

Gulf of Maine State of the Environment Reporting Scoping Document

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Executive Summary

The Gulf of Maine Council on the Marine Environment has recognized the importance of state-of-the-environment (SOE) reporting as a management tool. Although participating members are individually taking steps to catalogue the collective understanding of the Gulf of Maine and there are many fine examples of reports that address aspects of a state-of-the-environment report (SOER), there is currently no Gulf-wide synthesis of pressures on the environment, biophysical and socio-economic status and trends, and responses to identified issues.

The aim of this scoping document is to propose a reporting framework for SOE reporting for the Gulf of Maine. The intent is to produce a “straw dog” for discussion by the Council’s Working Group. This document:

- Presents an overview of SOE reporting and identifies some of the challenges;
- Summarises some of the reporting requirements for the Gulf of Maine, identified through available literature and interviews with Working Group, Council and ESIP members;
- Provides a brief overview of some aspects of information requirements and availability, and
- Proposes an approach to develop a SOER for the Gulf of Maine.

The main objective of a SOER for the Gulf of Maine would be to inform decision makers on the main issues affecting the Gulf. The aim would be to provide the information in a form that is easily accessible and readable, without compromising scientific validity. Through the 2006/7 listening sessions (Della Valle 2006) and 2009 interviews with Working Group, Council and ESIP members it was identified that the SOER report should:

- Describe pressures on the ecosystem and societal responses to those pressures;
- Focus on those issues that had already been identified as priorities;
- Discuss regional indicators including measures of societal response, where available;
- Evaluate the health or state of the Gulf measured against specific goals and threshold responses;
- Have a flexible format that allows updating and does not place too much pressure on limited resources;
- Include the historical context, if possible, in the form of anecdotal information and case studies;
- Clearly delineate the boundaries of the area or issue being reported, and
- Adopt new methods of accessing and using information.

SOE reporting should be guided by a conceptual framework that facilitates development of information and makes the linkages between the environment and socio-economic factors. The reporting framework recommended for SOE reporting in the Gulf of Maine is the driving forces-pressure-state-impacts-response (DPSIR) framework. This framework lends itself most easily to reporting on an issue-by-issue basis, so that the pressures, state, impacts and responses are described for each issue in turn.

The recommended SOE reporting system will be comprised of three main components:

- A **modular SOER** that can be readily updated as required (formal SOE document). This will include a context document and a series of theme papers. The context document will be a relatively static document that provides an overview of the Gulf of Maine. The information provided in this document will be the type of information that rarely changes, such as the boundaries of the area under discussion, the size of the watershed, history of the watershed, etc. It may also address the current management structure of the Council and related organisations.

The theme papers will provide an evaluation of priority issues. The intention is that the theme papers can be regularly updated at a time interval appropriate for each issue, without having to update the rest of the SOER. This complements the incremental approach for indicator development that is currently being taken by ESIP (Mills 2006). The titles for theme papers will need to be decided by the Working Group.

- **Wiki site** that allows for informal reporting on SOE by interested parties. The Gulf of Maine has numerous interested parties undertaking various initiatives, often generating information at a local level that is generally not reported in SOERs, except in the form of case studies. For the Gulf of Maine, there may not be resources to capture all this work in the form of theme papers, although some is captured by the Gulf of Maine Times. Many of these initiatives are aimed at meeting the goals outlined in the 2007-2012 Action Plan and it would be valuable to have these documented in some form that does not place an unnecessary financial burden on the Council and its members. The recommended approach is to establish a wiki for the Gulf of Maine that anybody with an interest (and a story) can contribute to.
- **SOER web portal** that provides linkages to other products and initiatives. This would be a mechanism to deliver the SOER and the wiki. The Council already hosts a website that provides ease of access to documents for members and the public alike, and a SOE portal can easily be attached to the current web structure. It should provide access to all SOE-related documents, including the formal SOER and the Gulf of Maine wiki. There is also potential to link to sites that are related to the SOE initiative, e.g., the ESIP site and Gulf of Maine Times.

Much of the information required for a SOER is already available in a variety of publications. The main challenges to developing a SOE reporting system are:

- Funding and human resource capacity. The project will require some dedicated funding to initiate and maintain the SOE reporting system. Long-term commitments will include maintenance of the web portal and moderation of the wiki site.
- The SOE reporting process requires ongoing commitment from the Council. The Council will need to take ownership of the process; however, member organisations should be willing to assist with the various aspects of initiating the SOER process.
- Data compatibility across jurisdictions makes Gulf-wide comparisons more difficult. However, SOE reporting does not necessarily require compatible data sources; rather it requires the ability to report in the current state using the various information sources in a cohesive manner.

1 Introduction

The Gulf of Maine Council on the Marine Environment was established in 1989 as a regional entity with the mission to “maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations” (GOMC 2007). Since then the Council and its members have supported numerous initiatives, ranging from bi-national actions to local projects, to improve water quality, conserve land, restore coastal habitats, and enable citizens to be better stewards of the environment around them.

More recently, the Council has recognized the importance of state-of-the-environment (SOE) reporting as a management tool. The *Gulf of Maine Council on the Marine Environment Action Plan 2007-2012* (GOMC 2007) puts forth several goals, of which one goal, “coastal and marine habitats are in a healthy, productive and resilient condition”, will require SOE reporting. According to the Plan, the Council needs to “respond[e] to managers’ needs for state-of-the-environment reporting and ecosystem indicators” (GOMC 2007, p. 22). The Council has also adopted the strategy for indicator development and SOE reporting developed through the Gulf of Maine Ecosystem Indicator Partnership (ESIP), and outlined in the document *A Strategy for Gulf of Maine Ecosystem Indicators and State of the Environment Reporting* (Mills 2006).

Participating members are individually taking steps to catalogue the collective understanding of the Gulf of Maine (e.g., Ecosystem Overview Report, Northwest Atlantic Bioregional Assessment, ESIP, etc.), and there are also many fine examples of reports that address aspects of a state-of-the-environment report (SOER) (e.g., Pesch and Wells 2004; ACZISC Secretariat and Dalhousie University 2006; New Hampshire Estuaries Project 2006; Wake *et al.* 2006; Taylor 2008). Despite this, there is currently no Gulf-wide synthesis of pressures on the environment, biophysical and socio-economic status and trends, and responses to identified issues.

The aim of this scoping document is to propose a reporting framework for SOE reporting for the Gulf of Maine. The intent is to produce a “straw dog” for discussion by the Council’s Working Group. This document:

- Presents an overview of SOE reporting and identifies some of the challenges;
- Summarises some of the reporting requirements for the Gulf of Maine, identified through available literature and interviews with Working Group, Council and ESIP members;
- Provides a brief overview of some aspects of information requirements and availability, and
- Proposes an approach to develop a SOER for the Gulf of Maine.

2 State of the Environment Reporting

2.1 Overview

In the past two decades the concept of *sustainable development* has been promoted as the most appropriate approach to achieving long-term security for humans. Sustainable development has been defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987) or “improving the quality of life while living within the carrying capacity of supporting ecosystems (Monro and Holdgate 1991). The term *sustainable development* describes an intended approach to development that provides solutions to all current and future social, economic and environmental problems (e.g., poverty, disease,

unemployment, violence, environmental pollution and loss of biodiversity). In essence, sustainable development refers to a kind of development that aims for equity within and between generations, and adopts an approach where the economic, social and environmental aspects of development are considered in a holistic fashion (Figure 1).

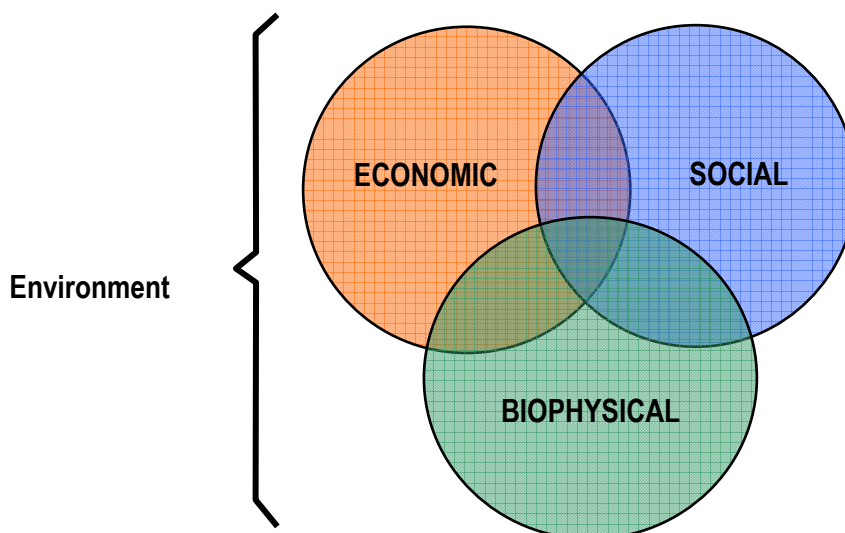


Figure 1: Inter-linkage between the three recognised aspects of sustainability.

In 1992, Agenda 21 identified the need for environmental reporting to support sustainable development. In particular, Agenda 21 stated that “[s]pecial emphasis should be placed on the transformation of existing information into forms more useful for decision-making and on targeting information at different user groups. Mechanisms should be strengthened or established for transforming scientific and socio-economic assessments into information suitable for both planning and public information”. Since then numerous regional, national and local efforts have been made to compile SOERs (see <http://www.grida.no/>).

The two main purposes of SOERs are to foster the use of science in policy- and decision-making and to report to the public on the condition of the environment (Environment Canada 2009). A SOER report should: provide a comprehensive analysis of environmental conditions and trends; measure progress towards sustainability; contribute to informed and open decision-making; contribute to public awareness about environmental health and what can be done about it; and serve the public's right to know by providing scientific information about the environment in an easily understandable form (BC Government 2009).

In general, SOERs attempt to answer five key questions (Environment Canada 2009):

- What is happening in the environment (i.e., what are the environmental conditions and trends)?
- Why is it happening (i.e., how are human activities and other stresses linked to the issue in question)?
- Why is it significant (i.e., what are the ecological and socioeconomic effects)?
- What is being done about it (i.e., how is society responding to the issues through government and industry action and voluntary initiatives)?
- Is this sustainable (i.e., are human actions depleting environmental capital and causing deterioration of ecosystem health)?

Successful preparation of SOERs is reliant on existing knowledge and information. The SOER process often brings together data and information that was previously available, but fragmented. The process also needs to take advantage of ongoing monitoring and research, and should seek to establish ongoing partnerships in data and information collection and sharing.

2.2 Key Challenges for State of the Environment Reporting

There are several challenges in producing a SOER. These include (Walmsley 2009):

Meeting expectations – Due to several challenges, the expectations of all the target audiences for a SOER are rarely met, and few SOERs have been able to satisfy the requirements of all audiences. SOERs should not be regarded as a one-off product, but rather as a regular feature of a long-term, ongoing process aimed at progressively understanding the environment and its management. Each SOER provides a snapshot of current understanding, and there is a need to identify and manage stakeholder expectations in the production of each SOER.

The level of detail and comprehensiveness – Many SOER processes have been aimed at producing comprehensive, detailed reports that require numerous resources (human and financial) to complete. It is now recognised that a more balanced approach, which focuses on the most important themes or issues, is appropriate.

