Northumberland Strait
Ecosystem Overview Report
Moncton, New Brunswick

<u>FINAL REPORT</u>

Submitted to:
Fisheries and Oceans Canada
Gulf Fisheries Centre
Moncton, New Brunswick
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LIST OF ACRONYMS

ACAP	Atlantic Canada Action Program
BIO	Bedford Institute of Oceanography
BOD	biological oxygen demand
CCME	Canadian Council of Ministers of the Environment
CEPA	*Canadian Environmental Protection Act*
CHS	Canadian Hydrographic Service
COD	chemical oxygen demand
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSO	Civil Society Organization
CTD	Conductivity, Temperature, Depth
CWS	Canadian Wildlife Service
DDT	Dichlorodiphenyltrichloroethane
DFO	Fisheries and Oceans Canada
EBM	Ecosystem Based Management
EC	Environment Canada
EEM	Environmental Effects Monitoring
EOAR	Ecosystem Overview Assessment Report
ESA	Environmentally Significant Areas
GOSLIM	Gulf of St. Lawrence Integrated Management
IBA	Important Bird Areas
IM	Integrated Management
JWEL	Jacques Whitford Environmental Limited
LFA	Lobster Fishing Area
MEEM	Marine Environmental Effects Monitoring
MEQ	Marine environmental quality
MPA	Marine Protected Areas
MREAC	Miramichi River Environmental Assessment Committee
MSX	Multinucleated Sphere Unknown
NACOSAR	National Aboriginal Council on Species at Risk
NB	New Brunswick
NBAPC	New Brunswick Aboriginal Peoples Council
NBDE	New Brunswick Department of Environment
NCNS	Native Council of Nova Scotia
NCPEI	Native Council of Prince Edward Island
NMCA	National Marine Conservation Areas
NOAA	National Oceanic & Atmospheric Administration
NPA	National Programme of Action
NPRI	National Pollutant Release Inventory
NS	Nova Scotia
NSDEL	Nova Scotia Department of Environment and Labour
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PEI	Prince Edward Island
POC	Particulate Organic Carbon
PWGSC	Public Works and Government Services Canada
SARA	*Species at Risk Act*
SFA	Salmon Fishing Area

SGSLC	Southern Gulf of St. Lawrence Coalition on Sustainability
TBT	Tributyltin
TC	Transport Canada
TEEM	Terrestrial Environmental Effects Monitoring
TEK	Traditional Ecological Knowledge
TKN	total kjedahl nitrogen
TP	total phosphorous
the Strait	Northumberland Strait
TSS	total suspended solids
UNESCO	United Nations Education, Science, and Cultural Organization

LIST OF UNITS

cm	centimetre
Ha	hectares
kg/day	Kilograms per day
km	kilometre
km^2	square kilometre
m	metre
m^3	cubic metres
m^3/day	cubic metres per day
mg/kg	milligram per kilogram
mg/l	millgrams per litre
mm	millimeters
mt	metric tonnes
STX eq/100g	Saxotoxin equivalents per 100 grams
t	tonnes
yBP	years before present
µg/g	micrograms per gram
µg/L	micrograms per litre

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EXECUTIVE SUMMARY

INTRODUCTION

The Northumberland Strait, located in the southern region of the Gulf of St. Lawrence between Prince Edward Island (PEI) and the provinces of Nova Scotia (NS) and New Brunswick (NB), has been an important area of economic and social activity since long before Confederation. The region's fish, forests, and fertile soils have been the foundation for Mi'kmaq, Acadian and British descendent communities for many generations. However, gradual changes in the abundance and distribution of the resources in the rivers, estuaries and marine environment upon which the local communities depend for their economic well being have raised concerns amongst the region's residents. This change in abundance has been linked to environmental degradation caused by a number of land-based and marine sources. Many of the changes in the quality of the local environment have been gradual, and as a result, often have gone without much notice. Over time these barely perceptible changes, combined with larger scale influences (for example climate change and sea level rise) have resulted in significant effects on the local environment and the resources upon which the people living along and near the Strait have depended for their livelihoods.

Due to the nature of the sources, rate of environmental change and the dynamic environmental interactions determining the specific causes of these changes is a difficult and complex task. However, there has been a strong desire expressed by local residents, fisher groups, and government representatives to understand the causes of the environmental degradation and associated decline in resource abundance. To this end, in September 2005 the Minister of Fisheries and Oceans established a Working Group to launch a Northumberland Strait Ecosystem Initiative to assess concerns over declines in productivity of the Northumberland Strait ecosystem and the fishery it supports. The Working Group was tasked with the development of an Ecosystem Overview Report (EOR) to bring together the available knowledge about the Strait ecosystem as a basis for identifying both appropriate actions and knowledge gaps for new research.

The EOR is intended to provide resource users, managers, and policy makers with a better understanding of the ecosystem actions and relationships of the Northumberland Strait. The EOR sets the stage for the future development of integrated management plans, protection of the environment, resource conservation, or recovery strategies. It also supports the efforts of the Working Group in the identification of ecosystem objectives within the Northumberland Strait and provides direction for governance, monitoring and science. This EOR is not intended to resolve the issues facing the Strait.

METHODOLOGY

In order to ensure timely preparation of a comprehensive EOR, AMEC Earth & Environmental, a division of AMEC Americas Limited (AMEC) established a team of experts knowledgeable with the various environmental disciplines who had previous experience and knowledge with the Northumberland Strait. The team undertook to collect all relevant documents, reports, and other information related to the Northumberland Strait ecosystem available from federal and provincial government departments, stakeholders and other organizations. In addition, the consulting firms and individuals that comprise the AMEC team provided information from their collections of relevant data and information in their corporate and personal libraries.

To augment the compiled information, the AMEC team undertook an intensive “data mining” exercise to collect and compile relevant information from the government departments, universities and non-governmental organization (NGOs) that have not been directly involved in the Northumberland Strait Environmental Initiative. Documents were sourced through visits to departmental libraries, contacting scientists and resource managers, and talking to relevant NGOs. The AMEC team also conducted an online search of the published scientific and technical literature for any papers and reports related to the Northumberland Strait. Collected documents were catalogued and an annotated bibliography of the collected documents was prepared.

A socio-economic analysis of the Northumberland Strait region was undertaken that included examination of the demographics, labour and economy; municipal services and infrastructure; transportation networks, land-use; Aboriginal resource-use; tourism; recreation; heritage and archaeological resources; and public health and safety (including emergency services). A separate policy and governance analysis was also conducted through consultations with the relevant federal and provincial government departments and agencies and NGOs responsible for environmental and resource management within the study area. The purpose of this analysis was to examine and identify strengths, weaknesses, overlaps, and gaps in the resource and environmental management systems.

Information collected by the project team was presented and discussed at four workshops (Physical Environment, Marine Environmental Quality, Biota, and Governance) involving key stakeholder groups and government representatives. These workshops were used to identify gaps in the information available on the Strait ecosystem, and gaps in the current models and predictive planning tools presently employed in resource and environmental management/planning in the region.

Throughout all stages of the project (information collecting, data mining, analysis and project workshops), the AMEC team consulted with various groups that have been undertaking and conducting studies and projects relevant to the EOR that may impinge upon activities in the Northumberland Strait including governments, academic institutions, private sector companies and groups, and NGOs. Efforts were made to include parallel processes and activities related to integrated management of the marine ecosystem in the activities and reporting for the Northumberland Strait EOR. Information was collected from other discrete EORs in the Northumberland Strait area, the Gulf of St. Lawrence Integrated Management Initiative (GOSLIM), the Southern Gulf of St. Lawrence Coalition on Sustainability, the Atlantic Coastal Action Program (ACAP), the Miramichi River Environmental Assessment Committee, the Bedeque Bay Environmental Management Association, the Southeast Environment Association, and the Pictou Harbour Environmental Protection Association.

KEY FINDINGS AND RECOMMENDATIONS

Physical System

Physical Oceanography

Information collected on the physical oceanography of the Strait indicates that the residence time of the water within the Strait is in the order of weeks to months, depending on the season and the occurrence of events such as storms. Considering that this is an important time scale with respect to biological processes (such as larval drift and settlement), efforts should be made to improve understanding of water movement through the Strait to better understand the ecosystem as a whole.

While it appears that the basic tidal environment in the Strait is stable, the application of new models may provide new insights into climate change impacts such as sea-level rise, and hydrographic changes. These models could also be instrumental in increasing the understanding of general processes and patterns near the shoreline, in bays and estuaries and patterns of mixing and dispersion based on study sites of where these patterns can be verified.

Understanding wave induced nearshore processes such as bar formation and nearshore drift is a complex area of research. If coupled with long-term weather data, it could identify areas of concern and enable better preparation for the potential impacts of sea level rise.

Waves and wave-induced processes play an important role in the ecosystem of the Northumberland Strait, most notably on the shoreline. Shoreline erosion is of particular concern especially in light of the potential for sea level rise in the near future. Near-shore dynamics associated with wave processes, including such processes as bar formation and sediment drift, is a complex area of active research. While this research is probably outside the scope of an integrated management system, coupling broad high-resolution wave modeling results with existing long-term weather data could provide a good basis for identifying sites of future concern and could assist in preparing mediation plans.

The timing and duration of annual ice cover in the Strait has been monitored for many years, since it has a direct impact on many economic activities. Indications are that the Confederation Bridge has enhanced ice break up and promoted earlier “ice-out”. However, the ecological consequences of earlier ice departure have not been studied. Considering there will likely be changes in the ice conditions in the Strait because of climate change, ice monitoring should be a priority in the future.

In order to understand better the physical oceanographic process within the Strait, it is recommended that researchers:

- Obtain rights to Sustainable Communities Initiative oceanographic data sets and use these data to conduct a model study of 3-dimensional currents in Abegweit Passage.
- Establish a long-term hydrographic reference station in the Strait.
- A meeting of key workers in the modeling field should be convened to resolve the best model approach and/or the best location for monitoring for model verification for the physical study components of an Integrated Management (IM) system.

Biogeochemistry

The chemical oceanography and sediment geochemistry of the Strait has not been well researched and much of the information on the chemical process in the Strait has been extrapolated from studies on the wider Gulf of St. Lawrence.

It is likely that the estuarine sedimentation process will have a significant effect on the geochemistry of the Strait. This will include inputs of organic matter (phytoplankton and detritus), nutrients (natural and introduced), and contaminants (i.e. Polychlorinated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAH), Tributyl-tin (TBT), and heavy metals). In addition to marine activities, many land-based activities affect geochemistry (i.e. mining and mineral processing, peat extraction, pulp and paper industry, agriculture, and urbanization.

In general, there is a lack of data on the geochemistry in the Strait, especially with respect to contaminants. Most of the current data on the geochemistry of the Strait is restricted to sediment texture. It has been noted by the Working Group "There are no current data illustrating temporal trends of any contaminants at any site in the Northumberland Strait". Further research on contaminants should be conducted to increase understanding of input from the wider Gulf: input from adjacent estuaries; processes within the Strait (i.e. deposition and re-suspension) that affect residence time and transformation in the sediments and water column.

A survey of baseline conditions of sediment geochemistry should be implemented as a foundation to further ecosystem assessment of the Northumberland Strait. This program will provide a benchmark for future assessment of ecosystem health in the Strait region.

Geographic Information Systems (GIS) analysis of the surrounding watershed should be undertaken to measure inputs of nutrients or other materials to the Strait via associated estuaries. This is an essential step in quantifying estuary-Strait coupling with implications for assessing eutrophication as well as dispersal of contaminants.

Geological Components

The geomorphology and geological structure of the Northumberland Strait has been well studied and the geological evolution of the region is well understood.

Seabed mapping surveys of the southern Gulf of St. Lawrence have been conducted over several decades; however, there is less detailed information on the bathymetry of the central Strait. The recent application of multi-beam bathymetric survey tools has provided much useful information on the bathymetry of the Abegweit passage area. This work has not been repeated nor extended to areas beyond the Strait crossing area. Furthermore, the existing data has not been processed for backscatter or seabed slope that can provide additional information on seabed texture.

Three major regional studies have been conducted on the sediment grain-size and geological history of the surface sediments of the Northumberland Strait. Two muddy-sand deposits occur in the Strait; the Pugwash mud is modern sediment presently being deposited, and the Malagash mud that is a glacial aged mud presently undergoing erosion by strong currents. Other areas of the Strait consist of sandy and gravely sediments and glacial till. The Boutouche sand and gravel covers the largest area. It is overlain by a modern deposit of sand called the Egmont sand that occurs in discrete sand bodies that are more widespread in the western area of the Strait. Correlation of the results of these studies with the geography of the Strait reveals that an alternating pattern of sediment banding related to zones of high and low energy is represented in the sediment distribution throughout the Strait. Mud deposits only occur in the wider regions of the Strait while the intervening narrow areas consist of coarser gravely and sandy sediments. This pattern is consistent with the expected higher energy environment resulting from stronger tidal currents that prevent deposition of muddy sediments.

Various investigations have revealed the occurrence of substrate modification by both human and natural influences. In one case, scallop drag marks have been found in areas where boulders, which are otherwise evenly distributed throughout the Strait, are absent. This coincidence of scallop drag marks and absence of boulders suggest the boulders have been taken up and disposed of in other locations. The investigations have also revealed areas of ice scour formed by pressure ridge keels.

The use of modern high-resolution mapping clearly shows that the seabed in the Strait is very complex. The processes of sand transport in a variety of bedforms, erosion by ice, and bottom fishing activity are altering the benthic habitat. Furthermore, the composition and depositional history of fine-grained muddy sediments is not well understood within the Strait and should be further studied. Multi-beam bathymetric surveys will greatly enhance the information on the small-scale features. This is necessary to understand better the ongoing processes and current state of seabed habitat.

One aspect of sediment transport that has been identified as a priority area of concern is the scope and impact of deposition of sediments eroded from the areas near the foundation of the Confederation Bridge. With respect to this “siltation” problem, it is likely that high-resolution video and camera systems together with seabed suction devices will need to be employed to augment seismic and multi-beam bathymetric surveys.

There is limited potential for the economic exploitation of geological resources. The greatest potential is for the exploitation of sand and gravel deposits for use in construction and beach restoration projects.

Biological Systems

The Northumberland Strait is inhabited by a range of biota including macrophytes (large plants), plankton, benthic species, reptiles, fish, marine mammals and marine birds, many of which are of economic importance to the local residents.

Seagrasses, such as eelgrass are important to the nutrient cycle in the Strait and provide important habitat for spawning and juvenile fish as well as seabirds. A noticeable decline in Seagrasses was first noticed in 2001; however, more extensive monitoring is needed to determine the extent of decline of this important component of the biological system.

Macro algae are also important in the nutrient cycle, provide habitat for fish and shellfish and in some instances, economic harvesting. Irish moss, once economically important, has dwindled to less than economic viability in the Strait in recent years. Additional research and study on the reasons for the disappearance of this species in localized areas is required. Similarly, there has been a noticeable decline in the kelp beds in the Strait. The participants at the Northumberland Strait EOR workshop noted the following areas of concern respecting macro algae in the Strait:

- excessive growth of some economically unimportant species (i.e., Furcellaria);
- disappearance of kelp beds in some areas;
- disappearance of Irish moss;
- declining health and range of eelgrass beds; and
- presence of anoxic areas.

The highest priority for investigation on marine plants identified in the EOR is with regard to excessive nutrient inputs and effects on the wider biotic communities of the Strait.

Phytoplankton is a major primary producer in the Northumberland Strait with seasonal production peaks during the summer and low production in the winter. It has been noted within the GOSLIM that the southern Gulf region is particularly rich and productive in plankton. Much of the work on plankton species identification in the Strait region has been conducted in recent years as part of the Marine Environmental Effects Monitoring activities related to the construction of the Confederation Bridge.

Surveys undertaken in the Strait since the first outbreak of paralytic shellfish poisoning in PEI in 1987 have noted the presence of and occasional blooms of phytoplankton species containing dioxin that contributes to paralytic shellfish poisoning by blue mussels.

Benthic Invertebrates species are more diverse and abundant than other marine communities in the Strait, primarily due to the diversity of habitats in the Strait. Many are of little or no commercial importance, while others such as lobsters, oysters, and scallops have contributed significantly to the local economy.

Recent studies of benthic infauna, species that live in the benthic sediments that are for the most part commercially unimportant, have shown signs of decrease in abundance and diversity.

Due to their commercial importance, the macrobenthic species, such as lobsters, snow crab and shrimp, have been better studied than the smaller microfauna and meiofauna. Studies on the Confederation Bridge piers have shown an increase in percentage coverage by anemones and sponges that did not have similar habitat before the Bridge structures were present.

As stated earlier, commercially important species have received the most attention with respect to monitoring of stock distribution and abundance. Lobsters, in particular, have been well studied in Atlantic Canada over the past century; however, these studies have focused on the adult populations and little is known about the planktonic stages of the species in the Strait. Movement during these stages is largely determined by current, tide and wind effects on the water column since the ability of the stage I to mid-IV larvae to control movement is minimal compared to these powerful environmental forces.

While the biology and overall health of lobsters is generally well understood, the population size and stock abundance in the Strait is less well known. Most population information is based on landing statistics as opposed to fishery-independent data. Landing statistics are influenced to an unknown degree by issues such as price, demand, input costs, market conditions, fishing effort, alternative income opportunities, weather, etc. Contrary to the general trend in the southern Gulf, there has been a steady decline in lobster landings in the Northumberland Strait. Many stakeholders believe that the decline is due to effects from the Confederation Bridge, while others have noted that increased contamination from terrestrial runoff and effluent may be a significant contributor to this trend. Additional research is needed to study a number of interrelated environmental and fishery factors that have likely caused the decline in commercially exploited marine stocks.

Rock Crab, which has been gaining importance as a commercial species, has also shown signs of decline in landings in the Northumberland Strait.

Scallops have also been well studied in the Southern Gulf of St. Lawrence with considerable information available on the historic abundance and distribution. There has been a decline in the landings of scallops in the Strait, which unlike the lobster fishery has resulted in a substantial decrease (79%) in fishing effort over the past several years. Stakeholders seek answers for the precipitous decline in this commercially important resource. Studies should be conducted to explore the possibility of increased total suspended solids (TSS) and increased sedimentation on spat settling areas, particularly in the middle reaches of the Strait, and the affects of extensive dragging of scallop harvesting gear and on populations.

PEI is Canada's largest producer of oysters, with production mainly in the Bedeque and Hillsborough Bays along the Northumberland Strait. It has been determined that production in these areas is below carrying capacity and as a result efforts have been undertaken by an industry association to enhance oyster habitat.

A number of Groundfish species inhabit the Northumberland Strait; however, many of the populations of these species have been below commercially significant levels. There is little information on these resources, even though they play an important role in the food web in the Strait. The existing groundfish survey information that does exist has shown a declining trend in average size and abundance. There has been an associated decrease in fishing effort.

Many species of migratory pelagic fishes are found in the Northumberland Strait including fishes that are important for commercial harvesting and anadromous species important for recreational fishing. Herring and Mackerel have been important to the commercial fishery. There is a declining trend in herring in the Central Strait not exhibited in the western Strait area. The reason for this trend is not known. While Mackerel is a highly migratory species believed to exist as a single population along the western Atlantic, there is anecdotal evidence that there has been a general decline in mackerel migration in the Northumberland Strait. More research is needed to determine the reasons for the changes in distribution of migratory pelagic species in the Strait. Research on pelagic fish should include fisheries independent monitoring of fish populations and biology; and better monitoring of commercial species landings.

Seals, whales, and porpoises are found in the Gulf. Many of these marine mammals have small populations (such as the harbour porpoise that is listed as threatened species) or only inhabit the region (fin whales) during annual migrations. It is believed that the grey seal population is increasing in the Northumberland Strait, which raises questions concerning predation affects on commercially important species.

There are four groups of marine birds that are common on the waters and shorelines of the Strait: inshore birds, offshore and pelagic birds, waterfowl, and shorebirds. Surveys of coastal birds have shown a decline in some populations such as the Tern, and Ring-billed Gull and most notably in Great Black Gull and Herring Gull which have declined significantly since the 1980's.

Surveys of critical habitat for various commercially important species have been conducted in the Strait; however, these studies have not provided complete coverage of the Strait. Further studies should be undertaken to provide greater coverage and update existing habitat information.

Several species listed as threatened or endangered by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under *Species at Risk Act* (SARA) are known to inhabit the Northumberland Strait. These are the Harbour Porpoise, Fin Whale Leather Back Turtle, Striped Bass, American Eel, Winter Skate, Atlantic Cod, Piping Plover, Barrow's Goldeneye, Roseate Tern, Harlequin Duck, and the Gulf of St. Lawrence Aster. In addition to the concern with the decline of these listed species, there is similar concern with the increased populations of non-indigenous species many of which have resulted in negative impacts on commercial activities. Invasive species of concern found in the Strait include the Green Crab, Oyster Thief, Clubbed Tunicate, Japanese Skeleton Shrimp, Marine Water Flea, and the diatom Pseudo-nitzschia. More research is needed to determine ways to prevent the continued decline of the endangered species in the region and to prevent and mitigate the effects of invasive species. Priority should be given to collecting additional information on invasive species including preparation of detailed and well-maintained distribution maps. Current species and threatening species need to be risk and trend analyzed with regard to risk to ecological systems and fisheries. Methods for mitigating or limiting the spread of invasive species, without detriment to resident species require research.

Human System

Governance

The Governance regime for the Northumberland Strait includes several federal, provincial, municipal, and First Nations governments and involves several acts, policies, and regulations. This governance regime involves multiple departments, agencies, non-governmental organizations, and industry associations as well as research and academic institutions. The governance system is complicated by the overlap of jurisdiction and mandates of the various groups involved. Issues that have been identified to improve the governance of the Northumberland Strait ecosystem includes regulator capacity; process overlap and disconnect, community capacity, lack of Aboriginal participation, enforcement, coordination of the regulatory framework, lack of strategic assessment, and management focus on fishers rather than the resource.

It was also noted that there is considerable uncertainty with respect to the role of communities, NGOs and First Nations in the governance process and that there is a need to clarify jurisdictions and establish a process to deal with overlaps. Attention must be focused on establishing appropriate and enforceable regulations and processes that will adequately respond to stakeholder requirements and changing environmental conditions. Recommendations include the following:

- A Regional Committee for Oceans Management as a model for Northumberland Strait governance should be investigated. To this end, the processes that are evolving from the Northumberland Strait Working Group approach should be legitimized and adequately funded.
- Efforts to increase the direct participation of as many regulators as possible in the EOR process should be encouraged and enhanced.
- Efforts should be made to streamline the regulatory framework and to establish specific tangible targets, timelines and measurable indicators regarding the socio-economic and resource parameters that need to be changed.

Human / Industrial Activity

Analysis of socio-economic impacts of ecological change within the Northumberland Strait must be considered within the context of the general socio-economic trends in Atlantic Canada, and in particular trends in the wider Gulf of St. Lawrence. The greatest effects are the result of changes in the fishing industry that has been the primary economic activity in the Strait. Considering that most, if not all fisheries have experienced fluctuations in landings and prices over the past decade, isolating the effects in the Northumberland Strait is not an easy task. Effects experienced in the Atlantic fishery include; depreciating assets; labour recruitment challenges; loss of direct and indirect income and employment; increasing reliance on employment insurance; rising intensity of competition; rising operational costs; safety concerns; eroded or liquidated savings; increasing debt; increased stress; substance abuse; increased crime and accidents; and ultimately migration to urban and western areas causing a loss of economic, social, and cultural assets in the communities.

All four of the major commercial fisheries in the Northumberland Strait (lobster, rock crab, scallops and herring) have experienced significant declines over the past decade. Lobster, which has historically been the most important fishery, has not experienced a similar decline in the adjacent areas of the Gulf. The average net fisheries income before taxes for respondents specializing in lobster within Lobster Fishing Area (LFA) 25 was $7,679, and employment insurance revenue was $10,855. The equivalent findings for LFA 26A were $12,958 and $12,057 respectively and, by comparison, LFA 24 figures were much higher at $50,731 and $12,255 respectively.

Economic analysis suggests an economic decline in the order of $7.5 million in the western and central regions of the Northumberland Strait. This decline has had a significant impact on other local businesses and public institutions. This has raised concern over the economic viability of the fishery in the area. The fishery is overcapitalized since the economic return cannot meet the level of economic investment. This state of overcapitalization, ever increasing operational costs, lack of alternative fisheries, and reliance on employment insurance provides different socio-economic circumstances than in past fisheries declines in the region. There is reduced capacity to “absorb” continued declines in catches and revenues. The current trends in the fishery have resulted in lost market value for licences making it difficult for fishers to retire. Shortened fishing seasons has reduced the insurable earnings, and further distances to fishing grounds results in greater costs and longer workdays. Furthermore, tourism effects through water quality problems, and sediment effects on wharves have increased costs or limited their use.

Increased fishing pressure in some areas will exacerbate problems by creating competition between fishers. Many communities now have fewer fishing licences, fewer boats, and fewer fishers which results in closing stores, churches, rinks, and other social institutions such as community halls. As a result, there is a general decline in the local standard of living.

Aquaculture is one industry that has been considered as an alternative. There has been an increase in investment, capacity, and technology over the past decade but sedimentation, changes in water quality and presence of invasive species has compromised the economic viability of this industry.

Priorities identified by those involved in the fishery include:

- improving resource conservation measures;
- adapting support systems to meet current needs;
- developing financial security by reducing investment;
- addressing issues related to general trends in the structure of the fishing industry that compromise local viability;
- increasing information sharing to improve understanding on the declining trend in the fishery; and
- improving consultation and collaboration within the community by involving women, youth, and community leaders.

Traditional and Local Knowledge

It is recognized that all members of a community posses Traditional Ecological Knowledge (TEK), including elders, women, men and children. However, the quantity and quality of this knowledge varies with a variety of factors including age, education, gender, social and economic status, as well as a variety of other factors. TEK is often transmitted in terms of stories or anecdotes.

The primary compilation of documented traditional knowledge on the fisheries for the Northumberland Strait region is the Atlas of Traditional Fisheries Knowledge, produced by Fisheries and Oceans Canada (DFO), Gulf Region. This collection consists of geo-referenced information on a wide range of marine species and other related information that is available in hard-copy atlas map format and via an on-line interactive atlas. The Atlas has been used as a source of information for the EOR. The Atlas does not provide information on the changes in resource abundance and distribution that have been highlighted in recent harvester discourse. It is recommended that a series of interviews be conducted to update the data to provide current harvester information. Furthermore, a project should be undertaken to build an historical baseline through extensive interviews of local knowledge experts.

As part of the ongoing efforts to prepare for treaty and title negotiations, Mi'kmaq tribal organizations (Confederacy of Mainland Micmac, Mi'kmaq Confederacy of PEI, and MAWIW) have studies on traditional resource-use in each province. These studies involve a series of structured interviews of Mi'kmaq community members to collect geo-referenced information on the use and location of coastal, terrestrial, and aquatic resources that were important to community economic and subsistence needs including game, fowl, fish, and plants. The projects have been largely completed in NS and PEI. The collected data is protected through confidentiality agreements between the collecting organizations and the individual interviewees; however, aggregated data has been mapped using GIS software.

While the Mi'kmaq mapping projects have not specifically targeted the Northumberland Strait, information illustrates the strong relationship between the Mi'kmaq and the Northumberland Strait region for harvesting marine fish and birds. In addition to historical information on the distribution of harvesting activities for waterfowl, salmon, lobster, groundfish, herring, mackerel, smelts and other species, this information contains interview information on the changes in accessibility of some species due to changes in land-use practices. Combined with the Atlas of Traditional Fisheries Knowledge in the Southern Gulf of St. Lawrence, this interview data provides useful insight in the analysis of ecosystem changes in the Northumberland Strait.

Ecological Assessment

Pressure and Stressors – Human Activities of Concern

Human activity along the coast and within the Strait can have a significant impact on the environment. Many activities in this region can or have affected environmental conditions of the Northumberland Strait including residential development, development of tourist facilities and attractions, commercial and recreational fishing activities, fish processing facilities, agricultural activities, forestry and mining.

Residential communities in the Northumberland Strait range in size, with the largest being Charlottetown with 32,000 inhabitants, while there are many smaller villages of less than 100 inhabitants. A significant environmental concern from the presence of these communities is sewage effluent that contains high concentrations of nutrients and human pathogens. While sewage treatment can reduce the concentrations of these contaminants, not all communities have treatment facilities and not all treatment facilities are 100% effective. In a recent study, residues of 12 different drug products were found in the effluent from eight Atlantic Canadian sewage treatment facilities. The presence of human pathogens has resulted in significant impact on human health and the economic success of the shellfish industry since filter-feeding bivalves such as clams and mussels bioaccumulate these pathogens to much higher levels than those found in the surrounding waters.

There are approximately 50 fish processing facilities in the Northumberland Strait. Many smaller plants are seasonal while some of the larger plants import fish from other regions. Since the regulation of fish plants is a provincial matter, there is no consistent approach to monitoring and reporting effluent water quality. These effluents can contain organic material and nutrients that can have adverse impacts on the ecosystem through eutrophication and anoxia.

The Northumberland Strait is not heavily industrialized. The Pictou area has the most history of heavy industry with coalmines and steel foundries dating back to the 1800's and more recent introduction of a pulp mill and tire manufacturing plant. Effluent water from these facilities is monitored in accordance with federal and provincial standards. These waters can contain byproducts from manufacturing, sewage treatment, and cleaning operations and have increased temperatures from use as a coolant.

Mining operations in the region (coal and salt) can increase sediment loads in adjacent waters. This is also a concern with peat extraction along the coastal areas near Shediac and

Bouctouche in NB and in the areas west of Summerside in PEI. Fine materials from peat have been associated with smothering of oyster beds in eastern NB.

Some areas of the Northumberland Strait have been developed for field crops and livestock grazing. It is estimated that over 70% of the land around Bedeque Bay, PEI has been cleared for potato farming. The marine impacts of agricultural development include soil erosion (sedimentation) causing habitat impacts, nutrient runoff leading to eutrophication, pesticide runoff leading to fish kills and release of pathogens from manure storage and application to fields.

There are numerous harbours along both shores of the Northumberland Strait ranging in size from small fishing ports to important ports like Charlottetown. These harbours often require dredging which is conducted in accordance with Environment Canada's policies and procedures that limit the potential for disturbance and release of contaminants that may be present in the sediments. The cargo ships, ferries, cruise ships, fishing boats, and recreational boats that use these ports have the potential to have adverse effects on the marine environment. Potential adverse effects on the marine environment include disposal or spills of oils and hydrocarbons; accidental spills; discharges of bilge water that can contain hydrocarbons or non-indigenous species; disposal of solid wastes; and sewage disposal.

The Northumberland Strait is a popular tourist destination and a number of private and commercial cottage developments, tourist accommodations, campgrounds, and many public parks are found along both sides of the Strait. The summertime influx of tourists can significantly increase the population of many maritime communities and put a strain on municipal infrastructure and services like water supply, solid waste management, and sewage treatment.

In addition to the existing land-use and marine-use activities that have had an impact on the environment of the Northumberland Strait, there are emerging activities and issues that can have significant environmental effects. These include exploration and development of oil and gas reserves; expanding shoreline development; development of wind power opportunities; expansion of aquaculture; continued decline in traditional commercial fishery; and global warming and climate change.

There has been concern that seismic testing for oil and gas exploration can have a negative impact on marine organisms. With the increased attention on alternative energy, the potential for wind farms in the Northumberland Strait has been explored. Land-based wind turbines can have an impact on resident and migratory birds, while sea-based facilities can create spatial conflicts with fishers, aquaculturists, and marine transportation routes.

Shoreline development can have an impact on habitat due to increased sedimentation resulting from forest clearing and construction activities. Increased fertilizer and pesticide use is also associated with new residential and tourist facility development. The sandstone, mudstone, and siltstone that comprise the shoreline of the strait are also susceptible to increased erosion when disturbed for construction of cottages, homes, and tourist facilities.

Increased development of the aquaculture industry can increase conflict for marine space with other user groups. Expansion of the shellfish aquaculture industry raises concern about oxygen depletion and nutrient build up in the bays and estuaries along the Northumberland Strait.

Further decline in the capture fishery can result in increased fishing pressure on existing resources and on new species not traditionally fished in the Strait.

The potential impacts of Global Warming can have significant effect on the Northumberland Strait, including:

- Increased frequency and intensity of storms causing increased terrestrial runoff, coastal flooding, and coastal erosion. This will likely stress water storage facilities and sewage treatment facilities with an associated increase in nutrient and pathogen transport to the marine environment.
- A rise in sea level will result in the disappearance of the low-slope shorelines and coastal wetlands along the shores of the Northumberland Strait. There is likelihood that there will be an increase in erosion of coastal headlands with an associated increase in sedimentation of coastal habitat.
- Increased air and water temperature which will likely result in less ice cover in the Northumberland Strait, changes in fish migrations and spawning times, and locations of grey seal pupping.

Threats and Impacts on Ecosystem Components – Key Issues

Biodiversity in the Northumberland Strait has been impacted as evident in four broad areas: invasive species, habitat degradation and loss, resource harvesting activities, and Species at Risk.

- Invasive species can cause a decrease in available habitat, and competition for food. Several invasive species have been noted in the region that have had a negative effect on the indigenous biota of the Strait.
- Habitat degradation and loss have been noted in the Northumberland Strait resulting from eutrophication, sedimentation, bottom disturbance, coastal developments, and contamination. These occurrences will likely be exacerbated by climate change impacts.
- Resource harvesting has lowered fish populations with an associated impact on other animals that depend on these resources as prey, such as seals, whales, dolphins and a variety of marine and coastal birds.
- Several Threatened, Endangered, or At Risk species occur in the Northumberland Strait.

The productivity and living resource harvesting activities in the Northumberland Strait have been undergoing noticeable changes over the past several years. This has been linked to many factors, including:

- The occasional outbreak of toxic algal blooms has had an obvious negative effect on the fishery with respect to landings and public perception.
- There has been a trend to larger vessels with an associated increase in infrastructure. Fuel, exhaust, fishing debris, and lost gear are also present in greater amounts adding stress to the system.
- Substrate disturbances from trawling activity has altered habitat.

- Introduction of alien and genetically modified species for aquaculture has caused a thinning of the gene pool. Aquaculture has also been linked to increased nutrient loading and decreased dissolved oxygen levels.

Participants in the EOR Workshop identified several key areas of concern respecting Marine Environmental Quality (MEQ) including nutrients, sediment, pathogens, contaminants, physical disruption of fish habitat, climate change, and invasive species.

- Increased nutrient loading from land-based activities was identified as the most important MEQ issue in the near shore areas such as the estuaries, harbours, and bays. The principal sources of nutrients to the coastal areas of the Northumberland Strait are sewage, agricultural runoff, fish plant effluents, and pulp mill effluent. Data on nutrient levels and sources in the Northumberland Strait is limited, and the quality and consistency of existing data is an issue. There is a need to develop a nutrient budget model for the Northumberland Strait. To this end, DFO should build upon past work conducted in the region, and other work conducted at Universities (particularly Acadia). Monitoring programs for nutrients, whether conducted by government, the private sector or community groups should be encouraged to measure a consistent set of nutrient parameters and to follow standard methods for surveys and measurements to improve the comparability of the data.
- Sediment deposition can increase turbidity, reduce light penetration, and smother bottom habitat. There is evidence that many locations in the Northumberland Strait have experienced increased sediment loads from known sources. A multi-beam mapping survey of the entire Northumberland Strait should be conducted to define bottom types and identify areas where sediment deposition is occurring. Core sampling could be conducted to determine sediment accumulation rates. DFO should review and build on work conducted by federal, provincial and university researchers, including video work conducted with fishers in the area of the Confederation Bridge. Samples of this sediment materials reported by fishers should be obtained and analyzed to determine its composition - silt, biological, or some combination. A modeling exercise should be undertaken to create a numeric model of a sediment budget for the Northumberland Strait. The results could be used to determine depositional areas that could then be targeted for research that is more detailed.
- Pathogens consisting of bacteria and viruses have a potential negative impact on humans and well as marine and coastal organisms. There have been a significant number of closures of shellfish harvesting areas, as well as public beaches, which has resulted in an impact of several millions of dollars on local economies. A history of disease outbreaks in the Northumberland Strait including fish, shellfish, and marine plants should be compiled and a GIS database should be established. Participants in the EOR noted that the discontinued parasite-monitoring program for fish should be reinstated.
- Chemicals that can have a variety of effects on marine organisms and humans, ranging from mortality, sub-lethal effects, and chronic effects such as cancer and reduced disease resistance enter the marine environment from a variety of sources in the Northumberland Strait. Many of these have been well studied; however, there is concern that additional information and controls are needed. An inventory of all potential sources of contaminants and the types of contaminants should be assembled. EOR Participants suggested that the first priority would be to assemble all of the environmental contaminant data and information from the sources. This assessment

would also identify areas where limited data exists. Once areas and contaminants of concern are identified, sediment samples should be collected to obtain up-to-date information on the current environmental quality. The Mussel Watch program should be reinstated in Northumberland Strait, in addition to expanding the Community Aquatic Monitoring Project to include pesticide monitoring. Research should be conducted on immunological responses in bivalves in the Strait. Greater efforts should be made to develop biomarkers (such as the research being conducted by Wayne Fairchild, DFO Gulf Region).

- Physical disruption of fish habitat is a major concern for fishers. Infilling of shoreline areas, construction of bridges, causeways, wharves and breakwaters, dragging for scallops, trawling for ground fish species, dredging, sediment inputs from land-based activities, and obstructions to tidal flows causing deposition of silt have been identified as key activities that have had an impact on fish habitat.
- Similarly, construction of shoreline structures and facilities in the Northumberland Strait has had a significant impact on coastal habitats resulting in a decrease in productivity. Many land-use practices result in the increase of erosion and silt loads into the coastal environment. Development in formerly undeveloped lands can dramatically alter the natural landscape and introduce contaminants into the environment, filling wetlands, and altering the natural flow of streams and tidewaters, displacing native species, and introducing invasive ones.

In addition to individual impacts of the various elements identified as having an impact on the environment in the Northumberland Strait, there can be cumulative impacts that exceed the individual effects. Some effort has been made to understand the cumulative impacts; however, more work is needed to understand better the cumulative impacts of human activities on the Northumberland Strait ecosystem.

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1.0 GENERAL INTRODUCTION

1.1 BACKGROUND

In 1996, Canada became the first country to enact a law on the oceans. Canada's *Oceans Act* states that "conservation, based on an ecosystem approach, is of fundamental importance to maintaining biological diversity and productivity in the marine environment." Taking an ecosystem approach to oceans management (or Ecosystem-Based Management (EBM)) recognizes the complexity of marine ecosystems including the interrelationships between organisms, their habitats, and the physical environment. Implementation of EBM must be planned in advance using a step-by-step process so that managers and stakeholders know the status and trends of the area's ecosystem and what impacts human activities will have on that ecosystem.

The *Oceans Act* gives Fisheries and Oceans Canada (DFO) a mandate to lead and facilitate the development of integrated management (IM) plans for oceans-related activities in Canada. DFO is working towards an EBM approach for oceans-related activities in accordance with this mandate and is in the process of developing comprehensive reports on certain Large Ocean Management Areas (LOMA) to achieve better management of large marine ecosystems such as the Gulf of St. Lawrence. These reports are aimed at defining and assessing the territory to be managed. It is within the LOMA process for the Gulf of St. Lawrence that the Northumberland Strait (the Strait) was identified as a territory requiring IM and an ecosystem assessment. This requirement was based on environmental changes and resource declines within the Strait which have become increasingly apparent in recent years.

To protect the aquatic resources that the Northumberland Strait supports, development of an understanding of the changing dynamics in fisheries resources and ecosystem characteristics has become a critical focus of the affected organizations and individuals. This collective investigative approach is referred to as the Northumberland Strait Ecosystem Initiative. In support of this Northumberland Strait Ecosystem Initiative, a Government/Stakeholder Working Group was established in the fall of 2005 by DFO. The mandate of this Group is to bring focus to increasing concerns over changes in the state of the Northumberland Strait ecosystem and the aquatic resources that it supports, through the development of an Ecosystem Overview Report (EOR).

1.2 EOR DOCUMENT

This document is the commissioned EOR for the Strait. It is a technical document developed to provide IM partners and stakeholders with relevant information on the Strait's marine ecosystems including the status and trends, impact assessment and recommendations to management – based on the best science and knowledge available – in order to support IM planning and further decision-making.

The objective of this EOR is to set the stage for the future development of IM plans, protection of the environment, resource conservation, or recovery strategies. This Report is not intended to resolve the issues facing the Strait - the EOR is to support identification of ecosystem objectives within the Northumberland Strait and provide direction for governance, monitoring and science.

1.2.1 Scope of the EOR

This document summarizes key features of the Northumberland Strait ecosystem and major human activities that are linked to it. The EOR contains all the available relevant information needed to understand the functioning of the Northumberland Strait ecosystem as a whole. It also provides a picture of the pressures and threats presented by human activity within the Strait and adjacent lands. It is a "living" document in that it can be modified and updated to integrate changes, new discoveries, etc. This overview report is a compilation of information gleaned from various sources, such as scientific, statistical, social, and economic study reports, traditional and local information, a technical consultative process, etc. Using this information as a starting point, IM planners can begin to understand how the environment works in relation to the threats and pressures so that management measures can be put in place to mitigate them.

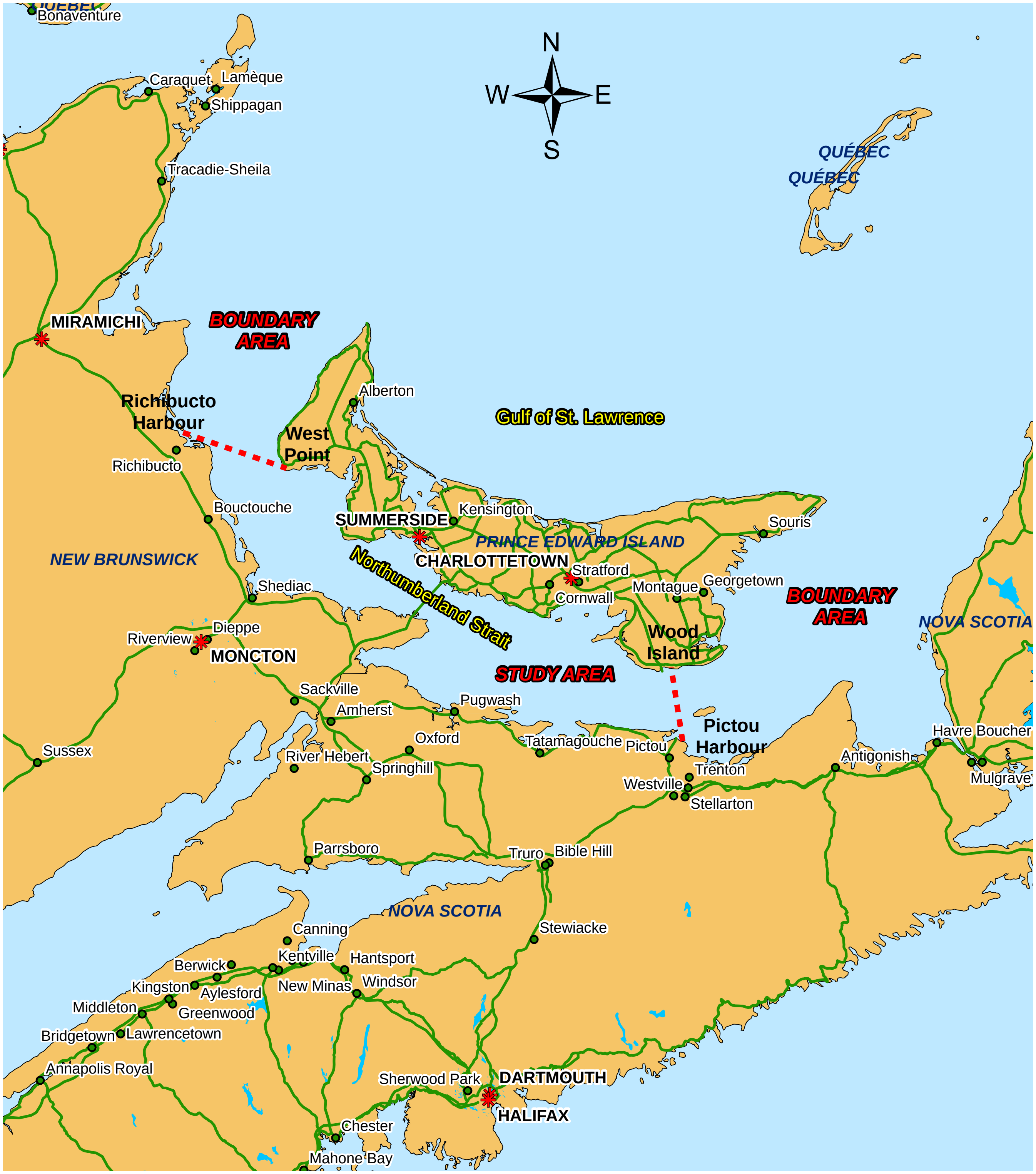
1.2.2 Geographic Area

For the purposes of the EOR, the Northumberland Strait is defined as the central Strait area on either side of the Abegweit Passage – extending from Richibucto Harbour, in the northwest of New Brunswick (NB), to Pictou Harbour, Nova Scotia (NS), in the southeast on the mainland of the Strait, and from West Point to Wood Island on Prince Edward Island (PEI) (including Bedeque Bay and Hillsborough Bay). Two boundary areas on either end of this defined zone were taken into consideration but were not the focus of the study. Figure 1.1-1 illustrates the geographic region of the EOR.

1.2.3 Methodology

The preparation of this document includes a literature review that brings together pertinent data available from a variety of sources. The authors have attempted to discover all sources of pertinent literature available regarding geographic and topic-specific information used in this overview report. Sources of literature include: government primary research publications, government policy and discussion papers, government grey literature (unpublished documents), academic journal articles, academic primary research documents (published and unpublished), proprietary consultant research documents (by permission), non-governmental organization reports, community group reports, personal communications with experts (cited with date of communication), and other sources deemed relevant and reliable (e.g. Traditional Fishers' Knowledge database). No primary research was undertaken specifically in support of this document.

Given the complexity of the EOR process and the substantial volume of documentation (studies, reports, data, legislation, regulations, etc.) involved, digesting and understanding the information represents a challenge for communities and stakeholders. As such, an additional technical consultation aspect was introduced into the Northumberland Strait EOR process. These technical workshops were convened to provide a review of the available information related to the Northumberland Strait by government, academe, the scientific community, industry, and non-governmental organizations, and to develop recommendations regarding possible solutions and future courses of action. The results of this exercise are presented throughout the EOR.



SOURCE:

Basemap Modified After ESRI Data & Maps, 2005.

SCALE: 1:2,000,000

0 20 40 60 80 100

Kilometers

DATE: December 6, 2006

DRAWN BY: D. McCoy

PROJECT No.: TE61035

FILE NAME: EOAR_study_area.mxd

NORTHUMBERLAND STRAIT ECOSYSTEM OVERVIEW REPORT

FIGURE 1.1-1
AREA OF STUDY

The template used to develop the EOR document was based on the information requirements of the National Technical Guidance Document (DFO, 2005a) and follows the methodology of study outlined on the Working Group on the Northumberland Strait Information Website (Appendix A): http://www.glf.dfo-mpo.gc.ca/sci-sci/northumberland/meeting-reunion/eoar-presentation-raee-e.jsp.

1.2.4 Report Organization

The EOR provides an ecosystem description (i.e., ecosystem status and trends, ecosystem relationships, and the state of the ecosystem), assesses the anthropogenic and environmental impacts, quality, and sensitivities in the context of the Northumberland Strait ecosystem, and provides recommendations to support planning and management actions in the areas of concern. Following this introductory section, the EOR is organized in the following manner:

- Section 2.0 provides a description of the Strait's physical system (i.e., oceanographic, physical-chemical, and geological properties).
- Section 3.0 provides a description of the Strait's biological system (i.e., biota and habitat components).
- Section 4.0 provides a description of the Strait's human system (i.e., governance structure and human/industrial activity).
- Section 5.0 provides a description of the state of Traditional Ecological Knowledge (TEK) within the Strait.
- Section 6.0 provides the ecological assessment with respect to the pressures and stressors – human activities of concern, threats and impacts on ecosystem components – key issues, and ecosystem relationships, and identification of key areas of concern within the Strait.
- Section 7.0 provides a summary of the relevant parallel processes underway in association with the Northumberland Strait.
- Section 8.0 provides a summary of the technical consultations and public participation associated with the EOR process.
- Section 9.0 presents the recommendations and research needs identified from the EOR processes to date. These recommendations are presented by discipline (i.e., physical environment, biota, marine environmental quality (MEQ), socio-economic/governance).
- Section 10 provides the EOR reference list.
- Appendix A presents a listing of the EOR Working Group members and their respective affiliations and a copy of the Methodology of Study posted on the Working Group website (link noted above).
- Appendix B presents the Proceedings Reports developed for each of the four Technical Workshops held as a component of the EOR process.

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2.0 PHYSICAL SYSTEM

2.1 PHYSICAL OCEANOGRAPHY

The Northumberland Strait is a long, narrow, and shallow body of water in the southern Gulf of St. Lawrence (Figure 2.1-1). Northumberland Strait waters are primarily derived from the surface layer of the Gulf of St. Lawrence system. The latter exhibits estuarine features associated with fresh water input via the St. Lawrence River and deeper saline flows from the Gulf Stream entering via the Cabot Strait along the relatively deep Laurentian Channel.

Estuarine exchange (seaward at the surface and landward at depth) plus seasonal cooling and ice formation drive complex processes that influence the nature and residence times of water masses within the Gulf. It is possible that these processes, which may vary on annual and decadal time scales, also influence the Northumberland Strait, but this discussion is outside the scope of this report. Mean flows in the Strait are from west to east driven primarily by the Gulf estuarine effect and the mean wind stress.

Residence times in the Strait are in the order of weeks to months and are expected to vary with season and the occurrence of short-term events such as storms. These time scales for biological processes (larvae drift, settlement) are important to improving our understanding of the ecosystem as a whole.

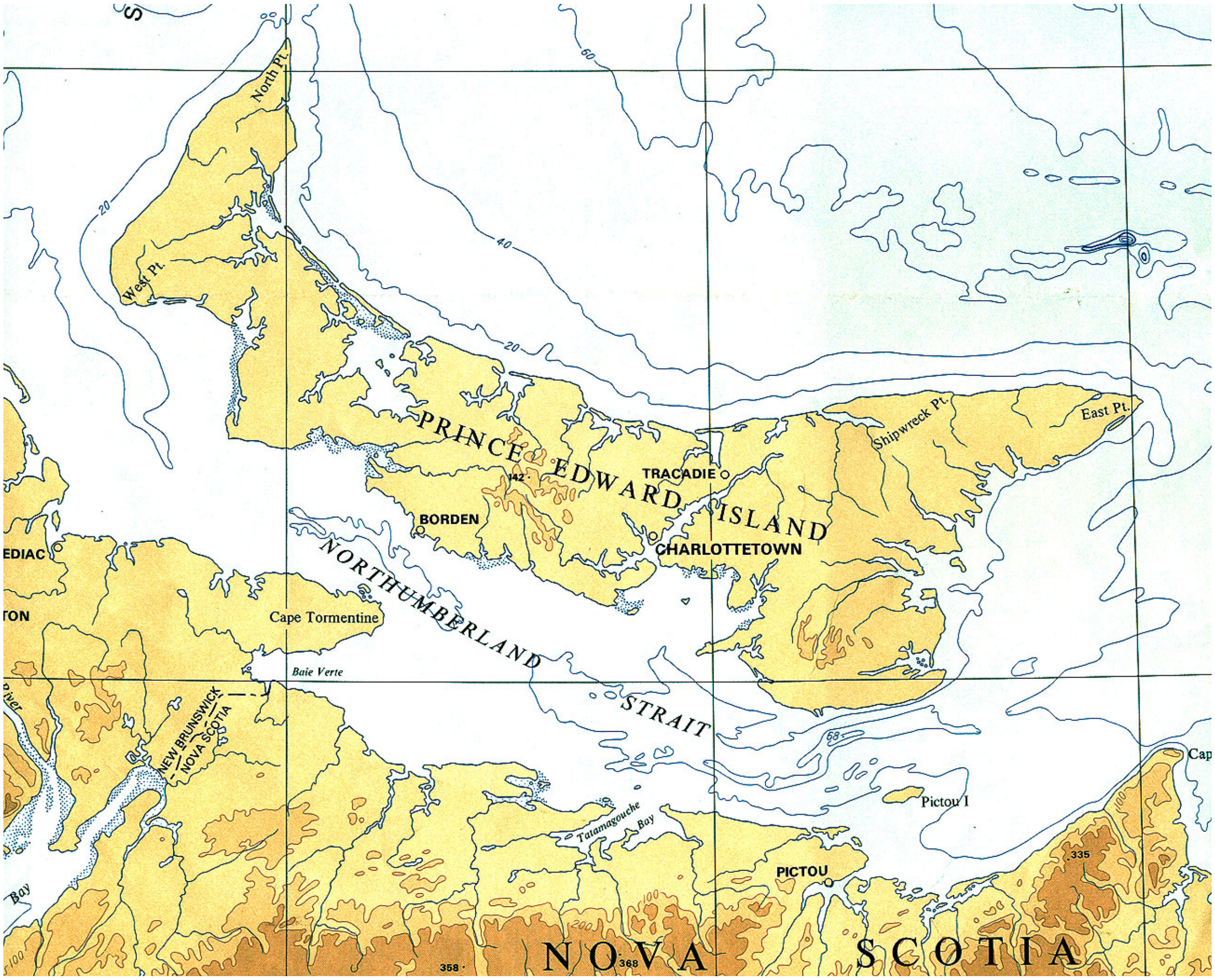
Data describing the variability in the mean current through the Strait at Abegweit Passage were published as part of the environmental monitoring conducted for Strait Crossing Inc. to document pre- and post-Confederation Bridge conditions (Jacques Whitford Environmental Limited (JWEL), 1994). Figures 2.1-2 and 2.1-3 show a month-long record of near-bottom (shown as “BIN 1”) and near-surface (shown as “BIN 20”) advection past the mid-Strait current meter site as a progressive vector plot of appended current observations versus day-of-the-year during fall. The plots show a net strong southeastern current at both the bottom and surface. Within the record are periods of rapid advection that were correlated with weather events. Importantly, during the fall period the water column is relatively uniform and current patterns vary little with depth.

Figures 2.1-4 and 2.1-5 show a similar plot of near-bottom and near-surface currents at the current meter site during summer. The data show a much weakened set with large vertical variations in the currents. In fact, the bottom set is to the west.

2.1.1 Tides in the Strait

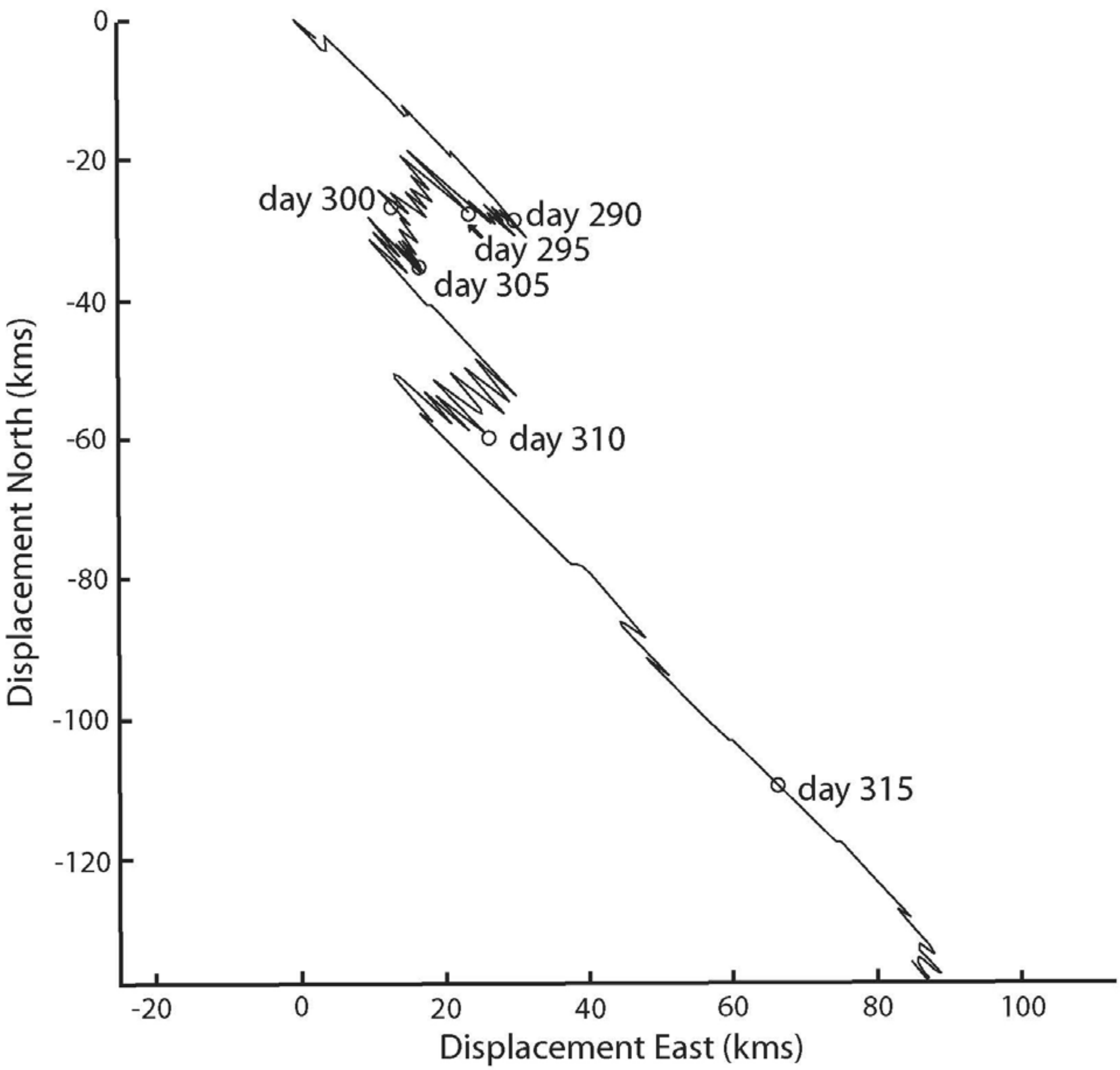
In contrast to the low-frequency variations in mean flow patterns, tides in the Northumberland Strait are relatively well understood, documented and modelled. Tidal energy is the largest component of the energy from currents. Abegweit Passage data show that tides constitute up to about 95% of the current variance (energy) near the surface in summer and about 80% of surface current variance in fall. These currents determine the mean stress felt on the bottom as well as the mean energy available for vertical mixing in the water column.

FIGURE 2.1-1 Generalized Bathymetry of the Northumberland Strait



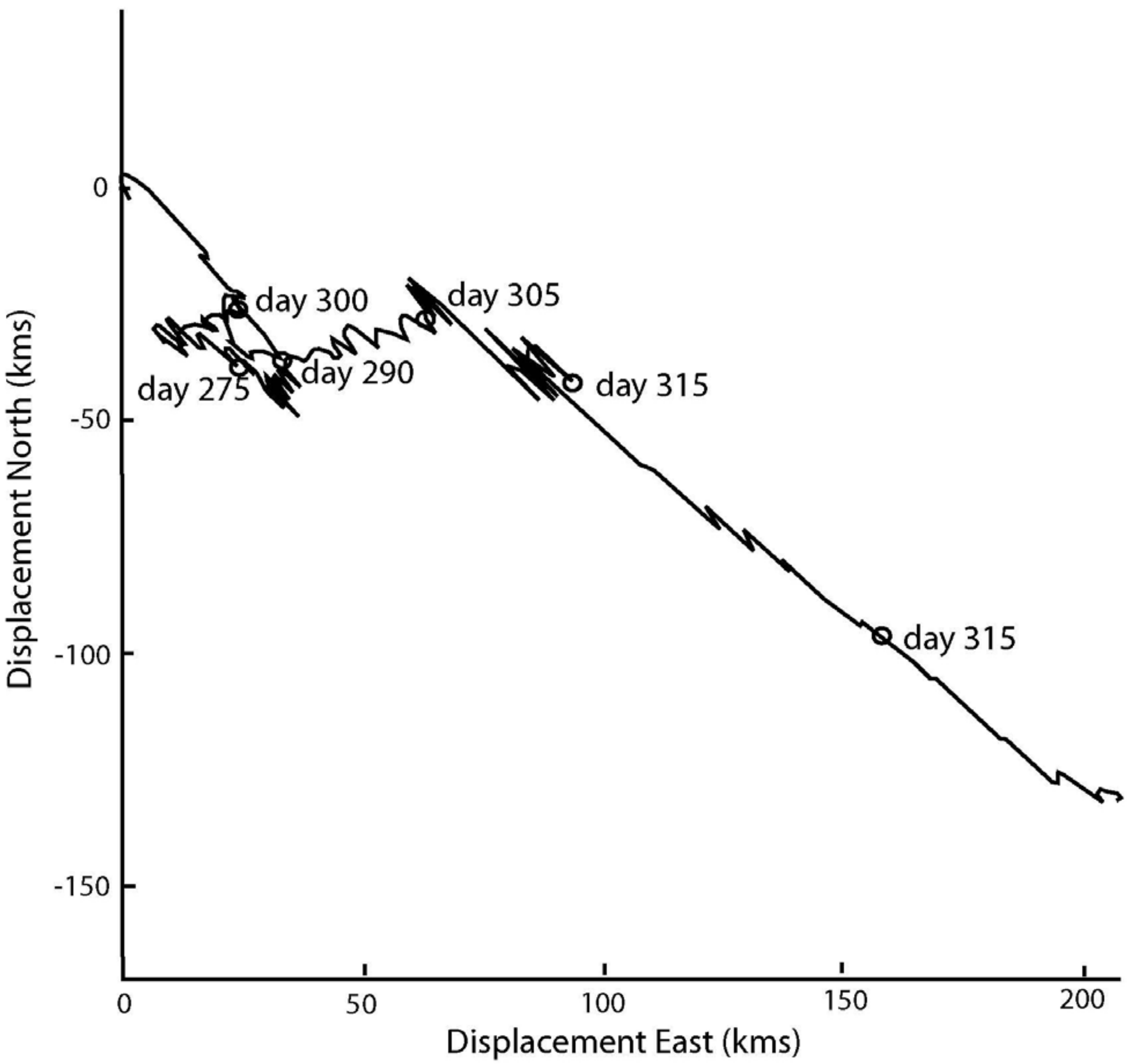
Canadian Hydrographic Service Map 801, 1975 edition.

