient ratios and the coastal Carbon: Chlorophyll *a* ratio. We hope that this amalgamated ratio will allow us to accurately convert between measured levels of nutrients and Chlorophyll *a* (an indicator of phytoplankton biomass) throughout the year. Adjusted nutrient levels for a given area will be compared to measured levels of total nitrogen and total phosphorous from the same area in an attempt to further assess their accuracy. Results from this study will be related to indices of land use in Nova Scotia (a separate and parallel research undertaking by Colleen Mercer-Clarke) in order to establish a better understanding of coastal zone eutrophication along the Atlantic coast of Nova Scotia.

ENVIRONMENTAL MONITORING OF AQUACULTURE IN NOVA SCOTIA

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Nova Scotia Fisheries and Aquaculture's Environmental Monitoring Program studies the relationship between aquaculture and the marine environment. Based on a protocol established by government, academia and industry, monitoring is conducted on both aquaculture leases and at reference stations in the surrounding bay. Monitoring consists of collecting qualitative (video) and quantitative (sediment and water analysis) elements from coastal areas throughout Nova Scotia.

The Environmental Monitoring Program (EMP) follows a risk-based approach that recognizes increased risk requires increased monitoring. All suspended sites currently in production are targeted and those that are larger or more intensive are given higher priority. Those sites of potential concern are subject to repeat sampling and, if required, remediation action is implemented.

By the end of the third field season in 2005, the EMP has taken over 1300 sediment samples from 461 stations in 40 different bays. This includes 67 stations at 36 finfish sites (mostly salmon and steelhead) and 183 stations at 123 shellfish sites (mostly mussels). In addition, 211 reference stations were also sampled as both a comparison to pre-culture conditions and as a way of assessing any bay-scale effects.

The EMP is finding that as sites are measured multiple times, in different seasons, it is possible to observe marine environmental change and act accordingly as responsible environmental managers. Nova Scotia Fisheries and Aquaculture (NSFA) can now measure and compare risk between variables (e.g., finfish vs. shellfish, bay vs. site, active site vs. non-active site). With such extensive baseline data, NSFA can better organize the field component of actual site monitoring by focusing on sites of particular interest.

The generally low level of impact found in Nova Scotia is in part due to the dispersed (low density) nature of aquaculture sites in Nova Scotia, and provides further support for the assertion that aquaculture in Nova Scotia can be environmentally sustainable.

The EMP is well on the way to exceeding its targets of completing the baseline sampling of all marine aquaculture sites by 2007. In addition, the EMP is already working on a variety of related projects with both regulatory and scientific partners to continue to expand the knowledge base of the potential environmental impacts of aquaculture on our coastal ecosystems. The EMP has also been communicating the results at presentations to a variety of audiences and has generated interest from across Canada. The feedback is very encouraging, not only on the program itself, but also on the results, which demonstrate low environmental impact of Nova Scotia aquaculture.

D. ORGANIZATIONS

THE FUNDY BIOSPHERE INITIATIVE

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This New Brunswick Biosphere Reserve proposal is nearing completion. It will be submitted to UNESCO before the end of the year. The development process has been a lengthy one and involves a diversity of partnerships starting with the community level. The area being proposed for the project is the watersheds and coastal marine areas on the upper Bay of Fundy, extending from the Tantramar Marsh through to St. Martins, and extending inland as far as Petitcodiac. The area represents a cross section of rural and urban communities.

The Man and Biosphere Program is guided by a set of principles and standards established by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Once achieved the UNESCO designation 'Biosphere Site' recognizes the uniqueness of the tract of the landscape involved and the commitment of the residents to sustainability of the area's natural biodiversity. It also recognizes the work being by communities, senior governments and resource managers to preserve and enhance the culture, heritage and ecological integrity in the area. An UNESCO designation has the potential to enhance the profile of the area nationally and internationally and assist with sustainable economic development opportunities. It will also facilitate public and private sector investment, attracting technical expertise and encouraging scientists and resource managers to enhance their sustainable development strategies.

All Biosphere Sites are intended to fulfill three complementary and mutually reinforcing functions: a conservation function, a development function, and a logistic support function.

BAY OF FUNDY ECOSYSTEM PARTNERSHIP: A DECADE OF ADDRESSING ISSUES INFLUENCING THE BAY OF FUNDY - GULF OF MAINE

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Abstract

The Bay of Fundy is a biologically productive and diverse coastal ecosystem, rich in renewable living resources and non-renewable mineral resources. For a number of years, many people and groups have been concerned about effects of various pressures, alone and together, on the bay's biota, habitats and ecosystems. Some species and habitats are at risk, especially from coastal industries and development, and the sustainability of some living resources is being compromised. Sustaining a healthy, high quality, functioning ecosystem requires the interest and cooperation of scientists, resource managers, business interests, resource users, and residents of the many coastal communities. The Bay of Fundy Ecosystem Partnership (BoFEP) was formally established in 1997 to foster such cooperative efforts. It comprises individuals and groups committed to acquiring and promoting information about the bay and its watersheds, as well as promoting environmental protection and conservation, sustainable resource use and integrated management. BoFEP sponsors a biennial science workshop, open to all citizens, to review results of new studies, promote the group's activities, discuss new initiatives on issues, and work collectively towards solutions. BoFEP has active working groups dedicated to specific topics and research areas, and promotion of communication and cooperation. BoFEP publications are available with a cumulative index on a CD; they include proceedings of workshops (seven since 1996) and the 28 Fundy Issues Fact Sheets. The Web site provides information about BoFEP, its committees, publications, Bay news, and hotlinks to other information sources and organizations pertinent to the Bay of Fundy.

The Origins of BoFEP

The Bay of Fundy between New Brunswick and Nova Scotia is a 270 kilometre northeastern extension of the productive Gulf of Maine. The Bay's 1,300 kilometres of coastline ranges from rugged, rocky headlands about its mouth to broad mudflats and salt marshes around its inner reaches. It has long been of economic, ecological and scientific importance, largely because of its world-renowned tides, exceeding 16 metres in height, drive a dynamic, productive and ecologically diverse coastal ecosystem and an abundance of valuable living resources.

However, there are signs that all is not well in the Bay of Fundy. Worrisome changes are happening beneath its roiling waters. For example, declining fish stocks threaten the livelihoods of coastal communities. Ship strikes and entanglement in fishing gear injure and kill endangered Right whales. Quarries, urbanization and industrial developments intrude into coastal areas. In the upper Bay, changes in salt marshes and mudflats threaten species that are dependent on these habitats. Causeways and dams obstruct the Bay's rivers and alter sediment transport, mudflats, salt marshes and ecological processes. With each such assault the vitality and integrity of the ecosystem is diminished. Slowly but surely, we are undermining the sustainability of the Bay's living resources and curtailing future economic opportunities.

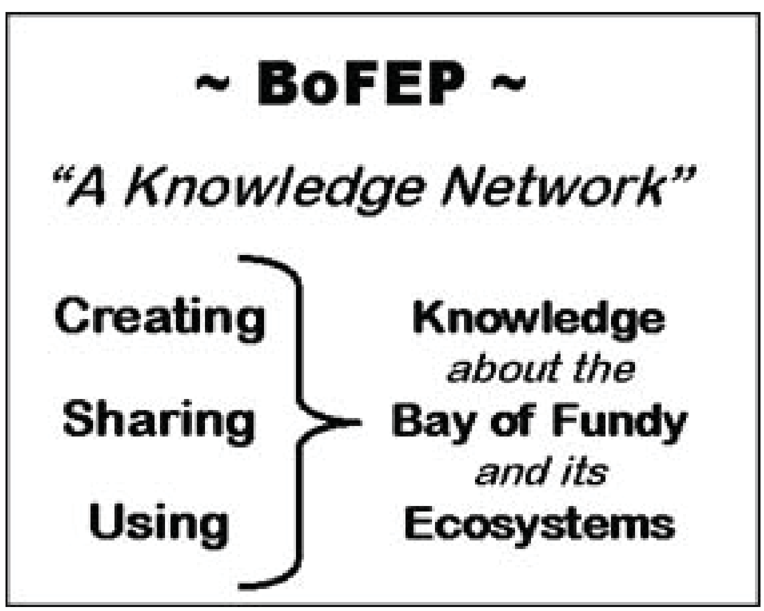
In order to review and assess the state of scientific knowledge of the ecosystem, the Fundy Marine Ecosystem Science Project (FMESP) was initiated in 1995, and held its first science workshop at Wolfville, NS, in January 1996. The outcome of that review was a recognition of the need for better integration of research on the Bay at an ecosystem scale. It was also realized that a broader organization was needed that would link the scientific enterprises of FMESP and the interests of many other stakeholders, such as coastal communities, resource users, governmental agencies and private sector groups, that share an interest in the Bay and its resources. Thus was initiated the renamed Bay of Fundy Ecosystem Partnership, which held its inaugural meeting in St. Andrews in November 1997 in conjunction with the Second Bay of Fundy Science Workshop.

Membership in BoFEP is open to all interested citizens and groups who share its fundamental vision and objectives, including community groups, resource harvesters, scientists, resource managers, coastal zone planners, businesses, government agencies, industries, shipping interests and academic institutions.

BoFEP as a Knowledge Network

The fundamental currency of BoFEP as an organization is "knowledge", specifically knowledge about the Bay of Fundy, its watersheds and biological communities. BoFEP is essentially a "knowledge network" that includes among its partners many diverse groups as well as individuals with an interest in the conservation and wise use of the Bay and its resources. This knowledge network is dedicated to creating, sharing and using knowledge to promote the ecological integrity, vitality, biodiversity and productivity of the Bay of Fundy ecosystem in support of the social and economic well-being of its coastal communities. Examples of recent initiatives pertaining to the three principal elements of the knowledge network include the following:

Creating Knowledge - BoFEP is a catalyst for stimulating and coordinating the creation of new knowledge about the Bay of Fundy. It identifies crucial gaps in our understanding of important issues and facilitates the creation of Working Groups to evaluate issues, develop proposals, recruit participants, secure resources and carry out research projects. BoFEP promotes the periodic assessment of the health of the Bay as a way to protect and enhance marine environmental quality by such initiatives as organizing a joint GPAC-BoFEP Coastal Forum "Taking the Pulse of the Bay" at the 5th Bay of Fundy Science Workshop and convening a State of the Minas Basin Forum as part of the Gulf of Maine Council's Summit process.



Sharing Knowledge - BoFEP facilitates sharing of knowledge about the Bay of Fundy. The Working Groups are an important means of sharing information and environmental concerns amongst partners from different disciplines and organizations, who might otherwise never meet regularly. In addition, the Bay of Fundy Science Workshops are popular and effective forums for sharing and discussing new research findings. The cumulative published Proceedings of these workshops forms an important repository of knowledge about the Bay, made more accessible by the recent completion of a comprehensive digital index of BoFEP publications. Another important tool for sharing knowledge is the steadily expanding series of popularly written Fundy Issues "fact sheets" summarizing selected issues or topics. A quarterly e-newsletter "Fundy Tidings" keeps members up-to-date about the activities of the organization and general news pertaining to the Bay. BoFEP's Web site is another key element in sharing knowledge. It serves as a portal to information generated by BoFEP and its partners as well to other sources of information about the Bay and its resources.

Using Knowledge - Several Working Groups address important practical problems requiring the gathering, analysis, interpretation and application of existing knowledge about the Bay. For example, The Salt Marsh and Restricted Tidal Systems (SMaRTS) Working Group has coordinated the synthesis of information about tidal restrictions that degrade salt marshes around the Bay in order to identify and prioritize potential candidate sites for restoration work. Similarly, the Eelgrass Working Group synthesizes information about the distribution and ecology of eelgrass beds in the region to promote and facilitate the development of long-term management and conservation plans. The Minas Basin Working Group works with municipal and regional planners around the Minas Basin to inform them of linkages between watersheds and coastal ecosystems and develop tools to assist them in finding relevant ecological information.