Defining the target groups – Many SOER related products have not met the expectations of stakeholders mainly because target groups were not adequately profiled or interacted with before production. There is a need for consultation in the process of developing SOERs, and the target group needs to be precisely defined and their expectations identified.

Specialist versus generalist approach – SOERs can become adversely influenced if there is too much focus on a specialist approach (detail and opinion) as opposed to a generalist (writing and facts) approach. There is a need for balance.

Processing and management of information – The most frequent limiting factor for SOER production is the availability of relevant and suitable information. For example, the time taken to process primary data can often hamper progress and production dates. It is often more appropriate to pick the “low-hanging fruit” when it comes to selecting information for SOERs by using information that is readily available. The SOER process should also be seen as an opportunity to identify gaps in information.

Structure and format of the SOER – the structure, format and content of any SOER depends on the objectives of the document and its intended uses. There are a variety of approaches to developing a SOER, such as an issues-based (thematic) approach, a logical framework analysis (see <http://www.gdrc.org/ngo/logical-fa.pdf>), or the cause-effect-response approach (see Shah 2000). Likewise a SOER can be produced in a variety of formats (e.g., document, web-based). It is important to develop the structure and format prior to beginning any drafting.

Indicators – All SOERs are dependent on the use of indicators (qualitative and quantitative). In many cases SOERs can get sidetracked because of the time and focus devoted towards the selection of “ideal” indicators, rather than the presentation of readily-available information. Many SOERs are a compilation of readily available information and the development of indicators is an iterative process.

3 Reporting Requirements for the Gulf of Maine

Identification of reporting requirements is an important step in the development of a SOER. For the Gulf of Maine, previous literature that outlined some of the user requirements was used; in particular, the *Final Report of Listening Sessions and Evaluation of the Tides of Change Report* (Della Valle 2006) prepared for ESIP was a valuable resource. In addition, several members of the Council, the Working Group and ESIP were interviewed with respect to reporting requirements for the Gulf of Maine, and possible ideas for the future SOER.

3.1 Target Audience

In compiling a SOER, it is critical that the target audience be identified. This allows the document or products to be customised to accommodate their needs and requirements. The *Gulf of Maine Council on the Marine Environment Action Plan 2007-2012* (GOMC 2007) identifies eight primary target audiences for the work of the Council: premiers and governors; coastal lawmakers; coastal decision-makers; coastal managers; academics; Gulf residents and visitors; marine-dependent industries and the science community. It stands to reason that the main target audience for the Gulf of Maine SOER would be a subset of these.

The listening sessions undertaken in 2005 and 2006, under the auspices of ESIP (Della Valle 2006), indicated that the most important audiences for reporting purposes generally fell into the first four categories: premiers and governors; coastal lawmakers; coastal decision-makers, and coastal managers. This was confirmed during interviews with the Working Group during the writing of this scoping document. Thus the primary target audience for the SOER should be decision makers (government and industry) within the Gulf of Maine watershed.

There was also some comment from Working Group members that the general public should be considered as a target audience, particularly due to their ability to influence coastal policy- and decision-makers. Targeting a specific audience does not preclude other users making use of any SOER products. If the products are well written and presented, they should also be of value to a wider audience than the target audience. Thus, despite the primary target audience being decision-makers, the public should also be able to make use of the Gulf of Maine SOER..

3.2 Objectives and User Needs

The main objective of a SOER for the Gulf of Maine would be to inform decision makers on the main issues affecting the Gulf. The aim would be to provide the information in a form that is easily accessible and readable, without compromising scientific validity.

Della Valle (2006) identified user needs for a future SOER for the Gulf of Maine as part of the 2005/6 listening sessions. These sessions were complemented by the interviews of Council, Working Group and ESIP members in 2009. The following were identified as important aspects of a SOER:

- The report should describe pressures on the ecosystem and societal responses to those pressures. The report should discuss efforts to address ecosystem health concerns and concrete actions to maintain or improve conditions.

- During the interviews in 2009 (for this scoping document), there was an overwhelming response that the report should focus on those issues that had already been identified as priorities. However, this does not preclude identifying and understanding some of the emerging issues that may impact the future of the Gulf of Maine, nor does it limit the SOER to those issues.
- To provide commonality in reporting, the SOER should discuss regional indicators including measures of societal response, where available. There has already been considerable effort by ESIP to develop indicators for the six focal areas, i.e., climate change, fisheries and aquaculture, coastal development, eutrophication and aquatic habitats. The climate change and eutrophication sub-committees of ESIP expect that indicator fact sheets will be available by summer 2009.
- Where possible, evaluation of the health or state of the Gulf should be tied to specific, measurable goals and threshold responses should be identified. The *Gulf of Maine Council on the Marine Environment Action Plan 2007-2012* provides three overarching goals that the SOER should address as appropriate (GOMC 2007):
 - Coastal and marine habitats are in a healthy, productive and resilient condition;
 - Environmental conditions in the Gulf of Maine support ecosystem and human health;
 - Gulf of Maine coastal communities are vibrant and have marine-dependent industries that are healthy and globally competitive.
- The reporting system should be flexible. In the mid- to late 1990s, when many countries were developing their first SOERs, a comprehensive approach was used to develop them. This took vast resources (time, human and financial) and few of these have been updated in the same format since. Since the aim of SOERs is to monitor trends over time, a more appropriate approach, which allows updating and does not place too much pressure on limited resources, is required.
- The historical context should be provided in a SOER if possible. This may be in the form of anecdotal information, which may also be considered to be as important as quantitative information. Case studies can play an important role in SOE reporting, particularly to tie the issues into the lives of the people living in the Gulf of Maine region.
- The boundaries of the area or issue being reported on should be clearly delineated in the SOER. Although the physical boundaries of the Gulf of Maine and its watershed are fairly well defined, the areas of influence or impact surrounding a particular issue may change according to the issue.
- Consideration should be given to new methods of accessing and using information. For instance, if appropriately formatted, younger generations of people are far more at ease reading information from a screen rather than hardcopy, and accessing data over the internet.

4 Recommended Reporting Framework and Products

4.1 Reporting Framework

An important principle in SOE reporting is that it be guided by a conceptual framework that facilitates development of information and makes the linkages between the environment and socio-economic factors. Such a framework should bring order and convergence to the structure of the presentation and analysis of SOE information (NETCAB 1999). The framework recommended for use in SOE reporting for the Gulf of Maine is the Driving Forces-Pressures-State-Impacts-Response (DPSIR) framework. The DPSIR framework is viewed as providing a systems-analysis view of the relation between the environmental system and the human system (Smeets and Weterings 1999). According to this framework, social and economic developments and natural conditions (driving forces) exert pressure on the environment and, as a consequence, the state of the environment changes. This leads to impacts on human health, ecosystems and materials, which may elicit a societal response that feeds back on all the other elements (see Figure 2). Although the DPSIR framework was developed as an extended cause-effect-response model, the framework is most useful in describing the origins and consequences of environmental problems.

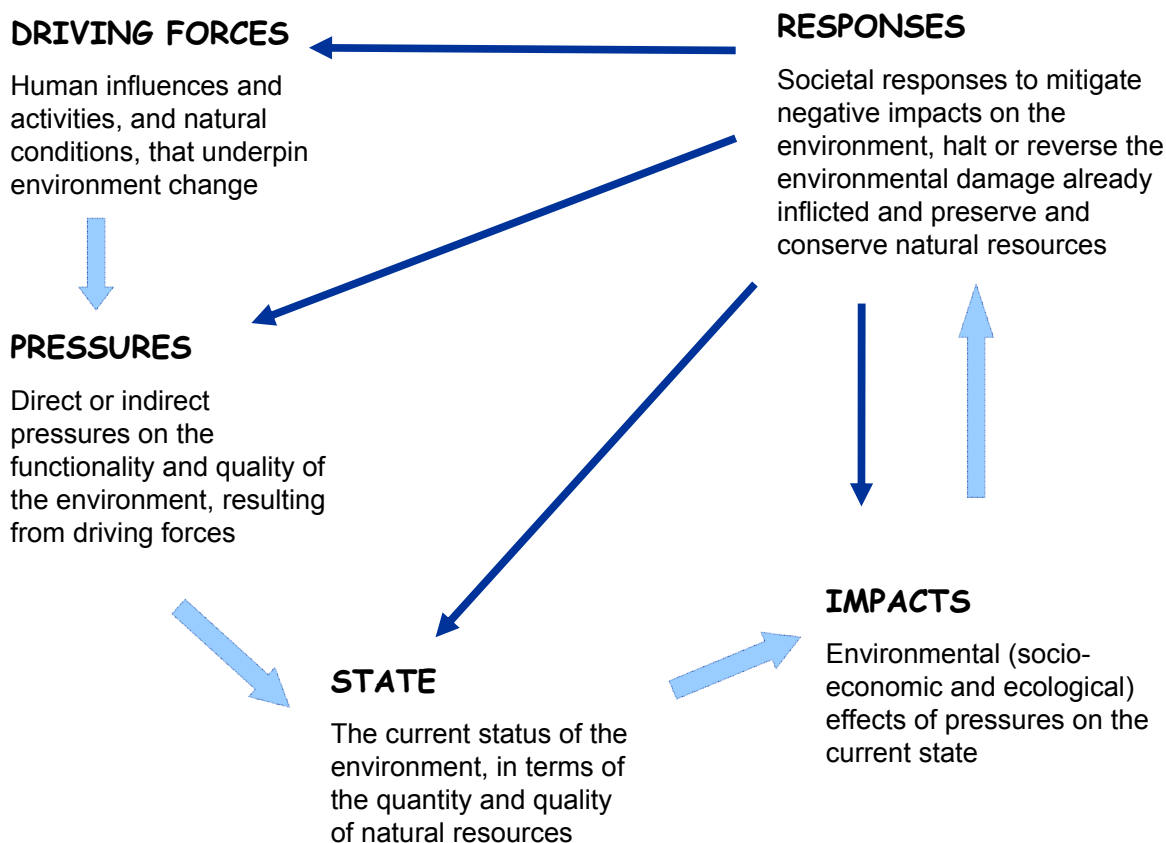


Figure 2: Inter-relationships between the components of the DPSIR reporting framework.

This framework lends itself most easily to reporting on an issue-by-issue basis, so that the pressures, state, impacts and responses are described for each issue in turn. When this approach is used, it does not really matter where you start reporting. The starting point should generally reflect the point you would like to emphasize most. In this way, the environmental issues are given prominence as the issues of concern, and the human influences are highlighted as causes, and effects of environmental conditions. By using the framework, the relationship between humans and the natural environment is seen to be more integrated, and sustainable development needs and actions are clearer to the reader.

Figure 3 provides a DPSIR analysis for the Gulf of Maine, providing an indication of some of the aspects that could be included in the SOER.