FIGURE 2.1-2 Progressive Displacement Plot – Fall ADCP – BIN 1



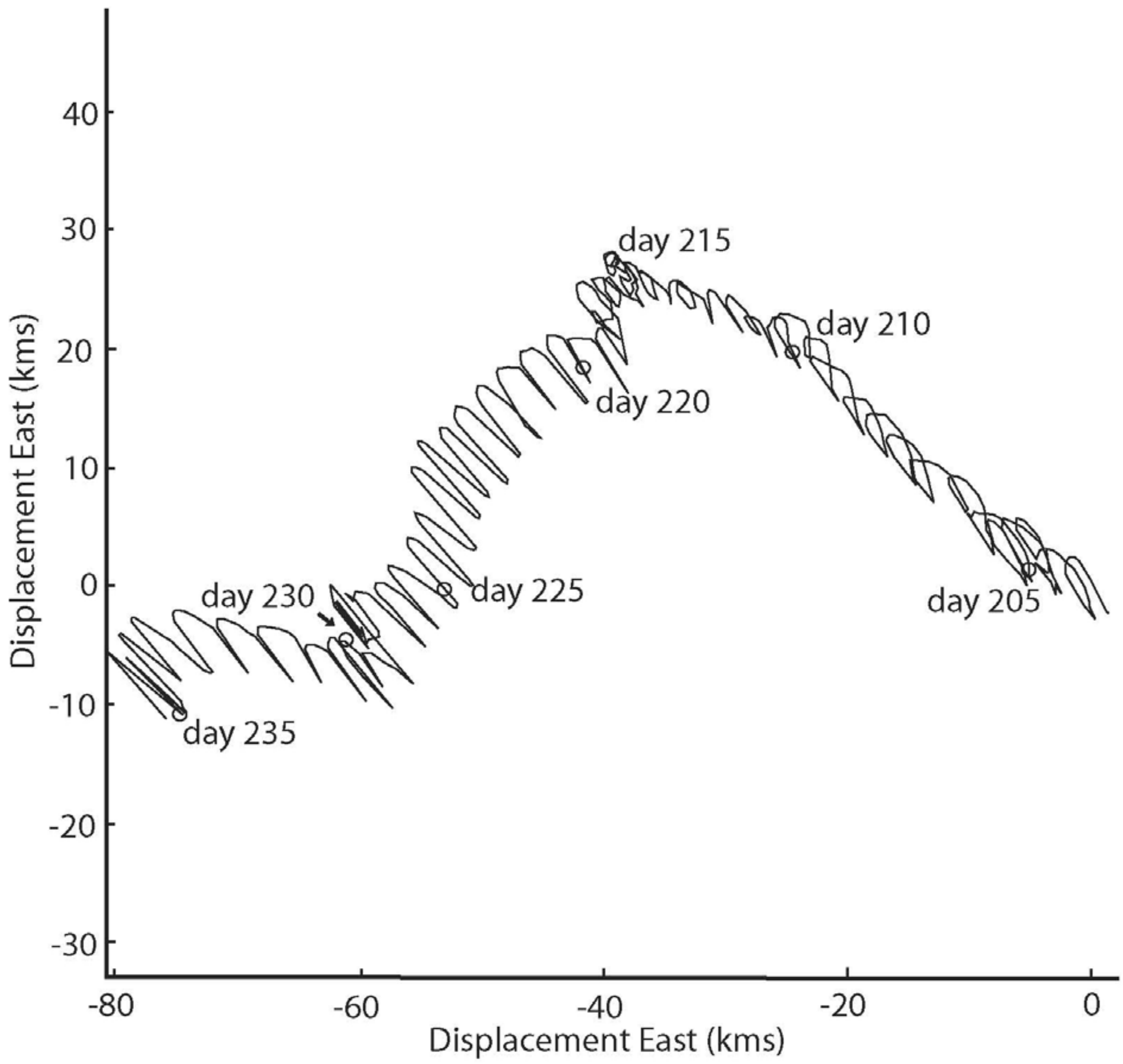
Source: JWEL, 1994

FIGURE 2.1-3 Progressive Displacement Plot – Fall ADCP – BIN 20



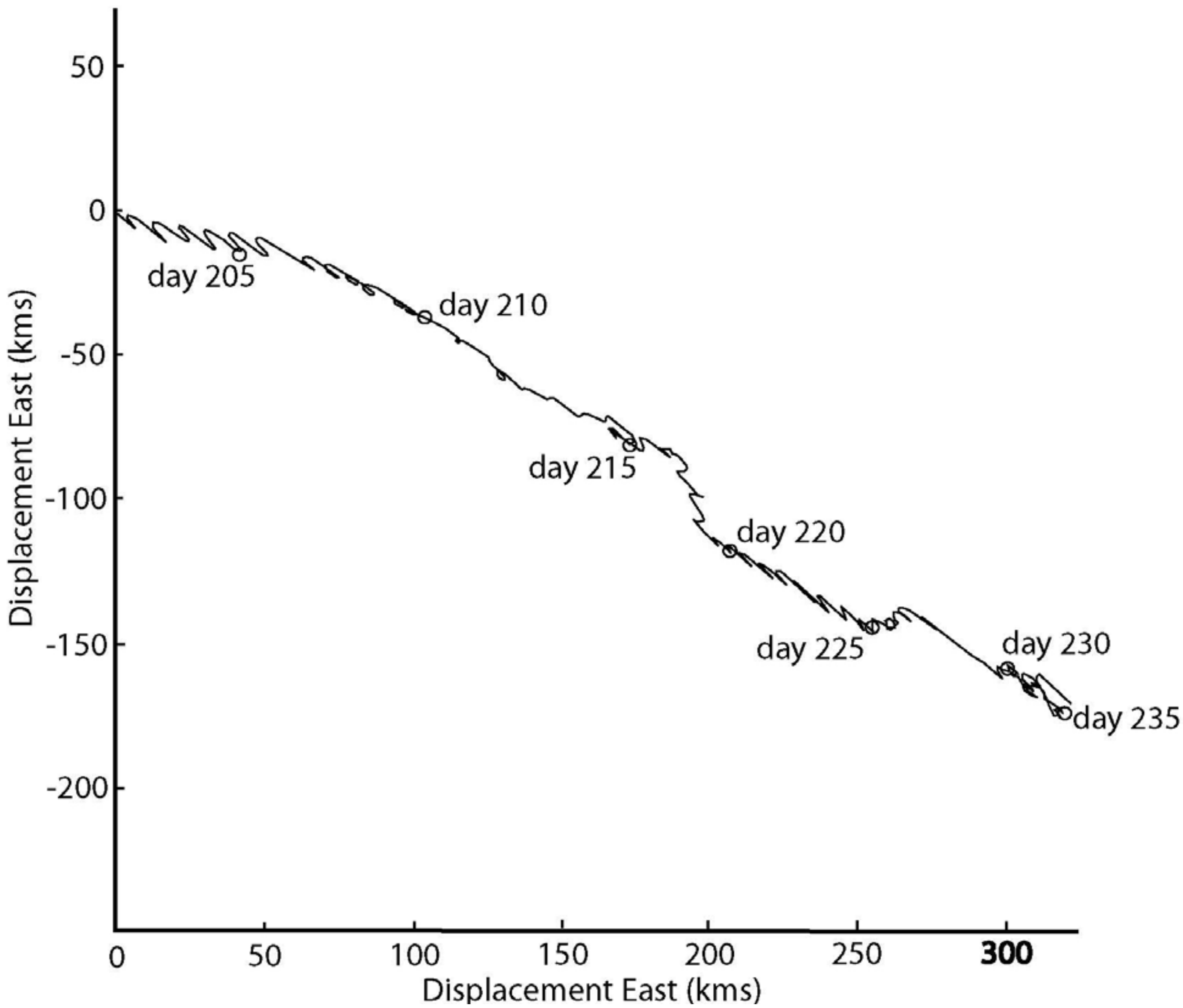
Source: JWEL, 1994

FIGURE 2.1-4 Progressive Displacement Plot – Summer ADCP – BIN 1



Source: JWEL, 1994

FIGURE 2.1-5 Progressive Displacement Plot – Summer ADCP – BIN 20



Source: JWEL, 1994

Recent models developed in the academic community and at DFO (Lu, Thompson and Wright, 2001; DFO, 2006a) describe tidal current patterns and the fundamental vertical variations in flows while reportedly reproducing about half the low-frequency variability. Furthermore, detailed data sets reported as a part of environmental monitoring for the Confederation Bridge (JWEL, 1993-1998) do not show any significant change in tidal properties. A part of this, these results reproduced in Table 2.1-1 compare the measured amplitude of the M2 tidal elevation constituent post-Bridge to the seminal early tidal results for the region prepared over 40 years previous. Within the accuracy of the measurements there have been no changes. Similarly, analysis of the pre- and post-Bridge currents at the present mid-Passage current meter location represented in Table 2.1-2 showed no significant changes. Hence it appears that the basic tidal environment in the Strait is stable. The new models available for currents in the Strait are unprecedented, however, and may provide new insights to subtle tidal questions such as stability in view of sea-level rise and hydrographic changes. Such models could also be instrumental in interpolating from sites of verification to general areas in order to resolve patterns near the shoreline, in bays and estuaries, and patterns of mixing and dispersion that occur there.

2.1.2 Waves in the Strait

Being narrow with a high percentage of shallow near-shore areas, waves and wave-related processes play an import role in the Strait system. In particular, wave-induced erosion is of concern especially in the likelihood of significant sea-level rise in the near future. Ecological issues include the associated modification to the morphology of the sea bottom and inherent changes in bottom habitat.

Although modeling surface waves within the Strait is non-trivial, especially in view of possible wave-current interaction, it is tractable by modern methods at least in the case of a static sea bottom and results could be developed for reference as a set of standard patterns covering the spectrum of possible winds and currents. An example of such a pattern is shown in Figure 2.1-6.

Near-shore dynamics associated with wave processes, including bar formation, sediment drift, etc., constitute a complex area of active research. This research is outside the scope of an IM system (i.e., when required for harbour design or modification, it will continue to be necessary to conduct a site-specific study). However, a broad set of high-resolution wave model results, coupled with existing long-term weather data (AES40, Charlottetown Airport records), would provide a good basis for identifying sites of concern and could be prepared for a range of sea levels so that long-term issues could be identified.

2.1.3 Ice in the Strait

Ice in the Strait, and particularly the timing of ice-out, has been an issue of greatest concern since the construction of the Confederation Bridge. According to the 2003 Northumberland Strait Ice Break-up model (IFN, 2003) observed ice-out shows good agreement with predicted dates in the model both with and without the presence of the bridge. The present view that global climate change will bring an end to annual ice formation in the Gulf is popular and is undoubtedly an issue of great ecological concern, with significant changes in water mass predicted throughout the Gulf. Ice monitoring should continue, therefore, to be a priority throughout the Gulf, including in the Northumberland Strait.

TABLE 2.1-1 Comparison of 1997 Tidal Analysis Results with Early Results (Farquharson 1962, 1970)

	Cape Pelé		Cape Egmont		Wood Island		Caribou	
	Farquharson	1997	Farquharson	1997	Farquharson	1997	Farquharson	1997
Mean M2 Amplitude	0.30	0.32	0.24	0.25	0.53	0.53	0.45	0.45
Mean M2 Phase	70°	65.0°	85°	81.6°	45°	42.6°	55°	49.6°

TABLE 2.1-2 M2 Tidal Current Ellipse Parameters

	1994		1997	
	Summer	Fall	Summer	Fall
Surface Bin M2 Major	54	48	57	49
M2 Minor	-5	-2	-2	-1
Inclination	138	133	140	127
G. Phase	129	119	127	119
Bottom Bin M2 Major	34	40	37	45
M2 Minor	6	1	6	1
Inclination	127	134	119	127
G. Phase	103	116	96	116

2.1.4 Near-shore and Estuarine Processes in the Strait

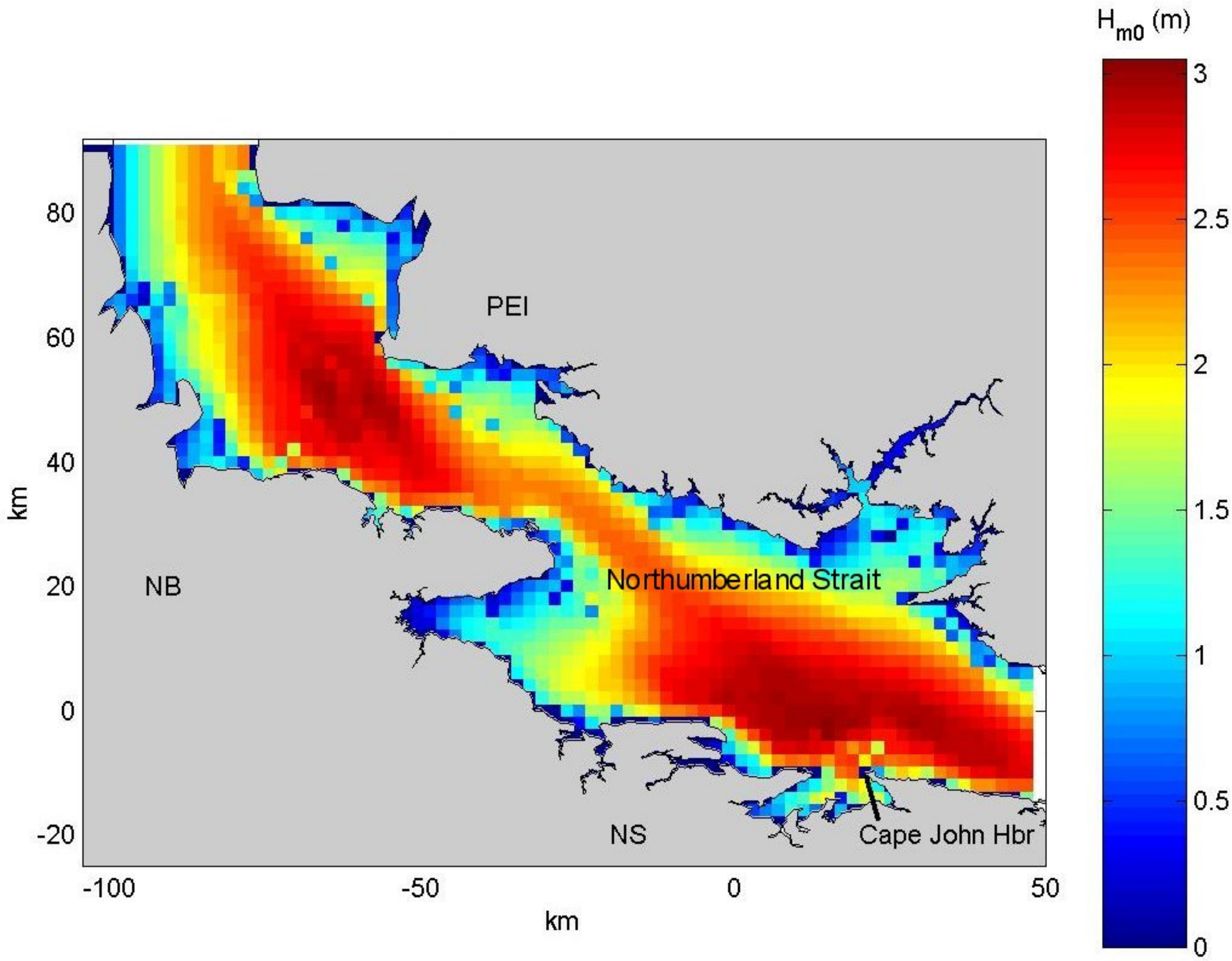
Near-shore issues abound in the Northumberland Strait. These include effluent dispersion and dilution, elevation of nutrient levels from run-off, the presence of pathogens, flushing at causeways and many others. An overview of some of these issues was presented at the physical oceanographic workshop. Modeling approaches for evaluating various processes were discussed (Appendix B; Physical Environment Technical Workshop Proceedings Report). From an oceanographic perspective, the emphasis on the present project appears to be more focused on deeper areas of the Strait in which fisheries concerns are predominant. For this reason, near-shore and estuarine oceanographic processes appear to be of secondary concern and are not reviewed here.

2.2 BIOGEOCHEMISTRY

The Northumberland Strait is a sub-region of the Gulf of St. Lawrence and might be expected to reflect various oceanographic and sedimentary conditions in the southern Gulf. It is, however, bounded by PEI, NB, and NS in a way that provides a potential local influence of coastal estuaries. Because the geochemistry of the Strait region is poorly known, any discussion must include the feasibility of extrapolation from conditions in the larger Gulf where there is extensive information on sediment geochemistry.

Geochemistry may be defined in the context of concentration and diagenesis of inorganic and organic compounds in sediments. Specifically, reference will be made to organic matter (phytoplankton and detritus), nutrients (natural and introduced), and contaminants i.e., Polychlorinated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAH), Tributyltin (TBT), and heavy metals. In addition to marine production, there are a variety of anthropogenic

FIGURE 2.1-6 Model Input: Wind at 25 m/s from NW



activities that affect geochemistry, including; mining and processing of minerals and peat, pulp and paper industry, agriculture, urbanization, and fisheries/aquaculture. Despite an emphasis on sediments, the water column plays an important role in the transfer of materials via diffusion/advection and resuspension/deposition. This coupling is especially significant in the shallow waters of the Strait. Sediments tend to be more useful for ecosystem assessment since they are repositories in which concentrations integrate input and diagenesis through time, creating a more persistent record than the water column.

In general, the Strait region is characterized by a lack of data; beyond this limited source of information is the potential to extrapolate from other studies in the Gulf. The website of the Working Group on the Northumberland Strait provides the following quote: "There are no current data illustrating temporal trends of any contaminants at any site in the Northumberland Strait" (http://www.glf.dfo-mpo.gc.ca/sci-sci/northumberland/si-is/contaminants-pesticides-e.jsp).

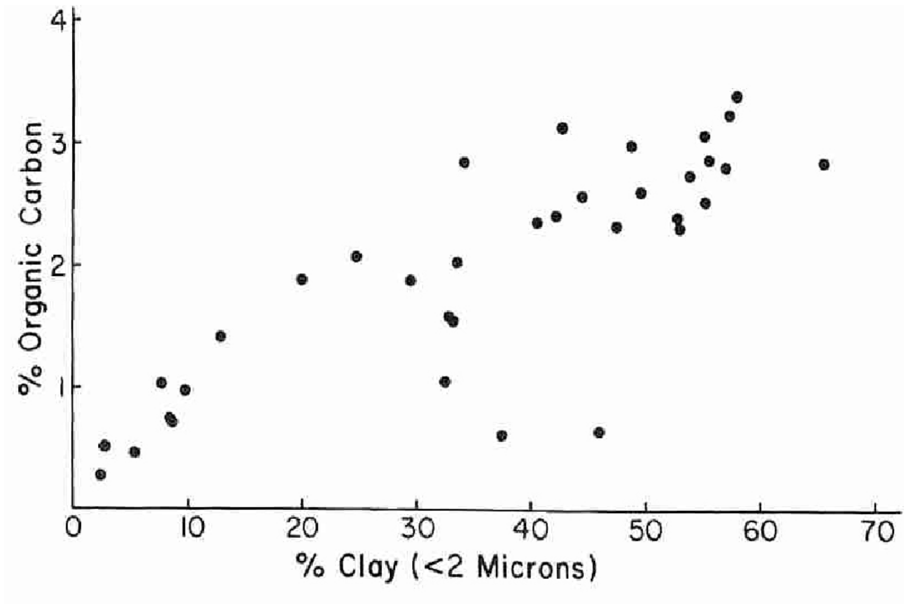
Any consideration of geochemistry in the Strait, especially with regard to contaminants, must consider (a) two source terms: input from the wider Gulf, and local input from adjacent estuaries, and (b) processes within the Strait, such as deposition and re-suspension, that affect residence time and transformation in the sediments and water column. Input from the Gulf is a function of 'upstream' concentrations and circulation patterns that direct water and suspended sediments in the Northumberland Strait area. For this reason, information on Gulf geochemistry and physical oceanography respectively are important to any consideration of local geochemistry in the Strait. As detailed below, the most available geochemical indicator of local processes within the Strait is sediment texture.

2.2.1 Geochemical Setting

Organic matter in the Gulf of St. Lawrence is generally characterized by material of marine origin, with minimal quantity of human input. Pulp and paper mills might be expected to contribute to organic content, but lignin as an indicator of terrestrial additions is small (Pocklington, 1988). In one of the few Strait studies, Rashid and Reinson (1979) were able to trace paper mill input to sediments of the Miramichi estuary, with attenuation of the signal seaward, suggesting only a local impact. The chemical oceanography of the Gulf of St. Lawrence has been the subject of entire books (Strain, 1988) and includes measurements of various sediment constituents as well as studies of diagenetic rates (Boudreau et. al., 1998). These data routinely exclude the Northumberland Strait as indicated by a blank region in contour maps of any specified compound. The Quebec region of the St. Lawrence River and Gulf has had significant pollution problems in the past, originating from shore-based industry (i.e., Saguenay River). Although there is some indication that sedimentary conditions are improving, sources of contaminants from upriver are still significant (National Program of Action (NPA), 2000).

Sediments of the Strait region are generally sandy or coarser (refer to Section 2.3), leading to an expectation of low particulate organic carbon (POC) content. Loring and Nota (1973) provide a significant relationship between clay content and carbon content for the Laurentian Trough (Figure 2.2-1), presumably mediated through increased surface area of fine sediments (Mayer, 1994). In one of the rare maps that includes the Northumberland Strait, Loring and Nota (1973) contour the entire region as <1% sediment POC. Because many contaminants and metals are particle reactive, one might hypothesize that the concentration of these compounds would also be low in Strait sediments (Pierard et. al., 1996). However, the possibility of local sources from estuaries due to extrapolation based solely on sediment texture would be risky.

FIGURE 2.2-1 Effect of Clay Content on Sediment Carbon Content (from Loring and Nota, 1973)

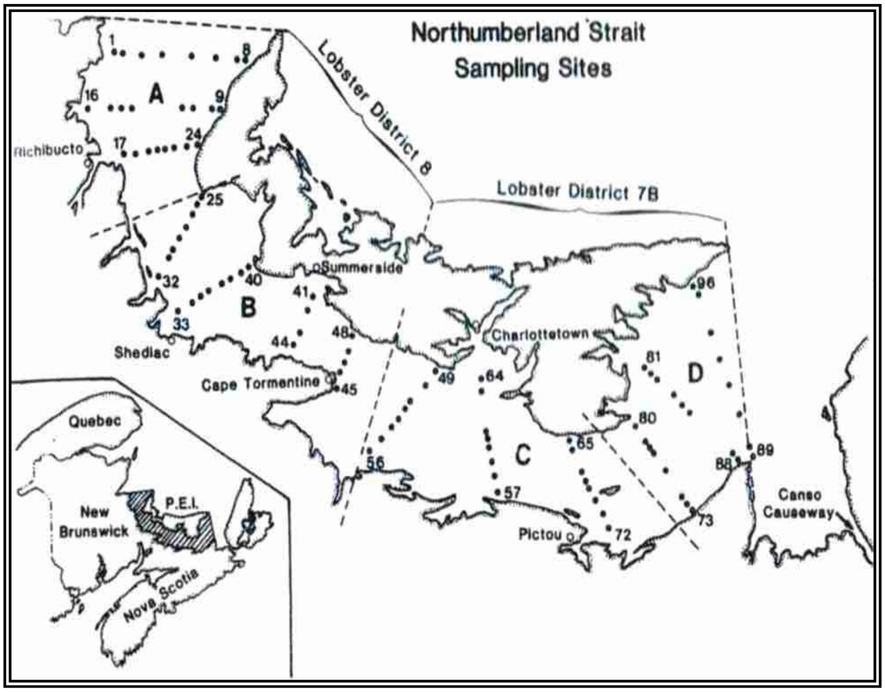


There are a variety of ecosystem studies within estuaries of the Northumberland Strait and a few examples of sediment geochemistry with respect to contaminants (mercury from peat extraction in Richibucto (Surette et. al., 2002)). Most of these studies, however, consider only body burden of various toxicants in fauna (i.e., Couillard and Nellis, 1989). These estuaries, in some cases, contain concentrated industrial activity and/or urbanization (i.e., Miramichi, Charlottetown), and the flux of outwelled nutrients and contaminants from these locations to the Strait is potentially significant. There is some concern that dissolved nutrients from sewage or agriculture have also been increasing in PEI estuaries (NPA, 2000). Eutrophication from these sources will be expressed via increased primary production, organic sedimentation, and potentially hypoxia within the estuaries, but there is no information to couple estuarine events with water quality or sedimentation in the Strait. Beyond measurements of chemical concentrations, estuaries within the Strait have been studied with respect to benthic oxygen consumption (i.e., Hargrave and Phillips, 1986), but these measurements are in fine-grained sediments atypical of conditions in the open Strait.

2.2.2 Data

A synopsis of geochemistry in the Strait is restricted to discussion of concentration of the few measured quantities. There is a single comprehensive study of the Northumberland Strait which includes cross-Strait transects over the whole region (Figure 2.2-2; Caddy et. al., 1984). A subset of the samples (n=28) was used to measure copper, zinc, manganese, cadmium, arsenic, and mercury in surficial sediments (0-10 centimetres (cm)) as well as in selected deeper horizons (n = 3 cores). Results indicate that there are 'no recent accumulations' of any of these metals in these sediments.

FIGURE 2.2-2 Sampling Transects from Caddy et. al. (1984) in Studies of Sedimentary Metals in the Strait



Lakshminaranaya and Jonnavithula (1989) surveyed heavy metals in the water column of the Northumberland Strait. Although they express concern about elevated levels of lead and manganese in this region, there is insufficient detail of location or environmental conditions to evaluate their statements. There are surveys of nutrients associated with biological oceanographic studies of the Strait published in technical reports (DFO, 2001) which provide snapshots of conditions in the region. In the latter reference, there are fairly low levels of nitrates in the Northumberland Strait compared to the Gaspé region for September samples.

2.3 GEOLOGICAL COMPONENTS

2.3.1 Geological Formations (Bedrock)

Information on the bedrock geology of the Northumberland Strait is provided by seismic reflection studies using a variety of sound sources (Kranck, 1971; Fader and Pecore, 1988). Other information is from boreholes and samples collected as part of the Confederation Bridge foundation assessment and construction, as well as that interpreted from sidescan sonar data (Fader and Pecore, 1988) and multibeam bathymetry collected by the Canadian Hydrographic Service (CHS). The bedrock in the Strait is very important to the EOR - not only because it has been a source for the glacial till and sediments that cover large areas of the seabed, but because it crops out on the seabed over many areas, forming marine habitat.

2.3.2 Distribution, Lithology and Structure

Most of the Strait is underlain by gently folded Upper Carboniferous and Permian sedimentary rocks consisting of sandstone, siltstone, mudstone, and conglomerate (Figure 2.3-1). These rocks display well-defined bedding and are red, orange-red, or red-brown in colour with green reduction patches along joint surfaces. They were originally deposited in a fluvial and/or estuarine environment. The coarser sediments in the bedrock have been interpreted to have been deposited in ancient braided river systems. Many of the beds are cross-bedded. Faults, joints, shear zones, and seams were detected in the boreholes but no evidence for major faulting was encountered. The upper section of the bedrock in the boreholes is weathered and the rocks are softer and weaker. For the Bridge footings, not only was the overburden removed, but the highly weathered bedrock zones were excavated and the piers founded on slightly weathered to fresh rock (Kosar et. al., 1993). The deepest excavations for the Bridge piers penetrated as much as 15 metres (m) of till and weak bedrock in the central part of the Strait to obtain an acceptable foundation.

In the western area of the Strait, the bedding is nearly horizontal, but the intensity of folding increases toward the east. In the eastern part of the Strait, broad anticlines form northeasterly-trending ridges, part of which form Pictou Island and Fisherman's Bank east of PEI. These rocks crop out on the adjacent shoreline, where they consist of soft banded grey to reddish-brown sandstones with minor conglomerate. In the Confederation Bridge crossing area, the bedrock dips at 2 – 4 degrees to the northeast toward PEI.

Results of a gridded survey with sidescan sonar in the central Strait and the multibeam bathymetry show large areas of the seabed as exposed bedrock. Nautical charts of the Strait also show rock reefs and bedrock exposed at the seabed in some areas of the nearshore, in depths to approximately 10 m. The areas of bedrock exposure at the seabed of the central Strait cover large areas and extend to depths of over 20 m, and suggest that bedrock is likely exposed at the seabed in other areas of the Strait.

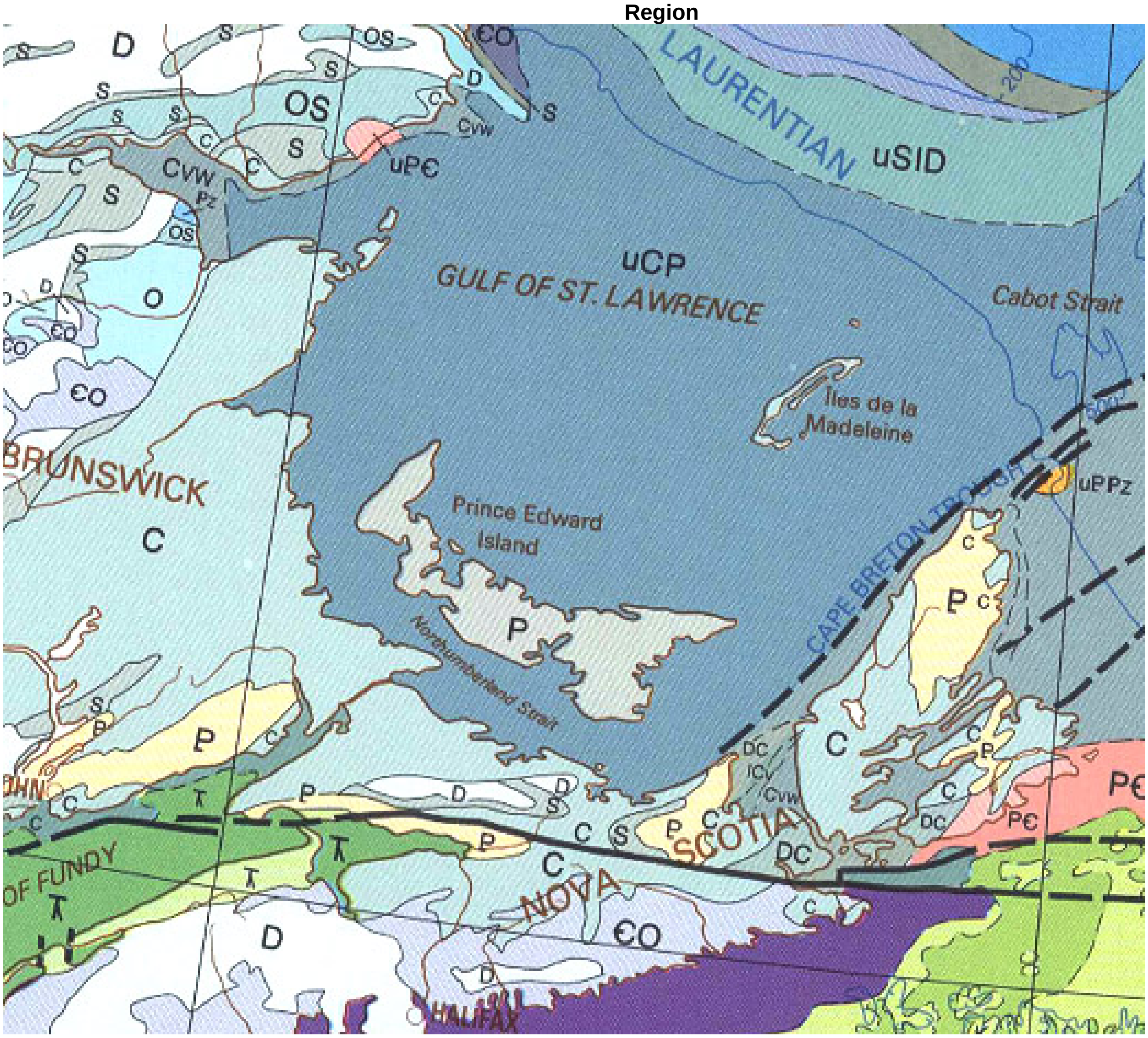
The bedrock surface, although buried by overlying till in most places, is an undulating surface that is smooth in some areas and rough in others. Relief on the bedrock surface is generally less than 20 m but increases to over 40 m in the eastern part of the Strait. The areas of highest relief are associated with channels that have been cut into bedrock.

2.3.3 Geomorphology

The Northumberland Strait is located in the southern region of the Gulf of St. Lawrence, between PEI and the provinces of NS and NB. Its western boundary lies between Richibucto Cape, NB and Cape Wolfe, PEI, where it is 24 kilometres (km) wide. Its eastern boundary lies between Cape George, NS and Cape Bear, PEI, where it is 41 km wide. The Strait is a narrow body of water approximately 222 km in length and oriented northwest - southeast with both narrow and broader areas ranging from 13 km at the Confederation Bridge crossing location to 43 km to the east of Baie Verte.

The coastline of NB and NS, which is the southern coast of the Northumberland Strait, is dominantly a strait coastline of minor bays, inlets and sand bars, with the exception of the Cape Tormentine region which from an easterly-trending headland that projects over 28 km into the

FIGURE 2.3-1 Regional Bedrock Geology of the Northumberland Strait and Southern Gulf of St. Lawrence Region



A portion of Map 1705A showing the regional bedrock geology of the Northumberland Strait and southern Gulf of St. Lawrence region produced by the Geological Survey of Canada, (Fader et al., 1989). Note that the Northumberland Strait region is underlain by upper Carboniferous – Permian sedimentary bedrock.

Strait at the narrowest mid-Strait location. This eastward land projection confines Baie Verte to its south. In contrast, the southern coast of PEI is dominated by three large bays; Egmont, Bedeque and Hillsborough, that occur from west to east and indent the southern coast of the island as much as 17 km. These bays and their adjacent offshore Strait areas also form the widest regions of Northumberland Strait.

2.3.4 Physiography

The Northumberland Strait occurs within the Canadian Appalachian Region physiographic province of Atlantic Canada. It also occurs within a subdivision known as the Carboniferous-Triassic Lowlands because it is dominantly underlain by sedimentary rocks of that age. Another name for that region is the Maritime Plain, which covers central NB, Northumberland Strait, PEI, and the southern Gulf of St. Lawrence, and is continuous across these areas.

2.3.5 Bathymetry

CHS Chart # 4023 shows the regional bathymetry of the Strait, contoured in fathoms. It depicts a number of closed bathymetric depressions that define the broad water depths and surface morphology throughout the Strait. Beginning in the west, a 10 fathom (18.5 m) contour extends northwesterly from south of Egmont Bay, opening and gradually deepening to the west as the Northumberland Strait merges with the Gulf of St. Lawrence. Maximum water depths in this area are 14 fathoms (26 m) with an average water depth of 12 fathoms (22 m). In the western area of the Strait there are many shallow nearshore shoals such as Egmont Bank that limit the width of the deeper central passage, and those shoal areas have depths as shallow as 3 fathoms (5.6 m). Most of the shallow areas away from the shoreline are offshore sand banks.

The area of the central Strait between Cape Tormentine and Port Borden presents more complex bathymetry. The deepest depth on CHS Chart #4023 is 15 fathoms (27.5 m), which occurs in a linear zone defined by the 10 fathom (18.5 m) contour. East of the Confederation Bridge the Strait broadens and widens toward the east. A linear 20 fathom (37 m) contour with maximum depths of 26 fathoms (48.2 m) occurs southeast of Wood Island, PEI, and is the area where some of the depths occur in the Strait. Water depths to the east of Pictou Island gradually increase to 23 fathoms (42.6 m) at the eastern boundary of the Strait where it broadens and widens between eastern PEI, St. Georges Bay, and Cape Breton Island.

CHS Chart 801 (Figure 2.1-1) presents a generalized depiction of the bathymetry of Northumberland Strait. The seabed in both the western and eastern areas of the Strait deepens toward the larger Gulf of St. Lawrence. The central area of the Strait is depicted as an isolated linear depression defined by the 20 m contour. The bathymetry of the eastern Strait is more complex and deeper, with an isolated maximum depth of 68 m northwest of Pictou Island.

2.3.5.1 Multibeam Bathymetry

The modern standard in seabed bathymetric mapping is provided by multibeam bathymetry surveys. They utilize a system of ship-mounted transducers that produce fan-shaped arrays of sound to measure water depth, providing 100% coverage of the seabed. The data is digitally collected and presented as a seamless continuous terrain map of the seabed. In the Northumberland Strait, the largest area of multibeam bathymetric coverage is in the Abegweit

Passage on either side of the Confederation Bridge (Figure 2.3-2). It was collected prior to Bridge construction and was never widely distributed or interpreted. When compared with the existing bathymetric map produced from conventional echosounder surveys, where survey tracks are separated by distances of 100s of meters, the imagery reveals that the seabed is morphologically complex. The bathymetric patterns can be interpreted to understand the origin of the features and seabed processes that may be active today.

Modern multibeam bathymetric mapping systems can attain seabed resolutions as high as 10 cm. Older systems, such as the one used to survey the Abeqwait Passage region of Northumberland Strait in 1995, were not capable of such a high resolution. The multibeam bathymetric image presented in Figure 2.3-2 has been processed at approximately 5 m resolution, so seabed features smaller than that would not be discerned on that image. However, the data can be processed with varying grid sizes, and 2 m is approximately the highest resolution at which the multibeam bathymetric image collected in 1995 could be processed.

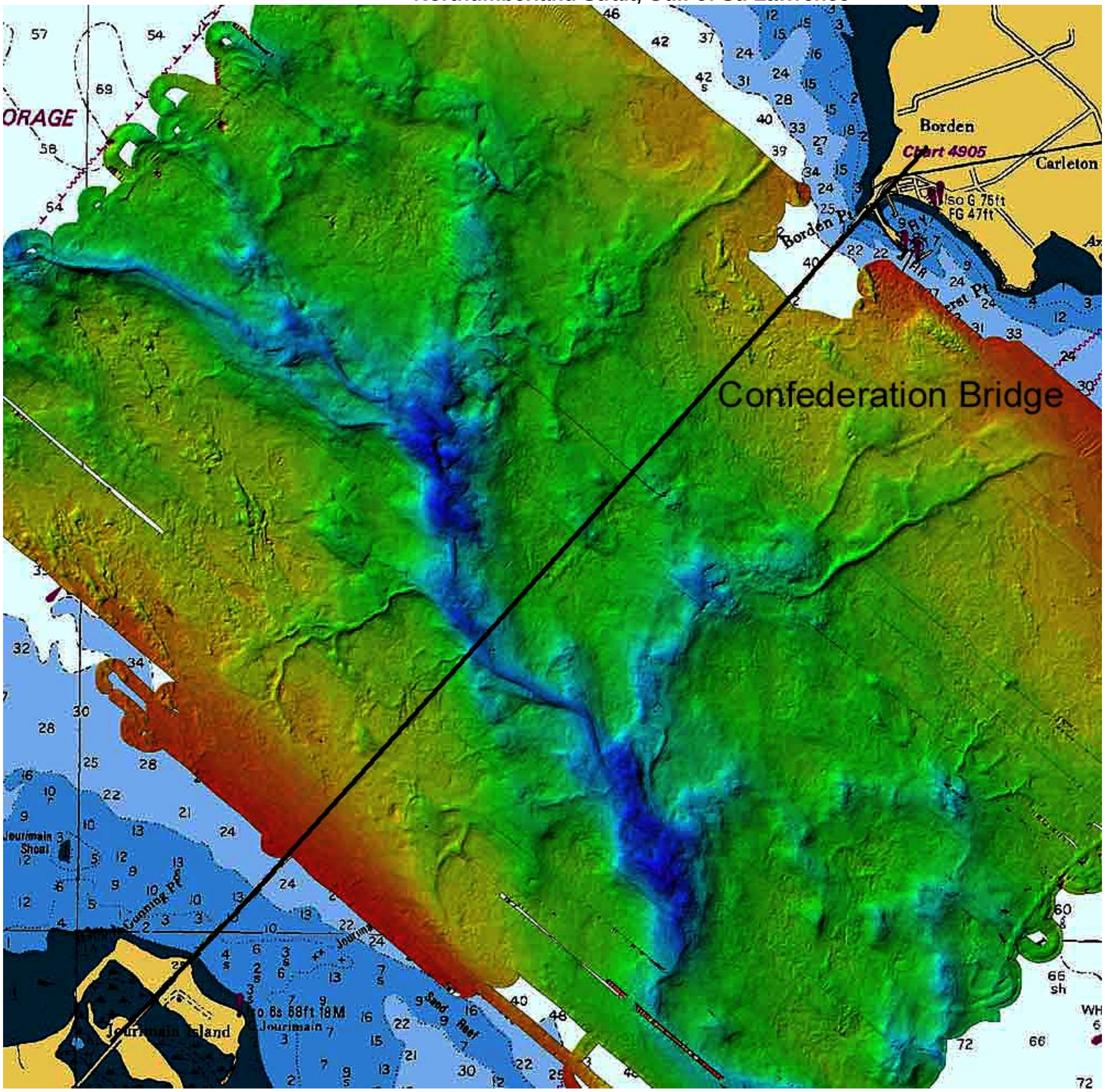
The multibeam bathymetric imagery shows that the seabed is dominated by an extensive channel system that trends southeast – northwest throughout the centre of the Strait. In places, the sides of the channel are straight and steep, while in other areas, the channel broadens. This suggests that lakes previously existed along the course of this old river system. Many small stream and river tributaries occur at right angles to the main drainage system. This system of channels at the seabed of the Strait retains many characteristics of its former subaerial state when sea level was lower. The drainage system is the major feature of the multibeam bathymetry and was unknown from the earlier surveys.

Both multibeam bathymetric and sidescan sonar systems complement each other in providing information about materials and topography of the seabed, but generally they are two entirely different systems. Multibeam bathymetry is a calibrated quantitative system with many independent sound beams. The incident angles with the seabed are very high as the systems are normally mounted on ships. The data is processed to remove ship motions and each sound beam is positioned to provide accurate maps of water depth or a view of the topography in a swath that varies up to 6 times water depth. If collected appropriately, the data can be processed to produce images of relief (morphology), backscatter (a proxy for seabed sediment or bedrock type) and seabed slope. Vertical exaggerations can be added to enhance subtle seabed relief. The imagery is normally produced as a shaded-relief map with an artificial sun shone across the image to help the viewer see the seabed as one would look across the land surface.

In the Northumberland Strait, the complex, large-scale morphology of channels and former lakes provided by the multibeam bathymetry was not observed on the sidescan data. Conversely, the ice scour features, individual boulders and details of small sand bedforms were not seen on the multibeam imagery.

The multibeam bathymetry also shows large areas of exposed bedrock on the seabed. The exposed bedrock surface has unusual v-shaped depressions that likely resulted from glacial erosion. Other areas of the imagery show the presence of sand bedforms, sand waves, and megaripples on the seabed, with sharp crests indicating that these bedforms are active and sand is in transport. Areas of dredge spoils occur in other regions. None of these features and characteristics of the seabed of Northumberland Strait were known from the standard CHS

FIGURE 2.3-2 Colour Depth-coded Multibeam Bathymetric Image of the Abegwait Passage Area of Northumberland Strait, Gulf of St. Lawrence



Deepest depths in blue range to 28 m water depth in the central part of the strait. A sinuous system of former rivers, streams and lakes runs through the central part of the strait. The multibeam bathymetric information was collected on survey "FixedLink 95-012" from the CCGS FGC Creed. The Hydrographer in charge was Gerard Costello, CHS Atlantic. The Creed was fitted with a Simrad EM1000 system. The resolution of this image is approximately 5 m.

bathymetric mapping or the earlier sediment and geological studies of Kranck (1971), and Loring and Nota (1973). The significance of these seabed features is discussed in Section 2.3.6 on surficial sediments.

Multibeam bathymetry has also been collected along the Confederation Bridge alignment to image the Bridge pilings and their associated dredged depressions. Several detailed multibeam surveys have also been conducted over areas of dredge spoils.

Backscatter is a measure of the reflected acoustic energy from the seabed, of multibeam bathymetric mapping systems. If the data is collected properly, backscatter maps can be produced that complement the multibeam bathymetric shaded-relief imagery. The maps of backscatter show the hardness or roughness of the seabed and can be presented in different formats, the most common being shades of grey that indicate relative hardness. These maps are a proxy for sediment type where, for example, mud shows as light toned regions and gravel as dark toned. Proper interpretation of the backscatter information requires some seabed samples to be collected and analysed, but the sample locations can be targeted to changes in backscatter, requiring a minimal number of samples.

Maps of seabed slope can also be produced from multibeam bathymetric information. They are commonly presented in colour where the colours represent ranges of seabed slope in degrees. They are particularly good at showing the steepness of the seabed and subtle aspects of erosion and deposition in areas of high currents. To date, both backscatter and seabed slope maps have not been prepared from the multibeam bathymetric data collected by the CHS in Abegweit Passage.

2.3.5.2 Side Scan Sonar

Side scan sonar provides information on two aspects of the seabed by sequentially scanning it with a narrow fan-shaped beam. One is the relative hardness or roughness of materials and the other is the presence of features on the seabed such as boulders, shipwrecks and bedrock outcrops. Side scan systems are uncalibrated so that the relative backscatter is important between different seabed types. Features are defined by their shape and the shadows they create, as side scan systems use low acoustic grazing angles and are normally towed close to the seabed. For example, a 15 m to the seabed is optimum for many 300 KHz systems. Side scan sonar requires trained operators and interpreters to collect the information, and the sonograms present a qualitative rather than quantitative assessment of seabed sediment type. They have a high spatial resolution but poor locational accuracy. Many modern multibeam sonars are now also capable of generating an acoustic backscatter image, and side scan sonars can have the capability of measuring seafloor topography, so these systems are becoming less distinct as the technology evolves.

2.3.6 Sedimentology – Surface Sediments

Three major regional studies have been conducted on the surficial sediments of the Northumberland Strait (Kranck (1971), Loring and Nota, (1973) and Fader and Pecore (1989)). These have provided information on the sediment grain size and geological history, and an assessment of both relict and modern processes that have and are affecting the seabed,. The first systematic mapping of the seabed sediments and study of the marine geology of the Strait was undertaken by Kranck, 1971. The study was based on the collection of 600 seabed grab samples for sediment analysis, 3500 km of echogram profiles, and 900 km of sparker seismic reflection profiles for sub-surface information on sediment thickness and bedrock. This study resulted in the publication of Marine Science Paper 5, Map 4023G (Geological Survey of Canada Paper 71-53 Kranck, 1971), that included a report and map (Figure 2.3-3) of the surficial geology at 1:300 000 scale. The following is a brief description of the sediments at the seabed of the Northumberland Strait based on that study.

Two mud to muddy-sand deposits occur in the Strait. The Pugwash mud is a modern sediment presently being deposited. The areas of deposition of the Pugwash mud occur in:

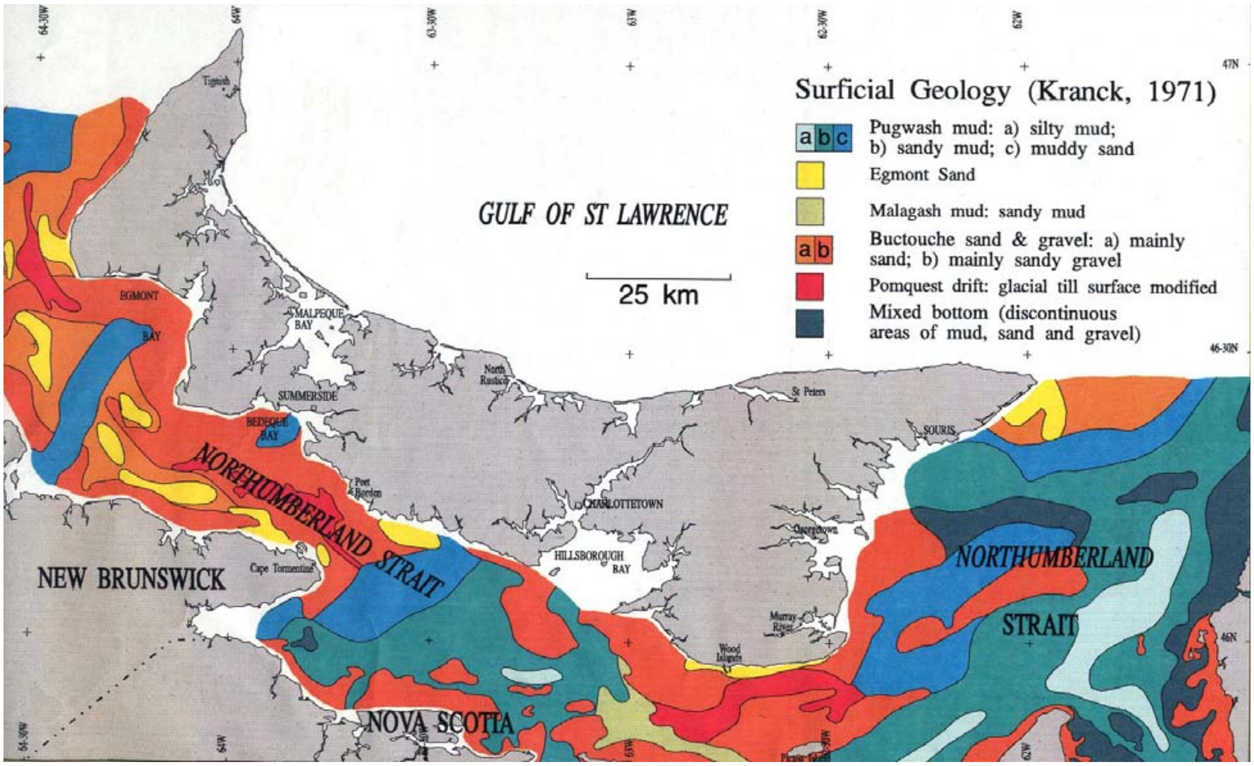
- a narrow band extending from Egmont Bay across the Strait to Shediac Bay;
- Bedeque Bay extending southwestward;
- a broad zone extending from Baie Verte across the Strait to the south coast of PEI and continuing to the east up the central part of the Strait; and
- a deposit south of Pictou Island extending to the northeast.

The other mud deposit, called the Malagash mud, occurs in the eastern part of the Strait but is interpreted as a glacial aged mud that is presently undergoing erosion by strong currents. Other areas of the Strait consist of sandy and gravely sediments and glacial till. The Bouctouche sand and gravel covers the largest area. It is overlain by a modern deposit of sand called the Egmont sand which occurs in discrete sand bodies that are more widespread in the western area of the Strait. The Egmont sand has active sand bedforms on its surface and moves in response to strong tidal currents. Kranck (1971) also interpreted buried glacial sediments within the Strait that do not crop out on the seabed.

Although not discussed in the Kranck, (1971) report, an analysis of the distribution of sediments from map 4023G clearly shows regional trends in sediment deposition that are related to tidal current energy in the Northumberland Strait system. The deposits of Pugwash mud define the modern depositional areas of the Strait. When compared with the geography of the Strait, it can be seen that these mud deposits only occur where the Strait broadens in width. Intervening areas, where the Strait narrows, consist of coarser gravely and sandy sediments, reflecting higher energy in these areas from stronger tidal currents that prevent deposition of muddy sediments. Thus an alternating pattern of sediment banding related to zones of high and low energy is represented in the sediment distribution throughout the Strait. This relationship can be summarized in the following manner beginning in the west:

1. Low energy and mud deposition occur off Campbellton, PEI, where the western area of the Strait is wide.
2. High energy and coarse sediment with active sand bedforms occur off West Point, PEI, where the Strait narrows.
3. Low energy and mud deposition, extending across the Strait from Egmont Bay to Shediac Bay, occur where the Strait is wide.
4. High energy coarse sediments exist from Cape Egmont, PEI, to Fagan Point, NB.
5. Low energy and mud deposition occur in Bedeque Bay in a small area extending into the Strait in a broad region.

FIGURE 2.3-3 Surficial Geology Map of Northumberland Strait Showing the Distribution of Sediments at the Seabed



Marine Science Paper 5, Map 4023G, (Geological Survey of Canada Paper 71-53), (Kranck, 1971).

6. High energy and coarse gravely sediments occur in the narrowest area of the Strait in Abegweit Passage.
7. A large regional area of mud deposition and low energy extends from Baie Verte across the Strait to Black Point, PEI.
8. A final eastern zone of high energy and coarse sediments is found between Wood Island, PEI, and Pictou Island where the Strait is narrow.

Loring and Nota, (1973) studied the sediments of the entire Gulf of St. Lawrence including Northumberland Strait, but concentrated on the textural aspects of seabed sediments and the geochemistry of the greater Gulf. Their surface sediment map for Northumberland Strait is very similar to that of Kranck, (1971), with minor variations in textural distribution.

In response to a requirement for a high resolution understanding of the marine geology of the Confederation Bridge crossing area and the development of a new Canadian program for an assessment of the offshore mineral and aggregate potential, Fader (1988) and Fader and Pecore (1989) conducted surveys within the Strait.

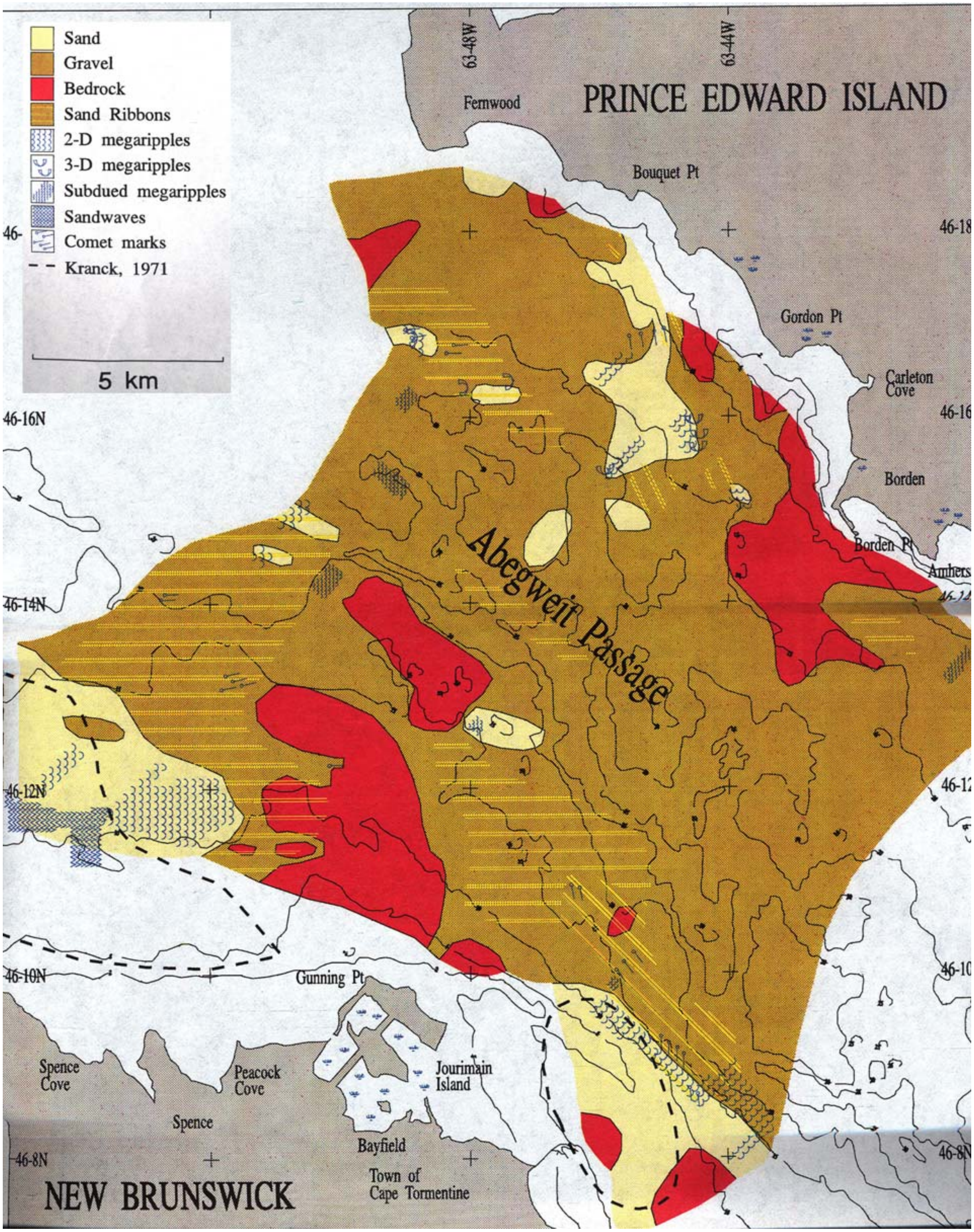
The side scan sonar systems used in the study of the Abeqweit Passage area of Northumberland Strait were operated so that the imagery was produced with a resolution of 0.25 m. This means that objects of that size and larger can be recognized and interpreted. Ice scours, boulders, sand bedforms, scallop drag marks, sand ribbons, and the boundaries of small sediment patches could be mapped with this survey. Side scan sonar systems do not provide good information on the regional shape or morphology of the seabed. This information is best provided by multibeam bathymetric mapping systems.

The detailed survey was conducted in the central part of the Strait that covered much of the Abegweit Passage area, with lines run in a closely spaced grid pattern.

The results of this survey revealed many new features on the seabed and both past and modern processes that were not previously recognized or understood (Figure 2.3-4). Large areas of bedrock crop out on the seabed, with scattered boulders. A central Strait zone of approximately 3 by 8 km showing scallop drag marks was identified and mapped. The drag marks occur in areas with no boulders. Although boulders are evenly distributed over most areas of the Strait, their absence in the areas of scallop drag marks suggests that the process of scallop fishing redistributes boulders from the seabed and to other locations.

A wide range of sand bedforms overlies areas of bedrock and gravel. The sand is in active bedload transport in features called sand ribbons that connect some of the larger Egmont sand banks mapped by Kranck (1971). Megaripples and 2 and 3 D sand waves are found in many areas. Comet marks are common and these are boulder related scour features that occur in areas of high velocity water flow. They indicate net sediment transport directions and clearly show net sand transport to the southeast. Additionally, areas of seabed mapped as Pomquet drift (till) by Kranck (1971), were found to be gravel covered till, and similar to the other gravel deposits throughout the Strait. Most of these features had not been known or imaged before. Additionally, many of the isolated sand bodies (Egmont sand) were studied in detail as part of an aggregate assessment project and were found to be very complex sand bodies with a wide

FIGURE 2.3-4 Abegweit Passage area Map of Northumberland Strait showing the distribution of bedrock at the seabed



Fader and Pecore, (1989). The orientation of the bedforms is indicated graphically.

variety of overlying sand bedforms. Some of the large sand bodies are in different locations from when they were mapped by Kranck (1971) indicating major changes to sand deposition within the Strait over the time interval. Areas of ice scour formed by pressure ridge keels were mapped to depths as deep as 11 m and perhaps deeper.

Most recently, Ollerhead (2005) collected water column samples to assess the suspended sediment in the central part of the Northumberland Strait. The study indicated that the level of inorganic suspended sediment is much higher than was reported over past decades. The average concentration was 30 milligrams per litre (mg/L) and the previous studies indicated 12 mg/L. Concerns have been expressed about the sample sizes and methodologies used in this particular study. These concerns have been outlined in a peer review by PWGSC and TC (2006). During the summer-early fall of 2006, a joint fisher/DFO suspended sediment survey was conducted in the Strait. Preliminary analysis of the data indicates that TSS levels are similar in concentration to those measured in the early 1970s and during the Marine Environmental Effects Monitoring for the bridge construction.

In summary, the early mapping of Kranck (1971) clearly defined the broad regional areas where fine-grained muddy sediments have been deposited within the Strait over the past several thousand years. New regional mapping of the Strait has not been conducted since the 1971 surveys, and it is not known if these depositional areas continue to be in exactly the same locations or if erosion of these muddy sediments has taken place. However, the early mapping represents the integration of approximately 6 thousand years of sedimentation and those locations are not expected to have changed considerably. The most recent high resolution surveys conducted by Fader (1988) show that the seabed of the harder areas in the central Strait is much more complex and that modern processes of sand transport in a variety of bedforms, seabed impact and erosion by ice, and bottom fishing activity, are altering the habitat.

The seabed in this area was mapped largely as stable gravel in the early Kranck (1971) work. This illustrates the advantages of high-resolution seabed mapping. All of the studies have addressed where sediments are located on the seabed, but the sources, transport pathways (especially for the fine-grained muddy sediments), their associated contaminants, and the depositional history of the entire Strait is not well-understood.

