The Bay of Fundy Coastal Forum

Taking the Pulse of the Bay

A GPAC-BoFEP Coastal Forum, held May 15-16, 2002,
as part of the 5th Bay of Fundy Science Workshop,
Wolfville, Nova Scotia

Prepared and Edited by P. G. Wells

Co-Editors: J. Harvey, J. A. Percy, G. R. Daborn, and S. J. Rolston

Contributors: Z. Koller, P. M. Strain, S. Brillant and P. R. Hinch

Environment Canada – Atlantic Region
Occasional Report No. 25
Environment Canada, Dartmouth, NS and Sackville, NB
March 2005

This publication should be cited as:

P. G.Wells, J. Harvey, J. A. Percy, G. R. Daborn and S. J. Rolston. (Eds). 2005. The Bay of Fundy Coastal Forum. Taking the Pulse of the Bay. A GPAC-BoFEP Coastal Forum, held May 15-16th, 2002, as part of the 5th BoFEP Bay of Fundy Science Workshop, Wolfville, NS. Environment Canada – Atlantic Region, Occasional Report No. 25. Environment Canada, Dartmouth, NS and Sackville, NB. 54p. plus Appendices (CD ROM format).

Copies can be obtained from:

Secretariat, Bay of Fundy Ecosystem Partnership
Acadia Centre for Estuarine Research
Box 115
Acadia University
Wolfville, Nova Scotia B4P 2R6

or

P. G. Wells
Ecosystem Science and Information Division
Environmental Conservation Branch
Environment Canada – Atlantic Region
45 Alderney Drive
Dartmouth, Nova Scotia B2Y 2N6

ISBN 0-662-40755-5
ISSN 1195-664X
Catalogue No. CW69-12/25-2005E

Table of Contents

Appendices (On CD only)

Summary – Bay of Fundy Coastal Forum 2002

The inaugural Bay of Fundy Coastal Forum was organized with GPAC by the Bay of Fundy Ecosystem Partnership (BoFEP) as part of its May 2002 5th Bay of Fundy Science Workshop, in Wolfville, NS. The region considered at the forum was coastal and outer Bay of Fundy, areas largely outside the smaller bays, basins, inlets and estuaries. At the forum, the EPA traffic-light, matrix format of reporting was proposed and a preliminary attempt was made to identify indicators and test the matrix. Following the Bay of Fundy Coastal Forum, the matrix approach was refined and then adopted for all the subsequent GPAC watershed forums to use. The primary results of this first Coastal Forum went forward to the State of the Gulf of Maine Summit Conference, held in 2004.

The Bay of Fundy Coastal Forum drew approximately 100 persons for the 1.5 days of presentations and discussions. After a morning of presentations and discussion, the participants formed four breakout groups to discuss five questions:

1. **Current state**: What is the present health or condition of the Bay of Fundy?
2. **Changes**: Are conditions improving or deteriorating?
3. **Indicators**: What kinds of indicators do we consider most useful in trying to answer these questions?
4. **Existing Resources**: Are there adequate resources (institutional, financial, scientific, etc) to protect or restore the health of the Bay of Fundy?
5. **Needs**: What kinds of new information and approaches do we need to protect the health of the Bay?

In discussions of the first question "**What is the present health of the Bay of Fundy**", it was considered imperative that a goal concerning acceptable health and environmental quality of the Bay has to be established, while taking into account a common understanding of important terms and concepts, and considering the watersheds as part of the Bay's overall ecosystem. An accessible and comprehensive information base on Fundy is essential for assessing the Bay's health. In discussions of the many issues facing the Bay, everyone who knows the Bay has a voice. The consensus view about the present health of the Bay was that it was degraded, although there were uncertainties about the extent of adverse change and recognition that the answer to the question depends upon which part of the Bay is being considered. The task of reporting on the Bay also needs to be manageable, using an approach of preparing individual reports on different areas or ecosystems before attempting a comprehensive report on the whole bay.

What is the direction of change? Are conditions improving or deteriorating? It was considered important to make a statement about the Bay as a whole and its major areas, identifying areas of concern. We need to build on the considerable reliable knowledge that we have and adapt knowledge and approaches from other geographic areas. In one analysis, six indicators were judged to show that conditions in the Bay of Fundy are getting worse; eight indicators show conditions are neutral or not shifting; one indicator showed improvement; and two indicators could not be judged. In a second analysis, three indicators were red (bad); three indicators were blue (caution); three indicators were not evaluated; and none were green (good). In a third analysis, the group answer was that there are more stresses on the Bay's ecosystem now, some reaching levels that are compromising either ecosystem integrity or components of the ecosystem to which human assign value (e.g., natural living resources). The recent work of Lotze, Milewski and others, using long-term data sets, indicate a deterioration of environmental quality for one bay, Passamaquoddy. But data are lacking for many issues and areas, and we should be documenting changes in both what is economically important and what is not.

What kinds of indicators do we consider most useful in trying to answer these questions? It is not an easy task to decide which indicators are most useful. One should always start by asking: What are the management objectives for the Bay of Fundy? What are its valued ecosystem components? What are the expectations of society with regard to the environment? Good indicators have a number of characteristics; they must integrate over areas and over natural communities, be simple and cheap, and have high signal to noise ratio, i.e. have the power to detect adverse change in the ecosystem against a background of high natural variability. Limitations of indicators were recognized, including taking measurements of/on migratory species, interpreting effects on individuals to the level of population trends, and over-reliance on a few sentinel species. Some indicators should be "eco-region"-based and some should assess different processes of the system that can be interpreted as a whole. Indicators are numerous and can be categorized in different types and classes, but there are a few vital signs or symptoms to judge whether an ecosystem is healthy or not. They include status of key ecological variables, presence and levels of contaminants and nutrients, changes in habitats and biodiversity, status of fisheries, and social and demographic measures and trends. There is a need to report periodically on the health of the Bay of Fundy using such indicators, recognizing that the indicator and reporting fields are developing quickly with new approaches and technologies.

Are there adequate resources (institutional, financial, scientific, and others) to protect or restore the health of the Bay? The two discussion groups agreed that there was not enough sharing of resources, resources were often inappropriately allocated, and there was a need for support for longer-term efforts. Available resources were identified and discussed in six categories – financial, human, infrastructure, data and information, commitment to action, and education and training. Importantly, more attention needs to paid to access to and use of information, particularly for the overview of the health of the Bay. As well, public support for protecting the health of the Bay of Fundy exists, but commitment for its priority and mandated action by governments, communities and industry has not been adequately established. (Note: A recent positive action has been the inclusion of some fiscal resources for the Gulf of Maine in the recently released Oceans Act Action Plan, May 2005).

What kinds of new information and new approaches do we need to protect the health of the Bay? Data acquisition and information management are one of our greatest needs. Searchable databases, in a GIS context, on Fundy are needed. Site-specific reports are required on the Bay. A comprehensive evaluation of the health of the Bay of Fundy, using the template at this Forum, is required. New approaches could include increased community participation in all Fundy decision-making, demonstration projects for research and education, better linkages between indicators and management action, more consideration of land-based sources of pollution, standardized protocols for assessing ecosystem health, and an institutionalized network of protected areas. We should also involve more students in BoFEP and other Fundy activities.

The GPAC-sponsored Forum and 5th Bay of Fundy Workshop concluded with a discussion of how to move forward, measure change in the Bay of Fundy and report on its health and ecological integrity. GIS systems should be utilized more actively to evaluate and manage Fundy information. Graduate programs should be utilized more to study and evaluate change in the Bay of Fundy. Funding for programs at all levels (community groups to governments and universities) should be enhanced. And the media should be more involved with our efforts and workshops. The matrix approach to analyzing issues was considered full of promise but needed more time, more access to information, and more people involved to complete the analysis for the coastal Bay of Fundy. Overall, participants felt that the GPAC Forum approach was valuable and should be pursued. Both the Forum and Workshop were deemed a success by the participants.

Acknowledgements

Workshop attendees, chairs, facilitators (Janice Harvey, Peter Hicklin, Marianne Janowicz, Barry Jones) and rapporteurs (Zsofi Koller, Peter Strain, Sean Brillant, Patricia Hinch, Jon Percy) of sessions, speakers, and workshop logistics committee members are all thanked for their participation in the Coastal Forum. This report was possible largely due to the dedicated efforts and notes of the rapporteurs. Special thanks are especially extended to the student volunteers who put in many hours to help make this Workshop and Forum a success.

The Fundy Forum was sponsored by GPAC, BoFEP and GOMCME. Responsibilities for content for content and interpretation of the report remain with the senior editor. Comments by the reader are welcome. It is hoped that this report contributes to the continued quest to discuss, study, monitor, understand, report on, and manage the Bay of Fundy and the Gulf of Maine!

This report is overdue! But as Bartusiak (2005) notes in this celebratory year for science, "Einstein concluded that the cosmos has no universal clock or common reference frame. Space and time are 'relative' flowing differently for each of us depending upon our motion". Your actions based on this report, amongst many others, can help protect the Bay of Fundy, our small part of the cosmos, within your time frame!

Plenary One: Taking the Pulse of the Bay

Co-Chairs: Janice Harvey, Conservation Council of New Brunswick
and
Peter Wells, Environment Canada

Introduction

The Bay of Fundy Coastal Forum, *Taking the Pulse of the Bay,*[1] held over 1.5 days, was co-sponsored by the Global Programme of Action Coalition for the Gulf of Maine (GPAC) and BoFEP, and was a continuation of the BoFEP Workshop. This forum was the inaugural one, the first of a series of GPAC sponsored forums conducted around the Bay of Fundy and Gulf of Maine from 2002 to 2004.[2] For this forum, the intent was to bring together participants with different backgrounds, from different groups or agencies, but all with an interest in Fundy. The aim was to discuss the health of the Bay of Fundy comprehensively and to identify the issues, the condition of the bay, and its needs, from individual or institutional perspectives.

The discussions focussed on five key questions:[3]

1. **Current State**: What is the present health or condition of the Bay of Fundy?
2. **Changes**: Is the health improving or deteriorating?
3. **Indicators**: What kinds of indicators do we consider most useful in trying toassess/monitor the health?
4. **Existing Resources**: Are there adequate resources (institutional, financial, scientific, etc) to protect or restore the health of the Bay of Fundy?
5. **Needs**: What new information and approaches do we need to protect the health of the Bay?

The questions were a starting point to the forum discussions. Other pertinent questions pertaining to the overall goal were also raised by participants.

The primary results of this first Coastal Forum,[4] went forward to the "State of Gulf of Maine Summit" Conference. The Summit was organized by GPAC and the Gulf of Maine Council on the Marine Environment (GOMCME), and partners. This Summit[5] integrated all of the planned Gulf of Maine and Bay of Fundy forums, to help provide an initial overview of the health of the whole Gulf.[6]

BoFEP also prepared a background paper on the concepts of ecosystem health in the context of the Bay of Fundy.[7] This working paper was available in hard copy, for reference during the discussions at this Workshop and Forum. We proceeded with the three keynote talks, after which there was time for discussion, and an explanation of how the breakout group discussions and reporting were to be conducted.

We took great pleasure at introducing our speakers and their topics. Dr. John (Jack) Pearce gave a keynote talk entitled, "Taking the Pulse of the Seas: Can it be Done?". This was followed by two talks on "Two Hundred Years of Ecosystem Change in the Outer Bay of Fundy," Part One – "Changes in Species and the Food Web" and Part Two – "A History of Contaminants: Sources and Potential Impacts" by Heike Lotze and Inka Milewski.

Keynote Papers

Chair, Peter Wells

Please refer to Appendix 1 on the CD, on the back page of this report, or the 5th Bay of Fundy Workshop Report (Wells et al. 2004) for the text of the following three keynote talks:

Taking the Pulse of the Seas. Can it be Done? by J.B. (Jack) Pearce

Two Hundred Years of Ecosystem Change in the Outer Bay of Fundy by Heike K. Lotze, Inka Milewski, and Boris Worm

Two Hundred Years of Ecosystem Change in the Outer Bay of Fundy by Inka Milewski and Heike K. Lotze

Discussion of Keynote Papers

Co-Chairs: Jon Percy and Peter Wells

A very lively discussion[8] of the keynote papers brought out the following points (see Appendix 2 on the CD for detailed notes):

Nutrients: Nutrification is a localized phenomenon around the Gulf of Maine and Bay of Fundy, but not a widespread Bay of Fundy phenomenon. The primary production cycle in coastal areas is largely driven by nutrient/nitrogen inputs from offshore, not from local inputs. (*Ed. Note*: This is clearly shown by the Cobscook Bay papers in the 6th Bay of Fundy Workshop Proceedings, Percy et al. 2005.) Both inorganic and organic fractions of nutrients should be measured.

Impacts of nutrients: There is good historical data on industrial influences in the New Bedford Harbour, MA. This has been compared to an estuary that is subjected to urban inputs, with the comparison being made using sediment analyses of silicon from diatoms. This recent study shows changes in biodiversity with nutrient enrichment. With a highly eutrophic system, there is a precipitous decline in production; sediment cores provide a good historical picture of this decline.

Monitoring the Fundy watershed: Though our concern is primarily with estuaries and other coastal watersof Fundy, there are places in the Bay of Fundy watershed offering opportunities to interpret the environmental history of the area. Lake sediments provide an historical record of many changes that have taken place in the watershed.

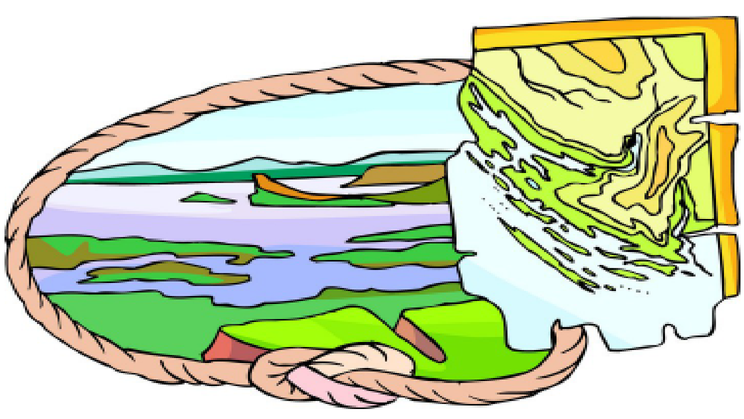
Monitoring invertebrate community changes: We do not have a good understanding of changes occurring in hard bottom communities due to the difficulty of sampling on hard bottoms; there is much better information available for soft bottom communities. This is important, because there appears to have been a shift in the invertebrate community structure in hard bottom species. Lobsters are now one of the top predators in the system and, with increased numbers, the lobster fishery is doing well.

Changes in ecosystem health: What constitutes ecosystem change – loss of predators? Presence of chemical contaminants in fish tissue? The cycling of trace contaminants? The condition of fisheries? And in what context is ecosystem change considered – human-induced, natural or both? In the last 200 years, humans have changed many ecosystems; they are no longer natural, and there may be thresholds of disturbance beyond which populations and ecosystems change and do not recover to the original state. On the other hand, as suspected with lobster populations, for example, we may be seeing a natural oscillationin population size, similar to that observed with other decapod crustaceans.

REPORTS[9] OF BREAKOUT GROUPS

Co-Chairs: Janice Harvey and Peter Wells

Rapporteurs: Z. Koller, P. M. Strain, S. Brillant and P. R. Hinch



Introduction

Following a brief discussion about the role and organization of the breakout groups, people chose to work in one of four groups: A. Questions 1 and 2 combined; B. Question 3; and C and D, two groups for Questions 4 and 5 (but also covering the earlier questions for context). The groups met for one full afternoon and part of the following morning. Detailed original notes, prepared by the rapporteurs, are in the appendices on the CD (see Appendices 3-6).

Highlights of the discussions are presented below under each question, recognizing the linkages between questions 1-3. The information has been reorganized and condensed for clarity. Some interpretation of the discussion notes was required at times, if they were short and cryptic! This was the trial run of the EPA-based traffic light approach to coastal assessment; the CD has the results of Group A's evaluation (see Appendix 3, p. 91). The results are not presented in the core report as they are preliminary and incomplete. A fuller picture of the state of the Gulf of Maine and Bay of Fundy using this approach, developed at the GPAC forums of 2002-2004, is found in the GOM Summit documents, particularly in Chapter 3 in Pesch and Wells (2004) and in GPAC (2004).

1. Current State: What is the present health or condition of the Bay of Fundy?

Highlights of the discussion were:

Goal: A goal(s) concerning the acceptable health (current structure and functioning) and environmental quality/ecological integrity (condition relative to original unimpaired state) has to be established. Questions such as "What do we want the Bay to be? What is(are) the baseline(s)? and What was the ecosystem like before it was altered? were posed and need answers before assessing the current "health" of the Bay of Fundy.

Definitions: Definitions and concepts are important; e.g., What are "acceptable" environmental impacts? What is "ecosystem health"? Epstein's definition[10] is a start, though imperfect. There are many different interpretations of what a "healthy ecosystem" is, so we should simply focus on symptoms based on what we know.

Broadening the approach: There is a need to consider the watershed(s) of the Bay of Fundy in the evaluation of the health of the system, as well as to broaden out to considering socio-economic and development issues. That way, the coastal zone and the interface between land and sea (including groundwater and surface water) are looked at comprehensively.

Using the information base: A major challenge of assessing the Bay's health is to have the information (formal, anecdotal or traditional) available as a reference so that opinions/judgements of condition are informed ones, not merely guesses.

Issues confronting the Bay of Fundy: (in no particular order) fate of coastlines; salt marsh numbers and condition; metal contaminants, especially in lobsters; mining of aggregates; tidal barriers; lack of knowledge of ecosystem processes in the Bay for management purposes; effects of fishing on benthic habitats; effects of harvesting on inter-tidal habitats; implications of coliform bacteria contamination to human health in the Bay; knowledge of how the Bay has changed over time; protection of wetlands; communication of scientific information to the public; the need for ecosystem-based integrated management; and the need for a coastal policy for Nova Scotia.

Comparing opinions and facts on issues: Everyone should be listened to, public and scientific opinions need to be compared on all major issues, and differences and misconceptions should be examined closely. The task of evaluating the health of the Bay should be based on peer-reviewed fact(s), not unsubstantiated opinion.

Conclusions about the present state or health of the Bay: We do have concerns about the health of the Bay, even when being conservative; overall, the number of "green assignments (good condition)" are very few. This signifies multiple problems. In one group, 11/19 people concluded that the Bay was degraded, while 8/19 were unsure (though even the "unsures" recognized the usually adverse impacts humans have on the Bay). Primarily, the feeling was that the quality of the ecosystem has been degraded. Another group concluded that this was a very difficult question and that the answer depends upon which part of the Bay or an ecosystem within the Bay (e.g., salt marsh) is being considered.

Making the task of reporting on the Bay manageable: Report on the Bay in detailed separate sections (e.g., inner/outer; inshore/offshore; inter-tidal versus sub-tidal). Prepare a comprehensive report based on this series of individual reports.

2. Changes: Are conditions improving or deteriorating?[11]

Highlights of the discussion were:

The task: It is important to make a statement about the Bay as a whole, and its major areas (upper, middle, outer) identifying areas of concern. We need to build on the considerable reliable knowledge that we have, and adapt knowledge and approaches from other geographic areas (e.g., Chesapeake Bay; Great Lakes) as appropriate. The EPA traffic light approach (in simplified form) seemed an appropriate one to Group A, which proceeded to go through each indicator for each part of the Bay. They assigned a color (red–bad; blue–caution; green–good; no color–no information) and an arrow or number to indicate direction of change (1–improvements; 2–neutral, no shifts; 3–getting worse; no number–no information)(see Appendix 3, p. 91).

Conditions for the whole Bay as assigned by Group A, using indicators randomly selected by the group: Six/17 indicators were red (bad): coastal wetlands (3), shellfish harvest (2), shellfish closures (2), fishery(ies) stocks (3), sediments as contaminants (3), threatened and endangered species (3). Seven/17 indicators were blue (caution): nutrients (3); sediment contamination (1); submerged aquatic vegetation (-); benthic habitat (3); contaminants in fish and shellfish (2); contaminants in birds and mammals (2); water-bird populations (2). Three/17 indicators were green – phytoplankton (2); dissolved oxygen (2); lobster populations (2). One indicator had insufficient information – diseases in wild fish and shellfish – for any evaluation (-). In summary, six indicators were judged to show conditions in the Bay of Fundy are getting worse; eight indicators show conditions are neutral or not shifting; one indicator showed improvement; two indicators could not be judged.

Conditions for the whole Bay as assigned by Group A based on nine ecosystem-based indicators: biodiversity (blue); impaired productivity (blue); altered food webs/biotic composition (red); reduced resilience (no color); contaminants (blue); exposure to pathogens (red); algal toxins (red); increased disease prevalence (no color); risks to human health/organism health (no color). Direction of change was not evaluated. In summary, three indicators were red (bad); three indicators were blue (caution); three indicators were not evaluated. None were green (good).

Conditions of the Bay (Groups C and D): To answer this question, the groups considered if the words “conditions” and “improving,” and the over-used word “stressed,” are too value-laden. As well, change does not automatically mean degradation. The group’s answer was that there are more stresses on the Bay’s ecosystem now, some reaching levels that are compromising either ecosystem integrity, or components of the ecosystem to which human assign value (e.g., natural living resources). For the most part, indicators of whether conditions are improving or not are value judgements. The work of Lotze and Milewski and others, using long-term data sets, indicate a deterioration of environmental quality for Passamaquoddy Bay. But data are lacking for many issues, and we should be documenting changes in both what is economically important and what is not.

3. Indicators: What kinds of indicators do we consider most useful in trying to answer these questions?

The groups discussed the choice of appropriate indicators. They agreed that important attributes of healthy ecosystems include biodiversity, productivity, resilience and balance. Support was given to evaluating the health, i.e. ecosystem structure and function, of the Bay of Fundy using Rapport’s indicators of stress (see Rapport et al. 1998; Wells 2004, Table 3) – biotic impoverishment, impaired productivity, altered biotic composition, reduced resilience, increased disease prevalence, reduced economics, and risks to human/organism health.

There are a number of characteristics of “good” indicators. They must integrate over areas and over natural communities (especially upper trophic levels within ecosystems). They preferably are simple and cheap. And there must be a good signal to noise (S/N) ratio, i.e. they must have the power to detect change in an ecosystem with much natural variability. There are also limitations to indicators, e.g., measurements on migratory species, whether on individuals or populations, can be difficult to interpret as they move from one location to another, hence reflecting the condition of many other environments than just Fundy; measurements on single species can be difficult to interpret in the context of their populations, and ecosystems; and if one chooses keystone or focal species, there is a need to understand their life history, e.g., blue mussels, amphipods, salmon, various shorebirds and seabirds.

It was recognized that some indicators should be "eco-region" based (matching typical conditions for a particular part of the Bay), and some should assess different processes of the system that can be interpreted as a whole. Indicators should: a) be locally determined; b) be biological, social, economic, etc; c) if possible, be applicable to the Bay as a whole; d) be practical for measurement; e) be suitable for a long-term focus and continuity (taking into account the needs of QA/QC); and f) have a pool of baseline data, so as to evaluate spatial and temporal trends, and overall directions.

Hence, which indicators are most useful? It is not an easy task to decide which indicators are most useful! One should start by asking: What are the management objectives for the Bay? What are its valued ecosystem components? What are the expectations of society – what do we want and not want regarding the environment of the Bay? And how do we consider or group the stressors (which determine the indicators) – By sector? By type of input? Or by type of impact?

Importantly, there are different types of indicators (e.g., biological; chemical; physical, related to habitat; social, economic and cultural indicators (not considered much in this Forum). And there are classes of indicators (e.g., habitat, stewardship, sustainable aquatic communities, chemicals) with various functions, e.g., early warning, trend analysis, economic state and prediction, public education (i.e. translation of science to the public). It is important to remember that environments change through natural processes and such change is not necessarily "bad," it is or may be just a shift or readjustment of natural conditions.

There are **vital signs or symptoms** to judge whether an ecosystem is healthy or not, and these translate into **indicators and specific endpoints or measurements**. These include (listed in no particular priority or order):

- **ecological variables** (e.g., physical change(s); phytoplankton; dissolved oxygen; population status of wildlife; status of threatened or endangered species; change in erosion rates off the land; phytoplankton (numbers and types of dinoflagellates); freshwater quality entering the bay; changes in nutrient inputs; precipitation levels and composition; change of weather and climate patterns). Indicators of natural change include: sea level; sea ice and impacts on coastlines; and erosion of sediments.
- **contamination and nutrients** (e.g., eutrophication; presence of shoreline; debris; contaminants in sediments and tissues; presence and effects of chemicals at low levels; contaminants in shellfish; contaminants in birds and mammals; sediment contamination; sediment as a contaminant; nutrient loading; contamination of habitat or biota by industrial, municipal and agricultural wastes).

- **changes in habitat and biodiversity** (e.g., loss of habitat; presence of introduced species; species richness; changes on trophic structure; occurrence of protected areas; area and condition of coastal wetlands; submerged aquatic vegetation; benthic habitat condition; habitat change (by destruction, disruption, fragmentation); sea level rise; changes in biodiversity; disturbance of natural populations (by noise, light, seismic exploration); air quality).
- **fisheries status** (e.g., shellfish harvest; status of lobsters; status of living resources; shellfish closures (numbers and extent); status of fisheries stock condition (salmon, gaspereau, herring, flounder, dogfish); seafood quality; disease(s) in wild fish and shellfish).
- **social and demographic indicators** (e.g., increased coastal development; land use/coastal development/human population changes; urban development patterns; family incomes).

There is a need for immediate reporting health of the Bay using indicators. Suggested indicators to meet this demand include – measures of changes in species composition in selected habitats (e.g., number of finfish species); area of salt marshes; areas of shellfish closures; persistence of critical habitats, such as spawning areas; presence and levels of toxic chemicals in mussels and seabird eggs;[12] measurements on individual shorebirds (e.g., weight gain) and seabirds (e.g., reproductive success); measures at the ecosystem level (e.g., resilience in large-scale experiments?); and presence and condition of inter-tidal algae.

There is a growing effort to develop new technologies and approaches for indicators. There are various new technologies such as remote sensing, high-density sampling (with multi-beam surveys and video surveys), and integrated physical modeling that can be deployed in monitoring, and approaches with community groups (e.g., reef-keepers, ACAP) interested in monitoring using suitable indicators.

4. Existing resources:[13] Are there adequate resources (institutional, financial, scientific, and others) to protect or restore the health of the Bay?

In identifying available resources, the two discussion groups generally agreed that: a) there is not enough sharing of resources; b) resources are not appropriately allocated; and c) there is a need for support for long-term efforts, as short-term initiatives are generally well-supported. Available resources were identified in the following six categories:

1. *Financial*

While there would seem to be public and private money available for essential support coordination staff, data collection and special projects, most of it is not accessible due to different donor priorities and lack of BoFEP fund-raising capability. Community organizations must develop creative ways to access these monies. The user-pay principle must be applied in some areas, e.g., do licensing fees recover appropriate amount to support required monitoring and remediation? When something goes wrong, there was general agreement that there were adequate resources to address it, but it is issue and priority dependent.[14] The opinion was that there seems to be a priority to protect but not to restore.

2. *Human*

The expertise and skills abound in both the public/private sectors and in the communities at large, but have not been prioritized or solicited toward our goals. In terms of scientific capacity,[15] several questions were posed: Are there enough trained and experienced scientists left in the federal, provincial and university institutions to conduct the necessary research, monitoring, analysis, synthesis, interpretation, etc? Is there still a capacity to study the whole ecosystem, rather than just its parts? This was deemed critical to being able to deliver reports on a periodic basis.

3. *Infrastructure*

While partnerships and infrastructure by and large exist in adequate measure, they will obviously continue to evolve to meet new challenges. Likewise, the essential tools and technologies are largely in place and adequate to the tasks at hand. The controlling mechanisms, i.e. governance and regulations, to address Bay health issues appears to be adequate, but the enforcement of these is insufficient, and the fines do not fit the real costs of mitigation.