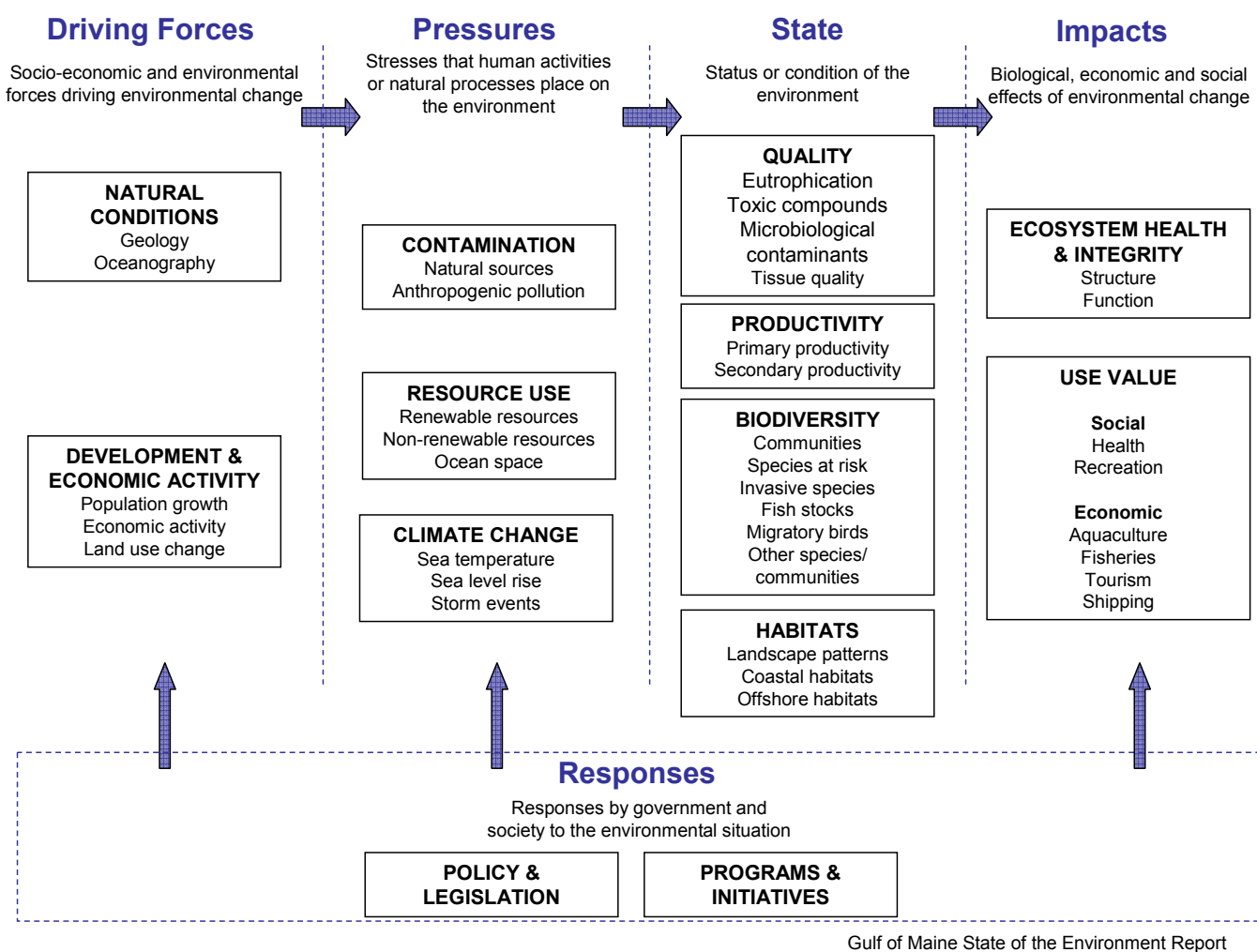


Figure 3: DPSIR Analysis

4.2 Products

SOE reporting does not necessarily result in a single product. In fact the current trend is for a SOE reporting system or process to be established that allows flexibility of use and links to a variety of initiatives that are SOE related. It is recommended that a similar approach be taken in the Gulf of Maine, with the following as products of the SOE reporting system:

- Modular SOER that can be readily updated as required (formal SOE document);
- Wiki site that allows for informal reporting on SOE by interested parties, and
- SOER web portal to be used as a communication tool, and that provides linkages to other products and initiatives.

A description of these products is provided below. It should be noted that not all off these products need to be developed immediately or simultaneously.

4.2.1 State-of-the-Environment Report

The formal SOER is envisaged as a modular document. It will include (see Figure 4):

- An upfront section or “context document” that provides the background and context to the Gulf of Maine, and
- A series of fact sheets or theme papers that focus on priority areas of the Council or its members.

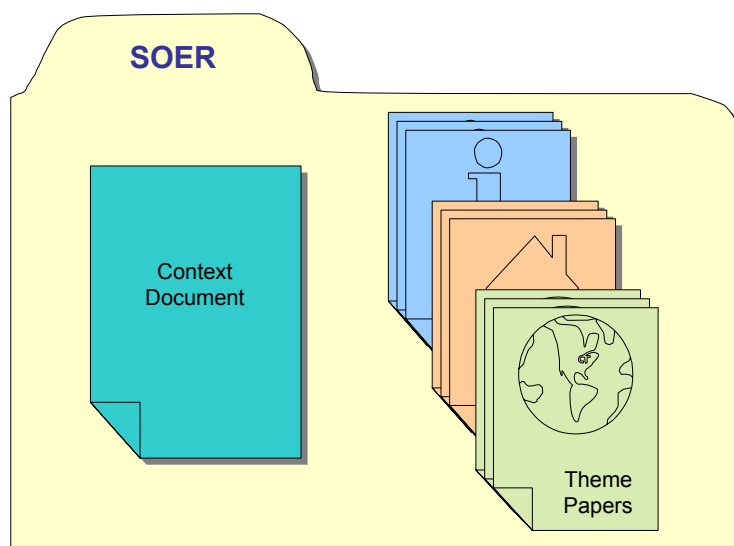


Figure 4: Gulf of Maine SOER Structure.

The context document will be a relatively static document that provides an overview of the Gulf of Maine. The information provided in this document will be the type of information that rarely changes, such as the boundaries of the area under discussion, the size of the watershed, history of the watershed, etc. It can also provide an overview of the driving forces (i.e., natural conditions and macro-economic and social conditions – see Figure 3). It may also address the current management structure of the Council and related organisations.

The theme papers will provide an evaluation of priority issues that are of interest in the Gulf of Maine. The intention is that the theme papers can be regularly updated at a time interval appropriate for each issue, without having to update the rest of the SOER. This complements the incremental approach for indicator development that is currently being taken by ESIP (Mills 2006). Because the theme papers will be part of the formal reporting mechanism for the Gulf, their structure will be formalised, based on the reporting framework discussed in Section 4.1. In addition, it will be critical that they are compiled in such a way that they take into consideration the user needs discussed in Section 3.2. The theme papers will be readable and concise, and could include the following (as appropriate):

- A summary of the issue in brief, including how the issue relates to GOMC goals and the DPSIR framework;
- Driving forces and pressures;
- Current status and trends;
- Impacts (ecological and socio-economic);
- Actions and responses;
- Indicators, information and data gaps;
- Linkages to other theme papers, and
- Case studies as required.

A sample theme paper on sea level rise has been drafted as an example of what one could look like and is presented in Appendix 1. This example should be considered a “mock up” theme paper. Although the data and information provided in the paper are from referenced sources, it may not be the latest available information.

4.2.2 Gulf of Maine Wiki

The Gulf of Maine has numerous interested parties undertaking various initiatives at different levels. Often the information generated by these initiatives is at a local level that is generally not reported in SOERs, except in the form of case studies. In the case of the Gulf of Maine, there may not be resources to capture all this work in the form of theme papers, although some is captured by the Gulf of Maine Times. Many of these initiatives are aimed at meeting the goals outlined in the 2007-2012 Action Plan and it would be valuable to have these documented in some form that does not place an unnecessary financial burden on the Council and its members. The recommended approach is to establish a wiki for the Gulf of Maine that anybody with an interest (and a story) can contribute to.

A wiki is a web page that anyone can edit. It exists as a tool for collaborative content creation and is designed to allow multiple authors to add, remove and edit content (text and graphics) (Government of Canada 2009). Wikis have been a dominant web-based collaboration tool for several years, have seen service in many environments and have been customised for many tasks (Government of Canada 2009). The best example of a wiki is *Wikipedia*, the online encyclopaedia (see <http://www.wikipedia.org/>).

Wiki is a Hawaiian word meaning “quick”. Wikis and the software supporting them are designed so that content can be made available quickly and easily. By its very nature a wiki sees the author and the audience participant as the same thing, and it is the exception rather than the rule that an audience member will only have read access to the wiki. The multiple author capability of a wiki makes it an effective tool for mass collaborative authoring. Wikis allow anyone to edit pages, but keep a complete track of version history. As such it is easy to compare differences across versions and to roll back changes. While it seems counterintuitive, this opening up of editing capability to everyone typically allows the best possible quality content to emerge. Where people spot something they believe to be incorrect

they can fix it immediately, rather than going through a lengthy editorial process. Advantages and disadvantages are listed in Table 1 below.

Table 1 Advantages and disadvantages of using wikis (adapted from Government of Canada 2009)

Advantages	Disadvantages
<ul style="list-style-type: none"> • Encourages collaborative document creation and sharing, as articles are created by the community through collaboration. • Facilitates the creation of a shared knowledge base. • Broadens participation and reach and builds horizontal community, particularly where people are separated geographically and where relationship-building is important. • By linking together stakeholders that would not otherwise connect and communicate, it becomes possible to harness learning and knowledge, leading to a greater capacity for innovation and organizational agility. • Allows the creation of unique content. The content is typically not the type to be found on intra- or internet sites. • Fosters innovation and the development of new ideas. • Makes use of expertise that may otherwise not be available (e.g., may harness traditional knowledge). • Wiki pages are dynamic (new articles added continuously) and content appears instantaneously. • Changes to the text are attributed to the author(s). • Reduces document version conflicts. Previous versions are archived and it is easy to revert to a previous version if required. • Wiki formatting syntax is easy to learn. • Content of pages can be semi-protected to protect pages from vandalism or violations of content policies by anonymous users. 	<ul style="list-style-type: none"> • All members can add or edit the work of others and disputes may arise. • Difficult to cite as an "authoritative source". • It is a challenge to keep content and links current (similar to websites and blogs). • Scientist or others who wish to publish their data in more formal reports may not wish to share data on a wiki. • Concerns about copyright for some people.

4.2.3 SOE Web Portal

The SOE web portal would be a mechanism to deliver the SOER and the wiki. The Council already hosts a website that provides ease of access to documents for members and the public alike. A SOE web portal can easily be attached to the current web structure. It should provide access to all SOE-related documents, including the formal SOER and the Gulf of Maine wiki. There is also potential to link to sites that are related to the SOE initiative, e.g., the ESIP site and Gulf of Maine Times.

Examples of SOE reports that use this mechanism to report on the environment are the Norwegian State of the Environment Report (see <http://www.environment.no/>) and the South African State of the Environment Report (see <http://soer.deat.gov.za/frontpage.aspx?m=2>). Appendix 2 shows the structure of these two websites. Both of these web portals use a modular approach to SOE reporting, with issues addressed as "topics" or "themes". They also both have links to indicators and to maps. The Norwegian site also has links to important databases, and the South African site includes sections on the driving forces of environmental change and on emerging issues. Both sites provide links to key reports of current interest.

4.3 Proposed Content of the State-of-the-Environment Report

This section focuses on the content of the SOER itself rather than the wiki site, the content of which is not yet determined. There are several considerations to be taken into account when developing the content of the SOER. These include:

- What should be included in the context document?
- How many theme papers should there be and what should they focus on?
- What is the required level of detail of each theme paper?