2.3.7 Resolution of Mapping Systems

This subsection is intended to clarify the resolution and issues related to the various seabed sediment mapping systems, and their ability to assess the fine-grained muddy seabed sediments and the deposition of thin layers of flocculated sediments overlying gravel. In a comparison of the multibeam bathymetry from the central Strait with the side scan sonar data, it is clear that the side scan sonar imagery is of higher resolution and able to recognize and characterize features such as scallop gear drag marks, sand in transport within thin sand ribbons, individual boulders, and ice scour features, as the resolution is approximately 0.25 m. The resolution of the multibeam imagery collected from the central Strait is approximately 2 m and features smaller than that cannot be detected. Habitat characteristics of importance to benthic organisms are often in the decimetre range, and gravel, boulders, and sand bedforms are small scale important habitat features. If such features cannot be imaged, then an adequate assessment of seabed habitat cannot be realized. Newer multibeam bathymetric mapping systems have a capacity for higher resolution that rivals the decimetre resolution of side scan sonar systems.

In comparing the relative resolution of the various systems used to sample and map the sediments of the Strait, it is appropriate to address the deposition of fine-grained sediments and the occurrence of organic floc or silt on the seabed. Observations indicate that silt may be eroding from the area around the foundations of the Confederation Bridge, and is transported and deposited over gravely sediments in other areas of the Strait. An understanding of this process called “siltation” has been based on interpretation of video imagery from towed bottom camera systems and visual observations of sediment plumes in the water column. Video that showed suspended sediments and the seabed, from various areas of the Strait, was viewed and discussed at the Physical Environment Technical Workshop. The general quality of the video was low because of the suspended sediment and high speed of travel, and it was difficult to clearly see the quantity and distribution of fine grained silt overlying gravel. Additional processing of the imagery, or the collection of higher resolution photography and video, could address the problem.

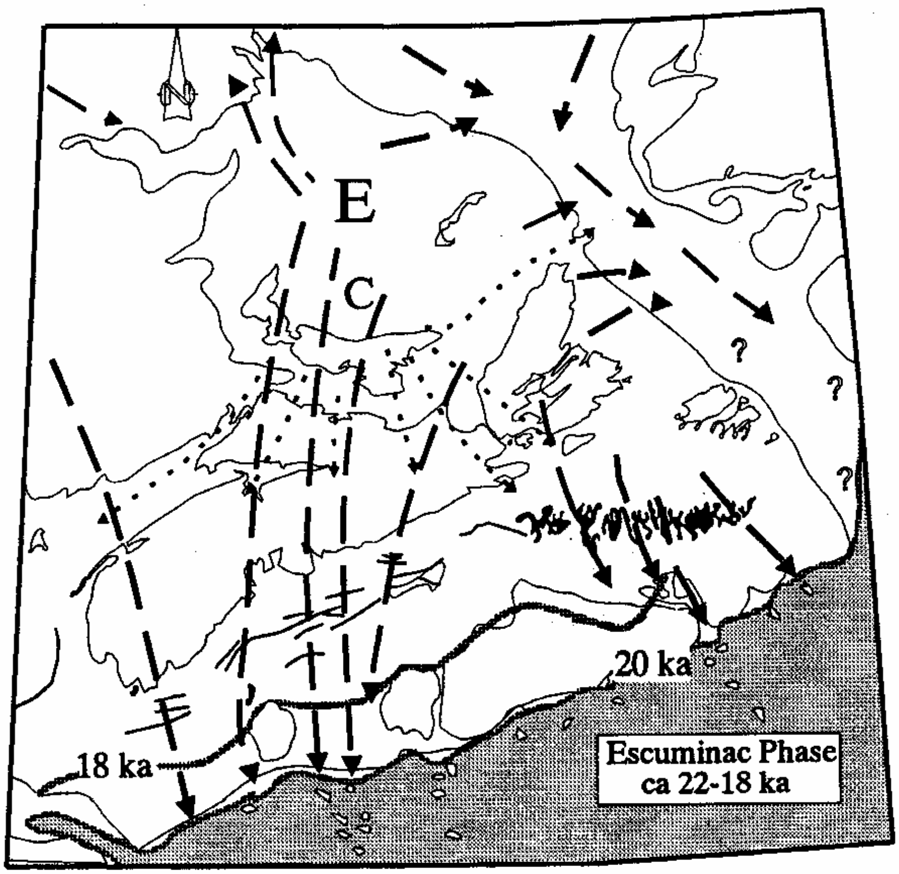
Unfortunately, no wide area remote sensing mapping tools exist for assessing the presence, absence, or thickness of very thin layers of flocculated sediments or silt overlying hard gravel seabeds. It is also very difficult to obtain samples for analysis as standard sediment grab samplers tend to disturb the seabed during sampling and the fine-grained sediments get washed off the gravel during recovery. Devices that use suction to collect samples are the most effective.

Hydrographic surveys that are undertaken annually by Public Works and Government Services Canada (PWGSC) and Transport Canada (TC), as illustrated in Appendix B (Review of Report on Consultations Completed as part of EOR for the Northumberland Strait), do not show significant changes in the seabed profile and shape of the areas around the Bridge foundations. It is recognized that it is difficult to measure the thickness and presence of very thin silt layers overlying gravel with standard seabed mapping systems. It is not known if the fine-grained sediments observed on the gravel seabeds of the Strait are silt, clay, or organic flocculated particles, where their source is located, their residence time in various areas of the Strait, or where they eventually end up in permanent deposition. Multibeam bathymetry, sidescan sonar, and seismic reflection systems are inadequate in their ability to detect and measure thin veneers of silt, clay and organic floc on hard gravely seabeds. High resolution video and camera systems, together with seabed suction sampling devices, are more appropriate tools for such an assessment.

2.3.8 Glacial History

The distribution of glacial till, striations on bedrock, and far-traveled distinct gravel clasts are all evidence for a complete glaciation of the Northumberland Strait and Gulf of St. Lawrence region. Glaciers are thought to have advanced and retreated across the region of eastern Canada many times during the Pleistocene Epoch. Most of the evidence for glaciation, however, results from the last ice to have crossed the area, as materials deposited prior to this advance were eroded and incorporated into the glacial products of the most recent advance. An ice centre, called the Escuminac Phase or ice advance (Stea et. al., 1998), centered over the region to the north of PEI is considered to represent the last major ice advance of the region that occurred during the Wisconsinan glaciation (Figure 2.3-5). This ice moved in a southerly direction across the Northumberland Strait and NS, and terminated at the edge of the Scotian Shelf at approximately 21 000 years before present (yBP). Late Escuminac phase ice flow directions along the Northumberland Strait veered to the southwest and into the Bay of Fundy.

FIGURE 2.3-5 A map of Atlantic Canada showing a cover of ice and glacial flow lines emanating from the Escuminac ice centre (E) located to the north of PEI in the southern Gulf of St. Lawrence.



This represents the glacial conditions during the “Escuminac Phase” that lasted from 22 000 – 18 000 years ago, from Stea et al., (1998). The frontal position of the ice is shown at 18 and 22 thousand years ago (ka) south of Nova Scotia.

During the advance and retreat of this ice, a wide variety of glacial deposits were left behind that include reddish till, moraines, and drumlin fields. The last Wisconsinan ice in the region was centered in western PEI at approximately 13 000 yBP and completely melted over the subsequent 1000 years.

Erosional depressions that lie on the exposed bedrock surface at the seabed of the Strait are interpreted to have resulted from Appalachian ice that moved from the northwest to southeast parallel to the orientation of the Strait. That ice was much older and flowed across the region approximately 75 000 yBP.

2.3.8.1 Sea Level History

The relative sea level history of the region has played a major role in the development of the landscape and seabedscape and the materials presently found on the seabed of the Northumberland Strait (Kranck,1972). Shaw et al, (2002) combined isobase maps with a digital terrain model of Atlantic Canada to map former coastlines extending from 13 000 years ago to the present. The glacial ice left the greater Gulf of St. Lawrence region in a large re-entrant 5000 years before it left the highlands in Newfoundland and the Maritime Provinces. As the ice first left the lowland areas of the Gulf, PEI was initially separated from the mainland, but became reconnected around 11 000 yBP. This connection lasted for a period of up to 5000 years, and by 6000 yBP, it was once again separated from the mainland with the formation of an early narrow Northumberland Strait (Figure 2.3-6). Since that time, the sea has flooded the Strait area and transgressed the former landscape, returning to its present position. During the interval of subaerial exposure, the Northumberland Strait was the location of a major river system with intervening lakes and minor stream tributary systems. The drainage system seen on the multibeam bathymetry is a vestige of that river system that presently remains at the seabed in a remarkably preserved state.

The marine flooding of the Strait reworked the previously deposited glacial till and other sediments, winnowing the fine-grained silts and clays from the coarser sand and gravel with the development of a gravel pavement or lag surface overlying till (Kranck, 1971). In some places it resulted in the burial of glacial sediments. This process of marine transgression was a major erosional and burial event in the Strait. Much of the characteristics of coarse sediment that occur on the seabed today resulted from this marine transgression and seabed gravel armouring. The upper surface of the till was winnowed in the beach face of the transgressing sea as the sea level rose (Kranck, 1971). Based on the modelling of Shaw et al. (2002), the armouring of the seabed of Northumberland Strait took place after 6000 yBP and lasted until the Strait was completed flooded. The timing of the armouring during the marine transgression is not well constrained and Kranck (1971) suggested that the time of the marine transgression varied with depth and location. The Bouctouche gravel formation formed by this process is time transgressive. Because the Northumberland Strait lies in a protected area of the southern Gulf of St. Lawrence, the marine transgression was not likely as effective an erosional agent as it was, for example, on the nearby open and exposed Scotian Shelf, where erosion of glacial sediments was extensive (Fader, 1989). In the Northumberland Strait, erosion was likely much less, as waves would have been low in height and ocean swell did not occur. This can account for some of the preservation of the ancient drainage patterns clearly observed in the multibeam bathymetry, despite being transgressed. The placement of armour rock on the seabed could function in much the same way as the natural gravel lag surfaces that protect the subsurface finer grained sediments from further erosion.

FIGURE 2.3-6 A Paleogeographic Reconstruction of Atlantic Canada at Approximately 9000 y BP

This figure shows the connection of PEI to the mainland. Water depth is shown in colour and the broad green region of Northumberland Strait is subaerially exposed land at this time. A river and lake system is thought to have occupied a portion of the central strait, after Shaw et al., (2002).

The post glacial sea level rise throughout the Strait, and resulting erosion and armouring of the till, provided a solid surface for the future deposition of sediments. The Pugwash mud mapped by Kranck (1971), was deposited overlying the transgressed glacial sediments as the Northumberland Strait sea level returned to its former pre glacial position. Currents dropped in velocity in the broad areas of the Strait and allowed depositional centers to develop.

2.3.9 Resource Potential - Highlights

The extraction of marine aggregate (sand and gravel) from the seabed is a large scale activity in many parts of the world. For example, over 20% of the aggregate requirements for the United Kingdom are met from seabed mining in the North Sea. Other countries such as France, Indonesia, and Japan meet a large part of their requirements through marine extraction. Canada investigated, in the early 1990s, the offshore potential for the supply of marine aggregate and the possibility of establishing a regime for management of such a resource. The resource potential of the coarse grained sediments of the Northumberland Strait, was assessed in a cooperative federal and provincial study in the late 1980s. This program surveyed many of the Egmont sand bodies first identified by Kranck (1971) that were considered to offer the greatest potential for aggregate applications because of the well-sorted grain size and a lack of silt and clay particles. In general, the gravel sediments are not suitable because of their sedimentary and soft sandstone character. The sands, on the other hand, could be used for a variety of applications, such as in asphalt, fillers, concrete, and beach reclamation projects. Sediment transport in the nearshore sand bars located off West Point, PEI, periodically results in the build-up of large sand deposits on shore and in the nearshore. Some of these sediments derived from the adjacent sea have been extracted and used for applications on land.

Oil and gas exploration activities in the regions bordering the Gulf of St. Lawrence have been taking place for over 160 years. Most activities have been on-shore, and findings have been minimal. PEI lies over a large sedimentary basin that may have reservoirs of natural gas. Exploration activities have identified the existence of these potential reservoirs, including a significant discovery made offshore near East Point. The sedimentary basins of PEI are characterized by structural traps formed by folding and faulting. These traps can be associated with salt domes which are the result of the upward movement of salt masses and anticlinal structures that occur from an upward arching of rock strata. However, PEI's hydrocarbon potential has yet to be fully assessed. The deep geological basins where hydrocarbons could potentially exist largely lie to the north and northeast of the Northumberland Strait. A large area of PEI is covered with permits that have been issued for oil and gas exploration and some of these regions extend into the nearshore of the Northumberland Strait particularly in eastern Egmont Bay, Bedeque Bay and Hillsborough Bay. A test well was drilled in Hillsborough Bay in the 1940s.

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3.0 BIOLOGICAL SYSTEMS

3.1 BIOTA COMPONENTS

This section presents an overview of the major living components of the Northumberland Strait. The information is provided in seven sections; Macrophytes, Plankton, Benthic Species, Reptiles, Fish, Marine Mammals and Marine Birds. The biology and ecology of each component is briefly described, with its nutrient and dietary needs, its habitat, and distribution, when available. Where significant differences exist, coastal and inshore populations are discussed separately.

3.1.1 Macrophytes

Macrophytes, or large plants, of two types occur in the marine environment: macro-algae (which lack a root system) and sea grasses, or vascular plants which are rooted to the bottom. Macrophytes are important in the coastal and the inshore marine environments, providing cover and food sources for an array of small animals, larval and immature fish species. They also play a key role in trapping and transporting nutrients.

3.1.1.1 Sea Grasses

The sea grasses inhabit the coastal, shoreline and intertidal reaches of the Strait, largely in marine wetlands, salt marshes and shallow water eel grass beds. They trap sediment, and the root systems aid in maintaining and shaping shoreline areas. By providing habitat for a variety of marine animals, they are also important to marine and coastal piscivorous birds. In the larger realm, sea grasses are a fixed carbon source for aquatic life. The most common species in the Northumberland Strait include the three-square bulrush (*Schoenoplectus pungens)*, smooth cordgrass (*Spartina sp.)*, and eelgrass (*Zostera marina)*.

The key species in the ecosystem would likely be eelgrass, which establishes in extensive beds on intertidal flats. A good example of the importance these beds play in the broader ecology of the Strait is presented in the Baie Verte draft Ecological Overview Assessment Report (EOAR) (Hart & Ripley, 2006):

> "Eelgrass plays an important physical role in the marine environment by stabilizing sediments. It also has a variety of important biological functions including providing a surface for the colonization by other plants and animals. In fact the amount of plant life growing on the eelgrass can be almost equal to the eelgrass itself (Mann, 1982). These plants are nourished, in part by nutrients that are drawn up from the eelgrass roots and leak out from the long narrow leaves. In this way eelgrass acts as a nutrient pump taking biologically available nutrients from the soil and returning them to the water column above. Eelgrass is also colonized by, and provides habitat for, a variety of invertebrates such as snails and mysid shrimp. Research on eelgrass beds in Kouchibouguac National Park found that they contained a higher species abundance and richness of fish than adjacent sandy sites. The beds were used by tomcod, winter flounder, sandshrimp, three-spine stickleback and cunner, and served a nursery function for white Hake and cunner (Joseph et. al., 2004). Despite the diversity of species occupying the water

column within the eelgrass beds, most of the plant biomass falls to the bottom where it is incorporated into the benthic food chain."

There is also evidence that eelgrass beds play an important role in the spawning and rearing of white hake in the Northumberland Strait area.

Unfortunately, given the importance eelgrass flats have in the marine environment, beds in the Northumberland Strait as well as much of the rest of Atlantic Canada have been in serious decline over the last several years (Hanson, 2004). Locke (2005a), in an article in the Working Group on the Northumberland Strait Information Website, discusses the issue of changes in the eelgrass beds in the estuaries of the southern Gulf of St. Lawrence with particular emphasis on those in the Strait. In the Strait, a notable decline in eelgrass beds is thought to have started around 2001. Surveys were carried out in a number of beds in 2001 and 2002, with notable declines identified in that one year period. In the NB area of the Strait, beds in Baie Verte, Cocagne, Kouchibouguac and Richibucto were examined. Declines ranging from 40% to 72% were recorded. In NS, a bed in Caribou was sampled and losses of 8.7% and 23.6% were recorded in 2001 and 2002 respectively. On the PEI shore of the Gulf, Bedeque Bay and Hillsborough Bay eelgrass beds were sampled. Bedeque Bay suffered a 61% loss while Hillsborough Bay was the only sampling location in the entire survey which recorded an increase in eelgrass production at 64.7%.

Researchers have noted a widespread decline in eelgrass distribution and abundance generally in the Maritimes area over the last decade. Reasons suggested for this decline, which in some areas has been catastrophic, have varied. The list of possible causes includes; eutrophication, disturbance by invasive green crabs, and environmental changes. The reasons suggested may be geography specific, or may be a result of the synergistic effects of several possible stresses working in concert. Work has been limited and no general conclusions can be drawn to date (Locke, 2005a).

3.1.1.2 Macro-algae

The large algal structures, or "seaweeds", occur in varying quantities throughout the Strait. The dominant seaweed in the coastal and near shore areas, particularly in the bays and estuaries of the Strait, is a green alga, known as sea lettuce *(Ulva sp.)*.

In some protected areas of the Strait, especially where water exchange is limited and there is human activity in the watershed, which results in significant nutrient enrichment, (i.e., Bedeque Bay, Egmont Bay, Hillsborough Bay), *Ulva* populations will become excessive, blanketing the bottom with a thick mat of the seaweed. In extreme instances, when the heavy layer dies and starts to decompose, it can cause anoxic conditions in the area, resulting in ecological upsets and subsequent local marine population die-offs.

Beyond the coastal and estuarial areas of the Strait, several large algal species form areas of "marine forest" in the near shore and portions of the inshore. The dominant forms in these areas are the kelp *Laminaria* and the branched red alga, *Phyllophora.* Other genera such as *Polyides, Desmarestia* and *Palmaria* occur in smaller amounts. Hurley (1989) notes a total lack of Irish Moss (*Chondrus)* during his investigations in the Abegweit Passage and adjacent areas. Irish moss is an important commercial species, particularly at the extreme North end of the

Strait, on the PEI side. In recent years it has been out competed in some areas by the red alga *Furcellaria*. This plant contains furcellaran which is of lesser commercial value than carageenan. There was a small reported Irish Moss harvest in some small, limited areas of the Strait in former years, particularly during the 1970s, but it has dwindled to be less than viable in recent times, as reported in the Technical Workshop on Biota conducted as part of this EOR process. The reason for the disappearance of Irish moss from these localized areas is unknown.

Alarm has been expressed by observers regarding the disappearance of kelp, (*Laminaria sp)* beds in some areas of the Strait and an observation that other species (often less desirable) are taking over depleted kelp beds has been voiced (EOR Technical Workshop on Biota, 2006).

The central area of the Strait, in and around the Abegweit Passage, has been studied in enough detail over a sufficient period to build some history with regard to macrophyte populations. Caddy et. al. (1977) carried out a macrophyte survey as part of a larger study in 1975. In 1998, Hurley surveyed the same area again, and found similar levels of macrophyte cover at the same stations, with the exception of one station, where *Phyllophora* had disappeared in the intervening 13 years. A series of Marine Environmental Effects Monitoring (MEEM) studies were conducted before, during and after the construction of the Confederation Bridge across the Abegweit Passage. The first MEEM study, conducted in 1993, also sampled in the same areas as Hurley and Caddy and state that the “distribution of macro-algae was similar to that reported by Hurley Fisheries Consulting Limited in 1989.” Sites with macro-algae were in shallow depths (less than 9 m) with at least some hard substrate. Sites without macro-algae had unconsolidated bottoms, or were in deep water where little light penetrates to the bottom. The 1996 MEEM study found little change in macrophyte cover.

The Northumberland Strait EOR Technical Workshop on Biota identified several key issues with respect to macrophytes in the Strait (Appendix B):

- excessive growth of some species (i.e., *Furcellaria*);
- disappearance of kelp beds in some areas;
- disappearance of Irish Moss;
- declining health and range of eelgrass beds; and
- presence of anoxic areas.

The overarching priority issues were determined to be: excessive nutrients in some locales, leading to overproduction and anoxia, and, the unknown effects of sedimentation and suspended sediment on the photic zone in the Northumberland Strait.

3.1.2 Plankton

Plankton are organisms suspended in the water column, free floating with limited mobility and largely dependent on movement of the surrounding water mass for transportation. For purposes of this discussion, plankton is separated into two components: phytoplankton – chlorophyll containing plants capable of photosynthesis, or zooplankton – animals in the water column which feed on plants, bacteria, detritus or other zooplankton.

3.1.2.1 Phytoplankton

Primary Production Levels

Phytoplankton is one of the major links in the marine food chain. By using sunlight to combine carbon dioxide and water to produce nutrients, it is a primary step in a very complex biological system feeding much of the biota of a marine area. A key indicator of phytoplankton abundance and photosynthetic activity (primary productivity) of an area is the measure of chlorophyll-a in a sample taken from the water column.

Hurley (1989) collected chlorophyll-a data from the Abegweit Passage study area during mid-July in 1988. The MEEM studies also collected chlorophyll-a data from the Abegweit Passage for 1993, 1994, 1995, and 1996. Table 3.1-1 shows annual ranges of chlorophyll-a during those years.

TABLE 3.1-1 Summary of Chlorophyll-a Concentration Data in Northumberland Strait

Year & Source	Time Frame	Chlorophyll-a Pigment Concentration, Range (Micrograms per litre (µg/L))
1988 – Hurley	Mid-July	1 – 5
1993 – MEEM	July – November	0.7 – 2.9
1994 – MEEM	Spring - Fall	Not recorded
1995 – MEEM	Spring - Fall	1 – 7
1996 – MEEM	Spring - Fall	2.4 – 5.0

Levels were generally between 1 and 7 µg/L with one notable exception of data point greater than 9 µg/L at a sampling station near the NB coast in 1988. Hurley (1989) reports that the range of chlorophyll values from these data sets are greater than those recorded in St. Georges Bay on the eastern side of the Northumberland Strait (0.4 – 0.7 µg/L in July of 1980 and 0.6 – 1.8 µg/L in another set of samples also taken during 1980). It was also higher than samples taken from the northwestern Gulf of St. Lawrence (0.1 – 1.9 µg/L) in 1979 but similar to concentrations found on the Scotian Shelf (up to 5 µg/L) in 1979.

The Northumberland Strait has been reported to be a region of high primary productivity during the summer, but relatively low productivity during the winter. This is in keeping with the rather shallow morphology of the area, as with much of the Southern Gulf of St. Lawrence. The information from the Abegweit Passage area supports that supposition, particularly for the period from 1988 to 1996.

Species Identification & Diversity

The most complete recent identification of phytoplankton species in the Strait was conducted on a representative sampling of fourteen water samples taken during the 1993 MEEM study (JWEL, 1994) plankton component. The samples were rich with diatoms, a common marine phytoplankton group. The species found are listed in Appendix 9 of the Report for that study.

In addition to species identification, the data was subjected to a Shannon-Weiner Index analysis. This test is a diversity measure that takes into account both the number of species and the relative frequency of each species. A higher H value indicates a more diverse species mix than a lower one. H values for the thirteen of the fourteen samples varied from 2.0 to 2.7 indicating a rich species diversity. One sample had an H value of 0.26. This was a sample taken in the midst of a strong single species algal bloom. Studies of phytoplankton in other areas of the Strait are very limited.

Another issue related to phytoplankton in the Strait has been the presence of toxin-containing algal species which have resulted in filter feeding shellfish containing these toxins entering into the food chain and, ultimately, causing sickness and/or death to humans who consume these products. This has been a more serious issue in other parts of the southern Gulf of St. Lawrence, but it has implications to the Strait as well, as pointed out in the Working Group on the Northumberland Strait information website (Bates, 2005):

> "Until 1988, the southern Gulf of St. Lawrence, including the Northumberland Strait, was thought to be free from harmful algal blooms and phycotoxins. However, after the 1987 domoic acid outbreak in estuaries on eastern PEI, an expanded phycotoxin monitoring program revealed the occasional presence of high levels of paralytic shellfish poisoning toxins (produced by the dinoflagellate *Alexandrium tamarense*) in several species of molluscan shellfish along the Gulf coasts of NB, PEI and NS. The 1988-1989 surveys showed that most paralytic shellfish poisoning -contaminated molluscan shellfish were from sites to the north of the Northumberland Strait, i.e., along the Acadian Peninsula and Miramichi Bay, as well as northwest PEI. Only a few contaminated samples of blue mussels and moonshells were reported, mostly under the regulatory limit of 80 µg Saxotoxin equivalents per 100 g (STXeq/100 g)".

The first closure in the Northumberland Strait due to paralytic shellfish poisoning toxins was in June 2003, when levels of 97-145 µg STXeq/100 g were found in bar clams from southwestern PEI (West Point to Egmont Point). During December 2001 to January 2002, the NS coast of the Northumberland Strait, from Malagash Point to Cape George, was closed due to domoic acid in blue mussels slightly above the regulatory limit of 20 micrograms per gram (µg/g). The source was likely the diatom *Pseudo-nitzschia multiseries*. During spring, 2002, most of the southern Gulf of St. Lawrence was closed due to unacceptable levels of domoic acid, produced by *Pseudo-nitzschia seriata*. The highest domoic acid level found (200 µg/g) was in blue mussels from Richibucto Bay. Toxin concentrations were lower or non-detectable farther to the south east, but then increased again within embayments of the NS coast.

There is, therefore, a history of occasional closures due to paralytic shellfish poisoning toxins and domoic acid in the southern Gulf of St. Lawrence since serious monitoring was started in 1989. However, the Northumberland Strait region, per se, has been less affected than the adjacent northwestern and southeastern portions of the southern Gulf.
This is somewhat surprising, since the prevailing currents are from the northwest, where the majority of toxin events have been recorded. The gyre in the northwestern portion of the Strait could potentially retain toxic phytoplankton and distribute them to coastal regions of northeastern NB and southwestern PEI."

3.1.2.2 Zooplankton

Zooplankton is comprised of a number of groups of animals inhabiting the water column. Holoplankton are animals which spend their entire life cycle in the water column environment (for example copepods). Meroplankton are represented by a life stage of an animal which spends only that component of the life cycle in the open water – for example, lobster larval stages 2 and 3, as well as some fish larvae, and icthyoplankton fit in this category.

There has been limited study carried out on the estuarial or near shore plankton communities of the Northumberland Strait. In 1982, Citarella published a survey of the zooplankton of Shediac Bay, carried out in the summer and fall of 1968. It highlighted the abundance of copepods (81%) and meroplankton (18%) in the water column of the Bay. A study of the plankton of the estuarial waters of Kouchibouguac National Park in 1997 also found an abundance of copepods in the zooplankton with a notable pulse of icthyoplankton during June and July (R. Bernier et al., 1997). The draft Richibucto EOAR (Turcotte-Lanteigne & Ferguson, 2006) presents expert opinion that zooplankton in the Richibucto estuarial waters would likely be quite similar to that found in the Kouchibouguac estuaries.

Much of the available information pertaining to zooplankton in the open waters of the Strait is derived from a study relating to the Confederation Bridge project. Samples from the Abegweit Passage area taken in summer, 1988 (Hurley Fisheries, 1989) revealed a dominance of calanoid copepods, principally medium-size, warm water and coastal species such as *Oithona, Acartia, Temora,* and to a lesser extent *Eurytemora* and *Pseudocalanus*. All of these species have also been observed in the summer in Saint Georges Bay, just beyond the eastern end of the Northumberland Strait. A group of planktonic mollusks, pteropods, constituted 20% or more of the zooplankton in 6 of the total of 22 stations sampled during the study. This is somewhat unique since pteropods were not reported in St. Georges Bay studies or southern Gulf of St. Lawrence samplings.

The Gulf of St. Lawrence Integrated Management (GOSLIM) web site (DFO, 2006b) indicates that:

> "Plankton organisms have limited swimming ability; their movements are mainly determined by water circulation. Scientists believe that there are four distinct food webs in the Gulf: 1) the region west of Anticosti Island along the Québec shore; 2) the Gaspé current flowing along the north shore of the Gaspé Peninsula, south of Anticosti Island; 3) the southern Gulf region, including the Northumberland Strait, Bay of Chaleur and Magdalen Shallows; and 4) the northeastern Gulf. The southern Gulf (region 3) is particularly rich and productive in plankton."

Information from studies referenced above would tend to support the statement.

The Northumberland Strait EOR Technical Workshop on Biota identified a key issue with regard to plankton in the Northumberland Strait (Appendix B):
The presence and occasional blooms of species of phytoplankton containing toxins which contributes to paralytic shellfish poisoning from blue mussels.

3.1.3 Benthic Invertebrate Species

The GOSLIM (DFO, 2006b) report defines the benthic community as:

> "The benthic community refers to a wide variety of organisms that live at the bottom of water bodies. There are probably more than 3,000 species living in the Gulf, from those that are commercially valuable (such as crab and lobster) to invertebrates and micro-organisms of many forms with little or no commercial value but with significant ecological importance. The benthic community is more diverse and more abundant than other marine communities, mainly because of the diversity of habitat types. The main classifications include:
>
> - Macrobenthos, including crustaceans (lobster, rock crab, lady crab), molluscs (oysters, mussels, snails) and echinoderms (starfish, sand dollar). The first two groupings are well known for their economic value;
> - Other benthic macro-invertebrates, such as annelids (marine worms), sponges and cnidarians (corals, anemones), ascidians (tunicates like the clubbed tunicate, an invasive species), and small orders of animals (flat worms);
> - Microfauna and meiofauna, including microcrustaceans (opossum shrimp, barnacles) which play an important role in nutrient recycling, through feeding on decaying wastes of other species. Algae, protozoa and bacteria are also an important part of the benthic community."

For purposes of discussion, it is easiest to consider the benthos of the Northumberland Strait as two sections: firstly, the near-shore including bays, estuaries, intertidal areas and the more shallow reaches of the Strait ; and, secondly, the deeper, inshore area of the Strait – that area beyond the nearshore (for example the central portion of the Abegweit Passage).

The macrophytes, an important component of nearshore and inshore benthos, are considered in Section 3.1.1. In this section, the benthic infauna (those animals living in the softer bottom sediments), and the epifauna or benthic invertebrates living on the bottom, at and near the bottom-water interface, will be discussed. Benthic fishes (groundfish) will be considered in Section 3.1.4.

3.1.3.1 Infauna

The infauna of the nearshore areas of the Northumberland Strait is largely unstudied. Shaw (1998) carried out a benthic survey of certain PEI nearshore locations. The purpose of the project was to explore differences in benthic characteristics and biota in areas of intensive mussel culture, compared to areas without a mussel culture component. The Dunk River in Bedeque Bay, and other nearshore areas along the Northumberland Strait, were used as "reference areas" – ones without any mussel culture operations. A general description of the bottom types and major infauna groups present are available. The studies carried out with regard to the Summerside West End Project in PEI involved sampling the shoreline and nearshore areas adjacent to the project.

The 2001 data set (JWEL) listed the presence of four species of bivalves, three crustacean species, five gastropods, and eight polycheate worm species. It is presented in Table 3.1-2.

TABLE 3.1-2 Marine Benthic Infauna from Summerside West End Project (JEWL, 2001)

Group	Scientific Name	Common Name
Bivalva	*Gemma gemma*	Gem shell
	Lyonsia arenosa	Sandy lyonsia
	Spisula solidissima	Surf clam
	Yoldia myalis	Oval yoldia
Crustacea	*Conchoecia haddoni*	Ostracod
	Idotea balthica	Slender isopod
	Pagarus sp.	Hermit crab
Gastropoda	*Crepidula plana*	Flat slipper shell
	Mitrella lunata	Crescent Mitrella
	Nassarious trittitatus	New England Dog Whelk
	Odostoma bisuturalis	Double-sutured odostome
	Odostoma seminuda	Half-smooth odostome
Polychaeta	*Clymenella torquata*	Bamboo worm
	Eteone longa	Paddle worm
	Eulalia bilineata	Paddle worm
	Heteromastus filiformis	Capitellid thread worm
	Lepidonotus squamatus	Twelve-scaled worm
	Neris diversicolor	Clam worm
	Spio setosa	Mud worm
	Syllis sp.	Syllid worm

The infauna of the inshore region has had considerably more attention, particularly in the Abegweit Passage area. The 1975 Northumberland Strait survey (Caddy et. al., 1977) analyzed grab samples from eight stations. This was followed by the Hurley Fisheries survey of 1988 (Hurley Fisheries, 1989), where samples were duplicated at six of the eight 1975 locations for comparative purposes. Overall, the species composition was similar for the two data sets. For example, the clam *Tellina* was reported in the sandy stations in both surveys. The polychaete families Maldanidae and Spionidae were present throughout. An exception was the dog whelk; *Nassarius trivitattus* was occasionally present in 1988 while it was common in 1975.

The MEEM studies of 1993, 1994 and 1995 included an infauna analysis component. Several of the same stations sampled in 1975 and 1988 were included for comparative purposes, however, a total of 22 stations were sampled spring and fall in this project. A summary of the identification of infauna is presented in Table 3.1-3.

The Hurley Report (1989) as well as the MEEM study reports (1993-1995) included Shannon-Weiner diversity indices for benthic infauna. The fauna was generally diverse, with Hurley Report values in the 2.2 to 3.2 range. The MEEM study results were slightly higher, but this was possibly accounted for by a different sampling protocol.

TABLE 3.1-3 Summary of Infauna Biota in MEEM Samples, 1993-1995

Taxa	Comments
Polychaetes	The most common group; 54 genera and/or species identified.
Other Vermiformes	Nematodes were abundant, and present throughout most samples.
Crustaceans	13 species listed including Amphipods, copepods, *Gammarus sp.*
Marine Spiders	3 unspecified Pycnogonid species
Molluscs	Common, particularly *Tellina sp.* Also 2 unspecified nudibranch species.
Echinoderms	Occasional

The 1994 MEEM (JWEL, 1994) report indicated diversity indices comparable with 1993 values but noted an apparent trend of decreasing numbers of species in some sampling locations. This trend was not indicated in the 1995 data.

3.1.3.2 Epifauna

The macrobenthos epifauna of the near shore reaches of the Northumberland Strait are better understood than the microbenthos and meiobenthos, which are largely unstudied. The draft Shediac EOAR (LeBlanc & Turcotte-Lanteigne, 2006) identifies seven molluscs, a snail and five crustaceans as present in the watershed (Table 3.1-4). The same species, as well as some additional gastropods and two species of sponges (*Haliclona oculata* and *Cliona* spp.) are present in Bedeque Bay watershed and are discussed in that draft EOAR document. The draft Richibucto EOAR (Turcotte-Lanteigne & Ferguson, 2006) identifies starfish, and striped mussels in addition to those species already mentioned.

The Baie Verte watershed has some epifauna quite unique to that near shore area of the Strait. Sand dollars (*Echniarachnius parma*) are present in large numbers in some parts of the near shore. The Northern Sea Star (*Asterias vulgaris*) is also present. The most common Gastropod in the Baie Verte area is indicated as the Channelled barrel-bubble (*Retusa canaliculata*).

The near shore epifauna of these areas are likely quite typical representatives of what would be commonly found throughout the nearshore regions of the Strait, with local difference prescribed by unique ecologically situations.

Detailed study of the inshore epifauna of the Strait has largely been limited to commercial species; scallop, lobster, crab. Occasional by-captures of non-commercial epifauna during the scallop monitoring component of the MEEM studies are mentioned, but no active monitoring was undertaken. The Hurley Fisheries Consulting Ltd. study of the Strait (1989) describes to some extent the distribution and relative abundance of the Abegweit Passage area epifauna based on scallop drag samples and videotape records taken during the summer of 1988. The sample data from 1975 (Caddy et. al.) is compared with the 1988 information. Generally, distribution had remained similar during the 13 year interval. Table 3.1-5 summarizes the data presented.

TABLE 3.1-4 Macro Epifauna Occurring in the Shediac Bay Watershed

Common Names	Scientific Names
Molluscs	
Razor clam	*Ensis directus*
Bar clam	*Spisula solidissima*
American Oyster	*Crassostrea virginica*
Soft Shell Clam	*Mya arenaria*
Northern Quahog	*Mercenaria mercenaria*
Blue mussel	*Mytilus edulis*
Creeper	*Stophitus undulatus*
Gastropods	
Moonsnail	*Lunatia sp.*
Crustaceans	
Grass shrimp	*Palaemonetes vulgaris*
Sand shrimp	*Crangon septemspinosa*
Rock crab	*Cancer irroratus*
Mud crab	*Neopanopeus sayi*
Lobster	*Homarus americanus*

TABLE 3.1-5 Non-Commercial Epifauna of the Abegweit Passage Area, Northumberland Strait

Group	Species	Comments/Habitat
Sand Dollars	*Echarchnius parma*	Highly abundant, often many thousands in drags over sandy areas. Distribution highly clumped and patchy. Similar distribution to 1975.
Starfish	*Asterias sp.; Henricia snaguinolenta*	Common throughout stations. Majority of specimens tiny – nursery area?
Mussels (horse mussels)	*Modiolus modiolus*	Two dense beds off Borden & Cape Tormentine. Cobble & sand bottom, 10 – 15 m depth
Slipper limpets	*Crepidula sp.*	On dispersed rocks in sand close to NB coast.
Rock Crabs	*Cancer irroratus*	Not associated with bottom type. Common at depths <15m.
Clams	*Astarte sp.*	Commonly encountered.

Annual data collecting trawls have been made in September in the Southern Gulf of St. Lawrence since 1971. Coverage of these trawls includes a mid-channel section of the western end of the Strait to approximately Egmont Bay, and into the end of the Strait to approximately Hillsborough Bay. The middle section of the Strait was not sampled during these annual trawls. Presence of non-commercial invertebrate epifauna collected during the trawls is presented in the Atlas of the Geographic Distribution of Marine Fish and Invertebrates – Southern Gulf, 1971 to 2002 (Benoit et. al., 2003). The atlas indicates presence in the trawl. Table 3.1-6 lists taxa identified in at least one trawl season and location.

TABLE 3.1-6 Invertebrate Epifauna Collected During September Trawls, Northumberland Strait

Taxa	West End of Strait	East End of Strait
Unspecified Marine Invertebrates	X	X
Decapod Shrimp	-	X
Pandalid Shrimp	-	X
Atlantic Rock Crab	X	X
Toad Crab (*Hyas sp.)*	X	X
Lobster	X	X
Snails & Slugs - Gasteropoda	X	X
Whelks (*Buccinum sp*.)		X
Bivalve Molluscs	X	X
Cockles - Cardiidae		X
Scallops - Pectinidae	X	X
Sea Scallop – Placopecten magellenicus	X	X
Iceland Scallop – Chlamys islandicus	-	X
True mussels - Mytillidae	-	X
Echinoderms	X	X
Starfish	X	X
Sun star *Solaster sp.*	X	X
Mud star *Ctenodiscus crispatus*	-	X
Sea urchins *Strongylocentrotus sp.*	-	X
Sand dollars	X	-
Sea anemones	-	X
Large jellyfish - Scyphozoa	-	X
Sponges - Porifera	X	X
Algae & kelp - Thallopyta	-	X

X indicates presences / - indicates absence

As part of the Confederation Bridge MEEM process, the rates of colonization of the Bridge piers, and the biota that settled on them, were examined (JWEL, 2003). The final report for the colonized study concludes:

> “Colonization surveys conducted in 1996, 1997, and 2002 found that pier column colonization assemblages have changed significantly over the years. A mixture of marine plants continues to colonize the upper surface of the ice shield and are sloughed off as a result of ice action each year. In 1996, bryozoans colonized the lowest level of the pier base, and a mixture of other species including sea anemones and starfish were scattered over the entire column. The 1997 study indicated a more complex assemblage of colonizing organisms with a notable increase in the percent coverage of barnacles. The 2002 studies indicate no dramatic change in community diversity but percent coverage of anemones and sponges has markedly increased. All pier columns were dominated by anemones intermixed with sponges and barnacles, in terms of percent coverage. Bryozoans and hydrozoans constituted the lesser fraction of coverage.”

The colonizing marine assemblages on the pier columns have not as of yet, or may never reach a distinct stable state, however, observations from the 2002 study indicate a trend towards what some researchers in the field describe as a state of equilibrium, where species change through die-off and immigration at fairly constant rates. It is recognized that the surface area of marine assemblages that now exist on the pier columns represent a substantial biomass that did not have similar habitat before the Bridge structures were present."

3.1.3.3 Commercial Species

Major commercial invertebrate epifauna species fished in the Northumberland Strait are lobsters, scallops, oysters, and rock crab which are considered individually below. Secondary commercial species, taken in habitats along mud/sand shorelines, include soft shell clams, quahaugs, and some occasional blue mussel harvesting. These secondary commercial species are harvested by license on public grounds on a somewhat irregular basis depending upon availability, market demand, and other socio-economic factors.

3.1.3.4 Lobsters

The biology and life history of the American lobster (*Homarus americanus)* has been well studied and researched by many investigators over the last century. It is well understood. In the Northumberland Strait, the life cycle of the lobster is summarized as:

> "In the Gulf of St. Lawrence, lobsters are found in depths ranging from 1 to 40 m. The life history of the lobster can be divided into planktonic and benthic phases. The planktonic phase follows the hatching of the eggs from late June to early September. The larvae are free swimming and remain in the plankton from 3 to 12 weeks depending on temperature.
>
> The planktonic phase ends when the larvae settle to the substrate part way through the fourth stage. To avoid predation settlement must be in an area where the juvenile lobsters can either occupy crevices or create burrows in the substrate.
>
> Female lobsters begin to be sexually mature after 5-6 years of growth, with a 50% onset of sexual maturity ranging between 72 and 75 millimetres (mm) carapace length. Males become sexually mature at smaller sizes and ages than females. Generally, female lobsters have a 2-year reproductive cycle with the extrusion and fertilization of the eggs one year after mating and carry the eggs, attached under the abdomen, until the following summer" (Mallet, 2005a).

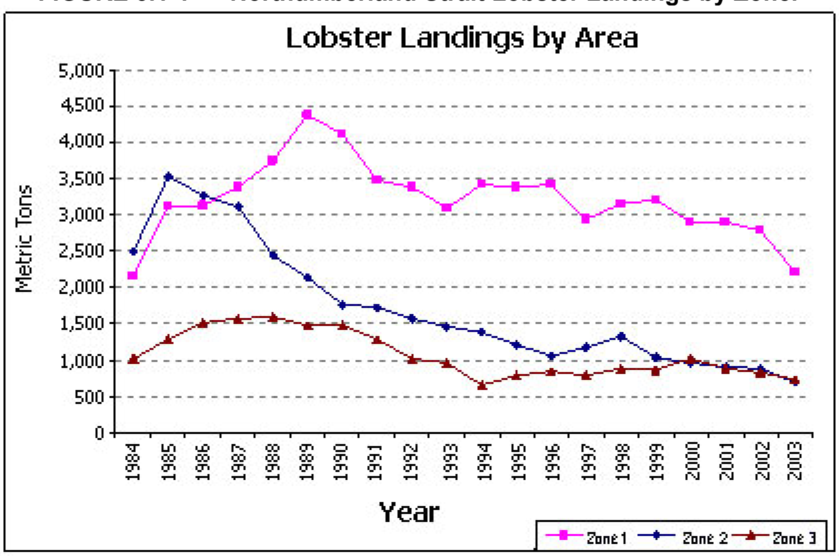
Details of the planktonic phase of the lobster life cycle, particularly movement, is poorly understood in the Strait. Movement during that time is largely determined by current, tide and wind effects on the water column since the ability of the stage I to mid-IV larvae to control movement is minimal compared to these powerful environmental forces.

While the biology and overall health of lobsters is well understood, the population size and stock abundance in the Strait is less well known. Most population information is based on landing statistics as opposed to fishery-independent data. Landing statistics are influenced to an unknown degree by issues such as price, demand, input costs, market conditions, fishing effort, alternative income opportunities, and weather, etc.

With regard to the fishery, lobster landings in the Northumberland Strait have been in general, in decline since 1985. For example, the landings in 2002 in the portion of the Strait in Lobster Fishing Area (LFA) 25 are only 24% of the 1985 recorded peak. For discussion purposes, the Strait lobster landings have been presented in three zones – Western (Zone 1), Central (Zone 2) and Eastern (Zone 3). As noted in Figure 3.1-1, the decline has been most pronounced in the Central Zone, while the Eastern Zone has exhibited the least change.

This trend in the Northumberland Strait is at odds with trends in the remainder of the southern Gulf of St. Lawrence lobster fishery. In a historical context, from 1947 to 1990, catch in the Strait exceeded total catch in the rest of the southern Gulf. That trend reversed in 1991 and the gap has been increasing since as the rest of the southern Gulf catch has remained more or less constant and the Strait catch has steadily decreased. This has taken place in the Gulf in spite of an approximately stable fishing effort in both the Strait and other areas of the Gulf. That is, while effort has increased throughout as a result of technology changes, it has remained more or less comparable in the two areas.

FIGURE 3.1-1 Northumberland Strait Lobster Landings by Zone.*



*Zone 1 (Western Northumberland Strait) (From Mallet, 2005a)
Zone 2 (Central Northumberland Strait)
Zone 3 (Eastern Northumberland Strait)

Possible explanations for the decline in lobster stocks in the Strait have been many. For example, the stakeholder consultations on the EOR for the Northumberland Strait (GTA Consultants, 2006) indicate stakeholder opinion that “the construction and placement of the Confederation Bridge has had significant impacts on the ecosystem, noting that fish stock declines began at the time of construction and have continued since.” The report also notes that research and remediation action is needed to address: “Change to the seafloor in the Strait and general build up of sediments related to the Bridge, more extensive coastal erosion, and changes in tide and current flows.", as well as: "Increased contaminants in the water column related to runoff and effluent from land-based activities."

A review of the GTA report by TC and PWGSC (2006) takes issue with direct Bridge construction based causes pointing out that: "… it is difficult to draw a correlation between reduction in lobster landings and the presence of the Bridge. In both LFA 25 and LFA 26A over 55% of the overall decrease in landings occurred prior to the start of Bridge construction." Further, Mallet (2005a) points out: "It is not likely possible to detect any effect of the Confederation Bridge on lobster populations from landings statistics. To make a determination of this kind a focused research program would be required." The TC and PWGSC review states: "An unknown number of interrelated environmental and fishery factors have likely caused the decline in commercially exploited marine stocks."

3.1.3.5 Scallops

As is the case with lobster, the biology and life history of the sea scallop species (*Placopecten magellanicus*) has been well researched and studied over a long period (for summary see Packer et. al., 1999). Details of some of the two larval stages of the scallop are not well understood, particularly with regard to vertical distribution. The spat and adult stages have been more fully studied. Some of the specific details of the life history of Strait scallop populations has also been examined over time. Distribution of scallop beds throughout the Northumberland Strait is documented in the Traditional Knowledge Fishery Maps series (Legault, 1998). Scallop beds are distributed throughout much of the inshore area of the Strait.

Scallop larvae are planktonic and as such exhibit considerable movement subject to water column activities while the spat stage is fixed to the bottom or bottom dwelling epifauna/flora. When scallop spat settle they are extremely delicate and do not survive on mobile substrates. Those that land on sedentary branching plants and animals or any other hard surface on or above the ocean floor, which offers freedom of shell movement on all sides, may have a distinct survival advantage.

During the second growing season, juvenile scallops leave the original substrate on which they settled and attach themselves to shells and bottom debris by byssus. As young sea scallops age, they become less mobile and show less tendency to attach to the bottom using byssal threads. Scallops are relatively active until they are about 80 mm long, swimming in response to disturbances, such as predation and commercial dredging. While swimming, young scallops can also be carried long distances by currents.

There is no evidence of mass migrations by scallops. The movements of sea scallops are usually localized and random or current-assisted. Numerous tagging experiments have shown that once aggregations of adults are formed, they remain fixed

Scallops are suspension, or filter, feeders, depending on plankton, bacteria, detritus, and other suspended organic materials for energy and growth. Because they are filter feeders, elevated levels of inorganic suspended solids and clay sized particles can interfere with scallop feeding (Packer et. al., 1999).

Caddy recorded scallop presence in the 1975 Abegweit Passage study and Hurley did so in 1988. However, in 1988 the levels of capture were far lower. Hurley Fisheries (1989) attribute this lower level of sightings to differences in sampling protocol and "reduced recruitment to the fishery in recent years."

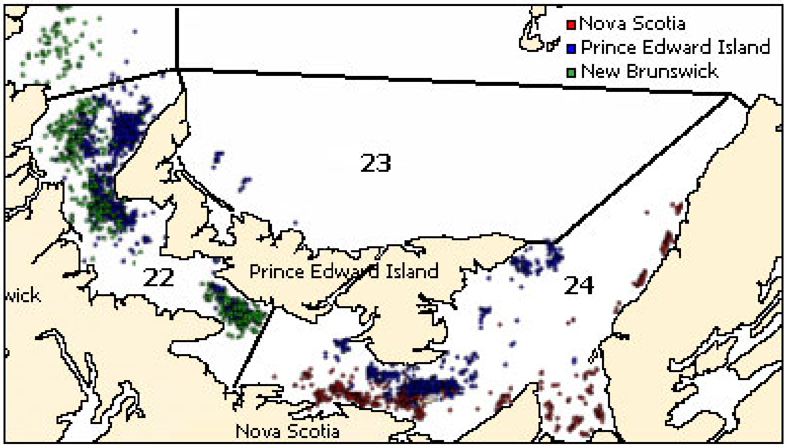
Hurley suggested the scallop as a possible sentinel or indicator species for monitoring change in the environment. The rationale was that adult scallops are sessile, restricted to deeper cobble bottoms and "support an important commercial fishery in Abegweit Strait – an area referred to as marginal habitat for scallops."

The Confederation Bridge MEEM studies monitored scallop populations in the vicinity of the Bridge prior to and during construction in order to test any possible construction affects. From 1993 to 1997, the monitoring process remained in place. A summary of the findings from the 1997 MEEM (JWEL, 1998) project document is presented below.

> "… Information was collected for scallop length frequency, catch per unit effort and natural mortality in the form of dead scallops with valves still attached (clucker analysis). This information was evaluated for comparison to baseline data collected on the scallop population in the area adjacent to and on the Bridge alignment prior to and during construction activities.
>
> There does not appear to be any missing (total mortality or cohort group) or reduced cohort groups in the scallop population length frequency data from 1994 to 1997. Results from 1993 to 1997 have indicated a general trend of decreasing catch per unit effort over the course of each scallop season. Clucker ratios were generally less in 1995, 1996 and 1997, than were observed during pre-Bridge baseline surveys in 1994.
>
> Post-construction underwater video and diver observations have indicated no habitat alteration adjacent to the pier base excavations as no accumulation or scouring of sediment was encountered.
>
> We continue to contend that the largest source of anthropogenic disturbance to the benthos in the Abegweit Passage is the habitat alteration that occurs as a result of the continued raking during successive scallop seasons."

The scallop fishery in the Northumberland Strait is important to fishers, although it has declined to record lows since 2001. Areas of fishery concentration are outlined in Figure 3.1-2. Unlike the lobster fishery in the Strait, fishing effort has not been sustained, as catch success has declined. For example, only 31% of fishers in the two scallop fishing areas (SFA) encompassing the Strait reported catches in 2003.

FIGURE 3.1-2 Scallop Fishing Locations (From Davidson, 2005a)



Scallop landing statistics for the southern Gulf were first recorded in the early 1900s. The highest landings recorded in SFA 22 were 619 metric tonnes (mt) in 1968. Since then, landings have fluctuated between 300 and 40 mt. A peak value of 2.4 million dollars was recorded in 1998. In the three years 2001-2003, landings went from 95 mt, to 41 mt, and to 55 mt respectively. In SFA 24 landings exceeded 250 mt in the late 1960s and early 1970s, but peaked in value ($4.5 million) in 1996. It was noted that the 1996 fishery, when the value peaked, included heavy fishing in an area that had been closed to fishing for three years. By 2003, landings were less than 30 mt. Scallop fishermen have launched several projects and participated in studies to understand and improve the scallop stocks, or explore alternative ways of growing them.

Recent scallop research and investigative work in the Northumberland Strait is reported by Davidson (2005a, 2005b) on the Northumberland Strait Working Group Information Website. Since 1995, work has been focused on poor spat collection success in the mid-region of the Strait, compared to high success at the two extremities. Scallop drag design modifications have been studied. In the last few years, work has commenced on scallop cage culture in the Strait. The effectiveness of closed areas in the Strait as a measure to allow scallop stocks to rebuild is also being explored.

As with the decline in the Strait lobster fishery, reasons for the precipitous decline in the scallop fishery have been much sought after. Possible explanations for the decline have been many and varied. A possible increase in total suspended solids (TSS) and increased sedimentation, particularly in the middle reaches of the Strait are being considered, as are the affects of extensive dragging of scallop harvesting gear and its possible effects on populations.

3.1.3.6 Rock Crab

Rock crabs are distributed from the intertidal zone to a depth of 40 m. On average, female and male rock crabs mature at 57 and 75 mm respectively. Female rock crabs carry eggs beneath the abdomen until hatched and the larvae are present in the plankton between mid-June and mid-September. Rock crabs are an important food source for lobster.

The rock crab had played quite a minor role in the southern Gulf of St. Lawrence fishery, being ignored or used as a source of bait for the lobster fishery until the mid-1960s when it became a by-catch component of the lobster fishery. A directed exploratory fishery (independent of the lobster fishery) was begun in 1974, but was limited in size until the late 1980s, when expanding markets and increased value resulted in a substantial growth in effort. Rock crab landings have increased steadily to about 1997. Since that year, landings have leveled to between 3,000 and about 4,000 mt annually. The fishery is limited to male rock crabs, which take approximately six years to reach a legal size (Mallet, 2005b). Rock crab tend to be expensive to harvest compared to lobster, but the fishery is not currently considered minor in the Strait, and as a result, governance issues are emerging as the demand increases.

Trawl surveys carried out in the Strait by DFO personnel in 2001 and 2005 showed a decrease in rock crab numbers.

3.1.3.7 Oysters

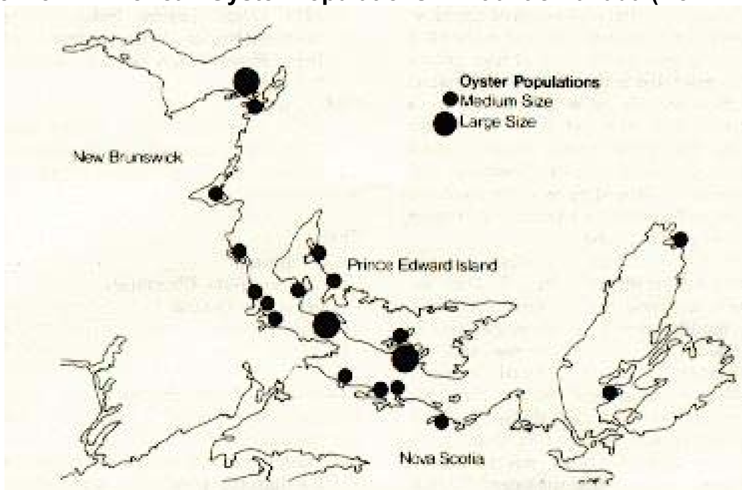
PEI is the leading oyster-producing province in the country followed by NB. The majority of that production is centered in Bedeque and Hillsborough Bays on PEI. Figure 3.1-3 indicates oyster growing areas in Atlantic Canada.

The Dunk and Wilmot estuaries of Bedeque Bay are the largest oyster producing areas on PEI. In 1973, the production of oysters from Bedeque Bay was about 395,000 pounds for an approximate value of $395,000. With several years of enhancement activities, annual production increased to over 3 million pounds annually, with a value of about $3 million. In the 1990s, over 75% of all the oysters shipped from PEI originated from Bedeque Bay.

More recently, with aquaculture activities starting to show increased contribution to landed value, the comparative value has declined slightly, with Bedeque Bay stocks accounting for about 65% of the total harvest of PEI oysters. In spite of challenges to the oyster grounds associated with erosion and siltation, eutrophication, etc., Bedeque Bay continues to be very productive for the culture of oysters. With over 65% of the oysters produced in PEI sourced from this watershed, it continues to be one of the most productive oyster areas on the eastern seaboard of North America. All oysters taken in this fishery are depurated prior to commercial sale.

Oyster spawning is predominantly temperature dependent and spat collection occurs in the estuary during the summer, usually in July and August. The fishery is primarily in the spring, and this has the additional benefit of acting to desilt oyster beds and may help to prepare the beds for subsequent spat settlement later in the summer. It has been determined that production in the area is much below carrying capacity. In order to encourage additional production, enhancement of oyster beds has taken place, led by the PEI Shellfish Association over the last several years. Enhancement of the habitat involves manipulation of factors limiting the population, by activities such as shell-bed cultivation, separation, and moving shell stock, as well as predator and disease control (Pinsent and Chan, 2006).

FIGURE 3.1-3 American Oyster Populations in Atlantic Canada (from DFO, 2006c)



Shediac Bay in NB historically had a very large oyster population which was decimated in the late 1800s. Recent attempts to rejuvenate oyster beds and re-establish a population has met with very limited success. Oysters are found occasionally in the area. Populations are also reported in Richibucto Bay. Historically, many of the bays and estuarial areas of the Strait reported significant populations of oysters, which have disappeared over time.

3.1.4 Fish

3.1.4.1 Groundfish

Groundfish are those species living largely on or near the bottom. Annual data collecting trawls have been made in September in the southern Gulf of St. Lawrence since 1971. Coverage of these trawls includes a mid-channel section of the western end of the Strait to approximately Egmont Bay and into the end of the Strait to approximately Hillsborough Bay. The middle section of the Strait is not included in trawl samples. Presence of bottom dwelling marine fish collected during the trawls is presented in the Atlas of the Geographic Distribution of Marine Fish and Invertebrates – Southern Gulf, 1971 to 2002 (Benoit et. al., 2003). The atlas indicates presence in the trawl. Table 3.1-7 lists taxa identified in at least one trawl season and location.

The Hurley Fisheries (1989) report mentions the winter flounder was the most frequently observed fish during their study, as well as the 1975 study, and were distributed throughout the area. At the time, they report a small, minor fishery for the species. The MEEM 1993 study report (JWEL, 1994) documents winter flounder in similar frequency with Hurley. It also indicates that a very few white hake and ocean pout were observed by divers and remote operated underwater vehicle cameras. They comment on the very low numbers of groundfish observed in the study area.

TABLE 3.1-7 Fish Species Collected During September Trawls, 1971 – 2002 Northumberland Strait

Taxa	West End of Strait	East End of Strait
Gaspereau, *Alosa pseudoharengus*	X	X
Herring, *Clupea harengus*	X	X
Fourbeard Rockling, *Enchelyopus cimbrius*	-	X
Atlantic cod, *Gadus morhua*	X	X
Greenland cod, *Gadus ogac*	-	X
Silver Hake, *Merluccius binlinearis*	-	X
White Hake, *Urophysis tenuous*	X	X
Three-spine stickleback, *Gasterosteus acculeatus*	X	X
Northern sandlance, *Ammodytes dubius*	-	X
Wrymouth, *Cryptacanthodes maculatus*	-	X
Cunner, *Tautogolabrus adspersus*	X	X
Mackerel, *Scomber scombrus*	X	X
Fourline snakeblenny, *Eumesogrammus praecisus*	-	X
Snakeblenny, *Lumpenus lampretaeformis*	-	X
Butterfish, *Peprilus tricanthus*	-	X
Eelpout, *Lycodes sp.*	-	X
Common oceanpout, *Zoarces americanus*	X	X
American plaice, *Hippoglossoides platessoides*	X	X
Yellowtail flounder, *Limanda ferruginea*	X	X
Winter flounder, *Pseudopleuronectes amiercanus*	X	X
Greenland halibut, *Reinhardtius hippoglossoides*	-	X
Windowpane, *Scophthalmus aquosus*	X	X
Winterskate, *Leucoraja ocellata*	X	X
Rainbow smelt, Osmerus mordax	X	X
Alligatorfish, *Aspidophoroides monopterygius*	-	X
Sea raven, *Hemitripterus americanus*	-	X
Longhorn sculpin, *Myoxocephalus octodecemspinosus*	X	X
Shorthorn sculpin, *Myoxocephalus scorpius*	-	X
Mailed sculpin, *Triglops murrayi*	X	X
Lumpfish, *Cyclopterus lumpus*	-	X
Spiny dogfish, *Squalus acanthius*	X	X

X = presence / - = absence

Little detailed information is available on many of the smaller species of groundfish that inhabit the Strait. They undoubtedly play an important role in the food chain, but this is not well studied. With the decline of cod populations and the moratorium placed on the fishery in 1993, the only groundfish fishery in the Strait at present is the limited fishery for winter flounder.

The Traditional Fisheries Knowledge Atlas (Legault, 1998) has distribution maps for cod, hake and winter flounder in the Strait, with skate and American plaice being indicated in the easternmost portions of the Strait only. Winter flounder and tomcod are noted in coastal EOARs as commonly observed groundfish, most often captured in smelt nets, etc., as by-catch.

There was an active hake fishery in the late 1960s and early 1970s in the Baie Verte area. By the late 1970s the fishery had moved to the Cape John and Lismore area. There is now an absence of the fishery in all these areas. The fishery for skate has followed a similar track (R. Heighton, Pers. Comm., 2006).

Winter flounder are associated with soft or moderately hard bottoms and depths less than 40 m. They occupy a range of water temperatures and are capable of inhabiting sub-zero water conditions. In the southern Gulf they overwinter in estuaries. Spawning occurs in late winter or early spring. Female winter flounder release several hundreds of thousands of eggs that settle to the bottom, adhering to rocks and vegetation. The larvae drift in surface waters for 2-3 months before metamorphosis. Growth rates vary widely between regions, with female winter flounder reaching sexual maturity by about 25 cm and with males maturing by approximately 20 cm. Winter flounder feed opportunistically on a variety of benthic organisms, mainly molluscs and small crustaceans. They also feed on the eggs of other aggregations of spawning fish, in particular capelin and herring.