4. *Data/Information*

While much data has been collected and information produced, little is available for practical purposes. There must be standard means of monitoring, collection and reporting, and data should be appropriately interpreted, freely available and publicized. More work must be done to evaluate the practicality and usefulness of indicators and monitoring tools, and a long-term commitment must be made for their support. In terms of the capacity to prepare a syntheses on the health of the Bay, the scope of the task, including reviewing the literature, should not be underestimated. New studies will also be required to fill "data gaps".

5. *Commitment to Action*

For the most part, public support for protecting the health of the Bay exists, but commitment for its priority and the mandated action among government-community-industry has not been adequately established. Points of contact and goal-appointed responsible champions must be identified to undertake specific tasks.

Typically, communications and marketing is the weakest link in protecting the health of the Bay. While much has been done, linkages among all groups must be forged, and information must be presented in the most appropriate manner to each group, with appropriate follow-up. Our message must be clear and the media utilized effectively.

6. ***Education/Training***

Many volunteers are available to assist in bringing about our/community Bay health goals, although appropriate training and field resources are essential to do the task. Public and school education should be paramount among our goals, so that current and future generations recognize Bay health as significant to their own health. School children should be given opportunity to participate in experiential environmental education programs. Teachers should be trained to lead these programs.

5. Needs: What kinds of new information and approaches do we need to protect the health of the Bay?

Participants identified the need for new information and approaches related to the task of understanding and protecting the health of the Bay. They recognized that developing the framework for analysis will take some considered thought and time. There was a desire to avoid re-inventing the wheel, particularly in the discussions of indicators, the conduct of monitoring, and the generation of reports.

Needs for New Information

- **Data acquisition and information management** are one of our greatest needs. This includes standardization, collection, interpretation, evaluation and distribution from multi-disciplinary sources in a timely manner. We should strive for all data to be gathered year-round, with time and GPS references. Warehousing or long-term storage, regeneration, logging and searchable databases are other issues that need to be addressed.
- Appropriate **indicators** of Bay health must be agreed upon, **baselines** must be established, and **monitoring** programs implemented in order to evaluate possible trends and the effectiveness of our actions for subsequent planning purposes.
- **Mapping** should be high resolution and include shoreline/coastal, habitats, watersheds, resources, land-use changes and exotics.
- **Survey and inventory** data should include bathymetry/Lidar surveys, 2D and 3D for relief flooding and coastal areas, resource inventories and remote sensing.
- **Site-specific reports** are required on the Bay and its inlets and harbours, such as those on Passamaquoddy Bay (see Lotze and Milewski 2002), the Minas Basin (Willcocks-Musselman 2004) and Cobscock Bay (Percy et al. 2005). We can then build on these synthesis reports to analyze the state of ecosystem health in the Bay.
- A **comprehensive evaluation of the health** of the Bay of Fundy, using the template developed at this Forum, is required.
- **Study and impacts research** priorities include ecological interactions, micro-organism in-

formation (natural history, evolutionary history) to understand the origins of life, and fishing gear and aquaculture impacts.

- **Scientific information** should be translated, communicated, and released in a timely manner, so that it is broadly accessible to the public.

Needs for New Approaches

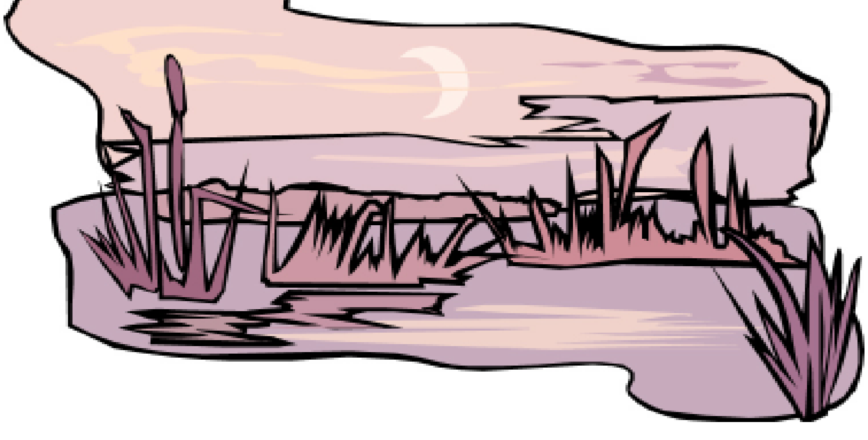
- **Public and private partnerships** must establish clear relationships to better address mutual goals, and **community participation** must increase in both the process and decision-making, including setting of the agenda for research and monitoring. To **encourage participation** from all sectors, some form of recognition or endorsement incentives should be developed and applied on a regular basis. **Linkages with industry and the media** must be strengthened.
- Focussed research projects reflecting the ecosystem approach of our mission, goals and objectives should be set up as **a demonstration project** to provide opportunities for education and community involvement. Opportunities for **large-scale (but reversible) experiments**, associated with determining assimilative capacity of the Bay, and the effectiveness of approaches to resource management must be explored.
- New mechanisms of **public education** need to be brainstormed, developed and explored.
- **New management options** include direct payback by impactors toward mitigation and restoration, and government cancelling their data /information cost recovery process.
- We must examine the **linkage between indicators and management action**. Do management systems respond to warnings given by indicators? There is a disconnect between indicators/monitoring and action on problems. (*Ed. Note*: Evidence to date shows that action seldom occurs without a crisis, unless the indicator information comes from a mandated, well-structured and supported monitoring program such as for harmful algal blooms or chemical contaminants.)
- **Land-based sources of pollution** must be examined more thoroughly; there was a lack of terrestrial expertise at the meeting and knowledge of input inventories.
- There is a need for **standardized protocols for assessing ecosystem health**, and for data management associated with it.
- **A commitment to monitoring,** conducted under regulation(s), is needed from Bay of Fundy users.[16]
- A **centralized agency or dedicated foundation for community group coordination** is needed as volunteer capacity is nearly saturated.
- A **network of protected areas** should be institutionalized and the idea of the (UNESCO) Fundy Biosphere Reserve should be pursued.

- There is a **role for BoFEP** to champion and co-ordinate Bay of Fundy efforts and serve as an advocate for reporting on the health of the Bay.
- There is a need for stronger and more active **stewardship** initiatives.
- We should **involve more students** in our activities, through BoFEP and other interested groups.[17]
- **Streamlining and co-ordinating government agency mandates** would improve cooperation,[18] be mutually beneficial to each agency, and facilitate more buy-in into stewardship work. In a research context, participation of university administrators and those of NSERC would assist in moving these efforts forward.
- Wider application of the precautionary approach, i.e. **being proactive, not reactive**, especially with Fundy EIAs and current industry(ies), should be considered.
- Regulatory agencies must **enforce existing regulations** under their mandates. Is there a greater role for the public to encourage regulation? Are we depending upon a regulatory system that does not work?
- **Other approaches** that can be considered in a Fundy context include eco-economics, or environmental capital; the different scales of monitoring and reporting change; issuing frequent "report cards" using different indicators.

Plenary Two: Sustaining the Pulse of the Bay

Co-Chairs: Graham Daborn and Peter Wells

Rapporteur: Jon Percy



Discussion and Next Steps

Four questions[19] were tabled as a guide to the discussion:[20]

1. How do we measure change in the Bay of Fundy?
2. Should we be publishing the matrix table of the Bay's condition, based on this workshop?
3. Is the GPAC Forum approach, with questions and matrices, a useful one for the Gulf of Maine as a whole?
4. Has this been an effective process?

1. How do we measure change in the Bay of Fundy? (Sub-question: How do we ensure that positive change happens?)

A discussion ensued about geographic information systems (GIS). How much data is in GIS format? A small percentage of Fundy information is in GIS form but is rapidly increasing. This is an important tool for displaying and analysing reference information. We need to collect geo-referenced spatial data and knowledge, and we need to emphasize that data collection is crucial for GIS overlays if GIS to be a useful tool.

For example, the coastal flooding issue(s) could attract media attention if we used a visual medium. For other issues, as well, a summary list or report card of issues and a matrix on a map of the Bay of Fundy could bring media attention. It could be prepared by community organizations and also be taken to the public in other ways.

Our graduate programs could be utilized more fully. We could be putting them to better use. We should direct a question or questions from the workshop to students for research purposes. We haven't talked much about research needs. The Centre for Geographic Studies (COGS), Lawrencetown, Nova Scotia, could be in a position to assist with research that required GIS support and training. Use of graduate programs could rapidly become the norm as we tackle Fundy issues.

Funding is a key issue for community groups. The real problem is that, periodically, a community has a problem, wants to talk about it, and wants to establish a monitoring program. But the community has no funding and no place to go for funding. In past years, there was competition for funding and it was difficult to obtain funds but there were funding sources available. With cutbacks, there is very limited available funding. There is a lot of interest on the part of communities to become involved in programs. However, we have not sufficiently empowered communities to work on key issues with government. Communities have the fewest resources. A number of groups are well supported, e.g., ACAP, but unless other groups become empowered, they cannot take action on issues and we cannot move ahead.

Funding is needed to precipitate action. Effort must be placed into education, hence increasing awareness for action on environmental issues. We need to make enough people aware of the issues to make progress. Progress takes time but there has been progress on several issues, e.g., water issues are now commonly known to have an impact on the economy and have become a priority area for GPAC and many other organizations. Relatively few community groups have paid coordinators yet this is a recognized key to success. Others groups are only funded on a short-term, year-to-year basis, after which continuity of programs is affected.

We should also spend time organizing conferences that involve the media. Our inability to attract media attention[21] and involvement in Bay of Fundy issues is deplorable. Political and management responsibilities are crisis driven. The media is inaccessible and so, unfortunately, we almost need a crisis to draw attention. We also need to take the necessary time to cultivate those we want to engage.

We need to encourage senior government decision-makers to participate in BoFEP workshops and to stay engaged in the procees of identifying priorities and funding new initiatives.

2. How many workshop/forum participants would be comfortable with us publishing the Bay of Fundy matrix table (see Appendix 3, p. 91) that we have produced for public distribution and media use?

The overall answer was “no”. While participants agreed, the idea was excellent, there was not enough time remaining in the workshop/forum to finalize the table. We have made a good start with the matrix but the most appropriate people to make the decisions, in response to matrix questions, have not necessarily been involved in this process. More issues should have been included in the matrix; we need to engage experts on the issues listed and to ask them to add other issues that may be missing.

We have reached an overall consensus on some of the important indicators. Perhaps a report on the state of the environment would provide ideas of funding required for further investigation and research on the issues. Why not plan a two-day meeting[22] to develop the report (define issues, processes and tasks, next steps) to serve as a guide allowing us to move forward? We need a process by which to make informed judgements and to measure progress.

In addition, if media are to be involved in a workshop or forums such as this, they need to be able to walk away with something that is reliable and interpretable (i.e. the completed matrix and report on the state of the Bay).

3. Is the Forum process[23] a good one or are improvements required? Is this a useful process for the Gulf of Maine as a whole?

Ideas varied on this question, but were generally positive:

> I encourage the report idea but am unsure about the matrix. The concept of a GIS map involving experts to fill in the layers of information is a good suggestion.
>
> This has been a valuable process. To work effectively in watershed areas, we need to have an open dialogue and to encourage the input of communities as we have seen here.
>
> This is not the appropriate forum to produce a report card. I challenge scientists at this workshop to produce a report card for publication and distribution to the public and the media and to develop a communications strategy which outlines how we can more effectively engage the media.
>
> The more we bring people together, the better we are able to deal with the Bay of Fundy as an ecosystem. We must not forget that the Bay of Fundy is an international body of water linked with the United States. We have a stewardship responsibility and need to make more people aware of the issues both externally and internally.

4. The final question: "Are you glad you came to the workshop? Has this been an effective process?

Resounding Yes!

Closing Remarks of the Chairs

The process we have experienced at this Forum shows that we must endure to see and make positive change. We cannot expect change to happen overnight, but we are making progress.[24] We will move ahead on the issues and problems. The report will be forwarded to the Gulf of Maine Council on the Marine Environment.[25] The messages and process will be incorporated into the GPAC Summit process.[26]

The next Bay of Fundy Workshop will be held in the Annapolis Valley in 2004, that year being an important milestone for outer Bay communities, as the Bay of Fundy was explored and first settled by European colonists 400 years ago. The workshop will be held at the Annapolis Basin Conference

Centre in Cornwallis Park with the co-ordination assistance of the Bay of Fundy Marine Resource Centre. The workshop will focus on 400 years of change within the watershed and emphasize the impacts of activities on the Bay. We will look at the past and also ahead into the future, focussing on where we are going, where we want to be 100 years in the future, and what needs to happen in the interim to make this a reality.[27]

List of Participants

This is a partial listing only; apologies to persons not listed who attended and participated, as almost 100 persons stayed the course of the Forum discussions to the end of the workshop. Note: Affiliations and addresses are in the Proceedings of the 5th Bay of Fundy Workshop (Wells et al. 2004)

Tony Bowron
Sean Brillant
Mike Brylinsky
Nancy Chesond
Thierry Chopin
Chiu Chou
Mark Costello
Graham Daborn
Elwood Dilman
Debra Dugas
Peter Eaton
Diana Hamilton
Gareth Harding
Janice Harvey
Steve Hawboldt
Jocelyne Hellou
Peter Hicklin
Patricia Hinch
Marianne Janowicz
Peter Johnson
Barry Jones
Zsofi Koller
Peter Larsen
Peter Lawson
Gary Lines
Heike K. Lotze
Inka Milewski
Bronwyn Musslemead
Jeff Ollerhead
Mary O'Toole
Ed Parker
Jack Pearce
Jon Percy
Pamela Person
Bob Rangley
Peter Strain
Michael Strong
Sarah Townsend
Danika Van Proosdij
Daryl Wells
Peter Wells
Maxine Westhead

Information Sources

Endnotes

1. The title for the Fundy Coastal Forum uses the metaphor of the human pulse, which is an easy to measure but critical indicator of human health. In contrast to measuring the health of individuals of any single species, e.g., humans, many types of indicators have to be measured over time and space for a description of ecosystem health and integrity, covering many species of different phyla, their populations, their communities and the habitats where they reside.
2. The Forum series was successfully held, under GPAC sponsorship, and their reports are summarized in the document entitled *United States and Canadian GPAC Forums and Meetings*, released at the 2004 GOM Summit Conference, October 2004. Individual Forum reports are also available. See <www.gulfofmaine.org/summit> and search under background documents.
3. Questions were developed for the workshop and forum by BoFEP members G. Daborn, B. Jones, J. Percy, M. Westhead and P. G.Wells. Also see the 5th Bay of Fundy Workshop Proceedings, Wells et al. 2004.
4. The experience of the inaugural Fundy Coastal Forum was very useful to those that followed (e.g., Shaw 2003 and Tekamp 2003), as well as to supporting many of the primary issues raised at later major meetings (December 2002, Northeast Monitoring Conference, Durham, NH; Indicators Conference, January 2004, Durham, NH; Summit Conference, October 2004; see <www.gulfofmaine.org/summit>).
5. The Gulf of Maine Summit Conference was held in October 2004, sponsored by GOMCME and GPAC. The results are available at <www.gulfofmaine.org/summit>, with the primary report being *Gulf of Maine Summit: Committing to Change*, St. Andrews, NB, October 26-29, 2004. Summit Report (King and Mackenzie 2005).
6. This integration was done for the Summit Conference through three routes – the preparation of individual GPAC Forum reports and a summary report on the Forums, called *United States and Canadian GPAC Forums and Meetings*; the preparation of a Summit Conference environmental report, entitled *Tides of Change Across the Gulf* (Pesch and Wells 2004); and the conduct of the Summit Conference itself with discussion groups and its report, published 2005 (see note 3).
7. The paper, “Assessing the Health of the Bay of Fundy – Concepts and Framework,” is published in the Proceedings of the 5th Bay of Fundy Science Workshop (Wells et al. 2004). It is also published in revised and updated form (Wells 2003, 2005). It served as one of the background papers at the 2002 Monitoring and 2004 Indicators Conferences (see <www.gulfofmaine.org> for web links). The paper is one of many useful backgrounders on the topic of ecosystem health and indicators (see also Strain and MacDonald 2002; Rice 2003; Jorgensen et al. 2005; Westhead 2005; and references to this report). Continued attention is being paid to the concept(s) and practice of (marine) ecosystem health measurement, the choice of appropriate indicators to protect both ocean and human health, and the various approaches to reporting on (i.e. assessing) the “health” of ecosystems for different audiences.

8. Discussion was recorded as accurately as possible. However, speakers are not identified and the information, though apparently accurate, has not been confirmed or referenced in most cases. The real value of this discussion is that it illustrates what was on people's minds regarding issues and effects.
9. Rapporteurs were Zsofi Koller (CCNB), Peter Strain (DFO), Sean Brillant (ACAP-Saint John), and Patricia Hinch (NSDEL); they produced excellent records of the discussions that form the basis for this section.
10. From Wells (2004) – The definition of ecosystem health by Dr. Paul Epstein (Harvard University) is that "an ecosystem must maintain its metabolic activity level, its internal structure and organization, and must be resistant to stress over a wide range of temporal and spatial scales." Forum participants felt that this definition does not consider standards, allow for change, or acknowledge use by humans, and that the term "resilient" might be better than "resistant." The discussion underlined the fact that the definition is evolving.
11. Information from research and monitoring programs using indicators is required to answer this question; some of the most useful indicators are described under Question 3 in the Breakout Group Discussion (see page 11).
12. The Canadian Wildlife Service of Environment Canada has conducted a toxic chemical monitoring program at seabird colony sites across Canada since 1968 and has reported on this program frequently. See, for example, Pearce et al. (1989); the review (p. 47-49) in Wells et al. (1997); and various papers by Neil Burgess of CWS-Atlantic.
13. The term is used in the broadest sense.
14. There are resources set aside for occurrences such as oil spills and outbreaks of harmful algal blooms.
15. This issue was discussed informally amongst participants. Some participants considered marine scientific capacity to be reaching an all-time low regionally, a crisis for continued high quality research and monitoring in and from the federal government institutes, and ultimately a crisis for effective coastal and marine environmental management, whether for living resources or for ecosystem health. Further recent cutbacks of staff (2004) at DFO in Halifax, planned cutbacks in toxic chemical programs (DFO 2005), as well as prior laboratory closures in Environment Canada in the 1990s, illustrate this serious problem. Also see Schindler (1998, 2001), amongst others, on the issue of current aquatic science capacity in Canada. An objective review of capacity in aquatic science and management to serve Canada's needs in the 21st century is urgently needed, given the priorities of water and oceans given in many sectors.
16. Such a commitment to monitoring from the Bay of Fundy community would presumably aid the existing regulatory monitoring conducted under the *Fisheries Act* (e.g., bacterial levels at shellfish beds, end-of-pipe industrial compliance monitoring, monitoring of aquaculture sites), the *Canadian Environmental Protection Act* (e.g., ocean disposal sites, such as off Saint John Harbour), and the *Canadian Wildlife Act* (e.g., toxic chemicals in seabird eggs). It would also aid research-oriented monitoring initiated by investigators at the Rivers Institute, UNBSJ, the Biology Department, UNB Fredericton, and others.

17. Students are becoming increasingly involved in BoFEP's working groups, e.g., Minas Basin WG, and a student award program was initiated formally at the biennial Bay of Fundy Science Workshops, starting in 2002.
18. An attempt was made for several years in the late 1990s to coordinate efforts of the federal government Natural Resource Departments (the so-called 5-NR departments) for new initiatives on the Bay of Fundy. Papers were tabled on monitoring and on an overview of the department's Fundy activities (Petrie 1998; Wells 1998). This work stopped in 1999.
19. The Fundy Coastal Forum's report, though delayed, has some important messages as we proceed towards a consensus on the choice of indicators and the approach to reporting on the state of the Gulf of Maine and Bay of Fundy. This report adds to the messages in the GPAC Forum report completed for the GOM Summit Conference, October 2004 (GPAC 2004), and to the Summit report itself (King and Mackenzie 2005). In addition, the questions that guided the discussion at this Workshop and Forum were well intended but are over-simplified, given the complex nature of marine (Bay of Fundy) ecosystem(s) and the challenge of choosing indicators for monitoring and appropriate approaches for reporting on the "health" of the bay. The coastal ecosystem is imperfectly understood, the choice of indicators is very user or client driven, and the concepts of "ecosystem health" and "ecological integrity" are still developing and have their detractors. But the questions posed at this workshop and forum continued the serious discussion of issues, indicators, monitoring and assessment, i.e. reporting, within BoFEP, GPAC, GOMCME and other circles. This hopefully will continue as we move towards better and preferably integrated management of the Bay of Fundy (including better co-ordinated research, monitoring, and reporting).
20. Approximately 100 people stayed for the duration of the workshop and forum and were present at the Thursday Plenary Two discussions. Detailed notes from the plenary are found in Appendix 7.
21. Media attention improved greatly in 2004, with considerable interest by CBC, other networks, and the print media in the 6th Bay of Fundy Workshop 2004, the GOM Summit Conference of 2004, and especially in the *Tides of Change Across the Gulf* report. There was also considerable CBC interest in the 4th BoFEP Bay of Fundy Science Workshop and Coastal Zone Canada 2000 Conference in Saint John. So it is not accurate to say there is no interest in Fundy issues by the media. Of course, more can always be done. Key issues have to be communicated clearly.
22. Another Coastal Bay of Fundy Forum to produce and complete a comprehensive defensible and referenced matrix, around key indicators, is still needed.
23. This question is answered for the record of this Forum, the first in the series. The GPAC Forums proceeded throughout 2002-2004, were judged to be successful by most participants, and were reported on at the GOM Summit, October 2004 (GPAC 2004; King and Mackenzie 2005; Pesch and Wells 2004). Next steps are now being considered by GPAC, the GOMCME and BoFEP regarding further state of the Gulf reporting, use of the indicator-based, "traffic-light", matrix approach for assessing broadly the health of the Gulf and Bay of Fundy, and assessing progress on the issue of land-based activities and land-based pollution of the marine environment.
24. Noting progress is very important, to keep a high level of interest and energy of involved parties and people. See Chapter 7 and appendices steered by Patricia Hinch in *Tides of Change Across the*

Gulf (Pesch and Wells 2004) and the Wall of Achievements at the GOM Summit Conference in October 2004 (King and Mackenzie 2005).

25. See Note 22.
26. See Note 22.
27. The 6th Bay of Fundy Workshop was held in Cornwallis, NS, September 29th-October 2nd, 2004; the Proceedings are published (see Percy et al. 2005). The 7th BoFEP Bay of Fundy Science Workshop will be held in St. Andrews, NB, October 25-27, 2006.
28. Other Fundy workshops preceded the series now run under the banner of BoFEP, especially in the 1980s when there was heightened interest in tidal power being developed in the upper bay. The reader is directed to the bibliography by Plant (1985), the reports by Gordon and Dadswell (1984) and Gordon and Hourston (1983), and the overview by Daborn (1997).
29. Many of the definitions are adapted from Pesch and Wells (2004) and are also sourced there. New terms are sourced in the References. Terms not sourced are original in this text.

References

Allaby, M. 1998. *A Dictionary of Ecology*. 2nd Edition. Oxford University Press, Oxford. 440p.

Atlantic Northeast Coastal Monitoring Summit. 2002. *Workshop Summary Report*, Dec. 10-12, 2002. Durham, NH. 11p.

American Public Health Association (APHA). 1998. *Standard Methods for the Examination of Water and Wastewater*. APHA, Washington, DC.

Barber, K. (Ed.). 1998. *The Canadian Oxford Dictionary*. Oxford University Press, Toronto, Oxford, New York.

Bartusiak, M. 2005. Beyond the big bang. Einstein's evolving universe. National Geographic 207(5):110-121.

Beanlands, G. E. and P. N. Duinker. 1983. *An Ecological Framework for Environmental Impact Assessment in Canada*. Institute for Resource and Environmental Studies, Dalhousie University, and Federal Environmental Assessment Review Office, Halifax, NS. 132p.

Bortone, S. A. (Ed.). 2005. *Estuarine Indicators*. CRC Press, Boca Raton, FL. 531p.

Busch, D. E. and J. C. Trexler. 2003. *Monitoring Ecosystems. Interdisciplinary Approaches for Evaluating Ecoregional Initiatives*. Island Press, Washington, DC. 447p.

Curran, K. J., P. G. Wells and A. J. Potter. 2005. Proposing a coordinated environmental effects monitoring (EEM) program structure for the offshore petroleum industry, Nova Scotia, Canada. Marine Policy (in press).

Daborn, G. R. 1997. Chapter One. Fundy marine ecosystem science project: science overview. Pages 1-9, in J. A. Percy, P. G. Wells and A. J. Evans, eds., *Bay of Fundy Issues: A Scientific Overview.*

Proceedings of a Workshop, Wolfville, NS., January 29th to February 1st, 1996. Environment Canada – Atlantic Region, Occasional Report No. 8, Dartmouth, NS and Sackville, NB.

DK Publishing, Inc. 1998. *DK Illustrated Oxford Dictionary*. DK Publishing, Inc., London. 1008p.

Environment Canada. 2003. *Species at Risk Act. A Guide*. October 3003. Environment Canada, Ottawa, ON. 17p.

EPA (Environmental Protection Agency). 1998. *Condition of the Mid-Atlantic Estuaries*. EPA 600-R-98-147. Nov., 1998.

GESAMP. 2001. *A Sea of Troubles*. GESAMP Reports and Studies No. 70, UNEP, Nairobi. 35p.

Gordon, D. C., Jr., and M. J. Dadswell (eds.). 1984. *Update on the marine environmental consequences of tidal power development in the upper reaches of the Bay of Fundy*. Can. Tech. Rept. Fish. Aquat. Sci. 1256. 686p.

Gordon, D. C., Jr., and A. S. Hourston (eds.). 1983. *Proceedings of the Symposium on the Dynamics of Turbid Coastal Environments*. Ca. J. Fish. Aquat. Sci. 40 (suppl. 1):1-365.

GPAC (Global Programme of Action Coalition for the Gulf of Maine). 2001. *The Gulf of Maine Summit. State of the Environment Reporting from the Bottom-Up: A Handbook for Forum Convenors*. GPAC, Blue Hill, ME. 18p.

GPAC (Global Programme of Action Coalition for the Gulf of Maine). 2004. *United States and Canadian GPAC Forums and Meetings.* Online: <www.gulfofmaine.org/summit)>.

Hildebrand, L. and E. Noreena. 1992. Approaches and progress toward effective integrated coastal zone management. Mar. Pollut. Bull. 25(1-4):94-97.

Hodgson, E., R.B. Mailman and J.E. Chambers (eds.). 1998. *Dictionary of Toxicology*. 2nd Edition. Groves Dictionaries Inc., New York, NY. 504p.

Jorgensen, S. E., R. Costanza and Fu-Liu Xu (eds.). 2005. *Handbook of Ecological Indicators for Assessment of Ecosystem Health*. CRC Press, Boca Raton, FL. 439p.

King, P. and K. Mackenzie (eds.). 2005. *Gulf of Maine Summit: Committing to Change. Summit Report*. Gulf of Maine Council on the Marine Environment, and the Global Programme of Action Coalition for the Gulf of Maine. 18p plus appendices.

Lewis, R.A. 1998. *Lewis' Dictionary of Toxicology*. Lewis Publ, Boca Raton, FL. 1127p.

Lillesand, T. M. and R. W. Kiefer. 1994. *Remote Sensing and Image Interpretation*. Third Edition. John Wiley and Sons, Inc., New York. 750p.

Lotze, H. K. and I. Milewski. 2002. *Two Hundred Years of Ecosystem and Food Web Changes in the Quoddy Region, Outer Bay of Fundy.* Conservation Council of New Brunswick, Fredericton, NB. 188p.

Mills, L. S., M. E. Soule and D. F. Doak. 1993. The keystone-species concept in ecology and conservation. Bioscience 43(4): 219.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and

Evolution 10(10): 430.