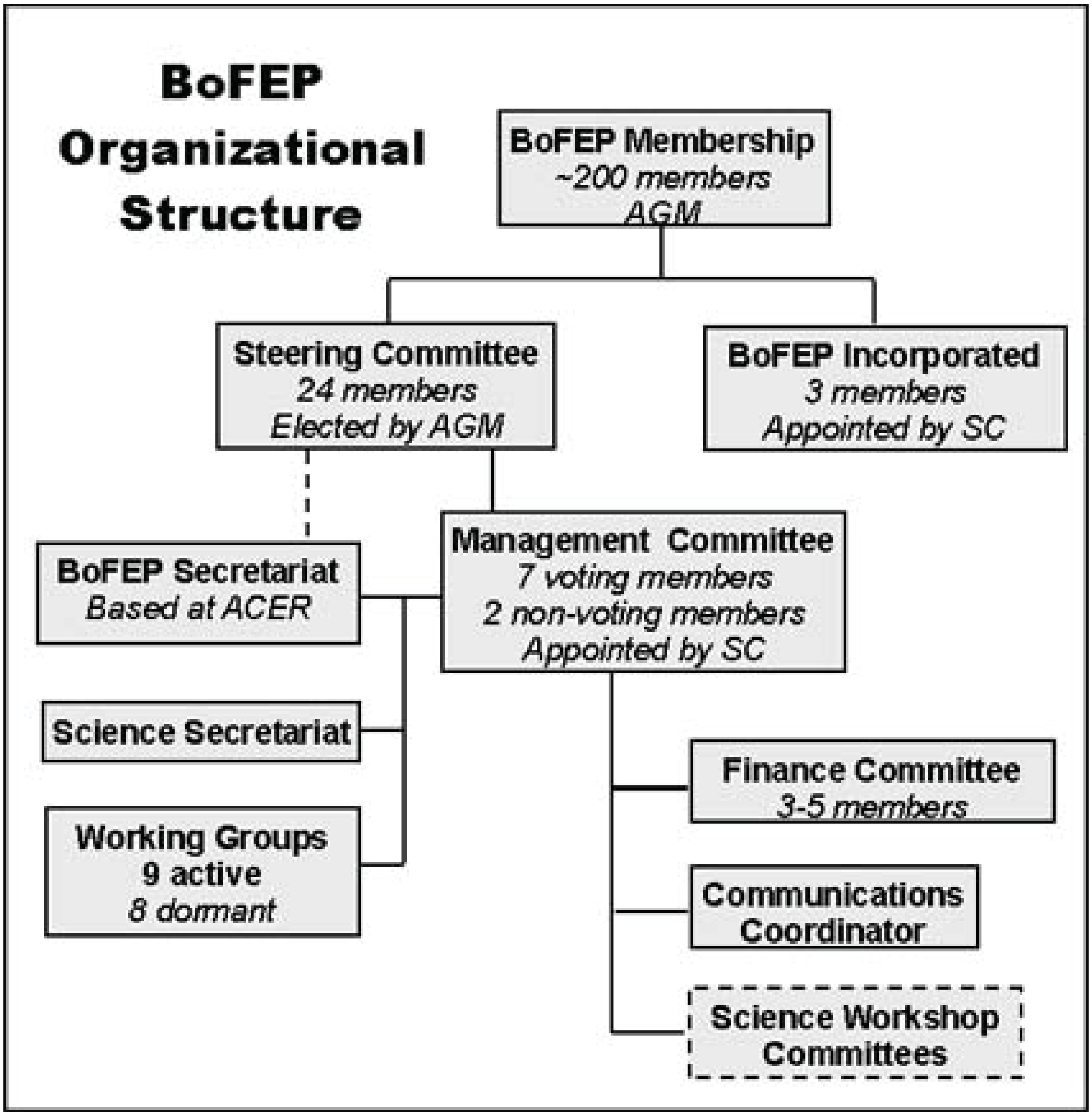
Bay of Fundy Science Workshops

The biennial Science Workshops are an opportunity for BoFEP Partners to get together to review the latest scientific findings, discuss pressing environmental issues and plan new research and conservation initiatives. The cumulative Proceedings of these Workshops form a valuable repository of knowledge about the Bay, its ecosystems and the issues confronting it.

- 1st **- "Bay of Fundy Issues: a Scientific Overview"** (Wolfville, NS, January 29–February 1, 1996)
- 2nd **- "Coastal Monitoring and the Bay of Fundy"** (St. Andrews, NB, November 11–15, 1997)
- 3rd **- "Understanding Change in the Bay of Fundy Ecosystem"** (Sackville, NB, April 22–24, 1999)
- 4th **- "Opportunities and Challenges for Protecting Restoring and Enhancing Coastal Habitats in the Bay of Fundy"** (Saint John, NB, September 19–21, 2000)
- 5th **- "Health of the Bay of Fundy: Assessing Key Issues"** including **"The Bay of Fundy Coastal Forum: Taking the Pulse of the Bay"** (Wolfville, NS, May 13–16, 2002)
- 6th **- "The Changing Bay of Fundy ~ Beyond 400 Years"** (Cornwallis, NS, September 29–October 2, 2004)
- 7th **- "Challenges in Environmental Management in the Bay of Fundy - Gulf of Maine (**St. Andrews, NB, October 25–27, 2006)

The eighth Workshop is scheduled to be held in Wolfville, NS, in the autumn of 2008 and will be hosted by the Acadia Centre for Estuarine Research (ACER) and the Arthur Irving Academy for the Environment.

Figure 1: Organizational structure of BoFEP



BoFEP Working Groups

Projects and other on-the-ground activities of BoFEP are primarily planned and implemented by a number of Working Groups approved by the BoFEP Steering Committee (Figure 1). BoFEP partners sharing an interest in a particular ecological topic or issue may join together to form a Working Group with clearly defined terms of reference to carry out specific projects that advance the overall objectives of BoFEP. Some of the currently active Working Groups include:

- Biosphere Reserve
- Corophium and Mudflat Ecology

- Eelgrass
- Fundy Informatics Working Group (FIWG)
- Coastal Zone Management
- Marine Energy
- Minas Basin
- Salt Marsh and Restricted Tidal Systems (SMaRTS)
- Stress and Cumulative Effects
- Sublittoral Ecology and Habitat Conservation

A number of additional Working Groups have recently been formed, while several others are currently inactive or dormant.

The "Fundy Issues" Series

Almost from its inception, BoFEP has been producing the Fundy Issues Series of popularly written overviews of our present scientific understanding of topics pertaining to the Bay of Fundy or about the environmental issues confronting the Bay and its watershed. To date, the following Fundy Issues are available both in a print version as well as an online version posted on the BoFEP Web site at www.bofep.org.

#1 Heeding the Bay's Cry: The Bay of Fundy Ecosystem Project.

#1a Working Together Within an Ecosystem: BoFEP.

#2 Tides of Change: Natural Processes in the Bay of Fundy.

#3 Sandpipers and Sediments: Shorebirds in the Bay of Fundy.

#4 The Seaweed Forest: Rockweed Harvesting in the Bay of Fundy.

#5 Dredging Fundy's Depths: Seabed Mining in the Bay of Fundy.

#6 Right Whales-Wrong Places? Right Whales in the Bay of Fundy.

#7 Farming Fundy's Fishes: Aquaculture in the Bay of Fundy.

#8 Fundy's Watery Wastes? Pollution in the Bay of Fundy.

#9 Dykes, Dams and Dynamos: The Impacts of Coastal Structures.

#10 Expanding Fundy's Harvest: Targeting Untapped Treasures.

#11 Whither the Waters: Tidal and Riverine Restrictions in the Bay of Fundy.

#12 Gulfwatch: Putting a Little Mussel into Gulf of Maine Marine Monitoring.

#13 Keystone Corophium: Master of the Mudflats.

#14 Fishing in Fundy: Harming Seafloor Habitats?

#15 Fundy in Flux: The Challenge of Understanding Change in the Sea.

#16 Salt Marsh Saga: Conserving Fundy's Marine Meadows.

#17 Fundy's Wild Atlantic Salmon: Doomed or Simply Down?

#18 Whither the Weather: Climate Change and the Bay of Fundy.

#19 Fundy's Minas Basin: Multiplying the Pluses of Minas.

#20 Managing Fundy's Fisheries: Who Should Write the Rules?

#21 Putting the Fun in Fundy: Possibilities and Pitfalls of Ecotourism.

#22. Taking Fundy's Pulse: Monitoring the Health of the Bay of Fundy.

#23. Alien Invasions: Introduced Species in the Bay of Fundy and Environs.

#24. Living Lightly on Land and Water: Native People and the Bay of Fundy.

#25. Contaminant Concerns: Heavy Metals and the Bay of Fundy.

#26. Saving Special Places: Protected Areas and the Bay of Fundy.

#27. Parlous POPs: Persistent Organic Pollutants in the Bay of Fundy.

BoFEP Sponsors

Since its inception, BoFEP has operated on a surprisingly small cash budget provided by a limited number of mostly governmental funders, the most notable of which has been Environment Canada - Atlantic Region. This support has ensured BoFEP's continuity and sustained many of its core functions. However, BoFEP's substantial record of achievement in many areas has largely been possible because of the ongoing provision of an immense amount of additional in-kind support by a lengthy list of governmental (federal, provincial and municipal), corporate, private, academic and organizational contributors in the form of supplies, work/meeting space, equipment use, expertise, services, person-hours, workshop sponsorship, student awards and assorted external contracts for specific projects that advance the objectives of BoFEP. In recent years, the Gulf of Maine Council on the Marine Environment has also supported BoFEP financially, most notably in the form of a three-year Cooperation Agreement (2004–2006) that provided funds for conducting research or conservation projects that furthered the objectives of both groups.

For BoFEP's future financial stability and continued growth, it is vitally important that its financial base, particularly the cash contribution component, be broadened. Dependence on a single major sponsor leaves the organization overly vulnerable to shifts in government policy and other financial exigencies. BoFEP is, therefore, reaching out to other potential financial supporters who share its goals and objectives to encourage them to help sustain BoFEP and support its worthwhile activities. Such support is critical for the core functions of BoFEP and for the continuation of the organization as it enters a second decade of addressing issues influencing the Bay of Fundy-Gulf of Maine.

THE GULF OF MAINE INSTITUTE

John P. Terry

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This presentation will discuss the preparing of future stewards. The Gulf of Maine Institute (GOMI) approach is to train community based initiative (CBI) teams of youth and mentoring adults from around the Gulf of Maine watershed. GOMI buttresses youthful enthusiasm and sense of the possible with solid training in environmental sciences and civic engagement.

Our systems approach uses sensorial immersion in real life settings. Participants develop a deep and intuitive sense of interconnected natural ecological and human political systems, and how to manage them: youth become aware and active contributing citizens. CBI team participation requires a two-year commitment: two summer Institutes and two academic years. The summer institute is a week-long residential immersion in environmental science, team building and civic engagement.

Currently CBI eight teams are operating: three in Massachusetts, one in New Hampshire, one in New Brunswick and three in Nova Scotia. These teams are impacting their communities through initiatives developed during the 2006 summer institute. In 2006, a New Brunswick team will conduct migratory waterfowl banding during which all Mallard ducks will be tested for bird flu; the team will present their findings to government officials and the public. Other CBI projects include: improving anadromous fish habitat (MA), turning a severely degraded urban salt marsh into a local wildlife sanctuary (NS), sustainable land use (NS), and creating a biological inventory of a local ecosystem (NS).