Winter flounder in 4T (the Southern Gulf of St. Lawrence) came under quota management in 1996. With the closure of the Atlantic cod fishery in 1993, concern was expressed that species without quota restrictions, such as winter flounder, would become subject to increased directed effort. The first assessment of the stock status was made in 1994. The 4T winter flounder resource supports localized fisheries for lobster bait and limited food markets. Winter flounder was also a by-catch in fisheries for cod, white hake and American plaice; however, since closure of the cod fishery, winter flounder has become a mainly directed fishery. The fishery in 4T is prosecuted mainly by mobile gear operated by vessels less than 45 feet (DFO, 2005b).

Winter flounder landings, which had remained close to 600 tonnes (t) from 1997 to 2001, declined to 381 t in 2004. This is the lowest harvest recorded over the 1960-2004 period. Landings have averaged 1671 t since 1960. The Northumberland Strait trawl survey conducted annually to monitor lobster numbers, also samples winter flounder. The biomass index from the trawl survey was more or less constant from 2000 to 2003, but dropped by about 50% in 2004.

In terms of future outlook for the winter flounder population of the southern Gulf: "The survey indicates that there has been a declining trend in the average size of winter flounder over most of the past 32 years, but this trend appears to have levelled since 1995" (DFO, 2005b). Data from the Northumberland Strait would seem to indicate that the decline may still be taking place.

Fishing effort for the fishery has declined in keeping with the drop in stocks.

As pointed out above, Atlantic cod populations have been in peril and a general closure with a recent very limited fishery in the last year has been instituted in the southern Gulf of St. Lawrence. The status of the population and fishery is outlined in the DFO (2005c) publication, Cod in the southern Gulf of St. Lawrence.

3.1.4.2 Pelagic and Migratory Fish Populations

Pelagic and/or migratory species which are recorded in the Northumberland Strait are referenced in Table 3.1-8 and summary of the general biology of the more common species is presented below.

TABLE 3.1-8 Pelagic and Migratory Fishes Reported in the Northumberland Strait

Common Name	Scientific Name	Comments
Atlantic Salmon	*Salmo salar*	Anadromous, remnant population, historically abundant. 8 rivers in Strait rivers in NS support populations, 2 in PEI, c.40 in NB.
Striped Bass	*Morone saxatilis*	
American Eel	*Anguilla rostrata*	Catadromous species. A small commercial and recreational fishery. Present year-round.
Gaspereau/Alewife	*Alosa pseudoharengus*	Migratory anadromous species spawning in many Strait tributaries.
Smelt	*Osmerus mordax*	Nearshore species, move into rivers and estuaries to spawn. Small commercial and recreational fishery.
Mackerel	*Scomber scombrus*	
Herring	*Clupea harengus*	Migratory. Spawn in nearshore areas. A major commercial species in the Strait.
Mummichog	*Fundulus heteroclitus*	
Threespine stickleback	*Gasterosteus aculeatus*	
Fourspine stickleback	*Apeltes quadracus*	
Ninespine stickleback	*Pungitius pungitius*	
Blackspotted stickleback	*Gasterosteus wheatlandi*	
Sculpins	*Myxocephalous spp.*	
Atlantic silverside	*Menidia menidia*	A small nearshore fishery in late fall.
Banded killifish	*Fundulus diaphanous*	
Brook trout	*Salvelinus fontinalis*	Major recreational angling species throughout the region. Freshwater and migratory.
Rainbow trout	*Salmo gairdneri*	Introduced species which has settled in some watersheds. Freshwater and migratory.
Atlantic Tomcod	*Microgadus tomcod*	
Capelin	*Mallotus villosus*	
Cunner	*Tautogolabrus adspersus*	
Arctic rockling	*Gaidropsarus argentatus*	
Sand lance	*Ammodytes americanus*	
Northern pipe fish	*Syngnathus fuscus*	

Mummichogs are common in brackish water over mud or mud-sand substrates. They are tolerant of a wide range of stressful conditions due to the environment they inhabit. Digging into a mud substrate to avoid low tides and undergoing a hibernation-like state in the mud in winter are characteristics of the species. They spawn from late spring through summer.

Sticklebacks are common estuarine fishes, found in saline, brackish and freshwaters. Three and ninespine sticklebacks spawn in freshwater, while four-spine sticklebacks spawn in brackish water.

Silversides occur year-round in bays and estuaries. They swim in schools in shallow water along the shore searching for food, and in marshes to feed at high tide. They spawn in June, with eggs hatching in about 10 days. Silversides are fished commercially in late fall. The fishery for silversides is based on servicing the pet and captive animal food industry.

Striped bass travel the shorelines and into marshes at high tide to feed. They also enter rivers to feed. A small recreational fishery exists in the watershed in the spring and summer. Striped bass populations are at low levels in the southern Gulf and are in the process of being declared under the *Species at Risk Act* (SARA).

Smelt overwinter in the estuaries and are present from fall through spring when the adults move a short distance upriver to spawn before migrating back to sea for the summer months. The smelt fishery is an active winter fishery in many parts of the Strait near shore. Gill nets, box nets, and smelt shacks are all part of this fishery in the bays, harbours, and estuaries. There is an active commercial fishery for smelt in the NB portion of the Gulf of St. Lawrence, accounting for 85% of the total commercial catch of the species. The remaining 15% of the Gulf catch is split between PEI, and the Gulf areas of NB and Québec. About one-half of NB landings come from the Miramichi River. Even though the fishery was a major economic contributor during the middle of this century, its importance has declined over time and it no longer appears on the list of major fisheries. Stock assessment is limited and there are no good estimates of population size.

Gaspereau spend most of their lives at sea, and come into the estuaries in large numbers, moving up rivers to spawn in late spring. After spawning, most adults return to the sea. Soon after hatching, the fry seek brackish and then salt water, moving oceanward quite quickly. The gaspereau spawning run provides an early spring bait fishery for a limited number of fishermen. An export food fishery has had some success in the recent past.

Brook trout are a major recreational fishery component of many rivers and estuaries in the Strait. The fish are both anadromous and freshwater. The sport fishery has declined over the history of settlement, primarily due to increasing siltation and habitat modification.

Rainbow trout are not native to the eastern coast, thus are an introduced species in some tributaries to the Strait. For example, in PEI, both planned and accidental releases have taken place in Island streams over the last half-century. While rainbow trout were introduced initially as freshwater populations, some are now running to sea. Habitat used by rainbow trout while in streams is very compatible with that required by young Atlantic salmon. Atlantic salmon and rainbow trout have co-existed in some rivers for decades.

Atlantic salmon have also been well studied in the Northumberland Strait and watershed. DFO Status Reports exist for the SFA's of the Strait (SFAs 16, 17 & 18). These anadromous fish move from the ocean into the freshwater streams in the fall. Spawning takes place in the late fall with the embryos overwintering in the gravel until May or June. Young fish stay in the river for two or three years until smolting and moving to sea.

Herring are the major commercial finfish species in the Northumberland Strait. In addition, they are an important part of the food chain for many of the predatory species in the ecosystem. Herring is a pelagic species which forms schools during feeding and spawning periods. In the southern Gulf of St. Lawrence there are spring- and fall-spawning components. It is these spawning aggregations that are targeted by fishermen, thus there is no overlapping of the fishing seasons. Spring spawning occurs primarily in April and May but extends into June, at depths of less than 10 m. Fall spawning occurs from mid-August to October at depths of 5 to 20 m. There is not an absolute distinction between spring and fall spawners, resulting in some population intermixing. Eggs are attached to the bottom and hatch after about 11 days at 10°C. They are extremely vulnerable to sedimentation. The larvae are planktonic. First spawning occurs primarily at age four years (Mallet, 2005c).

The total fishery during the spring is focused in the western and central Northumberland Strait, while the fall fishery is almost exclusively in the eastern part of the Strait (Figures 3.1-4 and 3.1-5, both from Mallet, 2005c).

The herring catch is highly variable, with ranges within spring and fall spawning populations of factors of 2 or more (i.e., spring '92 – 4,300 t; spring '94 – 10,600 t, and, fall '00 – 5,000 t; fall '03 – 10,000 t). The spring fishery has been generally in decline since the mid-1990s. However, this is a characteristic which is being observed with the entire spring fishery in the southern Gulf of St. Lawrence region. The 2005 spring catch was the lowest harvest and catch per unit effort in 1 ½ decades (DFO, 2006d). The decline of the herring fishery in the central Strait is noted in the consultations report (GTA, 2006) in relation to the timing of the construction of the Confederation Bridge. However, a discussion document on the Northumberland Strait Working Group website, which was prepared by David Scarratt under contract to DFO (Environmental Conditions in the Northumberland Strait and their Effects upon the Fisheries, 2005), makes the statement:

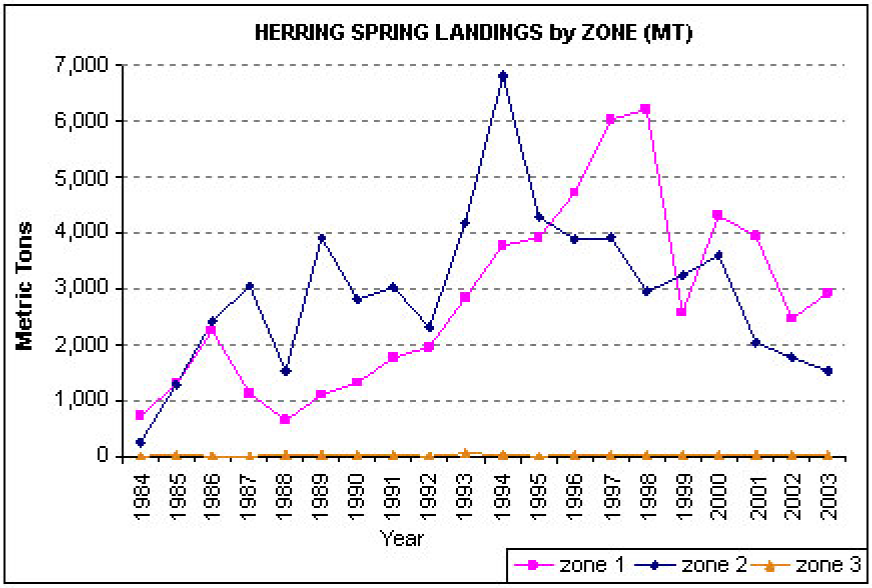
> "Landings plotted by zone (west, central, and eastern parts of the Strait) show little evidence of any easily discernible trends, except that landings from Spring spawners, which were the mainstay of the Central Strait fishery historically are declining more rapidly than those in the Western Strait. Reasons for this trend are not known."

Herring landings for the total year in Areas 25 and 26A are presented in Figure 3.1-6. For comparison, herring landings in the same time frame from the centre part of the Strait only – the eastern part of Area 25 and the western portion of 26A are presented in Figure 3.1-7.

<u>Mackerel</u>

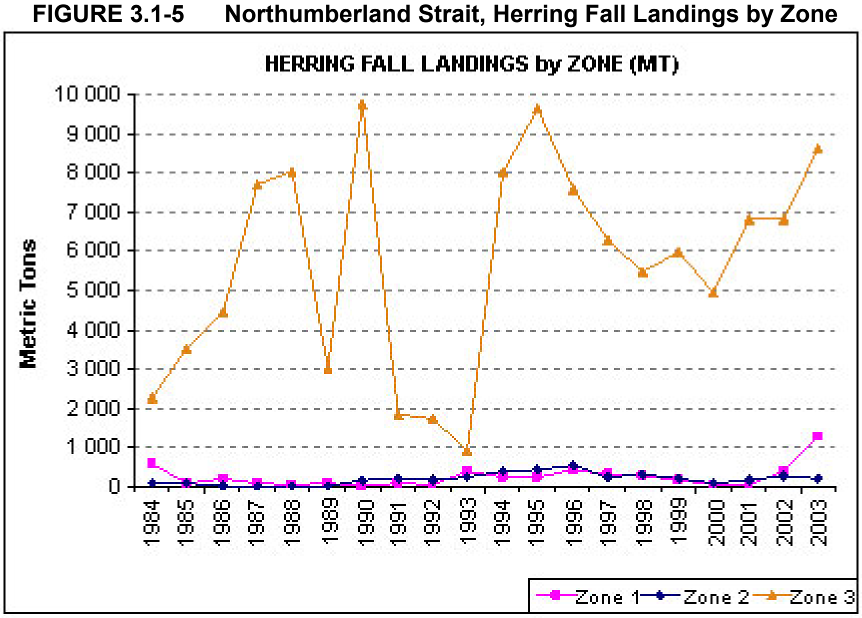
The mackerel population of the Northumberland Strait area is a portion of a major species population for the entire Gulf of St. Lawrence. In fact, United States of America (USA) officials consider the entire Atlantic Coast population, from North Carolina to the Gulf of St. Lawrence, as a single, intermingling population. Mackerel are a wide-ranging pelagic fish which move in large schools across their range, moving toward shore during the summer to spawn and feed and then well offshore during the winter months. The species biology, habitat, and life history are well presented in a number of publications (i.e., National Oceanic & Atmospheric Administration (NOAA) Technical Memorandum, 1999).

FIGURE 3.1-4 Northumberland Strait, Herring Spring Landings by Zone



Zone 1 – West, Zone 2 – Central, Zone 3 – East

FIGURE 3.1-5 Northumberland Strait, Herring Fall Landings by Zone



Zone 1 – West, Zone 2 – Central, Zone 3 – East

FIGURE 3.1-6 Herring landings 1984 – 2005, Northumberland Strait

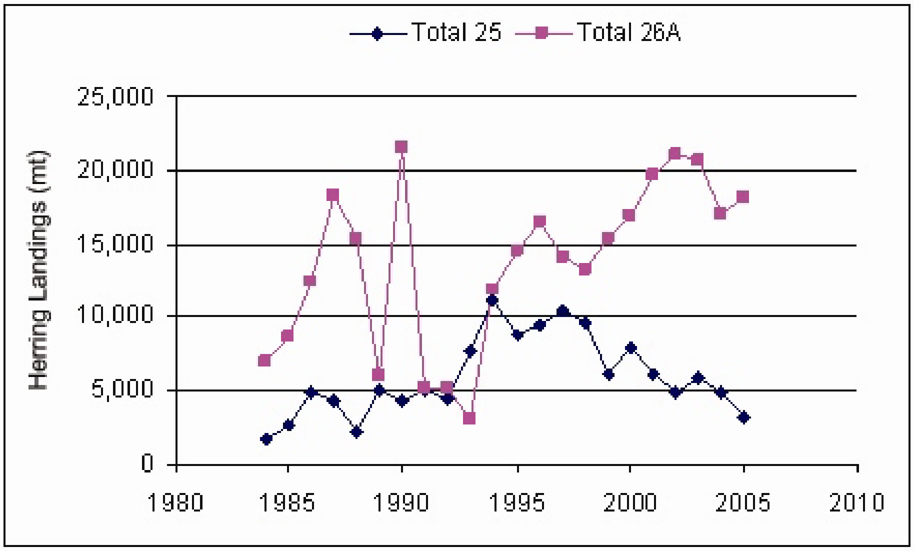
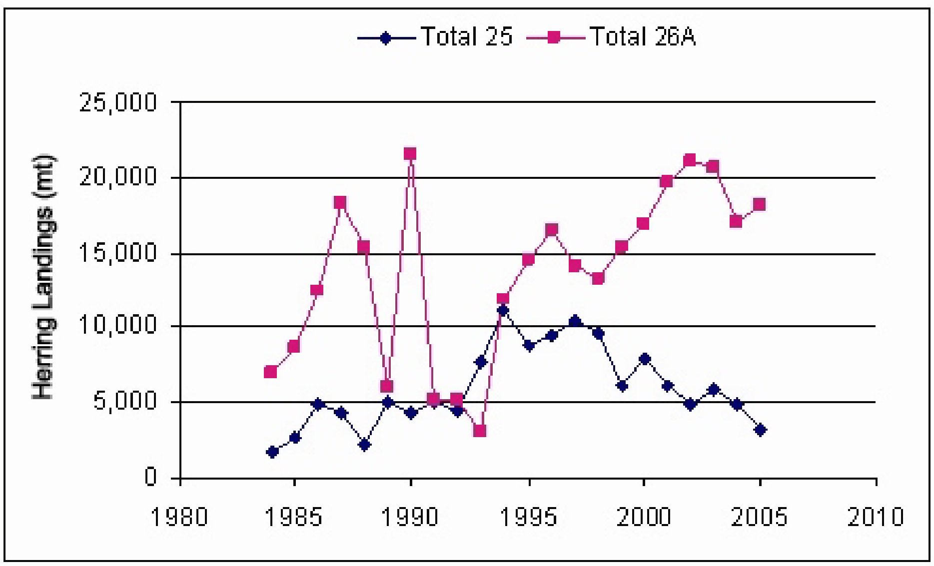


FIGURE 3.1-7 Herring landings 1984 - 2005, Central Portion of Northumberland Strait



The mackerel fishery in the Gulf of St. Lawrence is managed on a wide geographic basis due primarily to the biology of the species. The 2002-2006 IM Plan – Atlantic Mackerel (DFO, 2002) states:

> "Since 1994, recorded mackerel landings from Canadian waters have dropped to below 20,000 t annually. NS and Newfoundland are the Atlantic provinces with the highest mean landings. On a smaller geographic scale, landings may fluctuate significantly from one year to the next. The fluctuations are due to great variability in seasonal migration patterns, although fishing grounds usually remain the same."

The mackerel fishery in the southern Gulf is a minor fishery which is flexible dependent upon availability of product, price, and timing relative to other more lucrative fisheries. At one time, during the 1970s, there was a high demand for mackerel, and as a result, effort and landings increased in response. There is a bait fishery in the Strait as well as a recreational fishery.

Anecdotal evidence indicates a reduced movement of mackerel into the Northumberland Strait, particularly in recent years. The reasons for this are unknown at present.

3.1.5 Reptiles

The leatherback turtle (*Dermochelys coriacea)* is the only marine reptile known to visit the Northumberland Strait. It is a wide-ranging highly migratory species which concentrates in the coastal areas of Atlantic Canada during the summer months. The reason for its occurrence is linked to the abundance of jellyfish, which the turtle feeds on extensively. They tend to move freely, feeding throughout the Gulf of St. Lawrence. The remainder of the year they move out into deep ocean waters of the continental shelf, ranging as far south as South America and the Antilles (James et. al., 2005). Recent research into the turtle's distribution in the Maritimes has shown them to occur in the Abegweit Passage, but no known concentration has been documented in the Strait. The leatherback turtle is a listed species under SARA.

3.1.6 Marine Mammals

The Northumberland Strait plays host to a number of marine mammal species. Observations have been made over time but little detailed study of mammals, their ecology, or life history in the Strait has taken place. Observations tend to be anecdotal, or carried out as an adjunct to other investigative work. Seals, whales, dolphins and porpoises are known to occur in the Strait. Species are listed in Table 3.1-9.

TABLE 3.1-9 Marine Mammal Occurrence in Northumberland Strait

Species, Common Name	Scientific Name	Notes
Harbour Seal	*Phoca vituline*	Common, spring, summer & fall. Year-round resident in the Gulf.
Grey Seal	*Halichoerus grypus*	Common,
Hooded Seal	*Cystophora cristata*	Occasional
Harp Seal	*Phoca goenlandica*	Occasional
Atlantic White-sided Dolphin	*Lecopleurus acutus*	Common, summer and autumn
Harbour Porpoise	*Phocoena phocoena*	Common, summer and autumn
Fin Whale	*Balaenoptera acutorostrata*	Occasional, rare sitings
Pilot Whale	*Globicephala melaena*	Rare sitings
Sperm Whale	*Physeter macrocephalus*	Stranding occurred, Hillsborough Bay

Harbour seals and grey seals are common in the Strait. The grey seal has the most "antagonistic" relationship with fishers, being accused of using cod and other valuable commercial fish species as a primary food source. Grey seals whelp on the ice of the Gulf generally in late winter. They feed on a variety of fish including squid, herring, mackerel, cod, and flounder. The harbour seal is a smaller species which tends to occur during the ice-free months in the bays, estuaries and near shore areas of the Strait. The Traditional Knowledge Fisheries Atlas (Legault, 1998) records populations of them in the areas around Shediac Island, off Wallace, and on the northeast side of Pictou Island in the Strait. They tend to leave areas of heavy ice cover in winter and move off into more open water and warmer waters off New England.

Anecdotal evidence suggests that seals, once uncommon in the Strait, are now year-round residents. This increasing population has made it difficult to set herring nets in the daytime because the seals often scare the herring away from the nets (R. Heighton, Pers. Comm., 2006).

White-sided dolphins and harbour porpoises are commonly sited in the Strait in summer and fall. They occur in harbours, bays, and estuaries as well as in the mid-Strait areas. They are members of the “toothed whale” group of cetaceans and feed on a variety of fishes and squid. Both species move into warmer waters off New England during the winter months. The harbour porpoise is classed as a threatened species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) but the Maritimes tend to have a good population. Cetacean strandings on PEI during the period from 1980 to present have been recorded by the Atlantic Veterinary College at the University of PEI. Strandings of harbour porpoise are recorded in Egmont Bay, Bedeque Bay and Hillsborough Bay on the Strait side of the province. White-sided dolphin strandings have been noted in Bedeque, Hillsborough and Orwell Bays.

Pilot whales are occasional visitors to Strait waters during the summer or fall months. The MEEM study staff maintained marine mammal logs during their onsite work, and recorded pilot whales in 1993 (JWEL, 1994). Undetermined whale species were noted in 1994 and 1995. Pilot whale strandings have been recorded in the Cardigan Bay area of PEI, just outside the eastern end of the Northumberland Strait.

The Fin whale, a baleen filter feeding species, occasionally passes through the Strait area, particularly during spring and fall migrations. The Traditional Fisheries Knowledge Atlas records an area of sitings mid-channel between Bouctouche and Egmont Bay. A stranding occurred in the Cardigan Bay area in December of 1999.

A sperm whale, an uncommon occurrence in the Strait, was washed ashore in the Cherry Valley area near Hillsborough Bay on PEI in October of 1996.

A walrus sighting was reported by MEEM staff in 1993 (JWEL, 1994), however, this is thought to be a mis-identification. The last siting prior to this in the Northumberland Strait was in 1758, when they were thought to be extirpated.

An ongoing issue with relation to marine mammals in the Strait is the competitive role that seals (grey seals in particular), and other species to a lesser extent, play in competing predators with fishers for valued commercial species, and the effect they may be having on some species (i.e., cod). However, it is noted that in the Gulf of St. Lawrence, generally, knowledge of seal populations sizes and movement is either non-existent or out-of-date. Grey seal diet information is adequate, but that of other species is very limited.

3.1.7 Marine Birds

There are four groups of marine birds that are common to the waters and shorelines of the Northumberland Strait:

- Inshore birds – These feed in inshore habitats where food is found on or near the bottom of shallow water, and will normally return to land to spend the night. Examples include cormorants, gulls and terns.
- Offshore or pelagic birds – These spend long periods of time at sea, which provides them with all or most of their food requirements. Due to the comparatively limited pelagic area in the Strait, pelagic birds tend to be less common in the environment. A lack of rocky cliffs and islands in the Strait limit suitable nesting and breeding locations. Examples are petrels and auks. Together, inshore and offshore birds are also called seabirds. As might be expected, the great majority of seabirds in the Northumberland Strait are inshore birds.
- Waterfowl – Ducks and geese, usually migratory.
- Shorebirds – The majority of shorebirds are present only for a short time (mostly July to September) during their migration from the Arctic to their wintering grounds in South America. They stop to feed off mud flats, a crucial food source during their long trek. As an area of extensive mud flat, the Northumberland Strait is a significant component of the Gulf of St. Lawrence, which is second in importance, after the Bay of Fundy, for the number of shorebirds using its shores as a refueling station. Several species of shorebirds will also breed in the Northumberland Strait.

The Terrestrial Environmental Effects Monitoring (TEEM) report (1996) reported on extensive studies carried out to monitor the possible effects construction activities related to the Confederation Bridge might have on aquatic, marine and terrestrial birds in the area.
As part of that work they carried out detailed observations of avifauna in the Abegweit Passage portion of the Strait and in nearby marshes and wetlands. Table 3.1-10 below summarizes aquatic and marine bird species observations.

TABLE 3.1-10 Summary of Aquatic and Marine Birds Identified During TEEM 1995 Studies

Bird Group (Guild)	Number of Species
Dabbling ducks	13
Diving ducks	3
Sea ducks	13
Sea birds	9
Diving birds	9
Shorebirds	18
Waders	2
Geese	2
TOTAL	69

A total of 69 species were identified in the Abegweit Passage area of the Strait and adjacent coastline areas. Forty-five percent of the species were ducks and geese. Thirty-two percent were sea birds or sea ducks. Examples of species categorized as sea ducks include scoters, oldsquaws, goldeneyes, mergansers, scaup, and eiders. Sea birds included gulls, gannets, and terns. The detailed species list can be found in Appendix M of the TEEM 1995 final report.

The draft Bedeque Bay (Pinsent & Chan, 2006), Shediac (LeBlanc & Turcotte-Lanteigne, 2006), Baie Verte (Hart & Ripley, 2006) and Richibucto (Turcotte-Lanteigne & Ferguson, 2006) EOARs reference marine and aquatic birds common to these specific regions of the Northumberland Strait. The range of environments presented by these discrete EOARs might be considered representative of the shoreline and inshore areas of the Strait as a whole.

Coastal seabird counts carried out in NS in 2002 (Boyne & Beukens, 2004) and PEI in 2004 (Boyne & McNight, 2005) concluded that Great Black-backed Gull and Herring Gull populations have been declining sharply since the 1980s. Tern populations exist at much lower levels than during their peak also in the 1980s. Ring-billed gull populations continue to increase, but at a slower pace than in the past. Northumberland Strait colonies examined during these studies (Amet Island, NS; Indian Point Sand Hills, Hillsborough River, PEI) supported these findings.

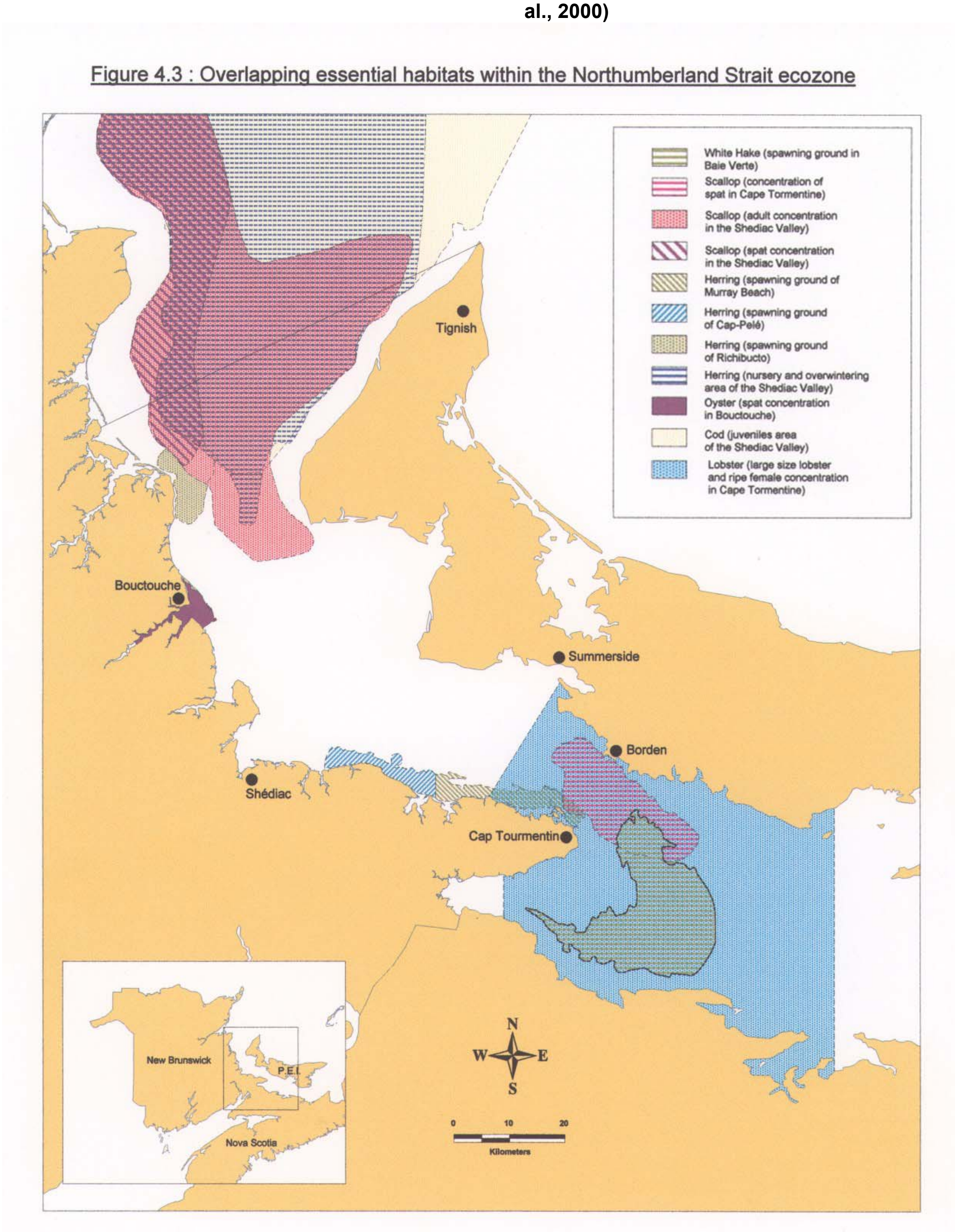
Cormorants are quite common throughout the Strait and interact with fish and aquatic fauna primarily as predators. Pictou Harbour has a notable population. A study in Summerside Harbour (Hill et al., 1997) analysed the diets of cormorants in the Dunk River estuary and determined it to be largely rainbow smelt and other minnow species.

3.2 HABITAT COMPONENTS

The known important habitat components of the Northumberland Strait near shore in NB, and the western inshore portion of the Strait bounded by NB and PEI, are extremely well documented in a recent report by Therrien et. al. (2000) entitled: A Preliminary Index of Essential Habitats for Certain Marine Species of Importance in the Eastern Region of NB. This document, commissioned by DFO, is designed as a useful planning tool for management and conservation needs.

With the help of many stakeholders (fishers, fishery officers and biologists), a representative portrait of the information currently available on major marine resources in Eastern NB was developed. The information is presented in the form of essential habitats for certain marine species, with a total of 30 habitats for 31 species or groups of species having been identified. They are divided in three ecozones: Chaleur Bay, Shediac Valley, and the Northumberland Strait. The term essential habitat is used to characterize each species-habitat grouping representative of a vital habitat for a particular wildlife species. These areas are essential for various crucial stages in the life-cycle of the species (spawning ground, rearing area, feeding ground, migration area, etc.), or they constitute a major area of concentration, particularly for mostly sedentary species, such as molluscs, for which the boundaries of the area would remain relatively constant from one year to another. Fish concentration areas are generally not included, with the exception of those associated with one particular life stage (larva or juvenile) or a threatened species (cod). Figure 3.2-1 taken from the report, provides an example of the type of information presented in the document with reference to overlap of habitat areas in the Northumberland Strait.

FIGURE 3.2-1 Overlapping Essential Habitats within the Northumberland Strait Ecozone (From Therrien et. al., 2000)



In addition to the information provided in the main body of the report, it also includes data on a number of supplementary species habitats which could be considered as potential essential habitats, but which are less fully documented. In the Northumberland Strait, these include habitats for grey seals, quahogs, scallops, soft-shell clams, bar clams, rock crab, and herring.

There are no similar information bases available for the eastern end of the Gulf adjacent to NS and PEI. However, Inshore Charts 4404 and 4405 from the Traditional Fisheries Knowledge Atlas (Legault, 1998) do provide some limited information on known rock crab and herring spawning areas as well as mackerel, silverside and shark distribution. Nearshore maps for eastern PEI identify eel, alewife and rainbow smelt distributions in Hillsborough estuary. In NS, nearshore maps identify eel, sea-trout and smelt distributions in the Pictou-Caribou nearshore; bar clam, oyster, quahog, blue mussel and soft shell clam distributions in the Amet sound nearshore. The draft Baie Verte/Cape Tormentine EOAR (Hart & Ripley, 2006) document identifies important habitats in that area of NS, as does the draft Bedeque Bay EOAR (Pinsent & Chan, 2006) document for that portion of the PEI nearshore.

A compilation document for the eastern Strait, of similar detail and magnitude to that of the NB document, would be a valuable addition to the catalogue of habitat components of the Northumberland Strait.

3.3 OTHER

3.3.1 Keystone Species

A keystone species is described as: "…a species that has a disproportionate effect on its environment relative to its abundance." Such an organism plays a role in its ecosystem that is analogous to the role of a keystone in an arch. While the keystone feels the least pressure of any of the stones in an arch, the arch still collapses without it. Similarly, an ecosystem may experience a dramatic shift if a keystone species is removed, even though that species was a small part of the ecosystem by measures of biomass or productivity." While this specific definition is taken from Wikipedia (2006) – it is essentially the same definition used in many other learned publications and recognized ecology texts.

In a review of the concept and its relevance for conservation management, Payton et. al. (2002) point out that the concept, originating in 1966, based on a rocky shore community, has proved both promising and elusive in applied ecology. They state that subsequent to the origination of the concept and its appeal, "numerous species in a wide range of communities … have been claimed to have keystone status, often with little experimental or quantitative evidence." Many of these have been dismissed as "anecdotal keystones".

It is apparent from examining the concept that it requires either taking a very small component of a larger ecosystem and subjecting it to detailed experiment and modification, or being highly knowledgeable of the species and interactions within an ecosystem. While some excellent detailed knowledge exists with regard to some species and species relationships within the Northumberland Strait, knowledge with regard to the broader ecosystem dynamics is largely wanting. This is in no small part due to the vastness, complexity, range of inputs, and difficulty of data gathering that the Strait presents to those studying it. Identifying keystone species in the Strait with any level of certainty would appear to be a formidable task.

No studies or work with regard to keystone species within the Strait was discovered during a review of existing data specific to the area. McKindsey and Bourget (2001) in a study of an ecological community in the Gulf of St. Lawrence near Matane, Québec did identify blue mussels in a bed there as being a keystone species. Sellers and Stanley (1984) in a species profile of the American oyster, identify it as a "keystone species in the diverse community of an estuarine ecosystem". These may be of some benefit in exploring the concept further in the Northumberland Strait.

3.3.2 Species at Risk

The species listed below are identified under the SARA or by COSEWIC as being at some level of risk. These species have also been identified in, or adjacent to, the Northumberland Strait. Where applicable, these species are also listed in the Species at Risk

COSEWIC was established in 1977 to provide Canadians with a single, scientifically sound classification of wildlife species at risk. COSEWIC gave its first designations in 1978 and has met yearly since then to evaluate the status of Canadian species.

COSEWIC uses a process based on science, Aboriginal Traditional Knowledge, and community knowledge to assess the risk of extinction for species. To legally protect species listed by COSEWIC, the Government of Canada passed the SARA in 2003. The purposes of the SARA are to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, and encourage the management of other species to prevent them from becoming at risk. Within the SARA, COSEWIC acts as an independent body of experts responsible for identifying and assessing species considered at risk.

The SARA acknowledges the valuable role Aboriginal people must play in the recovery and protection of species at risk. SARA provides for the establishment of two committees by Environment Canada:

- National Aboriginal Council on Species at Risk (NACOSAR)
    - NACOSAR will advise the Minister of the Environment on the administration of SARA and provide advice and recommendations to the Canadian Endangered Species Conservation Council.
- COSEWIC Aboriginal Traditional Knowledge Subcommittee on Species at Risk
    - This subcommittee will provide access to the best available Aboriginal Traditional Knowledge and facilitate the use of this knowledge by COSEWIC when assessing and classifying species at risk.

In 2003, SARA was proclaimed. The purpose of SARA is to protect wildlife species at risk in Canada. Within the Act, COSEWIC was established as an independent body of experts responsible for identifying and assessing species considered at risk. This is the first step towards protecting species at risk. Subsequent steps include COSEWIC reporting its results to the Canadian government and the public, and the Minister of the Environment's official response to the assessment results. Species that have been designated by COSEWIC may then qualify for legal protection and recovery under SARA. The species listed in Table 3.3-1 were identified by COSEWIC as being of special concern, threatened or endangered. Also included in the table are the species that have been subsequently listed under SARA. These species have been identified in, or adjacent to, the Northumberland Strait.

TABLE 3.3-1 COSEWIC and SARA Classifications for Species in the Northumberland Strait Area

	CLASSIFICATION	
	COSEWIC	**SARA**
Mammals		
Harbour porpoise, *Phocoena phocoena*	Special Concern	Under Consideration
Fin whale, *Balaenoptera physalus*	Special Concern	Special Concern
Blue Whale, *Balaenoptera musculus*	Endangered	Endangered
North Atlantic Right Whale, *Eubalaena glacialis*	Endangered	Endangered
Reptiles		
Leatherback seaturtle, *Dermochelys coriacea*	Endangered	Endangered
Fish		
Striped bass, *Morone saxatilis*	Threatened	Under Consideration
American eel, *Anguilla rostrata*	Special Concern	Under Consideration
Winter skate, *Leucoraja ocellata*	Endangered	Under Consideration
Porbeagle, *Lamna nasus*	Endangered	Not Listed
Atlantic wolfish, *Anarhichas lupus*		Special Concern
Atlantic cod, Maritime population, *Gadus morhua*	Special Concern	Not listed
Birds		
Piping plover melodus subspecies, *Charadrius melodus*	Endangered	Endangered
Barrow's goldeneye, *Bucephala islandica*	Special Concern	Special Concern
Roseate tern, *Sterna dougallii*	Endangered	Endangered
Harlequin duck, Eastern population, *Histrionicus histrionicus*	Special Concern	Special Concern
Plants		
Gulf of St. Lawrence aster, *Symphyotrichum laurentianum*	Endangered	Threatened

(COSEWIC, 2006; SARA, 2006)

Management, resource-based, and species harvesting decisions should take these species into account prior to any implementation. Species designated under SARA imply certain legal restrictions and considerations which must be taken into account.

3.3.3 Invasive Species

The Working Group on the Northumberland Strait Information Website contains an up to date information sheet on the status of invasive species in the Northumberland Strait. It is presented below.

The Northumberland Strait, like other waters throughout the world, is inhabited by both native and non-native species. Introduced species have been known in Canadian Atlantic waters probably since the earliest European explorers arrived. Transport can occur by a variety of mechanisms, including ship's ballast water, fouling of hulls, fishing gear or other equipment, deliberate transfers causing both intentional and non intended introductions, processing or disposal of live seafood, and purely natural dispersal processes. The speed of modern vessels and the sheer bulk of the ballast they carry are altering the distribution of the world's marine (and some freshwater) species to an unprecedented extent. At least 25 species have been introduced to or have otherwise entered the southern Gulf of St. Lawrence, most of which are found in Northumberland Strait. Some have created environmental and economic problems. The species of greatest concern are those that have arrived within the past decade:

1. Green crab (*Carcinus maenas*), a European species first observed at the eastern end of the Northumberland Strait in 1994 or 1995. It has since spread rapidly westward. On the mainland, the green crab reached Baie Verte near the mouth of the Gaspereau River in 2002. There have been no confirmed reports west of that site. The first report from PEI was from the Cardigan River in 1997. By 2001, they had spread as far west as Victoria. Further westward, expansion has been slowed because the prevailing currents in the Strait are not favourable to dispersal of the planktonic larvae, but adults can disperse by walking, or by "hitchhiking" on boats. The green crab eats a variety of species including molluscan shellfish, both wild and cultured, and probably contributed to the collapse of the soft-shell clam industry in the Gulf of Maine during the 1950s. Some researchers have suggested that in Northumberland Strait, green crabs might be the cause of recent declines of eelgrass beds in the eastern Strait, but eelgrass has also declined in the west where there are no green crabs.
2. The oyster thief (*Codium fragile tomentosoides*), a green alga from Japan, was first detected in the Strait in 1996 at Caribou, NS. It is patchily distributed throughout the Northumberland Strait from Caribou to Bouctouche. This species is considered a pest due to fouling, and it can multiply very rapidly. It smothers mussels and oysters, preventing them from opening their shells to feed. Starved and weakened shellfish become easier targets for predators. Gas bubbles trapped under dense mats of *Codium* can lift shellfish off their beds and float them away. A similar problem occurs when *Codium* attaches to eelgrass, which may be uprooted and cast onshore. Labour costs of cleaning harvested shellfish are increased.
3. The clubbed tunicate (*Styela clava),* another Asian species, was first reported from the Brudenell River, PEI, in January 1998. Clubbed tunicates grow in dense clumps (up to $1000/m^2$), and adults may reach 18 cm in length. The *Styela* infestation is so far restricted to PEI. Docks, buoys and other hard surfaces are colonized from the low tide mark to depths of 4-5 m.

   Clubbed tunicates are serious pests of aquaculture, as they interfere with the settlement of oyster and mussel larvae, and compete for space and food with young oysters and mussels.
4. The Japanese skeleton shrimp (*Caprella mutica)*, an Asian amphipod, was reported as a pest in the Brudenell River in 1998, but was only recognized as an invader in 2003. It

infests artificial substrates (ropes, buoys, artificial reef, or breakwater structures) throughout eastern PEI.

5. Marine water fleas (*Penilia avirostris,* a subtropical crustacean, was found in Colville Bay, PEI, in 2001, the first reporting from north of Cape Cod. A general northward movement on both sides of the Atlantic seems evident given recent reports from Denmark.
6. Species of *Pseudo-nitzschia* (a diatom) not hitherto recorded in the Strait have caused harmful algal blooms.

Other invasive species are present in the Gulf but not yet reported in Northumberland Strait at the time of this writing (April 2005). These include the tunicates *Botryllus schlosseri* and *Botrylloides violaceus*, both established in northeastern PEI. There are also reports of the tunicate, *Ciona intestinalis*, in the Strait portion of eastern PEI. It is not yet clear whether this species has established a reproducing population.

The EOR technical workshop on Biota discussed the issue of invasive species in the Strait (Appendix B). It was determined that research should be undertaken into methods of mitigating the spread of invasive species, but not at the detriment of resident species. It was also determined that there is a need to compare the biology of invasive species with the Strait ecosystem biology to aid in possible mitigation. Risk to the Strait ecology and fishery-based industries needs to be quantified. Trend analysis, in an attempt to anticipate future issues with regard to invasive species, should be a priority.

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4.0 HUMAN SYSTEM

4.1 GOVERNANCE

The role of policy and governance, as well as the ability of the governance regime to respond to changes that affect the integrity of the environment and well being of communities, is an important aspect of the EOR. The term governance is defined by wikipedia.org as the processes and systems by which an organization or society operates. As a working definition for this report, governance can be considered as the framework by which decisions are made albeit not necessarily in a structured or linear fashion, and that process is not the same as government. Governance involves planning, deciding, monitoring, responding, and mobilizing public action. However, the evolution of governance should not be construed to advocate for the delegation of regulatory responsibility.

Aspects that should be considered in an evaluation of the governance regime in the context of this EOR include the following:

- the present regulatory regime;
- the overlaps and divisions of roles and responsibilities that relate to management and regulation;
- the positioning of governments and institutions to respond to events (natural and manmade) that affect the ecosystem, resources, and communities; and
- ways and means whereby these systems can be improved to respond more effectively and expeditiously.

4.1.1 Present Governance Regime

The Northumberland Strait has a governance regime that includes several jurisdictions – federal, provincial, municipal, and aboriginal. Key federal and provincial departments and relevant legislation are provided in Table 4.1-1. This table should not be considered as all inclusive. In fact, there are likely more than ten other federal or provincial departments and pieces of legislation, as well as numerous associated regulations and policies that may be applicable to the governance regime. In addition, as discussed below, there are many areas of shared mandates. An example would be wastewater treatment plants operated under municipal jurisdiction, which must comply with provincial regulation and, in some cases, federal guidelines.

A more detailed description of the relevant jurisdictions and legislations for coastal planning in the Maritimes is provided in the report by Stewart et al. (2003). While this report applies to only coastal activities, it does describe the complexity of the governance regimes.

In addition to the federal and provincial jurisdictions, the governance regime includes many incorporated and unincorporated municipal areas, as well as aboriginal communities represented by several status and non-status groups. These areas and communities all have relevant legislation, regulation, and policies. The governance regime in the Strait also includes numerous non-governmental organizations that represent industry sectors, environmental interest, and community interests. Finally, the regime includes a number of academic and research institutions that have all been active participants in the governance process.

TABLE 4.1-1 Key Federal and Provincial Departments and Legislation

Department	Legislation
Fisheries and Oceans Canada	*Fisheries Act* *Oceans Act*
Environment Canada	*Canadian Environmental Protection Act* *Canadian Environmental Assessment Act*
Transport Canada	*Navigable Waters Protection Act* *Transportation of Dangerous Goods Act*
NB Environment	*Clean Environment Act* *Clean Water Act*
NB Agriculture and Aquaculture	*Aquaculture Act*
NS Environment and Labour	*Environment Act*
NS Fisheries and Aquaculture	*Fisheries and Coastal Resources Act*
PEI Environment, Energy, and Forestry	*Environmental Protection Act*
PEI Agriculture, Fisheries, and Aquaculture	*Fisheries Act*

The application of the mandates of each aspect of the governance regime in the Strait is all-encompassing. The following listing provides an overview of these applications:

- Municipalities/unincorporated areas:
  - developments; and
  - waste management – solid, liquid, air.
- Industries and Activities:
  - forestry and pulp and paper;
  - agriculture and aquaculture;
  - fishing and processing;
  - food processing;
  - commercial shipping;
  - recreational boating;
  - tourism;
  - other transportation – highways, bridges, causeways;
  - ports and harbours;
  - wind turbines;
  - oil and gas; and
  - research and development.
- Environmental management and conservation:
  - parks, reserves, Environmentally Sensitive Areas (ESAs); and
  - species of concern – endangered/threatened, invasive.

4.1.2 Divisions and Overlaps

While the mandates of groups involved in governance in the Strait can be divided in simplistic terms, there are many areas of overlap. The federal government is generally responsible for the environment and resources that fall within the boundaries of Canada. The provincial government and municipalities, in general terms, have responsibility for lands, industries, and activities that fall within their boundaries. Provinces generally have responsibility for resources such as minerals and aggregates, forests, and inland waters or submerged lands. Aboriginal groups have responsibilities, designated through various formats, for lands, environment, resources, industries, and activities.

These simplistic divisions, considered in isolation, do not reflect the high degree of overlap that exists across jurisdictions and mandates. The following list provides a general summary of areas of overlaps:

- environmental assessment;
- coastal zone planning;
- species of concern;
- air quality issues;
- climate change;
- human health issues; and
- management and regulation of some, if not all, resources, industries, and activities.

4.1.3 Positioning and Response

All participants in the governance regime of the Strait are active in positioning and responding to events. On the positioning side, the following means are employed:

- planning;
- decision-making;
- regulating;
- managing (including monitoring);
- research and development;
- accumulating knowledge; and
- communicating.

Response to events has occurred through a variety of means. Primarily this has involved application of existing legislation, regulation, and/or policy. In some cases there are requirements to modify or develop new governance to meet novel situations. Response can also occur through implementation or modifications of monitoring programs, through research and development, and through enhanced communications.

It should also be noted that response to events or anticipated events has, in many cases, involved collaborations and cooperation between various participants in the governance regime of the Strait. Examples include the EAOR efforts in specific watersheds, Northumberland Strait Working Group, and the Coastal Communities Network. This latter group prepared a discussion paper on models for co-management of fisheries that is considered to have merit for the Strait.

4.1.4 Issues and Gaps

This EOR process has identified the following key issues for governance:

- regulator capacity;
- process overlap and disconnect;
- community capacity;
- lack of participation of Aboriginal peoples;
- enforcement;
- voluminous regulatory framework with no centralized coordination;
- lack of strategic assessment; and
- fisheries management primarily applies to fishers and not the resource.

Most facets of governance are well known and well understood, but uncertainties remain regarding:

- roles of communities with respect to coordination of activities with regulatory agencies;
- role of Civil Society Organizations (CSOs), Non-governmental organizations (NGOs) and First Nations and Aboriginal peoples in governance and decision-making;
- clarity related to jurisdictions and an efficient and proper process to deal with overlaps;
- appropriate and enforceable regulations;
- mechanisms and capacity;
- adequacy of response to stakeholder requirements and changing environmental conditions; and
- inconsistent terminology and perceived different meanings for the same words (e.g., IM, economic compliance).

4.2 HUMAN / INDUSTRIAL ACTIVITY

4.2.1 Overview

As part of the EOR process, there is a need to understand the socio-economic changes that are occurring in the Northumberland Strait as direct and indirect consequences of the environmental changes observed. For many individuals and coastal communities along the Strait, life and well-being depends to a large extent on the local ecosystem and the health of its resources.

Socio-economic trends for the Northumberland Strait must be set in context. Some trends are shared with similar coastal communities outside the Northumberland Strait, while others differ, and this will affect opportunities and challenges going forward. For example, where there are positive trends outside the Northumberland Strait, this may suggest that capacity exists to help deal with localized issues within the Northumberland Strait. Alternatively, when negative trends are shared inside and outside, this will compound negative trends within the Northumberland Strait.

Although regional context provides a foundation for examining the Northumberland Strait, the socio-economic changes can best be understood at finer scales, including communities, enterprises, families, and individuals. Many aggregate statistics for the region tend to mask changes at these finer scales.

Given its relative socio-economic contribution to coastal communities in the Northumberland Strait, the commercial capture fishery is presented as the key element of socio-economic change. Focusing on the current four main species in the fishery and how they have changed over the last decade, trends in landings and landed values assessed by LFA reveal significant concerns.

Those involved in the fishery from different perspectives seem to be in agreement regarding a range of effects fisheries and dependent communities. The negative effects include: depreciating assets; labour recruitment challenges; loss of direct and indirect income and employment; increasing reliance on employment insurance; rising intensity of competition; rising operational costs; safety concerns; eroded or liquidated savings; increasing debt; increased stress; substance abuse; increased crime and accidents; and ultimately migration to urban and western areas causing a loss of economic, social, and cultural assets in the communities.

Despite general agreement on concerns, there are many perspectives on how to proceed. There appears to be a strong sense that resource conservation is the greatest priority, and reducing fishery pressure is commonly discussed. It is recognised that other conditions for successful maintenance and rebuilding of fisheries and communities may include; financial security measures; addressing industry structural issues; maintaining and developing community support programs; understanding and addressing ecosystem stressors; and basing future decisions and initiatives on sound understanding of local community needs. The details concerning the multitude of options is beyond the scope of this report, but outlining key points helps complete the socio-economic picture for the Northumberland Strait.

4.2.2 Context

Population changes often serve as key overall socio-economic indicators for communities since they encompass cumulative individual, family, and community decisions and sentiments regarding their sense of well-being. When migration occurs and local populations decline, economic, physical, social, and cultural systems in those communities begin to fail. This is significant since it seems to be at the heart of discussions and decisions for many of those connected to the Northumberland Strait area fishery.

Coastal communities throughout the Gulf of St. Lawrence region are typically facing low population growth compared to regional and national averages (DFO, 2001b, 2004). Northumberland Strait fishers and community members often describe the impact of local changes in terms of friends and family who have recently decided to move temporarily or permanently to other areas. There is also a more subtle influence on youth who may first leave their community for educational opportunities and never return due to their real or perceived lack of opportunity “at home”.

Decline in population occurs primarily as a response to greater employment and income opportunities elsewhere, but also in response to other factors including declining amenities in their communities. These trends are often intertwined, for example, outward migration undermines the municipal tax base and investment in amenities (eg., schools, hospitals, and other essential services). The result further motivates migration and the cycle continues. Indeed, these concerns have been raised as issues in the Northumberland Strait.

The realities of the precarious situation of the Northumberland Strait fishery is also included for study and serious inclusion, the events of the recent confirmation of access and harvesting rights by Aboriginal Peoples to harvest aquatic resources for food, social, ceremonial purposes, and the right to earn a moderate livelihood from the aquatic resources. On the one hand, Aboriginal Peoples have an access right meaning they have a need to increase the access to the resources to accommodate Aboriginal and Treaty rights and on the other hand they are faced by a serious decline in the resources. The Aboriginal Peoples indeed face the prospect of an even greater loss than a simple economic loss as Aboriginal Rights-holders stand to lose Treaty Rights if they were to be denied access to and use of the aquatic resources of the Northumberland Strait.

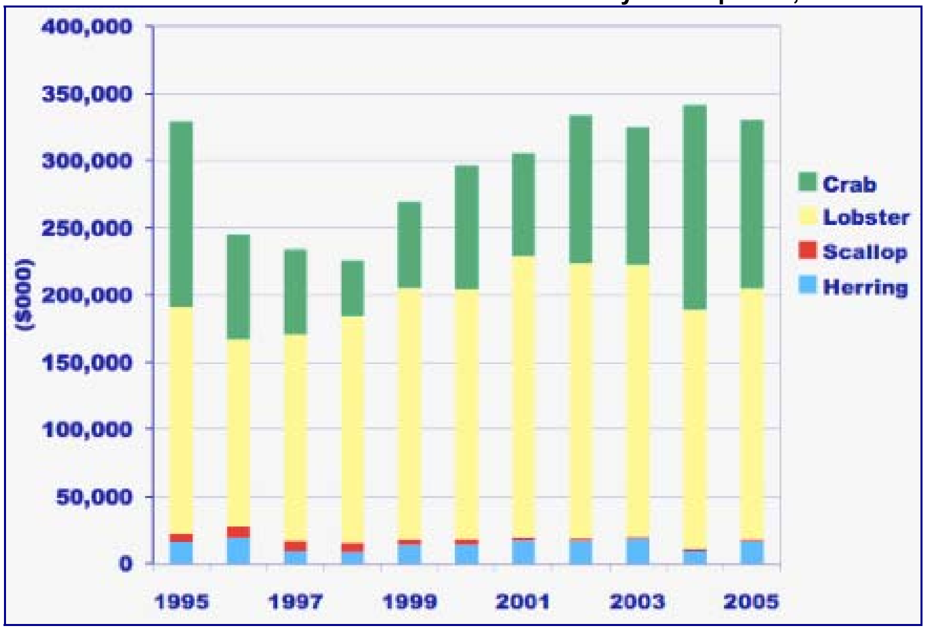
The relative contribution of changes to these trends in the Northumberland Strait is difficult to isolate, but it is possible to describe the nature of influence some changes may have. For instance, an individual or family facing declining income in the fishery will take many factors into consideration when deciding whether to live or work elsewhere, and declining fishery income will certainly underscore a decision to move. As the socio-economic and cultural portrait unfolds primarily around the harvesting activities of the Northumberland Strait, it should become evident that declining fishery catches and income, and the potential loss of Aboriginal access rights to fish for food, social, and ceremonial purposes and rights to earn a moderate livelihood from the aquatic resources are contributing greatly to these problems in Northumberland Strait area communities.

4.2.3 Northumberland Strait Fisheries

The four current main fishery species identified by DFO were lobster, crab, herring, and scallop. Historically, many other species formed the basis of the fishery but these are no longer of commercial significance, including: cod, hake, haddock, flatfish, skates, and halibut. Others form very small portions of the fishery, but they are also in decline. These include: eels, trout, salmon, gaspereau, and mackerel. Despite the commercial non-viability of the above listed species, it is vital to note that Aboriginal Peoples surrounding the Northumberland Strait continue to access and use these species for food, social and ceremonial purposes for the well being of family, community and the commonwealth of Mi'kmaq/Aboriginal society. The focus here will be on the remaining four significant commercial fisheries, and trends observed over the last decade (1995-2005). Historic records were requested for at least the last twenty years but this could not be granted due to time constraints and challenges identifying the appropriate data pertaining to the study area for earlier periods. Where declines or important trends occurred prior to the noted period, they will be recognized in the discussion.

The Gulf of St. Lawrence fishery (Figure 4.2-1) provides a regional context for changes in the Northumberland Strait, and the figures suggest the regional fishery performance in terms of landed values has been relatively stable over the last decade.

FIGURE 4.2-1 Gulf of St Lawrence Landed Values by Main Species, 1995-2005



Source: DFO, 2006e

This does not imply that underlying resources themselves are stable; landed values have been cushioned in some cases by rising prices when the landings are in fact decreasing. However, the regional context is at least more favourable than in the Northumberland Strait, suggesting there is some regional capacity to help deal with the local issues in the Northumberland Strait.

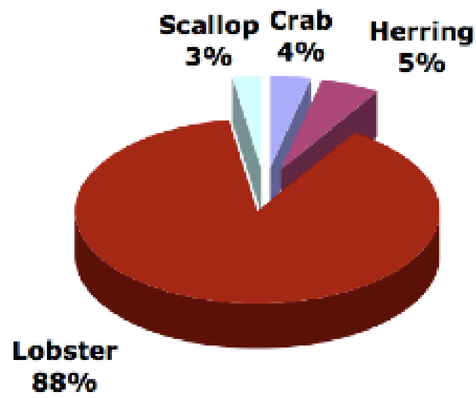
The four main fisheries in the Northumberland Strait were assessed on the basis of LFAs 25 and 26A, in part due to the dominant contribution of lobster, but also due to the geographic relevance of the LFAs to the Northumberland Strait and the EOR. Lobster has contributed over 80% of landed values as a proportion of the four main fisheries (Figures 4.2-2 and 4.2-3), and this has generally been consistent for each LFA since at least 1995. Herring is currently the second largest contributor, however, crab has been second in some years.

The trends for each fishery will be examined in turn as a basis for assessing the socioeconomic changes in the Northumberland Strait.

4.2.3.1 Crab

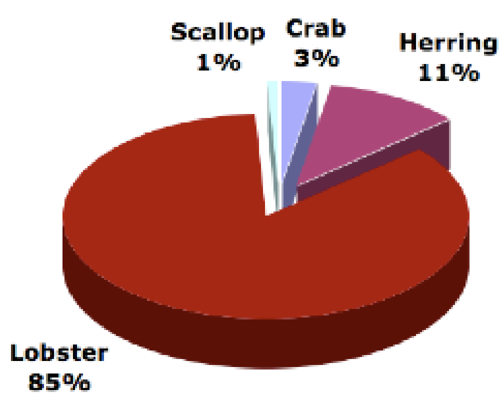
The crab fishery in this case refers to rock crab since it is the principal species caught. Comparing the end to the beginning of the decade, there was a 35% rise in landed volume for LFA 25 and almost no change in LFA 26A (see Figures 4.2-4 and 4.2-5). Prices dropped 15%, climbed 60%, then returned to the 1995 figures by the end of the decade. Overall, this left landed values up 37% in LFA 25 and down 5% in LFA 26A, primarily a reflection of the volume trends.