Pearce, P. A., J. E. Elliot, D. B. Peakall, and R. J. Norstrom. 1989. Organochlorine contaminants in eggs of seabirds in the Northwest Atlantic, 1968-1984. Environ. Pollut. 56:217-235.

Percy, J. A., A. J. Evans, P. G. Wells and S. J. Rolston (eds.). 2005. *The Changing Bay of Fundy: Beyond 400 Years. Proceedings of the 6th BoFEP Bay of Fundy Workshop, Cornwallis, NS, Sept. 29th – Oct.1st, 2004.* Environment Canada – Atlantic Region, Occasional Report No. 23. Dartmouth, NS and Sackville, NB. 480p.

Pesch, G. G. and P. G. Wells (eds.). 2004. *Tides of Change Across the Gulf. An Environmental Report on the Gulf of Maine and Bay of Fundy*. Gulf of Maine Council on the Marine Environment, Augusta, ME, and Concord, NH. 81p. Online: <www.gulfofmaine.org/summit>.

Petrie, B. 1998. *Monitoring Activities of the Four Natural Resource Departments in the Maritimes Region*. A report presented to the Federal Natural Resource Departments, Atlantic Pilot Project Coordinating Committee. Department of Fisheries and Oceans, Dartmouth, NS. Unpubl. Doc., Feb. 1998. 27p.

Plant, S. 1985. *Bay of Fundy Environmental and Tidal Power Bibliography*. Can. Tech. Rept. Fish. Aquat. Sci. 1339.

Rapport, D. J., R. Costanza and A. J. McMichael. 1998. Assessing ecosystem health. Trends Ecol. Evol. 13:397-401.

Rice, J. 2003. Environmental health indicators. Ocean and Coastal management 46:235-259.

Schindler, D. W. 1998. Sustaining aquatic ecosystems in boreal regions. Conservation Ecology (online) 2(2):18. Online: <www.consecol.org/vol12/iss2/art18/>.

Schindler, D. W. 2001. The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. Can. J. Fish. Aquat. Sci. 58:18-29.

Shaw, S. D. 2003. *Gulf of Maine Forum 2002. Protecting Our Coastal and Offshore Waters*. November 1, 2002, Blue Hill, ME. Summary Report, Aug., 2003. Marine Environmental Research Institute, Center for Marine Studies, Blue Hill, ME. 21p.

Sherman, K. and H. R. Skjoldal (eds.). 2002. *Large Marine Ecosystems of the North Atlantic. Changing States and Sustainability*. Elsevier, Amsterdam, Boston. 449p.

Strain, P. M. and R. W. MacDonald. 2002. Design and implementation of a program to monitor ocean health. Ocean and Coastal Management 45:325-355.

Tekamp, M. 2003. *Report on the Minas Basin Forum*. Minas Basin Working Group, Bay of Fundy Ecosystem Partnership Secretariat, Acadia Centre for Estuarine Research, Acadia University, Wolfville, NS.

Thain, M. and M. Hickman. 2004. *Dictionary of Biology*. Penguin Books, London, UK. 753p.

WCED. (The World Commission on Environment and Development). 1987. *Our Common Future*. Oxford University Press, Oxford, New York. 383p.

Websters Third New International Dictionary. 1966. G. & C. Merriam Co. Publishers, Springfield, MA.

Wells, P. G. 1991. Chapter One: Introduction. Pages 1-7, in P. G. Wells and S. J. Rolston, eds., *Health of Our Oceans. A Status Report on Canadian Marine Environmental Quality*. Environment Canada, Ottawa and Dartmouth, NS.

Wells, P. G. 1998. *The Bay of Fundy: Current Program Activities and Management Issues of the Federal Natural Resource Departments in the Maritimes*. A Report to the Federal Natural Resource Departments, Atlantic Pilot Project Coordinating Committee. Unpubl. Report, Environmental Conservation Branch, Environment Canada, Dartmouth, NS. Feb. 1998. 14p. plus appendices.

Wells, P. G. 2003. Assessing health of the Bay of Fundy – concepts and framework. Marine Pollution Bulletin 46: 1059-1077.

Wells, P. G. 2004. Workshop background paper. Assessing the health of the Bay of Fundy – concepts and framework. Pages 1-40, in P. G. Wells, G. R. Daborn, J. A. Percy, J. Harvey and S. J. Rolston, eds., *Health of the Bay of Fundy: Assessing Key Issues. Proceedings of the 5th Bay of Fundy Science Workshop and Coastal Forum "Taking the Pulse of the Bay", Wolfville, NS, May 13th - 16th, 2002*. Environment Canada – Atlantic Region, Occasional Report No. 21, Dartmouth, NS and Sackville, NB.

Wells, P. G. 2005. Assessing marine ecosystem health – concepts and indicators, with reference to the Bay of Fundy and Gulf of Maine, Northwest Atlantic. Chapter 17, in Jorgensen et al., eds., *Handbook of Ecological Indicators for Assessment of Ecosystem Health*. CRC Press, Boca Raton, FL.

Wells, P. G., G. R. Daborn, J. A. Percy, J. Harvey and S. J. Rolston (eds.). 2004. *Health of the Bay of Fundy: Assessing Key Issues. Proceedings of the 5th Bay of Fundy Science Workshop and Coastal Forum "Taking the Pulse of the Bay", Wolfville, NS, May 13th -16th, 2002*. Environment Canada – Atlantic Region, Occasional Report No. 21, Dartmouth, NS and Sackville, NB. 402p.

Wells, P. G., P. D. Keizer, J. L. Martin, P. A. Yeats, K. M. Ellis and D. W. Johnston. 1997. Chapter 3. The chemical environment of the Bay of Fundy. Pages 37-61, in J. A. Percy, P. G. Wells and A. J. Evans, eds., *Bay of Fundy Issues: A Scientific Overview*. Environment Canada – Atlantic Region, Occasional Report, No. 8. Environment Canada, Dartmouth, NS and Sackville, NB.

Wells, P. G. and S. J. Rolston (eds.). 1991. *Health of Our Oceans. A Status Report on Canadian Marine Environmental Quality*. Environment Canada, Ottawa and Dartmouth, NS. 186p.

Westhead, M. C. 2005. *Investigations of the Reference Condition Approach and inter-tidal ecology of Minas Basin, Bay of Fundy, with reference to the impacts of inter-tidal harvesting*. M.Sc. Thesis, Department of Biology, Acadia University, Wolfville, NS. (completed April 2005).

White, P. S. and S. T. A. Pickett. 1985. Natural disturbance and patch dynamics: an introduction. Pages 3-13, in S. T. A. Pickett and P. S. White, eds., *The Ecology of Natural Disturbance and Patch Dynamics*. Academic Press, Toronto.

Willcocks-Musselman, R. 2004. Planning for action in the Minas Basin watershed: a summary of the BoFEP Minas Basin Community Forums. Pages 228-247, in P. G. Wells, G. R. Daborn, J. A.

Percy, J. Harvey and S. J. Rolston, eds., *Health of the Bay of Fundy: Assessing Key Issues. Proceedings of the 5th Bay of Fundy Science Workshop and Coastal Forum "Taking the Pulse of the Bay", Wolfville, NS, May 13th -16th, 2002*. Environment Canada – Atlantic Region, Occasional Report No. 21, Dartmouth, NS and Sackville, NB.

Related Publications of BoFEP

Further publications are listed on the BoFEP website at <www.bofep.org>

Proceedings of Bay of Fundy Workshops[28]

Percy, J. A., P. G.Wells and A. J. Evans (eds.). 1997. *Bay of Fundy Issues: A Scientific Overview*. Proceedings of a Workshop, Wolfville, NS., Jan. 29th to Feb. 1st, 1996. Environment Canada – Atlantic Region, Occasional Report No. 8, Dartmouth, NS and Sackville, NB. 191p. (reprinted April 2002).

Burt, M. D. B. and P.G .Wells (eds.). 1998. *Coastal Monitoring and the Bay of Fundy*. Proceedings of the Maritime Atlantic Ecozone Science and Fundy Marine Ecosystem Science Project Workshop, November 1997. Huntsman Marine Science Center, St. Andrews, NB, and Environment Canada, Dartmouth, NS. 196p.

Ollerhead, J., P. W. Hicklin, P. G. Wells and K. Ramsey (eds.). 1999. *Understanding Change in the Bay of Fundy Ecosystem.* Proceedings of the 3rd Bay of Fundy Science Workshop, Sackville, NB, April 22-24, 1999. Environment Canada – Atlantic Region, Occasional Report No. 12, Dartmouth, NS and Sackville, NB. 143p.

Chopin, T. and P. G. Wells (eds.). 2001. *Opportunities and Challenges for Protecting, Restoring and Enhancing Coastal Habitats in the Bay of Fundy*. Proceedings of the 4th Bay of Fundy Science Workshop, Saint John, NB, Sept. 19-21st, 2000. Environment Canada – Atlantic Region, Occasional Report No. 17, Dartmouth, NS and Sackville, NB. 237p.

Wells, P. G., G. R. Daborn, J. A. Percy, J. Harvey and S. J. Rolston (eds.). 2004. *Health of the Bay of Fundy: Assessing Key Issues. Proceedings of the 5th Bay of Fundy Science Workshop and Coastal Forum "Taking the Pulse of the Bay", Wolfville, NS, May 13th -16th, 2002*. Environment Canada – Atlantic Region, Occasional Report No. 21, Dartmouth, NS and Sackville, NS. 402p.

Percy, J. A., A. J. Evans, P. G. Wells and S. J. Rolston (eds.). 2005. *The Changing Bay of Fundy: Beyond 400 Years. Proceedings of the 6th BoFEP Bay of Fundy Workshop, Cornwallis, NS., Sept. 29th – Oct.1st, 2004.* Environment Canada – Atlantic Region, Occasional Report No. 23. Dartmouth, NS and Sackville, NB. 480p.

Fact Sheets

Percy, J.A. 1996. Heeding the Bay's Cry: The Bay of Fundy Ecosystem Project.Fundy Issues #1. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Tides of Change: Natural Processes in the Bay of Fundy. Fundy Issues #2. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Sandpipers and Sediments: Shorebirds in the Bay of Fundy. Fundy Issues #3. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. The Seaweed Forest: Rockweed Harvesting in the Bay of Fundy. Fundy Issues #4. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Dredging Fundy's Depths: Seabed Mining in the Bay of Fundy. Fundy Issues #5. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Right Whales-Wrong Places? Right Whales in the Bay of Fundy. Fundy Issues #6. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Farming Fundy's Fishes: Aquaculture in the Bay of Fundy. Fundy Issues #7. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Fundy's Watery Wastes? Pollution in the Bay of Fundy. Fundy Issues #8. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Dykes, Dams and Dynamos: The Impacts of Coastal Structures. Fundy Issues #9. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1996. Expanding Fundy's Harvest: Targeting Untapped Treasures. Fundy Issues #10. Bay of Fundy Ecosystem Project Publication. 4p.

Percy, J.A. 1999. Whither the Waters: Tidal and Riverine Restrictions in the Bay of Fundy. Fundy Issues #11. Bay of Fundy Ecosystem Partnership Publication. 12p.

Fried, Suzy. 1999. Gulfwatch: Putting a little mussel into Gulf of Maine Marine Monitoring. Fundy Issues #12. *Gulf of Maine Times* and Bay of Fundy Ecosystem Partnership. 8p.

Percy, J.A. 1999. Keystone Corophium: Master of the mudflats. Fundy Issues #13. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 1999. Working Together Within an Ecosystem: The Bay of Fundy ecosystem Partnership. Fundy Issues #1a (revised). Bay of Fundy Ecosystem Partnership Publication. 6p.

Percy, J.A. 2000. Fishing in Fundy: Harming Seafloor Habitats? Fundy Issues #14. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2000. Fundy in Flux: The Challenge of Understanding Change in the Sea. Fundy Issues #15. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2000. Salt Marsh Saga: Conserving Fundy's Marine Meadows.Fundy Issues #16. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2001. Fundy's Wild Atlantic Salmon: Doomed or Simply Down? Fundy Issues #17. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2001. Whither the Weather: Climate Change and the Bay of Fundy. Fundy Issues #18. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2001. Fundy's Minas Basin: Multiplying the Pluses of Minas. Fundy Issues #19. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2001. Fundy's Fisheries: Who Should Write the Rules? Fundy Issues #20. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2002. Putting the Fun in Fundy: Possibilities and Pitfalls of Ecotourism. Fundy Issues # 21. Bay of Fundy Ecosystem Partnership Publication. 8p.

Percy, J.A. and P.G. Wells. 2002. Taking Fundy's Pulse: Monitoring the Health of the Bay of Fundy. Fundy Issues # 22. Bay of Fundy Ecosystem Partnership Publication. 8p.

Percy, J.A. 2003. Alien Invasions: Introduced Species in the Bay of Fundy and Environs. Fundy Issues #23. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2003. Living Lightly on Land and Water: Native People and the Bay of Fundy. Fundy Issues #24. Bay of Fundy Ecosystem Partnership Publication. 12p.

Percy, J.A. 2004. Contaminant Concerns: Heavy Metals and the Bay of Fundy. Fundy Issues #25. Bay of Fundy Ecosystem Partnership Publication. 12p.

List of Acronyms

ACAP	Atlantic Coastal Action Program
APHA	American Public Health Association
BoFEP	Bay of Fundy Ecosystem Partnership
CBC	Canadian Broadcasting Corporation
CCNB	Conservation Council of New Brunswick
COGS	Centre for Geographic Studies
DFO	Department of Fisheries and Oceans (Canada)
EC	Environment Canada
EIA	environmental impact assessment
EPA	Environmental Protection Agency (USA)
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GIS	geographic information system
GOM	Gulf of Maine
GOMCME	Gulf of Maine Council on the Marine Environment (or the Gulf of Maine Council)
GPA	Global Programme of Action (on Land-Based Activities)
GPAC	Global Programme of Action Coalition
GPS	global positioning system
MEQ	marine environmental quality
NSDEL	Nova Scotia Department of Environment and Labour
NSERC	Natural Sciences and Engineering Research Council
QA/QC	quality assurance and quality control
SCI	sustainable communities initiative
S/N	signal to noise ratio
UBC	University of British Columbia
UNB	University of New Brunswick
UNBSJ	University of New Brunswick, Saint John campus
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	World Commission on Environment and Development

Glossary[29]

Baseline – refers to the original, unimpaired (by man) environmental or ecological conditions, set at some arbitrary time. Baselines can shift, depending upon available data and the investigator's experience, resulting in the "shifting baseline syndrome" in fisheries biology described by Daniel Pauly of UBC (Pauly 1995). In the context of environmental effects (impact) monitoring, "baseline data" characterizes environmental conditions prior to project development against which subsequent changes following development can be detected through monitoring" (Beanlands and Duinker 1983, in Curran et al. 2005).

Bathymetry – the measurement of the depth of the ocean floor from the water surface; the oceanic equivalent of topography (Allaby 1998).

Biodiversity – biological diversity (Lewis 1998); the variety and variability among living organisms and the ecosystems in which they occur (www.epa.gov).

Capacity – the power to contain, receive, experience, or produce (DK Publ. 1998); in the context of environmental activities, it refers to the ability to produce essential work in the short and long term.

Change – the action of making something different in form, quality, or state: the fact of becoming different (Websters 3rd).

Coastal zone – various definitions. In practice, the coastal zone (or area) may include a narrowly defined area about the land-sea interface of the order of a few hundreds metres to a few kilometres, or extend from the inland reaches of coastal watersheds to the limits of national jurisdiction in the offshore. The definition will depend upon the particular set of issues and geographic factors which are relevant to each stretch of coast (Hildebrand and Norrena 1992).

Community – a general term applied to any grouping of populations of different organisms found living together in a particular environment; essentially the biotic component of an ecosystem (Allaby 1998).

Condition – the state of being or fitness of a person or thing (arrived in bad condition) (DK Publ. 1998); in the context of the environment, refers to the current state of ecosystems and their uses, with reference to the original or baseline condition(s).

Contaminants – potentially harmful substances or agents in the natural environment (including within individual organisms) that are present at concentrations above natural background levels, and below levels known to cause adverse effects.

Degradation – the act or state of being reduced to a lower condition.

Diatoms – microscopic algae in the Division Heterokontophyta (c. 10,000 species), accounting for about 20% of all primary production (Thain and Hickman 2004).

Disturbance – from an ecological perspective, disturbance is any event in time that disrupts ecosystem, community, or population structure and function, and that changes resources, substrate availability or the physical environment of biota (adapted from White and Pickett 1985; M. Westhead, pers. comm.).

Ecological change – a change in the health or quality of an ecosystem. Ecological change can be gradual or abrupt. It occurs naturally, occurs due to anthropogenic activities, or occurs due to a combination of natural and human-derived stresses. It can be subtle and takes place over various temporal and spatial scales (adapted from Wells 2003).

Ecological integrity – Ecological integrity (also called ecosystem integrity) is "the dimension of health that reflects the capacity to maintain organization; it is akin to the term 'integrity', especially when used at the scale of ecosystems" (from Wells 2003, based on Karr 1992). It incorporates the ideas of resilience, vigor, and homeostasis. "Many regard integrity, when used in a purely ecological sense, to refer to the evolution of the ecosystem without human disturbance" (from Wells 2003, based on Nielsen 1999).

Ecosystem (or ecological system) – a natural unit formed by the interaction of a community of plants and animals with their environment, physical and biological (EPA 1998). "The term was first used by A.G. Tansley (in 1935) to describe a discrete unit that consists of living and non-living parts, interacting to form a stable system" (Allaby 1998).

Ecosystem change – Change is always occurring in Earth's ecosystems and marine ecosystems are no exception to this rule. For each ecosystem under consideration, it is important is to distinguish between natural ecological change, anthropogenically driven change, and the two combined where appropriate and to identify the important adverse change(s) that can be ameliorated. Changes can and should be observed or measured over the long-term, and compared to measurements of or approximations of the original conditions (the so-called baseline conditions), set at some arbitrary time. The choice of appropriate indicators, the monitoring design, and modeling are critical to successful measurement of ecosystem change (Adapted from various authors, see Wells 2003, 2005).

Ecosystem health – is defined in terms of four characteristics applicable to any complex system – sustainability, activity, organization and resilience. An ecological system is healthy and free of distress syndrome if it is stable and sustainable – that is, if it is active and maintains its organization and autonomy over time, and is resilient to stress (from Wells 2003, based on Schaeffer et al. 1988 and Haskell et al. 1992)**.**

Environmental quality (marine) – is the condition of a particular marine environment measured in relation to its original unimpaired or "baseline" conditions, and in relation to each of its intended uses and functions. It can be described subjectively, especially if stresses impinging on the system are large and if the ecosystem or habitat are obviously degraded. However, marine environmental quality or MEQ is usually assessed quantitatively for each environmental compartment, on temporal and spatial scales. It is measured using sensitive indicators of condition and change. To be useful, such measures are interpreted using objectives and limits set by environmental, health and resource agencies (adapted from Wells 1991, 2003, 2005).

EPA traffic light approach - an approach developed by the USEPA to assign colours designating condition or level of severity of coastal variables, e.g., oxygen concentration, turbidity, chlorophyll, benthic condition. Each colour represents a specific range of measures for a particular variable. When used by a general audience, the collective opinion of the group leads to the color assignment for a particular issue or stress.

Eutrophication – a condition in an aquatic ecosystem where high nutrient concentrations stimulate blooms of algae (e.g., phytoplankton), and algal decomposition may lower dissolved oxygen concentrations (EPA 1998).

Food web – an assemblage of organisms in an ecosystem, including plants, herbivores and carnivores, which shows the relationship of "who eats whom" (EPA 1998).

Habitat (including critical habitat) – the place where a population or community (i.e. an assemblage of micro-organisms, plants and animals) lives, and its surroundings, both living and non-living (EPA 1998). Critical habitat is "the habitat that is necessary for the survival or recovery of a listed species and that is identified as the species' critical habitat in a recovery strategy or action plan" (Environment Canada 2003).

Habitat fragmentation – the division of a habitat, such as a forest, into many small parts, often too small to support critical habitat and wildlife species. The process whereby a large patch of habitat is broken down into many smaller patches of habitat, resulting in a loss in the amount and quality of habitat (<http://chesapeake.towson.edu/landscape/forestfrag/glossary.asp>).

Health – freedom from or coping with disease on the one hand (the medical view), and the promotion of well-being and productivity on the other (the public health view); "in essence, there are two dimensions of health – the capacity for maintaining organization or renewal, and the capacity for achieving reasonable human goals or meeting needs" (Nielsen 1999, in Wells 2003).

Indicator(s) – in an environmental context, they are measurable features of natural ecosystems that provide scientific and managerial information about the current status and change over time i.e. trends, of each ecosystem. Ideally, they are simple measures of natural ecosystems that represent complex phenomena in easily understood terms (G. Pesch, pers.comm.; Pesch and Wells 2004). Indicators important to human health are often included in assessments of marine ecosystem health, e.g., coliform bacteria counts, measures of PSP, levels of toxic chemicals in seafood, types and quantities of litter on beaches. Indicators can also be grouped or clustered and then used to generate indexes or indices of marine ecosystem health or coastal condition, e.g., the traffic light coding for coastal condition used by EPA; this is an important way to transmit all of the indicator information to decision makers and the public, and to track progress resolving issues.

Keystone species – a species, the presence or abundance of which can be used to assess the extent to which the resources of an area or habitat are being exploited (Allaby 1998). A keystone species is one whose impacts on its community or ecosystem are large, and greater than would be expected from its relative abundance or total biomass (Mills et al. 1993). Another definition, probably more widely accepted, is that a keystone species "is one whose impacts on its community or ecosystem are large and greater than would be expected from its relative abundance or total biomass" (Paine, R.T., in Mills et al. 1993). Keystone species are usually noticed when they are removed or they disappear from an ecosystem, resulting in dramatic changes to the rest of the community. The phenomenon has been observed in a wide range of ecosystems and for a wide range of organisms (Mills et al. 1993).

Land-based activities – the range of activities on land (i.e. in the watersheds) affecting the coastal zone. This term is formally defined in detail in the UN Global Programme of Action on Land-Based Activities (1995). GPA pollutant source categories include: wastewater/sewage, physical alteration or destruction of habitats, nutrients, persistent organic pollutants, radioactive substances, heavy metals, sediment mobilization, litter, and oil (hydrocarbons).

Lidar – light detection and ranging; a radarlike remote sensing system that uses pulses of laser light to illuminate the terrain (Lillesand and Kiefer 1994).

Monitoring – testing on a routine basis, with some degree of control, to ensure that the quality of water or effluent has not exceeded some prescribed criteria range (Wells and Rolston 1991). Measuring, usually over time, the concentration of substances in either environmental media or living organisms (Hodgson et al. 1998). The systematic process of collecting and storing data related to particular natural and human systems at specific locations and times; determination of a system's status at various points in time yields information on trends, which is fundamental to the potential for monitoring to detect system change (also termed status and trend detection) (Busch and Trexler 2003).

Natural – existing in or caused by nature (DK Publ. 1998). Also used in reference to the original or pristine state or condition of environments or ecosystems, measured at some point in time. In ecology, it is a term that is applied to a community of native plants and animals; there are a number of natural conditions – future-natural; original-natural; past-natural; potential-natural; and present-natural (Allaby 1998).

Natural oscillation – the regular spatial or temporal/seasonal change in a natural variable, e.g., water temperature.

Nutrients – essential chemicals (e.g., nitrogen, phosphorus, carbon) from the environment that are needed by plants and animals for maintenance and growth. Excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae (phytoplankton) (adapted from EPA 1998).

Phytoplankton – small, i.e. microscopic, often single-celled plants that live suspended in bodies of water, freshwater or marine.

Pollution – the UN GESAMP definition, widely accepted and in legal usage, is "the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as to harm living resources and marine life, be hazardous to human health, hinder marine activities, including fishing and other marine uses, or impair the quality of sea water and reduce amenities" (Wells and Rolston 1991; GESAMP 2001).

Precautionary approach – "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically" (from the January 1998 Wingspread Statement on the Precautionary Principle).

QA/QC – quality assurance and quality control – quality assurance is a definitive plan for laboratory operation that specifies the measures used to produce data of known precision and bias; quality control is a set of measures within a sample analysis methodology to assure that the process is in control (APHA 1998).

Resilience (ecological) – the ability to resist lasting change caused by disturbances; it can be defined operationally as the magnitude of disturbance the (eco)system can tolerate and still persist before the (eco)system changes its structure (Zurlini et al., in Jorgensen et al. 2005).

Sustainable (sustainability) – the process of conserving an ecological balance by avoiding depletion of natural resources (adapted from Barber 1998). Sustainable (adjective) refers to development. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987).

Stewardship – as environmental stewardship, it involves taking actions showing responsibility for the protection, conservation and restoration of the environment and its living and non-living resources. There are many specific actions of stewardship depending upon the issue. "Stewardship refers to the wide range of voluntary actions that people are taking to care for the environment" (Environment Canada 2003).

Stress – the state or condition of strain and especially of intense strain (Websters 3rd). Any factor (external or internal) that disturbs the equilibrium of a system (Lewis 1998).

Toxic chemicals – chemicals (single or as mixtures) that are poisonous, carcinogenic, or otherwise directly harmful to plants and animals at low levels. They are formally considered by regulatory agencies as the category of chemicals and chemical mixtures that are persistent, bioaccumulate and are toxic at low levels, and hence are of concern to the environment.

Toxins – naturally-occurring, naturally-produced chemicals that are toxic at low levels. They are produced by a wide range of plants and animals for self-protection, defence and predation. Not to be confused with so-called toxic chemicals, which generally are synthesized by man.

Trophic level – a grouping of organisms that uses the next lower grouping of organisms as a food source. Used to describe the relative position on a food web where organisms feed.

Watershed – also called a catchment or drainage basin – the area from which a surface watercourse or a groundwater system derives its water; they are separated by divides (Allaby 1998).

Appendices (On CD only)

Appendix 1

Taking the Pulse of the Sea: Can it be Done?
J. B. Pearce

Two Hundred Years of Ecosystem Change in the Outer Bay of Fundy. Part One – Changes in Species and the Food Web
H. K. Lotze, I. Milewski and B. Worm

Two Hundred Years of Ecosystem Change in the Outer Bay of Fundy. Part Two – A History of Contaminants: Sources and Potential Impacts
I. Milewski and H. K. Lotze

Appendix 2

Coastal Forum Plenary Discussion – Wednesday AM Summary

Appendix 3

Discussion Group A

Appendix 4

Discussion Group B

Appendix 5

Discussion Group C

Appendix 6

Discussion Group D

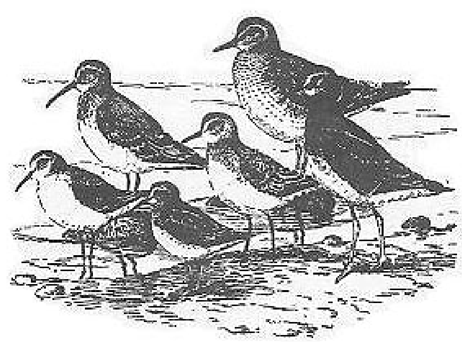
Appendix 7

Coastal Forum Final Plenary Discussion – Thursday AM Summary

Appendix 1

TAKING THE PULSE OF THE BAY: KEYNOTE PAPERS

Co-Chairs: Janice Harvey, Conservation Council of New Brunswick
and
Peter Wells, Environment Canada



TAKING THE PULSE OF THE SEAS: CAN IT BE DONE?

J. B. (Jack) Pearce

Buzzards Bay Marine Laboratory, Falmouth, MA. buzbay@cape.com

During the almost half century that I have been concerned with marine habitat quality and fisheries, there have been numerous positive changes in pollution sources, fates and effects. To a great degree this has been the result of ongoing research and monitoring by academics, government agencies and environmental organizations. The question remains today, what else must be done? You will find this an interesting question.

