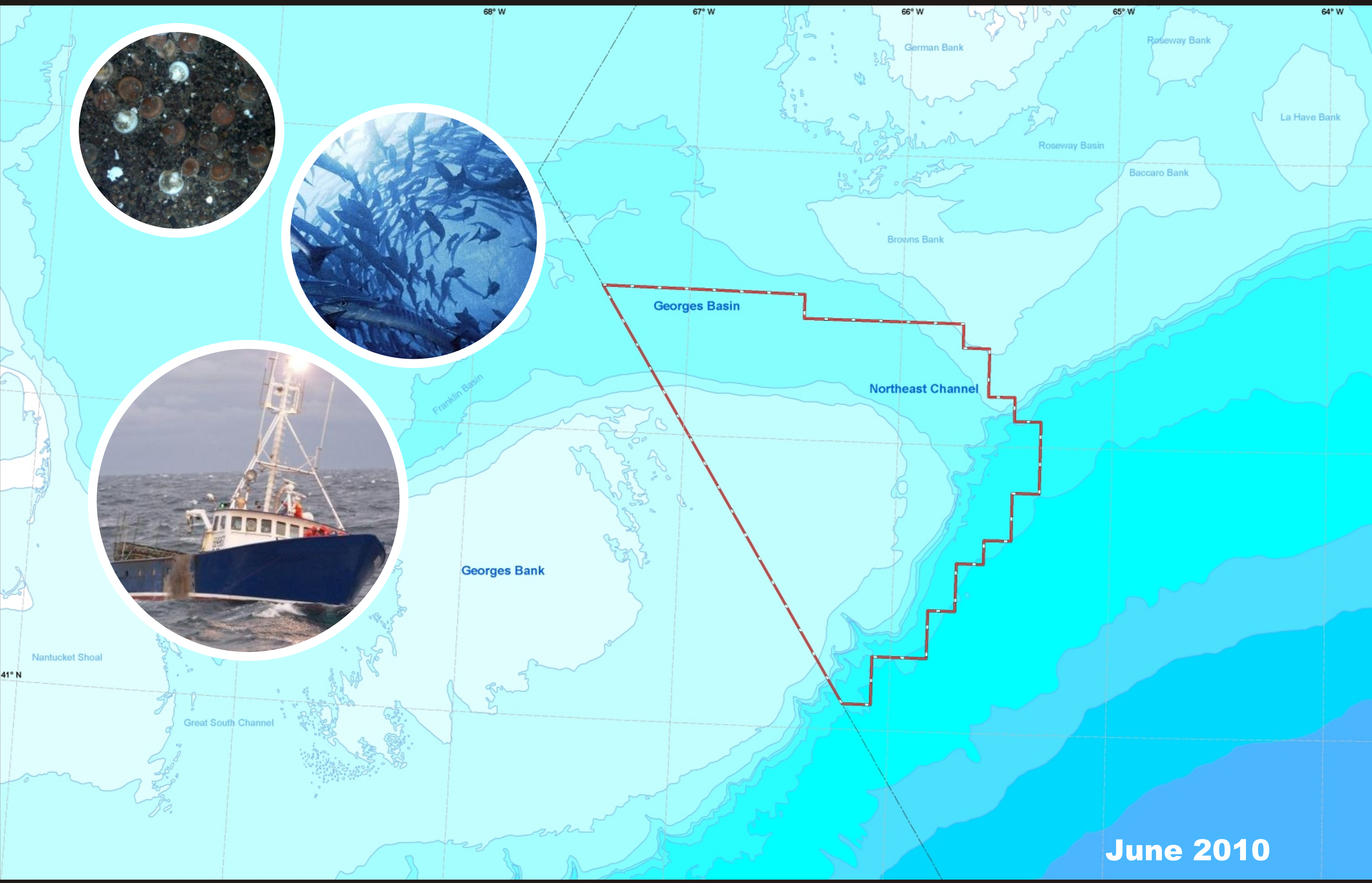
Offshore Energy Environmental Research Association



June 2010

Preliminary Review of Environmental and Socio-Economic Issues on Georges Bank

Stantec

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A Preliminary Review of Environmental and Socio-economic Issues on Georges Bank

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Executive Summary

In 1988, the governments of Canada and Nova Scotia placed a moratorium on all petroleum activities on the Canadian portion of Georges Bank and adjacent areas. The moratorium was then extended until 2012 following an independent panel review in 1999. This important regulatory decision was based on the most current information available at the time.

The moratorium of oil and gas activities on Georges Bank received international attention in 1999 and continues to be the subject of international interest. Since the Canadian moratorium boundary extends along the Canada-United States international boundary, both Canada and United States share an interest in the management of resources in this area. Recent decisions in the United States to expand oil and gas exploration on the outer continental shelf effectively excluded Georges Bank from new areas under consideration for drilling for at least another five years.

In Canada, the federal and provincial governments have recently launched independent science and technical reviews of Georges Bank and potential effects of oil and gas activities. These reviews are intended to update government decision-makers on the current state of knowledge on the science and issues that led to the 1999 Panel's recommendation to extend the moratorium.

In March 2008, the Nova Scotia Department of Energy provided the Offshore Energy Environmental Research Association (OEER), whose mission is to foster research and development related to offshore petroleum and renewable energy resources and their interaction with the marine environment, with a grant to support research on matters specific to Georges Bank. Under this mandate, OEER contracted Stantec Consulting Ltd. (Stantec) to review decision factors that led to the 1999 Panel's recommendation to extend the moratorium and to reassess these factors in light of:

- new scientific knowledge of the Georges Bank ecosystem;
- changes to the socio-economic environment;
- updates to the regulatory framework which govern offshore petroleum activities;
- new scientific knowledge of environmental and socio-economic effects pertaining to offshore petroleum activities;
- progress in mitigation of potential effects; and
- existing and emerging technologies.

New scientific knowledge of the Georges Bank ecosystem was derived primarily from research conducted by DFO and non-governmental agencies, and the fishing industry. A significant advancement in the knowledge of the Georges Bank ecosystem is the relatively recent multibeam bathymetric mapping of the Georges Bank moratorium area. Although proprietary until 2013 and therefore not publicly available, the data are permitted to be used for scientific purposes to further the bathymetric, sediment and habitat programs of the Geological Survey of Canada and Fisheries and Oceans Canada. Applications related to this data, such as habitat mapping, represent a substantial advancement in the identification and protection of sensitive habitats.

A review of the most recent economic data from Statistics Canada and fisheries data from Fisheries and Oceans Canada, supplemented with discussions with local development authorities and representatives from the fishing industry were used to inform changes to the socio-economic environment since 1999. In general, the socio-economic conditions remain unchanged, although the Southern Region now has the highest rate of unemployment in the province. The fishing industry continues to be the single largest source of industrial employment and income in southwest Nova Scotia. The scallop fishery on Georges Bank remains the most important fishery in terms of landed value, accounting for 75% of total landed value of all fishing activity in Georges Bank in 2008. However, fleet configuration has changed with the introduction of freezer scallop vessels, resulting in lower employment. Another socio-economic update since 1999 is that a quota allocation for both cod and haddock on Georges Bank was designated for the Aboriginal fishery in 2003.

Relevant environmental assessments, environmental effects monitoring (EEM) results, and scientific research papers were reviewed to identify advances in scientific knowledge regarding potential environmental and socio-economic effects of offshore petroleum activities. Key issues for consideration were identified by the study team, through review of the 1999 Review Panel Report and form the basis of the report. These include:

- Physical and behavioural effects on marine species from seismic noise;
- Drill muds and cuttings;
- Produced water;
- Accidental discharges (spills and blowouts);
- Loss of access and overcrowding;
- Greenhouse gas emissions and climate change; and
- Transportation issues (pipelines and tankers).

Results from EEM programs conducted offshore Atlantic Canada over the past ten years provide evidence of smaller zones of influence of environmental effects on the marine environment, than previously considered in the 1999 Panel Report. This is particularly true with regards to the extent of environmental effects associated with drill mud and cuttings and produced water discharges which were predicted in the Panel Report using predominantly laboratory and modeling studies.

Information on progress of mitigation related to these issues was also derived from environmental assessments and environmental effects monitoring plans, as well as through informal discussions with regulators and industry representatives. Information on existing and emerging technologies was dealt with at a high level in this document, referencing details in a separate, but complementary report prepared for OEER by Stantec, primarily just addressing technological issues.

Key updates to the regulatory framework include updates to the Offshore Waste Treatment Guidelines, which resulted in more stringent disposal limits for drill waste and produced water and these continue to be reviewed and updated on a regular basis. Also subjected to ongoing review and revision is the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment. The Statement of Canadian Practice, which is a culmination of a scientific review of regulators and technical experts, was developed as a national code of conduct that sets out minimum standards for seismic surveys to avoid significant effects on marine species. The proclamation of the *Species at Risk Act* in 2002 and continuous updates to the *Canadian Environmental Assessment Act* also have implications for the planning, environmental assessment, and management of offshore petroleum activities.

Another component of this study was to consider the economics of Georges Bank, both in terms of the fisheries and potential benefits associated with offshore petroleum activities. The estimated direct and spin-off economic impact of the fishing industry (harvesting and processing) is compared to the economic impact of the offshore oil and gas industry (development and production) at a provincial level. At a regional level, economic data on the value of the Georges Bank fishery is reported. The overall value of the Georges Bank region associated with petroleum can only be done in the abstract as there is currently no industry activity due to the moratorium. Therefore the potential type and rate of economic benefits associated with petroleum activity are discussed based on Nova Scotia offshore energy projects (primarily the Sable Offshore Energy Project), and potential opportunities and economic benefits to the region are considered. From this analysis, it is clear that the fisheries have provided and will likely continue to provide substantial economic benefits. Likewise, based on direct and spinoff effects observed from the petroleum industry offshore Nova Scotia, the oil and gas industry could also result in substantial economic benefits if permitted to occur in the moratorium area.

As required in the Terms of Reference for this study, an important part of this review involved identifying factors that led to the decision to extend the moratorium which:

- Could now be mitigated;
- Could not now be mitigated; or
- Might be mitigated pending additional research.

This assignment is not intended to be an update of the 1999 review process. An important distinction is that the Georges Bank Review Panel approached the issue of the moratorium extension as a yes-or-no question, rather than framing the review process as defined in the OEER scope of work outlined above. Another important and related distinction between the 1999 review and the current assignment is the consideration of the “precautionary principle”.

Although a considerable amount of research fed into the 1999 review process, there were areas where uncertainty and issue of potential harm remained. Since the moratorium decision was framed as a yes-or-no question, these potential threats were seen as a reason to avoid activities through a continuation of an outright ban.