There needs to be some discussion at Working Group level around these questions, as the content needs to reflect the requirements of the Council. Some guidance on possible content is provided below.

4.3.1 Context Document

The context document should provide the background to the main body of the report. As mentioned previously, the context document should be relatively static, without a need to update it too often (perhaps once every 10 years). It could include the following:

- Introduction
 - Background
 - Description of the Study Area
 - Purpose of the SOER
- Methodology
 - Reporting Requirements
 - Reporting Framework
- Natural Conditions
 - Geology, Geomorphology and Sedimentology
 - Oceanographic Conditions
 - Ecosystems, Habitats, Fauna and Flora
- Socio-Economic Overview
 - Historical Context
 - Economic Overview
 - Social and Cultural Context.
- Environmental Management in the Gulf of Maine
 - Governance Overview
 - Identification of Issues (may include summary of issues from theme papers).

It is envisaged that the context document will be written in summary form, without providing too much detail. Where necessary, reference should be made to other available documents (e.g., Ecosystem Overview Report). The document should be no more than about 30 pages long.

4.3.2 Theme Papers

The theme papers will focus on important management issues in the Gulf of Maine and will be in a format that can be readily updated. There are several challenges when deciding on what theme papers should be compiled and the breadth of the issue that the paper addresses.

The impact-probability framework (Figure 5) provides some strategic guidance on what issues should be considered for a SOER. High priority issues for the Gulf of Maine should be the active issues that have already been identified and are recognised as requiring attention, including: climate change; fisheries and aquaculture; coastal development; contaminants; eutrophication, and aquatic habitats. Although this would be the starting point in deciding the content of the theme papers, there is also opportunity for emerging issues to be identified and reported on, as well as other issues that may be of importance to a sub-set of the Council members.

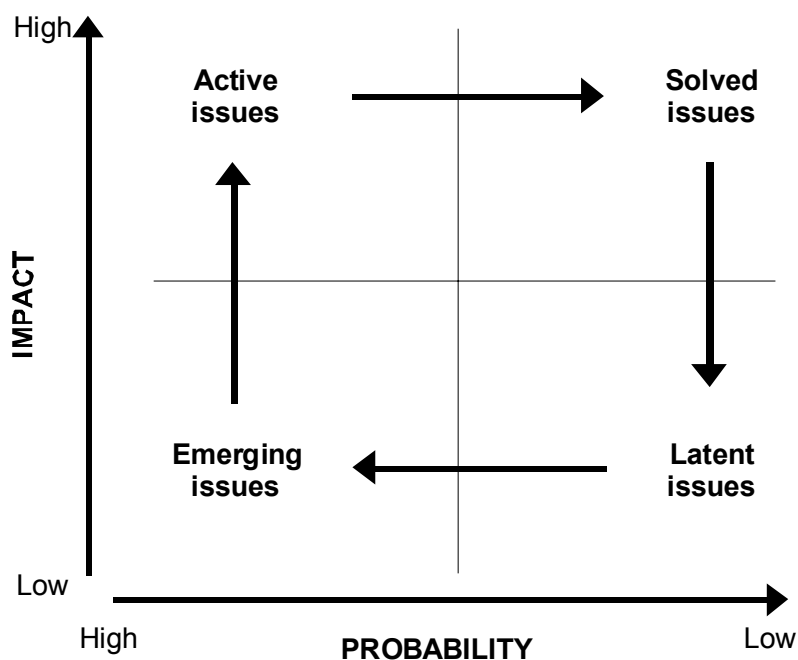


Figure 5: Impact-probability framework (adapted from Walmsley *et al.* 1999).

The challenge with using the existing six focus areas is that some tend to be more inclusive, covering a broader subject matter (e.g., coastal development; contaminants), while others are very focused (e.g., eutrophication). Ideally, all the theme papers should be at the same “level” as far as subject matter is concerned. This may be achieved by having more than one theme paper for some of the six priority areas. The splitting of a priority area into several theme papers may be influenced by the likely impacts and required responses for each issue. For instance, sea level rise and sea temperature are both important aspects of climate change. However, the impacts of each are vastly different (although some responses may be the same), and they may need to be reported on in two different theme papers. The final choice of theme paper may be influenced by indicators and data availability; funding and author availability. The choice of papers will rest with the Working Group; however, some examples are provided below.

Ideas for theme papers within the six focal areas include:

Climate Change

- Sea Level Rise;
- Sea Temperature Rise;

Fisheries and Aquaculture

- Sustainable Aquaculture;
- Sustainable Fisheries;
- Commercial Fisheries and Sustainable Communities;
- Fish Stock Status;

Coastal Development

- Land-Based Source of Pollution;
- Land Use and Coastal Development;
- Watershed Status;

Contaminants

- Inorganic Contaminants;
- Microbial Pathogens;
- Eutrophication;

Eutrophication

- Aquatic Habitats;
- Coastal Ecosystems and Habitats;
- Offshore Ecosystems and Habitats.

Other theme papers that could be considered, although they may not currently be identified as priorities in the Gulf of Maine include:

- Invasive Species;
- Migratory Birds;
- Species at Risk;
- George's Bank Ecosystem Status;
- Coastal Community Vulnerability;
- Emerging Issues.

5 Data and Information

5.1 Environmental Indicators

One method of providing information in a format that is usable by policy- and decision-makers is through the use of sustainability indicators. An indicator is a parameter that provides information about an environmental issue with a significance that extends beyond the parameter itself (OECD 1993). Agenda 21 (Chapter 40) states that "indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to the self-regulating sustainability of integrated environmental and development systems". This has led to the acceptance of sustainability indicators as basic tools for facilitating public choices and supporting policy

implementation (Von Meyer 2000). They provide information on relevant issues; identify development-potential problems and perspectives; analyse and interpret potential conflicts and synergies, and assist in assessing policy implementation and impacts (Von Meyer 2000). In essence, they allow us to better organise, synthesise and use information.

The main goal of establishing indicators is to measure, monitor and report on progress towards sustainability. Within this, indicators have numerous uses and potential for improving environmental management, including (Hammond *et al.* 1995; Walmsley and Pretorius 1996):

- Monitoring and assessing conditions and trends on a national, regional and global scale;
- Comparing situations;
- Assessing the effectiveness of policy-making;
- Marking progress against a stated benchmark;
- Monitoring changes in public attitude and behaviour;
- Ensuring understanding, participation and transparency in information transfer between interested and affected parties;
- Forecasting and projecting trends, and
- Providing early warning information.

Indicators should have three essential qualities; they should be “*simple, quantifiable and communicable*” (Walmsley and Pretorius 1996). The most effective environmental indicators are (BC Government 2009):

- Scientifically valid (i.e. credible and accepted by experts in the field);
- Representative of key issues and broader impacts or effects;
- Appropriate to the reporting time scale;
- Useful for prediction;
- Relevant to policy-makers and enable individuals to make meaningful decisions, and
- Compatible with other indicators to present an overall picture.

The BC Government (2009) states that the development of meaningful environmental indicators is not simple. A set of indicators should be broad enough to represent the overall environment, yet be few enough to present an understandable picture of environmental quality. Developing good indicators is in a continuous process of improvement (BC Government 2009).

Since 2006, ESIP has been active developing a set of core indicators for the six priority areas for the Gulf of Maine. The intention is that these indicators will feed into the SOE reporting process, but not necessarily drive it. Within the framework of the theme papers it is possible to highlight the core indicators used in any theme paper and provide a “report card” type analysis for that particular indicator as required. The following indicators have been identified as “core” indicators by ESIP:

Climate Change

- Air temperature trends and anomalies;
- Sea surface temperature;
- Sea level rise;
- Precipitation trends and anomalies;

Fisheries and Aquaculture

- Production/leased areas per unit area for:
 - Finfish;
 - Shellfish;
 - Integrated aquaculture;
- Economic value of aquaculture;
- Proportions of stocks at or above targeted abundance or biomass (wild fish);
- Mean length for fish for everything sampled (wild fish);
- Economic value of fisheries (either direct value or number of license/permits);

Coastal Development

- Percent of watershed covered in impervious surface;
- Point-sources of pollution (sewage, industrial effluent, fish plants, etc.);
- Population density;
- Employment;

Contaminants

- Sediment quality triad data;
- Shellfish sanitation data;
- Mussel tissue data (from Gulfwatch and comparable datasets);

Eutrophication

- Calculated nitrogen/phosphorus load;
- Secchi depth;
- Dissolved oxygen concentration;
- Chlorophyll-a concentration;

Aquatic Habitat:

- Extent and distribution of salt marsh;
- Extent and distribution of seagrass;
- Number and distribution of tidal restrictions.

The development of SOERs generally assists in identification of indicators that can be used on an ongoing basis for an area. The compilation of the theme papers may require the use of indicators (in addition to those identified as core indicators by ESIP) that do not have compatible data Gulf-wide, but are still valuable for reporting on status and trends. These indicators would complement the core ESIP indicators in providing an understanding of the state of the environment. In addition, some consideration should be given to complex indicators that link environmental impacts with human activities.

5.2 Information Resources

One of the challenges to compiling a SOER is information availability, either in the form of data or value-added information. The challenge is exacerbated in the case of the Gulf of Maine by the fact that there are multiple jurisdictions.

A review of current literature and information sources for the Gulf of Maine indicated that considerable work has already been undertaken to identify information sources and compile information that could be used for SOE

reporting. Of particular importance is the work already done by ESIP. For each of the six focal areas for which indicators are being developed, data discovery has been undertaken. The results of this are available on the ESIP collaborative planning site (<http://www.gulfofmaine.org/ESIPPlanning>) or through Christine Tilburg, ESIP co-ordinator.

Considerable effort has already gone into reporting on various aspects of the Gulf of Maine and its watershed. The documents that have been prepared provide a vital resource for compiling theme papers for a SOER. Some of these have been identified through the process of developing the SOE reporting framework, including (in date order):

- *Ecosystem Overview Report for the Gulf of Maine* (Parker in preparation) – an overview of the marine system of the Gulf of Maine, including the geological, oceanographic and biological systems.
- *Nova Scotia State of the Coast Report* (CBCL in preparation) – current status of Nova Scotia's coast with a focus on coastal development, working waterfronts, public coastal access, sea level rise and storm events, coastal water quality and sensitive ecosystems and habitats;
- *Salt Marshes in the Gulf of Maine: Human Impacts, Habitat Restoration and Long-Term Change Analysis* (GOMC 2008) – overview of salt marsh ecology, the human impacts on salt marsh systems in the Gulf of Maine and habitat restoration and monitoring.
- *National Coastal Condition Report III* (US EPA 2008) – comprehensive report on coastal areas throughout the United States, including the North-East Coast.
- *Seascapes: Getting to Know the Sea Around Us*, Appendix A (Taylor and Atkinson 2008) – Appendix A provides an overview of data sources for a wide variety of marine ecosystem elements.
- *Ecosystem Overview Report for the Minas Basin, Nova Scotia* (Parker *et al.* 2007) - an overview of the marine system of the Minas Basin, including the geological, oceanographic and biological systems;
- *Overview of Current Governance in the Bay of Fundy/Gulf of Maine: Transboundary Collaborative Arrangements and Initiatives* (ACZISC Secretariat and Dalhousie University 2006) – overview of governance structures, with a focus on some specific issues such as species at risk, migratory birds, acid rain, mercury pollution, climate change, fisheries, shellfish sanitation and science.
- *Cross Border Indicators of Climate Change over the Past Century: Northeastern United States and Canadian Maritime Region* (Wake *et al.* 2006) – overview of the status of climate change in the north-eastern US and the Maritimes.
- *State of the Estuaries 2006* (New Hampshire Estuaries Project 2006) – overview of the state of New Hampshire's estuaries and their watersheds.
- *Tides of Change Across the Gulf: An Environmental Report on the Gulf of Maine and Bay of Fundy* (Pesch and Wells 2004) – produced as a background document for the 2004 Gulf of Maine Summit, it provides information on land use, contaminants and pathogens, and fisheries and aquaculture.
- *Habitat Lost: Taking the Pulse of Estuaries on the Canadian Gulf of Maine* (Harvey *et al.* 1998) – provides a brief overview of each of the estuaries in New Brunswick and Nova Scotia.
- *Land-Based Sources of Pollution: An Inventory of the Gulf of Maine* (Maine State Planning Office 1995) - contains background information on the Gulf of Maine region, including its geology and ecology, values of the Gulf, environmental stresses, and regional initiatives. It also contains the point source inventory and the non-point source inventory.
- *Gulf of Maine Point Source Inventory: A Summary by Watershed for 1991*. (NOAA 1994) – inventory of point sources of pollution for the Gulf of Maine.
- *Gulf of Maine State of the Environment Fact Sheet: Marine Quality on the Gulf of Maine* (Thurston and Larson n.d.) – provides a summary of contaminant issues in the Gulf of Maine.