The literature is 'fat' with published papers documenting the effects of contaminants and physical disruptions, as well as the interactions between these and the natural environment and certain cyclic environmental changes. Today I want to document how managers in recent years have measured the *health* of marine habitats and their contained living marine resources (LMR). By health I mean the assessment of "the condition of being sound in body ...; freedom from physical disease", or "the general condition of the body", i.e. the bodies of food chain organisms culminating in fish.

To assess relative health we must always keep in mind water quality, 'a peculiar and essential character', or 'an inherent feature'. What was the quality of the habitat *before* man compromised the water (or sediment) quality? This has most effectively been accomplished using 'case studies' and emphasizing 'historical perspectives'. The scientist-manager must be willing to accept that data and information from one habitat or zoogeographic region (or large marine ecosystem) can be used in another. Moreover, one must agree that changes observed or measured two centuries ago are valid today. In other words, we must think in the context of 'ecology through time'. Just such a program was suggested in a recent issue of *Science*, where Jackson et al. (2001) considered "Historical overfishing and the recent collapse of coastal ecosystems" and Sugden and Stone (2001) wrote on "Filling generation gaps", a short essay on long-term monitoring.

These thoughts were further elaborated upon in more recent issues of *Science* where an author, Malakoff (2002), suggests that scientists might be "Going to the edge to protect the sea" and other authors ask, "Can we defy nature's end?" (Pimm et al. 2001). To address the consequences of mankind's effects now, and in the future, scientists are considering new (and old) tools, high tech themes, and 'new ways forward'. As Editor of *Fishery Bulletin* and North American Editor of the *Marine Pollution Bulletin* I have, over the past decade, reviewed some 1,700 manuscripts dealing with these issues in some manner. My files suggest that I have read another 5,000+ titles published in other journals. Over the past half decade there has been a crescendo of titles in those fields concerned with 1) 'bioinvasions', changes in diversity, 2) use of refuges or reserves for management of marine species, 3) management and protection of marine mammals (and other endangered species), and 4) overfishing and its effects on target species, incidental catches, and habitat quality. I have found that it is nigh impossible for any one human to 'digest' the resulting voluminous literature, much less to summarize it effectively so as to allow for rational use of these data and information! Yet most of these papers and reports have, or will have, some applicability to the wide range of the marine environmental literature.

As this paper is being drafted, a new National Report – *The State of the Nation's Ecosystems* – is being published by the Heinz Center (see Shouse 2002). This report grew out of the interests of the White House Office of Science and Technology Policy and had, as an important component, the development of *indicators* which integrate "biophysical and sociocultural measures". Some scientists are negative about such recommendations because "no attempt is made ... to relate human activities to the changes in American ecosystems, and no attempt is made to evaluate the health of US ecosystems" (again, see Shouse 2002). Most of the remainder of this (my) paper deals with past attempts to demonstrate through history, and monitoring, how people's activities have compromised estuaries and marine habitats and their contained LMR.

Over two decades ago I was working in Washington, DC as Director of NOAA's National Estuarine Program Office. A colleague, and close friend, Dr. James Thomas, suggested that this then new NOAA office should organize a series of major seminars on the theme "NOAA's Estuarine Seminar of the Month". As these seminars were expedited, it emerged that it was possible to garner data of an historical nature which demonstrated clearly how and where urbanization and industrialization reduced the quality of estuarine and coastal habitats, and *measurably* affected the abundance and distribution of LMRs. One case study that I have used involves the whaling and fishing port, New Bedford, Massachusetts (see Pesch et al. 2001; Pesch and Garber 2001). Briefly, the authors have divided the ecological history of New Bedford into four eras or periods: agriculture, 1650–1780; whaling, 1750–1900; textile, 1880–1940; and post-textile, 1940–present, which involved electrical equipment manufacturing, increased harbour modifications, and transportation infrastructure. Although I will use some 40 viewgraphs in my oral presentation, a few from New Bedford Harbour can serve here to detail how coastal habitats change with development! Pesch and her co-workers have done an admirable job in using indicators of development *and* simultaneous habitat degradation to suggest future management steps necessary to preventing further habitat degradation and losses of LMRs. Figures 1–6 include some variables that indicate degradation in the context of time.

In addition to having an *historical understanding* of habitat quality and the status of the biota, agencies responsible for management of LMRs, and the status of habitats, must have current information on key variables, i.e. those biological, chemical, geological and physical parameters necessary to assess the health of estuaries, coastal and marine ecosystems. The Heinz Report – *The State of the Nation's Ecosystems* – notes that many variables necessary to an assessment of environmental health are NOT being measured, or are being measured so infrequently or inefficiently that the data are meaningless (see Heinz Center 2002)! This situation has continued for some four decades in spite of the implementation nationally and internationally of scores of marine monitoring and research programs. Recognizing the need to understand the status of key variables in specific zoogeographic provinces, 'large marine ecosystems' and fishery management areas, the Northeast Fisheries Center of the National Marine Fisheries Service (NMFS) commissioned *Characterizations of the Middle Atlantic Water*

Management Unit and Gulf of Maine (see Pacheco 1988; Reid, Ingham and Pearce 1987). Agencies in Canada and northern Europe were doing and have done much the same. Most recently, the Northeast Fisheries Science Center has produced the reference document, *Status of the Northeast US Continental Shelf Ecosystem* (Link and Brodziak 2002), an update on the earlier *Characterizations*.

More recently, the concept of the large marine ecosystem (LME) has been elaborated upon by Sherman and Skjoldal (2002). This latest volume in a series addresses changes in environmental quality and resource status in certain LMEs of northern Europe. Particular emphasis is now placed on *sustainability* as based on information from studies of: 1) productivity, 2) fish and fisheries, 3) pollution and ecosystem health, 4) socio-economics, and 5) governance (management?). Almost simultaneously, Elsevier has published its *Seas at the Millennium: An Environmental Evaluation* (Sheppard 2000). A three volume set, the title includes 106 chapters covering "manageable regions" around the world, and in all hemispheres. A much smaller volume, published by the Worldwatch Institute, provides a wealth of information on *Safeguarding the Health of the Oceans* (McGinn 1999). Again, McGinn 1) covers the world's seas, with illustrations of "hot spots", 2) discusses the bridging of information gaps (similar to the Heinz Report), and 3) considers international policies and national and local efforts to "protect oceans".

Finally, almost all chapters in titles noted above ultimately conclude that the principal issues bearing on habitat quality and status of LMRs are centered in *overpopulation* (and over use of resources) and *urbanization*. The Worldwatch Institute, again, addresses the latter in its small volume, *Reinventing Cities for People and the Planet* (O'Meara 1999). Its basic conclusion is that if we are to manage, effectively, the coastal zone we *must* change how we allow our cities and industry to grow. Urban and industrial planning and population planning are *absolutely essential*, and not only in the coastal zone but in all riparian habitats leading to the seas; river basins are key "conduits" for contaminants from inland areas.

Because *almost* all the above reports and advisories are critical of past research and monitoring, it is essential that future research and habitat monitoring address the concerns brought forth from this late twentieth century introspection. It is particularly important that interagency and international monitoring programs 1) review past monitoring and research, 2) identify appropriate historical and case studies and 3) make those adjustments necessary to ensure that *all* data collected will be meaningful, and useful, to the processes of management, prevention and rehabilitation.

A starting point in these regards is the use of papers such as the ICES volume *Biological Effects of Marine Pollution and the Problems of Monitoring* (McIntyre and Pearce 1980). Although written two decades ago, its focus was the defining of adequate monitoring strategies, a problem as current today as in 1979 when the workshop was held at the Duke University Marine Lab. Working within the structure of the Marine Environmental Quality Committee (MEQC) of the International Council for the Exploration of the Seas (ICES), we established that responses to contaminants and habitat degradation were best measured in the field, where *changes* in population dynamics and structure could be observed and measured *at the same time* as toxicity of contaminants, nutrient overloading and stress due to physical degradation. Since then, scores, yes hundreds, of volumes have been written on the subject of environmentally appropriate research and monitoring. The monitoring of fish stocks has continued from 1963 to the present using the same sampling gear. But even with robust biannual cruises, and consistent use of sampling gear, the *exigencies* of the fisheries and fishing community may force the adoption of new methodologies (see Frasier 2002): Science, especially applied science tangential to 'economics', is rarely simple or straightforward (see Bonner 2002)! The earlier mentioned volume, *The State of the Nation's Ecosystems*, in Chapter 5, "Indicators of the Condition and Use of the Coasts and Oceans", now suggests that past indicators and research may not be useful in assessing the status of habitats and contained LMRs (Heinz Center 2002). This will surely be questioned by the hundreds of scientists and agencies which have conducted and sponsored thousands of research projects in order to evaluate man's effects on marine and estuarine habitats.

For my part I remain convinced that many programs have measured successively and successfully short and long-term changes in habitats and the contained biota. In fact, we *have* frequently taken the *pulse* of the seas. Moreover, many of the past studies have yielded data and findings which form the base and indicators for future long-term monitoring and research. What we must do now is to effectively educate the public and body politic as to the significance of past and future findings! As I read the final hand draft, my radio tells me that our local Congress-person has just countered a judicial decision to restrain fishing so as to maintain some semblance of fish stocks in the northeast. It is more important (politically?) to him to support a crowd of marginal fishers, rather than use excellent science to manage the fisheries!

Literature Cited

Bonner, J. 2002. *Lives of a Biologist: Adventures in a Century of Extraordinary Science*. Harvard University Press, Cambridge, MA. 215 pp.

Fraiser, D. 2002. Enmeshed in dispute. *Cape Cod Times*, 3 October, Hyannis, p. 1.

Heinz Center. 2002. *The State of the Nation's Ecosystems*. The H. John Heinz Center for Science, Economics and the Environment, Washington, DC. 270 pp.

Jackson, J. and 18 co-authors. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629–638.

Link, J. and J. Brodziac (Eds.). 2002. *Status of the Northeast US Continental Shelf Ecosystem*. NMFS/NOAA Northeast Fisheries Science Center (Woods Hole) Reference Document 02-11. 245 pp.

Malakoff, D. 2002. Going to the edge to protect the sea. Science 296: 459–461.

McGinn, A. 1999. *Safeguarding the Health of Oceans*. Worldwatch Paper 145. The Worldwatch Institute, Washington, DC. 87 pp.

McIntyre, A. and J. Pearce. 1980. *Biological Effects of Marine Pollution and the Problems of Monitoring. Proceedings from an ICES Workshop, Beaufort, NC, 26 February - 2 March 1979.* ICES, Copenhagen. 350 pp.

O'Meara, M. 1999. *Reinventing Cities for People and the Planet*. Worldwatch Paper 147. The Worldwatch Institute, Washington, DC. 94 pp.

Pacheco, A. (Ed.). 1988. *Characterization of the Middle Atlantic Water Management Unit of the Northeast Regional Action Plan*. NOAA Technical Memo NMFS-F/NEC-56, Woods Hole, MA. 322 pp.

Pesch, C., R. Voyer, J. Copland and J. Lund. 2001. *Imprint of the Past: Ecological History of New Bedford Harbour*. US Environmental Protection Agency, Region 1, New England, Narragansett, RI. Lab. Paper 901-R-01-003.

Pesch, C. and J. Garber. 2001. Historical analysis, a valuable tool in community-based environmental protection. Marine Pollution Bulletin 42(5): 339–349.

Pimm, S. and 32 co-authors. 2001. Can we defy nature's end? Science 293: 2207–2208.

Reid, R., M. Ingham and J. Pearce (Eds.). 1987. *NOAA's Northeast Monitoring Program: A Report on Progress of the First Five Years (1979–84) and a Plan for the Future*. NOAA Technical Memo NMES-F/NEC-56, Woods Hole, MA. 138 pp.

Sheppard, C. (Ed.). 2000. *Seas at the Millennium: An Environmental Evaluation*, Vols. 1-3. Pergamon (Elsevier) Press, Amsterdam. 2080+ pp.

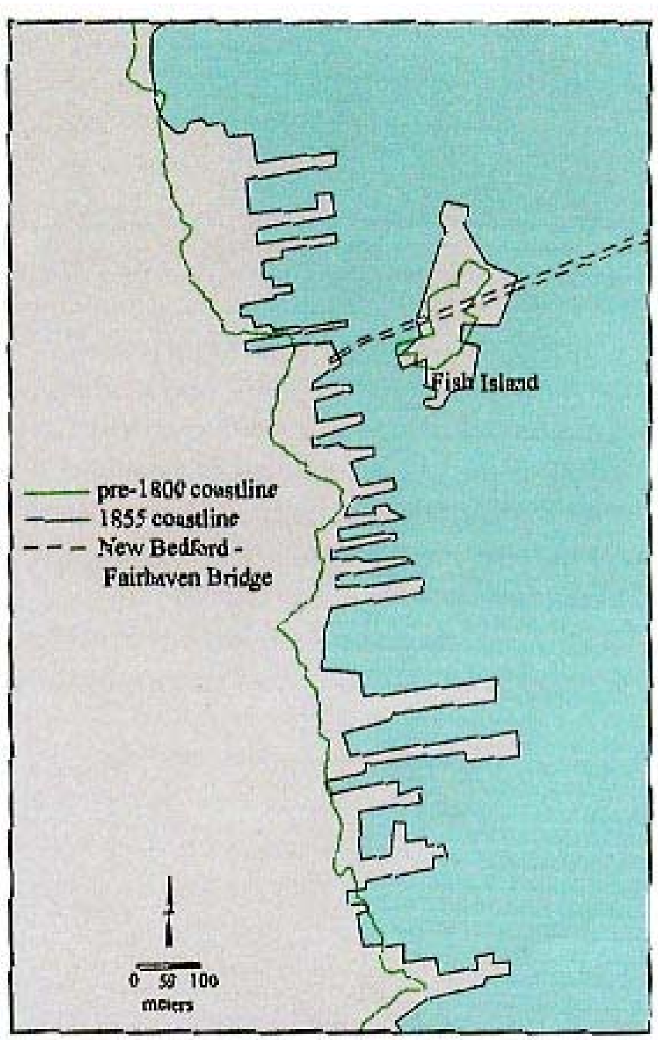
Sherman, K. and H. Skjoldal. 2002. *Large Marine Ecosystems: Changing States and Sustainability*. Elsevier, Amsterdam. 449 pp.

Shouse, B. 2002. Report takes stock of knowns and unknowns. Science 297: 2191.

Sugden, A. and R. Stone. 2001. Filling generation gaps. Science 293: 623.

Voyer, R., C. Pesch, J. Garber, J. Copland, and R. Comeleo. 2000. New Bedford, Massachusetts: A story of urbanization and ecological connections. Environmental History 5(3): 352–377.

Figure 1. The coastline in 1855 (surveyed by H. F. Hatting) shows that a considerable number of wharfs were built and some land gained since before 1800 (coastline from map of Original Purchasers of lots in New Bedford, 1753 to 1815, E. C. Leonard) when no wharves were present. (From Pesch et al. 2001.)



Reproduced with permission of D. Pesch

Figure 2. During the mid-nineteenth century, industries along the coast in what is now the historic section of New Bedford. Most industries not directly on the shore or a stream had access to the sewer system, which was installed in 1852. Sewer lines were located on east-west orientated streets and emptied directly into the harbour. (From Pesch et al. 2001)

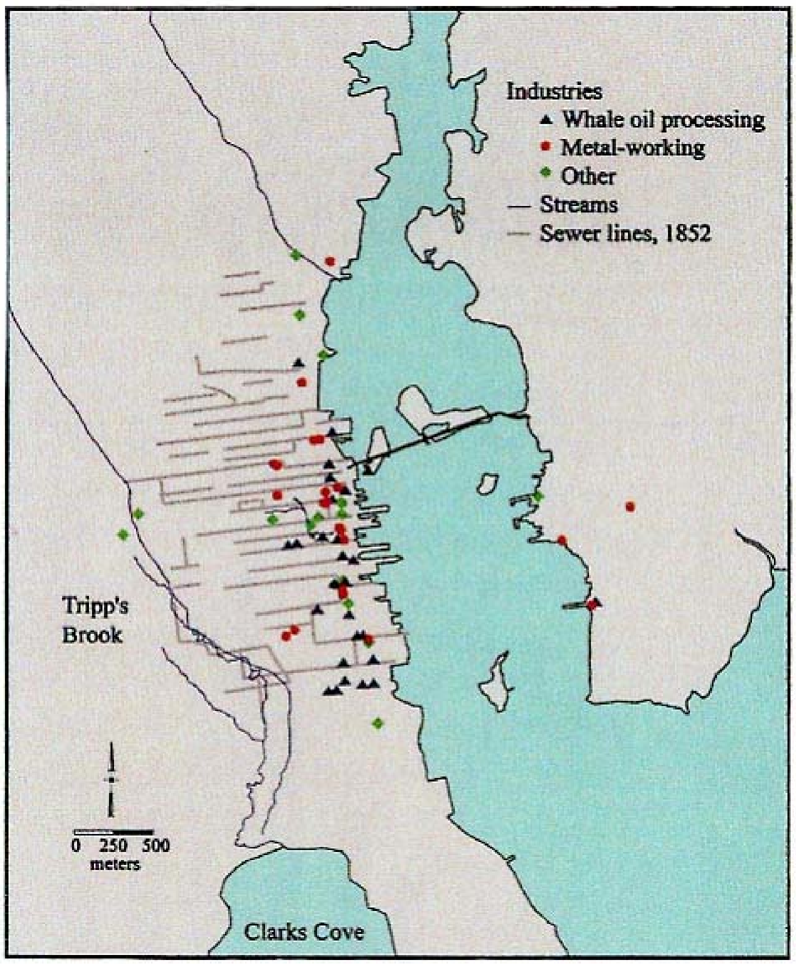
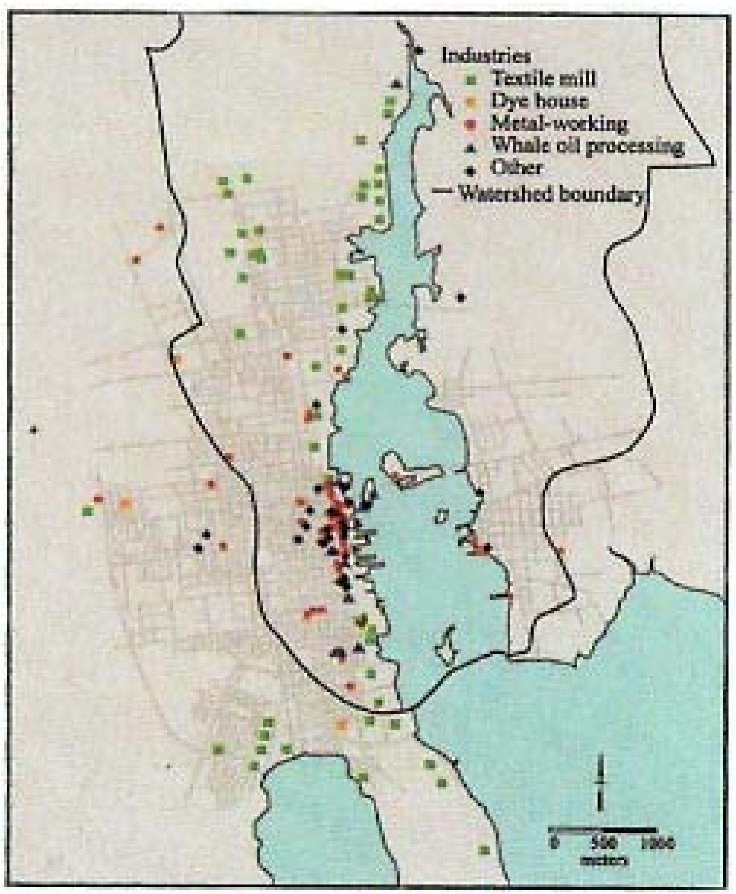
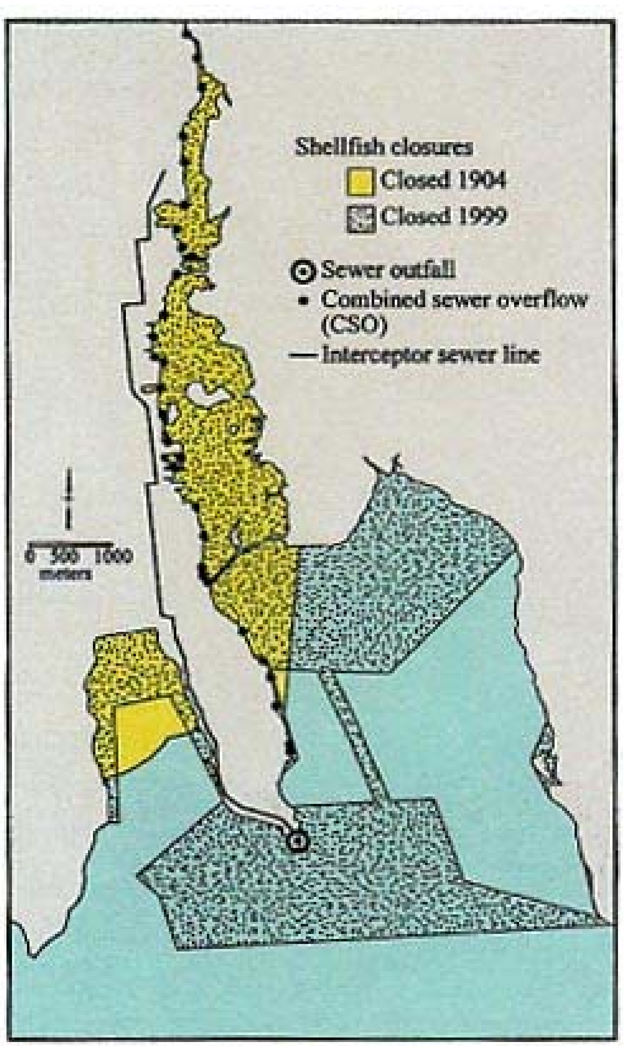


Figure 3. Locations of industries that may have released pollution during the textile period (1880–1940). (From Pesch et al. 2001)



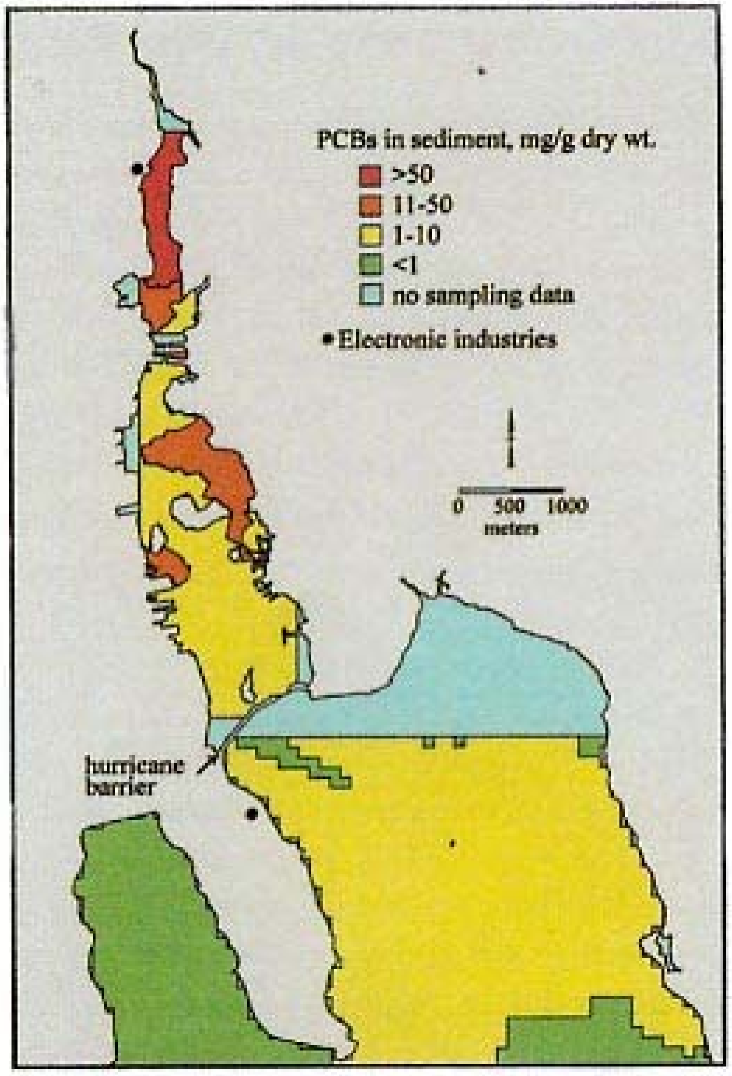
Reproduced with permission of D. Pesch

Figure 4. The State Board of Health closed the Acushnet River to shellfishing in 1904 and that section has remained closed since then. Raw sewage still enters the harbour through combined sewer overflows (CSOs) during periods of high rainfall. Additional areas in the outer harbour were closed after the interceptor sewer line diverted the outfall off Clarks Point. On this map, the four classifications for shellfish closures for 1999 were collapsed into two groups: open (approved and conditionally approved) and closed (prohibited and restricted). (From Pesch et al. 2001)



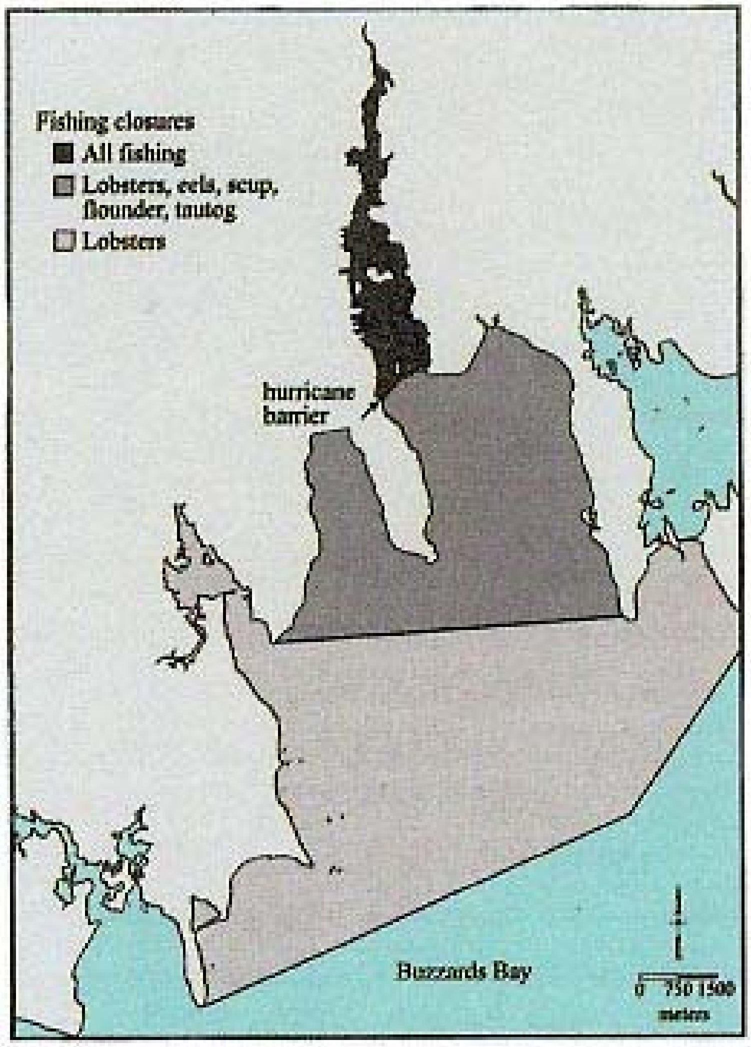
Reproduced with permission of D. Pesch

Figure 5. Concentrations of PCBs in sediments in New Bedford Harbour were exceedingly high in the upper harbour adjacent to the electronics part manufacturing company. (From Pesch et al. 2001)



Reproduced with permission of D. Pesch

Figure 6. In 1979, the harbour and areas south of the hurricane barrier were closed to fishing and/or shellfishing because PCB residue in fish and shellfish exceeded the FDA action level of 5 mg/kg. (From Pesch et al. 2001)



Reproduced with permission of D. Pesch

TWO HUNDRED YEARS OF ECOSYSTEM CHANGE IN THE OUTER BAY OF FUNDY
PART I – CHANGES IN SPECIES AND THE FOOD WEB

Heike K. Lotze[1], Inka Milewski[2] and Boris Worm[1]

[1] Department of Biology, Dalhousie University, Halifax, NS. hlotze@is.dal.ca
[2] Conservation Council of New Brunswick, Fredericton NB. milewski@nbnet.nb.ca

Abstract

The Quoddy Region and Grand Manan Archipelago form a hotspot of marine species diversity and productivity in the Northwest Atlantic. We present the history of major human impacts and their consequences on the ecosystem over the last centuries. Using all available data, we reconstructed historical changes that occurred in species of all trophic levels, from phytoplankton and invertebrates up to fish, birds and mammals.