E. SALT MARSHES

COMPARISON OF THE SPATIAL AND TEMPORAL PATTERNS OF CHANGE IN SALT MARSHES OF THE AVON AND CORNWALLIS RIVER ESTUARIES.

Jillian Bambrick and Danika van Proosdij

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The purpose of this research was to compare the spatial and temporal patterns of change in salt marsh habitat between the Avon and Cornwallis River Estuaries. Historical aerial photographs of the areas (1944 to 2003) were assessed for research suitability based on tidal level (e.g., exclude high tide). Unfortunately this resulted in gaps within the temporal record and even spatial gaps within a particular year. In addition, flight lines often were not flown within the same year in adjoining counties which limited comparison between study areas. The remaining air photos were scanned and rectified against digital 1:10,000 planimetric map sheets using ArcGIS 9.1. Salt marsh habitats were outlined using on-screen digitizing procedures in ArcView 9.1 and marsh area was calculated. The resultant polygons were compared on a decadal scale, and change was quantified using the geoprocessing capabilities within ArcGIS.

These data were normalized for each estuary as a percentage of change between each year and over the entire time period. Both estuaries have undergone periods of net loss of marsh, mostly through dyking; however, are now in a progradational phase due primarily to colonization of intertidal bars by *Spartina alterniflora*. By comparing the values gained for each estuary, the system stability can be evaluated, and potential reasons for the spatial and temporal patterns of change can be explored. These data can be used to show what has changed, where these changes have occurred, and how much has changed, and to examine the relative sensitivity of marshes within the Southern Bight of the Minas Basin.

GREATER RESISTANCE OF MACROTIDAL BAY OF FUNDY MARSHES TO SEA LEVEL RISE

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Abstract

Soil saturation, and thus water table depth, is important to salt marsh vegetation as it drives zonation, productivity, and survival. In organogenic, microtidal marshes tidal flooding is the main driver of water table. What driver(s) account for water table variability in minerogenic, macrotidal salt marshes? We examined sub-surface hydrology of four Bay of Fundy marshes. These marshes are flooded briefly several times a month by semi-diurnal tides with a 6–12 metre range. Over the course of neap tides, water tables were fairly stable (maximum 20-cm fluctuation occurred in marsh interiors). We observed a 10 cm or less change in water table in tidal channel edges directly flooded by tidal water. Yet, pronounced seasonal differences were observed. In May when there was prolonged, record precipitation, water table was near the surface. In summer, when there was little precipitation and maximum evapotranspiration, the water tables were generally >40 cm below the surface. Thus, soil characteristics and precipitation must be more important drivers of water table in Fundy marshes. With a high bulk density (mean 0.96 g/cc) and low infiltration rates (mean 2.8 cm/hr) it would take 22 hours for the unsaturated (vadose) zone to saturate. We conclude that Fundy marshes will be more ecologically resistant to rising sea level associated with greenhouse warming, as changes in tidal heights and flooding will have minimal impact on water tables, thus vegetation will be relatively stable. Since many Fundy marshes were drained for agricultural use, restoration of these resistant marshes could offset losses expected in more vulnerable, microtidal marshes.

Introduction

Since tidal salt marshes are regularly flooded by tidal water, there is a quite obvious need to understand surface hydrology. Less well studied but equally important is sub-surface hydrology. Depth to groundwater affects salt marsh vegetation productivity, zonation, and survival (Mendelssohn and Seneca 1980; Howes et al. 1981; Wiegert et al. 1983; Mendelssohn and McKee 1988). Sub-surface hydrology also influences rates of subsidence (Turner 2004), concentrations of nutrients and organic matter (Agosta 1985; Howes and Goehringer 1994), and sediment toxicity (Portnoy and Valiela 1997; Portnoy 1999). The ability of salt marshes to provide valued ecosystem services is therefore intimately linked to sub-surface hydrology. Therefore, baseline knowledge of sub-surface hydrology is crucial in predicting and managing change in salt marsh environments. In the Bay of Fundy, hydrological changes include both long-term projected sea-level rise and sudden changes resulting from breaching dykes to restore former salt marshes. Most previous sub-surface hydrology research has been conducted in microtidal, organogenic marshes; however, the macrotidal and minerogenic nature of Fundy marshes requires locally-based studies.

Study Area and Methods

The Bay of Fundy (Figure 1) has semi-diurnal tides which range from 5 m at the mouth to greater than 16 m in the upper reaches (Canadian Hydrographic Service 2005). Its marshes are minerogenic—the majority of accretion is due to tidally deposited mineral sediments. Reference and recovering marsh pairs were located in both the lower and upper Bay (Figure1). Dykes at recovering marshes breached during storm events over 50 years ago. Piezometers were constructed from 1.7 cm inner diameter PVC pipe with holes drilled in the lower 15 cm and installed to depths of 32 to 112 cm. Three to four piezometer transects were established in each study marsh in summer 2005. To determine the depth to sub-surface groundwater, metal tubing was lowered into the piezometer while simultaneously forcing air through attached plastic tubing until water bubbles were heard (Figure 2). Hydraulic head for each piezometer was calculated as marsh surface elevation minus depth to groundwater.

Figure 1. Map of the Bay of Fundy showing location of salt marsh study sites denoted by number: 1, Dipper Harbour marsh (reference); 2, Saints Rest marsh (recovering); 3, Wood Point marsh (reference); 4, John Lusby marsh (recovering). Modified from Conner et al. (2001).

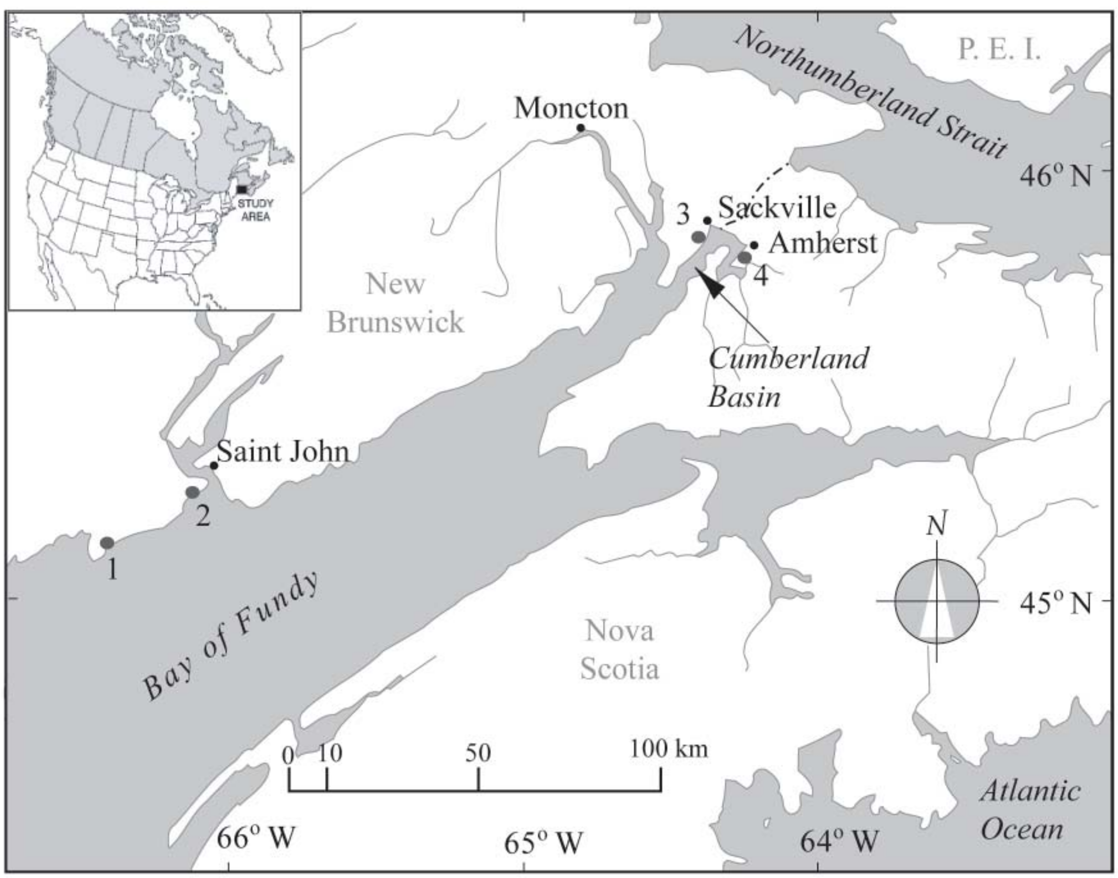


Figure 2. Using a metal and plastic tubing apparatus to determine depth to groundwater along a piezometer transect.

Research Question and Results

What drives water table variability in minerogenic, macrotidal salt marshes?

Tidal height is not a major driver. Studies of microtidal marshes indicate that changes in tidal height have the most effect near tidal channels. Groundwater at channel edges of microtidal marshes is displaced anywhere from 20 to 110 cm during a semidiurnal cycle (Figure 3a). In contrast, groundwater in Bay of Fundy channel edges is displaced 10 cm or less (Figure 3b) despite tidal height changes of several metres. Clearly, tidal height does not drive the sub-surface hydrology of Fundy marshes. If it did, then one would expect larger changes in hydraulic head compared to microtidal marshes.

Inundation characteristics are important drivers. Depth to groundwater is greater during the non-inundation period due to losses via evapotranspiration (ET) and drainage (Figure 4a). Inundating tides supply water to the marsh and therefore depth to groundwater is less (Figure 4b). Fundy marshes are infrequently inundated. On average, 1–46% of predicted high tides in 2005 inundated marsh platforms while 1–7 per cent of tides inundated the high marsh. Length of the non-inundation period is an important driver of Fundy sub-surface hydrology.

Sediment characteristics are important drivers. Hydraulic conductivity—the rate at which water moves through sediments—determines, in part, the rate at which groundwater recharge and discharge occurs in Fundy marshes. In the unsaturated (vadose) zone of Fundy marshes, the hydraulic conductivity is estimated to be on the order of

10^{-7} to 10^{-10} cm s^{-1}. Hydraulic conductivity in the saturated (phreatic) zone of Fundy marshes, ranges from 1.4 x 10^{-5} to 5.9 x 10^{-8} cm s^{-1}—one to five orders of magnitude lower than in marshes elsewhere (Hemond and Fifield 1982; Harvey and Odum 1990; Hemond and Chen 1990; Yelverton and Hackney 1986; Montalto et al. 2006). In organogenic marshes, water reaches the saturated zone fairly quickly—within zero to ninety minutes of high tide (Jordan and Correll 1985; Harvey et al. 1987; Howes and Goehringer 1994; Hughes et al. 1998; Blackwell et al. 2004; Montalto et al. 2006). Conversely, low hydraulic conductivity of minerogenic Fundy marshes further suggests that they are unresponsive to large changes in tidal height.

Figure 3. Changes in hydraulic head near (≤ 3 m) tidal channels of a) Bay of Fundy marshes and b) marshes previously studied elsewhere.