The interpretation of the precautionary principle used in this current research, is that where uncertainty surrounding environmental harm exists, a precautionary approach should be used to enable action and guide a constructive search for alternatives and practical solutions. Using this interpretation of the precautionary principle, monitoring and regular review are important to examine whether knowledge and understanding has improved and to examine effectiveness of the precautionary measure addressing the threat. Any new information gained through monitoring and further research can then be used to inform further management and decision-making, using an adaptive management approach. In some cases, this may lead to the precautionary measure no longer being needed, in others it may lead to the determination that the threat is more serious than expected and that more stringent measures are required.

The last decade has brought considerable oil and gas experience to Atlantic Canada in the form of exploration and production activities, none of which have demonstrated, through environmental effects monitoring, population level effects to the marine ecosystem, or on species at risk and their critical habitat. Although the key issues identified by the 1999 Review Panel remain relevant ten years later, based on advances in scientific knowledge and advances in mitigation and regulatory requirements, it is the professional opinion of the Study Team that these issues identified in the 1999 Review Panel report could be reasonably mitigated in the event that oil and gas activities are permitted to occur on Georges Bank.

It is important for the reader to note that the intent of the studies was to gather information on issues related to Georges Bank that have emerged since the 1999 Georges Bank Review Panel Report and to assess the current state of knowledge. The review does not take into consideration the recent Deepwater Horizon incident as the research was substantially completed prior to this major environmental incident occurring.

In an attempt to further advance science and improve industry practice, additional studies are recommended for consideration. Referring back to the precautionary principle, these studies could serve to inform further management and decision-making, using an adaptive management approach, should oil and gas activities be permitted to occur in the moratorium area.

As provincial and federal governments re-examine the Georges Bank moratorium and consider the option of a potential new Public Review prior to 2012, the information contained in this document may be used to inform decision-makers on key issues, updates and areas where the precautionary approach, as defined above, may be most appropriate.

Preface and Acknowledgements

The Study Team wishes to thank Brian Todd and Vladimir Kostylev of the Geological Survey of Canada, Eric Theriault of the Canada-Nova Scotia Offshore Petroleum Board, Dave Burley of the Canada-Newfoundland Offshore Petroleum Board, Zhengkai Li and Doreen Liew of Fisheries and Oceans Canada, Dave Warner of Southwest Shore Development Authority, David Hannay, JASCO Applied Sciences, and Dr. Robert Kenney, University of Rhode Island for their input and supply of data during the course of our research. We would also like to thank the fishing industry sources consulted for this research for their cooperation.

The Study Team would like to acknowledge that Fisheries and Oceans Canada is currently undertaking a science review of Georges Bank. The review consists of two documents, the first authored by Kennedy *et al.*, titled "The Marine Ecosystem of Georges Bank, Nova Scotia: Consideration of the Potential Interactions Associated with Offshore Petroleum Activities. Canadian Science Advisory Secretariat. CSA Working Paper 2010/04. Draft Report, February 2010" and the second authored by Lee *et al.*, titled "Environmental Impacts of Exploration and Production: Consideration of the Potential Interactions Associated with Offshore Petroleum Activities. Canadian Science Advisory Secretariat. CSA Working Paper 2010/05. Draft Report, February 2010". The Study Team acknowledges the reports are in a public review process and have not yet been published.

This report was prepared for the Offshore Energy Environmental Research Association by Stantec Consulting Ltd. in cooperation with Gardner Pinfold Consulting Economists Limited, with contributions by Gordon Fader, Dr. Ian McLaren, and Cal Ross. Key Study Team authors included Virginia Soehl, MRM; Benjamin Wheeler, M.Sc.; Julianne Sullivan, M.Sc.; John Walker, PhD; Heather Giddens, MES; and Bob Fraser (Gardner Pinfold Consulting Economists Limited). This report was senior reviewed by Earle Hickey, M.Sc. and Steve Fudge, M.Sc.

List of Acronyms

AP	Alkylphenol
AUVs	Autonomous Underwater Vehicles
BAT	Best Available Technology
BBLT	Benthic Boundary Layer Transport
BCF	Bioconcentration Factor
BMP	Best Management Practice
BSE	Bovine spongiform encephalopathy
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CAC	Criteria Air Contaminant
CAPP	Canadian Association of Petroleum Producers
CCA	Coral Conservation Area
CCS	Carbon Capture Storage
CEA	Cumulative Effects Assessment
CEAA	*Canadian Environmental Assessment Act*
CETAP	Cetacean and Turtle Assessment Program
CHS	Canadian Hydrographic Service
CITES	Convention on International Trade in Endangered Species
CL	Carapace Length
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CNSOPB	Canada-Nova Scotia Offshore Petroleum Board
COPAN	Cohasset Panuke
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSAS	Canadian Science Advisory Secretariat
DFO	Fisheries and Oceans Canada
DREAM	Dose-related Risk and Effect Assessment
E&P	Exploration and Production
EA	Environmental Assessment
EARPGO	Environmental Assessment Review Process Guidelines Order
ED	Electrodialysis
EDR	Electrodialysis Reversal
EEM	Environmental Effects Monitoring
EPA	(United States) Environmental Protection Agency
EROD	Ethyresorufin o-allthylase
ESRF	Environmental Studies Research Fund
ESSIM	Eastern Scotian Shelf Integrated Management
FAC	Fisheries Advisory Committee
FTE	Full-time equivalents
GBe	Georges Bank east
GBn	Georges Bank north
GHG	Greenhouse Gas
GOM	Gulf of Mexico
GPS	Global Positioning System
GSC	Geological Survey of Canada
GSI	Geophysical Service Incorporated

ICCAT	International Commission for the Conservation of Atlantic Tunas
IOPER	International Offshore Petroleum Environmental Regulators Group
ITQ	Individual Transferable Quota
IUCN	International Union for Conservation of Nature
JIP	Joint Industry Programme
LFA	Lobster Fishing Area
LTMO	Low-toxicity Mineral Oil
M&NP	Maritime and Northeast Pipeline
MEG	Monothylene Glycol
MFO	Mixed Function Oxygenase
MMO	Marine Mammal Observer
MMS	Minerals Management Service
MPA	Marine Protected Area
MWA	Marine Wildlife Areas
NAFO	Northwest Atlantic Fisheries Organization
NE	Northeast
NEB	National Energy Board
NEFSC	Northeast Fisheries Science Centre
NETL	National Energy Technology Laboratory
NMCA	National Marine Conservation Areas
NMFS	National Marine Fisheries Service
NORM	Naturally Occurring Radioactive Material
NPD	Naphthalene, Phenanthrene, and Dibenzothiophene
NS	Nova Scotia
OBM	Oil-Based Muds
OEER	Offshore Energy Environmental Research Association
OOC	Offshore Operators Committee
OSRR	Oil Spill Response Research
OTN	Ocean Tracking Network
OWTG	Offshore Waste Treatment Guidelines
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring
PCB	Polychlorinated Biphenyls
POCIS	Polar Organic Chemical Integrative Samplers
PWMIS	Produced Water Management Information System
RA	Responsible Authority
RAC	Regulatory Advisory Committee
REA	Regional Environmental Assessment
ROV	Remotely operated vehicles
SARA	*Species at Risk Act*
SBF	Synthetic-Based Fluid
SBM	Synthetic-Based Mud
SCOR	Scientific Committee on Oceanic Research
SOCP	Statement of Canadian Practice
SOEI	Sable Offshore Energy Inc
SOEP	Sable Offshore Energy Project
SPMDs	Semi-permeable Membrane Devices
SSC	Scotian Shelf Cross-over

TAC	Total Allowable Catch
TPH	Total Petroleum Hydrocarbons
UNESCO-IOC	United Nations Educational, Scientific, and Cultural Organization-Intergovernmental Oceanographic Commission
US	United States
USGS	United States Geological Survey
VOC	Volatile organic compounds
WBM	Water-based mud

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1.0 Introduction

1.1 STUDY PURPOSE AND OBJECTIVES

In 1988, the governments of Canada and Nova Scotia placed a moratorium on all petroleum activities on the Canadian portion of Georges Bank and adjacent areas. The moratorium was then extended until 2012 following an independent panel review in 1999 (Natural Resources Canada (NRCan) and Nova Scotia Petroleum Directorate (NSPD) 1999). This important regulatory decision was based on the most current information available at the time.

The federal and provincial governments have recently launched independent science and technical reviews of Georges Bank and potential effects of oil and gas activities. These reviews are intended to update government decision-makers on the current state of knowledge on the science and issues that led to the 1999 Panel's recommendation to extend the moratorium.

Since 1999, there has been scientific research focused on the Georges Bank ecosystem (see Kennedy *et al.* 2010), as well as numerous developments in technical procedures and practices employed by the offshore petroleum industry. Industry and regulatory experience in managing environmental effects of offshore petroleum activities in Atlantic Canada as well as other jurisdictions, also provides guidance on the efficacy of new procedures and processes for consideration on Georges Bank.

The nature and priority of environmental concerns has also changed over this 10-year period, with issues surrounding climate change and the growing global energy demand coming to the forefront. Changes in local socio-economic conditions in the region over the past decade may also influence the context within which these issues are examined.

These new developments in scientific and technological knowledge coupled with evolving environmental and socio-economic conditions provide the background for an opportunity to reassess the risks of petroleum exploration and development on Georges Bank. The purpose of this report is to research key environmental and socio-economic issues relating to Georges Bank that have emerged since the 1999 Georges Bank Review Panel Report and to assess the current state of knowledge (refer to Appendix A for Study Terms of Reference and Appendix B for concordance table). A companion report has also been prepared under separate cover (*A Preliminary Review of Existing Technologies and their Mitigative Potential in Offshore Petroleum Developments* (Stantec 2010a)), to specifically address advances in technology and mitigation to assist provincial and federal government decision-making on a new public review of the Georges Bank moratorium prior to 2012.