Selective fishing and hunting, and increasing effort, efficiency, and spatial extent of exploitation over time resulted in marked declines of target species abundance and size. This resulted in major shifts in dominance patterns and food-web structure, and shifts from high to low trophic level harvesting. Habitat degradation and destruction and chemical contamination reduced the amount of critical spawning, breeding, nursing, and feeding habitat. Multiple pollutants affected health, survival and reproduction of many species, and increasing human activities in coastal waters enhanced the level of stress and disturbance. Nutrient loads altered phytoplankton and phytobenthos communities, thereby favouring less edible or toxic species and mass occurrences of annual seaweeds. We demonstrate that this unique ecosystem over time expressed well-known signs of degradation typical for human-impacted coastal waters worldwide. Multiple human impacts affected species and their interactions on all trophic levels. This reduced productivity of traditional fisheries and predictability of the ecosystem. Compared to other degraded ecosystems, however, there is still potential to sustain a diverse and productive marine flora and fauna which could be restored if wise management actions are chosen.

Introduction

The Quoddy Region and the Grand Manan Archipelago form a hotspot of marine species diversity and productivity in the Northwest Atlantic. Ocean currents and circulation patterns, high tides, upwelling, and short, energy-efficient food chains support high concentrations of primary and secondary producers (Hardie 1979; Thomas 1983; Lotze and Milewski 2002). These lower trophic level species attract a wide range of birds, predatory fish and mammals which depend on the area for at least part of their life. In addition to the rich food supply, the diverse underwater and terrestrial landscapes provide an extraordinary variety of habitats fulfilling the species-specific needs for breeding, spawning, nursing, foraging, hiding and resting (Hardie 1979; Thomas 1983; Lotze and Milewski 2002). This habitat diversity, combined with the rich food supply, maintain the hotspot diversity and productivity.

TWO HUNDRED YEARS OF ECOSYSTEM CHANGE IN THE OUTER BAY OF FUNDY
PART I – CHANGES IN SPECIES AND THE FOOD WEB

Heike K. Lotze[1], Inka Milewski[2] and Boris Worm[1]

[1] Department of Biology, Dalhousie University, Halifax, NS. hlotze@is.dal.ca
[2] Conservation Council of New Brunswick, Fredericton NB. milewski@nbnet.nb.ca

Abstract

The Quoddy Region and Grand Manan Archipelago form a hotspot of marine species diversity and productivity in the Northwest Atlantic. We present the history of major human impacts and their consequences on the ecosystem over the last centuries. Using all available data, we reconstructed historical changes that occurred in species of all trophic levels, from phytoplankton and invertebrates up to fish, birds and mammals.

Selective fishing and hunting, and increasing effort, efficiency, and spatial extent of exploitation over time resulted in marked declines of target species abundance and size. This resulted in major shifts in dominance patterns and food-web structure, and shifts from high to low trophic level harvesting. Habitat degradation and destruction and chemical contamination reduced the amount of critical spawning, breeding, nursing, and feeding habitat. Multiple pollutants affected health, survival and reproduction of many species, and increasing human activities in coastal waters enhanced the level of stress and disturbance. Nutrient loads altered phytoplankton and phytobenthos communities, thereby favouring less edible or toxic species and mass occurrences of annual seaweeds. We demonstrate that this unique ecosystem over time expressed well-known signs of degradation typical for human-impacted coastal waters worldwide. Multiple human impacts affected species and their interactions on all trophic levels. This reduced productivity of traditional fisheries and predictability of the ecosystem. Compared to other degraded ecosystems, however, there is still potential to sustain a diverse and productive marine flora and fauna which could be restored if wise management actions are chosen.

Introduction

The Quoddy Region and the Grand Manan Archipelago form a hotspot of marine species diversity and productivity in the Northwest Atlantic. Ocean currents and circulation patterns, high tides, upwelling, and short, energy-efficient food chains support high concentrations of primary and secondary producers (Hardie 1979; Thomas 1983; Lotze and Milewski 2002). These lower trophic level species attract a wide range of birds, predatory fish and mammals which depend on the area for at least part of their life. In addition to the rich food supply, the diverse underwater and terrestrial landscapes provide an extraordinary variety of habitats fulfilling the species-specific needs for breeding, spawning, nursing, foraging, hiding and resting (Hardie 1979; Thomas 1983; Lotze and Milewski 2002). This habitat diversity, combined with the rich food supply, maintain the hotspot diversity and productivity.

Human Activities in Coastal Waters

The archeological record shows that Indigenous peoples have recognized and valued these diverse and abundant marine resources for several thousand years. Around Passamaquoddy Bay, prehistoric people focussed especially on marine resources and used a more diverse shellfish fauna than their neighbours in the Maritimes and Maine. Their distinct lifestyle was recognized as the 'Quoddy Tradition' in the Maritime Woodland period (2200-350 B.P.) (Black and Turnbull 1986). In their words, 'Passamaquoddy' denotes a "bay full of pollock" and "fishers of pollock" (Gatschet 1897). As hunters and gatherers, they targeted species from all trophic levels at low rates due to simple fishing and hunting methods and low population size. Therefore, we may describe them as 'low-impact omnivores'. Faunal remains from archaeological sites suggest that large cod, pollock and herring were used as food resources for more than 4,000 years without a visible decrease in body size, usually the first sign of overfishing (Black and Turnbull 1986; Spiess et al. 1990; Steneck 1997).

With European settlement in the late 18th century and subsequent industrialization in the late 19th century, human activities have altered this ecosystem at a rapidly increasing rate. Fishing and hunting pressure as 'top-down' impacts increased, especially on large species that were easy to catch. Whales were hunted from shore operations, seals were hunted for a bounty, and Harbour Porpoises were hunted by native people to trade oil with the Europeans (Ingersoll and Gorham 1978; Gaskin 1983; Percy 1996b). Birds were hunted heavily for food, but egg and down collection also occurred (Christie 1979). Large groundfish, especially cod and pollock were caught in the area, and herring was fished for bait (Perley 1852; Huntsman 1953). Thus, humans became 'top predators' in the food web, and by 1900 they had almost extirpated many birds and mammals.

In the case of fish, the first signs of overexploitation could be observed around 1900, when clear shifts in size distribution were observed. The size of cod and pollock strongly declined and the herring fishery shifted from large adults to medium "stringers" and further to small "sardines" (Perley 1852; Huntsman 1953). In the early 20th century, legal protection for some birds and mammals initiated slow recovery of some top predators. However, humans increased their pressure on fish, especially groundfish and herring through increasing effort, efficiency and spatial extent of fishing grounds (Steneck 1997, Percy 2000). Humans became 'highly efficient top predators'. Finally in the 1970s, a strong decline in abundance of groundfish and herring could be observed (Lotze and Milewski 2002). These strong recent declines or collapses of certain fisheries may be not only the result of actual high fishing pressure, but also of overfishing for decades and even centuries in the past. Jackson et al. (2001) suggested that extended time lags might occur between the onset of overfishing and the visible consequences. In our study area, the decline in formerly dominant groundfish species such as pollock and cod resulted in a shift in dominance patterns. Dogfish, hake and small groundfish such as sculpins increased in abundance over the last 20 years (Lotze and Milewski 2002).

The scarcity of traditionally abundant and valuable species induced the search for new resources and a shift to low-trophic level harvesting. Over the last 10–20 years, new fisheries for crabs, sea urchins and rockweed were developed, while traditional fisheries for periwinkles, scallops and lobster were intensified (Lotze and Milewski 2002). Further plans to develop fisheries for sea cucumbers, krill and mussels exist (Percy 1996a). This increasing exploitation of species at lower and lower levels of the food web has been identified as a global pathology, called "fishing down the food web" (Pauly et al. 1998). Many of these species are important prey or (in the case of rockweed) habitat-building species for upper trophic levels, including those species which were the traditional targets of the fishery. On the other hand, the fishery for large pelagic fish such as tuna, swordfish and sharks is of renewed interest.

Human Impacts in Coastal Waters

Around 2000, humans became 'top omnivores' targeting all trophic levels with increasing intensity. These strong top-down impacts resulted in clear shifts in food-web structure and species interactions. The loss or decline of high trophic level species resulted in shifts in species composition at the same and lower trophic levels because of the release from competition and predation pressure. In extreme cases, successive changes can be observed at several lower trophic levels known as "trophic cascades" (Steneck 1998).

In addition to top-down impacts, humans activities also altered species composition and productivity by 'bottom-up' impacts such as nutrient enrichment and shifts in nutrient ratios (N:P:Si). Nutrient sources include sewage, aquaculture (fish food, fish excrements), municipal runoff (garden and lawn fertilizer), organic discharges (food processing plants, pulp and paper mills), agricultural runoff (fertilizer, animal waste), burning of fossil fuel and atmospheric deposition (Bricker et al. 1999). This over-enrichment of the environment with the limiting plant nutrients nitrogen and phosphorus has severe consequences on the species composition and productivity among primary producers. Compared to the 1930s, we find a clear shift in the phytoplankton community from non-harmful diatom dominance to increasing amounts of less edible or toxic diatoms and dinoflagellates (Gran and Braarud 1935; Martin et al. 1999). In the phytobenthos, altered nutrient conditions result in a decline of long-lived rockweeds and eelgrasses, an increase in the amount of annual algal blooms, and partially a shift to the dominance of filter feeders. These changes are most visible close to nutrient point sources such as sewage outlets or fish farms (Worm 2000; Worm and Lotze 2000). In a recent eutrophication survey of estuaries in the United States, the St. Croix River/Cobscook Bay estuary was listed among the 44 out of 138 estuaries which showed the highest levels of expression of eutrophic conditions, which were expected to worsen towards 2020 (Bricker et al. 1999). Wastewater treatment plants were listed as the most important measure to mitigate nutrient inputs into rivers and the sea (Bricker et al. 1999).

When Europeans settled in the area, their activities led to a successive alteration, degradation and destruction of the coastal environment, which reduced habitat availability, heterogeneity and complexity, as well as sediment and water quality. Damming of rivers, settlement on islands, coastal constructions, dyking and draining of wetlands, bottom trawling and dragging, aquaculture operations, and other activities reduced the overall amount of undisturbed high-quality habitat in rivers, on land, and in the sea (Percy 2000). Organic loads from pulp and paper mills, lumber harvest, fish processing plants and aquaculture operations decrease water quality and clarity and degrade benthic habitat (Wildish et al. 1993; Pohle 1999). Chemicals from municipal and industrial discharges impair health, fecundity and survival (Wells et al. 1997). Moreover, increasing boat traffic, increasing noise, light and smell 'pollution', and increasing human recreational activities such as whale, seal and bird watching increase the level of stress for animals (Percy 1996b). All these impacts can be called 'side-in' impacts, which have severe consequences on the extent and quality of habitat for reproduction and recruitment (breeding, spawning, nursery), feeding and foraging, refuge from predators, and simply living (e.g., settling, growing, staging, resting, wintering) (Rangeley 1994, 2000; Percy 2000). For example, during several periods in the past, the St. Croix and Magaguadavic Rivers were not accessible (dams without functioning fishways) or had lethal water conditions to anadromous fish such as Atlantic salmon and gaspereau (Marshall 1976). Human settlements on shorelines and islands destroyed breeding colonies of many birds (Christie 1979). Dragging and trawling, as well as recent rockweed harvesting, destroys important three-dimensional seafloor habitat (kelps, rockweed, eelgrass, mussel reefs, sponges, corals) for recruitment, nursery and feeding as well as refuge for many fish, bird and invertebrate species, many of which are of commercial interest (Rangeley 1994, 2000; Steneck 1997; DFO 1999; Percy 2000). Many aquaculture operations are located within important feeding, nursing and recruitment habitat for fish, birds, mammals, and lobsters.

In essence, the hotspot of marine diversity and productivity became also a hotspot of human activities. Over time, this unique ecosystem expressed some well-known signs of degradation, which are typical for human-impacted coastal waters worldwide (Vitousek et al. 1997; Pauly et al. 1998; Jackson et al. 2001). Unfortunately, many human activities concentrate within critical habitats that are used by many species at once such as West Isles archipelago, Grand Manan Archipelago, the Wolves and Maces Bay (Lotze and Milewski 2002).

Conclusion

Today, most species are simultaneously affected by multiple top-down, bottom-up and side-in effects that can create synergistic and feed-back effects. The cumulative effects of multiple human stressors on single species and entire food webs are hardly—if at all—predictable on the base of our current knowledge of species and food-web interactions (Worm and Lotze 2000; Lotze and Milewski 2002). This has important implications for any attempt of 'species' or 'ecosystem management'. It might be more appropriate to consider strategies for 'human-impact management'. Any integrated management approach should include not only the diverse human interests but also the critical needs of marine species such as adequate food and habitat and undisturbed space and time (Lotze and Milewski 2002).

Although human impacts widely affect coastal ecosystems, there are some encouraging conservation and restoration successes. In the Quoddy and Grand Manan regions, protection efforts enabled many birds and some mammals to recover (Christie 1979; Lotze and Milewski 2002). Periods of lower fishing pressure during World War II and after the extension of the 200-mile limit in the 1970s have enabled fish stocks to increase in abundance until fishing effort increased again (Lotze and Milewski 2002). Restoration of river habitat and effective fishways enabled gaspereau populations to increase (Lotze and Milewski 2002). The use of acoustic 'pingers' in gill nets reduces the by-catch of Harbour

Porpoise (Trippel et al. 1999). In other marine habitats, effective sewage treatment plants reduced nutrient loads in the Baltic (Savchuk and Wulff 1999). Designation of protection zones resulted in the recovery of benthic habitat and the increase in fish biomass in tropical and temperate marine reserves, with beneficial effects on adjacent fisheries (Roberts and Hawkins 2000; Roberts et al. 2001). Therefore, we strongly recommend reducing the use of destructive and unselective fishing gear, protecting critical habitats, reducing nutrient pollution and chemical contamination, and reducing stress and disturbance on species.

For the full report on this topic refer to: Lotze H.K. and I. Milewski. 2002. Two-hundred Years of Ecosystem and Food Web Changes in the Quoddy Region, Outer Bay of Fundy. Conservation Council of New Brunswick, Fredericton, New Brunswick, 188 pp.

References

Black, D. W. and C. J. Turnbull. 1986. Recent archaeological research in the insular Quoddy region, New Brunswick, Canada. Current Anthropology 27: 400–402.

Bricker, S. B., C. G. Clement, D. E. Pirhalla, S. P. Orlando and D. R. G. Farrow. 1999. *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries*. NOAA, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science, Silver Spring, MD.

Canada. Department of Fisheries and Oceans (DFO). 1999. *The Impact of the Rockweed Harvest on the Habitat of Southwest New Brunswick*. DFO Maritimes Regional Habitat Status Report 99/2E. Maritime Regional Advisory Process, Department of Fisheries and Oceans, Dartmouth, NS.

Christie, D. S. 1979. Changes in maritime bird populations, 1878–1978. Journal of the New Brunswick Museum 1979: 132–146.

Gaskin, D. E. 1983. The marine mammal community. Pages 245–268. In: *Marine and Coastal Systems of the Quoddy Region, New Brunswick*. M. L. H. Thomas (Ed.). Canadian Special Publication of Fisheries and Aquatic Sciences 64. Department of Fisheries and Oceans, Ottawa.

Gatschet, A. S. 1897. All around the Bay of Passamaquoddy – with the interpretation of its Indian names of localities. National Geographic Magazine 8: 16–24.

Gran, H. H. and T. Braarud. 1935. A quantitative study of the phytoplankton in the Bay of Fundy and the Gulf of Maine (including observations on hydrography, chemistry and turbidity). Journal of the Biological Board of Canada 1: 279–467.

Hardie, D. 1979. West Isles natural area of Canadian significance. Pages 101–107. In: *Evaluation of Recent Data Relative to Potential Oil Spills in the Passamaquoddy Area*. D. J. Scarratt (Ed.). Fisheries and Marine Services Technical Report 901. Fisheries and Marine Services, St. Andrews, NB.

Huntsman, A. G. 1953. Movements and decline of large Quoddy herring. Journal of the Fisheries Research Board of Canada 10: 1–50.

Ingersoll, L. K. and S. W. Gorham. 1978. A history of the mammals of Grand Manan. Grand Manan Historian 20: 31–54.

Jackson, J. B. C., M. X. Kirby, W. H. Berger, K. A. Bjorndal, L. W. Botsford, B. J. Bourque, R. H. Bradbury, R. Cooke, J. Erlandson, J. A. Estes, T. P. Hughes, S. Kidwell, C. B. Lange, H. S. Lenihan, J. M. Pandolfi, C. H. Peterson, R. S. Steneck, M. A. Tegner and R. R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629–638.

Lotze H. K. and I. Milewski. 2002. *Two Hundred Years of Ecosystem and Food Web Changes in the Quoddy Region, Outer Bay of Fundy*. Conservation Council of New Brunswick, Fredericton, NB. 188 pp.

Marshall, T. L. 1976. *Historical Perspectives of Resource Development Branch Activities in Restoring Anadromous Fishes to the St. Croix River, New Brunswick – Maine*. Internal Report Series MAR/I 76-2. Freshwater and Anadromous Division, Resource Branch, Fisheries and Marine Service, Halifax, NS. 30 pp.

Martin, J. L., M. M. LeGresley, P. M. Strain and P. Clement. 1999. Phytoplankton Monitoring in the Southwestern Bay of Fundy during 1993–96. Canadian Technical Report on Fisheries and Aquatic Sciences 2265. 132 pp.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. Torres Jr. 1998. Fishing down marine food webs. Science 279: 860–863.

Percy, J. A. 1996a. Expanding Fundy’s harvest – Targeting untapped treasures. Fundy Issues, Bay of Fundy Ecosystem Partnership fact sheet 10. URL: <http://www.auracom.com/~bofep/underuti.htm>. Date accessed: 3 September 2002.

Percy, J. A. 1996b. Right Whales – Wrong places? North Atlantic Right Whales in the Bay of Fundy. Fundy Issues, Bay of Fundy Ecosystem Partnership fact sheet 6. URL: <http://netshop.net/~bofep/right.htm>. Date accessed: 3 September 2002.

Percy, J. A. 2000. Fishing in Fundy - Harming seafloor habitats? Fundy Issues, Bay of Fundy Ecosystem Partnership fact sheet 14. URL: <http://www.auracom.com/~bofep/Publications/Fundy%20issues/disturbance.htm>. Date accessed: 3 September 2002.

Perley, M. H. 1852. *Reports on the Sea and River Fisheries of New Brunswick*. Queen’s Printer Fredericton, NB. 294 pp.

Pohle, G. 1999. Benthos Assessment at Fallow Sites. Final Report to the New Brunswick Department of Fisheries and Aquaculture. Atlantic Reference Centre, Huntsman Marine Science Centre, St. Andrews, NB. 39 pp.

Rangeley, R. W. 1994. The effects of seaweed harvesting on fishes: A critique. Environmental Biology of Fish 39: 319–323.

Rangeley, R. W. 2000. Aquatic macrophytes as foraging and refuging habitats for fish. Pages 18-23. In: *Gulf of Maine Rockweed: Management in the Face of Scientific Uncertainty*. R.W. Rangeley and J. Davies (Eds.). Huntsman Marine Science Centre Occasional Report 00/1. Huntsman Marine Science Centre, St. Andrews, NB.

Roberts, C. M. and J. P. Hawkins. 2000. *Fully-protected Marine Reserves: A Guide*. WWF Endangered Seas Campaign, 1250 24th Street, NW, Washington, DC 20037, USA and Environment Department, University of York, York, Y010 5DD, UK.

Roberts, C. M., J. A. Bohnsack, F. Gell, J. P. Hawkins and R. Goodridge. 2001. Effects of marine reserves on adjacent fisheries. Science 294: 920–1923.

Savchuk, O. and F. Wulff. 1999. Modelling regional and large-scale response of Baltic Sea ecosystems to nutrient load reductions. Hydrobiologia 393: 35–43.

Spiess, A. E., E. Trautman and T. Kupferschmid. 1990. Prehistoric Occupation at Reversing Falls. Unpublished file report, Maine Historic Preservation Commission, Augusta, Maine, 28 pp.

Steneck, R. S. 1997. *Fisheries-induced Biological Changes to the Structure and Function of the Gulf of Maine Ecosystem. Proceedings of the Gulf of Maine Ecosystem Dynamics Scientific Symposium and Workshop, Hanover, NH*. Regional Association for the Research on the Gulf of Maine (RARGOM Report 91-1).

Steneck, R.S. 1998. Human influences on coastal ecosystems: does overfishing create trophic cascades? Trends in Ecology and Evolution 13(11): 429–430.

Thomas, M. L. H. 1983. *Marine and Coastal Systems of the Quoddy Region, New Brunswick*. Canadian Special Publication of Fisheries and Aquatic Sciences 64. 306 pp.

Trippel, E. A., M. B. Strong, J. M. Terhune and J. D. Conway. 1999. Mitigation of harbour porpoise (*Phocoena phocoena*) by-catch in the gillnet fishery in the lower Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences 56: 113–123.

Vitousek, P. M., H. A. Mooney, J. Lubchenco and J. M. Melillo. 1997. Human domination of Earth´s ecosystems. Science 277: 494–499.

Wells, P. G., P. D. Keizer, J. L. Martin, P. A. Yeats, K. M. Ellis and D. W. Johnston. 1997. The chemical environment of the Bay of Fundy. Pages 37–61. In: *Bay of Fundy Issues: A Scientific Overview. Proceedings of a workshop, January 29–February 1, 1996, Wolfville, NS*. J. A. Percy, P. G. Wells and A. J. Evans (Eds.). Environment Canada Atlantic Region Occasional Report No. 8. Environment Canada, Atlantic Region, Environmental Conservation Branch, Sackville, NB.

Wildish, D. J., P. D. Keizer, A. J. Wilson and J. L. Martin. 1993. Seasonal changes of dissolved oxygen and plant nutrients in seawater near salmonid net pens in the macrotidal Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences 50: 303–311.

Worm, B. 2000. *Consumer Versus Resource Control in Rocky Shore Food Webs: Baltic Sea and NW Atlantic Ocean*. Berichte aus dem Institut für Meereskunde 316. Institut für Meereskunde, Universität Kiel, Kiel. 147 pp.

Worm, B. and H. K. Lotze. 2000. Nutrient pollution, low-trophic level harvesting and cumulative human impact on coastal ecosystems. Pages 40–41. In: *Gulf of Maine Rockweed: Management in the Face of Scientific Uncertainty*. R.W. Rangeley and J. Davies (Eds.). Huntsman Marine Science Centre Occasional Report 00/1. Huntsman Marine Science Centre, St. Andrews, NB.

TWO HUNDRED YEARS OF ECOSYSTEM CHANGE IN THE OUTER BAY OF FUNDY PART II – A HISTORY OF CONTAMINANTS: SOURCES AND POTENTIAL IMPACTS

Inka Milewski[1] and Heike K. Lotze[2]

[1] Conservation Council of New Brunswick, Fredericton, NB. ccnb@nbnet.nb.ca
[2] Department of Biology, Dalhousie University, Halifax, NS. hlotze@is.dal.ca

Introduction

The history of contaminants in the outer Bay of Fundy region follows the history of settlement and industrial development. Numerous publications have documented the history of human settlement, communities development and industrial activity in the area. An extensive bibliography of these publications can be found in Harold Davis's (1974) comprehensive history (from 1604 to 1930) of the Canadian and American communities that straddle the St. Croix River and estuary.

Beginning in the late 1700s, the rivers, estuaries and marine waters of this area were used to transport logs, harvest fish and power sawmills. As the population of the region increased and other industries developed, they were used as waste dumps for a wide range of activities including logging operations, sawmills, fish processing plants, private septic systems, municipal sewage plants, pulp mills, and, more recently, aquaculture operations (Figure 1).

This paper is an extended summary of a review of some of the major classes of contaminants (suspended solids, persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs), metals and metalloids) associated with major development activities in the Quoddy region, outer Bay of Fundy, over the past 200 years. Since not all contaminants found in this region were the result of direct discharges from an identifiable point source, the review also examined contaminants found in sediments, water and/or organisms that were likely the result of atmospheric deposition, run-off or other non-point sources. The complete review appears in *Two Hundred Years of Ecosystem and Food Web Changes in the Quoddy Region, Outer Bay of Fundy*, a publication of the Conservation Council of New Brunswick (Lotze and Milewski 2002).

The list of contaminants reviewed was by no means complete. It has been estimated that 100,000-500,000 chemicals are now in regular industrial use and most have the potential to enter the marine environment through a variety of sources (Parrett 1998). For the purpose of the review, a contaminant was defined as the introduction of any foreign, undesirable physical, chemical, or biological substance into the environment (Environment Canada 1991) and could include anything from sawdust to nutrients, suspended solids, pesticides, and industrial chemicals.

Oceanographic Setting

Fresh water discharges, currents, and water circulation patterns are key parameters in characterizing the presence and concentrations of contaminants in a marine system. In the Quoddy region, a chain of islands across the mouth of Passamaquoddy Bay effectively creates a 'sea within a sea'. Three main rivers, St. Croix, Digdequash and Magaguadavic, and many smaller rivers and streams discharge into Passamaquoddy Bay. Outflow from Passamaquoddy Bay is primarily through the Western Passage and to a lesser extent the Letete Passage. Ketchum and Keen (1953) estimated the flushing time for the St. Croix Estuary at eight days, and that an additional 16 days were required for the exchange of water in Passamaquoddy Bay with the Bay of Fundy. The flushing time for the Bay of Fundy has been estimated at 76 days (Ketchum and Keen 1953).

Within Passamaquoddy Bay, the surface currents move in a counterclockwise direction creating a gyre or retention area in the centre of the Bay (Bailey 1957; Trites and Garrett 1983). Despite strong tidal currents, thermal stratification does take place in Passamaquoddy Bay (Robinson et al. 1996). The Bay is relatively shallow (an average depth of 27–30 m) and is identified as a depositional area (Loring et al. 1998). In depositional areas, suspended material is more likely to form into large fast sinking aggregates which quickly settle to the bottom where little or no resuspension occurs after deposition (Loring et al. 1998). As for the outer Quoddy region, there is a weak clockwise gyre centered around the Wolves (Figure 2).

Summary and Conclusions

Initially, the goal of this review was to link the impacts of the entire range of human activities, including contaminants, to changes in the ecosystem and food web of the region. Incorporating the ecological impacts associated with exposure of animals to contaminants and subsequent changes in population size and abundance, and ultimately to the food web, proved to be ambitious and, for the time being, impossible.

One key reason is a general lack of data, in particular long-term monitoring data, for the Quoddy region. Unlike fisheries statistics where information on historic catch, abundance and distribution are more readily available, long-term monitoring data on the type, amounts and distribution of contaminants discharged from point and non-point sources are largely unavailable. This type of information is necessary in order to examine the link between exposure to a particular contaminant and changes in the health or abundance of a population or species.