- *Gulf of Maine Marine Habitat Primer* (GOMC n.d.) – identifies marine habitats in the Gulf of Maine.

Much of the information required for the context document would be found in these documents, as well as some information that would be useful for the theme papers. There is also a large scientific literature on aspects of the Gulf of Maine system (see Parker *et al.* 2007), as well as numerous other reports in the grey literature (see Cordes *et al.* 2006).

6 Proposed Workplan

The proposed reporting framework for SOE reporting for the Gulf of Maine has been developed particularly with flexibility in mind. It is recognised that there are challenges for the Council with regard to continuity of funding and people's time. It is envisaged that the framework will mesh with current efforts and previously developed resources in such a way that the reporting burden is minimised, with maximum effect.

6.1 Tasks to Complete the SOER

There are several tasks associated with the completion of the report. They do not necessarily need to be completed consecutively, but may be implemented in parallel.

Task 1: Development and Maintenance of the Web Portal

Cordes *et al.* (2006) recognise that one of the challenges that faces the Council is distribution of the documents compiled and information collected. Critical to the distribution of the SOER is the development of the web portal. It is the key to making the SOER available to Council member organisations and to the public. There are two sub-tasks associated with the web portal: 1) development of the webpage, and 3) ongoing maintenance. The proposed schedule and budgetary requirements for each of these is provided in Table 2.

Task 2: Compilation of the Context Document

The context document can probably be compiled from existing information and documents and should not require extensive effort or resources. However, the Working Group will need to agree upon the content of the context document prior to any work being done to draft it. The proposed schedule and budget is provided in Table 2.

Task 3: Identification of Theme Papers

This task will be critical in making sure that the formal reporting structure (SOER) focuses on the priority areas for the Council. Although some suggestions have been made in this scoping document on theme papers, it is up to the Working Group to determine the papers that should be included in the report. It is recommended that a series of theme papers (no more than 12) be identified for the reporting period 2007-2012, and that these titles be adhered to.

Also, decisions need to be made on the timing for each of the papers. It is not necessary for all the papers to be drafted immediately. Rather, there is enough flexibility in the structure of the report that the papers may be staggered over several years, if necessary. The decision as to which papers will be drafted will also need to be made when the papers are identified.

There are several mechanisms for identifying theme papers. The most obvious and financially viable is during a regular Working Group meeting. It is estimated that discussion time required would be about three to four hours. This can be followed up through online discussion. An alternative is through a net meeting of Working Group members. This would allow use of audiovisual aids during the discussion, while minimising travel time. Both these methods may only be appropriate if the Working Group can easily reach consensus on the reporting framework. If a more wide-ranging discussion is required, it is recommended that a committed one-day workshop session be organised. The estimated budget for a one-day workshop is provided in Table 2.

Task 4: Drafting of Theme Papers

Drafting of theme papers will require a commitment for various organisations involved in the Council. It is not expected that the Council will take full responsibility for drafting the papers, but rather that various members would commit to drafting a paper that falls within their area of interest or mandate.

It is recommended that the first few theme papers be compiled from readily available information, particularly the work of the ESIP committees. For instance, the indicator fact sheets for climate change and eutrophication indicators will be available later in 2009. Drafting a theme paper from this information is an obvious next step and will not overextend Council resources. The proposed schedule and budget for developing the theme papers is provided in Table 2.

Task 5: Establishment of Wiki Site

Once up and running, the wiki site should self generate. However, initially it will take some effort to get interested parties to participate. It is envisaged that whoever is given the responsibility of the developing the website could also be tasked with establishing and promoting the wiki site. After the first year, there will need to be a moderator for the site on an ongoing basis, to facilitate good quality articles on the site. This position could overlap with that of the editor for the Gulf of Maine Times. The schedule and indicative budget for the wiki site is provided in Table 2.

6.2 Schedule and Budget

The proposed schedule and an indicative budget are provided in Table 2. The schedule is based on the premise that the Working Group will support the project and that project initiation will occur within three months of the March 2009 Working Group meeting. It also recognises that ideally the SOER should be ready to be showcased at the 2010 conference.

The budget is based on what this might cost if a consultant was brought in to do the job and is an indication of the level of effort that is required for each task. If theme papers are completed by member organisations, in-kind support would take the place of dollar figures

Table 2: Schedule and budget for development and maintenance of the web portal

Task	Proposed Schedule	Indicative Budget (US \$)
Task 1: Development and Maintenance of Web Portal		
Development of web portal	End 2009	\$16 000
Maintenance of web portal	Ongoing – long-term	\$10 000 / year ¹
Task 2: Compilation of Context Document		
Compilation of context document	End 2009	\$25 000
Task 3: Identification of Theme Papers		
Workshop to discuss framework and identify theme papers	Summer 2009	\$20 000 ²
Identification of theme papers in Working Group meeting or web meeting	Summer 2009	In kind support ²
Task 4: Drafting of Theme Papers		
Theme papers # 1-3	End 2009	\$4 000 / paper
Theme papers # 4-7	End 2010	\$4 000 - \$8 000 / paper
Theme papers # 8-12	End 2011	\$4 000 - \$10 000 / paper
Task 5: Establishment of Wiki Site		
Establishment of wiki site	End 2009	\$5 000
Ongoing moderation of wiki site	Ongoing - long-term	\$5 000 / year ³
Notes: 1. Supplementary to GOMC site budget 2. Optional (choice between two options in Task 3) 3. In addition to web portal		

7 Conclusion

This scoping document has proposed a reporting framework for SOE reporting for the Gulf of Maine. The system recommended is one that is compatible with the aims and objectives of the Council; is flexible enough to allow growth as resources become available, and is innovative enough to incorporate modern communication technologies. However, there are several challenges related to the development of a SOER for the Gulf of Maine, in addition to the generic challenges already identified in Section 2.2:

- Funding and human resource capacity continue to be issues of concern for the Council. The project will require some dedicated funding to initiate and maintain the SOE reporting system. Long-term commitments will include maintenance of the web portal and moderation of the wiki site.
- The SOE reporting process requires ongoing commitment from the Council. The Council will need to take ownership of the process; however, member organisations should be willing to assist with the various aspects of initiating the SOER process.
- Data compatibility across jurisdictions makes Gulf-wide comparisons more difficult. However, SOE reporting does not necessarily require compatible data sources; rather it requires the ability to report in the current state using the various information sources in a cohesive manner.

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Appendix 1
Example Theme Paper

This theme paper has been compiled as an example. It includes:

- **A summary of the issue in brief.** This section includes a DPSIR diagram for the issue, which identifies the discussion points that appear in the paper. The DPSIR diagram should highlight the main points and should not be too detailed. This section includes a text box on linkages to other theme papers.
- **Driving forces and pressures.** It is often difficult to discriminate driving forces from pressures as they are generally interlinked. It is, thus, easier to discuss them together as they have been in this paper. Although emissions are a driving force of climate change, they are not the focus of the paper and have been included in a text box.
- **Current status and trends.** This describes the current state of the issue. If possible trend data are used for “state” indicators – this provides the overall picture of the historic trend and an indication of the likely future trend.
- **Impacts (ecological and socio-economic).** Where possible, impacts should be quantified. In the case of this paper, there was little quantitative data available and the section is more descriptive.
- **Actions and responses.** This section outlines what has been done to improve the situation. It is always difficult quantifying the actions taken and this section is generally a qualitative description. The focus in this paper is on emergency response, as information on local mitigation and adaptation responses was not easy to obtain in the timeframe for compiling the paper.
- **Indicators, information and data gaps.** A table of the indicators that appear in the paper and an assessment of the indicator trend (rather subjective for this paper, but could be based on thresholds for all core ESIP indicators) is provided. This could include qualitative indicators, but these are more difficult to assess objectively. This table could also appear at the front of the document under the section “Issue in Brief”.

This paper does not include a case study, although a case study could provide local information on interesting adaptation or mitigation projects.

Gulf of Maine State of the Environment Report

Sea Level Rise

Action Plan 2007-2012 goals influenced:

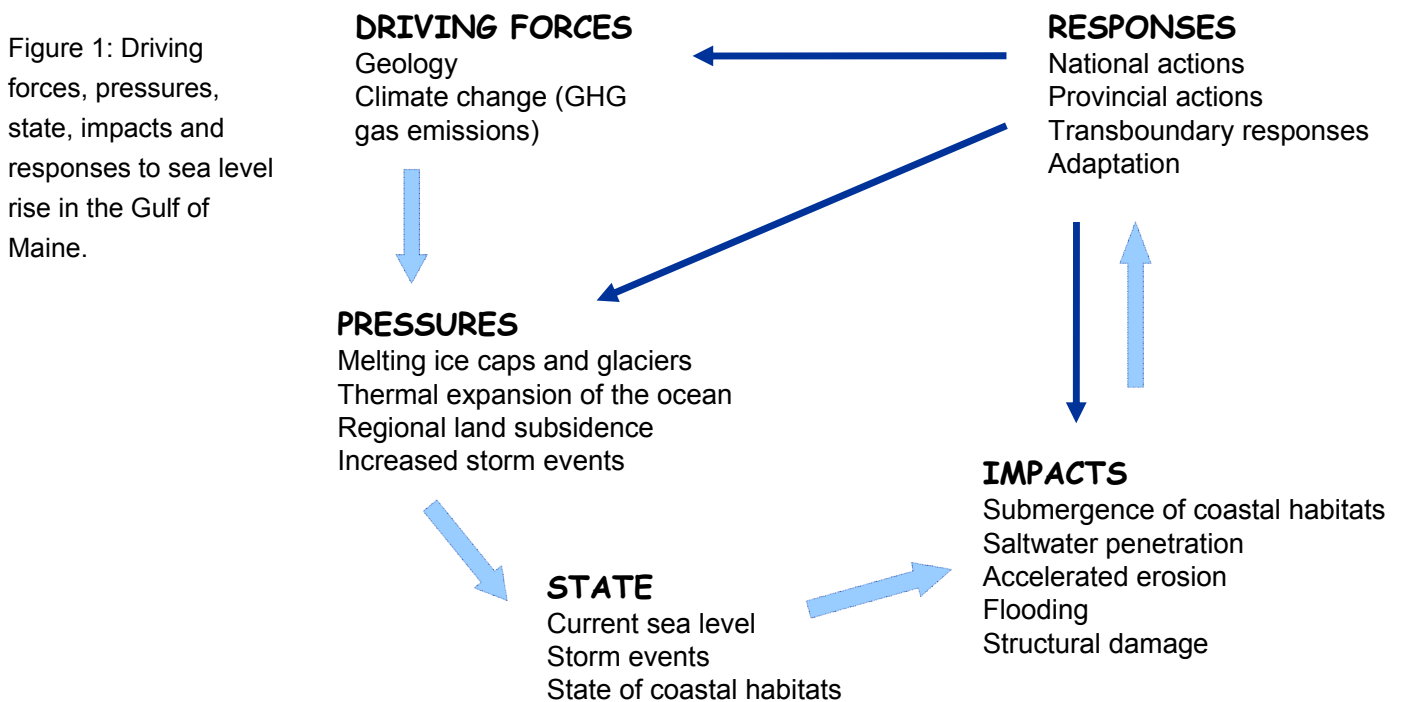
- Coastal and marine habitats are in a healthy, productive and resilient condition;
- Environmental conditions in the Gulf of Maine support ecosystem and human health;
- Gulf of Maine coastal communities are vibrant and have marine-dependent industries that are healthy and globally competitive.