1.2 GEORGES BANK OVERVIEW AND BACKGROUND TO MORATORIUM

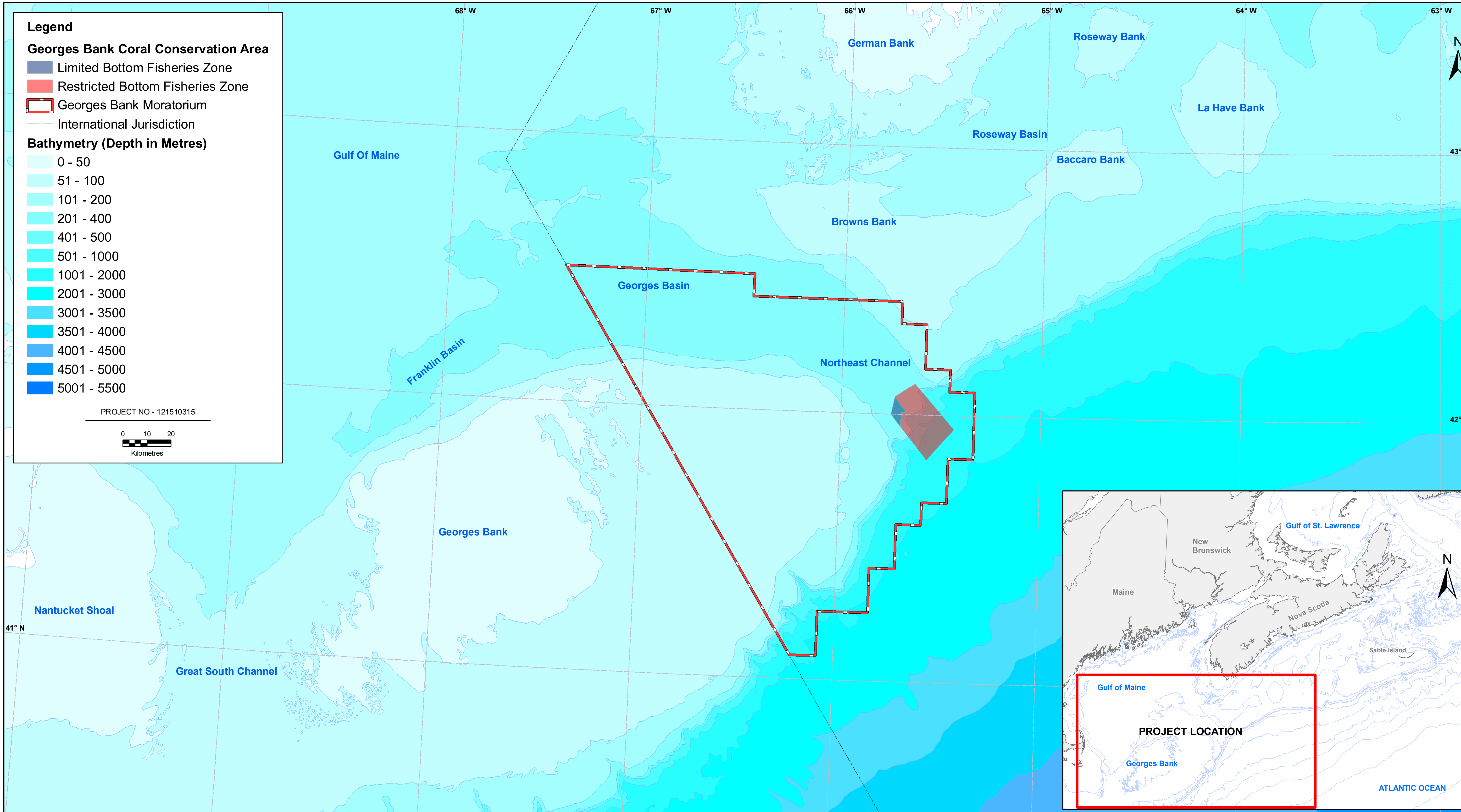
Georges Bank is located along the continental shelf of Eastern North America between the southern tip of Nova Scotia and Cape Cod, Massachusetts (Figure 1.1). The Bank is a biologically productive ecosystem that supports important commercial fisheries in Canada and the United States (US) and provides habitat to a wide range of marine fish, mammals, corals, and other organisms.

In 1988, a moratorium was placed on offshore petroleum activities on the Canadian portion of Georges Bank until the year 2000. This decision was primarily driven by concerned local fishing interests and residents. Based on recommendations made by an independent review panel, the Minister of the Nova Scotia Petroleum Directorate and the Minister of Natural Resources Canada announced on December 22, 1999, that the Georges Bank moratorium would be extended until December 31, 2012.

This decision was made following a review of scientific studies that had been commissioned following the 1988 decision, and a four-phase public review process which included introductory meetings, information sessions, community workshops, and the public hearings. Scientists from Fisheries and Oceans Canada (DFO) at the Bedford Institute of Oceanography led a research program to help address scientific questions related to the 1988 review. This research was conducted in consultation with representatives of the fisheries sector and petroleum industry and also included collaboration with American scientists. Physical oceanography studies coupled with laboratory bioassay tests resulted in development of a model of the fate and effects of discharged drilling muds on adult scallops on Georges Bank. This information was presented publicly at several meetings leading up to the 1999 Review Panel hearings, as well as at the hearings themselves. In addition, there was a website and newsletter dedicated to Georges Bank which helped to disseminate information about the review (NRCan and NSPD 1999).

In their 1999 Report, the Georges Bank Review Panel identified knowledge gaps on the potential environmental effects of exploration and production activities which made it difficult to assess the environmental and socio-economic risks of petroleum development. The Panel therefore recommended an extension to the moratorium.

In 1984, the United States Congress enacted a moratorium on petroleum exploration over the US portion of Georges Bank. In 1988, this area was enlarged. The US moratorium was extended twice, once until 2002 and then until 2012 by executive order. In 2008, President Bush lifted the executive order restricting offshore drilling and the US Congress allowed a 27-year-old ban on most offshore oil and gas drilling to expire, thereby opening up the US outer continental shelf for petroleum exploration. In March 2010, President Obama released a five-year drilling plan for the Outer Continental Shelf (OCS) that excluded any new oil and gas leasing activities in the north Atlantic, effectively reinstating the presidential ban on drilling on Georges Bank. However, seismic exploration is currently allowed to occur over the US moratorium area (refer to Section 3.2.3.2 for more information on the US moratorium on Georges Bank).



DATE: 16/02/2010	Georges Bank	FIGURE NO.: Figure 1.1
PREPARED BY: G. Mesheau		
CLIENT LOGO	**PROJECT LOCATION**	Stantec

The Canadian moratorium covers an area of 15,000 km^2 which covers the Canadian portion of Georges Bank (7,000 km^2) and extends to cover most the Northeast Channel (Figure 1.1). This moratorium area is referenced hereinafter as the “moratorium study area”. Unless otherwise stated, the moratorium study area referred to in this report considers only the area under Canadian jurisdiction.

1.3 STUDY APPROACH AND REPORT ORGANIZATION

The purpose of the report is to revisit decision factors that led to the 1999 Panel’s recommendation to extend the moratorium and reassess these factors in light of:

- new scientific knowledge of the Georges Bank ecosystem (refer to Sections 2.1 and 2.2);
- changes to the socio-economic environment (refer to Section 2.3);
- updates to the regulatory framework which govern offshore petroleum activities (refer to Section 3);
- new scientific knowledge of environmental and socio-economic effects pertaining to offshore petroleum activities (refer to Section 4); and
- progress in mitigation of potential effects (refer to Section 4).

Another aspect of this study is the economic valuation of Georges Bank to existing stakeholders (*e.g.*, fisheries) and potential effects on the economy in the event that oil and gas activities were permitted to occur (refer to Section 5).

As required in the Terms of Reference for this study, an important part of this review involves identifying factors that led to the decision to extend the moratorium which:

- Could now be mitigated;
- Could not now be mitigated; or
- Might be mitigated pending additional research.

These factors are reviewed in Section 4 and summarized in Section 6 along with recommendations for additional research to further advance scientific knowledge and improve mitigation of potential effects.

This assignment is not intended to be an update of the 1999 review process. An important distinction is that the Georges Bank Review Panel approached the issue of the moratorium extension as a yes-or-no question. As noted in Shaw *et al.* (2000), this approach tended to increase the importance of socio-economic and cultural values and preferences and decrease the importance of detailed and quantitative analysis of technical issues. Although this present document does consider socio-economic issues, there is an emphasis on including the scientific analysis of the technical issues, particularly given an additional ten years of results of offshore oil and gas experience offshore Nova Scotia since the Panel decision in 1999.

Another important and related distinction between the 1999 review and the current assignment is the interpretation of the “precautionary principle”. Although a considerable amount of research fed into the 1999 review process, there were areas where uncertainty and issue of potential harm remained. Since the moratorium decision was framed as a yes-or-no question, these potential threats were seen as a reason to avoid activities through a continuation of an outright ban.

The interpretation of the precautionary principle used in this current research, is that where uncertainty surrounding environmental harm exists, a precautionary approach should be used to enable action and guide a constructive search for alternatives and practical solutions. This approach to the precautionary principle is consistent with guidelines for applying the precautionary principle to biodiversity conservation and natural resource management as approved by International Union for the Conservation of Nature (IUCN) Council in 2007 (IUCN 2007). This interpretation is fundamental to the analysis contained in this report and provides the basis for the conclusions and recommendations. Using this interpretation of the precautionary principle, monitoring and regular review are important to examine whether knowledge and understanding has improved and to examine effectiveness of the precautionary measure addressing the threat. Any new information gained through monitoring and further research can then be used to inform further management and decision-making, using an adaptive management approach. In some cases, this may lead to the precautionary measure no longer being needed, in others it may lead to the determination that the threat is more serious than expected and that more stringent measures are required.

The following describes the report organization.

Section 1 identifies the purpose on the study and objectives and describes an overview of Georges Bank and background to moratorium.

Section 2 characterizes the Georges Bank ecosystem and socio-economic environment, focusing on advancements in scientific knowledge and changes to the socio-economic conditions since 1999.

Section 3 describes key environmental regulations and guidelines that govern Canadian offshore petroleum activities, and relevant environmental management frameworks, focusing on changes to the regulatory context since the 1999 Panel Report.

Section 4 provides a detailed review of the key environmental and socio-economic issues identified in the 1999 Georges Bank Review Panel Report. Each issue is examined first in the context of 1999 Panel comments, then advances of scientific knowledge (or in the case of socio-economic issues – evolution in socio-economic conditions) are noted, along with progress in impact mitigation to better understand residual risks which may remain in spite of these advances.

Section 5 describes the value of the Georges Bank region associated with the commercial fishing industry and includes a detailed account of the fishing activity that has occurred in the region since 1999. Section 5 also considers the potential scale of value associated with petroleum activity, drawing on the industry experience within the offshore oil and gas industry in Nova Scotia.

Section 6 provides a summary and discussion of the residual Issues (in spite of advances in scientific knowledge and progress in mitigation) and the implications for future consideration. It also summarizes the requirements for additional studies and research programs which would assist in addressing the residual issues.

References cited in the report are presented in **Section 7**.

2.0 Characterization of Georges Bank

This section of the report revisits the physical, ecological, and socio-economic context of the moratorium study area, as understood at the time of the Georges Bank Review Panel, focusing on scientific advancements that have improved the understanding of the ecosystem and socio-economic developments that have occurred since 1999. This is not intended to be an exhaustive description of the current ecological and socio-economic setting of the moratorium study area. For a comprehensive description of current conditions, refer to Kennedy *et al.* (2010).