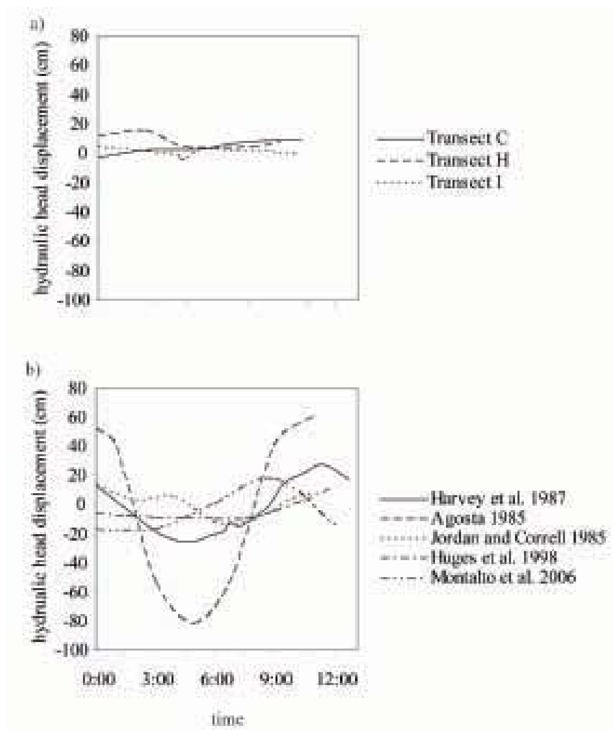


Figure 4. Wood Point hydraulic head measurements along a) transect J in July (25–27 days after spring tides) and b) transect J August 5 (15 days after spring tides).

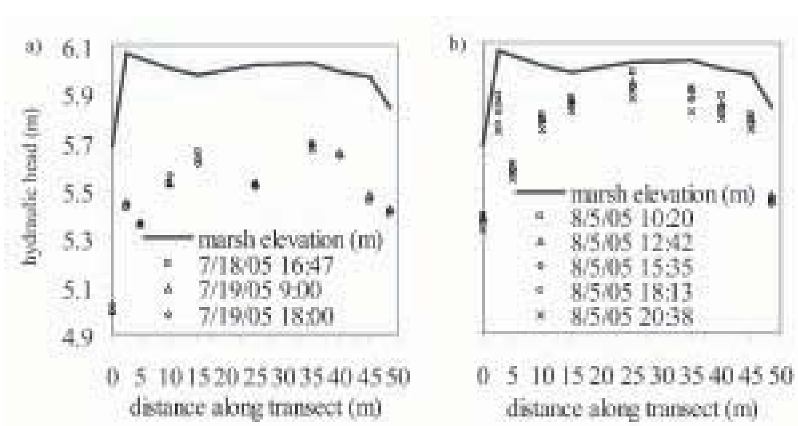
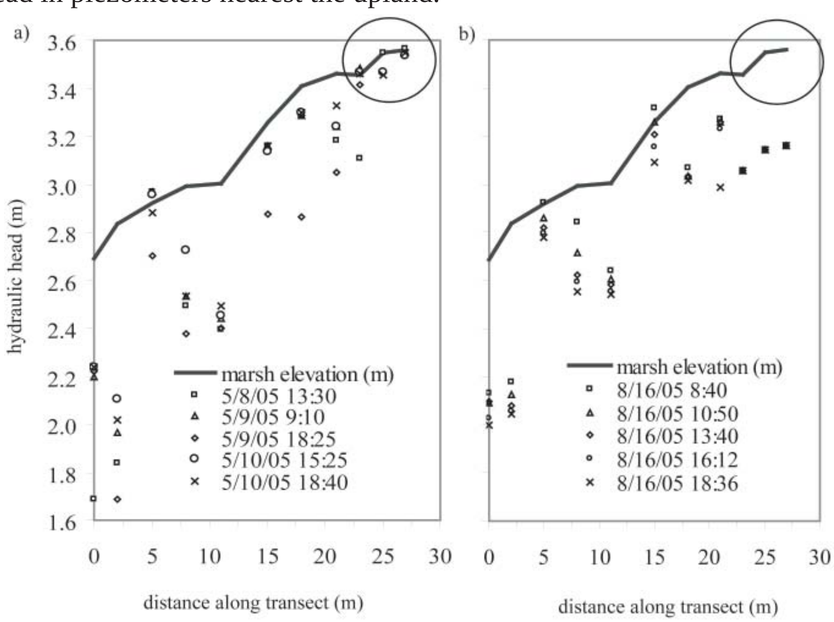


Figure 5. Steep-sided primary tidal channel in John Lusby marsh. Primary channels were defined as those first flooded by incoming tidal waters.

Marsh geomorphology is an important driver. Fundy tidal channel banks have steep slopes, ranging from 15–43 per cent (Figure 5). As a result, the hydraulic gradient within 3 m of Fundy tidal channels is 20–40 per cent. In microtidal marshes, channel banks have slopes of 1–20 per cent and the hydraulic gradient near tidal channels is 3–8 per cent (Howes et al. 1981; Balling and Resh 1983; Jordan and Correll 1985; Yelverton and Hackney 1986). Steep hydraulic gradients in Fundy marshes ensure constant drainage though channel bank sediments.

Precipitation is a likely driver. Pronounced seasonal differences in depth to groundwater were observed at Dipper Harbour. Near the upland, groundwater was at the marsh surface in May and > 40 cm below the marsh surface in August (Figure 6). Record precipitation (and lower ET) in May 2005 and low precipitation (and higher ET) in August 2005 explain this pattern. More seasonal comparisons are necessary, but preliminary results suggest that precipitation is an important water delivery mechanism in irregularly flooded macrotidal marshes.

Figure 6. Hydraulic head along a Dipper Harbour transect in a) May 2005 and in b) August 2005. The circles denote hydraulic head in piezometers nearest the upland.



Implications

As one of the first quantitative studies of Fundy sub-surface hydrology, this research provides important baseline information as well as insight into appropriate methodologies for monitoring sub-surface hydrology in Bay of Fundy salt marshes. Sub-surface hydrology models based on microtidal, organogenic marshes, where tidal height is a major driver, are not suitable for Fundy marshes.

Qualitatively similar sub-surface hydrology results were obtained at both reference and recovering Bay of Fundy marshes (results not shown). We conclude that sub-surface hydrological processes are operating similarly in both marsh types. Therefore, sub-surface hydrology processes can be restored in half-century time scales.

We conclude that Fundy marshes will be more ecologically resistant to rising sea level associated with greenhouse warming, as changes in tidal heights and flooding will have minimal impact on marsh water tables, thus vegetation will be relatively stable. Since many Fundy marshes were drained for agricultural use, restoration of these resistant marshes could offset losses expected in more vulnerable, microtidal marshes.

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YOU CAN HAVE YOUR MARSH AND EAT IT, TOO

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The Bay of Fundy has not only phenomenally high tides, but some of the world's highest concentrations of suspended sediments. Both characteristics provide Fundy salt marshes with increased resistance and resilience as ecosystems, while enhancing marsh ecological services. Large tidal ranges mean that Fundy marsh soils are better drained than most, providing improved growing conditions for salt marsh vegetation. The high concentrations of suspended sediment result in correspondingly high amounts of sediment deposition from tidal waters. Sediment deposition enhances the value of these salt marshes as sinks for carbon and heavy metals. Measurements of sediment deposition indicate that it will probably be adequate to maintain marsh elevations as sea levels rise with greenhouse warming. Further testimony to this is the rapid sediment accumulation in marshes like John Lusby where tidal flooding has been restored after 300 years of drainage: nearly a metre of soil has accumulated since the 1940s.

Over 70 per cent of the original salt marsh area on the Bay has been transformed to agricultural land through dyking and draining. The agricultural sector obviously is resistant to restoration of tidal flooding, and loss of agricultural lands. However, returning the tides could be a win-win for agriculture and environment. In Europe and Quebec, marsh-grazed sheep are gourmet items. Fundy salt marshes probably have enough ecological resistance to endure controlled grazing and allow the agricultural sector to adopt this niche agriculture.

THE HYBRID TIDAL CHANNEL NETWORK OF RECOVERING SALT MARSHES

Graham K. MacDonald[1], G.L. Chmura[1] and D. van Proosdij[2]

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This study examines the legacy of agricultural reclamation on surface hydrology of recovering Fundy salt marshes. Much of the reclaimed marsh is still in agricultural use, but some agricultural marshes have been abandoned, allowing dykes and aboiteaux to fall into disrepair. Upon abandonment, tidal flooding returns to a hydrological system comprised a grid of drainage ditches superimposed on the original dendritic network of tidal channels. We used field surveys and aerial photogrammetry to map the channel network at two recovering marshes: Saints Rest on the outer Bay and John Lusby on the inner Bay; and two reference sites: Dipper Harbour on the outer Bay and Allen Creek on the upper Bay. We assessed differences due to agricultural reclamation by two methods. We compared present conditions on recovering marshes to unditched reference marshes, but suspect that the smaller size of available reference marshes may bias these results. In the second method we interpret the original network from aerial photos taken before abandonment and compare it to the modern channel network. Both recovering marshes have hybrid channel networks in which original channels were abandoned and ditches were incorporated into the new network. The lower sinuosity and vertical banks of ditches reduces their value as habitat, as compared to natural channels. Using a geographic information system (GIS), we determined the channel density and sinuosity to assess the difference in ecological value of recovering marshes. These results can be useful in predicting outcomes of planned marsh restoration projects.

***** WINNNER STUDENT POSTER PRIZE*****

SALT MARSH SPECIES ZONATION IN THE MINAS AND CUMBERLAND BASINS: USING LIDAR TO EXAMINE SALT MARSH VEGETATION

Koreen Millard

Nova Scotia Community College, Lawrencetown, NS, and Acadia University, Wolfville, NS
(koreen.millard@nscc.ca**)**

High-resolution (ca. 2 m) airborne Light Detection and Ranging (LIDAR) data acquired for the Annapolis and Minas Basins have an absolute vertical accuracy better than 15 cm and 30 cm respectively. Digital elevation models (DEMs) have been constructed for a variety of geographic information system (GIS) applications. Because of the large tidal range in the Bay of Fundy, a significant portion of the inter-tidal area has been surveyed with LIDAR at low tide. In addition to terrestrial applications such as flood risk mapping and watershed extraction, these data provide an opportunity to examine the relationship between salt marsh vegetation and absolute elevation over large areas (i.e. several square kilometres). Salt marsh vegetation community types have been interpreted from 1:10,000 aerial photography, acquired at low tide in 2002, in the vicinity of the Cornwallis estuary and validated with field visits.

The community delineations have been compared with the LIDAR DEM to determine their elevation range and distribution. These results have been used with the DEM to construct a "potential" vegetation community map based on elevation alone for the coastal zone from Grand Pré to Blomidon. In addition to assisting with mapping vegetation community distributions, the DEM has been used to examine what areas are available for the salt marsh to migrate landward as sea level rises. Local relief, in addition to anthropogenic embankments (i.e. dykes and roadbeds), can impact the amount of area available for a salt marsh to migrate landward as sea level rises. These new high-resolution elevation maps can be used to plan salt marsh restoration projects and can assist in determining what features need to be removed or modified to allow natural processes to take place.

INVESTIGATION OF LOW DISSOLVED OXYGEN LEVELS IN THE ANNAPOLIS RIVER ESTUARY: SPATIAL AND TEMPORAL TRENDS

Andy Sharpe[1], Denise Sullivan[1], and Mike Brylinsky[2]

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For the past 15 years, Clean Annapolis River Project (CARP) has conducted a regular water quality monitoring program on Nova Scotia's Annapolis River. During this monitoring in September 2005, the salt wedge of the Annapolis River estuary was found to have reduced levels of dissolved oxygen (DO). DO values in the underlying saltwater were found to be mostly in the range of 3 to 5 mg/L, with the lowest value being 1.69 mg/L. The zone of oxygen depleted saltwater was found to extend over at least 10 km of the river, in the vicinity of Bridgetown. The DO levels observed are well below those recommended by the Canadian Water Quality Guidelines for the protection of freshwater and marine aquatic life.