Moreover, demonstrating simple cause-and-effect links between exposure to a contaminant and population-wide effects is difficult to do (Colborn et al. 1996; Johnston et al. 1996; Luoma 1999; Parrett 1998). Since natural populations can exhibit large year-to-year fluctuations in recruitment, it is difficult to isolate natural changes in population abundance from pollution effects. Furthermore, as this review demonstrated, the concentration of contaminants in organisms were often not limited to one compound. This fact makes interpretation of the results even more difficult because the additive, synergistic, and antagonistic effects of different contaminants must also be considered. Despite these limitations, some general conclusions can be made about the concentration, distribution and impacts of some contaminants.

Large quantities of organic material (in the form of suspended solids) have been discharged in the Passamaquoddy Bay/St. Croix Estuary over the past 200 years. A significant percentage of these discharges has likely remained in the area because of oceanographic conditions. An estimated three million tonnes of suspended solids were released into the St. Croix River from one pulp mill alone over a 60 year period. Pollution abatement measures to reduce and restrict the discharge of contaminants did not come into force until the mid- to late-1970s. Large volumes of suspended solids are still being discharged into the region.

A range of chemical contaminants have been released from point and non-point sources. The trend over time shows decreased concentrations of some of these compounds, particularly DDT, PCBs, and dioxins, in sediments and marine organisms. PAH levels remain high in some locations and the concentration of some metals (mercury, zinc and copper) and metalloids (selenium) are increasing in the tissues of some marine organisms and sediments. There is renewed interest in monitoring mercury levels.

The review identified two areas in the Quoddy Region as 'hot spots' where long-term habitat alteration and contamination have taken place: the St. Croix Estuary and the Letang Estuary. These areas have been and continue to be the focal points of considerable discharges from a wide range of sources. Direct and indirect evidence indicates that species composition and abundances in both estuaries have shifted and changed (Pohle and Frost 1997; see Lotze et al. this volume; Pohle et al. 2001). The evidence also identifies PAHs as the most significant toxic contaminant, particularly in the St. Croix Estuary.

The physical and oceanographic features of Passamaquoddy Bay (e.g., shallow, cyclonic circulation, stratified, and depositional) suggest that a significant portion of the large volume of organic material discharged into the Bay over the past 200 years may have remained in the Bay. If this is the case, several questions about the cumulative and long-term effects of organic enrichment on the benthic community of Passamaquoddy Bay arise. Are the relatively low redox values now observed in the sediments of Passamaquoddy Bay (Wildish et al. 1999) 'normal' (i.e., historic background levels) or do they reflect a modification from higher redox values to lower values as a result of two centuries of high sediment loading into the Bay?

If the benthic community in Passamaquoddy Bay has been affected by two centuries of organic enrichment, where along the pollution or benthic enrichment gradient, as proposed by Clarke and Warwick (1994) is Passamaquoddy Bay (Figure 3)? The response of marine/estuarine benthic communities to pollution, specifically organic enrichment, has been studied for relatively small (1–30 km^2) spatial and short (1–5 years) temporal scales (Poole et al. 1977; Pearson and Rosenberg 1978; Warwick et al. 1990; Clarke and Warwick 1994; Pohle and Frost 1997; Pohle et al. 2001). Larger regions such as Passamaquoddy Bay would benefit from this type of analysis as well.

Finally, if the benthic community structure of Passamaquoddy Bay has changed (e.g., reduced diversity) over the past 200 years, how have these changes impacted fish populations in the area? Cod and pollock were known to spawn in Passamaquoddy Bay as late as the 1950s, but those spawning stocks have since disappeared from the area (Coon 1999). Passamaquoddy Bay provided vital habitat for numerous other species such as haddock, herring, lobster, scallop, salmon, gaspereau, shad, smelt, and striped bass. The decline in fish populations began in the early 1960s and the groundfish fishery gradually dropped off to virtually nothing. After three decades of little fishing activity, and substantial improvements in the nature and quantity of contaminants released into the Bay (more recent salmon aquaculture developments notwithstanding), those fish have not re-populated the Passamaquoddy Bay ecosystem. The question is, why not? One part of the answer to these questions may well be linked to the gradual changes that may have taken place in the benthic community structure of Passamaquoddy Bay and the St. Croix Estuary over the past 200 years.

References

Bailey, W. B. 1957. *Some Features of the Oceanography of the Passamaquoddy Region*. MS Rep. Biol. Sta. 2. Fisheries Research Board of Canada, Atlantic Oceanographic Group, St. Andrews, NB. 30 pp.

Clarke, K. R. and R. M. Warwick. 1994. *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation*. National Research Council, UK. 144 pp.

Colborn, T., D. Dumanoski, and J. Peterson Myers.1996. *Our Stolen Future: Are we threatening our fertility, intelligence, and survival? A scientific detective story*. Dutton, New York. 306 pp.

Coon, D. 1999. *An Ecological Sketch of Some Fundy Fisheries*. Conservation Council of New Brunswick. Fredericton, New Brunswick. 32 pp.

Davis, H. A. 1974. *An International Community on the St. Croix (1604–1930)*. Maine Studies no. 64. University of Maine, Orono. 412 pp.

Environment Canada. 1991. *The State of Canada's Environment–1991*. Ministry of Supply and Services, Ottawa, En21-54/1991E.

Johnston, P., D. Santillo, and R. Stringer. 1996. Risk assessment and reality: recognizing the limitations, pp. 223-239. In: *Environmental Impact of Chemicals: Assessment and Control*. M. D. Quint, D. Taylor, and R. Purchase (Eds.). Spec. Publ. 176, Royal Society of Chemistry, Great Britain.

Ketchum, B. H. and D. J. Keen. 1953. The exchanges of fresh and salt waters in the Bay of Fundy and in Passamaquoddy Bay. Journal of the Fisheries Research Board of Canada 10 (3): 97–124.

Loring, D. H., T. G. Milligan, D. E. Willis and K. S. Saunders. 1998. Metallic and Organic Contaminants in Sediments of the St. Croix Estuary and Passamaquoddy Bay. Canadian Technical Report of Fisheries and Aquatic Sciences 2245. Department of Fisheries and Oceans, Dartmouth, NS. 44 pp.

Lotze H. K. and I. Milewski. 2002. *Two Hundred Years of Ecosystem and Food Web Changes in the Quoddy Region, Outer Bay of Fundy*. Conservation Council of New Brunswick, Fredericton, NB. 188 pp.

Luoma, S. N. 1999. Emerging contaminant issues from an ecological perspective In: *U.S. Geological Survey Toxic Substances Hydrology Program, Proceedings of the Technical Meeting, Charleston, South Carolina, March 8-12, 1999*. US Geological Survey Water Resources Investigations Report 99-4018B, Vol. 2 of 3.

Parrett, A. 1998. *Pollution Impacts on North Sea Fish Stocks*. Prepared on behalf of the European Commission, DG XIV - Fisheries. World Wildlife Fund–UK, Surrey, England. 122 pp.

Pearson, T. H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review 16: 229–311.

Pohle, G., B. Frost and R. Findlay. 2001. Assessment of regional benthic impact of salmon mariculture within the Letang Inlet, Bay of Fundy. ICES Journal of Marine Science 58: 417–426.

Pohle, G. and B. Frost. 1997. *Establishment of Standard Benthic Monitoring Sites to Assess Long-term Ecological Modification and Provide Predictive Sequence of Benthic Communities in the Inner Bay of Fundy, New Brunswick*. Huntsman Marine Science Centre, St. Andrews, NB. 119 pp.

Poole, N. J., R. J. Parkes and D. J. Wildish. 1977. Reaction of estuarine ecosystem to effluent from pulp and paper industry. Helgolander wiss. Meeresunters. 30: 622–632.

Robinson, S. M. C., J. D. Martin, F. H. Page and R. Losier. 1996. Temperature and Salinity Characteristics of Passamaquoddy Bay and Approaches Between 1990 and 1995. Canadian Technical Report of Fisheries and Aquatic Sciences 2139. Department of Fisheries and Oceans, St. Andrews, NB. 56 pp.

Trites R. W. and C. J. R. Garrett. 1983. Physical oceanography of the Quoddy Region. Pages 9–34. In: *Marine and Coastal Systems of the Quoddy Region, New Brunswick*, M. L. H. Thomas, Ed. Department of Fisheries and Oceans, Ottawa.

Warwick, R. M,, H. M. Platt, K. R. Clarke, J. Agard and J. Gobin. 1990. Analysis of macrobenthic and meiobenthic community structure in relation to pollution and disturbance in Hamilton Harbour, Bermuda. Journal of Experimental Marine Biology and Ecology 138: 119–142.

Wildish, D. J., H. M. Akagi, N. Hamilton and B. T. Hargrave. 1999. A Recommended Method for Monitoring Sediments to Detect Organic Enrichment from Mariculture in the Bay of Fundy. Canadian Technical Report of Fisheries and Aquatic Sciences 2286. Department of Fisheries and Oceans, St. Andrews, NB. 31 pp.

Figure 1. Timelines

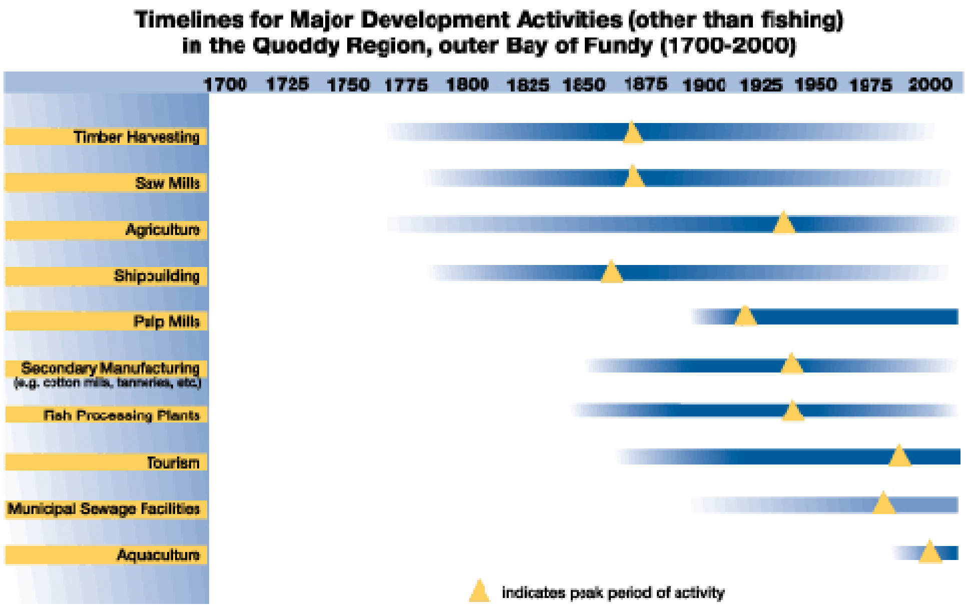
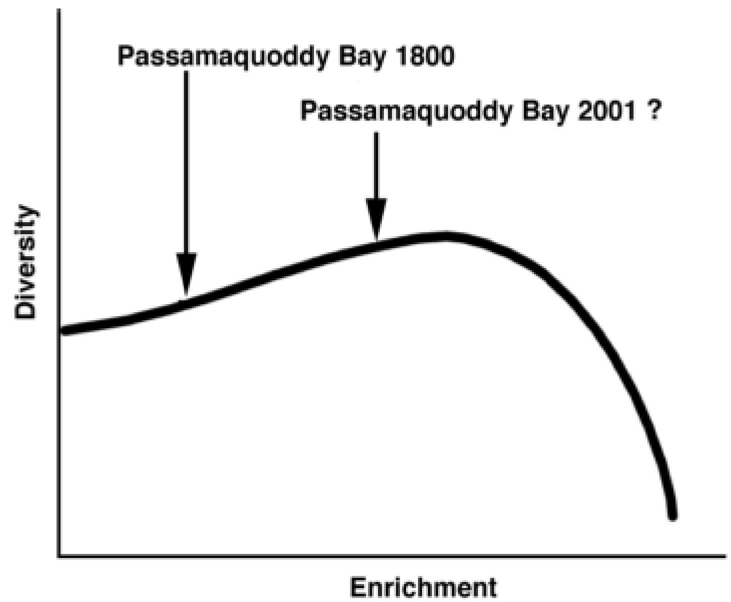


Figure 2. Circulation patterns in the inner and outer Quoddy region. Note the gyre in the centre of Passamaquoddy Bay. Adapted from G. Godin (1968) Natural Resources Canada, Neal Pettigrew (1996) University of Maine, and J. R. Chevries and R. W. Trites (1960) Journal of the Fisheries Research Board of Canada.

Figure 3. Influence of enrichment on diversity as proposed by Clarke and Warwick (1994). Where along the enrichment gradient is Passamaquoddy Bay today?



Appendices 2–7

DISCUSSION AND RAPPORTEUR NOTES

Appendix 2: Coastal Forum Plenary Discussion

Notes on discussion in plenary following Wednesday morning keynote presentations

Peter Strain: Comment re: Heike Lotze paper: Changes in phytoplankton community not necessarily attributable to nutrient inputs - there are a number of other possible causes e.g. light attenuation by solid particulates, etc. Also, nutrification is really a localized phenomenon around the Gulf of Maine/ Bay of Fundy, but not a widespread Bay of Fundy phenomenon, particularly in open ocean areas.

Heike Lotze response: Nevertheless, nutrient inputs are a part of the problem.

Thierry Chopin: We need to distinguish between inorganic and organic fractions of the nutrients - most people tend to focus on the organic and inorganic nutrients. However, it is the inorganic silt that causes problems for settling of spores etc. Have to be careful to distinguish between the effects of the different fractions. With nutrients, too much of a good thing is not good. There is a need for some enrichment, but too much causes problems. And it is not just the inorganic nutrients that cause problems.

Peter Strain: Primary production cycle in coastal areas still largely driven by nutrient/nitrogen inputs from offshore, not from local inputs. The nitrogen cycle will be a major emphasis for the Gulf of Maine Council Programs for the next 5 or 6 years.

Gail Chmura: Comments regarding indicators: Her lab has just completed collaborative study of New Bedford Harbor. There is good historical data on industrial influences in the area. This has been compared to an estuary that is just subjected to just urban inputs. The study shows changes in diversity with nutrient enrichment. With a highly eutrophic system there is a precipitous decline in production. The sediment cores provide a good historical picture of this, based on the silicon in the diatoms. There was a major shift in production at about the time people began clearing the watershed. There was a significant relationship between dinoflagellate diversity and organic carbon. However, the interpretation is complicated by simultaneous inputs of copper. In general though, one can monitor changes in the system by looking down into the sediments. The only difficulty is finding undisturbed sediment layers to sample, i.e. ones that have not been churned up by trawling etc.

Inka Milewski: Core work has also been done in Chesapeake Bay. There is a clear pattern emerging from all these different studies - we are loading nutrients into coastal waters and it is causing changes in diversity - now we need to do something about it and reduce the inputs.

Jack Pearce: Referred to paper by Carol Pesche(?). 150 years of history of New Bedford Harbour - historical studies of pollution effects and other effects in area. Increasing siltation is affecting shellfish stocks etc. There seems to be a flip-flop in the structure of the ecosystem. We have enough information to know that it happens, but we don’t know exactly when it happens, e.g., going from groundfish community to sand eel community. Regarding fish diseases: originally fish in the area were sold at the market in the round (preferred by ethnic communities). However, eventually the fish became so diseased that they started selling them as fillets, because no housewife would buy them in the round in their diseased condition. Also, New Jersey people got used to the oily taste of hydrocarbons in fish, eventually they didn't like the taste of clean fish. They adapted to and eventually preferred the oily tasting fish!

Graham Daborn: It is important to recognize the estuary as the interface between the marine environment and the land. There are lots of places in the Bay of Fundy watershed where we may be missing the opportunity to interpret the history of the area, e.g., work on lake sediments; such as Ian Spooner's work on lake sediment layers and long-term climate change. Lake sediments provide an historical record of many changes taking place in the watershed. Cited example of cumulative effects of 400 dams in the Saint Lawrence River watershed - this changed fundamentally the dynamics of the estuary. We need to look at various places in the watershed to find historical information about such events and their effects.

Peter Lawton: There has been a decline in the general fisheries, but the system is doing well in terms of the lobster populations - landings are now higher than they were in the late 1800s. This seems to indicate a shift in the invertebrate community structure as the lobster is now one of the top predators in the system. We don't have a good handle on the changes occurring in hard bottom communities because we don't really have the capacity to do proper surveys on hard bottoms; there is much better information available for soft bottom communities.

Heike Lotze response: Perhaps the crab fishing is increasing, the shrimp fishing is increasing because the predators are all gone, and nobody is eating them now.

Pam Person: It is important to talk about the total watershed. In Penobscot Bay there was also a loss of the larger groundfish that ate the lobster larvae.

Barry Jones: The concept of ecosystem change sells newspapers - but do changes in local populations (regional changes) really constitute ecosystem change?

Jocelyne Hellou: If we don't solve the problem at the smaller local level then the effects will gradually expand. Regarding the levels of contaminants: lobsters accumulate contaminants in their hepatopancreas; these are passed onto humans, leading to increasing rates of cancer. A lot of lipid material is being fed to salmon in aquaculture; some of this lipid has high concentrations of contaminants. We need to learn from other places where similar problems have occurred.

Peter Wells: It is a bit of a myth that DDT has disappeared from the ecosystem; some of it is still entrained in the sediments where it can be released back into the water column under certain circumstances.

Bradley Walters: From visiting Grand Manan, my impression is that things have never been so good in terms of the fisheries. There is a lot of wealth being generated in the area; the fishermen feel that everything is fine. Whose interests are we really talking about when we speak of health or ill health? If we extracted humans from the ecosystem we would still have changes occurring in the system. Are we being too "ecocentric"?

Peter Wells: There are many indicators of ecosystem health - not just fisheries production - although that is one measure - we need to use a range of indicators covering a lot of different areas.

Heike Lotze: At an upcoming California workshop they are going to try to compare several areas around the world, looking at the effects of European industrial developments on ecosystems. In the last 200 years we have completely changed many ecosystems; they are not natural anymore.

Thierry Chopin: We should stop looking at the fisheries landing numbers; these reflect management decisions and political decisions - they don't have much to do with the biology of the species.
Regarding dinoflagellates: there has been a resurgence of dinoflagellates - they are good at using whatever is available; they have pigments that are UV resistant - there is a resurgence of these more tolerant species that are better adapted to change.

Peter Wells: For any indicator species that you choose you really have to know the biology of that indicator species very well in order to properly interpret the results of any monitoring program.

Peter Lawton: The lobster data is derived from many different sampling techniques; e.g. fisheries catches and bottom surveys by divers etc. The changes in lobster populations occurred before the collapse of the groundfish stocks, so the resurgence in lobster populations is not simply due to the groundfish collapse.

Inka Milewski: In this report we have just begun the synthesis of a huge amount of data to see if we can discern changes in the system. Do we have the ability top predict changes? "I say no". However, there are cause and effect relationships. A pattern is emerging from the studies around the world - there is a threshold of disturbance beyond which populations and ecosystems just go into a free fall.

Jack Pearce: Re: lobsters. I have worked on the ecology of parasitic crabs (pea crabs) that live in mussels of area. There has been a tremendous oscillation in pea crab populations; sometimes drops to about three percent of the population; there are huge up and down fluctuations. In regard to the lobster populations we may be seeing a similar oscillation event. Eggs of many crustaceans are produced in large drifting clouds; maybe when populations crash the eggs and larvae are simply being carried away to unsuitable areas for development.
It also reminds me of a Cairn terrier that we had. These dogs are bred to hunt rats. We found that the dog was gaining weight. Upon examining his fecal pellets we found that the dog was eating acorns from the large oak trees in the yard and putting on weight at a great rate. Here was an example of an animal in transition from one type of food supply to a new food supply. Similar things occur in nature.

Peter Wells then reviewed the five questions that would provide guidance for the remainder of the Coastal Forum portion of the Workshop.

Appendix 3: Discussion Group A

Facilitator: Janice Harvey
Reporter: Zsofi Koller

Questions: #1: What is the present health or condition of the Bay of Fundy?
#2: Are conditions improving or deteriorating?

Discussion Members:
Gareth Harding (DFO)
Maxine Westhead
Bronwyn Musslemead (Minas Basin WG)
Diana Hamilton
Peter Eaton (EC, GPAC)
Darryl Wells (Stewardship, NBELG)
Bob Rangley (WWF)
Ed Parker (NB ELG)
Zsofi Koller (CCNB)
Janice Harvey (CCNB)
Sarah Townsened (SMU)
Mary O'Toole (SMU)
Nancy Chesond (sp?)
Tony Bowron (EAC)
Elwood Dilman (Hantsport)

1. How to Address the Questions?

- People seem to want to jump to the 'last step'—but we need to go back to the basics
- There is an assumption of ecosystem problems—and people have their own agendas as to what these problems are
- It would be helpful to address 'big picture' issues and have reach some consensus—yes, we need to look at the details, but we also need to look at changes in terms of the causal patterns leading to the problems
- Structures need to be in place to provide options for the future—we can't limit ourselves
- Things are probably deterioating if we don't provide mechanisms for change—then we can get down to the regional level
- Needs to be a questions "0": we need to set a goal: what do you want the BoF to be? Must be asked before we say: what that state of its health is?
- This is also a major challenge for the indicators: what is the baseline?
- Not: what do we want it to be, but what was the starting point? What was the foundation of the system before we altered it?
- We can't 'play God' and decide how the system 'should be'

2. Definitions

- What are *acceptable* environmental impacts?
- What will be our definition for "ecosystem health?" - Epstein's definition of pg 13 of Peter Well's discussion paper: "an ecosystem must maintain its metabolic activity level, its internal structure and org., and must be resistant to stress over a wide range of temporal and spatial scales."
- But this definition doesn't: 1. define standards, 2. allow for change, 3. acknowledge "use" from humans, 4. term 'resiliency' is better then 'resistant'
- It might be impossible to measure what a 'healthy ecosystem' is?
- We will always hold assumptions about what a 'healthy' system is
- We all have different interpretations of 'what a healthy' system is, so we should just focus on the symptoms of what we **know**

3. Important Biological Factors in 'Healthy Ecosystems"

a) biodiversity

b) productivity—must be maintained within a certain level—to increase or decrease too much would be a disturbance

c) resilience—due to the presence of stressors/impacts: toxics, chemicals, etc. If your system is resilient, it can deal with these stresses, but when it reaches the threshold, then it gets 'unhealthy', b/c organization and the metabolic activity, etc, will change

d) balance—doesn't mean 'change': it means how system respond to a perturbation

4. Symptoms Approach

- "Symptoms approach" to judging a system as 'healthy' or 'not'
- These are 'vital signs'—these are symptoms

a) fisheries decline

b) eutorophication

c) introduced species—there are invasive spp. in the Bay, not sure to what degree they are an impact; but we need to include invasive spp., b/c of the ships coming in w/ ballast that could introduce them

d) physical changes—e.g., tidal barriers

e) species richness

f) habitat impacts to processes (e.g., loss of habitat)

g) increased coastal development

h) debris on shorelines

i) contaimanants in sediments and tissues (in sediments or biota)

j) change in trophic structures

k) human component—understanding our effect on these systems-we have had a lot of improvements in our approach, and should realize that, but there are still many impacts we don't understand, and we are also extending our impact greatly

l) prevelence of protected areas in a system (but even protected areas don't necessarily mean that much, unless they are rigourously protected)

m) how the system impacts human health (e.g., getting ill from shellfish—most of this is unreported, though)

n) contaminants—Profile in the Bay: there are some long-term ones with long half-lives; these are low-levels. Some are recycling-there are commonly recognized trace contaminants in the system, at lower levels than we think make a difference. A few 'hot spots' exist in the Bay where there are elevated levels and some effects, where data is weaker than contaminant descriptor data. The system is also still exposed to low-level contaminants, such as air-born Hg and nitrogren coming into the bay. Not sure of the effects, of factors such as endocrine disrupters (this is probably over emphasized). The pulp mills need to be looked at very carefully—the only blessing is the 'flush' of the bay (though earlier in the day we heard that it doesn't really 'flush' out—it just swishes and re-suspends back and forth—so the whole system is exposed)

5. The Task at Hand: How to Approach it?

- note page 12 of P. Well's discussion paper (table 3): can we apply this table to say something about the bay as a whole? This is a huge intellectual risk, but we have to be risking to be wrong
- some things we just don't know about—but we have to pinpoint that what we don't know and try to figure it out—flag major concern areas
- there was a study done of the mid-Atlantic estuaries [EPA: MAIA Project Summary: "Condition of the Mid-Atlantic Estuaries"] with a colour chart of how each estuary stood in regards to a list of indicators—this could be a helpful guideline to understand the 'health' of the BoF
- we can't just indicate just the current state, but also change: what's changing, and how?
- this was done for Chesapeake bay: we can surely do this for BoF, maybe divided into upper bay, middle bay, and lower bay

- **NB**-the tension with integrating and gathering 'non-research' information
  - what do we do in the absence of scientific proof? -we have to be able to go on an informed hunch
  - we need to build on 'real information' that is reliable
  - we still have to do things now: change is happening that we don't understand—we need to use other tools as well.
  - some of the things we are talking about are GLOBAL: we should concentrate on the more local effects, and work towards educating the local politicians on the benefits of remedying

- when we look at the full range of things there are so many things that we don't know
- if we zero in on a place, we can look at local efforts
- we need to make use of the information we do have
- BoF does have a lot of information, we need to use it
- we should also borrow knowledge from other areas

6. Indicators and How Bay of Fundy 'Ranks'

1. We started with a summary table taken from the EPA MAIA Project Summary: "Condition of the Mid-Atlantic Estuaries
2. We went through each indicator and 'ranked' the status of the BoF, using colours to indicate the current status, and an arrow to indicate the direction of change.
   - to do this process properly takes a long time
   - it is also important to look at smaller areas before you can do the overall bof as a whole
   - remember the context this will be used in—an overall watershed forum
   - this can then be done in a very specific fashion within the smaller watersheds
   - to do it for the GoM needs a lot of breakdown—the abc's can be done at smaller watershed forums, and then pulled all together
3. We consider the following tables to be a **template** for future watershed forums to use.
   - our discussion is limited to outside of estuary limits—b/c there will obviously be problems in some estuaries

Legend:

State of the Health	**Directions of Changes**
red=bad	Arrow up: improvements
green=good	Arrow down: getting worse
blue=caution	Arrow sideways: neutral/no shifts
empty box=don't know	No arrow: don't know

Indicators	**Bay of Fundy**
Nutrients	-Elevated levels in parts of pass.bay -the local nutrient expert seemed to think that there was not a problem in the bof **-but we know that there are problems with sewage pipes in St.John Harbour, and problems in Pass. Bay** **overall: BLUE** **arrow: down**
Phytoplankton	-meaning: increases in phytoplankton/blooms (general, not just toxic) -(note: spring blooms are good-this correlates with nutrients) -(they used chlorophyll suspended in the water) (poor-blooms//good-healthy crops of algae)→but this requires a lot of work in the field to assign these values (they assign their yellow and red in the estuaries—not in the majority of the bay) -we are doing the indicator group work here -can we make a general statement about the bay? -phytoplankton appears to be good -the occurance of harmful species appears to be increasing, based on the quoddy research -the science behind this in the Bay might not be solid; Jennifer Morgan **overall: GREEN** **arrow: sideways**
Dissolved o2	**Overall: GREEN** **-arrow: sideways** (or maybe improving, like in Saint John harbour, w/ sewage treatment)
Sediment contamination (i.e contaminates in sediment: not the sediment itself)	-red for specfic areas, but as a whole, there should be a caution **overall: BLUE** (note that any caution has hot spots at some areas in the bay—note that Saint John would be red, etc.) **-there might be other indicators other than sediments (we can always add more—maybe birds should be there/ 'waterfowl' is too general)** **-should have sediments, with subsets of sedmiments, and then another subset of sediments** **-arrow: up** (the contaminants that are actually being measured are going down in levels—but we should question it—b/c this is a set of known contaminants. In general for the Bay, the levels are going down. DDT and PCB's are banned, so they should be going down—they are just residual) -PH's are high in the pass bay arrow: ??? (some are up, some are down).