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1 Issue in Brief

Global sea level is estimated to rise between 18 cm and 120 cm in the next century (IPPC 2007a; Rhamstorf 2007). Due in part to global warming, over the last 100 years mid-Atlantic sea level has risen approximately 10 cm more than the average global rise (Haile *et al.* 2008). Also the land around the Gulf of Maine is subsiding up to 20 cm per century (Leys 2009) and sea level rise is projected to accelerate due to climate change. Rising sea level in the Gulf of Maine will impact many coastal communities by threatening low-lying coastal infrastructure (roads, rail lines, bridges, buildings, wharves, sewage treatment plants, etc.) and possibly inundating coastal aquifers and surface water supplies (Burtis 2006; see Figure 1). Changes in sea level can also contribute to the loss of coastal habitats, particularly low-lying beaches, wetlands and salt marshes, and all shoreline glacial deposits are vulnerable to erosion (Burtis 2006; see Figure 1). These effects are worsened through increased vulnerability to storm surges (Leys 2009; see Figure 1).



Linkages

This theme paper also links to the following theme papers:

- Sea Temperature Rise
- Land Use and Coastal Development
- Watershed Status
- Aquatic Habitats
- Coastal Ecosystems and Habitats

2 Driving Forces and Pressures

Relative sea level rise experienced in the Gulf of Maine is due to a combination of processes including global mean sea level rise due to the thermal expansion of ocean waters and melting of the ice sheets (the process is referred to as 'eustatic' sea level rise), and regional land subsidence.

Post-glacial warming of the Earth is causing long-term global mean sea level rise. Since the peak of the last ice age, about 20,000 years ago, the global mean air temperature has risen 4°C to 7°C, leading to an increase in sea temperature. Recently this has been accelerated due in large part to human releases of greenhouse gases. Climate

Greenhouse Gas (GHG) Emissions

The main driving force of climate change is the increase in atmospheric concentrations of GHGs, which has altered the energy balance of the Earth's climate system and increased the global mean temperature. There is currently no comparable information on GHG emissions for the states and provinces around the Gulf of Maine; The following is provided as an indication of trends.

GHG Emissions in CO₂ equivalents (Mt) for Canadian provinces (1990 and 2006) (Source: Environment Canada 2008)

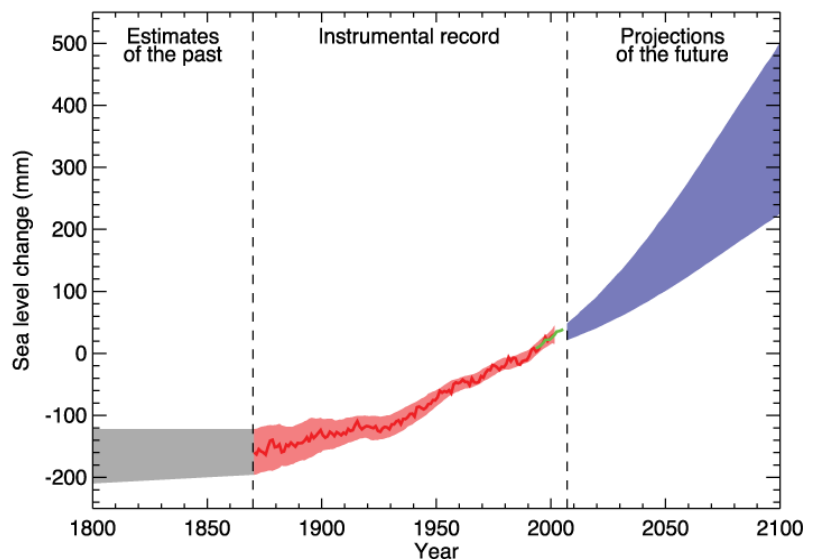
Province	1990	2006
Nova Scotia	19.0	19.6
New Brunswick	15.9	17.9

CO₂ emissions (Mt) from power plants in US states (2000 and 2007) (Source: RGGI 2009)

State	2000	2007
Maine	3.2	3.4
New Hampshire	5.2	7.6
Massachusetts	25.5	25.4

scenarios examined by the Intergovernmental Panel on Climate Change (IPCC 2007b) project a global mean temperature increase of 1.1°C to 6.4°C by 2100. From 1961 to 2003, the mean temperature increase for the 0-700 m layer of the world's oceans was 0.1 °C (IPCC 2007b). IPCC (2007c) estimates that, since 1993, thermal expansion of the oceans due to rising sea temperature contributed about 57% to sea level rise, while melting of ice caps and glaciers contributed about 28% and losses from the polar ice sheets contributed 15%. During the 20th century, the global mean sea level rose 17±5 cm (as opposed to about 6cm in the 19th Century) (IPCC 2007b; UNEP 2009). Projections for the 21st Century by IPCC (2007b), excluding future rapid dynamical changes in ice flow, range from 18 cm to 59 cm by 2100 (Figure 2). More recent projections (Rhamstorf 2007) estimate that a global mean sea level rise of up to 120 cm by 2100 could occur for strong warming scenarios (see also Figure 2 for mid-range scenarios).

Figure 2: Past and projected global average sea level. The grey shaded area shows estimated sea level change from 1800 to 1870. The red line is sea level change measured by tide gauges (the shaded area depicts uncertainty). The green line shows sea level change as measured by satellite. The purple shaded area represents the range of model projections for a medium growth emissions scenario (from IPCC 2007b).



Sea level rise in the Gulf of Maine is due to the combined effect of an increased global mean sea level, and the additional effect of regional subsidence of the Earth's crust. The subsidence is a manifestation of the crust's long-term response to the end of the last ice age, referred to as 'glacial isostatic adjustment' (Leys 2009). In the Gulf of Maine, subsidence rates are not uniform and are estimated to be from 0 cm to 20 cm/century (Figure 3). Reliable data are lacking to date, and only models can be used for estimates (see Peltier 2004).

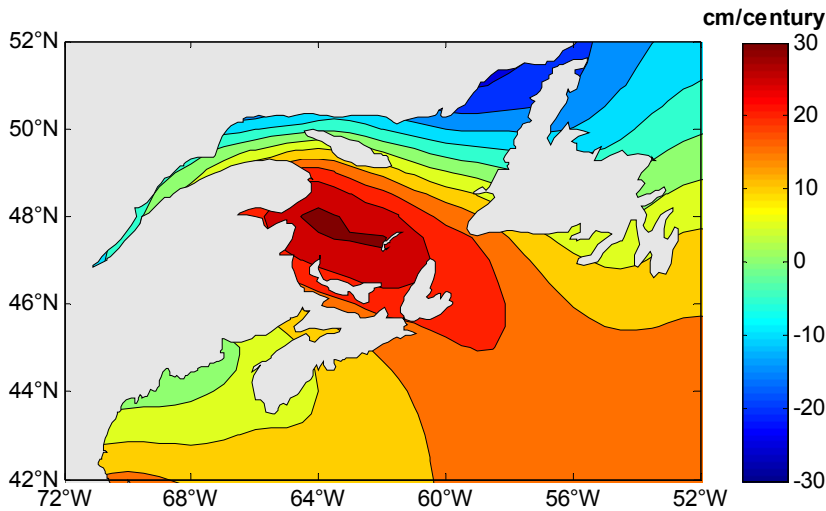


Figure 3: Regional rates of relative sea level rise due to glacial isostatic adjustment according to the Ice-5G model (Peltier 2004). Positive values indicate land subsidence, and negative values indicate land rebound (adapted from Leys 2009).