2.1 PHYSICAL AND BENTHIC ENVIRONMENT

2.1.1 Panel Context

In the Georges Bank Panel Report of 1999, the area of the moratorium (Figure 2.1) covers the Canadian eastern side of Georges Bank as well as Northeast Channel and part of Georges Basin. This section assesses all three of these regions in the context of what new studies have been undertaken since 1999 and what new technologies have been applied to understand seabed sediments, seabed dynamics and benthic habitats. The approaches to mapping the seabed of these three areas and partnerships for data ownership and data release plans vary for each area, so they will be discussed under separate headings.

With respect to seabed and habitat issues, the Georges Bank Review Panel identified physical characteristics and biological resources, ecosystem structure, stability and resilience, and currents and their effects, as aspects of Georges Bank that required additional research.

2.1.2 Advancement in Scientific Knowledge

Developments associated with the application of multibeam bathymetric mapping and its derived products, together with novel habitat template ideas and models have led to significant advancements in our understanding of the physical structure of Georges Bank. Technological advances and improvements in scientific knowledge regarding physical structure are discussed below. Following a discussion of recent surveys and technological advances, a description of the morphology and surficial geology of Georges Bank and surrounding areas (Georges Basin, Northeast Channel) is provided.

2.1.2.1 Technological Advances

In response to Canadian challenges of understanding climate change, offshore boundary delimitation, and sustainable management of the fishery, the Government of Canada enacted the *Oceans Act* in 1997, Canada's Ocean Strategy in 2002, and following that, the Geoscience for Ocean Management program of Natural Resources Canada (Pickrill and Kostylev 2007). The adoption of an ecosystem basis for the management of the fishery has necessitated the production of high-resolution maps and a detailed understanding of the seabed and immediate subsurface. Much of this knowledge is derived from the collection, processing and interpretation of multibeam bathymetry as the underpinning approach.

A new national marine-based mapping series of the Geological Survey of Canada (GSC) were devised through stakeholder meetings and the introduction of new mapping technology. Priorities were set for regions of the offshore. Previous mapping, approximately 20 years old, were largely reconnaissance in nature and lacked high-resolution content. These maps were based on the interpretation of widely spaced seismic reflection profiles, echograms, bottom photographs and targeted seabed samples. They did, however, provide a stratigraphic framework for sediments in the offshore and a basis on which to build on (Fader *et al.* 2004). The subsequent application of multibeam bathymetry filled the gaps between older survey lines and provided for 100% seabed coverage. The precision and accuracy of these new systems allowed for the production of a variety of bathymetric mapped products with resolutions as high as 0.25 m on continental shelves.

Based on experience gained from the application of multibeam bathymetry in the 1990s to a variety of offshore test areas, the new national mapping series was developed and refined to consist of four maps at each location. These were: multibeam bathymetry (shaded-relief maps); backscatter intensity (proxy for sediment type/seabed hardness); interpreted geology; and benthic habitat. The maps were to be produced at scales of 1:50,000 and 1:100,000 with special maps in nearshore and shallow areas to be at scales of 1:10,000 or less.

Multibeam Bathymetric Mapping Technology and Applications

Stantec (2010a) describes the revolution in mapping technology and how it has contributed to an improved understanding of the seabed of the world's oceans. The interpretation of multibeam bathymetry (Todd and Shaw 2009) has provided the basis for an understanding of the glacial and post glacial history of the seabed by characterizing various features and revealing previous sea level positions. The portrayal of sediment bedforms such as sand waves, dunes, barchans, and megaripples has provided an unprecedented understanding of seabed stability and sediment transport (dynamics). The interpretation of scoured regions and areas of sediment buildup have given insight into both short and long term erosional and depositional processes. Newer higher resolution multibeam bathymetric systems can also portray bioherms and communities of organisms on the seabed that can be differentiated from sediments and bedrock. The effects of trawling and the dragging of bottom fishing gear such as scallop rakes can be mapped and assessments of disturbed versus undisturbed bottom can be measured and quantified.

The maps and knowledge generated from the application of multibeam bathymetry in all its facets is clearly a very important component for management of the offshore fisheries. It can be used to select and evaluate potential marine protected areas and can also improve site-specific assessment of effects related to offshore development. The oil and gas operators can also use this technology and knowledge to improve infrastructure siting (*e.g.,* platforms, pipelines), to avoid sensitive areas.

Multibeam bathymetry was first collected on Georges Bank in 1999 and 2000. Prior to this time the only maps of sediment distribution and seabed features were by Fader *et al.* 1988, Valentine *et al.* 1992 and Poppe *et al.* 1989. These assessments were regional in approach and lacked detail both on morphology and sediment type. Multibeam bathymetric mapping is now considered a mature technology with calibration and georeferencing a main component. Resolutions have increased whereby in shallow water of 50 m, a resolution of 20 cm or better is achievable making these systems comparable to bottom photography and at the very least the essential groundtruth for bottom photography. Positioning with these systems is also very accurate as they are hull mounted and referenced to shipboard global positioning system (GPS) antennae.

Status of Multibeam Bathymetric Mapping in the Georges Bank Moratorium Area

Multibeam bathymetry has been collected across Georges Bank and in Georges Basin and Northeast Channel from a variety of different surveys (Figure 2.1). The data for Georges Bank portion was collected in a cooperative program largely funded by Clearwater Fine Foods Incorporated who supplied the survey vessel, in collaboration with the Canadian Hydrographic Service and the Geological Survey of Canada. The information collected from Georges Bank is to remain confidential to Clearwater until January 1, 2013, but the data are permitted to be used for scientific purposes to further the bathymetric, sediment and habitat programs of the Geological Survey of Canada and Fisheries and Oceans Canada at the Bedford Institute of Oceanography.

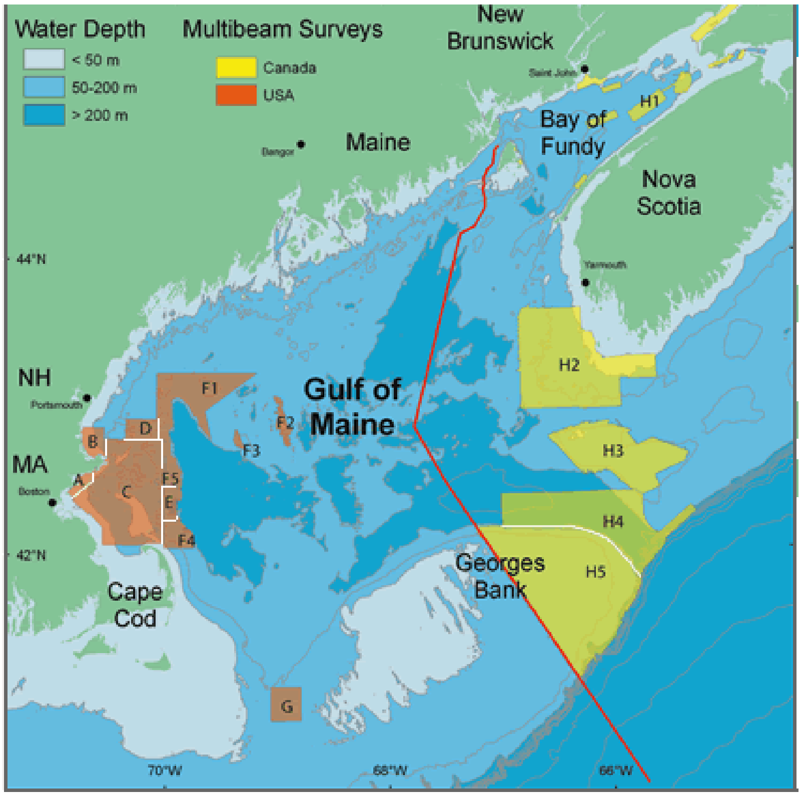


Figure 2.1 Map of the Gulf of Maine Region Showing Where Multibeam Bathymetry Has Been Collected by 2006 (http://www.gulfofmaine.org/gommi/coverage-map.php)

Papers have been published based on the data but the actual mapped imagery is limited to the release of page-sized only diagrams. Several key papers on the geology and habitats have been produced within this framework (Kostylev *et al.* 2005). In the meantime, the Geological Survey of Canada is in the interpretation and preparation stage of a suite of maps for the Georges Bank region. The area has been divided into nine map regions (Figure 2.2) and for each area, four maps (bathymetry, backscatter, seabed geology/sediments and benthic habitat) are in various stages of production, although they cannot be released before 2013 due to confidentiality of data.

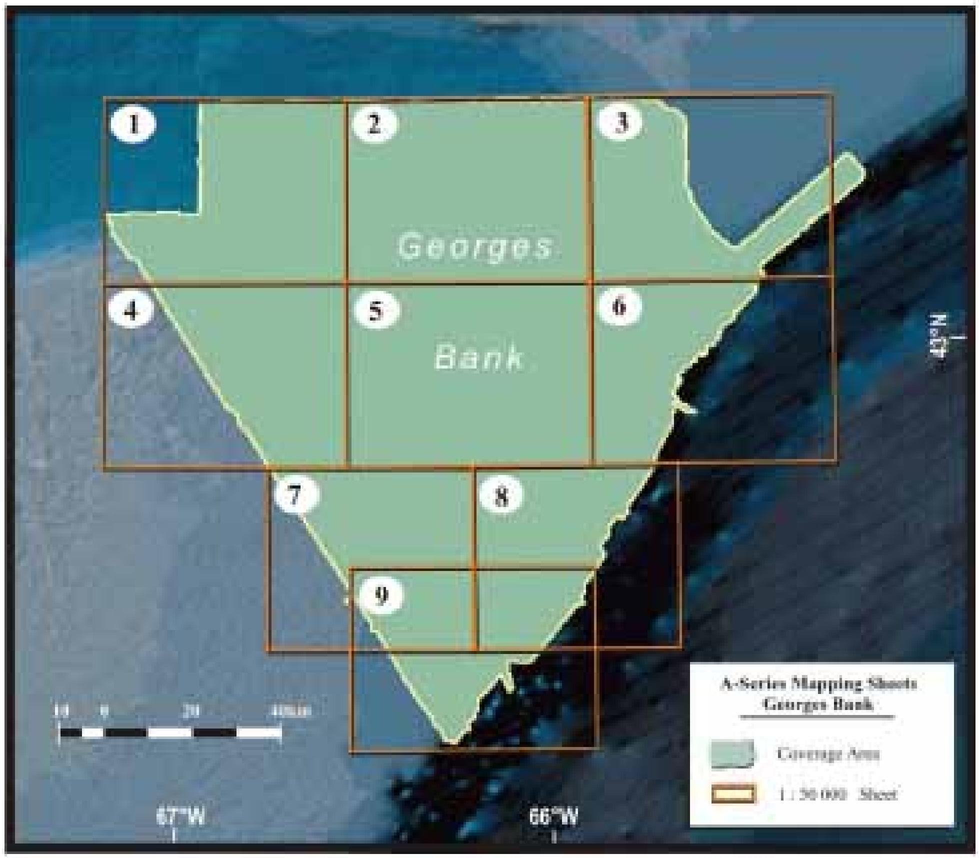


Figure 2.2 Map of the Georges Bank Region Showing the Multibeam Bathymetric Coverage and the Planned Designated Map Sheet Areas To Be Produced by The GSC (Image Courtesy of Brian Todd, GSC)

The multibeam bathymetric information from Georges Basin and Northeast Channel regions is not subject to the same publication restrictions. These surveys were conducted by the Canadian Hydrographic Service and the Geological Survey of Canada during their regular mapping programs and the data is available for scientific interpretation and full production. Papers have been published on some of this data (Mortensen *et al.* 2002; King 2005).