During 2006, an investigation was undertaken to better understand the spatial and temporal distribution of depressed DO levels in the Annapolis River estuary. The presentation will include field observations and possible driving mechanisms for this effect. The linkage between elevated nutrient levels in the upper river, the strong thermohaline stratification experienced in the estuary, and the observed DO results will be examined. The potential for the eutrophication of the estuary will be assessed, in light of experiences from similar estuaries.

F. TECHNIQUES

GULF OF MAINE MAPPING INITIATIVE: ADVANCING REGIONAL FISHERIES RESEARCH AND MANAGEMENT

Sara L. Ellis[1], Brian J. Todd[5], Megan C. Tyrrell[3], Thomas T. Noji[4], Page C. Valentine[5], Susan A. Snow-Cotter[6], Vincent G. Guida[4], Andrew L. Beaver[7], and James D. Case[8]

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[8]Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center, Durham, NH (casej@ccom.unh.edu)

The distribution, types, and quality of subtidal marine habitats are largely unknown in waters throughout the Gulf of Maine. This lack of information hinders the management of marine fisheries. Effective management requires knowing where distinct habitats occur so that productive and sensitive habitats can be protected or restored.

Maps of the seafloor are important tools for scientists, managers, and fishermen, alike. Scientists can use benthic habitat maps to study linkages between species abundance, depth, and habitat; recovery of closed areas; distribution of invasive species; and effects of fishing gear on bottom habitat. Managers can use seafloor maps to guide many types of decisions that can affect fisheries, e.g., the siting of closed fishing areas, aquaculture leases, oil and gas pipelines, fibre-optic cables, alternative energy projects, dredged materials disposal, and sand and gravel mining. The fishing industry can use maps of seafloor topography and habitat to improve fishing efficiency, minimize gear impact on seafloor, and reduce by-catch and gear loss.

Despite the proven value of seafloor maps for fisheries research and management, only about 20 per cent of the Gulf of Maine has been mapped using modern survey technologies. The Gulf of Maine Mapping Initiative (GOMMI) is a partnership of governmental and non-governmental organizations in the US and Canada whose mission is to map the entire Gulf of Maine basin. GOMMI's goals are to facilitate communication and collaboration within the mapping community, coordinate ongoing mapping efforts, spearhead new projects in priority areas, and make maps and data widely available to users and stakeholders.

URCHIN: A SURFACE-DEPLOYED VIDEO SYSTEM FOR UNDERWATER RECONNAISSANCE AND COASTAL HABITAT INVENTORY

Peter Lawton and Mike B. Strong

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(lawtonp@mar.dfo-mpo.gc.ca**;** strongm@mar.dfo-mpo.gc.ca**)**

During initial work with marine geologists to document coastal landscape structure in relation to lobster habitat use, we required a benthic video survey system which could be readily deployed off small inshore research launches and chartered fishing vessels. The system needed to be fully independent of the surface vessel for navigation and power requirements, as well as easily operated by a small field team. However, in designing this coastal research tool, we specified survey capabilities and equipment performance more typical of video survey systems found in larger, offshore research applications.

Thus, the original URCHIN system, developed in 1997, included a low-light sensitive black and white video camera, surface survey management with geographic information system functionality, and a geo-referenced habitat class and biological event recording capability. Following the adoption of a standard survey practice, we also devoted considerable effort to develop a relational database to house survey information for post-processing and reporting.

Two original black and white camera-based URCHIN systems have been used extensively by several regional DFO research teams in a range of coastal environments in New Brunswick and Nova Scotia. In addition to the original application for lobster habitat studies, the systems have been used for assessment of ocean disposal projects, and sea urchin stock assessment.

We are now conducting initial field trials with a second generation coastal video system modeled on URCHIN, but more specifically designed to support benthic biodiversity studies. This new system has a pan, tilt, and zoom-capable color video camera which allows for quantitative imagery of approx. 0.25 m^2 area, as well as a close inspection capability within and immediately surrounding this primary sampling area.

The poster presentation shows the system design and representative survey results. Depending on facilities available at the workshop, additional computer or video-based aspects of these coastal survey systems will be demonstrated.

FISHERMEN AND SCIENTISTS RESEARCH SOCIETY LOBSTER RECRUITMENT INDEX FROM STANDARD TRAPS (LRIST)

Carl MacDonald[1] and John Tremblay[2]

[1]Fishermen and Scientists Research Society, Halifax, NS (macdonaldcd@mar.dfo-mpo.gc.ca)
[2]Population Ecology Division, Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS

The Lobster Recruitment Index from Standard Traps (LRIST) project began in the spring of 1999. The goal of the project is to provide an index of the number of lobsters that will molt into the legal sizes in the coming seasons. The project was initiated by the Fishermen and Scientists Research Society (FSRS) in cooperation with the Invertebrate Fisheries Division, Department of Fisheries and Oceans, at the Bedford Institute of Oceanography (BIO). The initial phase of the project was planned for five years, but after reviewing the project's usefulness it is scheduled to continue for the foreseeable future.

The project involves over 180 volunteer fishermen fishing two, three or five standard traps each in fixed locations. The traps are fished in locations from the northern tip of Cape Breton around the southern tip of Nova Scotia and up the Bay of Fundy to Digby. The lobster fishing areas (LFAs) represented are 27, 28, 29, 30, 31a, 31b, 32, 33, and 34.

The standard trap is a trap with one inch mesh, wire construction, five inch entrance rings, without escape mechanisms. The fishermen sex and measure all the lobsters that they catch in the standard traps. The lobster's carapace is measured and assigned into one of 15 size groups using a specially designed gauge.

Participating fishermen also monitor bottom temperatures with a minilog temperature gauge in one of the standard traps. The bottom water temperature data are forwarded to the oceanographers at BIO and are an addition to their coastal temperature monitoring database.

CAN BIODIVERSITY BE MEASURED INDEPENDENT FROM SAMPLING EFFORT?

Thomas J. Trott

Friedman Field Station, Suffolk University, Edmunds, ME and Department of Biology, Suffolk University, Boston, MA (codfish2@earthlink.net)

Biodiversity is most frequently expressed as species richness and often in combination with some measure of species abundance distributions. Species richness (*S*) is simply the number of species present in an assemblage and can be modified to include also the total number of individuals in that assemblage. Species abundance distributions describe the number of individuals of each species in an assemblage and how individuals are distributed among species. Uneven species distributions are more commonly recognized as having dominant species. Evaluating species richness and species abundance distributions is dependent on sampling effort, illustrated by species accumulation curves that show ever-increasing effort is needed to discover new species. This requirement also applies when comparing biodiversity indices that must be generated using the same sampling protocols, i.e., sample size and effort, for the comparisons to be valid. Other major drawbacks that apply to most of richness and evenness-based diversity indexes are that there is no statistical framework to determine the departure of measured *S* from expectation and richness can vary markedly with different habitat type.

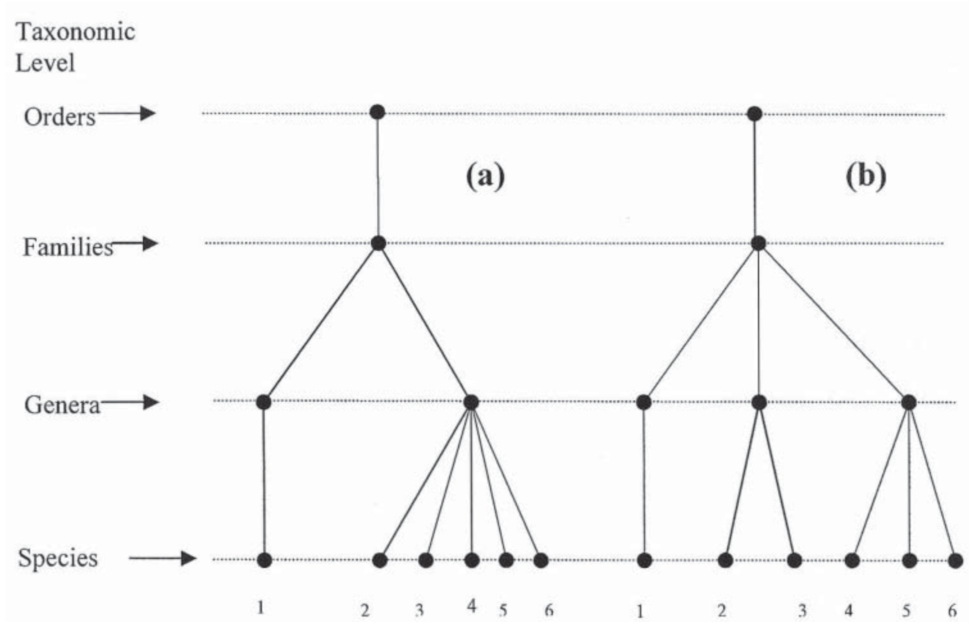
A relatively new index for measuring biodiversity is average taxonomic distinctness (Clarke and Warwick 1998). A nontechnical interpretation of average taxonomic distinctness (abbreviated as either AvTD or Δ^+) is that it is the average distance, based on Linnaean classification, between any two randomly chosen species in a classification tree representing a species assemblage (Figure 1) and is calculated as:

$$\Delta^+ = [\sum\sum_{i<j}\omega_{ij}]/[S(S-1)/2]$$

where ω is the distance between species and *S* is the number of species present, with *i* and *j* ranging over these *S* species. This metric has properties that overcome the limitations of species richness and evenness-based diversity measures. For example, average taxonomic distinctness of subsets of species chosen at random without replacement from a species assemblage will have the same AvTD as the assemblage they are drawn from, even when *S* of the subsets varies in size (Clarke and Warwick 1998). This exercise of choosing subsets of varying *S* simulates varying sample sizes. Average taxonomic distinctness, therefore, is not dependent on species richness and consequently is independent of sampling effort.

The present study tested the independence of average taxonomic distinctness from sampling effort a different way, by removing rare species from a species assemblage and observing the effect on the resulting calculated AvTD. The rationale for using rare species was that their discovery is heavily sampling dependent and requires greatest sampling effort. This was a robust procedure for challenging the sampling independent property of AvTD. Species assemblages used in this simulated change in sampling effort were samples from three intertidal areas (2.2–10 acres; 0.9–4.0 hectares) located on the shore of the Gulf of Maine. The samples, ranging from 44–71 species, were epibenthic macroinvertebrates documented in 2005 during a random walk through the intertidal area accompanied with random rock turning. Rare species were selected from a separate data set collected the previous year along line transects (20–230 m) in these same areas. Line transects were divided into continuous quadrats measuring 1 x 0.5 m oriented perpendicular to the shoreline. Sampling effort for line transects at these and three other sites sampled that same year varied from 65–305 minutes and was correlated with number of sample quadrats ($r = 0.84$; $P < 0.05$).

Figure 1. Two hypothetical communities with identical species richness ($S = 6$), organized by hierarchical Linnaean classifications into taxonomic trees. Community 'a' is less diverse than 'b' based on taxonomic relationships with 6 species represented by only two genera as opposed to three in 'b.'