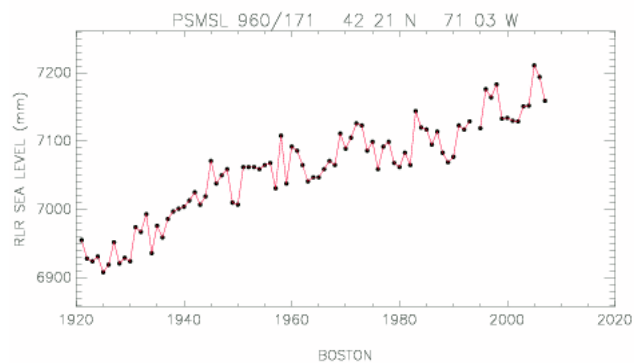
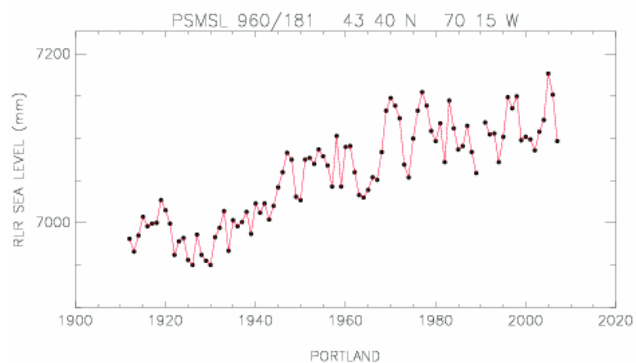
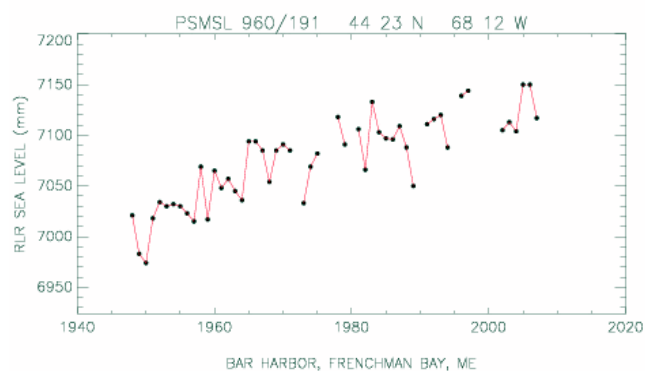
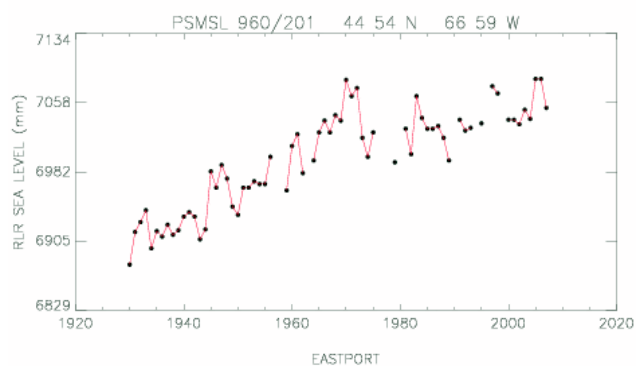
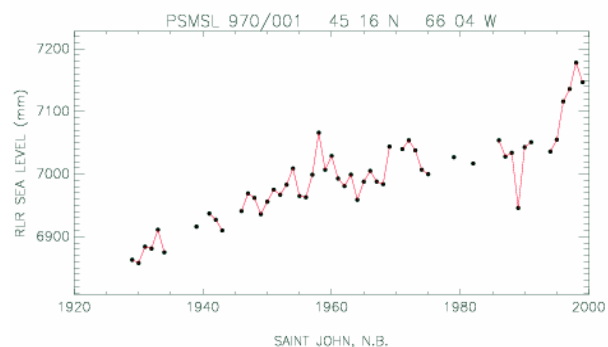
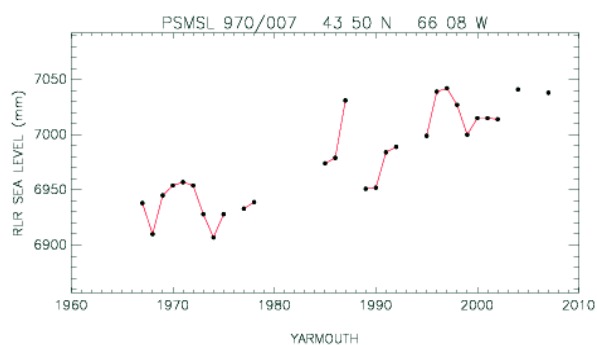
3 Status and Trends

3.1 Sea Level

According to Burtis (2006), sea level in Atlantic Canada and the north-eastern United States has risen approximately 25 cm since 1920. Permanent tide gauges have been established in the Gulf of Maine as part of the global network (see <http://www.pol.ac.uk/psmsl/>). Those with the most long-term data are represented in Figure 4 and include Yarmouth NS, Saint John NB, Eastport ME, Bar Harbor ME, Portland ME and Boston MA. The average sea level rise at these stations is provided in Table 1.

Table 1: Average Sea Level Rise at Stations in the Gulf of Maine

Station	Start Year	End Year	Average Sea Level Rise (mm/a)
Yarmouth NS	1929	1999	4.1
Saint John NB	1967	2007	2.5
Eastport ME	1930	2007	2.2
Bar Harbor ME	1948	2007	1.6
Portland ME	1912	2007	1.2
Boston MA	1921	2007	2.4



Note: RLR = revised local reference, which is comparable worldwide

Figure 4: Sea Level Rise at Stations in the Gulf of Maine.

Voice of the Gulf of Maine

In some ways, we have hit the fast-forward button, causing things to happen in decades that might ordinarily happen in centuries.

Ethan Nedeau , Gulf of Maine Times, Spring 2005

3.2 Coastal Vulnerability to Sea-Level Rise

Vulnerability (or sensitivity) of coastal areas to sea level rise is the degree to which coastal systems (human and ecological) are susceptible to adverse impacts (see Section 4) due to sea level rise.

The United States has undertaken a nationwide assessment of vulnerability of coastal areas to sea level rise (Thieler *et al.* 2001, <http://woodshole.er.usgs.gov/project-pages/cvi/>). The assessment focuses on the physical response of the coastline to sea-level rise. The relative vulnerability of different coastal environments to sea-level rise has been quantified at a regional scale using a coastal vulnerability index (CVI), based on coastal geomorphology, shoreline erosion and accretion rates, coastal slope, rate of relative sea-level rise, mean tidal range and mean wave height (Thieler and Hammer-Klose 1999). The results of the analysis for the Atlantic Coast, including Massachusetts, New Hampshire and Maine, are indicated in Figure 5.

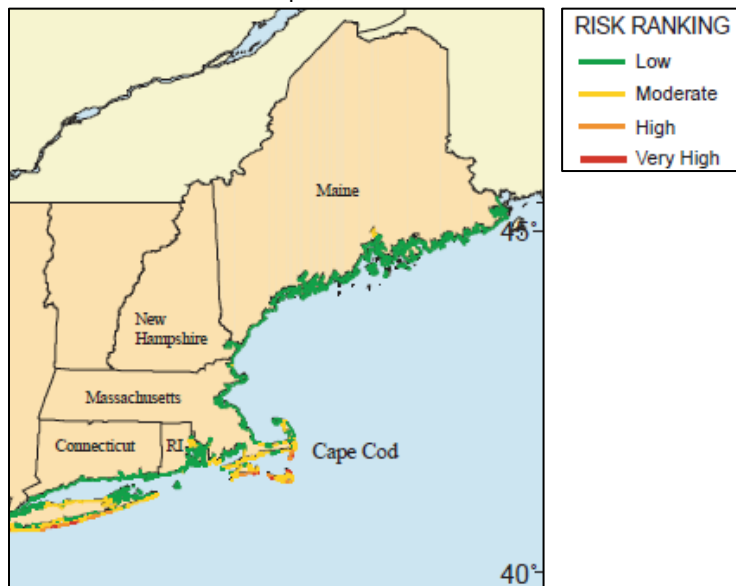
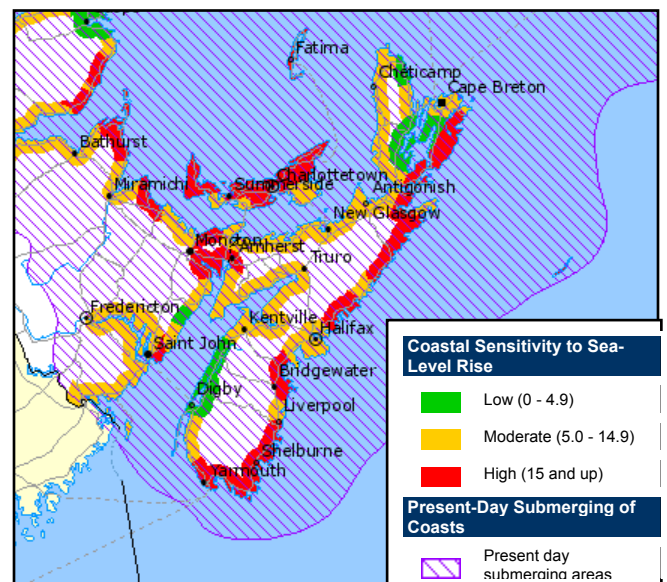


Figure 5: Map of the CVI for Maine, New Hampshire and Massachusetts. The CVI shows the relative vulnerability of the coast to changes due to future rise in sea-level. Areas along the coast are assigned a ranking from low to high risk, based on the analysis of physical variables that contribute to coastal change (see <http://woodshole.er.usgs.gov/project-pages/cvi/>).

A similar analysis for coastal sensitivity (or vulnerability) to sea level rise has been undertaken for Canadian coastal areas (Shaw *et al.* 1998). The coastal sensitivity index is based on general relief, rock type, coastal landform, sea level rise trend, shoreline displacement, tidal range and wave height using large-scale 1:50,000 maps (Shaw *et al.* 1998). Figure 6 depicts the broad regional scale sensitivity of Atlantic Canada to such physical impacts. There is no accounting for small areas of very high sensitivity, so the map should not be used for developing local, site-specific policies.

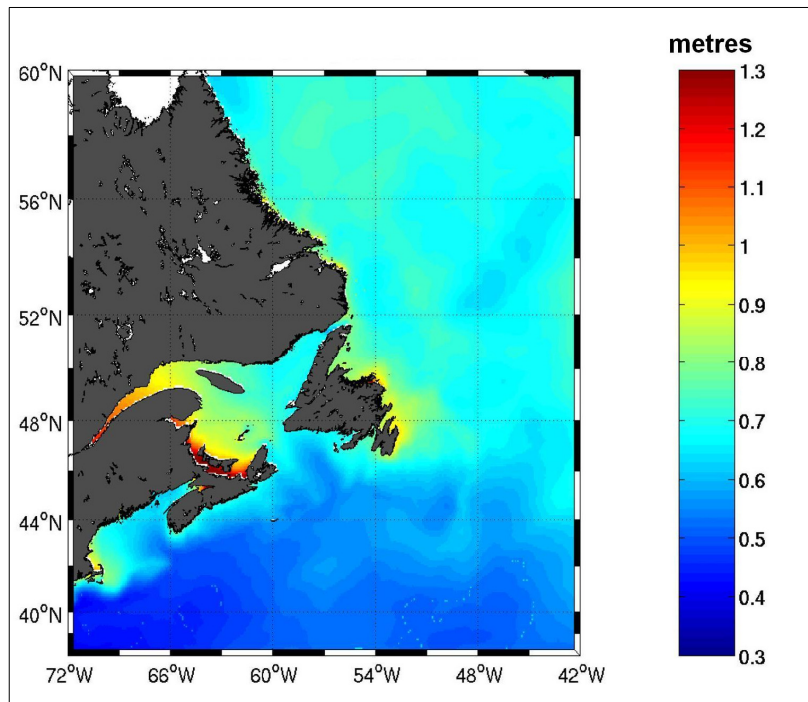
Figure 6: Regional physical sensitivity of coastline to sea level rise in Nova Scotia and New Brunswick (Source: <http://atlas.nrcan.gc.ca/site/english/maps/climatechange/potentialimpacts/coastalsensitivitysealevelrise>).



3.3 Storm Events and Storm Surge

The effects of sea level rise (see Section 4) are exacerbated by storm events, which are also affected by climate change. The storm surge is the height difference between the water level due to astronomical tides and the total water level at the peak of the storm. It is due to storm winds piling water onshore, low atmospheric pressure, wave setup, possible resonant effects within a bay and the coastal response to all these factors (Parkes *et al.* 1997). A rise in sea level would allow storm surges to reach further inland. Storm surges are typically associated with large-scale weather systems, and affect large areas. The surges mostly occur during extratropical storms in the fall and winter, but can also be caused by tropical cyclones in the summer and fall. Figure 7 shows positive storm surge heights that are exceeded on average once in 40 years. The highest surges around the Gulf of Maine tend to occur at the head of the Bay of Fundy and in Massachusetts. The most damaging storms are those occurring at high tide, or storms of long duration (over several tidal cycles) coinciding with spring tides.