Coastal wetlands	**Overall: RED**: (b/c of the problem with salt marshes, due to dyking) -3 priorities of the GoM: 1. habitat 2. contaminants 3. sustainability **arrow: down** (we're still losing coastal wetlands faster than we're gaining—this is documented. Things are infilling, coastal development. BUT there is new legislation coming in)
Submerged aquatic vegetation	-re: grasses (eelgrass) and macroalgae? We might want to include macroalgae (kelps, rockweeds) b/c we don't really have many eelgrasses in the bof -last eelgrass beds were wiped out by disease, and are starting to recover, but they are not a factor, like algae is a factor) -rockweed harvesting is an issue—which affects fish habitat/changes the structure/eutrophication (replacment of perennials w/annuals) **overall: BLUE verging on RED** -some major over-harvesting happening in Nova Scotia arrow: the rockweed situation in NS is improving—better management -we don't know very much about it **-but its not just harvesting—its also the perenaials to be replaced by annuals (green algaes are all over the place)** **arrow: ???**
Benthic habitat	-(animals)-lobsters are okay, but sea cucumbers/urchins/periwinkles/snails/ some getting v. overfished or contaminanted -we don't even know about the impact of all the taking of these -benthos is a huge category/confusing -b.c is often a good indicator of the local estuarine environment -Halifax harbour is an example of an impoverished benthic community -many benthic communities are hurt by some fishing techniques—dragging, etc. -we need expertise here—we will definitely get reds in some areas—and some greens -therefore, we don't know ???????????????? -probably most must be red/blue **overall: BLUE** arrow: ???? (we don't really understand the definition of this one—we should scratch this out—note this graph is for more estuarine conditions than the bof outside of estuarine resources) -we need to think about the gravel on the bottom of the upper bay (off scot's bay)—this might be harvested later on arrows (are making a prediction—not just the 'right now' arrows: dragging has been happening for the last few years, oil and gas are potentially coming—the beginning of that has been seen—some people think there has been a downward trend—nothing to indicate its going up **arrow: down**

Shellfish harvest	--'shellfish' [mollucs: bivalves] -**overall: RED** (compared to historic levels) -quahogs are not harvested in the bay arrow: over 50 years, its gone down, but over 5 years, its stayed the same **arrow: sideways**
Shellfish closures	**Overall: RED** (closed all the time) -clams are starting to move in a positive direction -you are getting more red times **-arrow: sideways**
Fishery stocks	Overall: RED **(based on pass bay talk this morning. Except that the herring is doing just fine. There is clearly a problem w/fish stocks)** **-haddock is decreasing, cod is coming in (this will eventually need to be broken down by species)** **Arrow: down**
Lobster (separate category b/c they are an anonomoly)	GREEN -an argument to take this out—we shouldn't list the species one-by-one -but fish are going down and lobster is going up, so it should stay Arrow: it can' t get better, its got to come down **Arrow: sideways**
Containiments in fish/shellfish	**Blue**—due to mussel watch **Arrow: sideways** -but we are not monitoring the fish—there are fish inspections, but we are not privy to that info
Sediment (soils) as a contaminant	A real problem below barriers—red in places -its an upper bay issue -where-ever there are barriers, there are issues -sedimentation around artifical barriers is a big problem -this happens around the bay -but many question marks here **overall: RED** **arrow: down** (until the petitcodiac causeway comes down)
Containiments in birds/mammals	-every 4 years analysis of containiments in seabirds -a wide range of ones in seabirds, but no evidence of any effect (as our techniques get better, however, we are finding effects) -mammals: might be a presence -a caution, b/c of their presence **overall: BLUE** **arrow: sideways**

Disease wild fish/shellfish	Some cases of disease in flounder in harbours -this area hasn't been researched enough -we don't have any real evidence of disease in mussels **-overall: DON'T KNOW** -there is disease in cultivated salmon—think about the RISK of catching it -where we see the disease, is aquaculture—we don't know about the risk of transfer to 'wild populations' -but there is lots of disease in cultured stock (there was an objection to this as considered a risk for wild populations, as it is not completely understood yet) **arrow: don't know ???**
Waterbirds (this is waterfowl plus shorebirds) -populations, not habitat	-population trends might be relevant here, to the artic -there doesn't seem to be any crisis in the bay of fundy, but there are issues with specific species, -like black-backed ducks and eagles hitting on eider ducks -some are great, some are not so great -bird counts are not always accurate -eider populations are unpredictable, but not endangered -in pass bay, eiders are red/in overall bay, they are green **-overall: BLUE** **arrow: sideways** (an averaged effect)
Threatened/endangered species (in report they listed ea.spp., and their status, and their trends) -in all, their populations were getting better, so they all got green or yellow	-RED -b/c of salmon, whales, -many species we don't know about -osprey is doing okay/so is bald eagle (due to decline of pesticides) -arrow: the endangered spp. List is getting longer b/c they're adding more species due to the effort—this makes it ambigious. But the ones that are listed are doing worse. Until everything else is green, species are going to be suffering) arrow: down (we don't know for sure—some have done better, some have done worst). We need to be consistent about how we are doing these details -we are in no ways insisting that these are right—this is just a guidelines -we have been conservative

- We are going to reanalysis this table—and do more of a quantitative approach to the table
- Do the morris spotlight approach (=it is essentially what we are doing—it gets quite sophisticated)
- This is what we'll do in the summit
- There are advantages of using the template of a report already done in the US

- The US EPA is doing a monitoring workshop, and maybe would do this for us in the fall
- We need to pick indicators that may be more relavent to the gulf of maine
- EPA has been doing this all around the continental US
- But haven't seen this for the GoM
- This above table only has meaning if you break the arrow down into smaller parts
- This is a complicated task
- Must keep the final report fairly simple
- This is because the people coming to the final summit has already done the work—we don't need to keep redoing it
- This method can highlight where more work needs to be done
- For example, we are not comfortable with the amounts of contaminents we are doing
- We could add human populations to this—need to outline the demographic
- Population wouldn't the final end of the stress on the system—there will be other kinds of stress that comes from
- We need to tie together the socio-economic management and development in the overall picture
- To manage the bof you need to manage the watershed—you need to look at the watershed's individually, and have a separate list that includes human indicators
- But it will muddy the waters if we add it to this
- This is another issue—we won't be able to add it to this today or tomorrow, but it will need to become a part of it
- Coastal zone issues are really in the watershed—that will affect surface water quality, and groundwater, and this will affect the marine water
- You have to include at least a portion of the interface that is connected to the marine to get an understanding of what's going on
- We need to understand the contributing factors to each indicator
- It's a matter of not 'adding' to the list (apples and oranges) but 'unpacking' the list to understand why the stress is creating that environmental response.
- The Summit process includes a HUGE amount of work
- This will all need to be documented, and done up with graphs, etc.
- But we can't expect each watershed forum to have a refernce document on hand to justify the colour of their box
- Next time around we'll be more rigourous—how do we get moving with the information we HAVE
- We need to dip into traditional knowledge—it's not guessing—its informed opinion, and observations—it should be documented

- ‘Opinion’ is worrying—it shouldn’t be a guesswork
- Engaging citizens must be able to marry science with the citizens
- Pass. Bay report is an example of the marriage of this
- We have to look behind the anecdotal observations and find the supportive documents
- There is a big difference betwn informed judgement and a guess
- But even drawing out misunderstanding and wrong opinions is important so we can put those misconceptions to rest
- To do this right, put out all the issues—compare the public opinion with the scientific opinion—but we need to get those opinions down and record them—we need to learn the opinions, and find out what they know
- Don’t trivialize the project—it shouldn’t be built upon on a deck of cards
- The problem with this project is that we have no money, and what studies have already been done—we’ll identify gaps, and say what they are, but this is a facilitated process to bring the data to the front
- It is a big effort to take even the current papers and synthethize them
- We need to be clear on what the expectations are, and what the document is going to say, and what we think its going to say, as possible

7. Looking at BoF overall, re: ecosystem structure and function

Summary taken from Table 3: page 12 of 43 in Peter W’s discussion paper

- This is a more generalized, overall assessment of ecosystem health of the Bay of Fundy
- The following conditions describe the conditions of **ecosystem structure and function** in the Bay.
- (We used the same colour scheme as yesterday’s table)
- The time scale=from historic time onwards, since European settlement? This was thought to be too far away, b/c everything has declined. But we still need to recognize that there *has* been a decline—this shouldn’t be overlooked.
- None of this is ‘for sure’: we are guessing with ‘informed’ opinion. But this is testing the analysis method.
- We don’t ‘know’ where we are with respect to this information. But we have to identify what we don’t know.
- We need more reports like the ‘Pass Bay’ report, because we don’t have these overall views of the state of the bay, broken down
- We need to understand that the final task is a huge one, but not impossible.
- But this doesn’t affect the bigger picture: a lack of peer review is not good. We need more scientific review, before we get carried away with this stuff. We should keep going, but we need loops to bring the scientists around to get the review and the informed consensus. We

have to go through the hard discussion, otherwise we will have problems running this through the political mill. Scientists need to have a uniformed consensus.

- The public is looking for answers: either they think: things are perfectly fine, and or they think things are going to hell in a handbasket
- We should recommend that to go forward in this process, that we need more synthesis documents to go forward on analysing the state of ecosystem health in the Bay, so that we can present a unified front.
- We can debate about WHY the lobster populations spiked, but we DO know that they greatly increased. We can all see the trends, which is what we need to note. We can't say the reasons for these things (due to differing opinions, and that this is more of a management approach) but we can say what we see now. Another example is the decline of the right whale. We might not know why, but we see that it is happening, and we can all agree on that.
- This table was more difficult to fill out, because it seemed like the collective knowledge gapped more.
- Each of these factors must be very clearly defined, and how we will answer them. For example: will we pick some keystone species, and focus on those?
- Have to be careful how we look at species, and which species: for example, lobsters, b/c they are an anomaly (probably doing so well b/c DFO don't do them by quota). We don't know enough about lobster.
- We also have to choose species that are non-migratory, and ones that stay in the bay: they will give the most info., e.g., Rockweed, non-migratory salmon

Condition: Health	**Bay of Fundy**	**Outer Bay**	**MidBay**	**Upper Bay**
Biodiversity [community struc.—spp. extinction, changes in spp. composition, or spp. extripication]	-depressions in the fisheries, in the mammals (sea otters) -if we look at a few key species, then we could document this -not necessarily a reduction in biodiversity, but a change in species composition overall: BLUE	-not a serious problem, except for the fishery -but we need to do this species by species -pass bay report provides a good basis for this for the outer bay -overall: RED	-striped bass is in decline -based on salmon, the fishery is gone -the spring cod/fisheries around St.John overall: BLUE	-harbour porpoise are doing find -shad? overall: BLUE
Impaired [abnormal] productivity	Overall: BLUE	-rockweed contributes this -overall: GREEN	Overall: BLUE	-taking out the salt marshes, it seems like there must be a major reduction overall: RED

Altered food webs/biotic composition (abundance, size)	Overall: RED	-based on the pass bay report (both wrt size, landings data) overall: RED	Overall: RED	-looking at mudflats, there is no evidence that the food web has changed, wrt corophium/shorebirds -fish: some species up, and some species down Overall: RED
Reduced resilience [stresses measured by using referenced chemicals—more a measure of physiological conditions] -a difficulty to define 'increased resilience'	?	-we have demonstrated this in the outer bay, as demonstrated by Terry Chopin (sp?)—b/c of algal blooms etc., which is producing hot spots of problems which never existed before ??	??	??
Contaminants (toxic substances—wrt risk to human health)	Overall system is not clean -but we don't have any evidence of this Overall: BLUE			
Exposure to pathogens [based on shellfish closures]	-permanent mussel closure in the BoF due to PSP	Overall: RED	Overall: RED	Overall: RED

Algal toxins	Globally, the data suggests this is increasing. This might not be able to be broken up into sub-regions. -not sure if this is due to increase of outbreaks in coastal areas are b/c of stressors on these areas, or due to shipping. Overall: RED Arrow: ??			
Increased disease prevalence [resistence to pathogens]	-if you take well-known organisms across the bay, then you can do a comparison	??	??	??
Risks to human/org. health				

8. Conclusions:

Overall conclusion to the health of the Bay: we should say two things:

1. We went thorugh an exercise to use a template to figure out the health of the bay, and it needs to be done again.

2. We do have concerns about the health of the bay, even when being conservative: overall, the number of “green squares” are very few in comparison to that of blue and red. This signifies multiple problems.

Draft Indicators Table

↑ Better ↔ Statis ↓ Down ? Unknown

Legend

	Caution – moderate problem
	Bad – problem
	Good – good

Indicators	Outside Estuary Limits Bay of Fundy	Outer Bay				Mid-Bay				Upper Bay			
		A	B	C	D	A	B	C	D	A	B	C	D
Nutrients		↓											
Phytoplankton		↔											
Dissolved Oxygen		↔											
Sediment contamination		↑↓											
Coastal wetlands		↓											
Macroalgae		?											
Benthic habitats		↓											
Shellfish harvest		↔											
Shellfish closures		↔											
Fish stocks – Lobster		↔											
Fish		↓											
Contamination in fish/shellfish		↔											
Disease in fish/shellfish	?	?											
Waterbirds population		↔											
Threatened/endangered species		↓↔											

Condition – Health	Bay of Fundy	Outer Bay	Mid-Bay	Inner Upper Bay
Biotic impoverishment			?	?
Impaired productivity				
Altered food webs/biotic composition				
Reduced resilience	?	?	?	?
Increased disease prevalence	?	?	?	?
Risks to humans/organisms				
health/pathogens				
algal toxins				

Appendix 4: Discussion Group B

Facilitator:Peter Hicklin
Rapporteur: Peter Strain

(PowerPoint presentation converted to text followed by rapporteurs notes file and text from large poster sheets)

What Indicators are Most Useful?

Not an easy task:

How to decide ?
Indicators not the place to start
Management Objectives ?
Valued ecosystem components (VEC) ?
Expectations ? What do we want, what don't we want ?
Stressors ?
  by sector ?
  by type of input ?
  by type of impact ?

Workgroup Questions

Briefly discussed Q1 and Q2:
  No consensus: eg
    Mudflat production low compared to 20 years ago
    Lobster fishery in outer Bay never better
  No simple answers:
    Bay is large and diverse
How to make task manageable ?
  Divide Bay into inner / outer, inshore / offshore (intertidal vs subtidal perspective ?

Stressors

- Nutrient loading
- Land use / coastal development / human population changes
- Toxic chemicals
- Disturbance of populations (noise, light, seismics)
- Habitat destruction, disruption, fragmentation
- Invasive species

Types of Indicators

- Biological
- Chemical
- Physical / Habitat
- Social / Economic / Cultural
- Actions: do management systems respond to warnings given by indicators ?

Classes of Indicators

- Habitat
- Stewardship
- Sustainable aquatic communities ?
- Toxic chemicals
- Varied functions:
  - Early warning, use existing EMAN indicators, extend into the marine environment
  - Trend analysis
  - Economic
  - Public education – translation of science for public, relevant to public experience, PR

Characteristics of Good Indicators

- Integrate
  - Over areas
  - Over communities (upper trophic levels)
- Simple
- Cheap
- Good S/N

Indicator Limitations

- Migratory species – may not be fatal
- Single species indicators hard to interpret
- Focal species – need in depth understanding of life history

New Technologies / Approaches

- Remote sensing
- High density sampling
  - Multi-beam surveys
  - Video surveys
- Integration of physical models, chemical dispersion

- Adopt a ___, Shore-keeper, reef-keeper programs
- Community resources
  - Oceans 11
  - Fishers
  - ACAP Programs

Other Concepts

- Ecoeconomics
  - Environmental capital
    - Must be inclusive definition (‘insurance’ of underlying ecosystem)
- Scales
- Report cards
- BoFEP as advocate

Some Possibilities

- Changes in species composition (eg number of finfish species)
- Area of salt marshes
- Area of shellfish closures
- Persistence of critical habitats, such as spawning areas (community input and TEK)

More Possibilities

- Toxins in seabird eggs
- Weight gain of migrating shore birds
- Reproductive success of seabirds
- Resilience of ecosystem – large scale experiments ?
- Intertidal algae, porphyra in inner Bay

Frustrations / Needs
- Coming to grips with the task (Framework ?)
- Reinventing the wheel
- Land-based sources only (GPAC)
- Lack of terrestrial expertise, input inventories (Geo-Connections ?)
- Disconnect between indicators / monitoring and action
- Lack of cohesive position from science community
- Lack of resources, inaccessibility of the marine environment – role for fishers, recreational boaters, divers ?
- Standardized protocols
- Data management

Rapporteur's Notes

Peter H – Ecosystem status is poor: mudflat prod'n very low compared to 20 years ago – upper bay

JH – more used, not poor ecosystem

GL – better or worse not possible

M Strong – too big an area to deal with at one time, no one answer

JP – indicators differ in upper bay

Indicators in upper bay

IM change in species comp'n

MB – populations live outside BoF as well

Sandpipers in decline – not because of the BofF

Non-migratory species

Indicators not first thing

What are expectations

Policy – changes detrimental or not – response a component

Indications – habitat, stewardship, sustainable aquatic communities – indicators early warning, economic, audience

VECs precede goals

JH –chemical levels

38 issues as a starting point

Chou – many expertises. Biological, habitat, chemical , economic / social

Salt marsh areas, beach closures, link indicators to how things are doing, aquaculture

Stressors, system responses,

Bob R – don't worry about policy, cultural things

Where do you want to be ? Focus on expertise, where do we want go, what are the risks

Inke – historical changes. Why is lobster so good right now, where will it be in 10 years

JP – ecosystem processes, what do we need to protect, what don't we want to see, what other areas in the world do we not want to emulate ?

What do we want: healthy mudflats, sustainable fishereies etc how do we measure changes

GPA – land based – must focus on the land

What constitutes health and what goes forward ?

Assets – natural capital ? must include insurance of the underlying ecosystem

PP – present day biodiversity

PL – Trophic levels

Suggested indicators:

- Divide lower bay, upper bay, inshore v offshore
- Scale important: nutrient levels, O2, chlorophyll
- Land-based only ? Or land-based and marine-based
- Focus back to indicators
- Target levels
- Remote sensing – goematics
- Population
- Chemical indicators
- Dissolved oxygen
- CARP monitoring
- Piece of work to be done
- Multi-beam – inventory – habitat mapping
- Ecotoxicology
- Lobster health
- Toxins in sea-bird eggs

- Fish species
- Spawning bed maintenance – TEK, ongoing – groundfish, pelagics, estuarine
- ‘Non-scientific knowledge’ ??
- Bird pop down – no problem in bay, but still an indicator
- Reproductive success of sea-birds
- Wt gain in sea-birds
- Single species indicators are frought with problems
- Fish datasets not available
- Art MacKay surveys in 1973 a reference point – benthic community structures, focus species
- Integrating indicators, over community, areas
- Cost effective, cheap, historic data
- Whale distributions
- Maritime Shorebird surveys
- Resources not adequate
- EMON – increasing into the marine scene
- Mar env very extensive – large dollars, power weak because everyone is working on too small a budget
- E.g., benthic videos
- Direct funding back to monitoring
- Fish stocks – not many in rivers, habitat assessments – productivity so low that results are questioned.
- Resilience of the bay – opening up of dammed / blocked rivers
- Adopt a stream
- Intertidal algae, sublittoral algae
- Porphyra in upper bay
- Fishery gone around upper bay
- Firm decisions about causeways in upper bay
- Restoring fisheries in watersheds
- Tidal barriers – inventory EAC / CCNB
- Petitcodiac WQ measurements
- Salmon River in Truro, Canard River, CARP, monitoring – no action
- Contaminants in Bay – Eastern flow into Minas Basin
- Interaction between different knowledge bases – geo-connections
- Agricultural inputs – representatives of land-based sectors

- Focal species ? life histories, scales of movement, interactions
- Disconnect between science/policy. Indicators can show problems and nothing will happen!
- Actions are indicators too
- Report cards
- Role of government scientists inside and outside gov't
- BoFEP advocacy role
- AGM meeting

	Phys	Biol	Chem	Eco
Lower bay				
Nutrient loading		Population changes		
Coastal erosion				
Land use / coastal development / human population changes				
Dykeing				
Toxics				
Benthic disturbance				
Disturbance of natural populations				
Jurisdictional problems (over management, inconsistent management)				
Fishing pressure / population declines				
Invasive species				
Habitat fragmentation, destruction, disruption				
Noise (acoustic), light, seismic				

Notes from Poster Sheets

1. Ecosystem Health

Resiliency (ability to tolerate stress)
Biodiversity
Maintaining productivity
Balance within – food web
Stressors

- contaminants

- harvesting
- habitat loss
- disease

2. What's the baseline starting point?

Back to basics

- let's not assume everyone understands what's happening and why

Need to look at big picture/large scale as our context, especially for changes
Is there a mechanism in place to detect changes and respond to them?
Need to recognize and acknowledge uncertainity
What is the goal or expectation of ecosystem health?
What is the present health or condition of the Bay of Fundy?
Are conditions improving or deteriorating? (Based on what?)

3. Symptoms

- fisheries decline (fishing down the food web)
- eutrophic zones
- physical disturbance, i.e. habitat loss (dykes, tidal barriers)
- species loss: extinctions
- change in trophic structure
- salt marsh loss – 85%
- debris on shorelines
- persistent contaminants in sediments and biota
- patterns of human impacts – extent of behaviour – changes in quality and extent
- disease – human, plants, critters
- introduced species invasive
- presence of protected areas or sanctuaries
- loss of historic natural refuges due to technology

Widespread presence of persistent contaminants

- low levels but measurable in tissues
- hot spots – L'Etang, Saint John Harbour, St. Croix, Petitcodiac, Minas – evidence of some effect
- airborne inputs – mercury, nitrogen
- exposed to low level contaminants
- not much info on effects

4. How to garner and integrate "non-research" information?

How to move forward with information we have without "proof" of cause - effect?
By the time we get to understand the science, it may be too late - threshold effect
Concentrate on local effects
Can borrow knowledge from other areas

Appendix 5: Discussion Group C

Facilitator: Marianne Janowicz
Rapporteur: Sean Brilliant

Questions 4 & 5 presentation converted to text

Time to Take Our Finger Out...

What is present state of Bay?

- o Lots of variables:
  - · Where, When, Type of Activity...
- o Around the table:
  - § 11 in degraded state
  - § 8 were unsure
- o Even "unsures" recognized the (usually adverse) impact humans have on BoF
- o Does this question even need to be answered...?
  - § The answer does not affect our ultimate goal
  - § MUST be cautious in presenting this view!!

What is present state of Bay?

- o Result:
  - § There have been some changes. Primarily the feeling is that the quality of the ecosystem has degraded
  - § Some say they do not know the quality but do recognize the impact humans have on the ecosystem
    - · Because we are cognizant of the ecosystem, we are more conscious of our actions
    - · This is a positive result!

Are conditions improving or not...?

- o Are these terms too value-ladden
  - § "stressed"?
    - · NOTE: change does not automatically mean degradation
    - · Does this remove too much value?
- o Answer:
  - § There <u>ARE</u> more stresses on the system now
  - § Some of these stress reaching a level that are compromising EITHER:
    - · integrity ecosystem AND/OR
    - · those components humans assign values (e.x. resources, etc)
  - § These MUST be addressed URGENTLY!

What kinds of indicators...?

- § "Eco-region" based
  - · Assessment must match typical conditions for that part of the ecosystem
- § Indicators should assess different processes of the system that can be interpreted as a whole
  - · Convergence of the monitoring strengthens the assessment
- § Indicators should be locally determined (i.e. more than biological: social, economical, etc) **BUT** must be used in the context of the Bay as a whole.
- § Must be practical for actually measuring, etc
- § Long-term focus and continuity (QA/QC, etc)
- § Baseline data is needed: which direction we are going

Are there adequate resources...?

- § Institutionally: yes they do exist,... BUT
  - · Not enough sharing
  - · Not appropriately allocated
  - · No long-term efforts - Support only for short term work
- § User-Pay Principle Must be applied:
  - · Does licensing recover appropriate amount of support for required monitoring or remediation?
  - · E.g. what happened to SCI research fund?
- § Community groups must be involved in monitoring and the research agenda
- § A commitment is needed from BoF users to monitoring
  - · This must be regulated

Adequate resources/New Approaches?

- § Centralized agency
  - · Volunteer capacity is nearly saturated - need for a dedicated foundation?
- § Dissemination strategy
- § Opportunities for large-scale (reversible) experiments
  - · Assimilative capacity
  - · Resource management, etc.
- o When something goes wrong are the resources there to address it?
  - § It is there but it is not a priority
  - § There seems to be a priority to protect but not to restore

New info & approaches to protect BoF

- o Network of "Protected Areas"
  - § Biosphere Reserve?
- o BoFEP to Champion/Coordinate BoF efforts
- o More industry involvement/buy-in
  - § Including media
- o Stronger/More active Stewardship initiatives
- o Involve students more

New info & approaches to protect BoF

- Government Agencies' Mandates must be streamlined and brought into coordination
  - Cooperative focus
  - Mutually beneficial
  - More buy-in into stewardship work - not control
- Participation and recognition from University Administrators and Research Administrators (NSERC) is an important component of moving these efforts forward.

New info & approaches to protect BoF

- A more proactive approach - not reactive
  - Is the Precautionary Approach being applied to BoF EIAs?
  - This will require planning on the part of industry
- Existing Regulatory Agencies MUST be enforce their regulations
  - Is there a greater role for the public to encourage regulation?
  - Are we depending on a regulatory system that doesn't work?

******

Discussion Notes

Question #1. What is the present state of the Bay of Fundy?
Does it matter?
Depends on where you look
Depends on the type of activity
Depends on the time/season

Some understanding is necessary to understand figure out sources, etc

Can we simply agree whether the BoF is good or bad?

What is the present health? Or Has it changed?

Around the table:

- degrading
- parts are worse
- declined
- degrading
- degrading
- degrading but be influenced

- no baseline

- only some areas are well known enough
  - ? – but of course humans…
  - last penny – wear your best suit – BoF and Lobsters
  - Degraded
  - Degraded
  - Health is not at best - Human activities are having an impact
  - ? – but of course humans…
  - ?
  - degrading
  - ?
  - ? as BoF as a whole
- **lots of changes – BUT not necessarily degradation!**
- Aquaculture and human population is a reality
  - ?
  - ? but thinking has improved!
  - ?
  - degraded
  - degraded

Result:
There have been some changes. Primarily the feeling is that the quality of the ecosystem has degraded. However, some people say they do not know the quality but do recognize the impact humans have on the ecosystem.
Because we are cognizant of the ecosystem
More conscious of our actions - a positive move
This question shouldn’t even be addressed (Sean didn’t say this)

Question #2. Are conditions improving or deteriorating?
- A statement of the problem is still needed
- It is our job/mandate to determine the present health of the BoF
- There is a give and take – ebb and flow along the BoF

What is health?
Ecosystems are dynamic – hard to measure.
The state of the BoF doesn’t change what practises should or shouldn’t be done
- filling in saltmarshes
- ATC-ing through streams

**Bad practises should be avoided even in a “healthy” ecosystem

Improvements shouldn’t reduce our efforts to continue to improve the ecosystem

Despite difficulties in measuring what is ecosystem health we still can obviously see what is healthy and what is not

The conditions to increase the health of the BoF is increasing improving. “The Time is right”

Negative effects of the BoF is much larger than the positive improvements

- one step forward 2 steps back
- SJ may be improving, but other problems are arising
  - o New causeway, dredging, etc

Are these terms too value-ladden (degraded, etc)?

- all a matter of perspective
  - o increased seaweeds

***Change terms to “Are there more stresses on the BoF now?”
Yes. No question.
We are acting on this and want to continue to act.
We must make a conscious decision to make a change.
Are “stresses” too value-less?