FIGURE 4.2-2 Percentage of $30 Million Landed Value by Main Fishery in LFA 25 for 2005



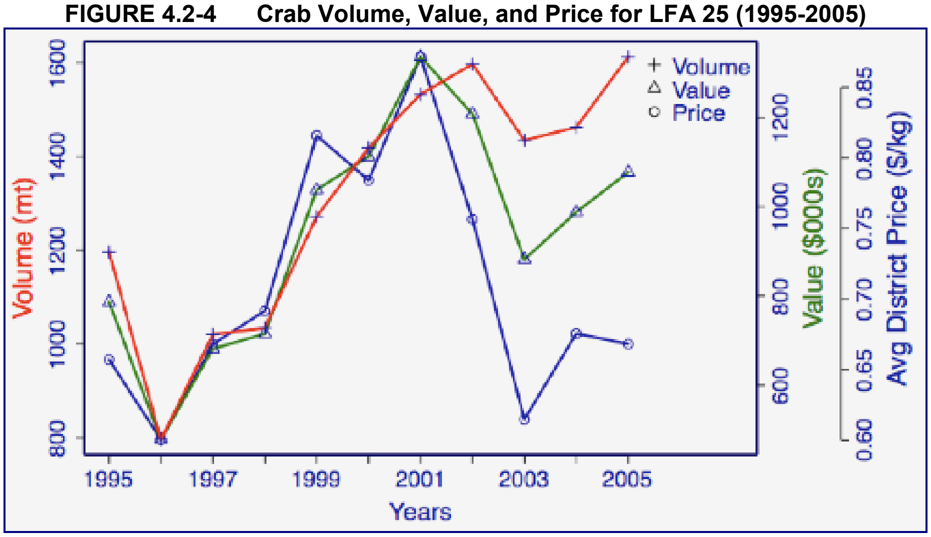
Source: DFO, 2006e

FIGURE 4.2-3 Percentage of $44.9 Million Landed Value by Main Fishery in LFA 26A for 2005



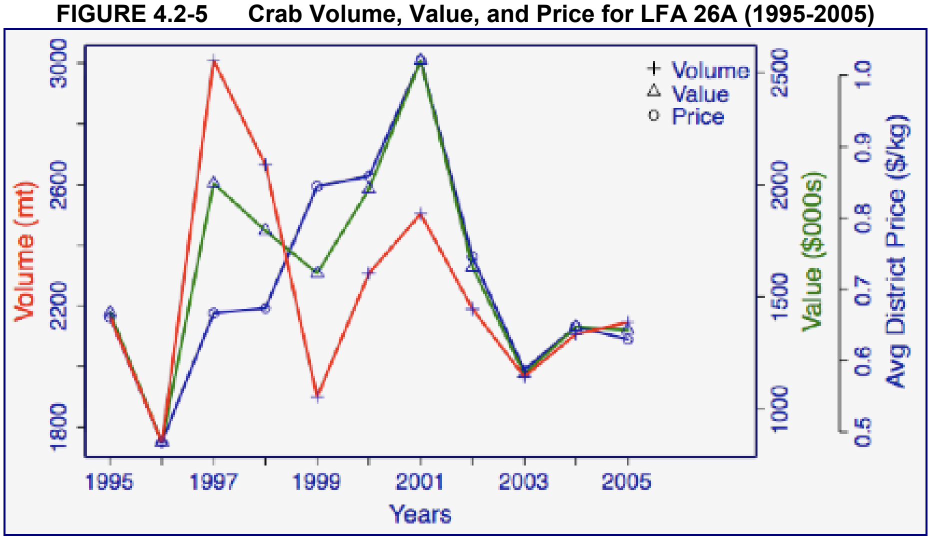
Source: DFO, 2006e

FIGURE 4.2-4 Crab Volume, Value, and Price for LFA 25 (1995-2005)



Source: DFO, 2006e

FIGURE 4.2-5 Crab Volume, Value, and Price for LFA 26A (1995-2005)

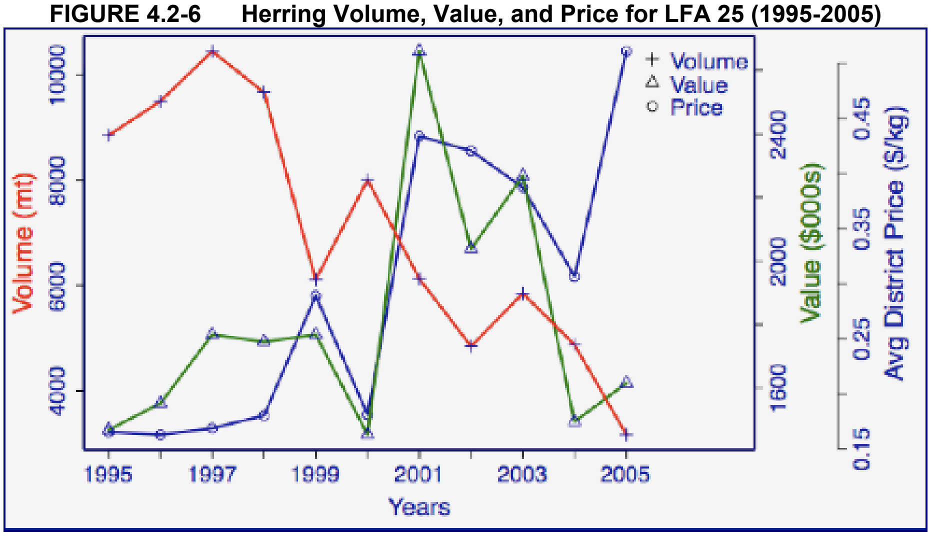


Source: DFO, 2006e

4.2.3.2 Herring

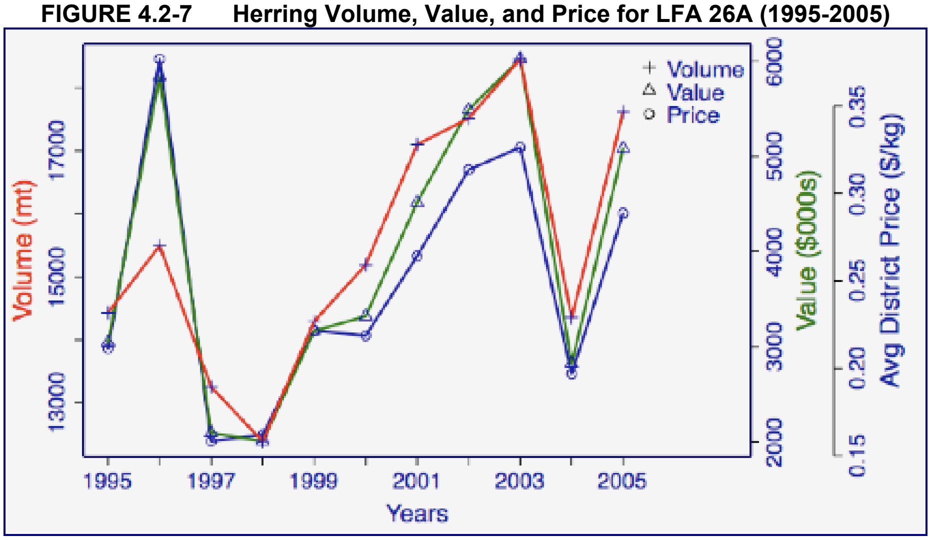
Comparing the end of the decade with the beginning of the decade, herring volumes fell 64% for LFA 25 and rose 22% for LFA 26A (see Figures 4.2-6 and 4.2-7). Prices tripled in LFA 25 and increased by 37% in LFA 26A, providing some assistance as stocks fell. Overall, landed values increased slightly by 10% in LFA 25 and were up 67% in LFA 26A. The declining stocks are the primary concern, as prices are not always able to compensate.

FIGURE 4.2-6 Herring Volume, Value, and Price for LFA 25 (1995-2005)



Source: DFO, 2006e

FIGURE 4.2-7 Herring Volume, Value, and Price for LFA 26A (1995-2005)

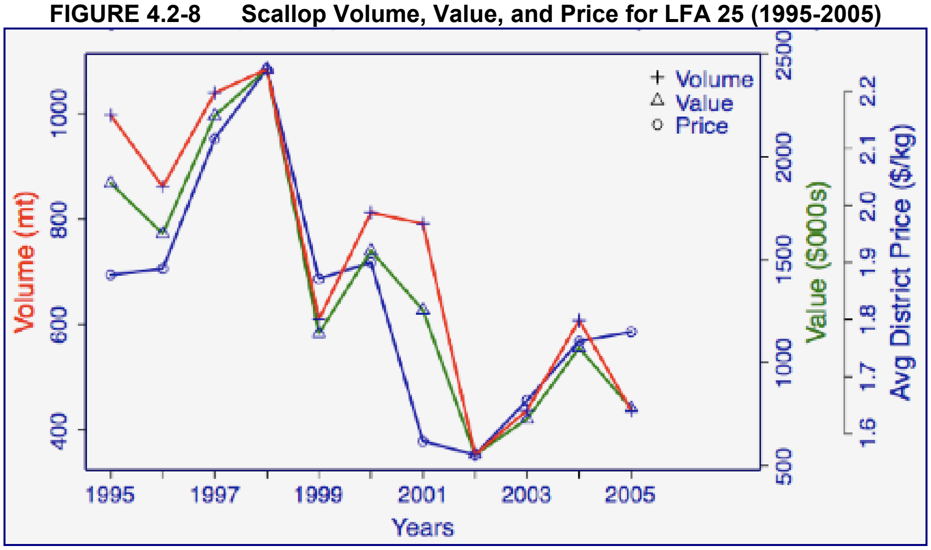


Source: DFO, 2006e

4.2.3.3 Scallop

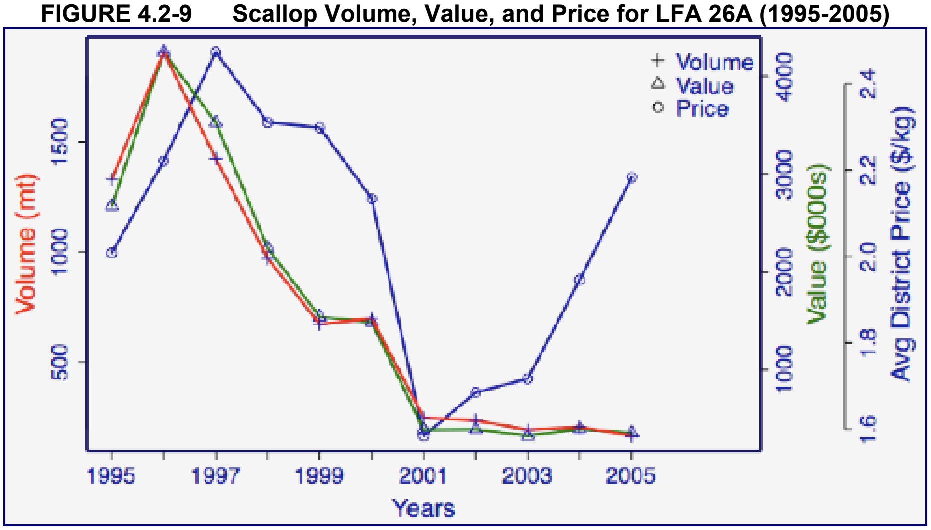
Comparing the end of the decade to the beginning of the decade, scallop volumes fell 56% and 88% for LFA 25 and LFA 26A respectively (see Figures 4.2-8 and 4.2-9). Prices decreased slightly (5%) in LFA 25 and increased slightly (9%) in LFA 26A. Overall, landed values were down 58% and 87% for LFA 25 and LFA26A respectively.

FIGURE 4.2-8 Scallop Volume, Value, and Price for LFA 25 (1995-2005)



Source: DFO, 2006e

FIGURE 4.2-9 Scallop Volume, Value, and Price for LFA 26A (1995-2005)



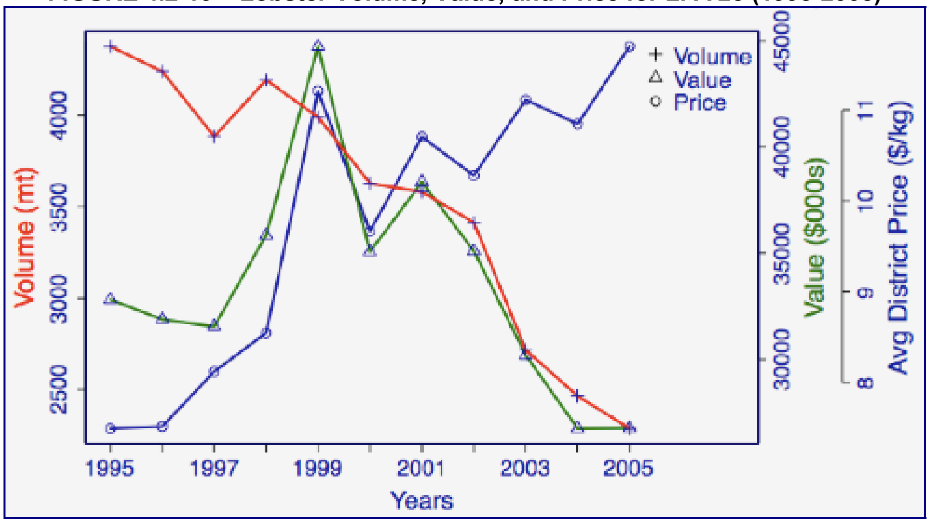
Source: DFO, 2006e

4.2.3.4 Lobster

The lobster fishery is the largest according to landed value, and is therefore an important driver of socio-economic trends. Declines began prior to the 1995-2005 period shown in Figures 4.2-10 and 4.2-11, however, much earlier catches in the last century were similar or lower than today's catches.

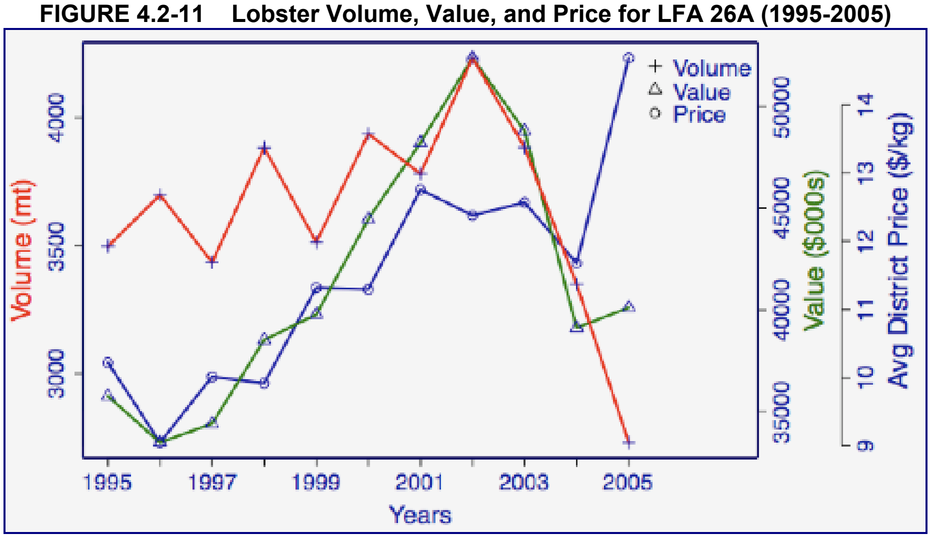
Comparing the end of the decade to the beginning of the decade, volumes fell approximately 48% in LFA 25 and 22% in LFA 26A over the ten-year period. The pattern of decline was different in each area; it was more gradual in LFA 25, and more precipitous after 2002 in LFA 26A. Prices rose by 56% and 44% in LFA 25 and LFA 26A respectively. Overall, landed values declined 18% in LFA 25 and increased by 12% in LFA 26A.

FIGURE 4.2-10 Lobster Volume, Value, and Price for LFA 25 (1995-2005)



Source: DFO, 2006e

FIGURE 4.2-11 Lobster Volume, Value, and Price for LFA 26A (1995-2005)



Source: DFO, 2006e

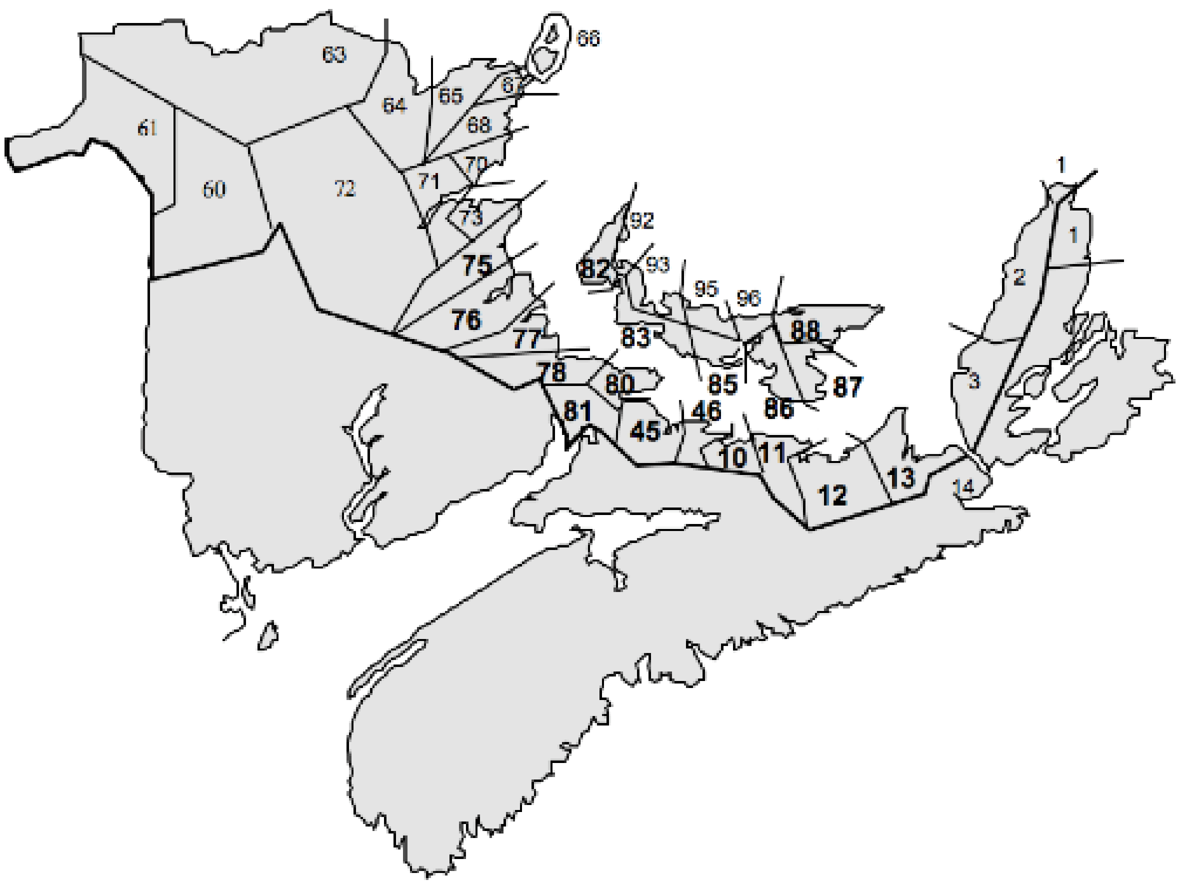
Although catches have been similarly low or even lower in the past as mentioned above, there are three important differences that make the present situation problematic. First, the trends in the Northumberland Strait are different from trends for other areas in the Gulf (especially LFA 24) and elsewhere in the Atlantic region. Second, current assessments of stocks and the general health of the Strait ecosystem may not suggest that this is simply a cyclical phenomenon and that near-term recovery might be expected. Third, economic circumstances and capacity to absorb adversity in the Northumberland Strait is very different than in the past, and this will be discussed further in Section 4.2.5.

4.2.4 Fisheries Communities

It is important to begin understanding the trends at finer scales, first at the community scale. DFO provided fisheries data corresponding to statistical districts shown in Figure 4.2-12. Fish landed in the Strait region are brought to ports in each of these statistical districts encompassing the fishing communities along the coastline.

Although travel distances from home ports to fishing grounds are constrained by operational costs, fishers may generally go anywhere in the Northumberland Strait area waters within the terms of their licences. Landings by statistical district should therefore not be construed as an indicator of where fish are caught in the Northumberland Strait; only where it is being brought onshore to those communities.

FIGURE 4.2-12 Map of Statistical Districts for the Study Region (Bolded Figures)



In order to better understand the impacts according to these statistical districts, the average landed values for the first three years of the decade (1995-1997) were compared to the last three years of the decade (2003-2005). The percentage changes by statistical district are presented in Figure 4.2-13 with colour shading to help visualize the trends across fisheries and the Northumberland Strait. Differences are evident, with scallops suffering the greatest declines overall, herring the least, and greater declines in the central Northumberland Strait compared to the extremities.

FIGURE 4.2-13 Change in Landed Values by Statistical Districts for Main Fisheries (1995-2005)

PEI Dist:	82	83	85	86	87	88
Lobster	0	-50	0	25	25	10
Crab	100	75	-50	-10	10	25
Scallop	-50	-50	-75	-75	-75	-75
Herring	10	50	10	100	10	100

NB/NS Dist:	75	76	77	78	80	45	46	10	11	12	13
Lobster	10	-10	-25	-25	-25	-25	-10	25	-10	10	25
Crab	50	0	100	0	-10	75	25	-50	0	100	10
Scallop	-75	-75	10	-25	-50	-50	-75	-75	-75	-50	-50
Herring	100	-75	100	-25	-25	-75	-75	-75	25	0	50

Legend	
up over 100%	100
up 75% to 99%	75
up 50% to 74%	50
up 25% to 49%	25
up 10% to 24%	10
0 +/- 9%	0
down 10 to 24%	-10
down 25 to 49%	-25
down 50 to 74%	-50
down 75 to 100%	-75

Of the 17 statistical districts assessed according to landed values, 10 experienced lobster value declines of up to 50%, 6 experienced crab value declines of up to 67%, 16 experienced scallop value declines of up to 100%, and 6 experienced herring value declines of up to 100%.

Keeping in mind that these are averaged figures, twelve statistical districts in the western and central portions of the Northumberland Strait experienced net declines across the four fisheries, where net landed value declines (four fisheries combined in each statistical district) ranged from $245,000 to $1.1 million. This signifies that, on average, revenues in essentially all of the western and central Northumberland Strait districts are now annually $245,000 to $1.1 million lower than they were a decade ago. For these twelve statistical districts, the corresponding total decline was approximately $7.5 million. Some landed values have been cushioned by rising prices, therefore declines in the physical fisheries resources are actually more severe. Also, considering the rising costs of fisheries operations and costs of living generally, in real terms these declines are more distressing.

Economic multipliers of between 1.5 and 2.5 are commonly applied to the fishing sector, generally meaning that for jobs and gross domestic product created within the fishing sector, this generates a certain proportion of further benefits through other sectors. In the case of fishery decline, as for the Northumberland Strait area, the reverse would also be assumed where jobs and revenue lost in the fishery would negatively affect other sectors with a comparable multiplier effect.

4.2.5 Fisheries Families, Enterprises, and Individuals

Further refining the scale of analysis to families, enterprises, and individuals, lobster is again used as a focus for understanding the significance of changes in the Northumberland Strait. The results of two recent surveys (Grant Thornton, 2006; DFO, 2006f) have provided insights into the current economic circumstances for lobster fishers at this scale. This helps build meaningful interpretation of the landed value declines described in the previous section.

In otherwise healthy economic circumstances, fisheries declines in catches and landed values might be “absorbed” by fishers, at least over the short-term. There are several reasons why the fishery at this time is not well positioned to respond to the declines.

From the DFO survey based on the 2004 season, the average net fisheries income before taxes for respondents specializing in lobster within LFA 25 was $7,679, and employment insurance revenue was $10,855. The equivalent findings for LFA 26A were $12,958 and $12,057 respectively and, by comparison, LFA 24 figures were much higher at $50,731 and $12,255 respectively. This provides a sense of the small fishing revenues in the Northumberland Strait. This already provides a sense of reduced capacity to deal with adversity.

The Grant Thornton (2006) survey provided further insight into those fishers "experiencing economic viability concerns." The report first described the euphoria of the 1980s and 1990s with record landings leading to major investments in enterprise assets. This led to a state of over-capitalization, considering the declining returns on those investments in recent years. Over-capitalization took on many forms; larger boats, larger engines, better fish tracking and detection technology, and very high access prices in the form of purchased licences. In addition to the simple need to service high debts from these investments, it has contributed to increased pressure on the resources and further undermining of future potential revenues. (Grant Thornton, 2006)

According to the Grant Thornton (2006) report, most respondents demonstrated that the high levels of investment leading to overcapitalization were generally based on sound historical reasoning that accounted for potential catch declines of 20-25%. However, "this tactic has failed in the face of the rapid, significant, and unanticipated catch and income declines since 2000." (Grant Thornton, 2000). Those most affected are the ones who entered the fishery just before the major declines, having paid high entry fees and possibly the cost of a new boat or engine.

At the same time, operational costs have been rising very rapidly, including; bait, fuel, maintenance, and labour. This is another problem, but it is connected to overcapitalization since larger boats and engines cost more to operate and maintain.

One insight into fishers' responses has been gained by observing how the nature of decline in different areas of the Strait appears to have influenced the economic decisions and circumstances of those fishers. Where the decline has been more gradual in LFA 25, there appears to have been some adjustments made by fishers such that their overall costs are presently lower than in LFA 26A where the decline has been more recent and sudden. Adjustments would occur over time within the current framework, but this may occur at a greater cost to those involved. Allowing bankruptcies and other crisis to adjust the fishery would not be the best approach for those involved or the resources themselves. Supporting an orderly transition will better preserve the integrity and value of the remaining fishery.

As mentioned previously, this discussion has focused mainly on the current four main fisheries. Fishers in the Northumberland Strait have commented that in the past, main fisheries might have declined for a period and this was acceptable as long as other species could be targeted temporarily to support income levels. These alternatives no longer exist since, as previously mentioned, several historic species are no longer of commercial significance.

Nearly all fisher families now rely on employment insurance to make their financial situation viable. Over just three years, the percentage of family income derived from employment insurance increased from 11.9% to 27.6% (Grant Thornton, 2006).

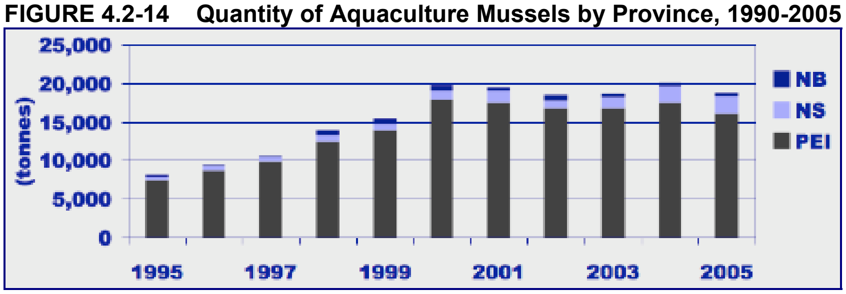
The state of overcapitalization, increasing operational costs, loss of other historic fisheries as alternatives, and reliance on employment insurance provides different socio-economic circumstances than in past fisheries declines. There is reduced capacity to "absorb" continued declines in catches and revenues.

4.2.6 Aquaculture

Aquaculture is another key industry that is dependent on the Northumberland Strait and sensitive to ecosystem changes. It is a developing fishery and "effort" is a more significant factor than in the capture fisheries. Fishing effort in the capture fishery has been relatively consistent over the last decade (1995-2005), whereas aquaculture effort in terms of investment, capacity, and technology has been increasing. Quantity and value figures should be interpreted with caution, keeping in mind that these factors contribute greatly to the trends in these fisheries.

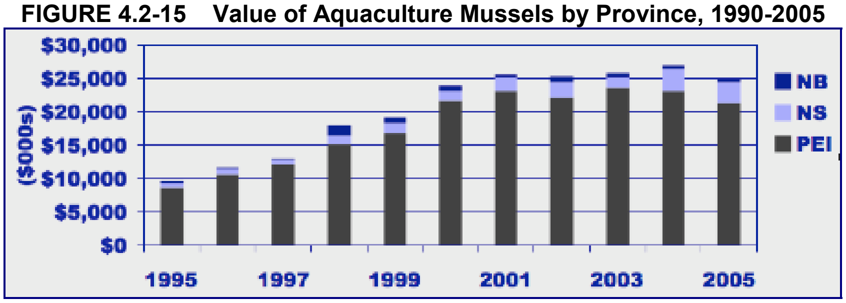
Aquaculture figures below (4.2-14 to 4.2-18) may include public fishery and lease production data from DFO, (i.e., oysters). Figures are given by province including some areas outside the Northumberland Strait, however, provincial government staff and industry association representatives consider these trends to be consistent with activities and experience in the Northumberland Strait.

FIGURE 4.2-14 Quantity of Aquaculture Mussels by Province, 1990-2005



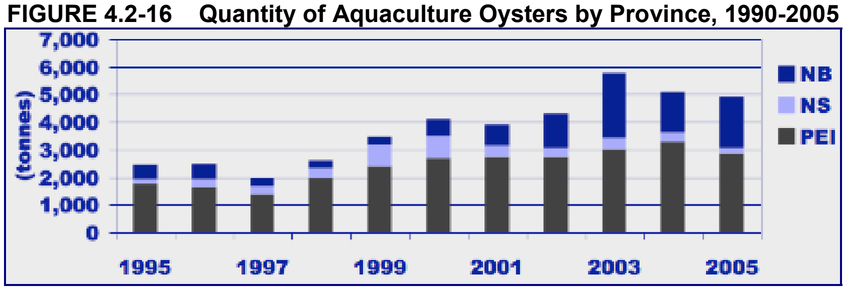
Source: DFO, 2006e

FIGURE 4.2-15 Value of Aquaculture Mussels by Province, 1990-2005



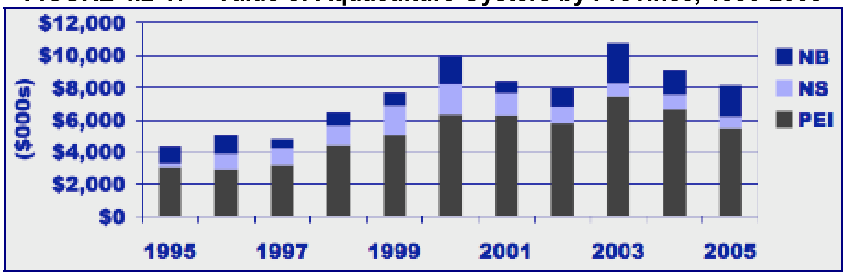
Source: DFO, 2006e

FIGURE 4.2-16 Quantity of Aquaculture Oysters by Province, 1990-2005



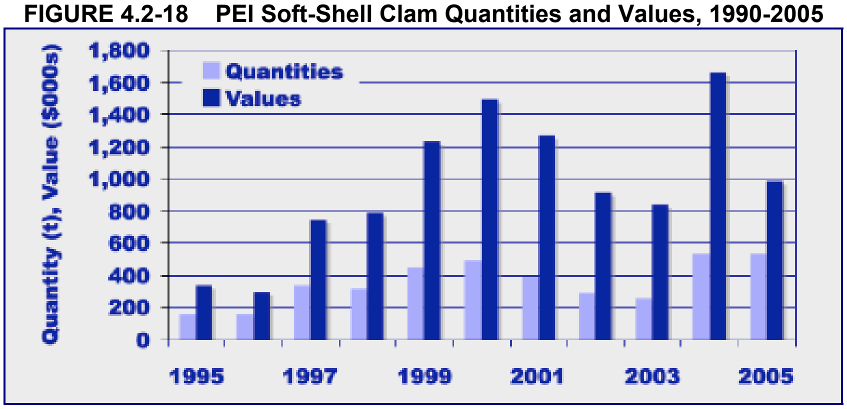
Source: DFO, 2006e

FIGURE 4.2-17 Value of Aquaculture Oysters by Province, 1990-2005



Source: DFO, 2006e

FIGURE 4.2-18 PEI Soft-Shell Clam Quantities and Values, 1990-2005



Source: DFO, 2006e

The aquaculture figures generally depict rising quantities and values in the early half of the last decade, with a levelling in recent years. Despite these apparently rising or stable trends in aquaculture, there have been many challenging issues in the Northumberland Strait.

Although difficult to quantify, there has been significant effort directed towards mitigating the effects of adjacent landscape change on aquaculture in the Northumberland Strait; agriculture, forestry, and road construction practices have been highlighted as particular concerns. These have been growing in intensity, and the aquaculture industry is particularly concerned where excess sediments, pesticides, animal wastes, and nutrients have contributed to problems in streams and estuaries (DFO, 2000). These issues have either driven costs upwards or suppressed the production and quality potential of the industry, and may have contributed to the recent levelling-off in quantities and values. For further discussion of anticipated and emerging activities related to aquaculture, see Section 6.1.2.

4.2.7 Other Human / Industrial Activities

Although the primary focus has been on fisheries and aquaculture, it is important to mention other activities that may be affected by changes in the Northumberland Strait area. The following serves as a short list of key activities: marine transportation; cable and pipeline corridors; oil and gas; minerals and mining; tourism and recreation; and coastal development including Bridge construction, wharves, and dredging. Sedimentation alone could affect most of these, but many other MEQ parameters would also register a range of socio-economic effects. The significant impacts observed in the fisheries are therefore only a conservative indication of the overall impacts resulting from changes in the Strait.

4.2.8 Local perspectives

4.2.8.1 Issues

Through interviews with members of the current EOAR working groups, a range of socio-economic concerns was raised with respect to changes in the Northumberland Strait. Concerns were organised into four categories presented in Table 4.2-1. This is not an exhaustive compilation, and many are interconnected.

TABLE 4.2-1 Socio-Economic Concerns Related to Decline in Northumberland Strait Area Fisheries

Industry Base	Industry Characteristics	Income and Employment	Family and Community
Declining Stability and Diversity	Competition not collaboration	Declining direct & indirect employment	Increasing stress
Overcapitalized, Depreciating Assets	High entry / access costs	Declining salary and profit	Rising debt, eroded savings / assets
Labour Recruitment, Aging Labour Force	Rising operational costs	Shortened season	Substance abuse, rising crime
	Fishing too hard, safety concerns	Employment insurance reliance	Lost culture, history, & forms of living
			Migration to urban & western centres

A great deal had already been written on fisheries-related socio-economic issues in the Northumberland Strait area (GTA Consultants, 2006). For a more complete picture, consider the following other concerns that were not captured above: lost market value for licences; shortened fishing seasons; fishers traveling further to fish, incurring greater costs and longer work days; increased fishing pressure in some areas will exacerbate problems; many communities now have less fishing licences, less boats, less fishers; closing stores, churches, rinks, community halls; declining standard of living; tourism effects through water quality problems; and, sediment effects on wharves have increased costs or limited their use.

The point in Table 4.2-1 regarding outward migration from fishing communities, is in many ways a cumulative indicator reflecting many of the impacts resulting from changes in the Northumberland Strait area. Fishers consistently describe peers, friends, and family members who have left temporarily or permanently for opportunities elsewhere.

This is perhaps a key socio-economic indicator of changes in the Northumberland Strait area because of its encompassing nature, but also because it underlies the full range of socio-economic impacts. Economic, physical, social, and cultural systems in those communities begin to deteriorate when population declines.

4.2.8.2 Priorities

When interviewed, participants were asked how these concerns might be addressed. Some common themes emerged. Again, this is only based on current interviews and is therefore not an exhaustive list.

Resource conservation: Reducing pressure on fisheries resources was among the top priorities discussed. Since many stressors are unknown or difficult to address, and fishing effort can at least be managed in some ways over the short-term, this would be a starting point for measures to improve the potential for resource recovery. Reductions in effort could be achieved in many ways. Only a few are mentioned here; retiring licences from the fishery, restricting the number of boats or traps, increasing minimum legal size, changing the fishery season, linking activities and decisions with ecosystem indicators (i.e., water temperatures, degree days, life cycle stages), and the idea of conservation-based employment insurance extensions.

Support adaptation: Although resource conservation through removal of fishing pressure is necessary, it is not sufficient. To be enticed to retire from the fishery and to divest their interests in licences and gear, developing alternatives to the fishery will be an important factor in these decisions. Some individuals can be innovative and adaptive with assistance, and these individuals could be encouraged to leave the fishery for other viable alternatives. Supporting alternatives through a wide range of existing or potential tools and programs would be an additional aid for those weighing their options.

Developing financial security: For those maintaining interest in the fishery, there is substantial risk even where the fishery is still supporting a reasonable livelihood. Investing in capital and operating costs is increasingly seen as a risk, given that fisheries can appear very unpredictable. This is an unhealthy environment for investment and long-term planning. The idea was raised that in other sectors (i.e., agriculture) there may be experience with financial security programs that could equally be applied to the fisheries, and that this could be explored.

Addressing industry structure: Even if the fishery resource is more secure in some areas, structural trends in the industry are seen to be undermining the viability of fishing individuals and communities. Trust agreements were discussed, and although there are broader debates regarding owner-operator policy, the point made was that concentration of licences in the hands of fewer individuals may have particular socio-economic effects for those connected to the fishery. It was observed in Western Canadian fisheries, that individuals or enterprises holding title to licences through trust agreements, were often wealthier and geographically removed from the fishery. This may have changed patterns of investment, such that fewer expenditures were made in local fishing communities, and there were shifts in the nature of goods and services purchased. Together, these had the potential to undermine viability of local fishing communities. Similar concerns were raised about the concentration of processing facility ownership. Here, the concerns were about unfair pricing from processors if they were, as a result of their regional acquisitions, able to derive most of their income from the regions enjoying more lucrative fisheries. This may leave less lucrative Northumberland Strait area fishers with prices that do not reflect local supply and demand dynamics.

Understanding decline: There appears to be support for efforts to investigate and explain the changes occurring in the Northumberland Strait. It seems widely accepted that there could be a multitude of causes contributing to the fisheries decline, and simple solutions may be elusive. However, even beginning to understand the underlying factors may help some individuals and communities cope with the changes and make decisions. Sharing the best available information as soon as possible is important, and delay of decisions while waiting for complete information is discouraged if there is sufficient information available for informed decision-making.

Consultation and collaboration: It would be important to consider elements beyond easily accessible socio-economic information that is primarily related to commercial activities and what is known about enterprises. Women, youth, and many community leaders are generally under-represented in the discussion and long-term decision-making. Since much of the pertinent socio-economic impacts and solutions unfold at local scales, it is important that consultation and collaboration be carried out at those scales including the wide range of affected constituents.

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5.0 TRADITIONAL ECOLOGICAL KNOWLEDGE

The United Nations Education, Science and Cultural Organization (UNESCO) has divided the term TEK, or Indigenous Knowledge, into three broad categories (Inglis, 1994), namely:

1. Knowledge about specific components/aspects of environment: plants, animals, soils and environmental phenomena which are comparable to systematics.
2. Development, evolution and use of appropriate technologies for farming, forestry, hunting, fishing, and trapping.
3. Understanding of, and intimate relationship with environmental, systems as a whole; the most complex and least understood.

While there is no universally accepted definition for TEK, or Indigenous Knowledge, the concept of TEK is generally accepted as "[a] cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationships of living beings (including humans) with one another and with their environment" (Berkes, 1999).

A universally accepted meaning of TEK remains both elusive and controversial, in part due to the fact it is an ever evolving and changing body of knowledge. The term "traditional", as used in this context, does not to refer to a static and homogeneous body of knowledge that has been continuously used throughout history. “Traditional” is not meant to imply that the “knowledge” is based in antiquity, but that the knowledge is acquired and used through a traditional social process of learning and knowledge-sharing (such as story telling, mentoring, rituals and ceremony) that is unique to each culture. Much of this knowledge is actually quite new; however, it has a social depth and legal character that differs from that established through formal academic and science-based knowledge systems.

It is recognized that all members of a community possess TEK, including elders, women, men and children. However, the quantity and quality of the indigenous knowledge that individuals possess varies with age, education, gender, social and economic status, daily experiences, outside influences, roles and responsibilities in the home and community, profession, available time, aptitude and intellectual capability, level of curiosity and observational skill, ability to travel and degree of autonomy, and control over natural resources (Grenier, 1998).

TEK is often transmitted in terms of stories or anecdotes. When trying to gather this information for use in a science-based management system it is often reduced to specific facts about the use of an area, or to descriptions of natural phenomena that can be explained in scientific terms.

5.1 TRADITIONAL FISHERIES KNOWLEDGE

The primary documentation on traditional knowledge related to the fisheries for the Northumberland Strait region is the Atlas of Traditional Fisheries Knowledge produced by the DFO, Gulf Region (1998). This collection consists of geo-referenced information on a wide range of marine species and other related information that is available in hard-copy atlas map format (Legualt, 1998) and via an on-line interactive atlas (DFO, 2006g). The information in this collection was compiled through an extensive series of standardized open-format interviews of local harvesters by a group of fisheries and geomatics experts during the mid 1990s. The data collection system has received some criticism by social scientists concerning the reliability of the data collection methods.

The data collected for the Atlas includes spatial distribution of principal commercial species including crustaceans, mollusks, pelagic fishes, benthic fishes and marine mammals.

Although some fishers have identified some discrepancies in the compiled information, this traditional knowledge tool highlights the extensive use of the Northumberland Strait region for livelihoods through commercial fishing. Of particular note is the diversity of fishery resources that are of economic importance to local coastal communities in the Northumberland Strait. The extensive overlap between spatially exclusive fishery practices during different seasons is evident from the on-line interactive atlas; however, this TEK tool does not provide information on the changes in resource abundance and distribution that have been highlighted in recent harvester discourse. It is therefore recommended that a series of interviews be conducted to update the data to provide current harvester information. Furthermore, a project should be undertaken to build an historical baseline through extensive interviews of local knowledge experts.

5.2 ABORIGINAL ECOLOGICAL KNOWLEDGE

In 1987, the World Commission on Environment and Development recommended that Indigenous Peoples be given a “decisive voice” in resource management decisions that affect them (Higgins, 1998). The Brundtland Report (1987), issued by the commission, pointed out that interactions between indigenous cultures and the instruments of the larger, global economy threaten the very survival of these cultures. Indigenous groups become marginalized, and their traditional practices disappear. This sentiment was further substantiated at the United Nations Conference on Environment and Development in Rio de Janeiro five years later. The Rio Declaration of 1992 states that Indigenous peoples have a vital role in environmental management and development, and that their knowledge and traditional practices clearly establish the relevance of Indigenous peoples and the importance of protecting their rights in order to attain sustainable development. One of the objectives established under the Convention on biodiversity, which was signed at the Rio conference, governs the use of traditional knowledge and conservation of genetic resources, while protecting indigenous peoples and local communities.

The study of indigenous knowledge is more than a study of current, or recent, uses of the land that may be the target of a development project. Indigenous knowledge is not the present-day application of individual experiences. It is the societal manifestation of peoples’ understanding of the environment, and the relationships between living things upon which these people depend for their survival. It is handed down through generations by cultural transmission as beliefs and traditions. TEK, in essence, forms the environmental foundation for culture. Therefore, it is important that a study of TEK gather information on how a community relates to a place or a particular resource. This information can be supported by additional information on the specific location and distribution of natural resources and historically/culturally significant site.

The Mi’kmaq people have a complex traditional system that can protect biodiversity and resource abundance. This system is based on a concept of human interactions with the environment and has evolved into a physical and spiritual understanding referred to as netukulimk in the Mi’kmaq language. Briefly, netukulimk is a concept that includes the use of the natural bounty provided by the Creator for the self-support and well-being of the community and its members (Native Council of Nova Scotia, 1994).

In order to survive in a variable and relatively hostile environment, the Mi'kmaq developed an appreciation for the temporal and spatial interconnections between resources, and developed a respect for all living things. Since time immemorial, this understanding has been passed down in songs, stories, dances, art, rituals and practices. Prior to the arrival of Europeans to the region, the Mi'kmaq employed codes of mutual respect and trust to govern themselves, in accordance with the laws of nature, through district councils. These councils worked on the basis of consensus. District Chiefs were responsible for planning seasonal movements within the districts, and for confirming and assigning hunting, fishing, and harvesting territories as deemed appropriate and necessary by the Grand Council.

"In every nation, tribe or a group of people, there is a set of rules which that certain group functions by. This set of rules can come in the form of values, customs, and oral traditions. In some nations, these are known as a code of ethics. Under one or more of these titles, a society recognizes and utilizes these modes to better function within their own world. It is these rules that make one's perspective of a world view unique.

In the Mi'kmaq world, these rules are known as oral traditions. To honour these oral traditions allow one to view the world though the window of tribal consciousness. It is through this window that our behavior has been governed, a behavior which is acceptable within our own tribal world. It is crucial that we are accepted in this world, initially. It is vital in order for one to survive in this world to earn this set of rules that has been given to us by the Creator" (Marshall, 1994).

The European newcomers to Mi'kmaq territory, who saw the lands as a resource to be developed in terms of their environmental ethic, did not understand this "world view". For the Mi'kmaq, the land and its life is not seen as a commodity, but rather as s source of life, and the heritage of the community. The Mi'kmaq world view is to live in harmony with nature. This world view is based on the development of an understanding of the local environment (indigenous knowledge). Historically, Mi'kmaq culture is not one that seeks to apply technologies to change the environment to suit the community, but rather, it is a culture that has complex social structures that permit the community to adapt to the local environment (Paul, 1993).

The Mi'kmaq/Aboriginal Peoples, as a coastal Aboriginal People on the East coast of Canada, continue to reside throughout the coastal areas of the Northumberland Strait. The Northumberland Strait is within the Traditional Ancestral Homelands of the Mi'kmaq. Mi'kmaq Homelands are known as "Mi'kma'ki" (place of my kin) - the land of the Mi'Kmaq.

On PEI, 2001 census enumeration reveals 2700 Aboriginal Peoples throughout the island, less than 350 reside within four Indian Act Reserves the remainder of over 2200 continues to reside on their Traditional Ancestral Homelands. In NB, of the 28,000 Aboriginal Peoples throughout the Province, less than 6000 reside within fifteen Indian Act Reserves, the larger number of 22,000 continues to reside on their Traditional Ancestral Homelands. In NS, of the 33,000 Aboriginal Peoples throughout the Province, less than 7500 reside within thirteen Indian Act Reserves, the remainder of 25,500 continues to reside throughout their Traditional Ancestral Homelands. Throughout the Maritime Provinces, approximately 49,700 Aboriginal Peoples continue to reside on their Traditional Ancestral Homelands.

The three Native Councils of the Maritimes, the Native Council of Prince Edward Island (NCPEI), the Native Council of Nova Scotia (NCNS) and the New Brunswick Aboriginal Peoples Council (NBAPC) are the Aboriginal Peoples representative organizations for the Traditional Ancestral Homeland Aboriginal Peoples (off-reserve) continuing throughout their traditional territories of PEI, NB, and NS. Collectively, the three Councils have and continue to place considerable resources into the collection and promotion of Aboriginal Traditional Knowledge. As the natural life management authorities for the Traditional Ancestral Homeland Mi'kmaq/Aboriginal Peoples of PEI, NS, NB, the duty and responsibility to ensure the continuum of Aboriginal Traditional Knowledge is paramount.

The NCPEI has an elder's group to advise the Council on matters relating to the management of a natural life harvesting regime that respects the Traditional teachings of the Mi'kmaq, for developing Aboriginal Traditional Knowledge collection and use protocols and to inform the Council of the issues, concerns, needs and interests of the NCPEI community of elders residing throughout PEI. The NCPEI is also engaged in a process to reorganize its natural life management authority as the Geleiwatl Commission, with the mandate to protect the natural life resources of PEI, and which will be informed by three governing committee's composed of NCPEI community members.

The NCNS has developed their Netukulimkewe'l Commission to administer harvesting guidelines and processes for harvesting natural life resources throughout NS, adhering to the proclamation and direction of the Mi'kmaq Grand council pursuant to the Mi'kmaq Netukulimkewe'l Wjit Pe'l Nike' (interim hunting guidelines). One mandate of the Netukulimkewe'l Commission is to keep the Treaty rights, practices and customs for resource access and use strong for us today, for our children and their children in the future by adhering to the Mi'kmaq principle of "Netukulimk". Towards achieving this goal, the Netukulimkewe'l Commission provides and produces publications toward a better understanding of the access and use of natural life resources for the large community of Traditional Ancestral Homeland Mi'kmaq/Aboriginal Peoples throughout N.S. The Netukulimkewe'l Commission uses Regional Netukulimkewe'l Advisory Councils as the vehicle by which the NCNS community harvesters provide advice in the implementation of their community's regional harvesting plan.

The NBAPC has an Aboriginal Fisheries Strategy Advisory Committee for Food, Social, and Ceremonial purposes, which is comprised of NBAPC community members from around the Province of New Brunswick to assist NBAPC in decision making on matters relating to the management of their natural life harvesting regime. NBAPC works closely with the Congress of Aboriginal Peoples New Brunswick representative on the NACOSAR and is fortunate to have a community representative on the COSEWIC Aboriginal Traditional Knowledge Sub Committee.

As part of the ongoing efforts to prepare for treaty and title negotiations, Mi'kmaq tribal organizations (Confederacy of Mainland Micmac, Mi'kmaq Confederacy of PEI, and Mawiw) have undertaken a series of traditional resource use studies to document the resource harvesting activities in each province. These studies involve a series of structured interviews of Mi'kmaq community members to collect geo-referenced information on the use and location of coastal, terrestrial and aquatic resources that were important to community economic and subsistence needs, including game, fowl, fish and plants.

The projects have been largely completed in NS and PEI. The collected data is protected through confidentiality agreements between the collecting organizations and the individual interviewees; however, aggregated data has been mapped using GIS software (MapInfo).

While the projects have not specifically targeted the Northumberland Strait, these data sets illustrate the strong relationship between the Mi'kmaq and the Northumberland Strait region for harvesting marine fish and birds. In addition to historical information on the distribution of harvesting activities for water fowl, salmon, lobster, groundfish, herring, mackerel, smelts and other species, this information contains interview information on the changes in accessibility of some species due to changes in land-use practices. Combined with the Atlas of Traditional Fisheries Knowledge in the Southern Gulf of St. Lawrence, this interview data provides useful insight in the analysis of ecosystem changes in the Northumberland Strait.

The Traditional Use Projects demonstrate the close relationship between the Northumberland Strait fishery and the Aboriginal communities in the region. Not only have the fishery and coastal resources provided a source of employment and income, but also an important source of food and medicines for Mi'kmaq families and communities. The attachment of the Mi'kmaq to the fishery resources in the Northumberland Strait has been an important part of their cultural identity. Historical annual community migrations to undertake seasonal resource harvesting cycles have remained important into the period of "living memory". The findings of the interview discussions suggest that changes in the abundance of the fishery resources, and changes in access availability, has had a significant impact on the social well-being of the Mi'kmaq communities.

There has not been a critical review of the evolution of indigenous knowledge due to changes in the relationships between the Mi'kmaq and the local resources upon which they have depended. Furthermore, cross-referencing indigenous knowledge with traditional fisheries knowledge compiled from Northumberland Strait fishers, may provide a useful insight into the Northumberland Strait ecosystem. It is recommended that more work be undertaken to collect and analyze indigenous knowledge.

5.3 OTHER SOURCES

In addition to the TEK inventories compiled by the DFO and the First Nations Tribal organizations in NS and PEI, researchers from St. Francis Xavier University have conducted an extensive project on traditional knowledge as part of the St. Georges Bay Ecosystem Project (MacInnes, 1999). While not specific to the EAOR study area, the information collected in this project is included in the Atlas of Traditional Fisheries Knowledge in the Southern Gulf of St. Lawrence, and supports the findings of the Mi'kmaq Traditional Use Studies that the region's fishery is important for cultural as well as economic reasons. Changes in the fishery economy will, in all likelihood, have a significant social impact that may not be addressed through alternative employment strategies.

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6.1 PRESSURE AND STRESSORS – HUMAN ACTIVITIES OF CONCERN

6.1.1 Major Activities and Uses

Human activities on the land and on the water have the potential to cause negative impacts on marine ecosystems. Human activities of many types occur within the boundaries of the Northumberland Strait. On the land, there are many communities of different sizes and with a wide range of infrastructure. Because the Northumberland Strait is blessed with warm waters in the summer and many kms of sandy beaches, both the south and north shores are lined with cottage developments and tourist accommodations. Both commercial and recreational fishing activities occur in the Strait, particularly within its many bays, estuaries, and its freshwater rivers. To support commercial fishing activities, there are many small craft harbours and fish processing plants handling the catches from the commercial fishers. Agriculture, in many forms, is practiced on the land along all areas of the Northumberland Strait. Natural resource extraction activities such as forestry and mining occur along the Northumberland Strait and, although there are not a large number of industrial plants, there are a few important ones. Transportation infrastructure such as highways, bridges and causeways can also have negative environmental impacts. Particular concerns have been raised about the impacts of the Confederation Bridge. This section will describe in more detail the types of human activities that are occurring in and along the Northumberland Strait and the potential ecosystem impacts that can result from these.

6.1.1.1 Municipal Sewage

Communities along the Northumberland Strait range in size from the City of Charlottetown with a population of about 32,000, to many small rural villages with populations of one hundred people or less. Most of the larger communities have municipal sewage collection and treatment systems in place. Municipal sewage treatment can range from lagoons to mechanical plants with disinfection stages. Most towns and villages in NB and PEI have municipal sewage collection and treatment systems in place. The Town of Pictou, NS (population of about 4,000), collects sewage and discharges it untreated into Pictou Harbour. Plans are underway to complete the construction of a treatment plant for the town and some adjacent rural areas by 2008. The majority of the shore-side cottages and tourist accommodations use septic tanks and dispersion fields for in-ground sewage disposal. Because many of these cottages date back to the 1950s and beyond, when regulations for septic systems were much less stringent than current standards, many of these systems are malfunctioning and can cause localized pollution problems (EC, 2004).

Municipal sewage contains high concentrations of organic material, nutrients and human pathogens, and sewage treatment can reduce the concentrations of these contaminants. For example, during the period from 2003 to 2005 inclusive, the sewage effluent from the aerated lagoon for the Town of Bouctouche contained average total phosphate concentrations of 1.7 milligrams per litre (mg/L) and total nitrogen (measured as total kjedahl nitrogen (TKN)) concentrations of 11.6 mg/L (New Brunswick Department of Environment (NBDENV), 2006a). The average concentrations for the effluent from the non-aerated lagoon at Cap Pelé, which also receives wastewater from a local fish processing plant, were higher with total phosphate of 4.3 mg/L and total nitrogen of 24.1 mg/L. A summary of the nutrient concentrations and biological loading from NB sewage treatment plants is presented in Table 6.1-1.

TABLE 6.1-1 Sanitary Wastewater Treatment Plant Discharge Data for the Northumberland Strait[1]

Site	Flow (m^3/day)[2]	BOD[3] Conc. (mg/L)	TSS[4] Conc. (mg/L)	TKN[5] Conc. (mg/L)	TP[6] Conc. (mg/L)	Nitrate Conc. (mg/L)	BOD Load (kg/day)	TSS Load (kg/day)	TKN Load (kg/day)	TP Load (kg/day)	Nitrate Load (kg/day)
Bouctouche	1,570	11.3	18.5	-	-	-	17.7	23	-	-	-
Cap Pelé	931	27.3	41.1	54.5	5.5	8	25.4	38.5	50.7	5.1	7.4
Port Elgin	19.4	12	12.5	5.9	1.3	0.32	0.23	0.24	0.11	0.03	0.06
Rexton	471	12.9	16.1	6.2	1.1	0.17	6	7.6	2.9	0.5	0.08
Richibucto	1,017	7.8	8.9	3.3	0.7	0.41	7.9	9	3.4	0.7	0.42
St. Antoine #1	117.5	21	35	8.1	0.6	0.04	2.5	4.1	0.9	0.1	0.005
St. Antoine #2	124.7	7.9	8.6	8.6	1.3	0.04	1	1.1	1.1	0.2	0.005
St. Louis de Kent	337	58.8	37.8	11.6	1.5	0.04	19.8	12.7	3.9	0.5	0.01
GSSC Shediac	8,632	15.8	17.1	10.7	1.5	0.24	136.4	147.6	32.4	12.9	2.1
GSSC Scoudouc	174.5	26.9	31	7.9	0.8	0.09	4.7	5.4	1.4	0.1	0.02

Source: (NBDENV, 2006b)

Notes:

1. All data is an annual average for each site
2. m^3/day – Cubic metres per day
3. BOD – biochemical oxygen demand
4. TSS -Total suspended solids
5. TKN – Total Kjeldahl nitrogen
6 TP – total phosphorus

Human pathogens released in municipal sewage have the potential to cause diseases in people exposed to them. Exposure can either be through direct contact such as swimming, or through consuming contaminated water or food. In marine waters, filter-feeding bivalves such as clams and mussels can adsorb the pathogens in their stomach as they filter the water for food, and can concentrate these pathogens to much higher levels than those found in the surrounding waters. Human consumption of contaminated shellfish becomes a public health concern because many potentially harmful bacteria and viruses can be ingested and people can become ill with diseases such as typhoid.

Untreated sewage can contain tens of thousands of pathogens and most sewage treatment plants use a final disinfection stage to kill any remaining pathogens in the sewage before it is released to the environment.

In a recent Environment Canada (EC) study (Brun et. al., 2006), eight Atlantic Canada sewage treatment plant effluents were surveyed and analyzed for residues of pharmaceutical products. The study detected residues of 12 different drug products. Residues of ibuprofen, naproxen, carbamazepine, and acetaminophen were the most common drugs measured and these were detected in most of the effluents sampled. Drugs were not generally detected at significant concentrations in larger bodies of receiving water, however; drug residues in smaller receiving streams were measured at concentrations that were 15% to 30% of the effluent median concentrations.

6.1.1.2 Fish Processing Plants

The Northumberland Strait has traditionally supported an active commercial fishery targeting such species as lobsters, scallops, crabs, and flounder. In support of this fishery, the study area contains about 50 fish processing plants. These plants process a variety of species and produce an array of fresh, canned, and frozen products. Many plants are seasonal in operation and only operate during the open fishing season in their area. Other plants import fish from other areas to extend their operating season. These facilities use fresh and/or salt water for the processing and discharge wastewater either directly to adjacent surface waters or to municipal treatment systems in their community. These effluents can contain organic material and nutrients that can have adverse impacts on the ecosystem through eutrophication and anoxia.

Each of the Maritime Provinces regulates and licenses fish processing plants in a different manner and there is no consistent approach to monitoring effluent quality and reporting results. A summary of effluent quality data for seven fish plants that discharge their wastewater into the Northumberland Strait is provided Table 6.1-2. There is substantial variability in the data, but the key points are that some effluents contain high levels of BOD and chemical oxygen demand (COD) that can contribute to the creation of anoxic conditions in the receiving waters. As well, concentration of nutrients (ammonia, total nitrogen, and phosphorus) can also be elevated in some effluents. Excess nutrients can lead to eutrophication in the receiving waters, which can also contribute to the formation of anoxic conditions.

Recent initiatives by the federal and provincial governments, in cooperation with the fish processing industry, are aimed at improving effluent quality from fish plants, and to reduce the environmental impacts of these effluents in near-shore areas (Morry et al., 2003).

TABLE 6.1-2 Summary of Effluent Quality for Seven Fish Processing Plants Discharging to the Northumberland Strait (mg/L)

Parameter	BOD	COD	TSS	Ammonia	Phosphorus	TKN	Grease
Number of Samples	26	26	26	26	26	25	23
Average	2627	4101	476	50	114	510	93
Minimum	53	70	24	1	1	3	1
Maximum	20000	23000	2570	282	736	2830	1450

Source: NBDENV, 2006c

6.1.1.3 Large Industries

The Northumberland Strait is not heavily industrialized, with the exception of the Pictou NS area with coal mines and steel foundries dating back to the 1800s. More recently a pulp mill and a tire manufacturing plant have established in the Pictou area. Table 6.1-3 provides a list of the larger industries that are currently operating within the Northumberland Strait study boundaries.

TABLE 6.1-3 Industrial Plants Located Along the Northumberland Strait

Company Name	Location	Primary Products	Discharges Effluent to
Neenah Paper	Pictou, NS	Kraft pulp	Northumberland Strait
NS Power, Trenton Generating Station	Trenton, NS	Electricity	East River
Trenton Works	Trenton, NS	Rail cars	East River
Maritime Steel and Foundry	New Glasgow, N S	Steel products	East River
Michelin Tire	Granton, NS	Tires	Middle River
Laurentide Chemicals	Bouctouche, NB	Paints and coatings	Bouctouche Bay
McCain Foods	Borden	Food products	Northumberland Strait
Atlantic Beef Products	Borden	Food products	Northumberland Strait

Neenah Paper operates under an approval from the Nova Scotia Department of Environment and Labour (NSDEL) and under the requirements of the federal Pulp and Paper Effluent Regulations. They are required to test their effluent for several parameters of concern and to conduct regular aquatic toxicity tests on fish and aquatic invertebrates. Every three years, the mill conducts an environmental effects monitoring (EEM) program that examines the health of the fish and biota in the area of their effluent discharge. Results of the EEM studies are reported to EC and the data are available from the regional office. In addition to suspended particulate material and oxygen demanding material, pulp mill effluents typically contain some nutrients. Table 6.1-4 provides effluent nutrient data for the Neenah Paper mill for 2002 and 2003.

TABLE 6.1-4 Nutrient Content in Final Effluent Discharged by Neenah Paper Inc.

Date Sampled	Total Phosphate (mg/L)	TKN (mg/L)	Discharge Volume (m^3/day)	Total Phosphate Loading (kg/day)	Total Nitrogen Loading (kg/day)
April 30, 2003	1.13	7.3	79,100	89.4	577.4
May 14, 2002	1.12	7.0	80,700	90.4	564.9

Source: EcoMetrix, 2004

Nova Scotia Power operates a coal-fired thermal power plant at Trenton. Cooling water and treated surface run-off from coal storage areas are released to the East River. Trenton Works Limited builds railway cars and the plant has an approval from NSDEL and discharges cooling water and plant wash water to the East River. Michelin Tire operates a tire manufacturing plant in Granton and discharges process water and treated sewage into the Middle River reservoir. Laurentide Chemicals in Bouctouche manufactures paints and protective coatings. They recycle used paint and also package industrial cleaners and chemicals. Their wastewater consists primarily of wash water and it is discharged to Bouctouche Harbour. The plant holds a Certificate of Approval from the NBDENV.

In Borden, PEI, a 30-cm effluent discharge pipe enters the Northumberland Strait under the piers of the Confederation Bridge. The discharge pipe has 16 diffuser ports at the discharge end to provide rapid dilution and dispersion of the discharged effluent. The pipe receives treated process effluent from the McCain Foods French fried potato plant in Borden and the Atlantic Beef Products plant in Albany. The maximum annual discharges through the pipe are:

- McCain Foods - 1,168,000 m^3, and
- Atlantic Beef Products – 65,000 m^3 .

There are only a few mines operating in the Northumberland Strait watershed. In NS, there are two active coal strip mines in the Stellarton area and an underground salt mine in Pugwash. The coal mines hold approvals from NSDEL and discharge surface runoff to the East River. The salt mine discharges mine water and brine from its processing plant into Pugwash Harbour. In NB, there are several peat extraction operations in the Shediac and Bouctouche areas.

The primary environmental concern with mining operations is the release of sediments to adjacent surface waters. The coal mines and the salt mine utilize on-site settling ponds to remove any suspended particulate material before wastewater is discharged. In the past, the release of fine particulate material from peat extraction has been associated with smothering of oyster beds in eastern NB. NBDENV now requires peat operations to utilize setting ponds to remove any particulate material from surface water draining from the peat extraction sites.

There are also numerous gravel pits and quarry operations found in the Northumberland Strait watershed. These can range from smaller operations extracting alluvial deposits of river gravel and fill material, to larger rock quarrying and crushing operations. The primary environmental concern with pit and quarry operations is the release of sediments to nearby surface waters, resulting in damage to fish habitat. Most pits and quarries hold operating approvals from the responsible provincial environment departments and these approvals require the operators to operate their sites to minimize erosion and to treat surface runoff waters to remove excess sediments.

6.1.1.4 Agriculture

Land on both sides of the Northumberland Strait is used for agricultural purposes, primarily for cultivation of field crops or for the grazing of sheep and cattle. On the PEI side, potato farming is a major user of the farmland. For example, in the Bedeque Bay watershed, 70 % of the land has been cleared and is in agricultural production, and in excess of 5,000 hectares (ha) of potatoes are grown annually (Pinsent and Chan, 2006).