The Geological Survey of Canada's new offshore mapping program has clearly defined long term goals for publication. The area of Browns Bank was the first full area to have had the suite of maps produced and published in both hard copy and digital format. These are available from the GSC GEOSCAN website (Todd *et al.* 2006a, b). Some of the region of the Browns Bank study area extends into the northeastern region of Northeast Channel.

Other Recent Geoscience and Habitat Studies on Georges Bank and Surrounding Regions

Canadian Researchers have conducted more detailed surveys of the Georges Bank region over the past decade. In Northeast Channel, King (2005) of the Geological Survey of Canada conducted a high resolution study of sandy bedforms, sediment distributions and dynamic features (Figure 2.3). Selection of study sites was largely based on an interpretation of the previously collected multibeam bathymetry. An extensive Cruise Report has been prepared from this research cruise and additional papers are planned.

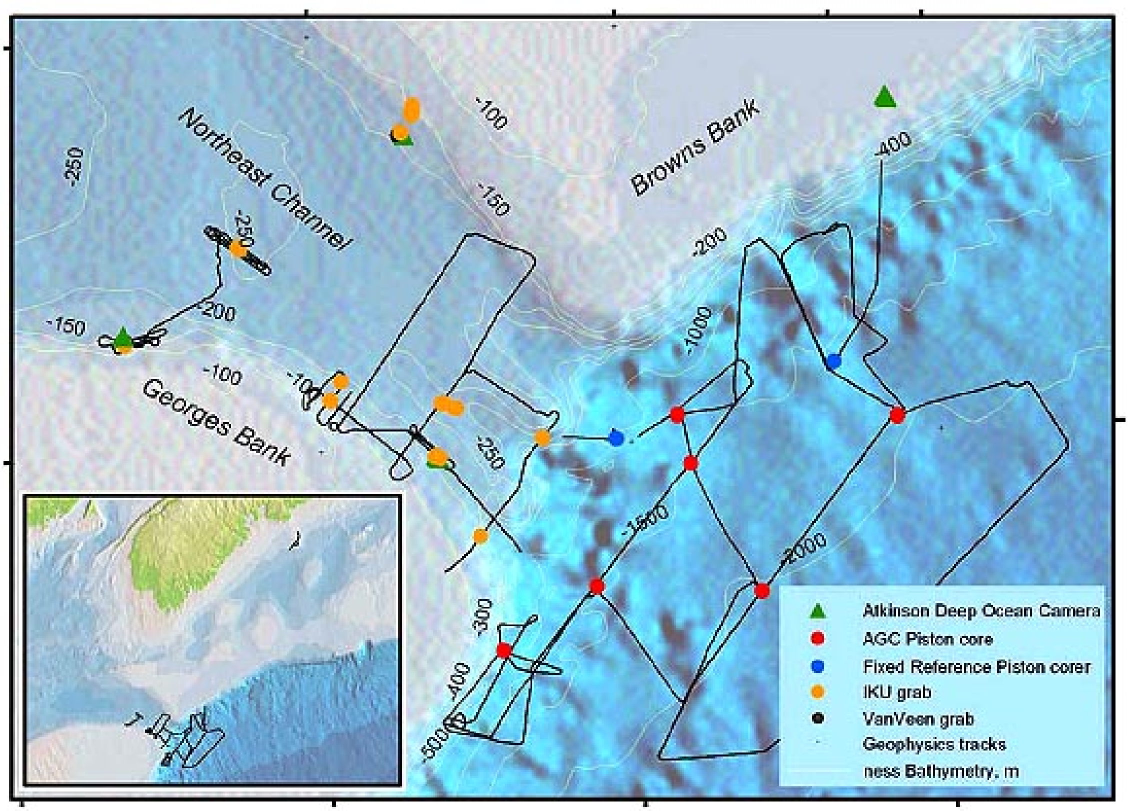


Figure 2.3 Map of the Northeast Channel Region of the Gulf of Maine Showing the Survey Tracks and Sample Locations from Hudson Cruise 2005-035 (GSC Open File Report # 5058, King 2005)

As part of a DFO study to assess the relationship between benthic habitat and haddock, surveys were conducted on several banks of the Scotian Shelf to define an appropriate study area. Georges Bank was one of the areas studied and as a result high resolution sidescan sonar data, bottom photographs and Towcam video were collected (Gordon 2001). However, Georges Bank was not selected as the test site for the subsequent surveys of this program.

During the assessment, a series of surveys were planned over an area dominated by gravel on the northern part of Georges Bank. Previously mapped zones of boulders and areas interpreted to have been minimally affected by bottom fishing activity were chosen to investigate with sidescan sonar, Towcam, and a van Veen grab sampler. The sidescan sonar survey revealed areas composed of very large boulders toward the northwestern end. Other areas consisted of flat gravel seabed without boulders. In one area the sonograms revealed an unusual backscatter character consisting of low backscatter in irregular patches with straight and sometimes poorly defined edges. Although resembling sand patches, the Towcam and Campod video revealed these areas of the seabed of low backscatter to be covered with dense communities of white calcareous colonizing tube worms (Figure 2.4) (*Filograna implexa)*. The sonograms revealed that the low backscatter patches were unscalloped seabed oasis within a dense crisscrossing grid of scallop gear drag marks. Grab samples were taken from one of these patches and consisted of well-rounded gravel in the pebble to cobble range and many of the clasts were completely covered with the colonizing tube worms. These colonies protrude approximately 5-7 cm above the gravel clasts giving the seabed an unusual white encrusting appearance.

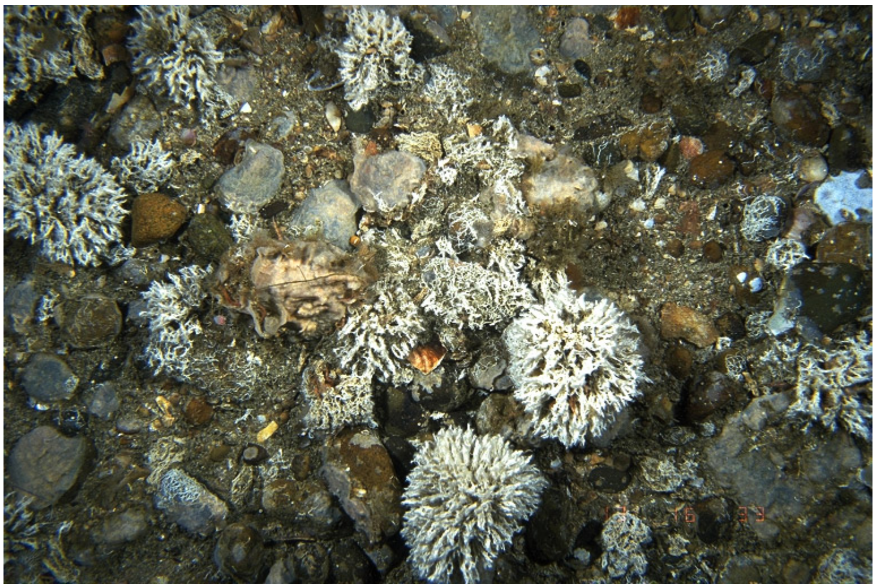


Figure 2.4 A Bottom Photograph From Northern Georges Bank Showing a Sandy Gravel Seabed with Some of the Larger Gravel Clasts Covered in Colonies of *Filograna implexa*, a White Calcareous Worm Tube (Image courtesy of Page Valentine, United States Geological Services)

The GSC and DFO also collaborated on a study of coral habitat in Northeast Channel and as a result of these surveys, a conservation area has been put into effect to protect the large cold deep water coral communities (Figure 2.5). During these surveys, the multibeam bathymetry was used as the basis for study, sidescan sonograms as well as bottom samples, coral samples, video and bottom photography were collected. Sites were well-targeted and broadly distributed over Northeast Channel and an interpreted map of the seabed geology was presented in Mortensen *et al.* 2002 (Figure 2.6). Additional detail concerning the Coral Conservation Area is presented below in Section 2.2.2.2 (Ecological Significance – Marine Fish and Invertebrates).

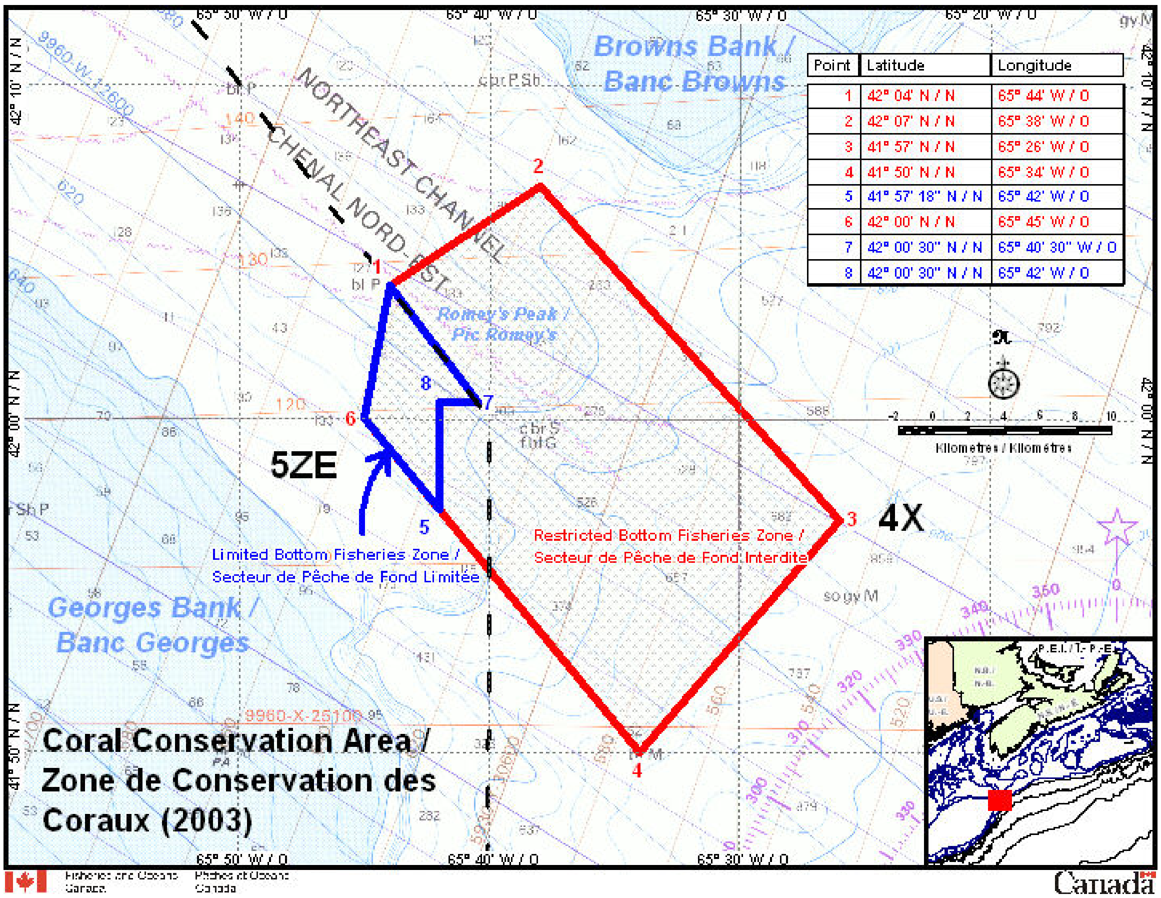


Figure 2.5 **A Map of the Outer Part of Northeast Channel Between Georges Bank and Browns Bank Showing the Limited Bottom Fisheries Zone and the Restricted Bottom Fisheries Zone of Fisheries and Oceans Canada Designed to Protect Deep Water Cold Corals**