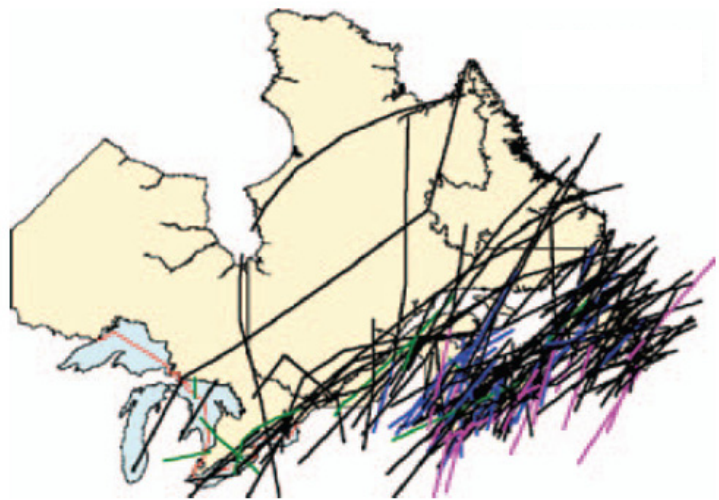
Figure 7: Forty-year return level of extreme storm surges based on a hindcast (reproduced from Bernier *et al.* 2006; Leys 2009). The colourbar indicates the 40-year surge levels independent of tidal elevations.



Climate change could cause an increase in the intensity of storms in the northern hemisphere, as well as a possible northward shift of storm tracks (McCabe *et al.* 2001, Wang *et al.* 2006). Trends in hurricane frequency are difficult to extrapolate in the long-term because of the cyclical nature of their occurrence. Still, intense tropical cyclone activity has increased since approximately 1970, with a trend towards longer lifetimes and greater storm intensity. Based on 1981–2000 averages, the number of hurricanes in the North Atlantic has been above normal with the highest number of hurricanes experienced in the 2005 season (IPCC 2007b). However, a major new modeling study has forecast that further warming of the North Atlantic could, in fact, discourage formation of hurricanes by up to 18 % (Knutson *et al.* 2008).

Figure 8 shows the storm track of tropical storms over eastern Canada, including the Gulf of Maine. Nova Scotia has experienced the most land-falling hurricanes (>20), while New Brunswick has experienced seven and New England has experienced four (Burtis 2009). The most devastating storm for New England was the New England Hurricane of 1938, which made landfall as a Category 3 hurricane on Long Island on September 21, 1938. Several tropical systems have reached the Maritimes while still classified as hurricanes. Hurricane Juan of 2003 is the most recent of these. The previous landfalling hurricane in Nova Scotia was Hurricane Gustav of 2002. The strongest hurricane to make landfall in Nova Scotia was an unnamed storm on August 22, 1893. This system went through St. Margaret's Bay as a Category 3 hurricane. One of the greatest Bay of Fundy flooding events recorded in history was the Saxby Gale of 1869. It had the highest storm surge ever recorded and flooding was extensive.

Figure 8: Storm tracks over Eastern Canada
(adapted from Burtis 2006). [Legend currently
not available.]



4 Impacts

The main impacts of sea level rise are inundation and flooding. In particular, rising sea levels inundate wetlands and other low-lying lands, erode beaches and promontories, intensify flooding, and increase the salinity of surface- and groundwaters. Table 2 provides a summary of the main biophysical and socio-economic impacts from sea level rise. Of particular concern for the Gulf of Maine is the loss of coastal habitats; damage to infrastructure and the intensification of all impacts due to storm events.

Table 2: Biophysical and socio-economic impacts of sea level rise in the Gulf of Maine (adapted from Leys 2009)

Element	Impacts
Biophysical Impacts	
Beaches	Large-scale morphological adjustments to absorb the wave energy, including: - Overwashing and increased erosion - Potential formation of new beaches downdrift of erosion areas - Landward migration of barrier beaches
Unconsolidated cliffs	Accelerated erosion
Estuaries and tidal rivers	Increase in tidal volume and exchange Further saltwater penetration
Freshwater marshes	Gradually become salt marshes or migrate landward
Salt marshes	More frequent tidal flooding Sedimentation and possible landward migration
Small islands	Submergence
Aquifers	Potential saltwater intrusion affecting potable and agricultural groundwater supplies
Species and ecosystems	Modification of coastal habitat as listed above Increase in invasive and pest species
Socio-Economic Impacts	
Land use	Erosion and flooding
Property, transportation infrastructure and municipal waste treatment facilities	Flooding, structural damage caused by loss of substrate, wave attack or rafting ice
Lowland agriculture	Saltwater flooding of dyked areas, with impacts on agricultural crops, property and infrastructure Upstream freshwater flooding due to higher downstream tidal elevations Structural damage to dykes from overtopping and erosion
Sewer systems	Increased frequency of backups and associated upstream flooding
Human health and safety	Spread of water borne illnesses during flooding Isolation of communities due to infrastructure damage Storm-related injuries or deaths
Aquaculture	Disruption of operations from coastal erosion of protective barrier dunes

Ports and harbours	Access for deeper draft vessels (if no sedimentation) Storm damage to coastal structures Increased length of shipping season due to climate change
Beaches, dunes, coastal trails and boardwalks	Erosion resulting in loss of coastal protection value, and loss in tourism revenue for recreational areas
Wetlands and forests	Loss of coastal protection and associated ecosystem services (e.g. water filtration, removal of air pollutants, control of runoff and erosion)
Cultural resources	Loss due to flooding

Coastal wetland ecosystems, such as salt marshes and mangroves are particularly vulnerable to rising sea level because they are generally within a few meters of sea level (IPCC 2007b). As the sea rises, the outer boundary of these wetlands will erode, and new wetlands will form inland as previously dry areas are flooded by the higher water levels. The amount of newly created wetlands, however, could be much smaller than the lost area of wetlands, especially in developed areas protected with bulkheads, dikes, and other structures that keep new wetlands from forming inland. The potential loss of wetlands due to sea-level rise in the Gulf of Maine has not been estimated, although Titus *et al.* (1991) estimated a 16% loss of coastal wetlands for the north-eastern United States.

Structural damage, flooding and loss of life are of particular concern during storms. The New England Hurricane of 1938 killed over 682 people, damaged or destroyed over 57,000 homes, and caused property losses estimated at \$ 4.7 billion (2005 US dollars). Hurricane Juan in 2003 caused the greatest recent storm damage recorded in Nova Scotia. The total loss reported by the Insurance Bureau of Canada for Hurricane Juan was \$130 million (Canadian dollars) and storm surge damage was estimated at an additional \$ 3.3 million (see Leys 2009).



Figure 8: Storm damage at Prospect NS from Hurricane Juan in September 2003 (photo: Doug Mercer; from Leys 2009).

5 Actions and Responses

Responses to sea-level rise can either be pro-active or reactive. Proactive responses are those that attempt to manage the problem at its source by alleviating pressures on the environment, while reactive responses are those that manage or mitigate the impacts.

In the case of sea-level rise, proactive responses include a commitment to preventing global warming through emission control. The Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) has committed to a *Climate Change Action Plan* (August 28, 2001; NEG/CEP 2001) that identifies steps to address those aspects of global warming that are within the region's control to influence. The Plan requires the development of a comprehensive and

coordinated regional plan for reducing greenhouse gases, and a commitment by each jurisdiction to reach specified reduction targets for the region as a whole. In particular, the mid-term goal is to reduce regional GHG emissions by 10% below 1990 emissions by 2020.

Many of the reactive (or adaptive) responses to sea-level rise need not be implemented until the rise is imminent. These would include activities such as rebuilding ports, constructing levees and pumping sand onto beaches. The impacts of sea level rise and storm events will likely be very site-specific and coastal risk is generally dealt with at a municipal planning level, with assistance from the provincial or state governments (Leys 2009). Strategic decisions will be required by communities and governments, and funds will be needed for programs to protect key public infrastructure and flood and hazard-prone communities (e.g., dyke lands, transportation systems). There is presently little information on current local initiatives to deal with sea level rise.

Emergency response preparedness both at a municipal and provincial/state level will be critical to ensuring minimal damage and loss of life due to impacts of sea level rise. The following legislation is already in place for the various provinces and states around the Gulf of Maine:

- New Brunswick – *Emergency Measures Act*, 1978 (<http://www.gnb.ca/0062/PDF-acts/e-07-1.pdf>);
- Nova Scotia – *Emergency Management Act*, 1990 (<http://www.gov.ns.ca/legislature/legc/index.htm>);
- Maine – *Maine Emergency Management Act*, 1987 (Maine Revised Statutes Title 37-B, Chapter 13; <http://www.mainelegislature.org/legis/statutes/37-B/title37-Bch13sec0.html>).

All jurisdictions have provincial/state emergency response organizations that are mandated to co-ordinate emergency response at all levels within each province/state. Responsibilities include mitigation of the effects of emergencies by providing assistance in planning before an emergency occurs, by coordinating the provision of resources when an emergency occurs and by assisting with analysis and evaluation after an emergency. These emergency management and response agencies include:

- Nova Scotia Emergency Management Office (<http://www.gov.ns.ca/EMO>);
- New Brunswick Emergency Measures organisation (<http://www.gnb.ca/cnb/emo-omu/index-e.asp>);
- Maine Emergency Management Agency, Department of Defense, Veterans and Emergency Management (<http://www.state.me.us/mema/>);
- New Hampshire Bureau of Emergency Management, Department of Safety, Homeland Security and Emergency Management (<http://www.nh.gov/safety/divisions/bem/>); and
- Massachusetts Emergency Management Agency (<http://www.mass.gov>).

National emergencies are dealt with in the US by the Federal Emergency Management Agency (FEMA; <http://www.fema.gov/>). National policy, response systems and standards for Canada are developed by Public Safety Canada (<http://www.publicsafety.gc.ca/prg/em/index-eng.aspx>), which works with provincial emergency management agencies across the country. The US has also implemented the National Incident Management System (NIMS) that is used for managing large-scale or multi-jurisdictional incidents. It is being phased in at the federal, state and local levels. Developed by the Department of Homeland Security and released in March 2004, it establishes a uniform set of processes and procedures that emergency responders at all levels of government will use to conduct response operations.

Summary

Indicator	Policy Issue	DPSIR	Assessment
Global sea level rise	Influenced by global warming	Pressure	☹
Land subsidence	Exacerbates sea level rise	Pressure	☹
Sea level in the Gulf of Maine	Causes inundation and flooding	State	☹
Coastal vulnerability indices	Sensitivity to sea level rise	State	☹
Occurrence of storm events	Worsens impacts from sea level rise	State	☹

Data Confidence

- Global sea level rise trends are determined through modelling based on scientific research. The range of sea level rise in the next century ranges from 18 cm to 129 cm, an order of magnitude difference.
- Regional land subsidence estimates are also modelled to determine current subsidence levels. However, these have been verified through values from local sea level gauges.
- Sea level rise at fixed points provide a close estimate of current sea level rise, although future trends are uncertain.
- Comprehensive information is available on storms that have affected the Gulf of Maine, but there is little confidence in future storm predictions.

Data Gaps

- There is currently a lack of information on the extent of coastal wetlands that are likely to be impacted by sea level rise, therefore this has been excluded as an “impact” indicator.
- Vulnerability of communities to sea level rise needs to be determined at a local level.
- There is little information on local responses to sea level rise.

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Appendix 2

Examples of Web Portals



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Norwegian emissions of greenhouse gases in 2007 were higher than ever - almost 11 per cent more than the emissions in 1990.

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See map of contaminated sites in Norway.

Environmental Directorates in Norway

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State of the environment

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16/09/2008



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