Stress is usually determined by breaking a material first
We don’t know the breaking point of the BoF

We want the ecosystem to retain characteristics that we see as important and should be there
This is confounded by individual interests. E.x. lobster fishemen want lobster.

****“We” is being used too much. This must be understood as a stakeholder “we”.

Stress? A conscious decision to do something that we recognize as a negative change in the environment.

Answer:

- There are more stresses on the ecosystem now
- Some of these stress reaching a level that are compromising either the integrity ecosystem or those components we assign values to (e.x. resources, etc)
  “Some” implies that the variability that exists within the BoF
- These MUST be addressed URGENTLY!

Questions #3. What kinds of indicators are most useful?

- All different

Most indicators have been fairly level of an ecosystem should be included.
At different "processing" levels
sediment processing vs nutrients specific things where we have the technology to measure – DDT, etc.

The more difficult indicators are the core functions of the ecosystem.
Biochemical compromises, etc
Some sense of the diversity of organisms that were characteristic of the BoF
Some changes are a result of "natural" physical stresses of the Bay
e.x. sedimentation, salinity, temp, etc

Dividing the BoF into regions then categorize each?

Indicators are a function of the value judgement of the monitors too!

If a suite of indicators are developed for ecoregion are there guidelines we can establish?
e.x. indicators that can converge.

Must remember Social, Economic, Cultural indicators too - another reason to divide into ecoregions?
Some baseline is required too.

Indicators:

1) **eco-region based**
2) **must converge to "tell the same story"**
3) **Community should be involved in establishing these indicators (locally determined i.e. more than biological: social, economical, etc) but must be in the context of the Bay as a whole**
4) **Be Practical for actually measuring, etc**
5) **Long-term focus – and continuity (QA/QC, etc)**
6) **Some baseline is required to tell us which direction we are going**

Question # 4. Are there adequate resources…
Institutionally there are many resources

- But there is not enough working together
- Resources need to be shared based on ecoregions
- Is the allocation appropriate?
- More responsibility to the community
- Government only give $ to community groups
- Capacity to provide resources is severely limited

- School programs have not be adequately used: Involving teachers may have a very positive spin off!

Transfer from research facilities to NGOs doesn't exist
- support from research facilities needs to be more accessible

Monitoring efforts are not adequately supported
Community groups must be approached/involved to conduct the monitoring that is necessary

Do we need an institution within the BoF that will take on the monitoring responsibilities
Gov't agency supported (financially, etc)

User-pay principle for monitoring?
- research fund?
- Scotian shelf oil exploration has similar program
- What happened to SCI research budget from fixed link?

Universities have $100,000s equipment but no operating $
Community groups have a potential use for the equipment but no $$

Are appropriate resources being generated by licensing for fishing, etc?

LOCAL people must be involved in monitoring

Community groups
Lots of hand holding
- developing capacity
- ongoing support
- QA/QC
- Use of data
- Recognition of the data
- $$ (overhead)

A commitment is needed from the users of the BoF to monitoring
This must be regulated to ensure it is carried out

This generated data must also be publicly available
- central repository? Comme ACZISC?

Dissemination strategy is also needed in this process

What about protecting and restoring?
When something goes wrong – are the resources there to address the issue?

THIS MUST BE A PRIORITY!

Why monitoring? Why a baseline?
Industry says occurrence of an oil spill is based on probability
In reality, a spill will occur at the least probable time (poorest time, etc)

Cooperation between researchers and community monitoring is needed
Volunteer capacity is nearly saturated. A dedicated foundation is needed

Do the resources exist?

Question #5. What new kinds of information and approaches do we need to protect the health of the BoF?

A list of what is being done needs to be made
Existing programs should be reviewed (SCI?)
Approach protection thru an ecoregion approach?

Network of MPAs? – expand to include the coastal zone
- some limitations to MPAs: no restoration, no exclusion, etc

Biosphere reserve?

Significant large scale experimentation should be allowed
- more flexibility than lab-scale experiments

BOFEP to become the Champion/Coordinator of the BoF

Industry needs to be much more involved with BOFEP and other BoF initiatives
Communication with Industry is needed
Students must be involved

NOTE: There is a discontinutity between answers 1&2 and 4.
Those that have the information need a forum for providing it to the greater community AND receiving feedback for direction.

Stronger/more active **stewardship** initiatives are needed

Gov't agency mandates need to be streamlined and brought into coordination

- cooperative and focus

- mutually beneficial
- must buy into stewardship more completely

Participation and recognition from University Administrators and Research Administrators (NSERC) is an important component of moving these efforts forward.

Taking advantage of the retiring population to become more involved
- well situated
- healthy, etc

Take a more proactive approach to the Bay rather than reactive!
- **therefore planning is needed**
  - **by industry? – allow them to develop their plans**

More energy is needed to support these initiatives
e.x. BOFEP, Fundy Forum, Fact sheets, etc
Promotion as a fun organizations

Media has not been well engaged

Existing Regulatory agencies must enforce their existing regulations
Community must be behind the regulations in order to make them work.
- are we depending on a system that doesn't work?

Better understanding of assimilative cap./carrying cap is needed

Are BoF EIA applying the Precautionary Approach?

Appendix 6: Discussion Group D

Facilitator: Barry Jones
Rapporteur: Pat Hinch

The discussion of this group began with a review of participant perspectives on the health or condition of the Bay of Fundy. This was followed by a roundtable discussion to determine the common interests of the assembled group and a discussion on whether conditions in the Bay are improving or deteriorating. In the final session, the group responded to the original questions posed which were Question 4: Are there adequate resources to protect and restore the health of the bay? and Question 5: Needs – What kinds of new information and approaches do we need to protect the health of the bay?

1. a) What is the present health or condition of the Bay of Fundy ?
The group quickly realized that this is a difficult question to answer. It was agreed that the answer depends on whether we are considering the bay as a whole or in part as we may have a different response depending on whether we are dealing with an entire saltmarsh or just the sediment dynamics of a saltmarsh.

1. b) Common interests of the group.
As individuals with varying interests, each participant has their own reason for attending the workshop. The group agreed to explore their interests and to determine common issues, what resources are needed to further action on this issues and to develop a common vision of the health of the bay.

Each participant spoke of issues of concern to them within the Bay of Fundy as follows:

- concern for fate of the coastline in view of sea level rise and the need for hi resolution baseline mapping of the coastal zone, and flooding areas - do we want to map this as no one identified mapping of these issues for the coast?
- geological evolution of the bay, expansion of the tides, mapping of the ocean floor
- population change and ecosystem change and whether they are compatible
- saltmarshes - there is a need for coordination and standardization of sampling techniques, and communication on the development of a GIS framework. The health of the Bay is okay now but we must take action to protect the quality of the environment for the future. Some areas have deteriorated while other areas have shown change. Our focus should be on the maintaining the environment of the near shore and coastal area.
- health of the system - There are many stresses on the coastal ecosystem that we can identify but from an overall coastal health point of view, much saltmarsh has been lost especially in the upper bay where it has been converted to agricultural production. There is nothing to protect remaining saltmarshes from being lost.
- metal contamination - There is a preliminary indication of metal contamination in lobster. Is there a relationship between anthropogenic sources of metals and the levels of contamination

in lobster tissues ? Data from St. John harbour indicated that there is an anthropogenic link but not in the upper Bay.

- fish populations - There isn't enough fish to meet market demands.
- endangered species and concern over ecotourism industry pressure on whales.
- conflicting resource use - Relative to conflicting uses, how do we balance multiple uses to foster a healthy coastal environment. The bay has many stresses but we're not sure what that means in terms of ecosystem health. Future stresses could involve mining for aggregate which could impose an additional stress on the ecosystem. There is a need for integrated management.
- health of the bay - People aren't sure if the bay is healthy or not what it should be as opposed to what it is now.
- future scientific research - What research is required to improve the situation when we don't know what "optimal" health means.
- cyclic changes of weather (global) whether hypothesized or observed) and how changes will impact the ecosystem.
- Pedicodiac project - Gaps in information must be filled to complete the project. We have not seen the end of large scale engineering structures. New development will be needed along ditch lines.
- health of the bay and ecosystem processes as a whole opposed to individual organism studt eg. food webs; It is important if dealing withe management strategies that you understand how the bay works and we don't know how the bay works. We don't know anything about the benthos or what supports it.
- fishing practices - Fishing activities now scour the bottom resulting in loss of critical habitat.
- saltmarshes - how important is the saltmarsh ? By turning to forage crops, perhaps we could put the marsh to better use. There are maringal dykelands that could be turned into saltmarsh.
- local issues e.g. baitworm harvesting.
- human health - Shellfish coliform counts are high in areas of the bay. We don't know how bad the problems are and don't have a clear understanding of how the bay processes work.
- funding for research - We are trying to do engineering without physics. Resources could be made available from the community not university or government provided that community can be motivated to take action. Support for environmental protection should come from the people of the community and be heard by politicians. Politicians won't respond until they know that's what the people want.
- the larger picture - An inventory of international activities that impact the Bay of Fundy /Gulf of Maine, identified 90 issues of concern. This information is to be used to develop a strategic framework to guide future activities. There is a need to identify priorities in this area. The gathered list of issues is very broad and there is no consensus on priority areas of concern. There is a need to produce a comprehensive list of priorities for program manager consideration in Environment Canada. The health of the bay could be improved but we need to find

areas of interest and we need to develop a catalogue and prioritization process. Funds will then potentially flow to priority area. The national ecosystem initiative is under review as is ACAP funding. The original national program focussed on ecosystems within all eco regions but Environment Canada now wants to focus on the Bay of Fundy/Gulf of Maine.

- health of the ecosystem - It is difficult to know what the state of the health of the bay is at any point in time but a measure of health involves not only considering what the health of the bay was in years goneby but also how the bay has changed over time. For this we need funds for research into past history.
- diatom research - When we reach a point of understanding how the bay has changed over time, we will have looked back in time at diatom populations. Examinations of diatom populations provide a history of basic life origins and insight into the ancient rhythms of organisms of the bay.
- coastal habitat and wetlands and stewardship - eg Eastern Habitat Joint Venture works with landowners and the agricultural community to protect wetlands and to minimize their impact on wetlands.
- shellfish bed closure - Half of the shellfish beds are closed. Shellfish are an early warning species. We don't have much time to reverse trend. Anything we can do to reverse river contamination would be beneficial to the Bay of Fundy.
- scientific information –Much scientific data/information is not being used as oftentimes. People don't hear about what scientists are doing. We must write in such a way that people can understand scientific information but we must also distribute information broadly for people to receive it. We need to find a reliable medium to deliver the information.
- best available technology economically achievable (batea) - Where there is identified harm, we need to address the issue immediately. We can't wait for the last bit of information to be gathered to take action on pollution prevention.
- integrated management - We're not sure of the status of the health of the bay or how to measure it. There are local issues but we generally don't know how one part of the ecosystem interacts with another. There are data/information gaps in our knowledge. We need to address many specific problems but we also must look at the ecosystem from a holistic point of view. Economic, social, and environmental factors must be considered and therefore need to involve a broad range of expertise to be effective in making decisions on an ecosystem integrated management basis.
- coastal zone management policy - Several people in the group congratulated New Brunswick for the recent release of its coastal zone management policy. They noted however that application of the 30 m easement clause in NS would be difficult as NS doesn't have 30 coastline. Enforcement would bring hardship to those wanting to develop coastal property. It was suggested that 30 metres be replaced with a distance appropriate to NS and a similar coastal policy be adopted.

2. Are conditions improving or deteriorating? Does it matter if we don't have a perspective of the health of the Bay?

Environments naturally change and change is not necessarily bad. In some cases change is merely a shift or a readjustment. Examples of changes/indicators of change are as follows:

- contamination of shellfish; (heavy metals, e coli contamination)
- depletion of habitat
- contamination by industrial, municipal and agricultural waste – we are at the border of buffer capacity to handle stress and contamination eg. acid rain
- acceleration of sea level rise (natural or anthropogenic) - catastrophic to areas suffering now; negative impact on property values
- impacts and adaptation of climate change - how do we intend to deal with sea level rise retreat or build dykes ?
- changes to storms ; storm waves, storm surges; ocean temperature, mapping and classification of changes, - who will track changes ?
- increase pressure of development and movement of large numbers to coastal areas
- dyke building, - results in a restriction of how the natural environment responds to climate change ie. locks the ability of coastal areas to respond in a natural way

Indicators of change:

- sea ice and impact on coastal erosion
- erosion - alters the natural flow of sediment and restricts the ability of coastal area to respond to sea level rise. Erosion also results in the inability to identify critical areas (no good baseline topography)
- rates of change of land use patterns within the watershed of the Bay of Fundy -Records of land use change between 1960 and the mid-1980's provides a good baseline and starting point to begin assessment of change since that time period. However, there is no program in place now to inventory land use
- erosion rates - soil erosion rates relative to land use practices (primarily agriculture)
- trend toward creating wetland - how much wetland has come back ? An indicator of ecosystem health is the ability of an ecosystem to revert when dykes are now maintained and saltmarsh returns naturally
- climate change since 1600 -If we understand how climate has changed in the past, is this an indicator of how it change similarly in the future ?

3. Are conditions improving or deteriorating?

For the most part indicators of whether conditions are improving or not are value judgements. Work presented this morning by Inka Melewski and others, presented long term data to indicate deterioration of environmental quality. Unfortunately data is lacking on many issues. Not only should we be documenting changes in things we recognize as being economically important, we should be documenting changes in things that we don’t find economically important.

Indicators of improvement/deterioration are as follows:

- economically useful resource status
- level of contamination
- shellfish closures resulting from chemical or bacterial contamination
- number of dinoflagellates (as the result of importation of species or the result of different nutrients in the water)
- fisheries status indicators: salmon counts, gaspereau reports, herring fishery, flounder and dogfish fishery - declines in population numbers indicate a decrease in the health of the bay;
- fishery/ecological interactions - hypothesis: depletion of cod comes with an increase in dogfish; interactions are not simple
- marine environmental quality and freshwater quality
- change in biodiversity
- nutrients from rivers (do they have a positive or negative environmental impact ?)
- impact of agricultural practices, forestry practices, aquaculture, erosion, pollution, storm surges, flooding, on water quality, species response, and coastal zone health
- precipitation changes and their impact on landform
- air quality
- precipitation composition
- human health
- seafood quality
- social indicators – population changes, family incomes - what draws people to the coast to influence water quality?

Question 4: Existing resources – Are there adequate resources to protect and restore the health of the Bay?

a) Money - Essential to support coordination staff, data collection and special projects. There would seem to be a certain amount of public and private money available for our purposes, but most of it is not accessible due to different donor priorities and lack of BoFEP fund-raising capability. Community organizations must develop creative ways to access resources. Effective marketing is essential to funding success.

b) Expertise/Skills - These abound in both the public/private sectors and in the communities at large, but have not been prioritized/solicited toward our goals.

c) Governance/Regulations - The controlling mechanisms to address such Bay health issues appear to be adequate, but the enforcement of these is insufficient, and the fines do not fit the real costs of mitigation.

d) Data/Information - Much has been collected, but little is available for prac tical purposes. There must be standard means of monitoring, collection and reporting, and data should be appropriately interpreted, freely available and publicized.

e) Indicators/Monitoring - Many are possible, but more work must be done to evaluate the practicality and usefulness of them, and long-term commitment must be made for their support.

f) Commitment/Priorities/Action - For the most part, public support for Bay health appears to exist, but commitment for its priority and the mandated action among government-community-industry has not been adequately established.

g) Technology/Tools - These are essentially in place and adequate to the tasks at hand although weak in terms of essential resources.

h) Communication/Marketing - Typically the weakest link. Much has been done, but much more needs to be done. Linkages among all groups must be forged, and information must be presented in the most appropriate manner to each group, with appropriate follow-up. Our message must be clear and the media utilized effectively.

i) Partnerships/Infrastructure - These by and large exist in adequate measure, but will obviously continue to evolve to meet new challenges as they arise.

j) Volunteers/Training - Many volunteers are likely available to assist in bringing about our/community Bay health goals, although appropriate training and field resources are essential to do the task.

k) Champions/Contacts - Specific points of contact and goal-appointed responsible champions must be identified if tasks are to achieved. These are not clear or do not exist now.

l) Education - Public and school education should be paramount among our goals, so that current and future generations recognize Bay health as significant to their own health. School children should be given opportunity to participate in experiential environmental education programs. Teachers should be trained to lead these programs.

Question 5: Needs – What kinds of new information and approaches do we need to protect the health of the Bay?

a) Public/Private Partnerships/Participation - Newer, more clear relationships must be established to better address mutual goals, and communities must have greater participation in both the process and decision-making.

b) Participation Incentives - To encourage participation from all sectors, some forms of recognition/ endorsement incentives should be developed and applied on a regular basis.

c) Demonstration Projects - Specifically focussed research projects should reflect the ecosystem approach of our mission, goals and objectives and be set up as a demonstration project which provides opportunities for education and community involvement.

d) Data/Information Management - One of our greatest needs, and includes standardization, collection, interpretation, evaluation and distribution from multi-disciplinary sources in a timely manner. Should strive for all data to be year-round with have time and GPS references. Should include warehousing/ long-term storage, regeneration, logging and searchable databases.

e) Indicators/Baselines/Monitoring - Decisions must be made on the most appropriate indicators of Bay health, baselines must be established and monitoring programs implemented in order to evaluate possible trends and the effectiveness of our actions for subsequent planning purposes.

f) Mapping - Should be high resolution and include shoreline/coastal, habitats, watersheds, resources, land-use changes and exotics.

g) Surveys/Inventories - New data should include bathymetry/Lidar surveys, 2D and 3D for relief flooding and coastal areas, resource inventories and remote sensing.

h) Studies/Impacts - Research should include ecological interactions, microorganism information (natural history, evolutionary history) to understand the origins of life, and fishing gear and aquaculture impacts.

i) Management Options - There should be direct payback by impactors toward mitigation and restoration, and government should cancel their data /information cost recovery process.

j) Marketing/Education - New mechanisms of public education need to be brainstormed, developed and explored.

k) Science translation - Scientific information should be translated and communicated in a form that the public can understand, should be released in a timely manner, and be broadly accessible to the public.

Appendix 7: Coastal Forum Final Plenary Discussion

1. How do we measure change or how do we ensure change happens?

Comments:

- I don't think we are using our graduate programs fully. We could be putting them to better use. We should put forward a question from the workshop to students to research. We haven't talked about research needs. The centre for Geographic Studies could be in a position to assist. Use of graduate programs could rapidly become the norm.
- How much data is GIS'd? A small percentage is in GIS form but is rapidly increasing. This is an important tool for reference information. We need to collect geological and spacial data and knowledge and emphasize that data collection is crucial for GIS overlays for GIS to be useful.
- Funding is a key issue. The real problem is that once every 1-2 weeks a community has a problem and wants to talk about it and wants to establish a monitoring program but has no funding and no place to go for funding. In years goneby, there was competition for funding and it was difficult to obtain funds but there were funding sources available. With cutbacks there is no funding available. There is a lot of interest on the part of communities to become involved in programs, but we haven't empowered communities and we need the support of communities to engage government response to issues. Communities have the least amount of resources. A number of groups are well supported eg. ACAP but unless groups become empowered they can't take action to generate support for issues and we can't move ahead.
- Not many groups have coordinators and this is the key to success. Others have no benefits and are only funded on a short-term year to year basis after which time they start again from square one.
- Funding and support has been available for decades for ocean dumping and ocean pollut8ion research. There was a time when people concerned with ocean pollution received action by involving womens' issues and objectives in their programs. This inclusion received the attention of US Congressmen which lead to the development of ocean dumping and marine debris legislation.
- Funding is needed to precipitate action. Effort must be placed into education, increasing awareness for action on environmental issues. We need to make enough people consciously aware of the issues to make progress. Progress takes time but there has been progress on a number of issues eg. water issues are now commonly known to have an impact on the economy and have become a priority area for GPAC and many other organizations.
- We should spend time organizing conferences which involve the media. Our inability to attract media attention and involvement in Bay of Fundy issues is deplorable. We need to get media on side ie. to get their attention. Political and management responsibilities are crisis driven. The media is inaccessible and so unfortunately we almost need a crisis to draw attention. We need to take the necessary time to cultivate those we want to engage. It was noted

during this conference and in others, that key government leaders do not have time to stay for the full workshop. We ought to request that they stay and participate in the workshop and experience the process.

- The coastal flooding issues could attract media attention as well as to other issues if we used a visual medium. A summary list or report card of issues and a matrix on the Bay of Fundy prepared by community organizations taken to the public could bring media attention.

2. How many would be comfortable with us publishing the table we have produced for public distribution and media use?

- Electronic questions should be included in the information for the public as well as references from which the data was derived.
- The idea is excellent but there is not enough time remaining in the workshop to finalize the table and not all workshop participants were involved in developing the tables as they had to leave early.
- If media are to be involved in a workshop such as this they need to be able to walk away with something.
- We have made a good start with the matrix but the most appropriate people to make the decisions in response to matrix questions, have not necessarily been involved in this process.
- I am surprised that more issues have not been included in the matrix. We need to engage experts on the issues listed and to ask them to add other issues that may be missing.
- We have reached an overall concensus on indicators of greatest concern to scientists. We should match matrix issues with stressors presented in the workshop report. Perhaps a report on the state of the environment would provide an idea of funding required for further investigation and research of the issues.
- Why not plan a two day meeting to develop the report (define issues, processes and tasks, next steps) to serve as a guide allowing us to move forward? We need a process by which to make informed judgements and to measure progress.

3. Is this process is a good one or are improvements required? Is this a useful process for the Gulf of Maine as a whole?

- I encourage the report idea but am unsure about the matrix. The concept of a GIS map involving experts to fill in the layers of information, is a good suggestion.
- This has been a valuable process. To work effectively in watershed areas, we need to have an open dialogue and to encourage the input of communities as we have seen here.
- This is not the appropriate forum to produce a report card. I challenge scientists within this room to produce a report card for publication and distribution to the public and the media

and to develop a communications strategy which outlines how we more effectively engage the media.

- The more we bring people together, the better we are able to deal with the Bay of Fundy as an ecosystem. We must not forget that the Bay of Fundy is an international body of water linked with the US. We have a stewardship responsibility and need to make more people aware of the issues both externally and internally.

4. Are you glad you came to the workshop? Has this been an effective process? (Resounding Yes).

Other reports in the Series:

Report No.

1. St Pierre, R., T. A. Clair, W. Prescott and C. Staicer eds. (1993) Atlantic Maritime Ecozone Research and Monitoring, Workshop Proceedings, March 1993, 43pp. (out of print)

2. Allen Y., T. A. Clair, C. Drysdale, H. Hirvonen, J. Kerekes eds. (1993) Ecological Monitoring and Research at Kejimkujik National Park, 1978-1992, 57 pp. (out of print)

3. Staicer, C. A., M. J. Duggan and J. J. Kerekes eds. (1994) Kejimkujik Watershed Studies: Monitoring and Research Five Years after "Kejimkujik '88", Workshop Proceedings, Kejimkujik National Park, October 20-21, 1993, 276pp. (out of print)

4. MacKinnon, B. M. and M. D. B. Burt eds. (1994) Ecological Monitoring and Research in the Coastal Environment of the Atlantic Maritime Ecozone, Workshop Proceedings Huntsman Marine Laboratory, March 9-11, 1994, 260pp. (out of print)

5. Elliott, R. D. and P. Chan eds. (1995) Ecological Monitoring and Research in Atlantic Canada: A Focus on Agricultural Impacts in Prince Edward Island, Workshop Proceedings, 77pp.

6. Shaw, R. W. ed. (1996) Science and Policy Implications of Atmospheric Issues in Atlantic Canada, Workshop Proceedings Halifax, N.S., November 28-30, 1995, 143pp.

7. Erskine, A. J. (1997) Canada Goose Studies in the Maritime Provinces 1950-1992, 179pp.

8. **Percy, J. A., P. G. Wells, A. J. Evans eds. (1997) Bay of Fundy Issues: a Scientific Overview, Proceedings of a Workshop, Wolfville, N.S., January 29 to February 1, 1996, 191pp.**

9. Shaw, R. W. ed. (1997) Climate Change and Climate Variability in Atlantic Canada, Proceedings of a Workshop, Halifax, N.S., Dec. 3 to 6, 1996, 348pp.

10. Clair, T. A., J. Pomeroy, A. Bouchard, A. Ouellet, R. Cook, C. McCarthy and K. Robinson (1997) Trends of Acid Precipitation Chemistry Variables in some Atlantic Canada National Parks, 56pp.

11. Shaw, R. W., and M. M. E. Danks eds. (1998) Using Environmental Prediction in Ecosystem Science in Atlantic Canada, Workshop Proceedings, Halifax, N.S. 132pp.

12. **Ollerhead, J., P.W. Hicklin, P.G. Wells and K. Ramsey eds. (1999)Understanding Change in the Bay of Fundy Ecosystem. Proceedings of the 3rd Bay of Fundy Science Workshop, Sackville, NB, April 22-24, 1999, 143pp.**

13. Clair, T. A. (2000) Climate Change and Ecosystem Research in Canada's North, A report to the Northern Ecosystem Initiative Management Team (english/francais), 115pp.

14. Clair, T. A. et al. (2000) Acid Precipitation Lake Monitoring Program in Canada's Atlantic Provinces. (Report in CDROM format)

15. O'Driscoll, N., A. Rencz, and T. A. Clair eds. (2000) Multi-disciplinary Study of Metal Cycling, Primarily Hg, in Aquatic and Terrestrial Environments, Workshop Proceedings, Sackville, NB, 55pp.

16. Clair, T. A. et al. (2001) Environment Canada's Acid Precipitation Monitoring Networks in Atlantic Canada Version 2. (Report in CDROM format)

17. **Chopin, T. and P. G. Wells eds. (2001) Opportunities and Challenges for Protecting, Restoring and Enhancing Coastal Habitats in the Bay of Fundy. Proceedings of the 4th Bay of Fundy Science Workshop, Saint John, NB, Sept. 19-21, 2000, 237pp.**

18. Driscoll, N., T.A. Clair and A. Rencz eds. (2001) Cycling of mercury in Kejimkujik National Park. Toxic Substance Initiative Projet /124 Summary, December 2001, 93pp.

19. Leblanc, C., D. Bliss and B. Burrell eds (2002) Petitcodiac River/Estuary Modelling Workshop Summary-Sommaire de l'atelier sur la modélisation de la rivière Péticodiac et de son estuaire, Moncton, March/mars 2002, 98pp.

20. Clair, T. A. ed. (2002) Atlantic Canada National Park Aquatic Resources Inventories: Kejimkujik and Gros Morne Republished from: J. Kerekes and P. Schwinghamer. (CDROM format)

21. **Wells, P. G., G. R. Daborn, J. A. Percy, J. Harvey and S. J. Rolston eds. (2004) Health of the Bay of Fundy: Assessing Key Issues: Proceedings of the 5th Bay of Fundy Science Workshop and Coastal Forum, "Taking the Pulse of the Bay", Wolfville, NS, May 13-16, 2002, 402pp.**

22. Curry, A. and T. A. Clair (2004) Lakes of southwestern New Brunswick: Summary of existing data/ Lacs du sud-ouest du Nouveau Brunswick: Résumé des données existantes, 2004. (CDROM format Cédérom)

23. **J. A. Percy, A. J. Evans, P. G. Wells, and S. J. Rolston. (Eds.). 2005. The Changing Bay of Fundy—Beyond 400 Years. Proceedings of the 6th Bay of Fundy Workshop, Cornwallis, Nova Scotia, September 29 – October 2, 2004. Environment Canada–Atlantic Region, Occasional Report No. 23, Environment Canada, Dartmouth, Nova Scotia and Sackville, New Brunswick, 480 pp. + xliv.**

24. Dennis, I.F., Carter, L., Ouellet, A.J., Ro, C.-U., Clair, T.A. Acid precipitation monitoring networks in Atlantic Canada: Update 1982-2003. Occasional Report No. 24, Environment Canada, Sackville, New Brunswick, Canada. (CDROM format)