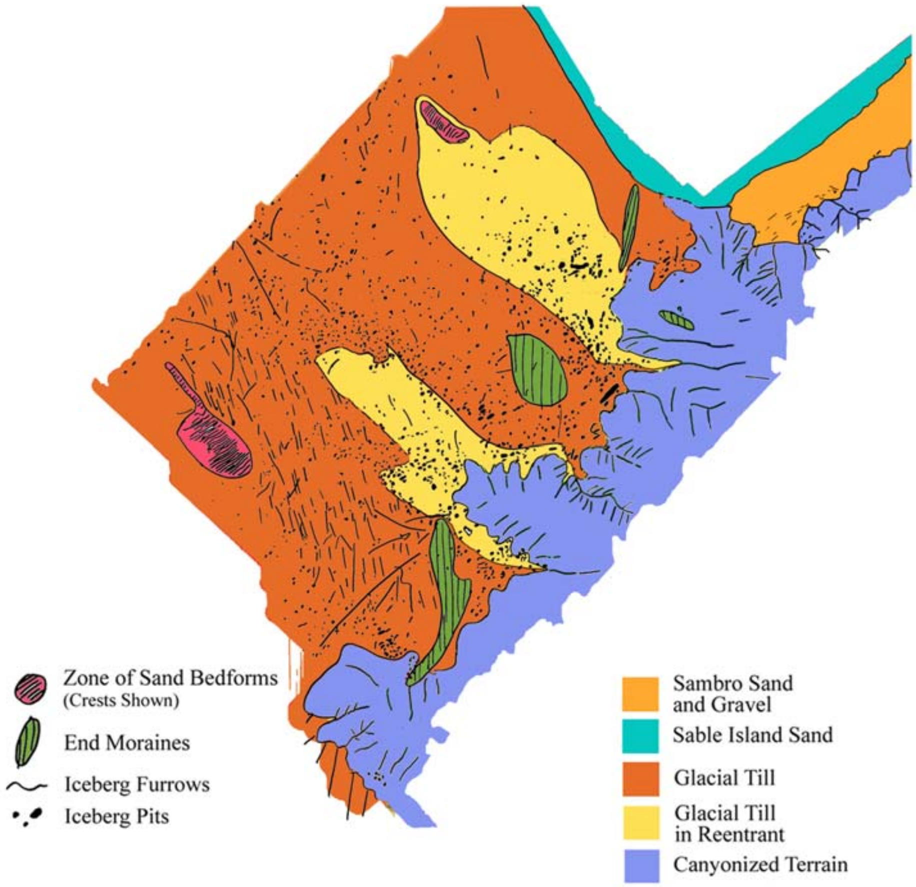


Figure 2.6 An Interpretation of the Multibeam Bathymetry from the Outer Part of Northeast Channel (Mortensen *et al.* 2002)

It depicts the seabed as largely consisting of glacial till at the seabed that is covered with ancient iceberg furrows and pits. Areas of sand bedforms overly the till and end moraines are interpreted at the mouth of Northeast Channel attesting to the advance of grounded glaciers through all of Northeast Channel.

As part of the GSC mapping series, additional regional geophysical and ground truth surveys have been conducted across Georges Bank (*e.g.*, Todd *et al.* 2000, 2003, 2004) in order to properly interpret the multibeam bathymetry and the subsurface geology. These surveys will provide targeted samples and high resolution seismic reflection profiles to interpret subsurface stratigraphy and the multibeam bathymetry for a geological history understanding (refer to Appendix C).

Cooperative GSC and USGS Research

The Geological Survey of Canada has a long history of research cooperation on Georges Bank with their American counterparts at the United States Geological Survey (USGS), particularly in the area of seabed habitat mapping (Todd *et al.* 2000; Valentine *et al.* 2005) Repetitive mapping has taken place at numerous locations on both the Canadian and American sides of the bank (Figure 2.7). The US researchers have determined that substrate type and water depth are two factors that exert a strong influence on the distribution of benthic communities. Using the ideas put forth by Southwood (1988), they also have adopted the concept of a habitat template whereby adversity and stability are two main defining characteristics. Such a theoretical approach uses the results of high-resolution acoustic multibeam mapping and bottom photographs and video.

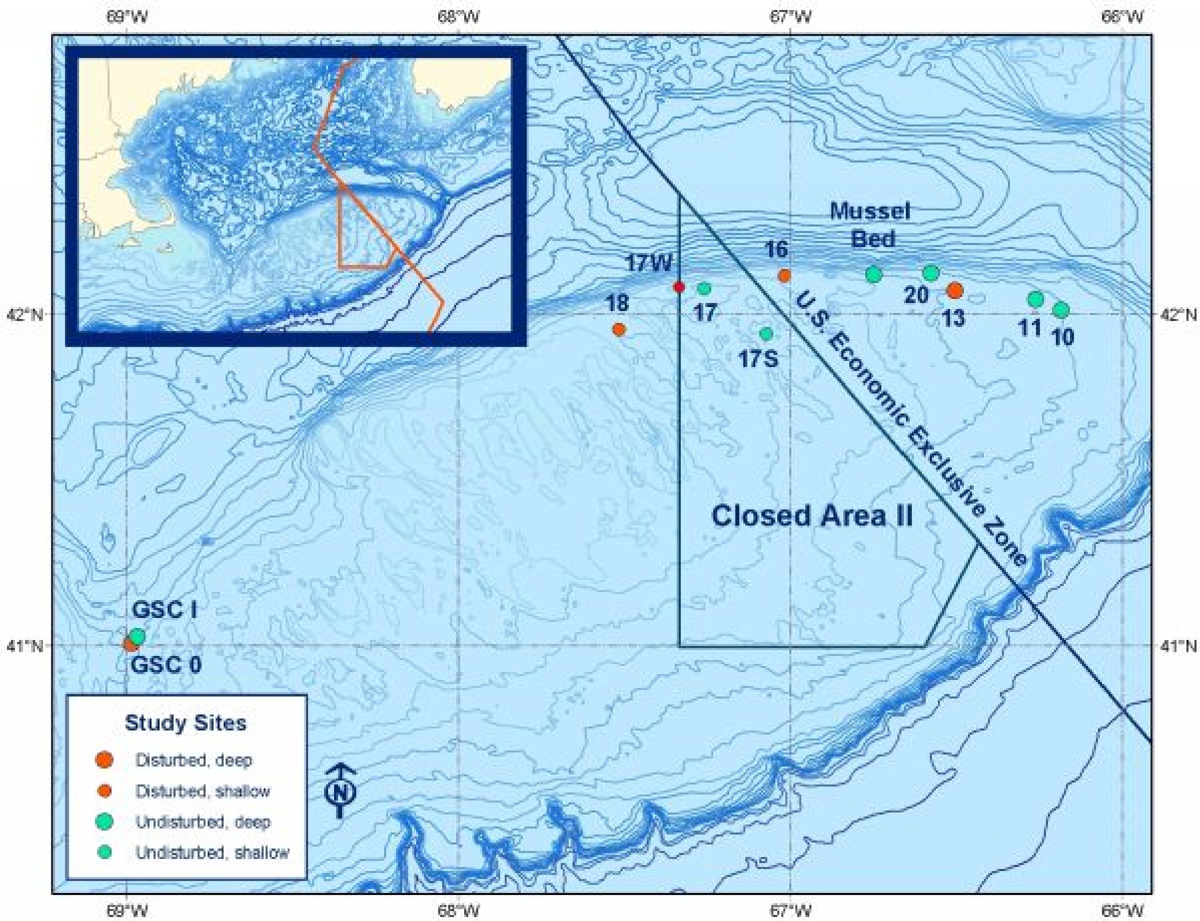


Figure 2.7 Map of Georges Bank Showing the US-Canada Border, the US Closed Area (Marine Protected Area Closed to Fishing) and Seabed Sites Where Repetitive Observations and Samples are Collected by US Researchers in the Northern Part of the Bank

Recent research by the USGS researchers have identified an invasive species of sea squirt on the northern edge of Georges Bank (Valentine, *et al.* 2007), on the American side colonizing at least a 6.5 square mile area at a depth of just over 150 feet. This sea squirt or tunicate has been identified as *Didemnum* cf. *lahillei* and is discussed in more detail in Section 2.2.2.2 below (Ecological Significance – Marine Fish and Invertebrates).

2.1.2.2 Georges Bank Overview

Morphology

Georges Bank buttresses the entrance to the Gulf of Maine as a large topographic feature. The Canadian-US boundary runs across the eastern part of the bank and it has been the focus of research for many years. Georges Bank is an oval-shaped bank in the outer part of the Gulf of Maine and is approximately 280 km long and 150 km wide. It is separated in the west from the Nantucket Shoals region by the Great South Channel and in the east from Browns Bank by Northeast Channel. In the north it is bounded by two westward shallowing basins: Georges and Franklin. It has been extensively studied for almost 100 years.

The new multibeam bathymetry image, shows much more detail on the morphology of the seabed, even at a small scale (Figure 2.8) (Kostylev *et al.* 2005). The large sand ridges in the northwestern and central area are composed of multiple fields of sand bedforms at varying scales. Figure 2.9 is a 3D multibeam bathymetric image looking across fields of sandy bedforms from the northern part of the Canadian sector of Georges Bank. Superimposed and isolated bedforms can be seen on the image. The asymmetry of the bedforms shows dominant sediment transport pathways from northwest to southeast that is in agreement with measurements of currents on the bank. The seabed of the northern part of Georges Bank is flatter with broad linear regions of bedforms separated by north-south trending deeper areas.