The potential effects of agriculture on the environmental quality of a watershed can be quite intense. These impacts can include:

- soil erosion leading to sediment transport into streams, causing fish habitat damage;
- runoff of nutrients (primarily nitrates and phosphorus) from fertilizer and manure application to crop land, leading to eutrophication in receiving waters;
- loss of pesticides through surface runoff to adjacent streams, leading to fish kills and chronic toxic impacts to aquatic biota; and
- release of pathogens from manure storage and land application practices, leading to contamination of surface waters and groundwater.

6.1.1.5 Dredging and Ocean Disposal

There are numerous harbours along both shores of the Northumberland Strait and these range in size from small fishing ports with ten or so fishing vessels, to larger ports such as Charlottetown that can accommodate cruise ships and cargo vessels. The majority of the Northumberland Strait harbours are located on estuaries and require regular dredging to maintain adequate depth for the vessels using the harbours.

The principal environmental concern for dredging activities is direct mortality of marine species and/or habitat alteration, disruption or destruction. The release of fine materials into the water column could have detrimental effects on marine life and habitat thereby leaving an environmental footprint on areas adjacent to dredge sites. Other concerns include the accidental release of petroleum, oils, and lubricants or other hazardous materials and the potential for accidents between vessels. Noise associated with dredging and the use of heavy equipment is also a concern for nearby businesses and residences, and for wildlife, particularly seabirds and marine mammals. Dredging activities may also obstruct and/or alter the normal passage and migration routes of fish.

The disposal of dredged material into the ocean is controlled by EC under the authority of the *Canadian Environmental Protection Act* (CEPA) Part VI. Persons wanting to dredge a harbour and dispose of the spoils in the ocean must apply for an ocean disposal permit from EC. The permit sets out specific definitions for the locations to be dredged, amount of material to be dredged, and the designation of a disposal site.

In order to be permitted for ocean disposal, the material to be dredged must meet certain environmental quality guidelines. If levels of the specified contaminants exceed the guidelines, a permit for ocean disposal cannot be issued and the dredge spoils must be disposed of on land. A summary of ocean disposal permits issued by EC for dredging projects in the Northumberland Strait in 2006 is provided in Table 6.1-5. Based on the allowable maximum amounts established by these 2006 permits, up to 121,000 cubic metres (m^3) of harbour sediments could be dredged from Northumberland Strait harbours in 2006. The actual amount of material dredged and disposed of could be less than the allowable maximum.

6.1.1.6 Tourism and Recreation

With its sandy beaches and warm summer waters, the Northumberland Strait is a popular tourist destination. There are private and commercial cottage developments, tourist accommodations,

TABLE 6.1-5 Summary of Ocean Disposal Permits Issued for Dredging Projects in the Northumberland Strait in 2006

Location	Permit Issued To	Amount of Material to be Dredged (m^3)
Chockpish, NB	PWGSC	15,000
Cap Lumière, NB	PWGSC	10,000
Saint-Édouard-de-Kent, NB	PWGSC	10,000
Cocagne, NB	PWGSC	6,000
Cap-des-Caissie, NB	PWGSC	6,000
Cap-Pelé Harbour, NB	PWGSC	10,000
Botsford Harbour, NB	PWGSC	7,000
Les Aboiteaux Channel, NB	PWGSC	8,000
Petit-Cap Harbour, NB	PWGSC	5,000
Charlottetown, PEI	Charlottetown Harbour Authority Incorporated	28,000
West Point, PEI	DFO, Small Craft Harbours	8,000
Cape Egmont, PEI	DFO, Small Craft Harbours	8,000

Source: EC, 2006a

campgrounds, and many public parks found along both sides of the Strait. PEI can have up to one million tourists annually although visitor numbers have been down somewhat in the past few years. Many of these visitors spend some time at attractions and accommodations on the Northumberland Strait side of the province. Parlee Beach, near Shediac, NB, can attract up to 25,000 visitors on a warm summer day. In addition to beach visits, tourism activities can also include water sports such as sea kayaking and windsurfing, seal and whale watching tours, hiking, recreational fishing, and visiting the many tourist attractions in the area. Many communities hold summer festivals and events to attract tourists, and there is significant investment in services for tourists in the form of accommodations, restaurants, shopping areas and museums.

This summertime influx of tourists can significantly increase the population of many maritime communities and put a strain on municipal infrastructure and services such as water supply, solid waste management, and sewage treatment.

6.1.1.7 Boating and Marine Transportation

The use of the waters and harbours of the Northumberland Strait for boating and marine activities is an important activity. Some of the uses include cargo ships, ferries, cruise ships, fishing boats and recreational boats, and all of these activities have the potential to have adverse effects on the marine environment. Within the study area, there are four major ports capable of docking cargo ships (Table 6.1-6). These ports are busy with shipping activities during the ice-free season (typically May to November). For example, Charlottetown had 25 cruise ship visits scheduled for 2006.

TABLE 6.1-6 Major Ports Within the Northumberland Strait

Port	Types of Shipping Activities
Summerside, PEI	Potatoes, fuel, fertilizer, aggregates
Charlottetown, PEI	Cruise ships, potatoes, fuel, fertilizer, aggregates
Pugwash, NS	Salt
Pictou, NS	Pulp, logs, aggregates

Northumberland Ferries Ltd. operates a vehicle and passenger ferry service between Caribou, NS and Wood Island, PEI during the ice-free season. The company operates two ferries and makes up to 18 crossings daily during the peak of the tourist season.

DFO reports that there are nearly one thousand lobster fishers active in LFAs 25 and 26A that cover the Northumberland Strait. That represents a great many boats on the water during the open lobster fishing seasons. There are 39 small craft harbour wharves located along the Northumberland Strait (Table 6.1-7).

Recreational boating has grown in popularity over the past twenty-five years and there are at least ten marina facilities that have been established to service this activity (Table 6.1-8).

TABLE 6.1-7 Small Craft Harbours Located in the Northumberland Strait

Province	Number of Small Craft Harbours
NB	14
NS	15
PEI	10
Total	39

DFO – Small Craft Harbours, 2006

TABLE 6.1-8 Recreational Boating Marinas Located in the Northumberland Strait

Marina	Location	Number of Berths	Sewage Pump-out Facilities
Palmer's Marine	Pictou, NS	200	No
Hector Quay Marina	Pictou, NS	40	No
Pugwash Marina	Pugwash, NS	8	No
Sunrise Shore Marina	Barachois Harbour, NS	80	No
Pointe-du-Chêne Yacht Club	Pointe-du-Chêne, NB	140	Yes
Shediac Bay Yacht Club and Marina	Shediac, NB	45	Yes
Bouctouche Marina	Bouctouche, NB	52	Yes
Cap de Cocagne Marina	Cocagne, NB	78	Yes
Silver Fox Marina	Summerside, PEI	75	Yes
Charlottetown Yacht Club	Charlottetown, PEI	115	No

Atlantic Marine Trades Association, 2006

Recreational boating and shipping involve activities that could have adverse effects on the marine environment including:

- disposal or spills of oils and hydrocarbons;
- accidental spills while offloading cargo;

- discharges of bilge water resulting in the release of hydrocarbons;
- discharges of ballast water resulting in the introduction of non-indigenous species;
- disposal of solid wastes; and
- disposal of sewage.

6.1.2 Anticipated and Emerging Activities

Ecosystems are constantly changing and evolving in response to the multitude of stressors that they are subjected to. It is a challenging task to understand how an ecosystem will respond to known stressors such as outlined in the previous section. In order to be able to fully understand how the ecosystem will respond to stress, it is necessary to make some predictions about what new activities or environmental issues could be coming in the future, that could have an influence on the Northumberland Strait ecosystem. It has been suggested that some of the emerging issues that could have an impact on the Northumberland Strait ecosystem in the next five years could include:

- exploration and development of oil and gas reserves;
- expanding shoreline development;
- development of wind power opportunities;
- tidal power development;
- expansion of aquaculture;
- continued decline in traditional commercial fishery; and
- global warming and climate change.

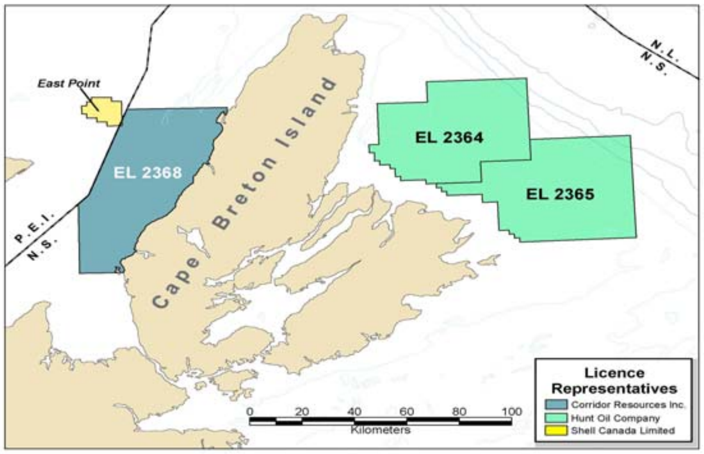
This section of the report will provide an overview of the first five of these issues and how they might have an influence on the Northumberland Strait ecosystem. Global warming and climate change will be discussed in more detail in Section 6.1.3.

6.1.2.1 Exploration and Development of Oil and Gas Reserves

There has been continued interest in exploring for oil and gas reserves on the East Coast of Canada for the past 3 decades. Oil and gas developments have gone forward on the Grand Banks off Newfoundland and Labrador, and on the Scotian Shelf off NS. In 2005, exploration leases were granted for areas of the Gulf of St. Lawrence to the west of Cape Breton Island and in the Cabot Strait (Figure 6.1-1). Hydrocarbons were discovered at the East Point site off of Cape Breton.

With the world's ever-increasing demand for hydrocarbons, it is quite possible that within the next few years, oil and gas exploration companies will seek to expand their activities westward towards and into the Northumberland Strait. An application to conduct seismic surveys in the Summerside area was withdrawn and never conducted.

FIGURE 6.1-1 Oil and Gas Exploration Leases in the Vicinity of Cape Breton Island



Source: Canadian-Nova Scotia Offshore Petroleum Board, 2006

The first stage of this type of exploration usually involves seismic testing and there are many concerns about the possible negative impacts of this type of testing activity on fish and marine mammals. Environmental concerns are that the noise, percussion, and vibration from the seismic testing work could result in:

- acute mortalities among exposed organisms;
- organisms avoiding areas where the testing is being conducted;
- alterations to migratory patterns of some fish species;
- abnormal behaviour during mating or molting; and
- physiological and physical damage to exposed organisms.

In 2003, a cooperative study on the impacts of seismic testing in the Gulf of St. Lawrence was conducted to examine possible negative effects on snow crab, a very important commercial species (DFO, 2004b). This study, the first of its kind in the world, placed snow crabs in cages near the seismic testing sites and in reference areas. The study concluded that:

- seismic testing did not cause any acute or mid-term mortality of the snow crab;
- there was no evidence of any changes in feeding behaviour;
- there were no impacts on crab embryos and larvae; and
- the hepatopancreas and ovaries of the crabs in the test sites were bruised.

Following seismic testing, the next phase of exploration usually involves exploratory drilling to further define and delineate potential hydrocarbon reserves. The primary environmental concern about drilling activity is the impact on fish habitat and marine organisms from the disposal of drilling fluids and drill cuttings.

6.1.2.2 Expanding Shoreline Development

The Northumberland Strait is currently a popular recreational area for cottages, tourism, and recreational boating. The level of these activities seems to be continually expanding and requiring additional infrastructure to support the increasing numbers of people coming to enjoy the area. Shoreline development in the form of private cottages and commercial accommodations continues to expand each year. The number of golf courses has been increasing over the past decade and there are currently about 25 golf courses located along the Northumberland Strait.

Harbour development activities can include infilling sections of the coastal zone to expand/improve docking facilities, or to provide land for shore side infrastructure. These infills result in changes to coastal morphology and the burying of former intertidal and subtidal fish habitat. These types of projects can also involve filling-in parts of salt marshes. The resulting changes to coastal morphology can cause alteration to tidal current patterns in the area of the infill.

An example of the extent of coastal development can be seen in Figure 6.1-2, which shows aerial photographs from the Hillsborough Park area, northeast of Charlottetown, PEI. These pictures serve as an example of the typical growth around the coastline in the Maritimes. The land has been transformed from field to a network of roads and residential neighbourhoods, and includes a golf course.

There are several important environmental issues related to this expansion and shoreline development. Key among these is increased erosion and sediment loading to the Strait. As more forested land is cleared for these development projects, the natural buffer zones are becoming reduced and much less effective at slowing down runoff from storms and filtering out sediment. The actual construction activities are prone to erosion problems and even using best construction practices such as settling ponds and silt curtains, siltation episodes are still common occurrences. Erosion of sediments from construction activities and shoreline developments can potentially cause damage to sensitive salt marshes and juvenile fish nursery areas in tidal estuaries.

The cottage developments, vacation resorts, and golf courses all incorporate large areas of manicured turf which require regular applications of chemical fertilizers and pesticides to maintain their desired qualities. This has the potential to increase the loading of nutrients and pesticide residues into the near-shore waters.

The shorelines along the Northumberland Strait are composed primarily of sandstone, mudstone and siltstone, and these soft materials are prone to natural erosion processes. These natural processes could be accelerated by increases in the number and intensity of storm events because of climate change. As well, any increases in tidal current velocities could lead to increased erosion of shorelines. Shoreline disturbance for construction of cottages, homes, and tourist attractions could lead to increased rates of erosion, leading to larger amounts of sediment being transferred into the waters of the Northumberland Strait.

FIGURE 6.1-1 Coastal Development in Hillsborough Park, PEI

Hillsborough Park Area, 1935
Source: Government of Prince Edward Island, 2006

Hillsborough Park Area – 2000
Source: Government of Prince Edward Island, 2006

6.1.2.3 Development of Wind Power Opportunities

The demand for electric power continues to increase, and in the Maritime Provinces, the majority of that power is currently generated through the burning of fossil fuels like coal and oil. Governments are promoting reductions in greenhouse gas emissions to reduce the impacts of global warming, and since fossil fuel power generation is such a large contributor of greenhouse gases, there is an increasing interest in the development of alternative sources of energy. One type of alternative energy that is gaining a lot of interest in Atlantic Canada is wind power. Wind energy, as a source of electricity, has significant environmental benefits, mainly in reducing air pollution and emissions of greenhouse gases. For this reason, there has generally been positive public support for the development of wind energy projects. There are already wind turbine installations in PEI and NS and larger wind turbine installations are being proposed for several areas along the NS shore of the Northumberland Strait. NB Power has set a policy to purchase 400 megawatt of wind power from private suppliers by the year 2016. The University of Moncton has been conducting studies to identify suitable locations for wind power installations in NB. There is very little doubt that with the prevalent strong winds on the east coast, the development of wind power projects is going to expand.

Although wind power does not create greenhouse gases, it is not without its environmental concerns. There are concerns about the negative impacts that wind turbines can have on resident and migratory birds. We can also anticipate possible resource user conflicts, particularly if the wind farms move from land-based installations to the sea-based installations that are common in Europe. Conflicts between the wind farm developers and the present users of the marine environment (fishers, shipping, recreational boaters) are inevitable.

6.1.2.4 Aquaculture

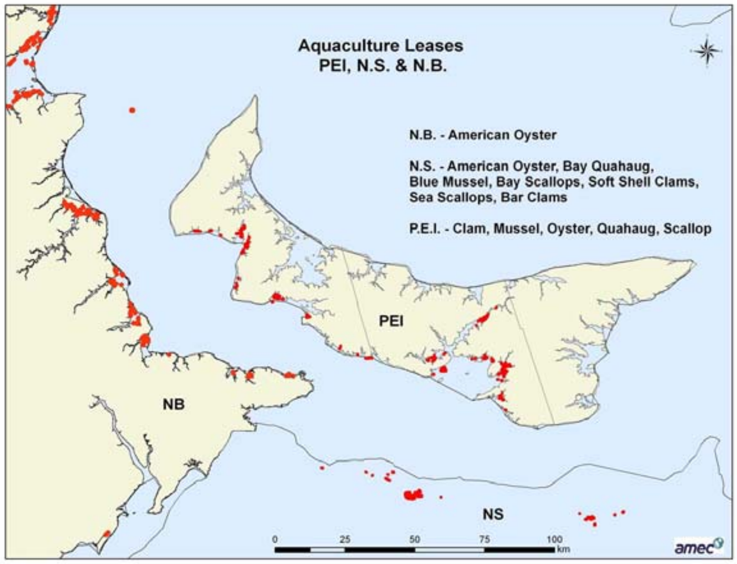
Aquaculture is an expanding activity in most coastal regions of the world and the Atlantic Coast of Canada is no exception. The Northumberland Strait supports an active aquaculture industry (Figure 6.1-3) including:

- American oyster culture along the eastern shore of NB; and
- mussel, clam, oyster, quahog, and scallop culture in PEI and NS.

These aquaculture operations include spat collection, bottom-culture, and suspended culture techniques (www.gov.pe.ca/af; www.gov.ns.ca/nsaf/aquaculture; www.gnb.ca/0027/index; www.aquaculturepei.com; www.glg.dfo-mpo.gc.ca/ao-bl/pei-ipe; www.aansonline.ca). There is currently no finfish farming conducted within the Strait.

In NB, the traditional way that oysters were cultivated involved seeding a leased area with spat, and growing the oysters on the bottom. In recent years, this method has been largely replaced by suspended culture methods where the oysters are grown in bags suspended in the water column. Using suspended culture, the numbers of oysters that can be grown in a given area is greatly increased. Since 2001, NB has seen a 25% to 30% annual increase in aquaculture oyster production due in large part to this change in culture method (S. Doiron, pers. comm., 2006). Concerns are being expressed about the sustainable level for suspended oyster aquaculture. Many of the areas where this technique is practiced are shallow and not well flushed by the tides, and there are concerns about oxygen depletion and nutrient build up with the large increases in biomass now in place in these bays and estuaries.

FIGURE 6.1-3 Aquaculture Leases Along the Northumberland Strait



Although there is not a lot of mussel aquaculture practiced in the Northumberland Strait at this time, there was a proposal in 1998 to develop a very large mussel farm (over 500 ha) in Tatamagouche Bay on the NS shore of the Strait. There were many concerns raised by the public about the possible cumulative impacts of such a large farm on the traditional and well-established activities in the bay such as lobster fishing and recreational boating. After extensive assessment and review, the project did not receive government approval to proceed (CBC, 1999). It may only be a matter of time before other similar projects are proposed.

6.1.2.5 Continued Decline in Traditional Commercial Fishery

There have been significant declines in the landings of the traditional commercial fishery in the Northumberland Strait. Lobster catches in LFA 25 have been in decline since the mid 1980s and in LFA 26A have shown a steady decline since the late 1980s (Figure 3.1-1) and are not showing any indication of recovery. The scallop fishery has shown similar declines in some areas of the Strait and the ground fishery for flounder has all but disappeared. The rock crab fishery in the areas fished by members of the Botsford Professional Fisherman's Association (BPFA) is on the decline as well (pers. comm., Donna Murray, BPFA). The herring fishery has shown variability from year to year but overall the catches have been close to historic levels. The declines in Northumberland Strait fisheries were discussed in more detail in Section 4.2.

6.1.3 Global Warming and Climate Change

EC defines climate change as follows:

> "Human activities are altering the chemical composition of the atmosphere through the build-up of greenhouse gases that trap heat and reflect it back to the earth's surface. This is resulting in changes to our climate, including a rise in global temperatures and more frequent extreme weather events." (EC, 2005)

Climate change is one of the most important environmental issues of the 21st century and experts predict that the effects could be long lasting, and will be observed over large geographical areas. The challenge in this EOR is to attempt to assess the effects of climate change in a specific geographical area like the Northumberland Strait and within the near future (5-10 years). Since the Northumberland Strait is relatively shallow and well mixed vertically, climate change impacts could be more severe in the Strait than in the overall Gulf of St. Lawrence or other coastal areas of Atlantic Canada. Climate change is unlike most other environmental stressors where the problem can be identified and defined, and management approaches can be introduced to correct the problem. With climate change, no one is sure if the present trends can actually be slowed or reversed by reducing emissions of greenhouse gases. If the trends can be reversed, we are not able to determine how long that reversal process could take.

There are three primary environmental effects predicted to occur as a result of climate change that are important to consider in the context of the Northumberland Strait:

- an increased frequency and intensity of storm events;
- a rise in sea level; and
- an increase in air and water temperature.

6.1.3.1 Frequency and Intensity of Storms

Scientists have predicted that climate change will result in an increasing frequency of violent climatic events like storms and hurricanes. There are also predictions that storms will be more intense in terms of duration, wind speeds, and amounts of precipitation.

These storms, with greater rainfall intensity and snowmelt runoff, could result in more frequent flooding along the rivers and streams that flow into the Northumberland Strait. Flooding in these watersheds can result in property damage, dams being overflowed, and bridges and culverts being washed out. In addition, the flooding can increase the occurrence of spills from municipal sewage systems that are not designed to handle the larger flows, resulting in human health concerns. The flooding will result in increased erosion of sediments into streams and out into the Strait. Along with silt, there will likely also be an increase in the transport of nutrients and pesticide residues from farmland into the aquatic environment.

The shores of the Northumberland Strait consist of many low-lying areas that are particularly susceptible to impacts from storm surges. As well, there are exposed coastal environments, like wetlands, beach, and dunes systems, that are very sensitive to waves and storms. Storm surges can occur when sustained winds combine with high tides to create tides that are much higher than normal. This can lead to flooding of coastal areas.

The increase in the frequency and intensity of storms will likely result in increased occurrences of storm surges. This resulting flooding could cause property damage, damage to infrastructure like roads and wharves and increased erosion in the coastal zone. Coastal wetlands, salt marshes, beach dunes, and eelgrass beds could all be damaged by storm surges.

6.1.3.2 Sea Level Rise

A 2001 study conducted with support from the Government of Canada's Climate Change Action Fund indicated that sea levels at Charlottetown may rise by close to three-quarters of a metre over the next 100 years, nearly double the rate recorded since 1900 (EC, 2001). As mentioned earlier in this section, the topography of the coastal landscape of the Northumberland Strait contains many low-lying areas and low slope shorelines that will be more prone to impacts of a higher sea level. As the sea level rises, the coastline will change and present infrastructure (wharves, breakwaters, causeways, buildings) may become more susceptible to flooding from storm surges or even become submerged over time. Sea level rise could result in the loss of coastal wetlands that are so important as nursery areas for marine life. As the sea level rises, we can also expect increased erosion of coastal headlands resulting in sediment transfer to the marine ecosystem.

Environment Canada, in partnership with several other government departments and academic institutions, has recently completed a detailed study on sea-level rise along the Gulf of St. Lawrence including the Northumberland Strait. This study was released in December 2006.

6.1.3.3 Air and Water Temperatures

Most people relate climate change with warmer temperatures. However, in Atlantic Canada, climate change has not followed the national warming trend of the past century and this region has actually experienced a slight cooling trend over the past 50 years (EC, 2005). This trend is consistent with projections by climate models, but predictions are that temperatures in Atlantic Canada will gradually increase in the future.

As air and water temperatures increase in coastal areas, there could be impacts on primary productivity, species migration, and the colonization of invasive species. Growth rates, age of sexual maturity, and distribution of some marine fish species, are sensitive to water temperatures, and warmer temperatures could result in earlier spawning and a shift in distribution to the north. There is an inadequate understanding of the potential impacts of climate change on lobsters and other marine organisms. Research is needed to determine if increased water temperatures could have an effect on the survival, growth, and migration of lobsters and other species.

There are records of water temperatures in the Northumberland Strait dating back to the early 1800s. A review of this historic water temperature data should be completed to gain a better understanding of patterns and trends.

With warmer temperatures, there will likely be less ice in the Northumberland Strait. The hypotheses are that the ice will form later, not be as thick, may not completely cover the Strait, and will melt out earlier in the spring. An increase in ice-free days in the Northumberland Strait could have a positive effect on marine transportation that is normally limited to the ice-free periods.

There has been less ice in the Northumberland Strait during the past two winters (2005 and 2006) and this has forced grey seals to come ashore in late January and early February for the birthing of their pups instead of having them born out on the ice flows. This has exposed the seals and their pups to human interactions and land-based predators that were never an issue for them out on the ice. It has also made the pups more susceptible to drowning from wave action and storm surges. About 1500 grey seal pups drowned along Pictou Island when a winter storm hit the area in 2006 (Reuters, 2006).

Shoreline ice can provide protection to shorelines prone to erosion and slumping because of winter storms and storm surges. With less ice forming in the Strait, this protection could be reduced, and erosion and sediment transport into the Strait could increase.

6.2 THREATS AND IMPACTS ON ECOSYSTEM COMPONENTS – KEY ISSUES

6.2.1 Biodiversity Related Issues

Biological diversity (or biodiversity) has been defined as "the variety of living forms, the ecological roles they perform, and the genetic diversity they contain" (Wilcox, 1984).

There are several factors that can affect the biodiversity of an area and these can be broken down into four broad categories:

- invasive species;
- habitat degradation or loss;
- effects of living resources harvesting; and
- species at risk.

6.2.1.1 Invasive Species

The arrival of aquatic invasive species into an ecosystem is one of the most serious threats to marine biodiversity. Compared to other threats to biodiversity, invasive introduced species rank second only to habitat destruction, such as forest clearing (Simberloff, 2000). Of all 1,880 imperiled species in the United States, 49% are endangered because of introduced species alone or because of their impact combined with other forces (Simberloff, 2000). The influx of aquatic invasive species into the Northumberland Strait, as described in Section 3.3.3, has had a negative impact on native species and continues to be a major threat to biodiversity.

6.2.1.2 Habitat Degradation or Loss

As reported by Simberloff (2000), habitat degradation and loss is the biggest threat to the biodiversity of an ecosystem. There are many factors that contribute to this scenario, including:

- eutrophication;
- climate change;
- contaminants;
- sediment;
- bottom disturbance; and
- coastal development.

As reported in Section 3.1.1 (macrophytes), there has been a significant reduction in the biomass of eelgrass throughout the Strait. These eelgrass beds normally provide depositional areas for fine-grained sediments, and the beds can help minimize erosion of fine–grained sediments from tidal estuaries during storm events and spring freshets. The eelgrass beds also provide critical habitat for many life stages of fish and invertebrates. The loss of eelgrass beds can increase the chance of sediment loss through storm events and erosion, as well as removing critical habitat and nursery ground for several species (Locke, 2005). Coastal development, as described in Section 6.1.1, can result in excess sediment transport into tidal estuaries and may play a major role in the loss of these eelgrass beds. In the 1930s, there were large-scale decimation of eelgrass beds attributed to an identifiable disease (the slime mold *Labyrinthula zosterae* for example). The current decline in eelgrass beds is not attributed to a disease (Locke, 2005). Too much deposition of fine-grained sediments may be choking out the macrophytes. There are also concerns about damage to eelgrass beds by the invasive green crab.

Eutrophication has been identified (Section 6.1.1) as a major issue in the Strait (GTA, 2006). It leads to changes in water chemistry, algal blooms, and areas of anoxia. Eutrophic conditions also have negative impacts on eelgrass beds due to reduced oxygen levels in the water column and in the sediment (Lotze et. al., 2003). These anoxic water bodies, however localized or seasonal, represent a loss of habitat for the species that would normally have used them in some aspect of their lifecycle. The effect of contaminants is seen in much the same light, where a degradation of the water or sediment quality leads to a reduction or removal of necessary habitat for species survival. A further discussion of contaminants in the system can be found in Section 6.2.3.4.

Climate change, discussed in detail in Section 6.1.3, is a factor that contributes to the remainder of the topics being reported. A reduction in ice cover due to warming waters results in increased sediment loss over previous years. If the water temperature increases only slightly, there could be negative effects on species already existing at the limits of the range. This also opens the door to increased aquatic invasive species as the extent of their range is increased.

Sedimentation is another factor in the reduction of habitat. As discussed in Section 6.2.3.2, the primary sources of sedimentation are runoff from land erosion, agricultural runoff or coastal development. This input of fine sediment has dramatically changed the composition of the sea bottom. The hard bottom, critical to the development of several mollusk species, lobster and some marine plants, has disappeared in some areas, and has been replaced by a mat of sediment. Most fishing activity takes place on hard-bottomed areas, and sediment deposition results in the loss of areas suitable for fishing. A reduction in the benthic invertebrate community due to smothering removes an important prey source for groundfish. This close association with the benthos also potentially exposes the fish to sediment toxins and interferes with reproduction because eggs are deposited directly on the substrate.

Several factors can contribute to physical disturbance of the sea bottom including ice scour, coastal development activities, and scallop dragging. The disposal of dredge spoils can also lead to smothering of fish habitat. In addition to habitat alteration, dredging can lead to the redistribution of sediment contaminants. Dredging and dumping of dredged materials can adversely affect oyster reefs, as can bacterial pollution and increased sedimentation from land erosion (Milewski et. al., 2001).

Oyster reefs are important structures in estuarine ecosystems. They increase biodiversity of an area by providing substrate, shelter for both predators and prey, and a viable food source. The

Shediac Bay Watershed Association has undertaken a shellfish restoration project to enhance oyster habitat in that bay (Audet, 2006).

The destruction of habitat can be directly linked to the increased development of the Northumberland Strait coast for both industrial and residential use (Section 6.2.4). In some areas such as Pointe-du-Chêne (the bluff) and Cap Bîmet, development has reached its maximum capacity (LeBlanc et. al., 2006). The result has been a loss of important salt marshes and coastal habitats within the Shediac Bay watershed (Jordan, 2000; Milewski et. al., 2001). Wetland alteration can reduce the amount of available habitat for various terrestrial and aquatic species dependant on these ecosystems (NPA, 2000). Wetlands help maintain and improve water quality by filtering contaminants and excessive nutrients, and help reduce erosion.

6.2.1.3 Effects of Living Resources Harvesting

The decline of the fishery in the Northumberland Strait has been mentioned throughout this report and is identified as a serious issue. Biodiversity can be impacted when the removal of biomass from a system exceeds a level where reproductive success can keep the population stable. Harvesting of marine species by commercial and recreational interests must be managed to ensure that a sustainable population of the targeted species is maintained. A lack of genetic diversity is also an issue when population levels reach low levels. The loss, or serious reduction, of any species can impact predator/prey interactions. The reduction in fish species will have serious implications to several other species that rely on it for food. Seals, whales, dolphins and avian species all require fish or shellfish for their diets.

As discussed in Section 6.2.2, the expansion of aquaculture activities in the Strait can impact the biodiversity of the system by competing with natural stocks for food and oxygen supplies and creating an increased potential for disease outbreaks.

Marine plants like eelgrass, provide important nursery grounds for many animals. There was once a thriving Irish Moss harvest in both Cap Lumière, NB, and Toney River, NS, but both fisheries have ceased due to poor harvests and a decline in industrial demand. The only current harvest of marine or coastal plants is peat (Section 6.1.1.3).

6.2.1.4 Species at Risk

Section 3.3.2 provided a discussion of the species at risk issue in the Northumberland Strait and the species at risk were listed in Table 3.3-1. Regardless of how a species becomes endangered or threatened, its disappearance from an ecosystem adds to the overall reduction of biodiversity. Recent evidence suggests that marine biodiversity loss is increasingly impairing ocean ecosystem capacity to provide food, maintain water quality and recover from perturbations. A decline in a species, even before it becomes noted as a species at risk, can cause irrevocable damage to the reproductive success and genetic diversity of that species.

6.2.2 Productivity and Living Resources Harvesting

The decline of the fishery is a well-established fact and a major catalyst for the production of this report. The landings and species involved were discussed in detail in Section 3.1 and the socio-economic impacts were discussed in Section 4.2.

Primary productivity in the Northumberland Strait is diverse and rich, particularly in the summer when the water temperature is warm and the amount of sunlight increases (Section 3.1.2). The Strait has experienced occasional outbreaks of toxic algal blooms. The development of these algal blooms can be accelerated by excess levels of nutrients being discharged to the Northumberland Strait. The blooms can have negative effects on the fishery due to reduced concentrations of dissolved oxygen or the presence of biotoxins associated with some algal species. This can lead to the closure of shellfish harvesting, reduced landings of certain species, and negative public perception about seafood quality.

Reported landings of major commercial species in the Strait have all seen serious declines over the last 20 years (Section 4.2). Continued pressure on these species, due largely to economic factors, exacerbates the situation. In addition, the decline of one fishery tends to place increased pressure on those that are doing well until they themselves begin to suffer. Fisheries that were once minor or non-existent are forced to become primary contributors to the fishery as a whole. The overall effect to the ecosystem is the removal of biomass from an ecosystem beyond the level from which it can recover, through its natural reproductive success. If the trend continues, a particular species may be reduced in numbers or even completely removed from an ecosystem. A more detailed description of the effects of the fishery on biodiversity can be seen in Section 6.2.1. The trend to larger vessels (Section 4.2.5) brings with it increased fishing pressures as vessels can fish in poorer weather, travel faster and farther to reach fishing grounds, and deploy larger nets or numbers of traps. Modern electronic equipment improves industry safety but also allows vessels to work in poorer weather and extend the hours spent fishing. In addition to resulting in increased fishing pressure on the target species, all of these factors can lead to increased fuel consumption, high levels of air emissions, and more fishing debris and lost gear, adding to the strain on the ecosystem.

Several avenues causing disturbance of the ocean substrate have been identified. Chief amongst those avenues is the disturbance caused by trawling and dragging for groundfish, marine plants, or scallops. The Strait has very little history of marine plant harvesting, and the groundfish fishery has declined to the point that there is a limited quota for winter flounder. The scallop fishery has been an important staple fishery in the Strait for several years. Multibeam mapping (Section 2.3.5.1) has shown scour marks from years of scallop dragging. This has resulted in the removal or reduction of the boulder/gravel substrate and uncovered the fine silt sediments below. The presence of fine sediments (Section 6.2.3) significantly hinders the development of several species; scallops, and lobster among them. The impacts of dragging are initially greater on sandy and muddy-bottomed areas however the duration of impacts is usually greater on hard complex bottoms (DFO, 2006h).

The shellfish aquaculture industry as practiced in the Strait collects spat from open water areas and transplants the spat to leased areas in near-shore areas. There are no species cultured in the Northumberland Strait that are not native to the area. Shellfish aquaculture does not involve feeding the cultured species but instead allows the shellfish to filter feed from the water they are held in. The shellfish farms do not produce the excess organic waste, nor do they require the use of therapeutic chemicals associated with marine finfish cage aquaculture, but they can have an impact on the surrounding ecosystem. The transition to floating bag oyster culture increases the shellfish biomass per hectare (S. Doiron, pers. comm., 2006) and there has also been an increase in the number of farms, particularly in NB. The size and number of these farms can have a negative impact on the level of dissolved oxygen in a bay, particularly since these bays are generally shallow and have poor tidal mixing. In addition, these farms have the ability to out compete natural shellfish stocks for food supplies.

6.2.3 Water/Sediment Quality, Pollution and Toxicity

According to the National Technical Guidance Document for the EOR (DFO, 2005a), the ecological objective for this component of the ecosystem assessment is to: "Conserve the geological, physical, and chemical properties of the ecosystem so as to maintain the overall MEQ, i.e., water, sediment, biota and habitat quality". In this section, the existing status of the MEQ of the Northumberland Strait and its watersheds will be discussed in terms of available information (what is known) and where there is insufficient information. As part of the Northumberland Strait EOR process, a workshop and a meeting were held to discuss MEQ issues (Appendix B) and the findings and recommendations from those sessions provide the foundation for this section.

Over the past several years, draft Ecosystem Overview Reports have been completed for a number of bays and estuaries along the Northumberland Strait including:

- Richibucto, NB;
- Bouctouche, NB;
- Shediac Bay, NB;
- Cocagne, NB;
- Shemogue, NB;
- Bedeque Bay, PEI; and
- Baie Verte, NB.

Based on these seven-site specific Ecosystem Overview Assessment Reports and the discussions at the MEQ Workshop and meeting, the key MEQ issues for the Northumberland Strait were identified as:

- nutrients;
- sediment;
- pathogens;
- contaminants;
- physical disruption of fish habitat;
- climate change; and
- invasive species.

Climate change has been discussed in Section 6.1.3 of this report and invasive species were discussed in Section 3.3.3. This section of the report will focus on the remaining five key MEQ issues.

6.2.3.1 Nutrients

Nutrients, as discussed in this report, include nitrogen (total nitrogen, nitrate, nitrite, ammonia-nitrogen), phosphorus, carbon, and silica. Nitrogen and phosphorus are a concern in the near-shore areas because an abundance of these nutrients in the water can result in excessive algae growth that, in severe cases, can lead to anoxic conditions and obnoxious odours. Carbon and silica are more important nutrients in marine waters where they are essential for phytoplankton growth (primary productivity).

At the MEQ Workshop and follow-up meeting, increased nutrient loading from land-based activities was identified as the most important MEQ issue in the near-shore areas such as the estuaries, harbours, and bays. This is an opinion shared by estuary researchers around the world. There are also concerns about changes in nutrient composition in the open waters of the Northumberland Strait, but the transport, fate and effects of nutrients in this ecosystem are not well understood at this time.

The principal sources of nutrients to the coastal areas of the Northumberland Strait are sewage, agricultural runoff, fish plant effluents, and pulp mill effluent. As discussed in Section 6.1.1, all of these land-based activities are found along the Northumberland Strait. Monitoring data for nutrient concentrations exists for many of the effluent discharges to the Strait (sewage treatment plants, fish plants and the pulp mill - Tables 6.1-1, 6.1-2 and 6.1-4) so it could be possible to obtain an estimate of the actual nutrient loading (e.g. kg/day) to some harbours and estuaries. This would assist in identifying problem areas. However, not all fish plants and sewage treatment plants conduct regular nutrient monitoring (pers. comm., S. Drost, NBDENV; P. McLeod, NSDEL). In order to accurately determine the total amount of nutrient entering the waters of the Northumberland Strait, either additional monitoring of discharges would need to be conducted or loading values could be estimated from similar facilities that do have monitoring data. There is little or no data on nutrient contributions from non-point sources, such as storm runoff from municipalities and agricultural runoff, so determining total loadings of nutrients could be a challenge.

Data on the concentration of nutrients in some of the estuaries and harbours does exist, but overall, the information is incomplete. The province of PEI conducts an annual estuary monitoring program that includes measurements of nutrient concentrations. There is no similar program in NB or NS. A summary report for PEI examined 20 to 30-year trends in water quality (Somers et. al., 1999) and concluded that: “Nutrient enrichment of PEI estuaries is a growing problem, and too often has implications for dissolved oxygen levels as well.”

More recent information has indicated that nitrate levels have continued to increase in the tributaries of Bedeque Bay between 1995 and 2005 (Pinsent and Chan, 2005). Nitrate concentrations have reached 4 mg/L in the Dunk River and as high as 6.7 mg/L in the Wilmot River. These concentrations exceed the interim Canadian Aquatic Life Guideline threshold. In the tidal waters of the estuaries of these rivers, nitrate levels ranged from 0.9 - 0.12 mg/L. Total phosphorous has been measured at levels from 70 - 120 ug/L in the estuarine waters of Bedeque Bay, and declines to concentrations of 60 - 90 ug/L farther out in Summerside Harbour. These elevated levels have raised concerns about possible eutrophication and anoxia in these rivers and Bedeque Bay, one of the most productive areas for oyster harvesting on PEI.

In 2002, the Conservation Council of NB (Lotze et. al., 2003) surveyed 10 estuaries and bays in east and northeast NB to determine if eutrophication was a problem. Two of these sites, Bouctouche Bay and Cocagne Bay, showed signs of eutrophication.

In 1990 and 1991, scientists from the Bedford Institute of Oceanography (BIO) conducted water quality surveys in Pictou Harbour in support of the Pictou Harbour Environmental Action Plan project (Dalziel and Yeats, 1991). They measured salinity, temperature, nutrients, total organic carbon, and dissolved trace metals. The results indicated that phosphate levels were elevated in the upriver stations and decreased to background concentrations in the outer harbour sites. Silicate concentrations followed a similar pattern, with the highest levels in the most upriver stations, and concentrations decreasing as the sampling gradient moved seaward. Nitrate concentrations were generally low throughout the East River estuary and Pictou Harbour.

The quality and consistency of the data is an issue. The monitoring programs often measure different nutrients such as total nitrogen, nitrate, nitrite, ammonia-nitrogen, or TKN. As well, the measurement techniques can vary between surveys. Nutrient fluxes in the streams, estuaries, and coastal waters are not well understood.

The sources of excess nutrients in estuaries and coastal areas are fairly well understood and pollution control initiatives are underway in many areas to reduce or eliminate these sources. Improved land-use practices for agriculture (buffer zones, cover crops, avoidance of steeply sloped areas, reduced use of chemical fertilizers) would all help to reduce nutrient losses to surface waters. Increased efforts to expand sewage treatment to areas not currently served, and the installation of improved sewage treatment processes, would help reduce nutrient concentrations in coastal waters. Efforts are underway through EC's NPA to evaluate effluent quality from fish processing plants and to recommend amendments to the fish plant effluent guidelines as required. This effort should be expedited to ensure prompt action to reduce nutrient emissions from these facilities. A research effort involving the federal and provincial governments in cooperation with the fish processing industry is also examining and implementing best management practices to improve effluent quality from fish plants (Morry et al 2003).

6.2.3.2 Sediments

In this section, sediments refer to fine grain materials that are transported and deposited by water, wind, and gravity into surface waters. As described in Section 6.1.1, most sediment entering the Northumberland Strait originates through the erosion of coastal shorelines, runoff from agricultural lands and forestry operations, construction activity in coastal areas, or runoff from industrial-scale extraction of minerals, aggregates, or peat moss. Although not a toxic substance per se, sediment is included in the definition of deleterious substances under the *Fisheries Act* (R.S., 1985, c. F-14, s. 1). In a later section, there will be a discussion of contaminants in marine sediments (the substrate material that forms the bottom of the ocean).

Sediments can cause several types of environmental problems. Sediments in the water column cause an increase in turbidity that reduces the penetration of light through the water. Reduced light penetration can lead to a decrease in photosynthesis, primary productivity, and algal growth. Increased turbidity can also make it more difficult for predator fish species to find their prey. As the sediment is transported, the heavier particles settle out to the bottom and can cause smothering of the bottom and damage to fish and fish habitat. As suspended sediments settle out of the water column, they can cause siltation of harbours. As sand bars and mud flats build up, water depth is reduced and dredging could be required to permit boat traffic to navigate the harbour.

Because sediments primarily originate as non-point sources from surface runoff, the measurement of their quantities released to streams is practically non-existent. A sedimentation study (P. Lane and Assoc., 1991) of the Wilmot River, a tributary to Bedeque Bay in PEI, estimated that soil erosion from farmland contributed between 2,000 m^3 and 20,000 m^3 of sediment to the river annually depending on climatic conditions and farm practices in use in any particular year. Cliff erosion along the river estuary was estimated to supply another 3,000 m^3 of sediment annually. Overall, the study estimated that sediment had accumulated to depths between 2 and 5 m in the Wilmot River estuary over the past two centuries. In another monitoring study of the Wilmot River watershed (Burney and Edwards, 1995), the researchers established automated monitoring equipment to measure stream flow and sediment concentration from several test plots. Sediment loss from croplands (potatoes and barley) was greatest in the spring to fall period following heavy rainfall events.

Environment Canada has been conducting a comprehensive study into the impacts of climate change and sea level rise along the coast of southeastern NB (EC, 2006). The final report was released in December 2006, too late to be incorporated into this document. The Northumberland Strait EOR Technical Review Committee should review this report and incorporate its findings into their recommendations.

The offshore areas of the Northumberland Strait near Shemogue have experienced an increase in sediment loads. A preliminary study (Ollerhead, 2005) in that area confirmed anecdotal reports from area fishers. Although only a limited number of samples were taken, the results showed consistently high sediment loads throughout the western part of the Strait, with TSS levels in the range of 30 mg/l, more than double the highest previously recorded concentrations. A peer review of the Ollerhead study (Jacques Whitford, 2005) raised concerns about the conclusions based on the methods that were used and the interpretation of the data. Some local fishers have also reported observations of sediment plumes up to a mile from the Confederation Bridge and this has led them to conclude that scouring around the bridge pier bases is contributing to the increased sediment loads in the Strait (S. Jones, pers. comm., 2006). PWGSC/TC conduct annual hydrographic surveys around the Confederation Bridge and the results of those surveys do not indicate any scouring or erosion around the bridge piers (PWGSC/TC 2006). There is substantial anecdotal evidence of increased fine sediments being deposited on the bottom of the Northumberland Strait and on stationary fishing gear deployed in this area.

There is no broad understanding of overall sediment conditions (concentrations, transport and deposition) in the open water areas of the Northumberland Strait.

The PEI estuary monitoring program has data for the PEI section of the Northumberland Strait (Somers et. al., 1999). For the open water areas, there is a 1973 dataset from Kate Kranck's surveys (Tim Milligan, pers. comm., 2006). In 2006, DFO, in cooperation with Northumberland Strait fishers conducted a sampling program through the summer and fall. The fishers collected samples while out on the water conducting their regular fishing activities and DFO provided the laboratory analyses. Preliminary analyses of the data collected so far indicates that the TSS levels in surface water samples from the summer of 2006 are similar in concentration to those measured by Kate Kranck in 1973 (Tim Milligan, pers. comm., 2006).

The basic physical processes that affect sediment transport in aquatic systems are fairly well understood, but the specifics of these processes in the Northumberland Strait are not fully known. It is known that man-made structures such as causeways, bridges, wharves, and breakwaters can alter tidal currents and result in either increased erosion or deposition of suspended sediments. Certainly, members of the fishing community have expressed concerns about the changes in current patterns around the Confederation Bridge and increased erosion around the bridge piers, and sediment deposition in nearby areas as a result (S. Jones, 2006).

A group of scientists at BIO is conducting detailed analyses of Landsat satellite images to examine sediment transport characteristics and patterns in the Northumberland Strait.

The sources for sediments in streams and coastal areas are well known, and for human activities, there are effective control strategies that can be incorporated to reduce siltation. For forestry operations, reducing the size and extent of clear-cuts, avoiding working during wet seasons, and imposing adequate setbacks and buffer zones along streams can all help to reduce siltation. Improved land-use practices for agriculture (buffer zones along streams, the use of cover crops, avoidance of steeply sloped areas, and increasing the organic content of soils) would all help to reduce sediment losses.

Implementing adequate erosion controls for construction projects located near waterways can be effective at reducing siltation. In recent years, the implementation of environmental protection plans (EPP) by contractors working in or near the coastal zone, has improved and has probably resulted in a reduction in sediment losses. Unfortunately, there is not much that can be done to reduce coastal erosion due to natural processes.

6.2.3.3 Pathogens

Pathogens include bacteria and viruses that have the potential to cause diseases in humans, other land animals, or marine organisms. Municipal sewage and manure from farming operations can contain pathogens that can cause serious diseases. Filter-feeding shellfish like clams, mussels, and oysters accumulate fine particulate material from the water that can include these pathogens if present in the water. The pathogens are concentrated in the digestive tract of the shellfish and can be transmitted to humans when eaten. Consumption of shellfish containing pathogens can cause serious illness such as typhoid. Exposure, through swimming, to water containing elevated amounts of pathogens can also cause diseases in human. The principal sources of pathogens to the Northumberland Strait include municipal sewage, faulty septic systems, and runoff from agricultural operations (Section 6.1.1).

Because of these potential effects, the human health aspects of pathogens are thoroughly regulated and monitored. The Canadian Food Inspection Agency, EC, and DFO work jointly to protect the quality of shellfish under the Canadian Shellfish Sanitation Program. Canadian Food Inspection Agency monitors shellfish products to ensure that no contaminated shellfish products enter the marketplace. Environment Canada monitors water quality in coastal areas and classifies areas as to whether they are suitable for harvesting shellfish or not. DFO enforces the licensing of shellfish harvesters and the harvesting of shellfish from approved areas.

Public beaches along the Northumberland Strait are monitored regularly through the summer season by provincial public health departments to ensure that bacteria concentrations are within safe levels for contact recreation. If bacteria levels exceed safe levels, the beaches can be closed to swimming.

In 1996, 35% of the classified shellfish growing areas in all of the Atlantic Region were closed to harvesting of shellfish because of fecal bacteria pollution (Table 6.2-1) (NPA, 2000). DFO estimates that income of over $8 million is lost every year due to closures of the soft shell clam fishery in southwestern NB alone. Municipal wastewater is implicated as the pollution source for more than half of the closed shellfish areas. Areas in the Northumberland Strait closed to shellfish growing and harvesting are identified in Figure 6.2-1 and in Table 6.2-2. In 2006, there were 97 areas closed to shellfish harvesting in the Northumberland Strait, representing about 22

% of the available shellfish growing areas that are classified (pers. comm., Chris Roberts, EC, January 19, 2007).

TABLE 6.2-1 Summary of Closures of Classified Shellfish Growing Areas in Atlantic Region, 1996

Province	Number of Closures	Area Closed (km^2)	Shoreline Length Closed (km)
NB	127	571	699
Newfoundland	81	425	1019
NS	278	939	3314
PEI	83	110	783
Atlantic Region Totals	569	2044	6815

Source: NPA, 2000

TABLE 6.2-2 Shellfish Closures in the Northumberland Strait, 2006

Province	Classification Type	Number of Closures	Area (km^2)	Percent of Total Area Closed	Shoreline Length (km)
NB	Approved	-	216.5	-	282.9
	Closed	38	55.5	19.1 %	580
	Conditional	-	18.8	-	75.4
NS	Approved	-	218.4	-	335.3
	Closed	29	90.3	29.3 %	570.8
PEI	Approved	-	342.9	-	196.9
	Closed	30	74.7	17.4 %	506.1
	Conditional	-	10.7	-	78.5
Totals For Closed Areas		97	220.5	21.5 %	1656.9

Source: EC, 2006

In addition to the human health issues with pathogens, there are also concerns about pathogens that cause health problems in aquatic organisms. These include such things as shell disease and gaffkemia in lobsters and Multinucleated Sphere Unknown (MSX) in oysters. There is a general lack of understanding about the conditions that result in diseases outbreaks in fish and other marine life. Dispersion of these disease pathogens, and the influence of environmental conditions on disease outbreaks in fish, is not well understood.

6.2.3.4 Contaminants

In the context of this EOR, contaminants refer to chemicals that can have negative effects on marine organisms, and include hydrocarbons, pesticides, metals and persistent organic chemicals, PCB, and PAH.

FIGURE 6.2-1 Areas Closed to Shellfish Harvesting in the Northumberland Strait

Contaminants can be toxic to marine organisms if they are present in the environment in sufficient concentration and are in a form that can be taken up by the organisms. The chemicals can be in the water or in the marine sediments. Toxicity from contaminants can range from:

- acute mortality;
- sublethal effects:
  - effects on reproduction;
  - effects on growth; and
  - effects on mobility;
- chronic effects:
  - cancers and tumours;
  - reduced disease resistance; and
  - physiological effects reducing survival.

In addition to impacts on marine organisms, many contaminants can be accumulated in their tissues and render those organisms unsuitable for human consumption.

Environmental contaminants can originate from many sources. Contaminants can enter the environment through liquid effluents and aerial emissions to the atmosphere. In the context of the Northumberland Strait, contaminants can originate locally from incinerators, power generating stations, industrial effluents, municipal wastewater, urban runoff, pulp mills, landfills, residues from current and past applications of pesticides to agricultural and forest lands, oil spills, and antifouling paint used in marine industries.

Contaminants can also originate from distant sources and be carried by the prevailing continental winds to Atlantic Canada. For instance, atmospheric mercury that originates from the burning of coal for power generation in the Midwestern United States can be carried through the atmosphere and deposited with precipitation onto Atlantic Canada (Eaton et. al., 1993).

There are several sources of information regarding concentrations of contaminants in the Northumberland Strait. There does not appear to be any regular monitoring program that looks at contaminants in the Strait on a broad scale. The province of PEI conducts annual water quality monitoring in rivers and estuaries in that province and they do monitor for the presence of pesticides as part of that program.

Environment Canada requires anyone applying for an ocean disposal permit to conduct an extensive monitoring program to determine if the sediments to be dredged meet the requirements of the ocean disposal regulations and are of suitable quality for ocean disposal. Since many of the ports and harbours along the Northumberland Strait require regular dredging to maintain adequate depths for marine traffic, a substantial quantity of sediment quality data for these harbours has been submitted to EC over the past few decades.

The Canadian Food Inspection Agency conducts regular inspections of seafood processing plants. These inspections include a monitoring program that analyzes samples of seafood products for an extensive list of environmental contaminants to determine if these products are of suitable quality for human consumption. The chemical analyses are performed on the edible portion of the products and are targeted at chemical contaminants that could be present in fish products as a result of the environmental conditions to which the fish was exposed (eg., mercury, PCB and Mirex). The Canadian Food Inspection Agency should have a large database containing the results of this inspection program for fish captured in the Northumberland Strait.

In 1990, as part of the Pictou Harbour Environmental Action Plan, Dr. Doug Loring of the BIO conducted core sampling in Pictou Harbour and measured heavy metal concentrations on those core samples (Loring, 1991). This study determined that the fine grain sediments near the mouths of the East River and West River contained levels of some metals (cadmium, lead, and zinc) that exceeded natural background levels for the Gulf of St. Lawrence. Of a total of 156 samples, 14 had concentrations of cadmium that exceeded the ocean disposal guideline of 0.6 milligrams per kilogram (mg/kg) and 2 had concentrations of mercury that exceeded the ocean disposal guideline of 0.75 mg/kg.

The concentrations of copper and chromium were similar to background levels. When the metal levels were normalized to lithium concentrations, Dr. Loring concluded that only cadmium indicated possible anthropogenic inputs of this metal.

In support of an application to conduct a dredging project in Summerside Harbour, sediment sampling was conducted in the areas of the harbour to be excavated (JWEL, 1998). These samples were analyzed for heavy metals, PAHs, DDT (dichlorodiphenyltrichloroethane) and PCB. No PCBs, DDT, or DDT derivatives were detected in any samples. Total PAH was above ocean disposal limit of 2.5 mg/kg in one sample collected along the East Berth at the Summerside Marine Terminal Wharf. Six other samples from along the East berth had low concentrations of PAHs. PAHs were not detected in any of the six samples from the Summerside Channel. One sample of the seven collected along the West Berth, and one sample from the seven collected from the turning basin, had detectable PAHs but the concentrations were below ocean disposal criteria.

Of the 27 samples collected for heavy metal measurement, none exceeded the ocean disposal guidelines for cadmium, mercury, zinc, and copper. The ocean disposal limit established by EC for lead is 66 mg/kg and one sample of the seven collected along the East Berth had a concentration of 100 mg/kg of lead.

In 2006, the Charlottetown Harbour Authority applied for an ocean disposal permit for a dredging project required for expansion to the port's facilities (JWEL, 2006). In support of this application, sediment samples from the area to be dredged were collected an analyzed for metals, mercury, PAHs and PCBs.

The results of these measurements are provided in Table 6.2-3. All of the samples met the criteria for metals and mercury. No PCBs were detected in any samples. One sample exceeded the limit for PAHs but the 95 % confidence limit for the sample set met the criteria.

TABLE 6.2-3 Summary of Sediment Chemistry for 2006 Charlottetown Harbour Dredging Project

Parameter	Units	Range of Concentrations in area to be Dredged	CEPA Ocean Disposal Guidelines
Cadmium	mg/kg	<0.15 – 0.43	0.6
Copper	mg/kg	3.8 – 65	81
Lead	mg/kg	6.9 – 34	66
Zinc	mg/kg	17 – 110	160
Mercury	mg/kg	<0.01 – 0.02	0.75
PCB	mg/kg	<0.01	100
Total PAH	mg/kg	<0.8 – 3.94	2.5

There are several other sources of information that may be able to provide data and information on environmental contaminants in the Northumberland Strait:

- In the mid 1990s, Dr. John Smith, DFO Gulf Region, conducted monthly sampling surveys during the ice-free period for phytoplankton, zooplankton, conductivity, temperature, depth (CTD), and contaminants. Dr. Smith is now retired and the results of these surveys have not been completely compiled and reported on. DFO should make an effort to synthesize and interpret the complete dataset.
- There is one pulp mill within the study boundaries for the EOR. Neenah Paper operates a bleached kraft mill near Pictou, NS. The mill has operated at this location since 1967 and produces more than 260,000 metric t of pulp per year. The mill has conducted environmental monitoring studies in the area near its effluent discharge over that period but none of that monitoring has looked at contaminant levels in the environment. In 1988, the United States Environmental Protection Agency (USEPA) discovered that some pulp and paper mills using elemental chlorine for bleaching were creating chlorinated dioxins and furans that may have been discharged in mill effluents. In 1990, EC conducted a national survey at 47 pulp and paper mills that used chlorine bleaching to determine if dioxins and furans were present in the sediments near the effluent discharges from these mills (Trudel, 1991). No dioxins and furans were detected in the

sediments near the Pictou mill. The Neenah Paper mill has now been equipped with a modern bleach plant producing 100% elemental chlorine-free pulp.

- In 1967, the Government of NS built the Boat Harbour Treatment Facility in Pictou County, NS, to treat wastewater effluent from the nearby bleached kraft pulp mill. With updated treatment processes now available, part of that treatment system known as the effluent stabilization lagoon, will be decommissioned and returned back to a natural tidal estuary. The NS Department of Transportation and PWGSC are completing an environmental impact assessment for the lagoon decommissioning and numerous studies have been conducted in recent years in support of this process. Concerns have been raised about a possible buildup of mercury, heavy metals, PCB, and dioxins in the sediments of the lagoon and in the adjacent areas of the Northumberland Strait.
- The Mussel Watch program used to have some sampling stations in the Northumberland Strait and there should be data available from that program.
- EC operates the National Pollutant Release Inventory (NPRI) that requires industries to report total amounts of designated environmental contaminants that they discharge each year in their liquid effluents, their air emissions, and as solid waste. EC prepares summary reports on this information and some data is also available through the EC website (www.ec.gc.ca).

6.2.3.5 Physical Disruption of Fish Habitat

Physical disruption of fish habitat by human activities is a serious concern in the Northumberland Strait. A healthy habitat is critical for all life-stages of marine organisms and for their long-term survival. In the previous sections, things that can impair water and sediment quality have been discussed. This section will examine activities that cause physical damage to fish habitat.

Physical disruption means actual changes to marine substrates due to smothering, siltation, burying, removing, or altering the grain size. Physical disruption to fish habitat can result from the following activities:

- infilling of shoreline areas;
- construction of bridges, causeways, wharves and breakwaters;
- dragging for scallops;
- trawling for ground fish species;
- shoreline armouring to reduce erosion;
- dredging;
- sediment inputs from land-based activities; and
- obstructions to tidal flows causing deposition of silt.

There is not much information available on physical disruption. There have been some surveys in specific areas, but not much is known about the majority of the Northumberland Strait. There is speculation that fishing with mobile gear such as scallop drags, Irish Moss drags, and otter trawls damages the bottom and may have direct impacts on lobsters and other benthic creatures.

Gordon Fader's presentation at the Physical Environment Workshop date showed multi-beam hydrographic survey images in areas near the Confederation Bridge. These clearly showed drag marks in the gravel substrate from scallop dragging. It was also noted that these areas have no boulders; the boulders have all been removed or broken by the dragging activity over the years. This represents a fundamental change in the habitat characteristics.

The images shown by Gordon Fader also indicated that in some areas that were subjected to scallop dragging, the firmer surface sediments, primarily gravel, had been stripped away and the underlying layers of less consolidated, finer material, were exposed. Again, there is not a good understanding about how this change in habitat might affect the marine animals and plants that normally occupy these areas. Some areas of the Northumberland Strait have buffer zones and no-fishing zones for scallop dragging. The effectiveness of these conservation measures is not fully understood and needs to be evaluated.

There are a large number of existing coastal structures such as wharves, breakwaters, causeways, marinas and bridges. Not only can these types of structures result in infilling of segments of the habitat, but they can also have an effect on tidal currents. Increased currents can result in erosion and decreased currents can result in siltation. It was suggested at the MEQ workshops that an inventory of major coastal zone construction activities in the Northumberland Strait should be prepared and used to provide focus for follow-up studies on the long-term impacts of these structures on fish habitat. Particular attention should be paid to potential effects on salt marshes.

Many sections of the shoreline of the Northumberland Strait are prone to erosion from wave action, storm surges, and heavy precipitation events. In an effort to reduce erosion and protect their shoreline properties, many landowners have installed a variety of shoreline armouring techniques. There does not appear to be any data on how much shoreline has been armoured or if there are any construction standards to be followed for this practice. Shoreline armouring practices should be investigated to determine potential effects on tidal currents, sediment transport, and deposition.

6.2.4 Integrity of Marine Landscape and Coastal Development

Shoreline construction and alteration activities include coastal flood protection works, erosion control structures, bridges, marinas, wharves, breakwaters and infilling, and sewer works.

Impacts of these activities include loss of primary ecosystem production and long-term impact on local food production, disruption, or complete destruction of fish and wildlife habitat, changes in sedimentation patterns, and eventual loss of economic opportunity. The construction along, and alteration of, coastal shorelines can also result in contaminant loading due to releases of toxic chemicals, leading to water and sediment quality problems in both the short- and long-term (NPA, 2000).

Harbour and channel dredging are major activities taking place in coastal areas. Although these activities are aimed at reducing the effects of sedimentation within constructed infrastructure (wharves, harbours) they can disrupt benthic communities, diminish phytoplankton production, and reduce feeding and respiration by fish. Dredging is an on-going activity and is considered as part of regular maintenance to wharves and marine infrastructure, resulting from the necessary removal of large quantities of sediment introduced to the shoreline transport system from erosion of coastal landscapes. This sediment gathers and settles near protruding coastal structures and sandbar barrier channels and becomes a significant navigational issue, especially to commercial fishers (NPA, 2000).