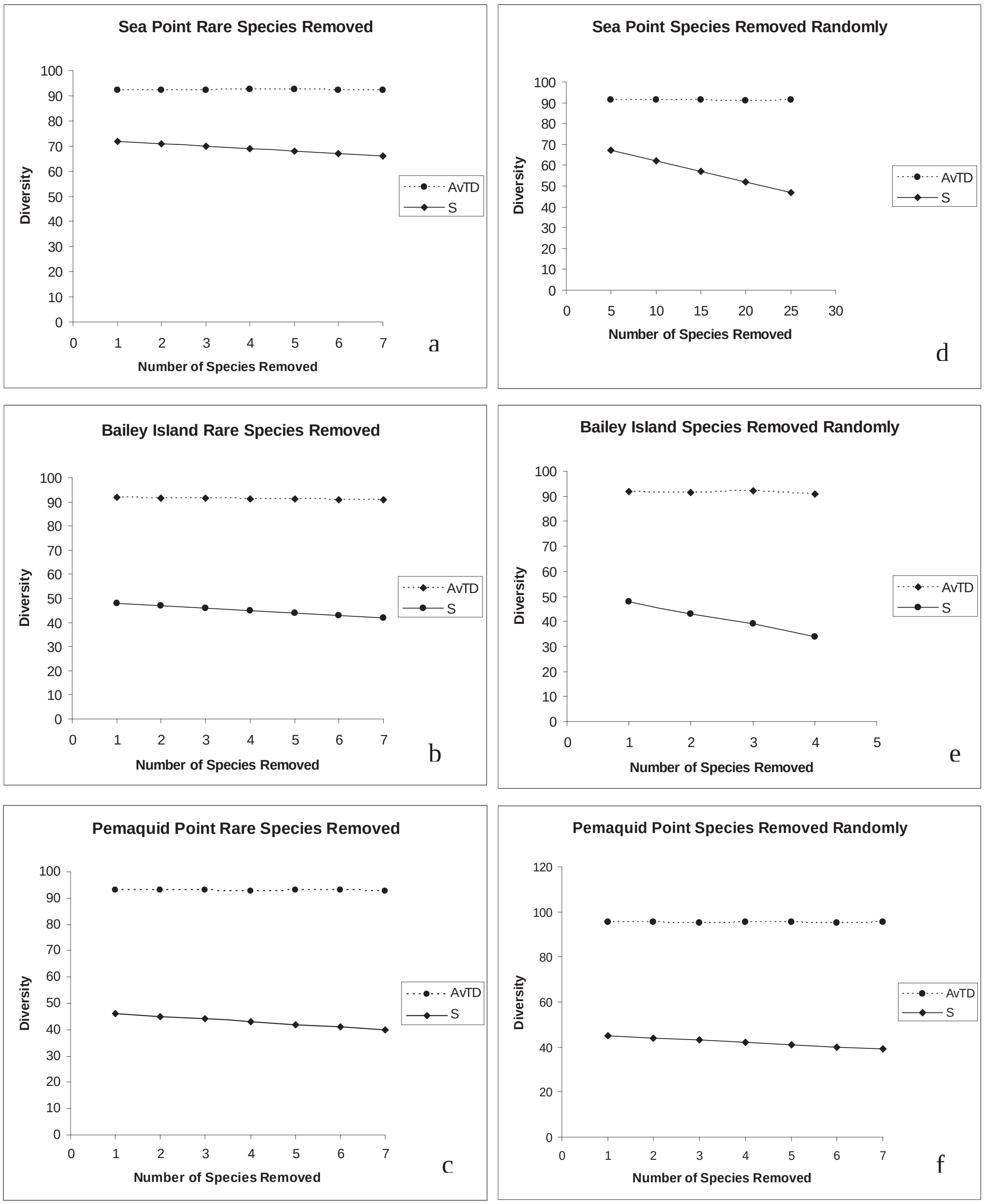
A rare species was defined as one occurring in only 1–2 quadrats. They were then removed, one by one, from their respective species assemblage documented in the 2005 random walk of sample areas. As rare species were removed successively without replacement, average taxonomic distinctness of 2005 samples was barely affected (Figs 2a –c). The absence of affect on AvTD from random removal of species without replacement reported by Clarke and Warwick (1998) was confirmed by repeating their procedure (Figure 2d–f). Since AvTD is barely affected, considerable time can be saved in sampling as shown by the corresponding decrease in sampling time with each quadrat removed (Table 1).

Table 1. The corresponding decrease in sampling time (min) with each reduction in sample quadrat is considerable

	Number of Quadrats Subtracted						
Sample Site	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Seapoint	1.33	2.66	3.99	5.32	6.55	7.98	9.31
Bailey Island	1.82	3.64	5.46	7.28	9.1	10.92	13.44
Pemaquid Point	2.48	4.96	7.44	9.92	12.4	14.88	17.36

These results confirm that AvTD does not depend on species richness and demonstrate that biodiversity can be measured independent from sampling effort using this metric.

Figure 2. (a–c). Removal of species defined as rare by their occurrence in only one quadrat in a line transect has little effect on average taxonomic distinctness (AvTD), although a large effect on species richness (S). (d–f). These results are similar to random removal of species without replacement as previously demonstrated by Clarke and Warwick (1998).



Acknowledgements

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ENHANCING INFORMATION AND KNOWLEDGE OF THE BAY: ACTIVITIES OF THE FUNDY INFORMATICS WORKING GROUP

Peter G. Wells[1], Mike Butler[2], Ruth E. Cordes[3], Patricia R. Hinch[4], Bertrum H. MacDonald[5], Jon A. Percy[6], Susan J. Rolston[7] and Elaine G. Toms[8]

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For effective environmental management of the Bay of Fundy, there needs to be efficient access to existing data, information and knowledge of relevance. Such access is essential for scientists, environmental and resource managers and decision makers, educators, community groups, and interested members of the public. Hence, the Fundy Informatics WG (FIWG) was established in Fall, 2005. It has brought together like-minded people from several sectors to interact, share ideas and initiate new projects.

The proposed terms of reference of the group are: to stimulate new informatics research pertaining to more effective use of data, information and knowledge for resource and environmental management of the Bay of Fundy, the greater Gulf of Maine, and the northwest Atlantic; to facilitate dissemination and use of Bay of Fundy and greater Gulf of Maine scientific information; to coordinate with other relevant information-oriented research groups; and to secure funding to advance the group's objectives. To date, projects of the group focus on the impact of information and access to information. They include enhancing the BoFEP Web site (www.bofep.org); conducting a citation and influence analysis of all Gulf of Maine Council on the Marine Environment (GOMC) publications (1989-present); producing a searchable cumulative index to all the proceedings of BoFEP's workshops, forums and fact sheets; setting up a system for the standard production of BoFEP specialty bibliographies; and developing proposals and seeking research funds for a Bay of Fundy-Gulf of Maine knowledge collaboratory. Interested persons are encouraged to join this exciting new working group, which meets periodically at Dalhousie's new Faculty of Management building.

Minutes of the 2006 BoFEP Annual General Meeting

MINUTES OF THE 2006 BOFEP ANNUAL GENERAL MEETING

Van Horne Ballroom, Fairmont Algonquin Hotel, St. Andrews, NB
Wednesday, 25 October 2006, 6:30-8:30 p.m.

Present: Barry Jones (chair), Pat Hinch, Peter Wells, Graham Daborn, Marianne Janowicz, Rabindra Singh, Larry Hildebrand, Maria-Ines Buzeta, Gerhard Pohle, Jon Percy, Susan Rolston, Owen Washburn, Anna Redden, Mark TeKamp, Elizabeth Kosters, John P. Terry, Hugh Akagi, Peter Fenety, Maria Recchia, Bill Campbell, Mike Brylinsky, John Coon, Andy Sharpe, Deanne Meadus, Peter Etheridge, Thomas Trott, Leanna McDonald (scribe)

Welcome and Introductions

B. Jones called the meeting to order and welcomed all to the BoFEP Annual General Meeting. He noted that enough members were in attendance to achieve a quorum.

2) Additions to/Acceptance of Agenda

The agenda had been circulated and no additions or changes were made. ***Motion*** to accept the agenda, Graham Daborn. ***Second:*** Pat Hinch. ***Motion Carried.***

3) Minutes of October 26, 2005 AGM

Jon Percy indicated under item 10 that Gerhard Pohle's name was spelled incorrectly.

Motion to accept the minutes as amended, Mark TeKamp. ***Second*:** Pat Hinch ***Motion Carried.***

4) Business arising

Action Item 1 – A Chair for the Resource Development Working Group will be found in order to get the WG moving ahead. *No chair has yet been identified at this time and this item has been directed to the Steering Committee and will appear on their Action Item list.*

Action Item 2 – Gordon Fader will be invited to speak at one of the upcoming Steering Committee meetings to discuss mining issues in the Bay of Fundy. *Graham has attempted to contact Gordon but has been unable to do so. This item has been directed to the Steering Committee and will appear on their Action Item list.*

Action Item 3 – The Steering Committee will be asked to consider holding a small one-day workshop concerning mining issues in and around the Bay of Fundy, possibly in conjunction with the Marine Resource Centre. It has been suggested that this workshop should be considered along with Action Item 2 and that the Steering Committee should follow up on this item.

Action Item 4 – The Huntsman will be looked into as a possible location for the 7th BoF Workshop. The Algonquin will be considered should the Huntsman be found not suitable. Gerhard Pohle will join the meeting to discuss this item later in the meeting under item #10. – *This item is considered complete.*

Action Item 5 – The Steering Committee will consider holding a meeting with the SGSL Coalition in order to discuss the possibility of a joint WG, topics for a joint workshop and partnership initiatives.

A meeting was held with representatives of the Southern Gulf Coalition and it was agreed that there should be further discussion. In an effort to coordinate this, a letter will be sent to Ms. Nadine Gauvin, Executive Director, inviting her to the next Steering Committee Meeting. – This meeting was held and the Southern Gulf Coalition has agreed to consider to continue to liaise with the Steering Committee.

Nadine Gauvin was in attendance and agreed also, to liaise with the Steering Committee.

Action Item 6 – The position of the BoFEP Past-Chair will be created for the next AGM. This item was discussed at the 2005 AGM under 7 – Constitution/By-Law Changes*. This item is considered complete.*

Action Item 7 – Purchase of a laptop computer to assist Pat Hinch with BoFEP Treasurer duties. Approval was given for a laptop computer system up to $3,000 plus a high-speed Internet connection will be charged to office services. – *This item is considered complete.*

Action Item 8 – All Constitution and By-Law decisions made at today's meeting would be sent to the membership for ratification via e-mail. – *This item is considered complete.*

Action Item 9 – Geoconnections – Pat Hinch has been contacted by Patricia Dingle who is coordinating an, invitation-only, meeting on behalf of Natural Resources Canada. Funding is increasing for next year and they are seeking community mapping needs. They have invited provincial agencies, NGOs, and private sector participants to a meeting in November. Pat will be attending, but is looking for input. There is $60 million on the table. – *Pat has attended this meeting. This item is considered complete.*

5) Report from the Chair

During the past year there have been eight Management Committee meetings, almost half by conference call, and two meetings plus two future-focused retreats of the Steering Committee. Our activities have been well summarized in the year-end report that was submitted to Environment Canada in support of our funding application for 2006–2007 available through the secretariat office at ACER. A brief overview of BoFEP achievements of the past year follows, with highlights of a major issue.

On the broad front, our editor, Jon Percy, has produced a quarterly newsletter *Fundy Tidings* and sent it by e-mail to all members to keep them up-to-date on BoFEP activities. Unfortunately once again we lost our secretariat coordinator, but through the generosity of ACER we gained the services of Leanna McDonald. However, we are still working to resolve our secretariat funding stability issue. Meanwhile, our nine active Working Groups, including the newly-minted Fundy Informatics WG, have been working hard but quietly in the background. Seven others still require champions/chairpersons to move them forward. Our most significant activity this year has been the planning of our 7th Bay of Fundy Science Workshop, sponsored by the Huntsman Marine Science Centre in St. Andrews, New Brunswick, where we now participate.