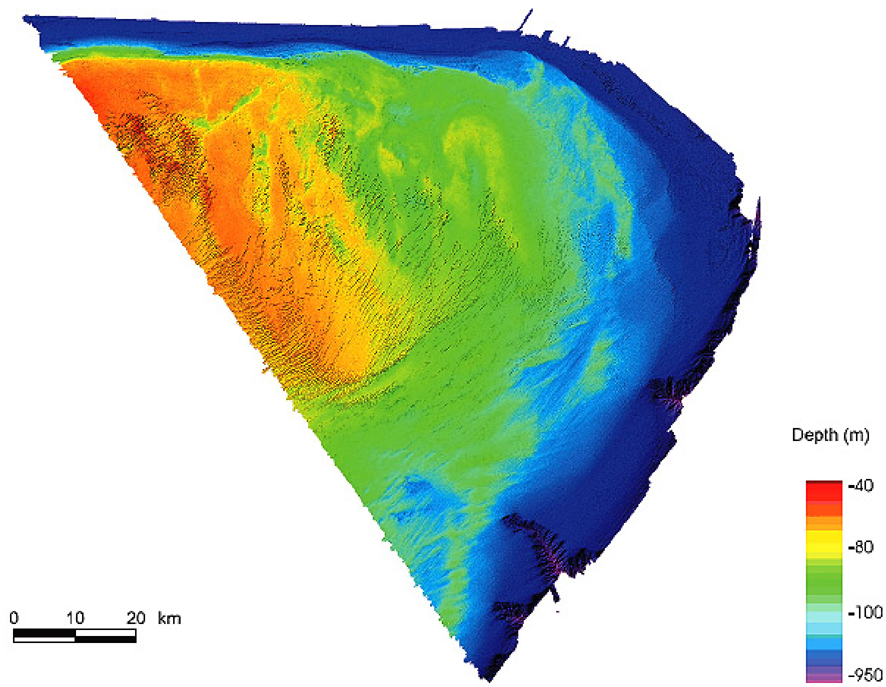


Figure 2.8 Coloured Shaded Relief Map of Bathymetry for Eastern Georges Bank Based on Multibeam Bathymetry (Kostylev *et al.* 2005)

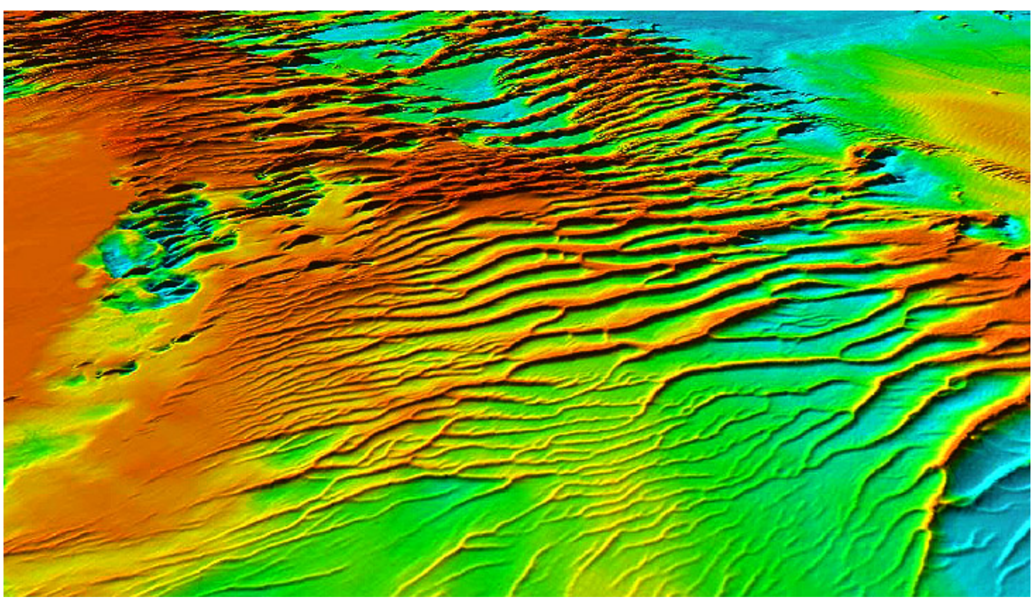


Figure 2.9 An Oblique Shaded Relief Image of Multibeam Bathymetry Looking to the North Across a Sand Bedform Field on Georges Bank (Image courtesy of Brian Todd, GSC)

Surficial Geology and Seabed Studies

Many studies have been conducted to assess the distribution of sediments and sand bedforms across the seabed of Georges Bank (Fader and Geonautics 1984; Valentine *et al.* 1992). The new multibeam bathymetry collected from the Canadian sector of Georges Bank has been processed for backscatter (Figure 2.10). Backscatter is used as a proxy for sediment texture and this greatly reduces the number of samples required to map the distribution of sediments. Areas in light tone are sand while darker regions are admixtures of sand and gravel and perhaps biogenic materials (*e.g., Filograna implexia)* that also shows a high degree of contrast on the sidescan sonar data. These calcareous tube worms can occur in densities so great that they change the reflectivity of the seabed as observed on sidescan sonar data. The presence of the calcareous tube worms called *Filograna implexia* is discussed further in Section 2.2.2.2 (Ecological Significance – Marine Fish and Invertebrates).

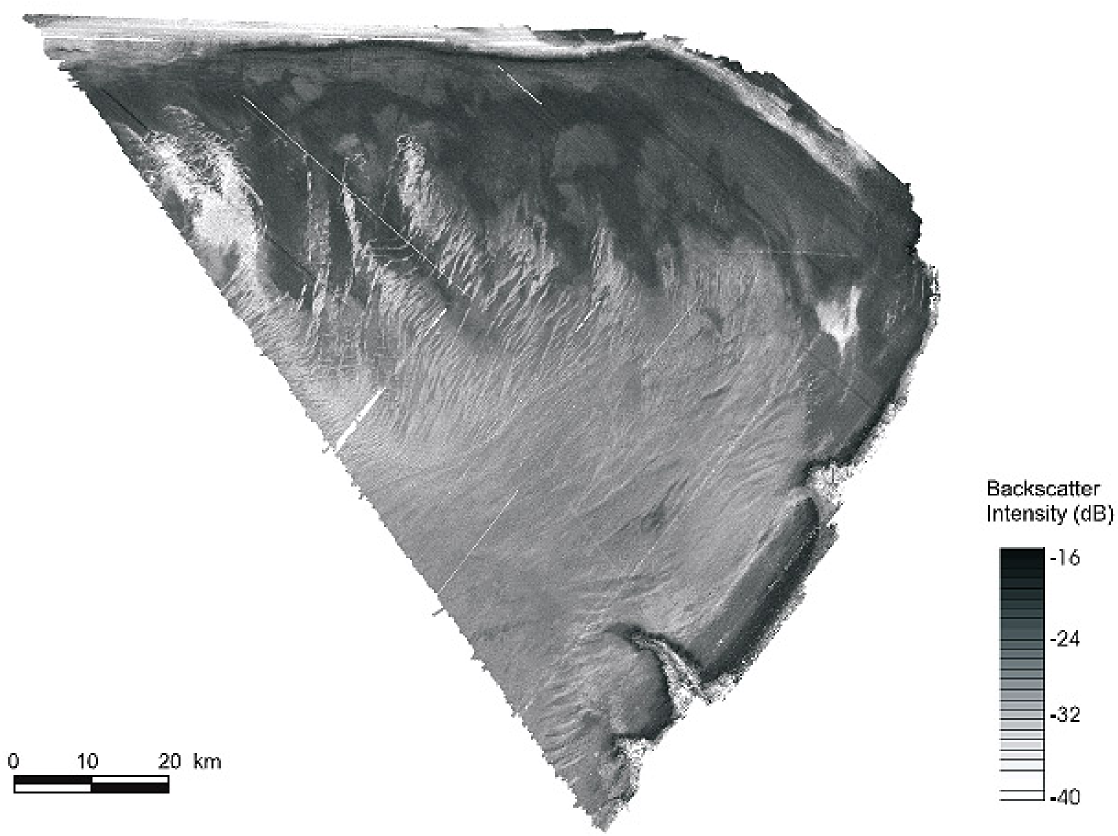


Figure 2.10 Backscatter Map of Eastern Georges Bank Showing Variations in Sediment Texture (Kostylev 2005)

The new maps of the Geological Survey of Canada planned for Georges Bank will incorporate information from bottom samples and photographs with the backscatter information that will result in the production of very high resolution and accurate maps of seabed sediments. Figure 2.11 is an interpreted map of sediment distribution across Georges Bank based on analysis of the multibeam bathymetry, backscatter and groundtruth.

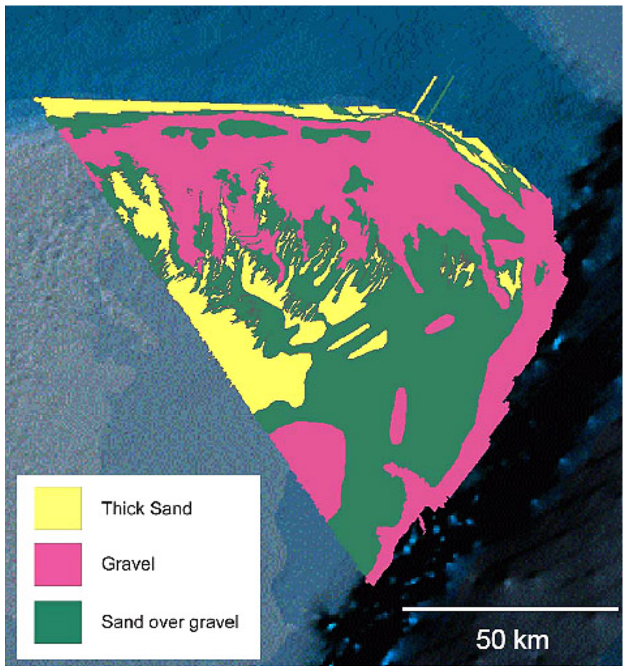


Figure 2.11 A Map of the Distribution and Thickness of Sediments of Georges Bank Based on Interpretation of the Multibeam Bathymetry, Backscatter and Ground Truth (Kostylev *et al.* 2005)

Of importance to the fishery and potential future seabed engineering activities on Georges Bank was the discovery of several large and dangerous shipwrecks on the seabed that was based solely on the multibeam bathymetry (*e.g.,* German U-Boat U-215; M. V. Alexander Macomb).