Many land-use practices result in the increase of erosion and silt loads into the coastal environment. Silt is a major carrier of contaminants such as pesticides and heavy metals, as well as nutrients from watersheds to coastal waters where it settles into the sediment. The disturbance of such sediment can lead to the potential release of these toxic substances into the ecosystem (NPA, 2000).

In an effort to reduce shoreline erosion and sedimentation, control structures are often constructed which consist of large rocks, boulders, cement, steel, or a combination of these materials, to re-enforce weakening shorelines from climatic forces. Although this practice has proven successful in certain areas, it is not yet understood what impact these structures may have on the stability of the shoreline should a severe storm event destroy the structures.

Development in formerly undeveloped lands can dramatically alter the natural landscape and introduce contaminants into the environment, filling wetlands, altering the natural flow of streams and tidewaters, displacing native species, and introducing invasive ones. Along the coast, new roads prompt the construction of causeways that alter coastal habitats by restricting normal tide flows. “Per capita, coastal residents are consuming more land, driving more, boating more, and generally using up more resources than they were 30 years ago” (Pesch & Wells, 2004).

Sources of pollution are not limited to discharges from coastal industries and sewage treatment plants. Every time it rains or snow melts, contaminants are carried into water that runs off impervious surfaces (rooftops, roads, and parking lots) and other uses eventually reaching streams. Bacteria from septic systems and animal wastes; sediment, pesticides, and herbicides from farming; and petroleum products from parking lots, roads, marinas, landfills, and mines move relatively quickly into aquatic systems that feed coastal waters, instead of naturally moving more slowly through soil that captures many of these contaminants. Many studies conclude that once roads, parking lots, and roofs cover 10% of a watershed’s acreage, aquatic systems begin to degrade. Changes in particular pollutant levels; changes in the physical structures of streams, creeks, marshes, and rivers; and changes in the number of species and abundance of aquatic life lead to a less diverse, less stable coastal aquatic ecosystem. The 10% threshold is an empirical point beyond which ecosystem function, in general, declines because of individual and cumulative effects (Pesch & Wells, 2004).

6.2.5 Cumulative Impacts

The concept of cumulative environmental effects recognizes that the environmental effects of individual human activities can combine and interact with each other to cause aggregate effects that may be different in nature or extent from the effects of the individual activities. In other words, the various stressors that have been discussed in the previous sections of this report do not work independently from the other stressors, and there are probably combined effects of the various stressors that may be more severe than the effects of individual stressors. Cumulative effects can also include the interaction of human activities with natural conditions. The EOR Technical Guidance Document (DFO, 2005c) recommends using a matrix to highlight these interactions. In situations involving multiple or persistent sources of perturbation caused by human activities, it can be difficult to establish or predict cause-effect relationships. Cumulative impacts can occur when there is a single activity (an industrial effluent discharge for example) that continues to have an impact on an area over a long period of time.

An overview of the potential cumulative effects that could occur in the Northumberland Strait is provided in Table 6.2-4. For example, the matrix indicates that in locations where agricultural runoff could be combined with sewage discharges, the potential for eutrophication or pathogen contamination could increase. In locations where agricultural runoff flowed into an impoundment created by a causeway or a breakwater, increased siltation could result in damage to fish habitat. In areas where climate change results in increased water temperature and there is an input of nutrients, increased algal growth could occur. Clearly, along the Northumberland Strait, there are many harbours and estuaries where multiple activities occur that can cause cumulative impacts on the ecosystem.

TABLE 6.2-4 The "Impacts Matrix" to Help Review Impacts of Activities and Organize the Ecological Assessment Around over-Arching Themes

Activities of Concerns	Key Ecosystem Properties			
	"Impacts On"			
"Impacts of"	Biodiversity	Productivity	Water / Sediment Quality	Integrity of Marine Landscapes and Habitat
Municipal Sewage	Eutrophication can cause anoxia and species shifts Increased algal growth can impact native species	Eutrophication Pathogens impair shellfish quality	Nutrient enrichment Introduction of pathogens	N/A
Fish Processing Plants	Eutrophication can cause anoxia and species shifts Increased algal growth can impact native species	Eutrophication	Nutrient enrichment	N/A
Large Industries	Eutrophication can cause anoxia and species shifts Loss of species due to habitat change Toxic effects of contaminants	Possible toxic effects of contaminants	Nutrient enrichment Sediments Contaminants	Siltation, habitat damage, smothering
Aquaculture	Competition with native species	Competition with native species	N/A	N/A
Fishing and Fishing methods/techniques	Loss of species due to overfishing	Decreased productivity due to decreased population	Siltation, habitat damage	Habitat damage

Activities of Concerns	**Key Ecosystem Properties**			
	"Impacts On"			
"Impacts of"	**Biodiversity**	**Productivity**	**Water / Sediment Quality**	**Integrity of Marine Landscapes and Habitat**
Tourism and Recreation	Eutrophication can cause anoxia and species shifts Toxic effects of contaminants	Eutrophication Toxic effects of pesticides	Nutrient enrichment Pesticides	N/A
Mining Operations	Loss of species due to habitat change Toxic effects of metals and acid generation	Possible toxic effects of contaminants	Introduction of sediment Acid generation Metals	Siltation, habitat damage, smothering
Agriculture	Eutrophication can cause anoxia and species shifts Toxic effects of pesticides	Eutrophication Pathogens impair shellfish quality Toxic effects of pesticides	Introduction of: nutrients, sediments or pesticides	Siltation, habitat damage, smothering
Causeways, wharves, bridges or breakwaters	Loss of species due to habitat change	N/A	Introduction of sediment	Increased siltation
Dredging And Ocean Disposal	Loss of species due to habitat change	N/A	Introduction of sediment	Siltation, habitat damage, smothering
Boating and Marine Transportation	Toxic effects of hydrocarbons Introduction of invasive species	Toxic effects of hydrocarbons	Introduction of hydrocarbons	Can require dredging Construction of wharves & breakwaters
Climate change	Warmer temperatures can allow invasive species to expand range and/or force native species to alter range	Warmer temperatures can allow invasive species to expand range and/or force native species to alter range	N/A	More intense storms cause increased erosion and siltation

6.3 IDENTIFICATION OF KEY AREAS

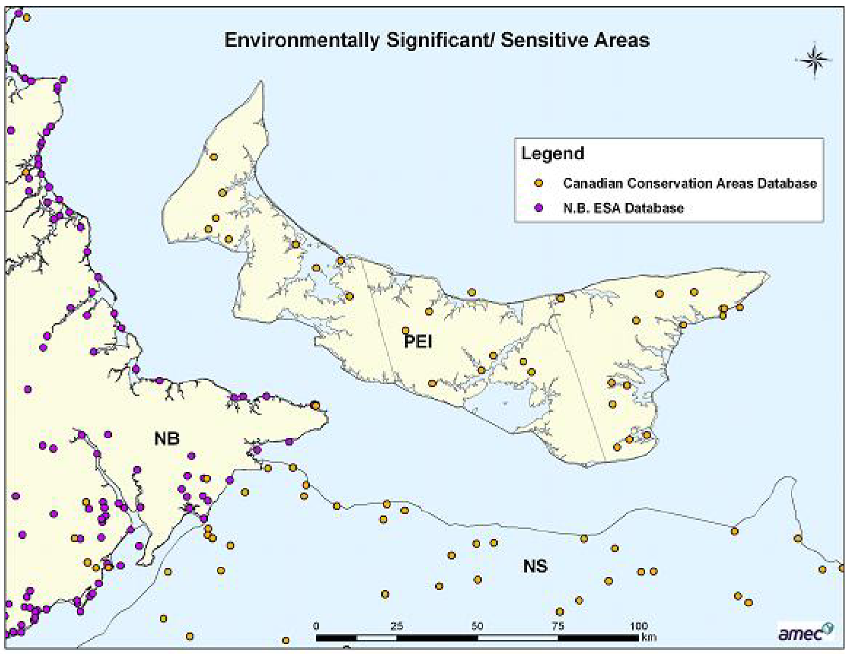
6.3.1 Enivronmentally Significant Areas (ESA's)

The sources of information identifying Environmentally Sensitive Areas (ESAs) are varied and plentiful, ranging from Federal and Provincial jurisdiction to special interest groups. These sources identify areas owned by both governments and by private landowners. The Canadian Conservation Areas Database identifies areas such as National and Provincial Parks, Game

Sanctuaries, Natural Areas and Wildlife Areas (Figure 6.3-1) (Canadian Conservation Areas Database, 2006). It does not identify privately owned land.

Between 1993 and 1995, the Nature Trust of NB, in cooperation with the Government of NB, created a database on sites with a rich diversity of species or with special features. More than 900 ESA's were identified within the province of NB (Nature Trust of NB, 1995). Approximately 21 of these sites have been identified on the NB Northumberland Strait coastline (Figure 6.3-1). The Island Nature Trust owns and protects 38 pieces of property in PEI including some in the Northumberland Strait (J. Waddell, pers. comm., 2006). They have also identified several candidate natural areas, including all off-shore islands.

FIGURE 6.3-1 Environmentally Significant and Sensitive Areas



Canada's Important Bird Areas (IBA) program is a science-based initiative to identify, conserve, and monitor a network of sites that provide essential habitat for Canada's bird populations (IBA, 2006). Four IBAs have been identified as occurring in or near the study area. In NB the Kouchibouguac National Park Sand Islands IBA has been identified for its populations of common terns, Piping plover, Red-breasted mergansers, herring, ring-billed and great black-back gulls, while the Bouctouche Bar IBA hosts important populations of common terns, Piping plover, great blue herons, and teal and American black ducks. In PEI, the Bedeque Bay IBA has been identified for its populations of Canada Geese, Atlantic brant, Black-bellied plover, willet, and red knot. The Orwell Bay IBA hosts important populations of Canada Geese and migratory waterfowl (IBA, 2006).

The Federal Government has several programs in place to protect environmentally sensitive areas or habitats. Environment Canada's Canadian Wildlife Service (CWS) administers a network of protected areas, which protects an estimated 11.8 million ha of wildlife habitat. The components of the network are National Wildlife Areas, Migratory Bird Sanctuaries, and Marine Wildlife Areas. These sites contain a wide diversity of habitat of national and international importance. There are two National Wildlife Areas in the study area, Cape Jourimain, NB and

Wallace Bay, NS. No migratory bird sanctuaries have been identified within the study area of the EOR. Sites to be designated Marine Wildlife Areas are currently being considered in offshore and coastal areas where plants, animals, and ecosystems will be protected (CWS, 2006). National Marine Conservation Areas (NMCAs), managed by Parks Canada, are marine areas managed for sustainable use and containing smaller zones of high protection. They include the seabed, the water above it, and any species which occur there. They may also take in wetlands, estuaries, islands and other coastal lands. Currently there are no NMCAs in Atlantic Canada but Kouchibouguac Bay has been identified as a potential site (Parks Canada, 2006).

Canada's *Oceans Act* gives government the ability to establish Marine Protected Areas to conserve and protect unique habitats, endangered or threatened marine species and their habitats, commercial and non-commercial fishery resources (including marine mammals) and their habitats, marine areas of high biodiversity or biological productivity, and any other marine resource or habitat requiring special protection. Currently there are no Marine Protected Areas designated in the study area but Basin Head, near Souris PEI, has been designated as the first Marine Protected Area in the Maritimes (DFO, 2006i).

6.3.2 Contaminant "Hot Spots"

The term "hot spots" refers to locations where environmental contamination is severe enough to be a cause for concern for ecosystem health. The term originated in the 1980s with the USEPA's Superfund program which directed federal funds to the clean-up of hazardous waste sites. "Hot spots" were contaminated sites that were severely contaminated with toxic chemicals and posed a risk to human health or sensitive ecosystems. There are no environmental quality guidelines that one can use to define a "hot spot"; it is more of an intuitive process.

The ecosystem overview and assessment did not identify any severely contaminated areas in the Northumberland Strait that would be considered "hot spots". There were locations where contaminant levels in marine sediments exceed the Canadian Council of Ministers of the Environment (CCME) Environmental Quality Objectives and where the harbour sediments may exceed the criteria for ocean disposal under CEPA Part VI (Section 6.2.3.4).

6.3.3 Bottom Disturbance

As discussed in Section 6.2.2, there are several activities that take place in the Northumberland Strait that can cause physical disturbances to fish habitat. These include:

- infilling of shoreline areas;
- construction of bridges, causeways, wharves and breakwaters;
- dragging for scallops;
- trawling for ground fish species;
- dredging;
- sediment inputs from land-based activities; and
- obstructions to tidal flows causing deposition of silt.

Multi-beam hydrographic survey images have been collected for some limited areas of the ocean bottom near the Confederation Bridge and these images clearly show drag marks in the gravel substrate and a lack of boulders as a result of scallop dragging. Only a very small portion of the Northumberland Strait has been surveyed using this technology so there is no way of knowing the extent of the damage in the Strait as a whole. These images also indicated that in some areas that were subjected to scallop dragging, the firmer surface sediments, primarily gravel, had been stripped away and the underlying layers of less consolidated, finer material were exposed. Although there is no empirical information available, dragging for Irish moss or trawling for groundfish would also be expected to cause disturbance to bottom conditions.

Dredging and disposal of dredge spoils can also cause serious disturbance to natural bottom conditions. Due to siltation, many of the ports and harbours along the Northumberland Strait require maintenance dredging on a regular basis to sustain adequate depths for marine traffic. Shoreline construction activities can result in siltation that can smother or alter fish habitat.

6.3.4 Areas of Anoxia

The Northumberland Strait has experienced localized pockets of anoxia in several bays and estuaries. The primary trigger for these events appears to be the seasonal bloom of micro- and macro algae due to the eutrophication of the water column. Eutrophication is a result of excess nutrient concentrations in the water as discussed in Section 6.1.1. Areas in the Strait that have experienced anoxic conditions include Richibucto Harbour, Cocagne Bay, Bouctouche Harbour, and Shediac Bay near the Pointe-du-Chêne wharf. In all cases, the anoxia was traced to the bloom and die-off of species such as macro algae, eelgrass, diatoms, and blue-green algae. Cocagne and Bouctouche also have reports of anoxic sediments in their harbour/bay areas.

The inner portion of Pictou Harbour experiences anoxic conditions in the warm summer months (Pictou Harbour Environmental Protection Project, 2004). The tidal flushing of the inner harbour is very restricted due to the Highway 106 causeway. Nutrient inputs are suspected of originating from agricultural activities in the watersheds of the Middle and West Rivers and from malfunctioning septic systems along the harbour.

It has been suggested that some aquaculture practices exacerbate the situation, however, the PEI Benthic Survey (Shaw, 1998) indicated that the muddy bottoms of PEI estuaries are highly anoxic with high organic matter levels, regardless of the presence of aquaculture activities. Some areas, such as Bedeque Bay, do not seem to be affected by eutrophication, and therefore anoxic conditions, because of good tidal exchange and along-shore current flows in the Strait (Pinsent and Chan, 2006).

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7.0 INTEGRATION OF OTHER INITIATIVES

As part of the compilation of the Northumberland Strait EOR, information from relevant parallel processes was assessed and integrated. Parallel processes are those activities that are being conducted independently of the Northumberland Strait EOR, but whose focus is relevant to the Northumberland Strait ecosystem components and dynamics. Parallel processes were considered in order to avoid duplication of research efforts and to ensure that all applicable research completed on the Northumberland Strait to date is incorporated into EOR findings.

Parallel processes, in the form of research and studies, have been completed by government, resource users, non-governmental organizations and by academic institutions. The EOR assesses the scope of previously collected data and research results in order to identify information gaps that remain to be studied. Relevant parallel processes are described below.

7.1 DISCRETE EOARS

EOARs are an initiative of DFO as a step in developing an overview to define and assess territories to be managed in response to the *Oceans Act*. As outlined in Section 1.1, the *Oceans Act* was enacted in Canada in 1996, giving DFO the responsibility to develop a strategy for the IM of the estuarine, coastal, and marine environments of Canada.

The Oceans Strategy was introduced in July 2002. The Strategy meets the requirements of the *Oceans Act*, and is aimed at increasing public participation in the management of marine activities, through the implementation of a planning process for the IM of Canada's coastal and marine areas.

The first step proposed was to define and assess the territories to be managed in order to account for economic, ecological, and social components when making decisions that affect these territories. Under Canada's Ocean Action Plan, the DFO Gulf Region, in cooperation with its area offices, is facilitating the development of ecosystem overviews at the community coastal management level. These overviews will serve as the basis for analyses as part of the IM process of these coastal zones.

Eight individual draft EOARs were compiled within the Northumberland Strait Area of Interest: Richiboucto, Bouctouche, Cocagne, Shediac, Shemogue, Baie Verte, Pictou Harbour, and Bedeque Bay. These overview reports are compilations of information from scientific, statistical, social, and economic study reports, as well as traditional and local information. The intended audiences are managers, partners, and stakeholders throughout the IM processes. To date, these individual EOARs remain in draft form.

7.2 GULF OF ST. LAWRENCE INTEGRATED MANAGEMENT INITIATIVE (GOSLIM)

The Gulf of St. Lawrence was identified by the Canadian Ocean Action Plan as one of five priority Large Ocean Management Areas in Canada. The Gulf area has been managed primarily by DFO since 2001, with a goal of focusing on science to develop ecosystem objectives for EBM of the fisheries.

The Gulf of St. Lawrence initiative concentrates on Health of Oceans, Oceans and Science Technology, and Integrated Oceans Management for Sustainable Development.

In particular, integrated resource management, the development of ecosystem objectives, as well as seabed mapping, are considered priority tasks. The initial goal of GOSLIM is to describe the Gulf of St. Lawrence ecosystem and to identify activities and issues from a broad Gulf-wide perspective.

Tools used to manage the Gulf of St. Lawrence include EOARs, identification of Ecologically and Biologically Significant Areas, seabed mapping, and development of ecosystem objectives. The process involves federal, provincial, and First Nations governments, and other stakeholders.

The GOSLIM initiative explains why the Gulf of St. Lawrence is a unique ecosystem with complex oceanographic processes and a high biological diversity of marine life. The report provides an overview of the physical, biological, and human systems in the Gulf, and summarizes the stressors, issues of concern, and key human activities impacting the ecosystem.

7.3 SOUTHERN GULF OF ST. LAWRENCE COALITION ON SUSTAINABILITY

Created in 1999, the Southern Gulf of St. Lawrence Coalition on Sustainability (SGSLC) involves non-governmental, community, private, and all levels of government stakeholders in NS, NB, PEI, and Québec. Its mission is to promote the long-term viability of the Southern Gulf of St. Lawrence ecosystem.

The SGSLC identifies pertinent long-term ecosystem issues within the southern Gulf of St. Lawrence watershed and coastal ecosystems, and uses these issues as guidelines for initiatives and projects. Out of 350 identified issues, the top three include the need to harmonize government policies, threats to natural habitat, and a need for increased awareness and knowledge about the region.

The SGSLC currently has seven working groups addressing the identified issues:

1. Science, Research & Habitat
2. Fund
3. Coastal Erosion
4. Communication & Education
5. Technical Advisory
6. TEK

SGSLC projects include a coastal erosion annotated bibliography, the Sustainable Communities Initiative Project, an Indicators workshop, and a climate change and coastal communities workshop. Each year, a conference is held on an environmental issue important to the watershed. In the past, these issues have included climate change, alternative energy, and sewage disposal.

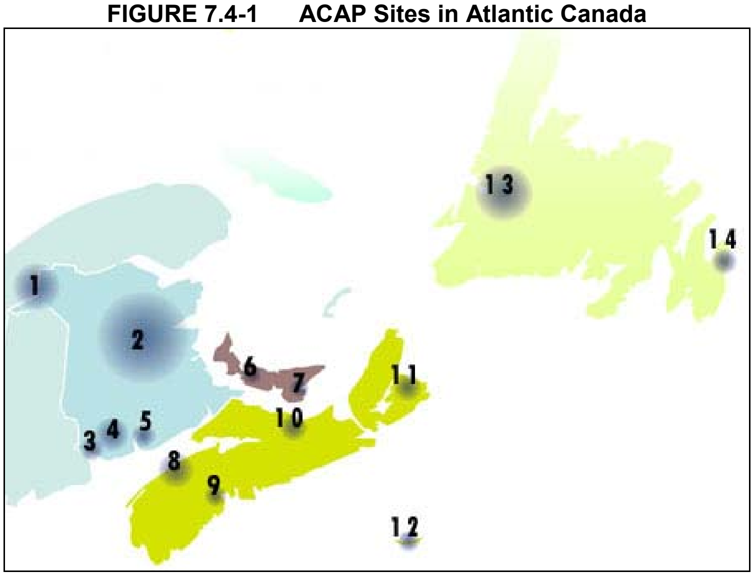
The SGSLC Archives are available at the following website: http://www.coalition-sgsl.ca/archives.php and include project, workshop, and conference documents.

7.4 ATLANTIC COASTAL ACTION PROGRAM (ACAP)

The Atlantic Coastal Action Program (ACAP) is a community-based initiative of EC. Initiated in 1991, its goal is to help Atlantic Canadians restore and sustain watersheds and adjacent coastal areas. ACAP is currently made up of 14 organizations in the four Atlantic Provinces. Each one of these non-profit organizations operates independently, but is formally linked under the umbrella of ACAP. ACAP works with communities towards developing sustainable coastal-based livelihoods, and helps define common objectives for environmentally appropriate use of their resources and the plans to achieve those objectives.

Figure 7.4-1 shows the locations of ACAP sites in Atlantic Canada. Organizations around the Northumberland Strait include the Miramichi River Environmental Assessment Committee (MREAC) in NB (#2), the Bedeque Bay Environmental Management Association in PEI (#6), the Southeast Environmental Association in PEI (#7), and the Pictou Harbour Environmental Protection Project in NS (#10).

FIGURE 7.4-1 ACAP Sites in Atlantic Canada



ACAP sites each have their own unique environmental concerns, and Comprehensive Environmental Management Plans have been produced for each site. Furthermore, a list of ACAP publications is available through the ACAP website at:

http://atlantic-web1.ns.ec.gc.ca/community/acap/default.asp?lang=En&n=D2574285-1

These publications include: economics, science, guidebooks, newsletters, academia, journal, workshop, conference, and symposium papers; and reports.

Those ACAP sites located in the Northumberland Strait are also involved in the SGSLC.

7.5 MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE (MREAC)

The Miramichi River watershed drains a territory comprising one-quarter of NB's surface area. It measures approximately 13,000 square kms (km^2), of which 300 km^2 is an estuarine environment in the inner part of Miramichi Bay. This estuarine environment is where the geographical mandate of MREAC and the Northumberland Strait EOR overlap.

Formed in 1989 MREAC was a response to an expansion of the Miramichi Pulp and Paper Mill. The Committee's original mandate was to protect the internationally renowned Miramichi River and its watershed from environmental degradation.

In 1989, MREAC conducted an evaluation of the health of the Miramichi watershed. The "MREAC Final Report" was completed in 1992, revealing that the Miramichi River was not as environmentally degraded as previously suspected, but recommending that the river be subject to continued surveillance. MREAC implemented a comprehensive environmental program.

In 1992, MREAC became affiliated with ACAP, a division of EC, combining resources and knowledge to better help coastal communities set objectives and strategies for the future. In 1993, MREAC became an ACAP site, allowing it to hire full-time staff and establish a business office.

MREAC's activities include constructive consultation, cooperation, and partnering with government, industry, municipalities and other stakeholders wherever possible. The Committee supports the advancement of scientific knowledge, and promotes an appropriate level of enforcement of environmental regulation. MREAC is actively involved in independent environmental monitoring, and ventures beyond the watershed boundaries to understand external factors impacting the watershed.

Current MREAC initiatives include: environmental management plans; environmental monitoring; research on climate change, air quality, water quality, communities and land use; waste stream management; public awareness and information; and international twinning.

7.6 BEDEQUE BAY ENVIRONMENTAL MANAGEMENT ASSOCIATION

Established in 1992 by ACAP, the Bedeque Bay Environmental Management Association is a not-for-profit organization focusing on sustainable, community-based ecosystem management, with a goal of integrating economic growth and environmental conservation. As shown in Figure 7.6-1, the Bedeque Bay Environmental Management Association's territory is located on the south shore of PEI near Summerside. It includes three watersheds and the coastal area around Bedeque Bay. The territory consists of rolling terrain, woodlots, agricultural land, and various freshwater and saltwater environments. Bedeque Bay contains saltmarshes that provide breeding and migrating habitat for waterfowl and shorebirds.

FIGURE 7.6-1 Bedeque Bay Environmental Management Association Territory

Bedeque Bay Environmental Management Association projects include education, research, and environmental action. Key management areas include erosion control, water quality monitoring, natural habitat conservation, public education, and climate change.

7.7 SOUTHEAST ENVIRONMENTAL ASSOCIATION

Created in 1992 by ACAP, the Southeast Environmental Association is a community stakeholder group that focuses on bays and estuaries as well as the watersheds that feed them. Southeast Environmental Association aims to protect, maintain, and enhance the ecology of the territory, with consideration given to the environmental, social, and economic components of the area.

Southeast Environmental Association projects include water conservation, water quality monitoring, education, land stewardship, biodiversity and habitat, energy conservation, climate change, and litter. The Water Conservation project involves two phases, the first allowing an accurate measurement of the total residential water usage in the area, and the second phase intending to show how the average usage can be reduced.

A 2005 survey conducted for all ACAP sites reviewed the status of data sharing between groups. It was found that data management was lacking for most groups due to a lack of technical expertise, staff, and time resources. Results of the survey recommended the development of a standardized template for data entry for common monitoring programs, including water quality monitoring. The survey also found a need for tools that facilitate data sharing, analysis and manipulation, improved capacity-building opportunities, and promotion of the GeoConnections Discovery Portal as a means of increased data sharing between ACAP groups and provincial and federal governments.

7.8 PICTOU HARBOUR ENVIRONMENTAL PROTECTION PROJECT

The Pictou Harbour Environmental Protection Project (PHEPP) is also an ACAP project. Since its inception, PHEPP has undertaken several projects focused on the environment of coastal Pictou County. These projects include community knowledge generation and support activities. Goals have been the support of existing and new scientific and technical knowledge, studies for efficient energy use, promotion of community-based approaches to environmental protection such as fish habitat protection and environmental education, and investigation of the sustainability of rural forestry-dependent communities. A water and air quality monitoring program has been implemented, and household hazardous waste disposal awareness has been promoted. Immunological biomarkers have been developed for fish and bivalve molluscs, to aid in a better understanding of the marine environmental health of Pictou Harbour.

PHEPP has focused on community capacity-building and providing support to partners. It is important to identify common goals between different groups, and to establish trust, enabling consensus decision-making. PHEPP has partnered with the Pictou Landing First Nation to meaningfully engage the group in the development of community sustainability projects.

Another focus involves the reduction of habitat degradation and increased efforts aimed at habitat enhancement. Aquatic environmental health and habitat in Pictou Harbour and its watershed have been monitored and enhanced through activities such as stream clean-ups, pollution prevention, habitat restoration, and habitat surveys.

The Pictou Airshed Management Project has quantified local emission sources affecting local air quality. The project has been aimed at better understanding the relationships between pollution sources and pollution receptors. This knowledge will contribute to a future air management strategy.

PHEPP has addressed the loss and degradation of natural capital within the Pictou Harbour estuary ecosystem. Activities have included pollution prevention, air quality improvement, climate change education, a reduction in toxic loadings, biodiversity conservation, and habitat remediation. Community volunteers and partners have participated in collecting and evaluating various project data.

A further new project aims at initiating and supporting partner actions that promote community sustainability by reducing air pollution, and addressing the issue of climate change. While there are many ongoing individual initiatives, PHEPP has identified a need for collective community-based action, such as municipal environmental management systems. As well, PHEPP encourages ‘lichens-as-bioindicators’ studies to be undertaken by students during science classes.

7.9 LOBSTER AND SCALLOP ENHANCEMENT REJUVENATE (LASER) PROJECT

Work regarding lobster and scallop enhancement may be integrated into ecosystem initiatives. Activities such as a Lobster and Scallop Enhancement Rejuvenate (LASER) Project are being considered by the Botsford Professional Fishers Association. The project proposal lays out a five-year plan for the undertaking of three years of research followed by a two-year commercial start-up period. The final goal of the project is a permanent aquaculture venture. Cages would be strategically placed to create an artificial reef, habitat for lobster, and a new ecosystem for further fish and plant communities.

Incentives for such a project include the fact that cages currently in use become fouled with plankton, phytoplankton and other micro-organisms, in turn creating food for other fish species. These cages could be applied to mussels and oysters by placing the cages at different water depths.

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8.0 TECHNICAL CONSULTATION AND PUBLIC PARTICIPATION

8.1 TECHNICAL CONSULTATION

AMEC convened a series of four technical workshops in late October and early November 2006 as part of the overall Northumberland Strait EOR process. The workshops were intended to focus on scientific and technical issues related to the physical environment, MEQ, biota, and governance, and one workshop was held on each of these specific subject areas.

The objectives of these workshops were to:

- review the current status of scientific information related to the Strait;
- identify key issues;
- identify information gaps; and
- identify and prioritize research needs.

Following the completion of the four workshops, AMEC provided individual proceeding reports to DFO, who in turn distributed the Reports to the workshop attendees. These Proceedings Reports have been distributed for review and comments but have not yet been finalized. The Proceedings Report for each of the four disciplines is provided in Appendix B.

8.1.1 Location and Timing

The venues and dates for the technical workshops were presented in Table 8.1-1:

TABLE 8.1-1 Technical Workshops – Location and Timing

Topic	Date (2006)	Location	Venue
Physical environment	October 12	Moncton, NB	GFC boardroom and auditorium
MEQ	October 18	Stellarton, NS	NS Museum of Industry
Biota/biology	October 20	Summerside, PEI	Loyalist Inn
Governance	October 30	Moncton, NB	GFC boardroom and auditorium

DFO expressed some concerns about the adequacy of information and discussions at the MEQ workshop. Due to scheduling conflicts, several key DFO research scientists could not attend the MEQ workshop (October 18, 2006, in Stellarton, NS) and as a result DFO felt that some key environmental issues had not received the attention that they warranted at the workshop. DFO wanted to focus the discussions on some of the key problems. To that end, DFO invited specific technical and research staff to attend a follow-up meeting, and to contribute their knowledge and experience to the overall MEQ issue in the Northumberland Strait. The meeting was held on November 9, 2006 at the Gulf Fisheries Centre in Moncton, NB. The Proceedings Report provided in Appendix B captures this follow-up meeting.

8.2 PUBLIC PARTICIPATION

A project-dedicated public website was developed and maintained throughout the course of the study (http://www.northumberlandstraiteoar.com/home.htm).

The website features items such as terms of reference, scientific papers, progress reports, major presentations, primary personnel contacts, links to appropriate federal and provincial sites and other stakeholder sites (as permitted), and contain easily downloadable bilingual content.

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9.0 RECOMMENDATIONS AND RESEARCH NEEDS

The objective of this EOR is to set the stage for the future development of IM plans, protection of the environment, resource conservation, or recovery strategies. This report is not intended to resolve the issues facing the Strait - the EOR is to support identification of ecosystem objectives within the Northumberland Strait and provide direction for governance, monitoring and science. In accordance with this objective, the subsections below present the recommendations and research needs coming out of this EOR process, to address the gaps in information necessary to better understand the status and trends of the Northumberland Strait ecosystem.

The recommendations and research needs have been presented within respective project disciplines. The recommendations and research needs have not yet been formally prioritized - collectively or within their discipline. It is understood that the finalization and prioritization process will be completed by the Working Group.

9.1 PHYSICAL SYSTEM

9.1.1 Oceanography

The following summarizes the actions recommended in order to achieve a greater understanding of oceanographic processes in the Strait to allay some existing concerns expressed throughout this document.

The rights to the Sustainable Communities Initiative (SCI) oceanographic data sets should b e obtained and these data used to conduct a model study of 3-dimensional currents in Abeqweit Passage. The present state of the art is vastly superior to that existing during Confederation Bridge construction and the new models may help resolve concerns that the Bridge has caused changes in the tidal regime in the Strait. Furthermore, application of the models to the monitoring periods will provide a good test of their ability to reproduce important 3-dimensional flows, including the mean set and its variation with hydrological variability (summer stratification). This exercise is of more than academic interest in that these flows very likely affect many aspects of the ecology in the Strait in ways we as yet do not understand. As a first step of study, it would appear to be appropriate to test modelling of these currents.

A long-term hydrographic reference station should be established in the Strait. Although it is an area of relatively high vertical mixing and hence relative vertical uniformity, currents in the Strait appear to be sensitive to the presence of even modest stratification. Observations of that stratification will play an important role in quantifying conditions during other sampling programs and hence provide an important component of the meta-data recorded attached to those samples. In addition, observations of the properties of water masses in the Strait are essential to the evaluation of predicted change, whether climatic or seasonal, and will form a basic oceanographic data stream that will have application in a variety of areas.

After a level of commitment is established, a meeting of key workers in the modelling field should be convened to further resolve the best model approach and/or the best location for monitoring for model verification, for the physical study components of an IM system. Based on input received during the technical consultations (Appendix B), the meeting should include representatives from DFO/BIO, Maurice Lamontagne Institute, and Dalhousie University as a minimum.

9.1.2 Marine Geology

One of the major habitat concerns in the Northumberland Strait is related to an understanding of the source of fine-grained sediments, their potential associated contaminants, pathways of transport, and eventual depositional sites. There is some evidence that fine-grained sediments (floc) are being deposited on gravel seabeds in the central area of the Strait in a region that represents important habitat for lobster and scallop. Very little is known about these fine-grained sediments overlying gravel, and it is not understood where these sediments are sourced from, their residence time on the gravel seabeds, their associated contaminants if any, their composition, and their eventual depositional locations. The following is a discussion of potential study options to address this issue.

Kranck (1971) mapped depositional areas throughout the Strait. Although it is not known if they have changed over time, knowledge of regional conditions suggests that in general, the depositional areas likely remain the same with minor variations. A multibeam bathymetric survey of the areas of sediment deposition would provide an understanding of how sedimentation has changed since the first survey. The multibeam bathymetric backscatter information would define sediment type and depositional areas in detail, and allow a comparison with the results of the previous mapping to assess if the sediment areas have remained the same, are eroding, or increasing in size. Based on a multibeam bathymetric survey, type section cores could be located and collected to investigate the most recent history of sedimentation including contaminants. Together with high resolution sediment dating techniques, it is possible to obtain a clear picture of the recent history of inputs to the Strait.

Another approach to an assessment of change to the seabed of Northumberland Strait would be to rerun the sidescan survey lines that were collected in Abegweit Passage before the construction of the Confederation Bridge. This pre-Bridge older survey is a high resolution baseline of information on sand bedload transport at the seabed and the deposition of sand in areas of large bedforms. Modern sidescan sonograms could be collected, compared, and contrasted with the older data set to assess if change has occurred, and the nature of that change. An increase or decrease in current velocity affecting the transport of sand would be evident from such a survey. Additionally, the survey would determine if the major sand bodies have shifted their position. It would also assess if and how the Bridge footings are affecting sand transport through the central Strait, as the earlier surveys clearly show widespread sand in transport through the Abegweit Passage.

The existing multibeam bathymetry from the Abegweit Passage area has never been interpreted. This could be undertaken using, as ground truth, the sidescan sonograms, seismic reflection profiles, and grab samples that were previously collected in the same area. These data sets have never been integrated with the multibeam bathymetry. It would provide an important baseline assessment for comparison with new surveys that are conducted. Both multibeam bathymetric and sidescan sonar surveys were undertaken before the Bridge was constructed and largely within the same timeframe.

The ultimate survey to assess present processes on the seabed of Northumberland Strait would be a full multibeam bathymetric survey of the entire area. Particular emphasis should be placed on the previously interpreted depositional areas and also the zone of Malagash Mud. This mud was identified as a glacial mud presently undergoing erosion. It is not known if this mud deposit is the source of fine-grained sediment that has been observed to overly the gravels in the central Strait. Areas that require a higher resolution understanding because of their importance or complexity should be surveyed with sidescan sonar systems following regional multibeam bathymetric surveys.

The multibeam bathymetry should be processed for backscatter and seabed slope as well as bathymetry. Follow up ground truth cruises to collect targeted seabed samples, cores and bottom photographs, as well as seismic reflection information for the third dimension, are essential components of a comprehensive study. Such a data package would allow a full interpretation of the existing seabed conditions, processes and materials, sediment transport pathways, and sinks. A targeted study could address the effects of bottom fishing, particularly scallop raking, concerning the role it may play in the supply of fine-grained sediments to the transport system. The effects of scouring pressure ridge ice keels as an erosive seabed process should also be studied.

9.1.3 Biogeochemistry

The potential for the Strait to receive contaminants from local estuaries or the Gulf must be considered in future studies of this region. Pathways of water and sediment transport can be used to quantify some of these fluxes. It is also important to understand the geochemistry of the Northumberland Strait in the context of its associated estuaries and bays. Although there are no indications of contaminants or other problems in Strait sediments, there are few data available with which to make this judgment. The sedimentological setting suggests that there are no depocentres in the Strait in which to trap fine grain sediments and associated organic matter. However, more detailed facies maps reveal the occurrence of muddy sediments in the Strait which should be included in survey or monitoring programmes.

A survey of baseline conditions of sediment geochemistry should be implemented as a foundation to further ecosystem assessment of the Northumberland Strait. A series of cross-Strait transects could be sampled, with locations extending into the major bays or estuaries. The location of the transects should also be planned with respect to facies distribution so that muddy sediments can be included. Sediment sampling should be accompanied by CTD casts and dissolved nutrient samples. Analysis of sediments should include grain size, carbon, hydrogen, nitrogen (CHN), and a selection of heavy metals and persistent organic pollutants. Metal analyses should be normalized to lithium to account for grain size differences (Niencheski et. al., 2002). This program will provide a benchmark for future assessment of ecosystem health in the Strait region.

Geographic Information Systems (GIS) analysis of the surrounding watershed should be undertaken to measure inputs of nutrients or other materials to the Strait via associated estuaries. This is an essential step in quantifying estuary-Strait coupling with implications for assessing eutrophication and dispersal of contaminants.

9.2 BIOLOGICAL SYSTEMS

The biological systems of the Northumberland Strait are complex and in many cases difficult to access and to study. As a result, much investigation into the biological systems of the Strait has been focused on species of significant commercial value, or on potential threats to the habitat of the valued biotic components. Unfortunately, this makes it more difficult to develop an overall understanding of the ecological communities of the Strait, how they interact, and how they respond to threats.

This EOR has acted as a consolidation and organization of biological knowledge of the Strait. Many critical knowledge gaps have become apparent as a result of this process. The challenge is to judiciously apply the resources available to continue to deal with the immediate threats and stresses on valued biological components, while still continuing to investigate the system as a whole in order to gain a more complete overall understanding of ecology, in order to become confidently proactive in dealing with future threats and even encouraging positive ecosystem changes. A statement at the technical workshop on Governance held as part of this EOR process perhaps makes the point best: "It is impossible to manage what you don't understand." An overarching recommendation may be to strive to more completely understand the ecological interactions affecting the biota of the Northumberland Strait.

The technical consultation session on Biota/Biology of the Northumberland Strait identified key issues, information gaps, and priority research needs for finfish, shellfish, plants, and invasive species in the Northumberland Strait (Appendix B). Those findings are presented as recommendations in the sections below.

9.2.1 Finfish

The key issues with regard to finfish management revolve around: the lack of fisheries independent data; the lack of quantification and qualification of populations of harvested species; and, a poor understanding of what affect issues such as decreased market values, increased value of substitute species, increase in costs, etc. may be having on decreased landings.

With regard to information gaps, the basic biology of major species is considered fairly complete, however, little is known about species abundance. Landings independent data and data for immature stages are lacking. The commercial fishery is not monitored to the needed level of accuracy.

A number of possible solutions were identified, with the recommended research priority being:

- fisheries independent monitoring of fish populations and biology; and
- better monitoring of commercial species landings.

9.2.2 Shellfish

The key issues for shellfish populations were identified as: serious declines in lobster and scallop landings, over-harvesting, the negative impacts of effluent outputs, sedimentation and storm surges, and habitat degradation resulting in loss of habitat.

The basic biology of shellfish is understood, but there is a serious gap with regard to the possible impacts of sedimentation and sediment movement on shellfish larvae. Other information gaps include: knowledge of the carrying-capacity of harvested species, the effects of habitat alteration, effects of sedimentation, re-suspension of sediments, nutrient levels, and anoxic areas for near-shore species.

A number of possible solutions were explored with the highest priority for study being:

- the extent and effect of habitat alteration; and
- the extent and effects of sedimentation/re-suspension of sediments in the water column.

9.2.3 Plants

The key issues identified with regard to marine plants in the Strait were: excessive growth of some less desirable species; disappearance of some species such as kelp, Irish moss, eel grass; increased turbidity; and the increases in anoxic areas due to eutrophication and excessive algal growth.

A major information gap is in relation to excessive nutrients from land-based sources and the effect it is having on plant communities. The highest priority for investigation is with regard to excessive nutrient inputs and effects on the wider biotic communities of the Strait.

9.2.4 Invasive Species

Invasive species pose a biological threat to indigenous species, a financial threat to fisheries, and an ecological threat to ecosystem balance.

There is a good understanding of the existing levels of invasion in the Strait, but little good information on where and how fast present invasive species are expanding and what possible further incursions may be made by new invasive species which are in water nearby.

Priority areas for seeking additional knowledge include detailed and well maintained distribution mapping. Current species and threatening species need to be risk and trend analyzed with regard to risk to ecological systems and fisheries. Methods for mitigating or limiting the spread of invasive species, without detriment to resident species, requires research.

9.3 HUMAN SYSTEM

9.3.1 Governance Structures

With respect to the Northumberland Strait, the legislative and regulatory framework involves many federal, provincial and even municipal (land use planning) levels of government. The EOR process has identified limitations in the ability and capacity of DFO to influence other regulatory bodies. Recommendations are presented below.

The applicability and suitability of the Regional Committee for Oceans Management as a model to emulate for Northumberland Strait governance should be investigated. The Regional Committee for Oceans Management is considered to be a legitimate practice which has evolved from an environmental assessment orientation to a broader process. There is a need to evaluate the integration of the Regional Committee for Oceans Management, IM, and the *Oceans Act.* A similar process has been implemented for the Eastern Scotian Shelf.

The processes that are evolving from the Northumberland Strait Working Group approach need to be legitimized. The structure and procedures put into place should be able to continue. It should be recognized that the current approaches, modified as necessary, are the beginning of a long process to effectively manage the resources of the Northumberland Strait. Adequate funding to ensure that the process is sustainable in the long term is required.

The direct participation of as many regulators as possible in the EOR process should be encouraged and enhanced. In particular, federal and provincial departments responsible for environment and agriculture should be engaged in the discussion so that they can gain first-hand appreciation of the issues and, accordingly, frame their policy formulation and decision-making in the context of the Northumberland Strait EOR process. It must also be recognized that effective accountability requires a strong top-down effort. The timing for more integrated participation is opportune as the committee of Deputy Ministers (resulting from the July 31 2006 PEI summit) is being held accountable for the broader Northumberland Strait process, and the channels of government communication (federal and provincial) can be leveraged to stimulate better engagement of relevant departments and agencies. In short, there is a need to formalize, fund, and broaden the participation in the EOR process, including non-traditional partners such as provincial economic departments. Some of these issues could be furthered through the *Fisheries Act* renewal discussions.

The concept of a single entity having a high level of jurisdiction over the Northumberland Strait should be considered. The above-noted approaches provide opportunity for the many federal, provincial, municipal, Local Service Districts, First Nations, Aboriginal peoples, CSOs, and NGOs to work together. However, they do not necessarily allocate one group as having the highest level of decision making, authority, and responsibility. Perhaps the model that comes closest to this concept in eastern North America is that applied to the Gulf of Maine. The Gulf of Maine Council on the Marine Environment (see www.gulfofmaine.org/council) is a

> "partnership of government and non-government organizations working to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations."

While the participating governments maintain their jurisdictions, they do prescribe to all aspects of the Council including adhering to missions and action plans. Since its establishment in 1989, the Council has had considerable impact on long-term planning and decision-making.

Categories for specific tangible targets, timelines and measurable indicators regarding the socioeconomic and resource parameters that need to be changed (i.e., stabilize landings by 2008) should be articulated. The notion of time scales is very important and in many cases immediate action is warranted and possible. In many cases the regulatory tools are in place, but connecting harmful alterations and ecosystem impacts is difficult. There is a need for improved timeliness and responsiveness.

Ways and means to streamline the regulatory framework in the context of potentially suitable models that have been applied elsewhere, and incorporate the ongoing work of other parties with interest or jurisdiction in the Strait, should be investigated.

9.3.2 Human/Industrial Activity

The socio-economic impacts resulting from changes in the Northumberland Strait are evident particularly in reduced fisheries landings and values. The twelve western and central statistical districts in the Northumberland Strait area are now experiencing combined total annual revenues across the four main fisheries that are approximately $7.5 million lower than they were a decade ago. Given the rising costs of operation, rising costs of living, and economic multiplier effects, the overall socio-economic impacts are considerable.

Although similarly low catches have been observed in the past, current circumstances are different, namely; the situation in the Northumberland Strait is different than catches for other areas in the region, current assessments of stocks and the general health of the Strait ecosystem may not support the view that near-term recovery can be expected, and economic circumstances for fishers and capacity to "absorb" adversity is very different than in the past due to overcapitalization, rising costs, lack of alternative fisheries, divergence from regional trends, lack of short-term hope for resource recovery, and rising family reliance on Employment Insurance.

Population decline encompasses the full range of socio-economic concerns including; economic, physical, social, and cultural deterioration at the community scale. Fishers consistently describe the number of peers, friends, and family members who have left temporarily or permanently for opportunities elsewhere.

The socio-economic concerns raised are not generally disputed, although they may be considered conservative compared to "full-cost" accounting measures that would more fully capture social and ecological concerns. Regardless, the need to address the issues is recognised, and the level of concern serves to motivate ongoing efforts and collaboration. Resource conservation, support for alternatives to the fishery, addressing financial security and industry structure issues, understanding stressors contributing to fisheries declines, and meaningful consultation at community scales, would all be recommended priorities for ongoing work.

9.3.3 Traditional Ecological Knowledge (TEK)

It is recommended that a series of interviews be conducted to update the data to provide current harvester information. Furthermore, a project should be undertaken to build an historical baseline through extensive interviews of local knowledge experts.

9.4 MARINE ENVIRONMENTAL QUALITY (MEQ)

The key MEQ issues for which specific recommendations were developed were identified as:

- Nutrients;
- Sediment;
- Pathogens; and
- Contaminants.

9.4.1 Nutrients

There is a need to develop a nutrient budget model for the Northumberland Strait. DFO should consult with John Roff at Acadia University, who is working on a nutrient model for estuaries. There is a need to understand the work underway at Acadia University, and what information is necessary to advance the understanding of nutrient inputs and distributions within the Strait. This exercise would assist with determining if nutrients could be causing any problems in the open water areas of the Northumberland Strait.

Dr. John Smith, DFO Gulf Region, conducted environmental quality surveys in the Northumberland Strait for several years in the mid- 1990s. He collected monthly samples during the ice-free period, for phytoplankton, zooplankton, CTD, and contaminants. Dr. Smith is now retired and DFO should focus some efforts to organize this survey dataset to make use of this important information on environmental quality in the Strait a decade ago. One report has been completed that synthesized some of this dataset (Waite et. al., 1998), but significant more work is needed to synthesize and interpret the complete dataset.

Monitoring programs for nutrients, whether conducted by government, the private sector or community groups, should be encouraged to measure a consistent set of nutrient parameters and to follow standard methods for surveys and measurements, to improve the comparability of the data.

9.4.2 Sediments

A multi-beam mapping survey of the entire Northumberland Strait should be conducted to define bottom types and identify areas where sediment deposition is occurring (refer to Section 9.1.2 Physical Systems).

In these depositional areas, core sampling could be conducted to determine sediment accumulation rates (refer to Section 9.1.1-9.1.3 Physical Systems).

Dominique Bérubé is a geomorphologist with the NB Department of Natural Resources who has done considerable work in coastal geomorphology. There should be a review of the work completed to date.

Some of the Northumberland Strait lobster fishermen have reported that they are observing a fine grain material that settles on their lines and traps. The material is slimy and sticky and is difficult to remove. Samples of this material should be obtained and analyzed to determine exactly what it is - silt, biological, or some combination.

PWGSC Charlottetown (Don Maynard, pers. comm., 2006) is in the process of obtaining the underwater videos from the developer, taken during the bridge construction, which will then be digitized so the information will be more widely available to address the concerns about erosion and sediment transports and as scientific benchmarks.

The cooperative DFO/fisher TSS surveys that were conducted in 2006 are providing some useful and much needed information. Efforts should be made to continue this work.
A modeling exercise should be undertaken to create a numeric model of a sediment budget for the Northumberland Strait. The results could be used to determine depositional areas which could then be targeted for more detailed studies on the impacts of siltation (refer to Section 9.1.1-9.1.2 Physical Systems).

9.4.3 Pathogens

A history of disease outbreaks in the Northumberland Strait including fish, shellfish, and marine plants should be compiled, and a GIS database should be established. This database can then be examined for patterns of disease outbreaks and any dominant areas of outbreaks could be identified.

Consideration should be given to reinstating the discontinued parasite-monitoring program for fish (Gary MacLellan).

Thomas Landry, DFO Gulf Region, has been conducting a caged bivalve program that focused on measuring growth but not disease. One technical report has been published. This program could be expanded to include monitoring for disease occurrences.

9.4.4 Contaminants

An inventory of all potential sources of contaminants, and the types of contaminants, should be assembled to identify potential problem areas and contaminants of concern. The first priority would be to assemble all of the environmental contaminant data and information from the sources suggested by the meeting participants and provided in this EOR. This assessment would also identify areas where limited data exists.

Once areas and contaminants of concern are identified, sediment samples should be collected at those locations to obtain up-to-date information on the current environmental quality. The focus of any investigations about contaminants should be the estuaries, harbours, and near-shore areas (refer to Section 9.1.3 Physical Systems).

The Mussel Watch program should be reinstated in Northumberland Strait.
Pesticide monitoring could be added to the Community Aquatic Monitoring Project.

There have been some studies that looked at immunological responses in bivalves (St.-Jean et. al., 2003). This research could be continued and expanded to other areas in the Strait.

Any sediment-coring program aimed at assessing sediment deposition could also include measurements for pesticide residues (refer to Sections 9.1.1-9.1.3 Physical Systems).

There should be more efforts to develop biomarkers such as the research being conducted by Wayne Fairchild, DFO Gulf Region.

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APPENDIX A
Northumberland Strait Ecosystem Initiative Government/Stakeholder Working Group Member List and Methodology of Study

Northumberland Strait Ecosystem Initiative

Government/Stakeholder Working Group

Terms of Reference

Revised, September 2006

Mandate

The Northumberland Strait Ecosystem Initiative was established to bring focus to increasing concerns over disturbing changes in the state of Northumberland Strait ecosystem and the aquatic resources that it supports.

Objectives

It is the purpose of the Northumberland Strait Ecosystem Initiative Working Group to:

- represent all interests in the Strait
- concentrate collective efforts on gathering information on and implementing new studies and monitoring programmes to measure ocean health and marine environmental quality in Northumberland Strait
- assess and validate apparent causality between environmental stressors, fishing activities, land based activities, etc and observed changes in the ecosystem and its resources
- foster immediate action through research and monitoring programmes to elucidate and then address these issues.

Guiding Principles

The principles guiding the Working Group include:

- Communication: In using the approach of information-sharing and openness, the Group will seek to reach consensus and avoid duplication.
- Results-based: The Working Group will focus on achieving environmental results through cooperative action.
- Commitment to action: Members will work cooperatively and with a commitment to take action within their areas of jurisdiction.
- Partnerships: The Working Group will use a partnership approach among jurisdictions, and will recognize and respect the priorities and mandates of these jurisdictions.
- Regular review and assessment: The Working Group will regularly review the results and effectiveness of its work.

Composition

In the interests of economy of action, it is desirable that membership in the Northumberland Strait Ecosystem Initiative Government/Stakeholder Working Group not exceed 20 representative of stakeholder interests and government agencies. Each member may be supported by one alternate. In selecting its members, the Working Group will be guided by the objective of ensuring sufficient representation of stakeholders and government agencies with concerns in the Northumberland Strait to adequately serve the interests of all others not directly participating are nevertheless fully represented. To this effect, membership (which may vary from time to time at the discretion of the Working Group itself) will be selected from among the following groups in each of the three Provinces bordering on the Northumberland Strait:

- associations representing the interests of fishers and aquaculturists
- community groups
- environmental non-governmental organisations
- Aboriginal groups
- federal government departments and agencies
- provincial departments and agencies

In addition, *ex officio* participants, representing specific areas of expertise required by the Working Group, may be invited to participate on an *ad hoc* basis as required. These resource persons will be selected from academia, government, industry and the consulting community.

Methods of Operation

The Working Group will meet regularly, in person or by teleconference, to discuss progress on objectives and conduct the business arising from the Mandate and Terms of Reference. The Working Group will operate strictly on a consensus basis.

The Working Group will be chaired by DFO and Prince Edward Island. DFO will provide the secretariat to ensure effective communications and record keeping and to provide for planning of meetings.

Budget and Financial Arrangements

The cost of routine operations of the secretariat will be borne by DFO. Each member of the Working Group will bear the costs of his or her own participation and attendance at meetings. Financing for all projects, studies, research, monitoring or data gathering exercises recommended or undertaken on behalf of the Working Group will be a matter for the Working Group to arrange jointly from existing programmes and funds available to its members or by application to appropriate funding sources.

Annex I: Membership

Elsipogtog First Nation	Mary Jane Peters
Botsford Professional Fishers Association	Donna Murray
Southern Gulf Coalition on Sustainability	Nadine Gauvin
DFO Science	Marc Lanteigne
DFO CHS	Dick MacDougall
EC	Larry Hildebrand
MFU	Eric Arsenault
NB-DELG	Marianne Janowicz
Northumberland Fishers Association	Ronnie Heighton
Little cape Fishermen's Association	Steve Jones
Cumberland North Fishermen's Association	Wallace Allen
NS-DAF	Justin Huston
DFO Fisheries and Aquaculture Management	Laurent Paulin
DFO Oceans and Habitat	David Dunn
PEI-DAFA	Barry MacPhee
PEIFA	Ed Frenette
Maritime Aboriginal Aquatic Resources	Tim Hainer
PEI Aquaculture Alliance	Jean MacDonald
PEI Shellfish Association	Frank Hansen
Transport Canada	Roger Saunders
Parks Canada	Eric Tremblay
UPEI	Irene Novaczek
NS Bonafide Fishermen	Kay Wallace
Shediac Bay Watershed Association	Dominique Audet

Ex Officio / Resource People

PEIFA	Keith Paugh
MFU	Edmond Drysdale
CFIA	Paulette Hall
PEI Shellfish Association	Clifford Bernard
NB-DAFA	Russell Henry
DFO Small Craft Harbours	Jim Morriscay
DFO Antigonish	Ray MacIsaac
DFO Charlottetown	Collin MacIsaac
DFO Oceans	Pierre Mallet
DFO Oceans and Habitat	Ross Alexander
DFO Science	Joel Chassé
DFO Oceans	Wade Landsburg
NRCan	John Shaw
DFO Communication	Krista Petersen

APPENDIX B
Technical Consultation Proceedings Reports

Northumberland Strait
Environmental Overview and Assessment Report
Technical Workshop on the Physical Environment
Draft Proceedings Report

Gulf Fisheries Centre
Moncton, New Brunswick
October 12, 2006

Submitted to:

Fisheries and Oceans Canada
Moncton, New Brunswick

Submitted by:

AMEC Earth & Environmental,

A Division of AMEC Americas Limited
Saint John, New Brunswick

October 23, 2006

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1.0 INTRODUCTION

This report presents the results of the first of four technical workshops conducted in support of the Northumberland Strait Environmental Overview and Assessment Report (EOAR). The workshop was convened on October 12, 2006 at the Gulf Fisheries Centre in Moncton, New Brunswick, and focused on the physical environment of the Northumberland Strait.

In recent years, environmental changes and resource declines have been observed in the Northumberland Strait, a body of water generally delineated by Prince Edward Island, New Brunswick and Nova Scotia. The purpose of the Northumberland Strait EOAR is to provide an overview and insight into the Strait's ecosystem health and challenges.

EOARs are an initiative of Fisheries and Oceans Canada (DFO) in response to the Canadian *Oceans Act* of 1996. Under the Act, DFO must develop a strategy for integrated management of estuarine, coastal and marine environments of Canada. The Oceans Strategy, introduced in 2002, is aimed at increasing public participation in the management of marine activities through the implementation of a planning process for the integrated management of Canada's coastal and marine areas.

The EOAR process is complex and involves a substantial volume of documentation (studies, reports, data, legislation, regulations, etc.), which represents a challenge for communities and stakeholders to digest and understand. As such, a technical consultation aspect has been introduced to the EOAR process. These "technical workshops" are being convened to provide a review of the available information related to the Northumberland Strait and to develop recommendations regarding possible solutions and future courses of action. The workshops will focus on scientific and technical issues (in a narrow sense). Thus, it was determined that four separate sessions covering the physical environment, marine environmental quality (MEQ), biota, and governance would be necessary. The governance workshop will discuss legislative and regulatory response mechanisms as well as present, discuss, and debate the overall findings and cross-cutting themes of the other workshops.

Due to the complexity and volume of the documentation, explanations and discussion in a workshop setting enhance the participants' capacity to more easily understand the scope and purpose of the EOAR. As well, the technical workshops will provide a focus on the availability, reliability, accuracy and timeliness of information and data related to the key ecosystem issues. The technical workshops will also comprise a gap analysis of the knowledge base and an elaboration of potential effects management measures (i.e., actions and recommendations).

Proceedings reports will also be prepared for three future workshops which will address Marine Environmental Quality (MEQ), Biota, and Governance.

1.1 Workshop Objectives

The objectives of the workshop were to:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The workshop agenda is presented in Appendix A.

1.2 Participants

Attendance at the workshop comprised a broad representation from government, academe, the scientific community, industry, and non-governmental organizations. A list of participants is provided at Appendix B.

1.3 Workshop Process

The workshop was subdivided into two sessions. The morning session comprised eight presentations summarizing the body of existing information on the physical environment of the Northumberland Strait, followed by a question and answer period (Appendix C). The topics of the presentations, as well as the presenters and their respective affiliations, were as follows:

- Jacques Paynter AMEC "Overview of EOAR Process"
- Gordon Fader AMEC "Substrate Characteristics"
- Mark McNeil AMEC "Ocean processes"
- Jon Grant AMEC "Geochemistry";
- Brent Law BIO "Update on current findings from the Northumberland Strait Total Suspended Solids (TSS) Sampling Program"
- Gerard Costello CHS "Canadian Hydrographic Survey (CHS) multi-beam platforms"
- John Shaw BIO "Sediment Transport"
- Steve Jones Little Cape Fisherman's Association "Underwater Video Transects - Sedimentation Effects on Commercial Fishing in the Northumberland Strait".

The afternoon session focused on identifying information gaps and specific scientific research and project requirements needed to close information gaps. The participants also prioritised the research and project requirements.

1.4 Structure of the Report

This report is structured as follows:

- **Chapter 2.0** Summary of Presentations – provides an abstract of each the presentations.
- **Chapter 3.0** Summary of Discussion Session – provides the overall consensus items from the discussions in terms of identification of key issues, understanding of existing information and gaps, the required research and the prioritization of that research.

- **Chapter 4.0** Conclusion and Recommendations

2.0 PRESENTATIONS

The following section provides a brief synopsis of each presentation. All presentations are provided in Appendix C.

Overview of the EOAR Process

In recent years, environmental changes and resource declines have been observed in the Strait. The Strait provides livelihoods to many commercial fishermen and their families through a diversity of fish species and marine resources. The Northumberland Strait EOAR intends to provide an overview and insight into the Strait's ecosystem health and challenges. Acquiring this understanding has become a critical focus of the affected organizations and individuals. This collective investigative approach is referred to as the Northumberland Strait Ecosystem Initiative.

The EOAR functions as a planning tool under the Oceans Action Plan to define and assess a management area in support of Integrated Oceans Management planning and decision-making. The objective of the EOAR is to engage stakeholders in a coordinated and integrated management process, support identification of ecosystem objectives, and provide direction for governance, monitoring and science.

Substrate Characteristics

The substrate of the Northumberland Strait has been altered historically by glaciation and sea level rise. Observations of the changes in the Strait date from the earliest systematic seabed and sediment mapping programs of Kranck, 1972 and Loring and Nota, 1973 to a recent multibeam bathymetric survey, including high-resolution seabed mapping programs completed for the Confederation Bridge construction.

Based on the presented geoscience information on materials, morphology and processes, an understanding of the character of the seabed of Northumberland Strait is presented. This can be placed in the context of both "before and after" construction of the Confederation Bridge, and modern and relict processes that have and are continuing to affect the seabed. An assessment of the quality and quantity of geoscience information are discussed as well as the remaining questions that need to be answered to adequately characterize and understand the seabed of the Strait.

Ocean Processes

This presentation focused on the physical oceanographic character of the Strait in relation to ecosystem controls and the available data on which to evaluate these controls. The presentation comprised tidal current data, both long term and pre- and post- bridge construction. Tidal models capable of providing a "state of the Strait" output will need ongoing current and stratification input. The former is standard practice in the offshore industry while local instrumentation has been developed to provide the latter. These inputs are not limited by the development of new technologies and could be automated in a fashion similar to the recent storm surge model of the area.