For a host of reasons, but principally funding application, we have revised our Strategic Plan into three major thrusts: creating knowledge, sharing knowledge and utilizing knowledge, and expect to be following this format for the foreseeable future. In this context we have identified secretariat and communications support as major elements of each BoFEP activity. As you may know, our principal funder, Environment Canada, changed the rules for application, and the process is now far more complicated. Indeed, the money did not flow until almost year-end, and we were required to spend everything within three weeks or return it. Through a tremendous degree of coordination and cooperation we accounted for about 95% of our typical allotment. Unfortunately, most of our Working Groups were not able to rely on their normal stipend for travel and meeting costs. We set up a Finance Committee to assist the Treasurer and now go through an annual audit of our accounts. This is also the last year of our three-year agreement with the Gulf of Maine Council on the Marine Environment, for which three projects have been approved and are now underway, although such funds may not be available for a continuation of this agreement into the future.

All of which brings us to our most pressing issue, that of how BoFEP will function and survive into the future with this type of funding variability. This challenge is the basis of our most important discussion at this AGM later in the agenda, in preparation for which an ad hoc Strategic Development Committee was set up, two Steering Committee retreats were held and a discussion/recommendations document was prepared which you should all now have.

Barry Jones, BoFEP Chair

As well as reviewing the above report Barry noted that three kiosks have been purchased: one to be located at ACER, one to be located in NB and the other in Southwest NS. These kiosks are available for use of displaying BoFEP and WG materials. If you wish to borrow one please contact Jon Percy or Leanna McDonald.

Larry Hildebrand emphasized that there is an on-going commitment by Environment Canada to support BoFEP.

Barry added that the document *BoFEP into the Future*, largely put together by Marianne Janowicz, will address the funding issues and will be discussed in Item 9.

Action Item – Leanna to e-mail copy of this report to Jon Percy.

6) Financial Report

Pat reviewed the year-end report for 2005-2006. Details available upon request.

Motion to accept the 2005–2006 financial report, Marianne Janowicz. ***Second***: Graham Daborn. ***Motion Carried.***

Appointment of an Auditor

Motion to approve that current auditors, Teed Saunders Doyle, be appointed as auditors for the upcoming fiscal year, Pat Hinch. ***Second***: Peter Wells. ***Motion Carried*** with the following amendment "pending further consideration of information required for audits."

Action Item – Barry to formally e-mail Larry Hildebrand regarding the audit requirements of Environment Canada.

The current bank account balance is $34,909.20. However, all of this funding is dedicated and therefore BoFEP has no discretionary funds available at this time.

SETAC Honorarium

Peter Wells received a SETAC honorarium in 2006 for US$15,000 which he has donated to BoFEP under the jurisdiction of the Management Committee.

In-Kind Contributions

The importance of tracking in-kind contributions was stressed and the members were reminded that the procedures for submitting this information has been posted on the BoFEP Web site. Last year BoFEP received

$375,000.00 in in-kind support. This information helps with the application process for funding.

Barry put forward a motion to capture the workshop income in our financial reports. ***Motion*** to accept, Graham Daborne. ***Second***: Marianne Janowicz. ***Motion carried***.

7. Working Group Activity Overview

Report on the BoFEP Working Groups and Their Activities

There are nine active working groups, two previously active working groups, and seven proposed or dormant working groups. The active ones are: biosphere reserve; *corophium* and mudflat ecology; eelgrass; Fundy informatics; marine energy; minas basin; salt marsh and restricted tidal systems (SMARTS); stress and cumulative effects; and sub-littoral ecology and habitat conservation. Some of these are less active than in previous years, due to the restricted resource situation within BoFEP or its partners.

The two previously active working groups are: ecotourism; and integrated fisheries management. Given the interest in and immense value of tourism around the Bay of Fundy, it would make some sense to restart the ecotourism group.

All of the others, as displayed on the Web site are proposed or dormant. They include: coastal development; eutrophication and nutrients; resource development; fish migration; zooplankton; integrated coastal zone management; and toxic chemicals and marine environmental quality. These groups are looking for champions and members, and will stay on the books in that context.

Six sub-contracts from Environment Canada went to working groups in FY 05-06, from the Coastal and Water Science Section, EC, Atlantic Region. The contracts supported work on mapping projects, Fundy information, a thesis study on Minas Basin, and others (see PGW for details).

Of the active groups, highlights included:

1) Completion of the Fundy Biosphere Reserve proposal and its submission;
2) Continued studies on Corophium ecology in the upper Bay of Fundy, and a publication in Hydrobiologia, and continued interest in completing the Corophium literature review;
3) Initiation of a study on the Fundy Information Collaboratory, with joint funding from GOMC and EC, and a biometrics study of Gulf of Maine Council on the Marine Environment publications (now available on the GOMC Web site);
4) Completion of a thesis study at UNB on the fate of mercury near salmon aquaculture sites in the outer bay;
5) Continued monitoring near a restored salt marsh ecosystem in the upper Bay;
6) Continued mapping of the biodiversity of hard-bottom habitats in the outer Bay of Fundy;
7) Discussion of priority projects in the Minas Basin and interaction with local groups on issues such as monitoring and effects of causeways; and
8) New science on the ecology of eelgrass.

Details of the specific studies and activities of working groups can be obtained from the Web site maintained by Jon Percy or from WG chairpersons and their members.

Working groups and their joint and collaborative projects are part of the core activity of BoFEP. One major concern is that the function of the working groups is very dependent upon continued minimal basic funding from BoFEP, and its sponsors, covering travel expenses of members to the key coordination meetings. Without this, work is slowing significantly. It is hoped that this is resolved soon for the current FY.

In conclusion, working group activity is fairly high and members have made significant contributions to the current 7th BoFEP Bay of Fundy Science Workshop, through both papers and posters.

Respectfully submitted,

Peter G. Wells
October 26th, 2006
St. Andrews, NB

8. Report of Communications Coordinator

The Communications Coordinator (Jon Percy) reported that he has accomplished the following duties and tasks:

1) Communications Coordination

Participation in most of the BoFEP Management and Steering Committee **meetings** and completed various communications and other **tasks assigned by the committees**. Providing regular reports and recommendations to both Committees about ongoing communications matters.

Meeting with **EC communications specialist** and revised BoFEP communications plan and developed simplified strategic objectives for use in BoFEP publicity.

Assisting the various active working groups with publicity and communications as required. Maintaining and routinely updated several Webmail lists that are being used to facilitate communications within and amongst BoFEP Committees and Working Groups.

Formatting and preparing a camera-ready copy of a booklet featuring BoFEP's recently revised Constitution and By-Laws and arranged for printing by a commercial printer as well as distribution to members and a subsequent reprinting of the booklet.

Assisting in the development of the BoFEP annual workplan and also prepared the final report to Environment Canada on BoFEP's 2004-2005 activities. Serving as BoFEP's liaison with the Bay of Fundy Marine Resource Centre and also with the North Mountain Preservation Group and regularly attended meetings of both groups.

Working routinely with the BoFEP Secretariat on a variety of matters related to the organization and activities of BoFEP and also provided periodic advice on communications matters. Participating actively in the two Steering Committee Retreats designed to chart future directions for BoFEP. At the first of these I prepared and delivered a PowerPoint presentation on past and current Strategic Objectives of the organization and recommended ways of simplifying these to better convey what BoFEP is all about. Preparing a draft of supporting document to further define BoFEP strategic directions.

2) Working Groups

Participation in the meetings of the more active working groups and provided advice on communications and other matters as required. Maintaining and routinely updated the Webmail lists and membership lists for the active working groups as needed. I maintained and regularly updated the information on the Working Group pages on the BoFEP Web site as required, including reports of their meetings and activities. Several publications sponsored by various WG were also posted on Web site as they are received (see item 4). Assisting in preparation of Terms of Reference for new Working Groups and in the revision and updating of those of existing groups as required. Participated in formation of a new informatics WG to find ways to facilitate access to BoFEP publications, bibliographies and other literature on Fundy.

3) Fact Sheets

The Fundy Issue on Protected Places (#26) was converted to html format and posted on the BoFEP Web site. Completion of Fundy Issue #27 on Persistent Organic Pollutants. Nearing completion is Fundy Issue (#28) dealing with Environmental and socioeconomic consequences of Avon River Causeway at Windsor and some of the related issues pertaining to the planned twinning of a major highway in the area. Preparation of several new graphics for the new Issues. Research is already underway on Fundy Issue #29 dealing with Sewage in the Bay of Fundy. Continuation of ongoing preliminary research on a number of additional potential fact sheet topics for possible future use. Disseminating paper copies of existing Fundy Issues at various events and venues and also responded to e-mail requests for copies. Arranging to have three of the existing very popular Fundy Issues reprinted.

4) BoFEP Web Site

Maintaining and routinely updating the BoFEP Web site as required. Converting documents to the appropriate formats and posted the following publications and reports on the Web site:

- Bay of Fundy Tidal Barriers GIS Database Development - final report
- Fisheries Management Issue in the Upper Bay of Fundy - final report
- Fundy Issue #26 on Protected Places.
- Revised copy of BoFEP Constitution and By-Laws
- Investigations of the Reference Condition Approach and Intertidal Ecology of Minas Basin, Bay of Fundy, with Reference to the Impacts of Intertidal Harvesting.
- Environmental and resource management in Minas Basin, Bay of Fundy – the role of appropriate indicators and indices to assess marine ecosystem health.
- Conservation and Local Communities: Exploring the Upper Bay of Fundy Biosphere Reserve Initiative in Nova Scotia.
- Thirty Year Assessment of the Cornwallis Estuary Evolution: Aerial Photograph and GIS analysis.
- Developing a Strategic Framework for National Marine Conservation Area Establishment in the Bay of Fundy. Victoria Sheppard, 2004 Thesis.

Posting of informational material from the Management Committee, Steering Committee and Working Groups on Web site in a timely manner. Routinely updating the Calendar and Fundy Newsclips pages on the Web site. Regularly responding to many requests for information received from users of the BoFEP Web site. Plans are being made to upgrade the Web site structure, to make it more user friendly and eye-catching.

5) BoFEP Science Workshops

Assisting the organizers of the 7th Science Workshop by providing paper and digital copies of all the relevant files used in preparing for and implementing the 6th Science Workshop. Serving on the organizing committee for 7th Workshop (see meetings attended in section 8) and providing ongoing advice about planning procedures, logistics, publicity and program organization as required. Placing information updates and various forms pertaining to registration for the workshop on the BoFEP Web site as they became available. Receiving and formatting the abstracts submitted for the workshop and posting all program information and abstracts on the Web site. Prepared letters, certificates and bookplates for student awards at workshop.

6) BoFEP Newsletter

Researching, writing, formatting and circulating to all BoFEP members copies of the Fundy Tidings quarterly newsletter as follows:

Issue: #9 December 2005
Issue #10 March 2006
Issue #11 September 2006
Issue # 12 is currently in preparation for circulation in December. Any input is always welcome. Copies of the newsletter are also archived on the BoFEP Web site. Maintaining and regularly updating the Webmail circulation list (260+ addresses) that is used to forward the newsletter to BoFEP members and other interested individuals.

7) BoFEP Publicity

BoFEP display mounted at Nature NS Conference in late May along with distribution of BoFEP posters, Fundy Issues and other promotional material

Active participation in a one-day “Coastal Clinic” Workshop in Saint John, NB, and took the opportunity to also set up a BoFEP display booth and distribute BoFEP publications and brochures and to advertise the 7th Science Workshop. Arrangement for the distribution of Fundy Issues and BoFEP brochures at various events and responding to mail requests for copies.

New BoFEP display units have been acquired. The plan is to have one at ACER, one somewhere in NB and one with communications coordinator. New informative display material (about BoFEP and its working groups) is being prepared for use with the display units. One of the units is on display at this workshop. BoFEP pins have been designed and are now available for distribution. They are mounted on card stock featuring BoFEP publicity and contact information.

The BoFEP brochure “A Call to Action” was very outdated and it has been completely revised and reformatted with spot colour on glossy paper. It has been printed and is now being distributed

A press release pertaining to the 7th Science Workshop was prepared and circulated to New Brunswick media.

The media database is routinely being updated and expanded.

The idea of creating a book based on the Fundy Issues as a cumulative document for the tenth anniversary of BoFEP which will be in 2007. Rob Fenson at DFO may be someone who could provide some useful suggestions regarding this.

Respectfully submitted, *Jon Percy*

9. BoFEP 8th Workshop Report

Gerhard reviewed the 7th BoFEP Workshop by reflecting on the fact that he thinks it is a worthwhile task, bringing people closer together, especially researchers interested in this area. BoFEP fills a role that no other organization provides by creating new appreciation for the groups interested in the Bay of Fundy and the workshop is the showcase of this organization. He expressed appreciation for the many supporters who made the workshop possible such as the New Brunswick government, The Atlantic Salmon Federation, the Department of Fisheries and Oceans and Environment Canada, to mention only a few.

Barry requested potential offers for a host for the 8th Workshop.

Anna Redden offered for The Acadia Centre for Estuarine Research to host the next workshop at the Old Orchard Inn in Wolfville, Nova Scotia.

Motion to accept ACER as the host of the 8th Workshop, Pat Hinch. ***Second***: Al Hanson.
Motion carried.

10. Discussion: "The Future of BoFEP; its long-term support"

Introduction

BoFEP was established to provide information to all sectors so that the ecosystem of the Bay of Fundy would be managed in a manner that would sustain the Bay and its people. Over the years, BoFEP has primarily accomplished its objectives through the biannual workshops that take the pulse of the Bay.

BoFEP members maintain an interest in taking a more active role in aspects of ecosystem management. This requires that the membership rethink or reconfirm its operational practices. It needs to build flexibility into its mandate and objectives in order to truly meet the needs of the people and the ecosystem of the Bay of Fundy and its watersheds. It also needs to have the flexibility to adjust to a changing political and social climate of the area.

It is with this in mind that the Management Committee met for a two-day Retreat in July of 2006 to assess the strengths and weaknesses of the organization and find ways to make it relevant today and even more relevant tomorrow.

The following recommendations are the outcome of the discussion at the Retreat. It is hoped that a number of them can be moved forward quickly and the others become stimulus for discussion among membership leading to a revitalized organization.

Objectives of BoFEP

- Inclusiveness is critical for the ongoing success of the organization and it should be fostered with industry, NGOs, First Nations and governments and institutions.

- The strategic goals of creating, sharing and utilizing knowledge should incorporate language that makes them accessible to industry, NGOs, First Nations and government/institutions and specific actions should be developed under each goal relative to those sectors.

Structure of BoFEP and Role of Members

- The Steering Committee needs to be enlarged to include industrial representatives and more government agencies.
- As a means to make participation the Steering Committee more interesting and involving, members could be asked to make a choice of either belonging to a Working Group or becoming involved in outreach.
- In all matters related to structure, BoFEP should have flexibility to adjust to changing circumstances.

Increase sector involvement

- Projects and research should include the social/economic factors as well as traditional knowledge rather than be primarily pure science-based.
- The organization needs to take on the challenge of developing new objectives under creating, utilizing, and sharing knowledge that fulfill industry needs. The revised strategic objectives should be sent to industry as a means of informing the sector about BoFEP and what it offers and solicit comments on services BoFEP could provide.
- Industry and other sectors should be consulted to identify projects that they require in order to be more sustainable.
- BoFEP needs to inform industry of its capacity in providing forums for disseminating information, information access and interactive tools. A plan is required for approaching key people in industry on a one-on-one basis.
- The Management and Steering Committees need to assess ideas for an industry advisory committee and identify the way to implement the agreed on direction. Those ideas are the following:
- An advisory committee composed of industrial associations dependent on a healthy Bay of Fundy ecosystem;
- An industry advisory committee with a terms of reference related to that of the committee providing advice to the Gulf of Maine Council;
- Organizing localized meetings with industry to discuss potential for linkages with BoFEP.
- BoFEP should establish an informal discussion group with fisher organizations and other NGO's to increase their understanding of BoFEP and discuss research or other projects relevant to them that BoFEP might be able to undertake.
- The relationship with the Gulf of Maine Council and specifically, the Canadian Association of Gulf of Maine Council should be formalized. BoFEP could fulfill the role of facilitator for feedback on draft action plans and other activities and documents.
- Identify and carry out an outreach approach relevant to the Canadian Council needs.
- BoFEP should solidify and expand linkages with research and academic institutes around the Bay of Fundy.

New Approaches or roles for BoFEP

- Identify a champion for BoFEP. That person would have the connections necessary to approach senior government people as well as with the other sectors.
- BoFEP must make a commitment to be more socially responsive and include the cultural and spiritual component and traditional knowledge in all aspects of ecological planning.
- The boundaries of BoFEP involvement need to expand to include watersheds of the Gulf of Maine and also the North West Atlantic and North East America from a land-based viewpoint.
- Further develop the opportunity for BoFEP to become a facilitator and initiator of forums for issue discussion, information gathering and dissemination. BoFEP is in a position to facilitate community involvement such as in the early stages of an ecological assessment of the Bay of Fundy as a starter to integrated management. It could also organize forums on behalf of industry to disseminate information to the public and create the venue for discussion. Alternative energies, wind and tidal power industries may be interested in such forums, as may be the nuclear energy and nuclear waste management industries.
- BoFEP should consider pursuing the activity of linking research institutes to industries with specific needs for knowledge sharing as one of the services the organization provides.
- BoFEP should take on as an activity the role of bringing Native communities and government and others together to share views on conservation so that a greater understanding is built.

Revitalizing Working Groups

- Working groups must be inclusive, responsive and relevant while fulfilling the objectives of creating, sharing and utilizing knowledge.
- Working groups need to incorporate traditional knowledge into science and create a balance between science orientation and social and cultural issues that are the drivers along the Bay of Fundy.
- Working groups must be provided with funding in order to effectively carry out the work they wish to do.
- A champion should be sought for a working group to look at the issue of cumulative impacts and the creation of a tool box for assessing cumulative impacts.
- In order to create better communication between the working groups and Management and Steering Committee, working groups would identify a member who acts as the reporter to Steering Committee.
- Chairs of working groups should be members of BoFEP and should also attend the AGM.
- Establishing an outreach committee may be necessary, with a first task of identifying a mechanism for outreach that will be utilized. A target for increasing the profile of the organization would be senior government people, particularly with the Canadian GOMC members. Outreach should also involve bringing people to the table who can help support BoFEP either with direct funding or through networking.
- Consideration should be given to soliciting voluntary contributions for working groups in the Workshop registration form. The section would briefly identify the intent of the Working Group and could spark a bit of interest and encourage people to take ownership and participate.

Indicators of Success

- The organization needs to examine progress on a regularly basis and develop a report card on itself. A specific forum or a special Steering Committee meeting should be devoted to discussion on identifying progress over the past two years and where further work is necessary.
- Indicators of progress can be developed by taking the issues of concern from the first workshop and assessing them related to information provided at subsequent workshops.
- The next discussion topic for the workshop could be the trends and conditions of the health of the Bay of Fundy eg. a synthesis of monitoring programs in the Bay of Fundy and the messages from monitoring (e.g., Are we using the right indicators? Are we monitoring the right species?). This would create our report card.

Financial Issues

- BoFEP should have a membership fee—there could be two workshop registration fees—one for members and one for non-members, with the members fee at a lower cost thereby providing a benefit to being a member. Members would have the following benefits: Web site access, reduced rates at workshops, factsheets in the mail, an electronic newsletter, invitations to workshops, the right to participate in Working Groups and guide the direction of the organization through the constitution.
- There needs to be a discussion within the steering committee and management committee on the best approach for funding the biennial workshop.
- Travel subsidies must continue for non-government representatives on the Management Committee and Steering Committees.
- A stipend should be provided to the treasurer for assistance with administrative work.

Larry stressed the importance of following up on the recommendation for a champion. A small world knows BoFEP and there is a real need for the right people to know what BoFEP has to offer. This leads to issues regarding communication where there is a real need to clearly ID and articulate the benefit of BoFEP to other groups. Communication products need to be developed that will bring the specific benefits to specific audiences. BoFEP came from an identified need and has an informal structure. There is a formal coastal ocean agenda in the Oceans Act Action Plan. BoFEP needs to identify what is the relationship between the Federal government's ocean agenda and what will be supported. There is a three week timeline where many of these decisions are going to be made at the federal level and BoFEP has to be serious about getting their message across.

John Terry added that GOMI is in a similar struggle. There is a need for better communication between scientists to and the outside world.

The suggestion to have membership fees was discussed, with most members who are currently familiar or involved in collecting or paying membership fees discouraging the idea, based on the fact that it would be more work than what the funds generated would be worth.

Motion to forward the "BoFEP Into The Future" report to the Steering Committee, conditional on the removal of the point on individual membership fees, Graham Daborn. ***Second:*** Peter Wells. ***Motion carried***.

Peter Fenety added that his experience tells him that the best option for raising funds is to put on relevant one-day workshops for issues applicable to industry and government.

11. Other Business

Peter Wells thanked Marianne for organizing the resulting information from the two retreats and formatting into a concise and accurate document.

The role of BoFEP interactions with educators was discussed. There is a lot of school board bureaucracy to deal with. It was pointed out that many of BoFEP's members are already doing this, e.g., The Huntsman, The Atlantic Salmon Federation, CARP and Ducks Unlimited. We need to ensure that we are not competing within our membership.

12. Nominations and Election of Steering Committee

Barry read a nomination report. The following individuals have agreed to be on the Steering Committee (there are 24 positions):

Ex officio: Graham Daborn (immediate Past-Chair)
1) Hugh Akagi
2) Mike Brylinsky
3) Mick Burt
4) Michael Butler (alt: Claudette LeBlanc)
5) Marine-Ines Buzeta
6) Andy Didyk
7) Elwood Dillman
8) Peter Fenety
9) Steven Hawbolt
10) Russell Henry
11) Pat Hinch
12) Marianne Janowicz
13) Barry Jones
14) Romney McPhie
15) Owen Washburn
16) Jon Percy
17) Gerhard Pohle
18) Anna Redden
19) Christine Smith
20) Mark TeKamp
21) John Terry
22) Raul Ugarte
23) Danika van Proosdij
24) Peter Wells

There was one vacant seat which Christine Smith was nominated to fill.
Moved. Graham Daborn. ***Second***: Al Hanson. ***Motion Carried.***

The Chair congratulated those newly elected.

Larry added he would still like to be invited to the Steering Committee meetings without officially serving on the Steering Committee.

Graham replied that the Steering Committee has the option of inviting any person deemed to be of interest as a non-voting guest. Mike added that the Steering Committee meetings are open to all BoFEP members. Barry agreed but unless invited, most people would not be aware of when the meetings are being held.

Following adjournment of this meeting, the Steering Committee will meet to elect Officers and others on the Management Committee.

13. Date and Location of the Next AGM

The next Annual General Meeting will be held at the call of the Steering Committee.

14. Adjournment

Motion to adjourn the meeting at 9:00 pm, Graham Daborn. **Second**: Peter Wells. ***Motion Carried.***

Appendix A

Outstanding Action Items

Meeting	Action Item #	Date Generated	***Description***	***Responsible***	***Status***
Annual		25-Oct-06	Barry to formally e-mail Larry Hildebrand regarding the audit requirements of Environment Canada.	AGM	On-Going

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