The effect of strong offshore tides on exchange of coastal waters including bays and estuaries is complex. As a starting point the investigator is normally directed to the physical summary handbook for overall statistics. In many cases, however, it is important to determine detailed current patterns. Detailed patterns of pathogen and nutrient levels as well as transport producing bottom stresses need to be addressed on a case-by-case basis. Therefore, the determination of the "assimilative capacity" in these coastal systems often varies with the assessment technique and data available. In the later part of the presentation several specific examples of coastal issues requiring physical oceanographic assessment and the type of approach used and associated data collection are presented.

Geochemistry

For the purpose of the EOAR, the geochemistry of the Northumberland Strait may be considered in terms of natural components of the sediment and water column (organic matter, dissolved nutrients) as well as contaminants (metals, pesticides, hydrocarbons) recognizing overlap in cases such as nutrients which have multiple sources. In general, there is sparse data coverage of the Strait region, despite fairly good coverage of the wider Gulf of St. Lawrence. Because circulation and sediment type are important in the accumulation and adsorption of some compounds, it is feasible to extrapolate from Gulf to Strait sediments, especially for organic matter.

However, the proximity of the Strait to multiple estuaries makes this approach uncertain. Various estuaries have been sampled for contaminants, especially in areas of industrial activity or urbanization such as Pictou or Miramichi, but without specific linkage to sites offshore. A regular monitoring program could be recommended in order to establish present-day geochemistry for the Strait region.

Other Presentations

Information on the other three presentations are not provided in this section as these presentations were extremely brief and are considered to be self-explanatory – refer to Appendix C. The sediment transport presentation essentially comprised several video clips of bottom conditions in various locations in the Strait with the intent of illustrating siltation and sediment deposition. Based on observations made by commercial fishers in the Northumberland Strait, siltation is believed to be a significant environmental contributing factor in the decline of fisheries resources.

3.0 DISCUSSION

3.1 Format

During the afternoon session, the participants agreed that the discussion be structured into three topic areas:

- The physical characteristics of the Strait and seafloor;
- The behaviour of the water in the Strait; and
- Geochemistry.

For each of the three topics, participants followed the format below:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The results of the discussions are presented in the following subsections. It is apparent that there are overlapping themes between the three topic areas which will be addressed in future workshops and elaborated by the EOAR Working Group Physical Environment Technical Review Committee.

3.2 Physical Characteristics of the Strait and Seafloor

3.2.1 Key Issues

The following key issues were identified.

Erosion Relative to the Confederation Bridge: In order to understand the potential erosion problem under the Confederation Bridge, an erosion study of the complete Northumberland Strait would need to be conducted to place the issue in context with the Strait ecosystem. A detailed sediment budget would have to be established, including consideration of estuaries, land run-off, air, coastal processes, resource uses and the water column.

Response to Climate Change: An investigation of the response of the Northumberland Strait to climate change is required, as changes in water levels would affect sedimentation. Sea level rise will impact beaches, the ice regime, and coastal bluff erosion.

Definition of Coastal Watersheds: All watersheds that enter the Northumberland Strait, including tributaries and estuaries, should be defined in order to determine sediment loads originating from within each watershed.

3.2.2 Information Currently Available/ Information Gaps

The information currently available on the Northumberland Strait's seafloor is limited. Approximately 10% of the Northumberland Strait has been covered spatially with a multi-beam survey. The last systematic seafloor survey was completed in the 1940's.

Information gaps include the lack of a study on the sources and effects of fine-grained sediments and of these sediments' deposition centres to determine the link and interaction between estuaries and the Northumberland Strait, as well as a lack of bathymetry and time series data.

3.2.3 Solutions

A multi-beam survey covering the entire Northumberland Strait is required, as well as backscatter, interpretation and ground-truthing. Multi-beam interpretation should be supported by the inclusion of sub bottom-profiler equipment during sampling. Since multi-beam surveys do not capture fine changes in textures, side-scan surveys must also be conducted in site-specific locations where the ocean floor is not clear and higher resolution is required.

Core sediment sampling should be conducted in the main deposition centres to characterize the material and assess temporal changes.

Fine-grained sediment transport must be characterized. However, it will be a challenge to identify appropriate sampling equipment.

In order to understand the connection between the estuaries and the open water environment, estuary shelf models should be created to study water exchange. This may be achieved through enhancement of existing DFO models, and through interpolation of existing data models to new areas. Existing data for such models should be collected from river gauges, from watershed groups, from coastal water temperature series, from wind and tide gauges at the Charlottetown Airport, etc. A model on how climate change will affect nearshore estuaries should be developed. Such a model should include tide changes and the quantity of sediment transport.

Metadata is identified as a critical factor for the interpretation and usefulness of existing or future data, and should be collected and maintained as accurately and completely as possible. A web-based GIS portal should be created and maintained, in order to provide decision-making support and information to as many users as possible.

An effective approach to mapping the nearshore zone (high-water mark to 10 metres) must be devised.

3.2.4 Priorities

After reviewing the issues and information gaps for the container/ seafloor, the following three research projects were identified as priorities and are ranked as follows:

1. Multi-beam mapping;
2. Fine-grained sediment dynamics (, what, when, where, and why); and

3. Nearshore dynamics modelling (land use, saltwater, freshwater, and GIS).

3.3 Behaviour of Water in the Strait

3.3.1 Key Issues

Tides and currents were identified as key issues with regards to physical water behaviour. Circulation dynamics within the entire Northumberland Strait should be determined, including changes to these patterns. There is a lack of real-time and up-to-date data, as the circulation patterns and transport pathways for all elements are dynamic.

The effect of the bridge on ice flow was considered an issue, as well as the effect of decreasing ice cover. There is a lack of knowledge about the ice regime and the impacts and interactions with the tidal regime.

Contaminant loading, whether organic or inorganic, is considered an issue. Also, the effects of natural or man-made alterations to water flow, such as causeways or bridges, should be considered.

Seasonal variability of particulate matter was voiced as a concern.

Lastly, climate change was also noted.

3.3.2 Information Currently Available/ Information Gaps

The information on the physical behaviour of the water within the Northumberland Strait is limited. Approximately 1% of the Northumberland Strait has been covered spatially. Information has been collected for temperature and salinity; however, there is not enough winter data. Water level data has been collected; however, there may not be 100% spatial coverage. Time series data is inconsistent; good for some attributes but missing for others. Universally, improved numerical simulation and modelling for nearshore zones is required. There is a definite lack of ice monitoring data.

3.3.3 Solutions

Data collected for the Confederation Bridge pre- and post-construction must be evaluated. This will provide a baseline and identify information gaps. Current monitoring was conducted pre-bridge construction and should be reinstalled for long term monitoring. The current meter should have CTD profile capabilities.

The ice regime requires further study to determine thickness, freeze-up, and ice-out in the Northumberland Strait.

TSS sampling for the entire Northumberland Strait is currently an ongoing project and will continue into the fall (2006). The TSS results need to be linked to satellite images.

Another aspect that should be studied is geologically determined friction patterns to be included in numerical nearshore bathymetry modelling and simulation.

Mapping of freshness/ buoyancy at nearshore locations is also recommended.

3.3.4 Priorities

The following research projects were identified as priorities and are ranked as follows:

1. Current Meter / CTDD – short term and long term;
2. TSS Sample collection and satellite imagery interpretation – short term and long term; and
3. Improved modelling, including effects of bridge.

3.4 Geochemistry

3.4.1 Key Issues

Determination of any increases in fine-grained sediments in the Northumberland Strait (silt, clay, and organic matter) is required. Nutrient transport/loading from land sources should be investigated. The role of the St. Lawrence River as a large source of toxins for the Northumberland Strait was raised as an issue. The inputs and contaminant loading from other major rivers that drain into the Northumberland Strait may be affecting the ecosystem. Point sources of pollution from mills, fish plants, aquaculture, or other industry are considered an issue. Culverts, barriers, or nutrification in shallow estuaries may be impacting on the Strait's ecosystem health.

3.4.2 Information Currently Available/ Information Gaps

The information currently available on the Northumberland Strait's geochemistry is very limited.

3.4.3 Solutions

Contaminant maps and sediment maps must be overlaid to identify any connections or links between the two. A sampling program should be implemented which focuses on the triage of hot spots. Contaminant load versus natural load should be analysed, to determine whether the natural loads of chemicals are elevated to what would be considered contaminated levels.

A shore-based survey should be conducted, identifying sources of contaminants in each community; this would likely take the form of a desktop study. Such a study would determine where to collect nearshore samples. Core sediment samples must be collected to obtain a history of chemicals identified in sediments.

Water modelling can be used to determine outwelling. Major rivers, such as the St. Lawrence River, should be evaluated to incorporate fine-grained sediment surveys conducted on the Restigouche, and Miramichi Rivers. Groundtruthing and baseline data should be collected for all surveys at once as necessary and possible.

The modelling will commence at the Gulf, move to the Strait and then on to the individuals bays. Before the bays are modelled, there should be a search to determine which bays and rivers have already been modelled. Subsequently, a few significant bays should be selected to be modelled. A good starting point would be to search the Canadian Water Monitoring Network.

3.4.4 Priorities

The following research projects were identified as priorities and are ranked as follows:

1. Shore-based survey;
2. Contaminant and sediment mapping; and
3. Determination of contaminant load versus natural load.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary

The purpose of this workshop was to share information on the present state of scientific knowledge related to the physical environment of the Northumberland Strait. The workshop resulted in the following key findings:

- Identification of the key target areas (physical characteristics / seabed, water behaviour, and geochemistry) related to the physical environment which must be further understood to provide insight into the Strait's ecosystem health.
- A number of ecosystem issues within each of the target areas have been identified.
- Overall, data on the physical environment of the Strait is either not available or is not suitable in its present state to facilitate further understanding of the issues in the Strait. Further study is warranted to improve the reliability, accuracy and timeliness of information and data related to the key ecosystem issues.
- A prioritized list of research projects to eliminate information gaps regarding the Strait.

As a result of the workshop the study areas for the physical environment are:

- Multi-beam mapping;
- Fine-grained sediment dynamics (what, when, where, and why);
- Nearshore dynamics modelling (land use, saltwater, freshwater, and GIS);
- Current Meter / CTDD – short term and long term;
- TSS Sample collection and satellite imagery interpretation – short term and long term;
- Improved nearshore and open water modelling including effects of bridge;
- Shore-based mapping survey;
- Contaminant and sediment mapping; and
- Determination of contaminant load versus natural load.

It is recognized that much of these study areas will blend together as the scope of the prioritized studies become more defined.

4.2 Going Forward

The Workshop was successful from several perspectives:

- The participants have been afforded the opportunity to come together, increase their technical and scientific understating of current status of the Strait's physical environment and discuss common concerns and potential solutions.
- The workshop participants were in consensus regarding key issues, information gaps identified and prioritized study areas.
- All workshop participants expressed positive feedback regarding the day's proceedings and expressed a desire to continue deliberations in the future through appropriate mechanisms.

Northumberland Strait
Environmental Overview and Assessment Report
Technical Workshop on Marine Environmental Quality
Draft Proceedings Report

Nova Scotia Museum of Industry
Stellerton, Nova Scotia
October 18, 2006

Submitted to:

Fisheries and Oceans Canada
Moncton, New Brunswick

Submitted by:

AMEC Earth & Environmental,

A Division of AMEC Americas Limited
Saint John, New Brunswick

October 26, 2006

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1.0 INTRODUCTION

Environmental Overview and Assessment Reports (EOAR) are an initiative of Fisheries and Oceans Canada (DFO) in response to the Canadian *Oceans Act* of 1996. Under the Act, DFO must develop a strategy for integrated management of estuarine, coastal and marine environments of Canada. The Oceans Strategy, introduced in 2002, is aimed at increasing public participation in the management of marine activities through the implementation of a planning process for the integrated management of Canada's coastal and marine areas.

To date, EOARs have been or are being drafted for several areas in the Northumberland Strait:

- Richibouctou
- Bouctouche
- Cocagne
- Shediac
- Shemogue
- Baie Verte
- Pictou Harbour (pending)
- Bedeque Bay

In response to environmental changes and resource declines which have been observed in the Northumberland Strait, it was decided to commission an overarching EOAR to provide an overview and assessment of the Strait's ecosystem health and challenges.

The EOAR process is complex and involves a substantial volume of documentation (studies, reports, data, legislation, regulations, etc.), which represents a challenge for communities and stakeholders to digest and understand. As such, a technical consultation aspect has been introduced to the Northumberland Strait EOAR process. These "technical workshops" are being convened to provide a review of the available information related to the Northumberland Strait and to develop recommendations regarding possible solutions and future courses of action. Since the workshops are intended to focus on scientific and technical issues (in a narrow sense) it was decided to convene four separate sessions covering the physical environment, MEQ, biota, and governance.

This report presents the results of the second of four technical workshops conducted in support of the Northumberland Strait EOAR. The workshop was convened on October 18, 2006 at the Museum of Industry in Stellerton, Nova Scotia, and focused on Marine Environmental Quality (MEQ) in the Northumberland Strait.

Explanations and discussions in a workshop setting enhance the participants' capacity to more easily understand the scope and purpose of the EOAR. The technical workshops focus on the availability, reliability, accuracy and timeliness of information and data related to the key ecosystem issues. The technical workshops also comprise a gap analysis regarding the knowledge base, as well as an elaboration of potential effects management measures (i.e., actions and recommendations).

1.1 Workshop Objectives

The objectives of the workshop were to:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The workshop agenda is presented in Appendix A.

1.2 Participants

Attendance at the workshop comprised a broad representation from government, academe, the scientific community, industry, and non-governmental organizations. A list of participants is provided at Appendix B.

1.3 Workshop Process

The workshop was subdivided into two sessions. The morning session was comprised of three presentations summarizing the EOAR process and body of existing information on MEQ within the Northumberland Strait, followed by a question and answer period. The topics of the presentations, as well as the presenters and their respective affiliations, were as follows:

- Kerry Hughes AMEC "Overview of EOAR Process"
- Roy Parker AMEC "Marine Environmental Quality"
- Steve Jones Little Cape Fisherman's Association "Underwater Video Transects - Sedimentation Effects on Commercial Fishing in the Northumberland Strait".

The afternoon session focused on identifying information gaps and specific scientific research and project requirements needed to close information gaps. The participants also prioritized the research and project requirements.

1.4 Structure of the Report

This report is structured as follows:

- **Chapter 2.0** Summary of Presentations – provides an abstract of each the presentations.
- **Chapter 3.0** Summary of Discussion Session – provides the overall consensus items resulting from the discussions: identification of key issues, understanding of existing information and gaps, the required research and the prioritization of that research.
- **Chapter 4.0** Conclusion and Recommendations

2.0 PRESENTATIONS

The following section provides a brief synopsis of each presentation. The presentations are provided in Appendix C.

Overview of the EOAR Process

In recent years, environmental changes and resource declines have been observed in the Strait. The Strait provides livelihoods to many commercial fishermen and their families through a diversity of fish species and marine resources. The Northumberland Strait EOAR intends to provide an overview and insight into the Strait's ecosystem health and challenges. Acquiring this understanding has become a critical focus of the affected organizations and individuals. This collective investigative approach is referred to as the Northumberland Strait Ecosystem Initiative.

The EOAR functions as a planning tool under the Oceans Action Plan to define and assess a management area in support of Integrated Oceans Management planning and decision-making. The objective of the EOAR is to engage stakeholders in a coordinated and integrated management process, support identification of ecosystem objectives, and provide direction for governance, monitoring and science.

Marine Environmental Quality

Based on the results of the seven previously completed site–specific ecosystem overview and assessment reports and many other studies, the major MEQ issues were identified as impacts on water quality, sediment quality, and climate change. Specifically, the threats to marine water and sediment quality were documented as increased nutrient concentrations, erosion and sediment release, the release of pathogens to the marine environment and the presence of environmental contaminants. In general terms, the sources of these threats were specified, the types of impacts that these threats could cause were outlined and examples of where these issues occur in the Northumberland Strait were provided. As well, the presentation identified the monitoring programs in place to assess the present conditions related to these threats. The presentation also provided information about marine species at risk in the Strait and identified environmentally sensitive areas.

Underwater Video Transects - Sedimentation Effects on Commercial Fishing in the Northumberland Strait

This presentation comprised several video clips of bottom conditions in various locations in the Strait with the intent of illustrating siltation and sediment deposition. Based on observations made by commercial fishers in the Northumberland Strait, siltation is believed to be a significant factor contributing to the decline of fisheries resources.

3.0 DISCUSSION

3.1 Format

During the afternoon session, the participants agreed that the discussion be structured into the following MEQ topic areas:

- Nutrients
- Pathogens
- Sediment
- Contaminants
- Climate Change
- Invasive Species

For each of the three topics, participants followed the format below:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The results of the discussions are presented in the following subsections. It is apparent that there are overlapping themes between the topic areas which will be addressed in other workshops and by the EOAR Working Group Technical Review Committees.

Since the issues, availability of data, solutions and priorities of some of the above-mentioned MEQ topic areas are quite similar; those topic areas are presented in a blended format.

3.2 Nutrients/Pathogens

Key Issues

The key issue identified was increased loading and changes in nutrient composition.

Information Currently Available/ Information Gaps

The available information is not well understood in terms of physical location (i.e., who has it?), geographic range, timeliness, accuracy, or breadth (i.e., for which parameters). Several potential data sources were identified which will be cross-referenced against those presently captured in the EOAR data library.

Solutions

The following solutions were proposed:

- Identify baseline loading and composition conditions and assess temporal changes relative to these conditions. The establishment of baseline conditions would require a data compilation and collation exercise from the various data sources to provide an accurate understanding of what is known and not known (i.e., identification of gaps).

- Identify land-based / near shore influences as well as offshore influences and map these ‘hot spots’ in GIS overlay to focus monitoring efforts.

- Coordinate study efforts with John Roff’s work (Acadia University) on nutrient inputs and distributions.

Priorities

1. Understand work underway at Acadia University and what information is necessary to advance the understanding of nutrient inputs and distributions within the Strait.
2. Compile and collate the available data such that its usefulness relative to the first priority is understood (i.e., metadata).
3. Identify gaps in available information and define a monitoring program to fill those gaps. Consider the studies proposed for the physical environment issues since it is expected that there will be significant overlap in the type of study and nature of monitoring required for both the physical and MEQ issues.

3.3 Sediment

Key Issues

The majority of the issues identified under sediment as an MEQ issue are the same as those discussed during the physical environment workshop. Essentially, a detailed sediment budget would have to be established to consider sources and load, impact to estuaries / near shore environments, air, coastal processes, resource uses and the water column.

Information Currently Available/ Information Gaps

Information gaps include the lack of a study on the sources and effects of fine-grained sediments and of these sediments’ deposition centres to determine the link and interaction between estuaries and the Northumberland Strait, as well as a lack of bathymetry and time series data. As presented in the Nutrients/Pathogens section above, several potential data sources were identified which will be cross-referenced against those presently captured in the EOAR data library.

Solutions

The solutions to the sediment issues were less clearly defined in the context of the MEQ workshop relative to the physical environment workshop. As such, the solutions are similar to those presented in the physical environment workshop, which were:

- Multi-beam mapping;
- Fine-grained sediment dynamics (what, when, where, and why);
- Nearshore dynamics modelling (land use, saltwater, freshwater, and GIS);
- TSS Sample collection and satellite imagery interpretation – short term and long term;
- Improved nearshore and open water modelling including effects of bridge; and

- Shore-based mapping survey.

Specifically, the biological impact of fine-grained sediment transport within the Strait was not considered in MEQ, but will be brought forward to the biota workshop.

Priorities

In terms of understanding the sediment budget within the Strait, the prioritized studies would be:

4. Multi-beam mapping;
5. Fine-grained sediment dynamics (, what, when, where, and why); and
6. Nearshore dynamics modelling (land use, saltwater, freshwater, and GIS).

3.4 Contaminants

Key Issues

The primary issue related to contaminants was the constituents of the material being transported within the Strait.

Information Currently Available/ Information Gaps

The available information is not well understood in terms of physical location (i.e., who has it?), geographic range, timeliness, accuracy, or breadth (i.e., for which parameters). As with the Nutrients/Pathogens issue, several potential data sources were identified and these will be cross-referenced against those presently captured in the EOAR data library.

Solutions

In addition to the solutions presented in previous sections, the following solution was proposed:

- The contaminant load within the Strait must be characterized so that suspect or indicator contaminants can be monitored in a focused manner.

Priorities

The prioritized studies would be:

1. A shore-based survey (desktop study) conducted to identify sources of contaminants in each community. This study must also consider the impact of vessel movements as a contributor to the contaminant load within the Strait, as well as the history of use of the suspect contaminants. This historical review will facilitate temporal understanding of environmental changes within the Strait. Such a study would determine where to collect nearshore samples. Core sediment samples must be collected to obtain a history of chemicals identified in sediments and deviation from background or control levels.

3.5 Climate Change

The consensus amongst workshop participants was that climate change could not be studied in a manner that could be practically applied to understand MEQ issues within the Strait. Climate change is recognized as a likely overall contributor to the environmental changes and resource declines that have been observed in the Strait. Collectively, the decision was to focus efforts on specific studies with direct applicability to understanding the Strait's environmental issues (i.e., sediment budget, contaminant mapping, etc.).

3.6 Invasive Species

The consensus amongst workshop participants was that an evaluation of the impact of invasive species would be best captured in biological discussions at the biota workshop. The presence/absence of invasive species and their proliferation in a given area is likely an indicator of changing MEQ and may warrant further consideration.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary

The purpose of this workshop was to share information on the present state of scientific knowledge related to MEQ within the Northumberland Strait. The workshop resulted in the following key findings:

- Identification of the key target areas (nutrients, pathogens, sediment, contaminants) related to MEQ which must be further understood to provide insight into the Strait's ecosystem health.
- A number of ecosystem issues within each of the target areas have been identified.
- Overall, data on MEQ within the Strait is decentralized and therefore not well understood in terms of its reliability, accuracy, timeliness, etc. A compilation and collation exercise (i.e., metadata) is warranted to understand available baseline information.
- A prioritized list of research projects to eliminate information gaps regarding the Strait is needed.

As a result of the workshop the study areas for MEQ are:

- Understand work underway at Acadia University and what information is necessary to advance the understanding of nutrient inputs and distributions within the Strait.
- Compile and collate the available data such that its usefulness relative to the first priority is understood (i.e., metadata).
- Identify gaps in available information and define a monitoring program to fill those gaps. Consider the studies proposed for the physical environment issues since it is expected that there will be significant overlap in the type of study and nature of monitoring required across both disciplines.
- Multi-beam mapping.
- Fine-grained sediment dynamics (what, when, where, and why).
- Nearshore dynamics modelling (land use, saltwater, freshwater).
- A shore-based survey (desktop study) conducted to identify sources of contaminants in each community. This study must also consider the impact of vessel movements as a contributor to the contaminant load within the Strait, as well as the history of use of the suspect contaminants.

It is recognized that many of these study areas could be combined as the scope of the prioritized studies become more defined.

4.2 Going Forward

The Workshop was successful from several perspectives:

- The participants have been afforded the opportunity to come together, increase their technical and scientific understating of current status of the Strait's MEQ and discuss common concerns and potential solutions.
- The workshop participants were in consensus regarding key issues, information gaps identified and prioritized study areas.
- All workshop participants expressed positive feedback regarding the day's proceedings and expressed a desire to continue deliberations in the future through appropriate mechanisms.

Northumberland Strait
Environmental Overview and Assessment Report
Technical Workshop on Biota
Draft Proceedings Report

Loyalist Inn
Summerside, Prince Edward Island
October 20, 2006

Submitted to:

Fisheries and Oceans Canada
Moncton, New Brunswick

Submitted by:

AMEC Earth & Environmental,

A Division of AMEC Americas Limited
Saint John, New Brunswick

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1.0 INTRODUCTION

Environmental Overview and Assessment Reports (EOAR) are an initiative of Fisheries and Oceans Canada (DFO) in response to the Canadian *Oceans Act* of 1996. Under the Act, DFO must develop a strategy for integrated management of estuarine, coastal and marine environments of Canada. The Oceans Strategy, introduced in 2002, is aimed at increasing public participation in the management of marine activities through the implementation of a planning process for the integrated management of Canada's coastal and marine areas.

To date, EOARs have been or are being drafted for several areas in the Northumberland Strait:

- Richibouctou
- Bouctouche
- Cocagne
- Shediac
- Shemogue
- Baie Verte
- Pictou Harbour
- Bedeque Bay

In response to environmental changes and resource declines which have been observed in the Northumberland Strait, it was decided to commission an overarching EOAR to provide an overview and assessment of the Strait's ecosystem health and challenges.

The EOAR process is complex and involves a substantial volume of documentation (studies, reports, data, legislation, regulations, etc.), which represents a challenge for communities and stakeholders to digest and understand. As such, a technical consultation aspect has been introduced to the Northumberland Strait EOAR process. These "technical workshops" are being convened to provide a review of the available information related to the Northumberland Strait and to develop recommendations regarding possible solutions and future courses of action. Since the workshops are intended to focus on scientific and technical issues (in a narrow sense) it was decided to convene four separate sessions covering the physical environment, MEQ, biota, and governance.

This report presents the results of the third of four technical workshops conducted in support of the Northumberland Strait EOAR. The workshop was convened on October 20, 2006 at the Loyalist Inn in Summerside, Prince Edward Island, and focused on Biota in the Northumberland Strait.

Explanations and discussions in a workshop setting enhance the participants' capacity to more easily understand the scope and purpose of the EOAR. The technical workshops focus on the availability, reliability, accuracy and timeliness of information and data related to the key ecosystem issues. The technical workshops also comprise a gap analysis regarding the knowledge base, as well as an elaboration of potential effects management measures (i.e., actions and recommendations).

1.1 Workshop Objectives

The objectives of the workshop were to:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The workshop agenda is presented in Appendix A.

1.2 Participants

Attendance at the workshop comprised a broad representation from government, academia, the scientific community, industry, and non-governmental organizations. A list of participants is provided at Appendix B.

1.3 Workshop Process

The workshop was subdivided into two sessions. The morning session was comprised of two presentations (Appendix C) summarizing the EOAR process and body of existing information on Biota within the Northumberland Strait, followed by a question and answer period. The topics of the presentations, as well as the presenters and their respective affiliations, were as follows:

- Jacques Paynter AMEC "Overview of EOAR Process"
- Morley Pinsent AMEC "Biota"

The afternoon session focused on identifying information gaps and specific scientific research and project requirements needed to close information gaps. The participants also prioritised the research and project requirements.

1.4 Structure of the Report

This report is structured as follows:

- **Chapter 2.0** Summary of Presentations – provides an abstract of each the presentations.
- **Chapter 3.0** Summary of Discussion Session – provides the overall consensus items from the discussions in terms of identification of key issues, understanding of existing information and gaps, the required research and the prioritization of that research.
- **Chapter 4.0** Conclusion and Recommendations

2.0 PRESENTATIONS

The following section provides a brief synopsis of each presentation. All presentations are provided in Appendix C.

Overview of the EOAR Process

In recent years, environmental changes and resource declines have been observed in the Strait. The Strait provides livelihoods to many commercial fishermen and their families through a diversity of fish species and marine resources. The Northumberland Strait EOAR intends to provide an overview and insight into the Strait's ecosystem health and challenges. Acquiring this understanding has become a critical focus of the affected organizations and individuals. This collective investigative approach is referred to as the Northumberland Strait Ecosystem Initiative.

The EOAR functions as a planning tool under the Oceans Action Plan to define and assess a management area in support of Integrated Oceans Management planning and decision-making. The objective of the EOAR is to engage stakeholders in a coordinated and integrated management process, support identification of ecosystem objectives, and provide direction for governance, monitoring and science.

Biota

Quantity of information

Of the references collected for the Northumberland Strait ecosystem, about 276 items (35% of total) are relevant to biological systems. Thirty-six reports in the database were prepared in specific response to the Northumberland Strait Crossing (Confederation Bridge) project. A further breakdown regarding the number and percentage of references for five data categories is provided in Table 2.1.

Table 2.1: Data Entries by Type

DATA TYPE	# OF INFORMATION ENTRIES	% OF TOTAL BIOTA ENTRIES
Published & peer reviewed	33	12
Ongoing data collection &/or monitoring	48	17
"Popular" writing	29	11
"Grey" studies &/or specific issue studies	164	59
Traditional knowledge	2	1

DATA range and gaps

In general, the biology of major commercial species in the Northumberland Strait (lobster, scallops, oysters, herring, herring, mackerel, cod) is quite well understood. In many instances, there is adequate data available to make species-specific decisions.

The basic biology of lesser commercial species in the Strait (clams, quahogs, mussels, smelt, silversides, eels, winter flounder, tomcod, trout, salmon, etc.) is also adequate for decision-making and management.

The gaps that exist in the database essentially concern all other biological components in the marine ecosystem (invertebrates, benthos, plankton, phytoplankton, primary and secondary production levels, energy flows through various biological components, non-commercial fish species, marine birds, marine mammals, etc.).

There are many studies and information available on the estuarine, inter-tidal and near shore areas. In addition, there is a relative abundance of information on the upstream and freshwater tributary biology for certain areas (Bedeque Bay watershed, Baie Verte watersheds). With the exception of some work on pelagic commercial fish species (scallops and lobster, particularly free swimming stages) and extensive work on sea turtles, there is little biota information available on the open water areas of the Strait.

Decline of Commercial Fishery Stocks

The socio-economic impacts resulting from the decline of commercial fish species in the Northumberland Strait has been of paramount concern to adjacent communities. Available information indicates that several species stocks have been in decline for an extended period of time. The literature suggests the following reasons for resource declines:

- changes to the seafloor in the Strait and general build up of sediments related to the Confederation Bridge;
- more extensive coastal erosion and changes in the tides and current flows; and
- increased contaminants in the water column related to runoff and effluent from land-based activities.

Many interrelated environmental and fishery-related factors are likely to have caused the decline in commercial marine stocks, and many of these factors remain as yet unknown. As well, there is no established relationship between resource declines and the Confederation Bridge. Enhanced and reliable data on biology and biota would be helpful in resolving the issue of resource declines.

3.0 DISCUSSION

3.1 Format

During the afternoon session, the participants agreed that the discussion be structured into the following Biota topic areas:

- Finfish
- Shellfish
- Invasive Species
- Plants

For each topic, participants followed the format below:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The results of the discussions are presented in the following subsections. It is apparent that there are overlapping themes between the topic areas which will be addressed in other workshops and elaborated on by the EOAR Working Group Biota Technical Review Committee.

Since the issues, availability of data, solutions and priorities of some of the above-mentioned Biota topic areas are quite similar; those topics are presented in a blended format.

Each topic was considered in terms of near-shore and open water locations for the purposes of the workshop. Near-shore areas were broadly defined as bays, estuaries, coves, waters not much deeper than 5 m, or areas that could be accessed by chest-waders.

3.2 Finfish

3.2.1 Key Issues

The key issues for finfish were identified as follows:

- Lack of fisheries-independent data;
- Landing statistics only represent the amount of fish harvested;
- Lack of records showing required effort to harvest fish;
- Lack of quantification and qualification of the biological population of species; and
- Decreased landings may reflect decreased market values, increased market value of substitute species, or increase in catch effort required.

In general, the data indicates that commercial landings are increasing. It is not clear whether this is due to increasing populations or due to an increase in fishing effort. A comparison of trawl surveys in 2001 and 2005 showed a decrease in lobster, lady crab and winter flounder landings, while hake, smelt and gaspereau increased slightly. The data also indicates that spring herring catch in the Northumberland Strait is decreasing, while fall herring catch is increasing. A decrease in the key species of rock crab was identified as an issue, as well as the bottom survival and harvest age of fish. Poor catch reporting is also considered an issue.

3.2.2 Information Currently Available/ Information Gaps

Information regarding basic species biology is considered fairly complete, however, little is known about the abundance of each species. Landings-independent data and data for small fish are lacking. More effort is required to accurately monitor the commercial fishery. Market influences and non-market species must be considered, as these topics constitute a data gap.

3.2.3 Solutions

<u>Biology Monitoring</u>
There is a lack of biology monitoring programs. Upper stock reference points, or thresholds and indicators, must be identified for each species, in order to determine relationships between fecundity and mortality. Ecosystem indicators must be identified for each species.

<u>Time Series & Existing Information</u>
More time series data must be collected for populations and landings statistics. Much of this information has already been collected in the past, and should be included in evaluations. Ecosystem sampling must be continued and evaluated.

<u>Ocean Bottom Dragging</u>
The effects of dragging on the ocean bottom and associated habitat are not well understood and should be studied further.

<u>Landings Monitoring</u>
In order to enhance correct interpretation, landings statistics should be compared to fisheries-independent data such as biological populations, as well as to market conditions, such as the changing market values of each species. It is also necessary to monitor levels of fishing effort and more comprehensive catch reports from every fishing vessel, albeit that this may pose challenges due to the documentation effort required from all fishers, as well as literacy and cost implications.

<u>Primary Productivity</u>
Primary productivity should be monitored for the Northumberland Strait and stock assessments should be conducted.

<u>Biomass Recruitment</u>
While identification of biomass recruitment relationships would be very helpful, monitoring of life cycle by means of juvenile and mature surveys may be the only option available at this time. A method for determination of biomass recruitment relationships is not commonly in use.

<u>Communication</u>
The communication gap between fishermen, scientists and managers needs to be enhanced through better consultation and cooperation.

<u>Geographic Monitoring Units</u>

The Northumberland Strait could be subdivided into separate monitoring units for the purpose of data collection, taking into consideration both ecological and political boundaries when defining such units.

Species Movement
Species movement should be monitored and impacts of the movement determined.

Predator/ Prey Relationships
Relationships and interaction between predator/ prey species should be studied.

Habitat & Species Mapping
Habitat and species mapping is required to establish relationships, characteristics and to monitor shoreline changes.

Disease Agents
Research on disease agents should be conducted, such as survival, life cycle and blood disorders.

Commercial Opportunities
Commercial opportunities for sea lettuce and other alternative species can be explored.

Land Use Impacts
Land use impacts need to be better understood, such as the impacts of golf courses that are located close to shore.

Interaction with surrounding Ecosystems
An unknown factor is the interaction between the Northumberland Strait and the surrounding open water in the Gulf of St. Lawrence. Specifically, this aspect should be studied in terms of species movement and migration.

Near-shore/ Open Water Interaction
The interactions between near shore and open water habitat should be investigated as some species spend their lifecycles in both regions and both regions are critical to the development and survival of some species.

3.2.4 Priorities

In terms of understanding of finfish within the Strait, the prioritized studies would be:

1. Fisheries-independent monitoring of fisheries and biology; and
2. Better monitoring of commercial species landings.

3.3 Shellfish

3.3.1 Key Issues

The key issues identified for shellfish are as follows:

- Declines in lobster and scallop landings in the Northumberland Strait;
- Over-harvesting;
- Shoreline infill and development;
- Nutrification and anoxia;
- Shellfish contamination and closures due to toxins and algal blooms;
- Negative impacts of effluent outputs, sedimentation and storm surges;
- Excessive dirt, described as a brown dust-like substance, found on fishing equipment when retrieving equipment from water;
- Lack of habitat; and
- Invasive species.

3.3.2 Information Currently Available/ Information Gaps

The basic biology of shellfish is understood, but further information is required on the impacts of sedimentation on shellfish larvae. The larvae spend the first weeks of their life in shallow, near-shore waters where the temperature does not drop below ten degrees Celsius. It is suspected that as they mature, they also spend some time throughout the water column. Therefore, the effects and levels of near-shore sedimentation would be worth investigating.

Information gaps include:

- Carrying capacity of each species;
- Effects of habitat alteration;
- Effects of ocean floor sedimentation;
- Locations and effects of excessive nutrient levels, primary productivity and anoxic areas;
- Effects of changes in the photic zone;
- Time series data; and
- Causes of declining Irish moss population.

3.3.3 Solutions

<u>Existing Data</u>
Much zooplankton data exists within DFO and remains to be analyzed and evaluated. Any other existing data should also be identified, evaluated and results communicated to appropriate parties.

<u>Species movement</u>
Species movement between administrative fisheries boundaries, international boundaries and biological boundaries must be better understood.

<u>Habitat Mapping & Characterization</u>

Shellfish habitat should be mapped and characterized, including a quantitative assessment of shellfish populations and identification of shellfish bed locations.

Land Use Impacts

Land use impacts upon shellfish must also be understood in more detail.

Scallop Landing Declines

Scallop landings have been decreasing since 1985. Biological scallop populations have been found to remain somewhat stable; however, the population, as well as fisheries, would benefit from improved living conditions. Scallops benefit from cold water periods as this increases the meat / shell ratio. A further consideration for scallop populations is the fact that a decreased population density means that less fertilization will occur. It is suspected that poor survival on the ground is a factor in population mortality, for example through dragging. As well, scallops require approximately eight years to reach marketable size, requiring landing data to be related to conditions approximately eight years prior to catch for evaluation and comparison.

Baseline Data

In order to address habitat alteration issues, baseline / control work is necessary. Sediment monitoring, time series mapping, control sites, harvest method studies, fisheries composition studies, pier-related erosion studies, contaminant studies and top / bottom temperature monitoring are required. Larvae distribution and survival must be monitored.

Scallop Enhancement

Scallop enhancement such as culture cages and brood stock habitat should be considered. Protected areas may be used as habitat refuges for shellfish.

Human Interaction

Species and human interactions within the Northumberland Strait ecosystem and related inputs and outputs must be studied and issues identified.

Green Crab

To better understand species interaction, the invasive green crab population should be considered.

Species Biology Indicators

Health and survival thresholds must be determined and more information gathered on reproduction, recruitment and survival of shellfish species.

Habitat alteration

Habitat alteration and sedimentation was considered a major contributor to changes in shellfish populations. Baseline control work should be conducted, for example in a lab environment. The effect of ground fish dragging should be considered. Near-shore sedimentation and suspended sediment must be studied to determine whether there are negative effects of shellfish larvae.

3.3.4 Priorities

In terms of understanding of shellfish within the Strait, the prioritized studies would be:

7. Habitat alteration and sedimentation.

3.4 Invasive Species

3.4.1 Key Issues

The key issues identified for invasive species are as follows:

- Biological threat to indigenous species;
- Financial threat to the fisheries;
- Disturbance to the ecosystem balance; and
- Anticipated influx of new invasive species into Northumberland Strait.

3.4.2 Information Currently Available/ Information Gaps

Currently, it is known which invasive species occupy the Strait and the impacts they have on target species. These species are an issue in both the near shore environment and open water, however, they are considered to be a lesser issue in open water. The green crab has been found to damage mussel and oyster beds and some data has determined that they damage eel grass beds. Codium has been found in the central Strait area attached to fishing gear. Several species of tunicates (violet, clubbed, goldenstar, sciona) have been found in the Strait and are known to be expanding their territories. There is some data available showing the increased costs to the fishery due to invasive species. Knowledge gaps include where or how fast the currently known species are expanding and what potential invasive species are "on the doorstep"

3.4.3 Solutions

There must be research into methods of mitigating or limiting the spread of invasive species, but not at the detriment of resident species. The transfer of species, which may aid in the spread of invasive species, should be under more stringent governmental control. There is a need to compare the biology of the species with the Strait ecosystem biology specifically.

3.4.4 Priorities

In terms of understanding of invasive species in the Strait, the prioritized studies would be:

Mapping the distribution of the relevant species, possibly in a macro-mapping style'
The current species and future threats must also be identified and the risk to the ecology and industry in the area be quantified; and
There must be an understanding of the trends and effects to understand future issues.

3.5 Plants

3.5.1 Key Issues

The key issues identified for plants are as follows:

- Excessive growth of some species (e.g. furcelleria);
- Disappearance of kelp beds as other species take over kelp habitat;
- Presence of Red tide (nipchzit, ASP, DSP, PSP);
- Presence of sea lice;
- Presence of green algae;
- Increased turbidity;
- Decreased light penetration;
- Disappearance of Irish moss;
- Eelgrass bed health; and
- Presence of anoxic areas.

3.5.2 Information Currently Available/ Information Gaps

Excessive nutrients are considered a priority in terms of research needs. As well, fishers have noticed increased "dirt" on their nets after pulling them out of the water. The dirt was described as a type of brown dust that clings to the equipment. Also, little is known about the effects of sedimentation and suspended sediment on the photic zone of the Northumberland Strait.

3.5.3 Solutions

Solutions to improving flora health in the Northumberland Strait include characterization of anoxic areas and investigation of their effects on plants. The excessive dirt found on fishing gear should be identified and analyzed. CTC studies must be continued and evaluated. Changes to the photic zone should be measured and mapped / documented.

3.5.4 Priorities

In terms of understanding of plants within the Strait, the prioritized studies would be:

1. Excessive nutrient studies.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary

The purpose of this workshop was to share information on the present state of scientific knowledge related to Biota within the Northumberland Strait. The workshop resulted in the following key findings:

- Identification of the key target areas (nitrification, fisheries-independent data, sediment, habitat characterization, invasive species, land use) related to Biota which must be further understood to provide insight into the health of the Strait's ecosystem;
- Identification of a number of ecosystem issues within each of the discussed topics;
- Improved understanding that biota data within the Strait is decentralized and therefore not well understood in terms of its reliability, accuracy, timeliness, etc.;

- Requirement for a compilation and collation exercise (i.e., metadata) to understand available baseline information; and
- Identification of a prioritized list of research projects to eliminate information gaps regarding the Strait.

As a result of the workshop the study areas for Biota are:

- Collection of fisheries-independent data;
- Improved reporting of catch statistics by fishers;
- Correlation of fisheries-independent data to landing statistics;
- Analysis of fine-grained sediment dynamics;
- Mapping and characterization of habitat;
- Compilation of existing data that remains to be evaluated and analyzed;
- Quantification of species populations; and
- Monitoring and prediction of invasive species

It is recognized that much of these study areas will blend together as the scope of the prioritized studies become more defined. As well, the studies will blend with the scope of the studies being defined for the Physical Environment discipline and for the MEQ discipline.

4.2 Going Forward

The Workshop was successful from several perspectives:

- The participants have been afforded the opportunity to come together, increase their technical and scientific understating of current status of the Strait's Biota and discuss common concerns and potential solutions.
- The workshop participants were in consensus regarding key issues, information gaps identified and prioritized study areas.
- All workshop participants expressed positive feedback regarding the day's proceedings and expressed a desire to continue deliberations in the future through appropriate mechanisms.

Northumberland Strait
Environmental Overview and Assessment Report
Technical Workshop on Governance
Draft Proceedings Report

Gulf Fisheries Center
Moncton, New Brunswick
October 30, 2006

Submitted to:

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1.0 INTRODUCTION

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To date, EOARs have been or are being drafted for several areas in the Northumberland Strait:

- Richibouctou
- Bouctouche
- Cocagne
- Shediac
- Shemogue
- Baie Verte
- Pictou Harbour
- Bedeque Bay

In response to environmental changes and resource declines which have been observed in the Northumberland Strait, it was decided to commission an overarching EOAR to provide an overview and assessment of the Strait's ecosystem health and challenges.

The EOAR process is complex and involves a substantial volume of documentation (studies, reports, data, legislation, regulations, etc.), which represents a challenge for communities and stakeholders to digest and understand. As such, a technical consultation aspect has been introduced to the Northumberland Strait EOAR process. These "technical workshops" are being convened to provide a review of the available information related to the Northumberland Strait and to develop recommendations regarding possible solutions and future courses of action. Since the workshops are intended to focus on scientific and technical issues (in a narrow sense) it was decided to convene four separate sessions covering the physical environment, marine environmental quality, biota, and governance.

This report presents the results of the fourth of four technical workshops conducted in support of the Northumberland Strait EOAR. The workshop was convened on October 30, 2006 at the Gulf Fisheries Center in Moncton, New Brunswick, and focused on socio-economic and governance issues in the Northumberland Strait.

Explanations and discussions in a workshop setting enhance the participants' capacity to more easily understand the scope and purpose of the EOAR. The technical workshops focus on the availability, reliability, accuracy and timeliness of information and data related to the key ecosystem issues. The technical workshops also comprise a gap analysis regarding the knowledge base, as well as an elaboration of potential effects management measures (i.e., actions and recommendations).

1.1 Workshop Objectives

The objectives of the workshop were to:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The workshop agenda is presented in Appendix A.

1.2 Participants

Attendance at the workshop comprised a broad representation from government, academia, the scientific community, industry, and non-governmental organizations. A list of participants is provided at Appendix B.

1.3 Workshop Process

The workshop was subdivided into two sessions. The morning session was comprised of six presentations (Appendix C) summarizing the EOAR process, the previous three technical workshops (physical environment, marine environmental quality, and biota) and the body of existing information on governance and socio-economics related to the fishery within the Northumberland Strait, followed by a question and answer period. The topics of the presentations, as well as the presenters and their respective affiliations, were as follows:

• Jacques Paynter	AMEC	"Overview of EOAR Process"
• Gordon Fader	AMEC	"Physical Environment Summary"
• Mark McNeil	AMEC	"Oceanography Summary"
• Roy Parker	AMEC	"Marine Environmental Quality Summary"
• Morley Pinsent	AMEC	"Biota Summary"
• Gregor McAskill	Gardner Pinfold	"Changes in the Fisheries"
• Jamey Smith	AMEC	"Governance Issues"

The afternoon session focused on identifying information gaps and specific scientific research and project requirements needed to close information gaps. The participants also prioritised the research and project requirements.

1.4 Structure of the Report

This report is structured as follows:

- **Chapter 2.0** Summary of Presentations – provides an abstract of each the presentations.
- **Chapter 3.0** Summary of Discussion Session – provides the overall consensus items from the discussions in terms of identification of key issues, understanding of existing information and gaps, the required research and the prioritization of that research.
- **Chapter 4.0** Conclusion and Recommendations

2.0 PRESENTATIONS

The following section provides a brief synopsis of each presentation. All presentations are provided in Appendix C.

Overview of the EOAR Process

In recent years, environmental changes and resource declines have been observed in the Strait. The Strait provides livelihoods to many commercial fishermen and their families through a diversity of fish species and marine resources. The Northumberland Strait EOAR intends to provide an overview and insight into the Strait's ecosystem health and challenges. Acquiring this understanding has become a critical focus of the affected organizations and individuals. This collective investigative approach is referred to as the Northumberland Strait Ecosystem Initiative.

The EOAR functions as a planning tool under the Oceans Action Plan to define and assess a management area in support of Integrated Oceans Management planning and decision-making. The objective of the EOAR is to engage stakeholders in a coordinated and integrated management process, support identification of ecosystem objectives, and provide direction for governance, monitoring and science.

Summary of the Technical Workshop on the Physical Environment of Northumberland Strait

The bedrock and surficial geology, including the dynamics of seabed sediments, depositional areas, transport pathways and seabed features of Northumberland Strait was summarized. Permian sandstone bedrock crops out on the seabed in several areas and is overlain by till and glaciomarine sediments. Modern sand is in transport in a wide variety of bedforms across gravel surfaces. Regional sediment maps show that in the narrow areas of the Strait, the seabed is dominantly gravel with sand. Where the Strait widens, deposits of muddy sand occur and these sediments have only been deposited since approximately 6000 yBP. Recently collected multibeam bathymetry shows a variety of features that were previously unknown and include former rivers, streams and lakes, sand bedforms, bedrock surfaces, dredge spoils and ice scour features.

Objectives of the physical characteristics and geochemistry sections included discussion of key issues, available information, potential solutions and priorities. Measured resource declines have been suggested to result from erosion around the Confederation Bridge foundations, increased regional siltation, and increased suspended sediment concentrations. Critical information on the regional sediment budget that includes sources, pathways and sinks is limited. Potential solutions include multibeam bathymetric surveys to define depositional zones and transport pathways, the collection and analysis of sediment cores to determine temporal change, and programs to measure suspended sediment and seabed siltation. An understanding of fine grained sediment dynamics that includes the nearshore, underpins many of the issues.

The key issues regarding geochemistry are closely related to sedimentation and include an understanding of nutrients and contaminants from adjacent land, the greater Gulf of St Lawrence, other Strait rivers and point sources. There is very limited information available on contaminants in the Strait and their relationship to coastal estuaries. Potential solutions include the preparation of sediment and associated contaminant maps, the collection of base line data, and the development of transport models for the Strait, Gulf and bays.

Based on the workshop presentations and discussions, agreement was reached on an understanding of the important aspects of the physical environment that must be understood for an ecosystem assessment.

Summary of the Technical Workshop on the Marine Environmental Quality of Northumberland Strait

The four main MEQ issues were identified as being nutrients, pathogens, sediment/siltation and environmental contaminants. For nutrients, the participants determined that there was considerable data available on quantities of nutrients discharged and concentrations in near-shore areas (estuaries and bays), but not much information was available on nutrient concentrations in the open-water areas. Useful suggestions were made about sources of additional data. Follow-up with a researcher at Acadia University was recommended to help with interpreting the nutrient data. Pathogens are a potential human health issue and as a result, the knowledge base is extensive and several government agencies conduct regular monitoring and enforcement. For suspended particulate material, sediment and siltation, there is considerable overlap with the physical environment and the biota components of the EOAR. Data on sediment concentrations in the open-water areas of the Strait is limited and a monitoring program is currently underway to partially address this. It was determined that better information was required on sources of sediment, quantities released, transport and deposition and on how sediment affected marine life. The participants were challenged with the discussion of the contaminant issue because of the wide array of contaminants and the complexity of the fate and effects of these compounds. Very little information is available with respect to open water in Northumberland Strait, but some information exists for near shore areas. The recommended approach to address the contaminant issue was to identify potential contaminant sources and inputs from land-based activities and then to initiate monitoring of specific target areas for contaminants of concern.

Summary of the Technical Workshop on the Biota of Northumberland Strait

The available information regarding the biota of the Northumberland Strait is largely "grey literature". The major commercial species are quite well understood - with some significant gaps. The biology of lesser commercial species is adequately understood. Knowledge of all other biota in the strait is limited, with the exception of turtles and some shore birds. Ecological interrelationships amongst species is often found wanting. There has been a general decline in many of the commercial species in the strait for an extended period. Many interrelated environmental and fishery-related factors are likely to have caused the decline. Many causes have yet to be positively determined. Enhanced and more reliable data on biology and biota would be helpful in resolving the issue. Priorities for filling critical existing critical data gaps based on workshop results included:

For finfish,

- Fisheries independent monitoring of fisheries and biology
- Better monitoring of commercial fisheries landings

For shellfish,

- Habitat alteration and sedimentation

For invasive species,

- Mapping the distribution of relevant species in the strait
- A quantified risk assessment of current and future affects on the ecology and industry of the strait
- Understanding the likely trends and effects

For plants,

- Excessive nutrient inputs and impacts on plant life in the Strait.

Socio-Economic Focus on Changes in Fisheries

The socio-economic changes that are occurring in the study area are direct and indirect consequences of the environmental changes being observed. For many individuals and communities, life and well-being depends to large extent on the Strait ecosystem and the health of local resources. Trends for Strait rural communities and enterprises must be set in regional and temporal context. Some dominant rural coastal community trends are shared with similar communities in other jurisdictions and it is important to distinguish how ecosystem changes in the Strait are different or compounded with general trends. Assessing information and consultation at finer geographic scales has been most helpful in understanding Strait changes and impacts. Aggregate statistics for the region tend to mask effects at community levels, but the regional context may identify both challenges and opportunities.

The commercial capture fishery is presented as the key indicator of socio-economic changes, given its relative socio-economic contribution to coastal communities in the Strait area. Focusing on the four main species in the fishery over the last decade, trends assessed by lobster fishing area (LFA) reveal significant concerns. Lobster provides the largest share of total landed values for the main species (approximately 85%), and declines in this species alone are cause for concern. The magnitude and longevity of the decline in commercial fisheries for highly dependent communities is more problematic than cyclical patterns experienced elsewhere or in the past.

Those involved in the fishery from different perspectives have described many effects on the industry and communities including; depreciating business capital, labour recruitment challenges, loss of direct, indirect, and induced income and employment, increasing reliance on EI, rising intensity of competition, rising operational costs, safety concerns, eroded savings and assets, debt, family stress, migration to urban or western centres, substance abuse, crime and accidents, loss of culture, history, and traditional living.

There is a strong sense that resource conservation is the greatest priority, with a range of harvesting controls discussed. However, other conditions for successful maintenance and rebuilding of fisheries and dependent communities may include; financial security measures, addressing industry structural issues, community support programs, understanding the present decline even if simple solutions are not clear, and basing future decisions and initiatives on sound understanding of communities.

Governance

The EOAR must consider the role of policy and governance as well as the ability of the governance regime to respond to changes that affect the integrity of the environment and well being of communities. The relevant questions are clearly expressed in the Statement of Work:

- How are governments/institutions positioned to respond to events (natural and manmade) that affect the ecosystem, resources, communities?
- What are the overlaps and divisions of roles and responsibilities that relate to management?
- What is the present regulatory regime?
- How can these systems be improved to respond more effectively and expeditiously?

The presentation provides information to facilitate discussion of the governance regime in the study area, and poses a series of questions to facilitate discussion on how this system can be improved. Information is provided to describe the mandates of federal, provincial, and municipal governments, and First Nations. The application of these mandates to resources, industries, and activities is also presented. The presentation provides general information on how jurisdictions are divided, and provides a series of examples of how they overlap. With regards to positioning to respond, the presentation sets out for discussion the various means by which these are accomplished. Finally, the presentation poses a series of questions related to issues of applicability and coverage, clarity, communication, responsibility, and funding.

DISCUSSION

2.1 Format

During the afternoon session, the participants agreed that the discussion be structured into the following topic areas:

- Fisheries (socio-economic focus)
- Governance

For each topic, participants followed the format below:

- Review the current status of scientific information related to the Strait;
- Identify key issues;
- Identify information gaps; and
- Identify and prioritize research needs.

The results of the discussions are presented in the following subsections. It is apparent that there are overlapping themes between the topic areas which will be addressed in other workshops and elaborated on by the EOAR Working Group Governance Technical Review Committee.

2.2 Fisheries (Socio-Economic Focus)

2.2.1 Key Issues

The key issues for fisheries were identified as follows:

- Amount of effort in the fisheries relative to the available resource;
- Stability/sustainability of the resource;
- Overcapitalization;
- Broader gender and intergenerational social impacts;
- Erosion of owner/operator policy – puts increased pressure on communities that no longer have access to a previous resource;
- Lack of options outside the fisheries/displacement of labour force into sectors that are already overprescribed (i.e., forestry);
- Decline in landings/species diversity;
- Fisher exodus;
- Increased cost;
- Decline in communities/loss of infrastructure;
- Decline in fiscal capacity to manage and enforce;
- Offloading costs from government to fisheries (downloading dollars and responsibilities);
- Adequacy of science; and,

- Community decline:
    - Increased competition/conflict between communities;

- Infrastructure stress;
- Tax base;
- Amenities.

2.2.2 Information Currently Available/ Information Gaps

The discussion revolved around the understanding and management of the current state of the resource and the socio-economic information available.

Information regarding shellfish (i.e., bivalves and lobster) is lacking with respect to environmental quality, land based impacts, stock assessments, and nursery habitat and habitat health. The related biodiversity and interspecies relationships are not well understood, particularly the relationships impacting human activities and vice versa.

Knowledge regarding the true value of the fishery, the cultural factors, and the associated rural community health (i.e. full cost accounting) is lacking. Particularly lacking is knowledge regarding the gender and intergenerational impacts of the declining fisheries.

A substantial amount of fisheries data is collected. Knowledge regarding overcapitalization is considered fairly complete, however, little is known about the technologies used and associated effort for the catches. As well, the data that is accumulating is very aggregated, hindering the understanding of particular areas of concern (i.e., catch data vs. stock assessments, recreational fisheries and the associated sideline income). Communication of the analyzed data results is lacking.

2.2.3 Solutions

Biology Monitoring
Nursery habitat health, biodiversity, and interspecies relationships must be monitored in order to determine relationships between fecundity and mortality. Ecosystem indicators must be identified for each area of concern.

Time Series & Existing Information
More time series data must be collected for populations, habitat characteristics, stock assessments, and landings statistics. Much of this information has already been collected in the past, and should be included in evaluations. Ecosystem sampling must be continued and evaluated.

Socio-Economic Landings Monitoring
In order to enhance correct interpretation, landings statistics should be compared to fisheries-independent data such as population monitoring, indicators of community health, technology relative to effort. As well, the available fisheries data must be re-assessed by data type in support of the socio-economic considerations.

Communication

The communication gap between fishermen, scientists and managers needs to be enhanced through better consultation and cooperation. As well, public education and community based visioning and planning, beyond the fishery, are required.

2.2.4 Priorities

In terms of understanding of the socio-economic fisheries issues within the Strait, the prioritized studies would be:

3. Development of a social safety net – understand the community impacts, immediate requirements to remain viable, community linkages, etc. to stimulate political will and raise financial awareness;
4. Maximize fisheries revenue; and,
5. Rationalize the fisheries sector – must address science and structural needs in both coastal and upland areas.

2.3 Governance

2.3.1 Key Issues

Participants had difficulty grappling with the governance issue. The group agreed that, as a working definition, governance is the framework by which decisions are made albeit not necessarily in a structured or linear fashion, and that the process is not the same as government. Governance involves planning, deciding, monitoring, responding, and mobilizing public action. However, the evolution of governance should not be construed to advocate for the delegation of regulatory responsibility.

The key issues identified for governance are as follows:

- Regulator capacity;
- Process overlap and disconnect;
- Community capacity;
- Lack of Aboriginal participation;
- Enforcement;
- Voluminous regulatory framework with 'no home';
- Lack of strategic assessment; and
- Fisheries management primarily applies to fishers and not the resource.

2.3.2 Information Currently Available/ Information Gaps

Most facets of governance are well known and well understood, but uncertainties remain regarding:

- roles of communities regarding coordination of activities with regulatory agencies;
- role of CSOs, NGOs and First Nations;
- clarity related to jurisdictions and an efficient and proper process to deal with overlaps;
- appropriate and enforceable regulations;
- mechanisms and capacity;

- adequacy of response to stakeholder requirements and changing environmental conditions; and
- inconsistent terminology and perceived different meanings for the same words (e.g., integrated management, economic compliance).

With respect to the Northumberland Strait, the legislative and regulatory framework involves many federal, provincial and even municipal (land use planning) levels of government. Many participants questioned DFO's ability and capacity to influence other regulatory bodies.

2.3.3 Solutions

Recommendations include the following:

Investigate the applicability and suitability of Regional Committee for Oceans Management (RCOM) as a model to emulate for Northumberland Strait governance. RCOM is considered to be a legitimate practice which has evolved from an environmental assessment orientation to a broader process. There is a need to evaluate the "fit" and integration of RCOM, IM and the Oceans Act. A similar process has been implemented for the Eastern Scotian Shelf.

Provide legitimacy to the processes that are evolving from the Northumberland Strait Working Group approach. The structure and procedures put into place should be able to continue. Recognize that the current approach (modified as necessary) is the beginning of a long process to effectively manage the resources of the Northumberland Strait. Provide adequate funding to ensure that the process is sustainable in the long term.

Encourage and enhance the direct participation of as many regulators as possible in the EOAR process. In particular, federal and provincial departments responsible for environment and agriculture should be engaged in the discussion so that they can gain first hand appreciation of the issues and, accordingly, frame their policy formulation and decision making in the context of the Northumberland Strait EOAR process. It must also be recognized that effective accountability requires a strong "top down" effort. The timing for more integrated participation is opportune as the deputy minister's committee (resulting form the July 31 2006 PEI summit) is being held accountable for the broader Northumberland Strait process and the channels of government communication (federal and provincial) can be leveraged to stimulate better engagement of relevant departments and agencies. In short, there is a need to formalize, fund, and broaden the participation in the EOAR process, including non-traditional partners such as provincial economic departments. Some of these issues could be furthered through the *Fisheries Act* renewal discussions.

Articulate categories for specific tangible targets, timelines and measurable indicators regarding the socioeconomic and resource parameters that need to be changed (e.g., stabilize landings by 2008). The notion of time scales is very important – in many cases immediate action is warranted and possible. In many instances the regulatory tools are in place, but connecting harmful alterations and ecosystem impacts is difficult. There is a need for improved timeliness and responsiveness.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Summary

The purpose of this workshop was to share information on the present state of scientific knowledge related to fisheries and governance within the Northumberland Strait. The workshop resulted in the following key findings:

- Identification of the key target areas (stock assessments, and nursery habitat and habitat health, interspecies relationships impacting human activities and vice versa, rural community health (i.e. full cost accounting), disaggregating effort type) related to fisheries and governance which must be further understood to provide insight into the health of the Strait's ecosystem;
- Identification of a number of ecosystem issues within the discussed topics;
- Improved understanding that information available within the Strait is decentralized and therefore not well understood in terms of its reliability, accuracy, timeliness, etc.;
- Requirement for a compilation and collation exercise (i.e., metadata) to understand available baseline information; and,
- Identification of a prioritized list of research projects to eliminate information gaps regarding the Strait.

As a result of the workshop the study areas are:

- Development of a social safety net – understand the community impacts, immediate requirements to remain viable, community linkages, etc. to stimulate political will and raise financial awareness;
- Maximize fisheries revenue; and,
- Rationalize the fisheries sector – must address science and structural needs in both coastal and upland areas.
- Investigate ways and means to streamline the regulatory framework in the context of potentially suitable models that have been applied elsewhere and incorporate the ongoing work of other parties with interest or jurisdiction in the Strait.

It is recognized that much of these study areas will blend together as the scope of the prioritized studies become more defined. As well, the studies will blend with the scope of the studies being defined for the Physical Environment, Marine Environmental Quality and Biota disciplines.

3.2 Going Forward

The Workshop was successful from several perspectives:

- The participants have been afforded the opportunity to come together, increase their technical and scientific understating of current status of the Strait's Physical Environment and discuss common concerns and potential solutions.

- The workshop participants were in consensus regarding key issues, information gaps identified and prioritized study areas.
- All workshop participants expressed positive feedback regarding the day's proceedings and expressed a desire to continue deliberations in the future through appropriate mechanisms.