2.1.2.3 Georges Basin Overview

Morphology

Georges Basin is an elliptically-shaped, large depression in the southern part of the eastern Gulf of Maine and is oriented east west. It lies to the north of eastern Georges Bank and is 115 km long and 60 km wide. It shallows in the east where it joins with Northeast Channel and shallows in the west where it joins with Franklin Basin. It has a maximum depth of 377 m. The seabed is regionally smooth in the basin except for a local high near the centre that results from a bedrock protrusion of hard acoustic basement. The subsurface bedrock is varied, including hard and undulating, Paleozoic rocks in the north, flanked by younger less consolidated sedimentary Triassic/Jurassic, and Cretaceous/Tertiary bedrock in the south.

Surficial Geology

The surficial geology has been previously mapped by Fader and Geonautics, (1984) and Fader *et al.* 1988 and has been described by Fader *et al.* (1977). The new multibeam bathymetric data from Georges Basin only covers the southern and eastern part of the basin (Figure 2.12). The southern part of the image extends down the north slope of the Canadian sector of Georges Bank into Georges Basin. It does not cover the northern half extending toward Sewell Ridge.

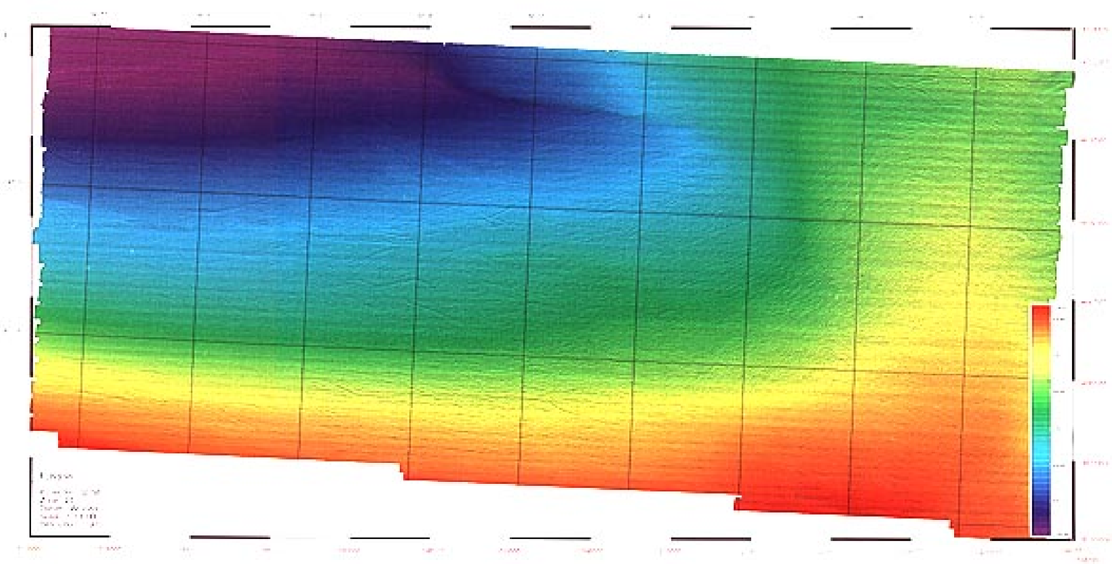


Figure 2.12 A Shaded-relief, Multibeam Bathymetric Image of Eastern Georges Basin (Image courtesy of the Canadian Hydrographic Service (CHS))

The new multibeam bathymetric image shows the seabed as uniform and generally flat with large areas covered in iceberg furrows with little variation. A detailed assessment shows that the seabed is more complex with a variety of iceberg furrow provinces, a field of sand bedforms and some areas entirely devoid of iceberg furrows likely resulting from burial by more recent sand transport or deposition of Holocene LaHave Clay.

Most of the seabed of this region is covered with iceberg furrows. They are long and linear, subparallel, and tend to follow the contours. They trend more or less east-west on the inner and southern part of the area and swing to the southeast in the eastern part. The iceberg furrows in deeper water tend to be wider than those in shallower water and those in shallower water tend to be more densely distributed. Iceberg pits are rare in this area but a grouping occurs on the south easternmost area of the image where Northeast Channel curves around the northeastern flank of Georges Bank.

There are several areas where the iceberg furrows are not evident on the multibeam imagery. The furrows may be buried in these areas. They occur in the deeper water to the northwest, in an area of the central western part of the image and along the flank of Georges Basin. In several areas the zone of no furrows projects into Georges Basin from the flank of the Bank and may have resulted from sand transport off the Bank.

A field of sand bedforms trending northeast – southwest occur on the upslope of a sill separating Georges Basin from Northeast Channel. The shallow part of the sill is covered with southeast trending iceberg furrows.

A regional assessment of the multibeam data suggests that bottom currents progressively become stronger from west to east in Georges Basin toward Northeast Channel (refer to Section 2.2.1 for more information on oceanographic conditions).

2.1.2.4 Northeast Channel Overview

Morphology

For the purposes of the current report, Northeast Channel is divided into two regions: inner and outer. It is the largest and deepest entrance feature to the Gulf of Maine from the open Atlantic Ocean crossing the outer continental shelf between Georges and Browns Banks. It is oriented northwest and swings westerly at the inner portion where it merges with Georges Basin and together they form a large deep area of the outer eastern Gulf of Maine that surrounds the eastern area of Georges Bank. The Channel can be morphologically divided into two segments. There are two curvilinear sills (shallower regions) that occur in Northeast Channel. The innermost lies in approximately 240 m water depth off the northeast peak of Georges Bank and lies near the junction with adjacent Georges Basin in the west. The second shallow sill occurs to the east of the above in water depths under 240 m. These sills likely represent till highs on the seabed that were deposited during ice stream retreat as grounded ice shelf features.

A description of the morphology of Northeast Channel area is based on interpretation of multibeam bathymetry (Figure 2.13 and 2.14) collected by the Geological Survey of Canada and the Canadian Hydrographic Service and an interpretation of the outer part of Northeast Channel is published in Mortensen *et al.* (2002).

On the basis of analysis of the seismic reflection, multibeam bathymetry and sample data, Northeast Channel is interpreted to have formed as a result of preglacial erosion by rivers which cross the Gulf of Maine. Subsequent erosion by glaciation widened and straightened the channel and deposited multiple tills. The ridges of till at the mouth of the channel formed during maximum ice extent in the channel as end moraines. Subsequent retreat of glaciers and the breakup of ice sheets produced large icebergs which impacted the seabed creating iceberg furrows and pits. Other than some recent sand transport, most areas of the Northeast Channel are relict reflecting former glacial environments.

Inner Northeast Channel Morphology

The inner Northeast Channel multibeam bathymetric image (Figure 2.13) shows two regions of sand bedforms at the seabed ranging up to 8 m in height. The larger northwestern sand wave field occurs in a gentle depression that almost extends across the entire Northeast Channel. The crests of all the sandwaves are oriented normal to the axis of the Northeast Channel indicating formation from strong currents, likely tidally driven. On the flanks of both Georges and Browns Banks occur linear zones of smaller sand bedforms. They extend in linear fields for distances of 10 km.

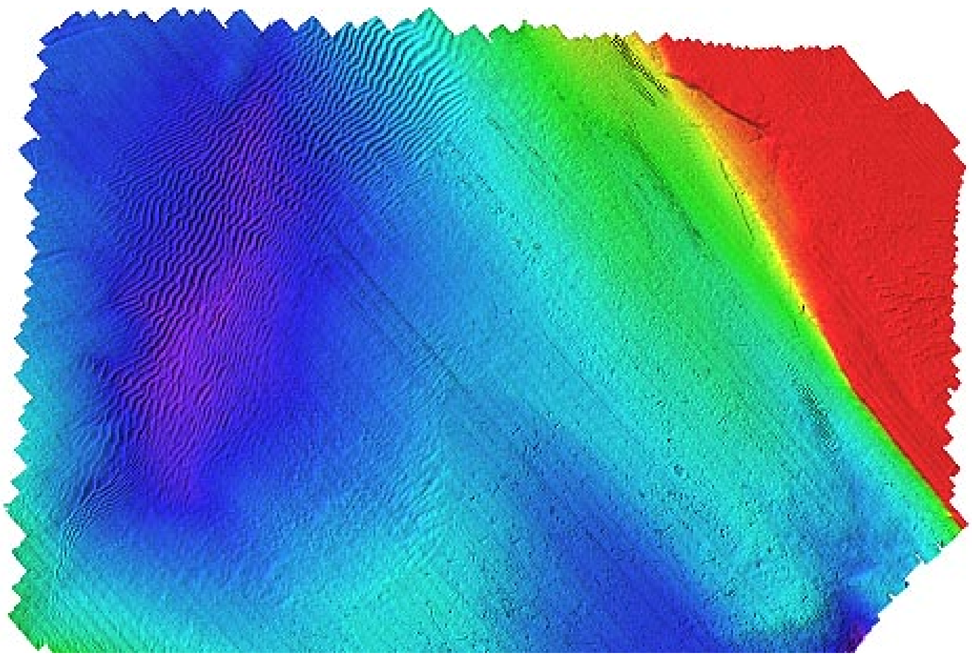


Figure 2.13 A shaded-relief multibeam Bathymetric Image of Inner Northeast Channel (The upper left part of the image shows a large field of sand bedforms. The lower right part of the image shows a seabed covered in linear old iceberg furrows and isolated iceberg pits) (Image courtesy of the CHS)

To the southeast the seabed is an iceberg pitted and furrowed glacial till bottom that continues further to the southeast toward the mouth of Northeast Channel. It can be subdivided into a southwestern area of predominantly linear iceberg furrows and to the northeast a zone of predominantly isolated iceberg pits. Observations from other similar areas on the Scotian Shelf and the Grand Banks of Newfoundland suggest that where iceberg pits are the dominant iceberg formed feature, they result from a harder seabed of more compact or bouldery till or the presence of bedrock in the subsurface close to the seabed. Iceberg pits and furrows that form in till usually have linear and circular berms along their flanks. The floors of the pits and furrows are often flat covered in cobbles with occasional ice rafted large boulders. Slopes can be steep on the furrow and pit flanks and sand and mud can sometimes accumulate in the troughs. This is not the case in Northeast Channel where the currents are very strong and little fine-grained muddy sediment appears to lie on the seabed.

Inner Northeast Channel Surficial Geology

The sediment overlying bedrock of inner Northeast Channel is largely the Scotian Shelf Drift and is a thick till deposited by grounded glaciers. Airgun seismic reflection profiles collected in the study area show at least 3 multiple stacked tills in the subsurface overlying Tertiary bedrock. It is not known if the three tills represent only the last or earlier ice advances that moved through the channel. Based on regional considerations, it is interpreted that Northeast Channel was completely covered by ice during the last major glacial advance, the Wisconsinan, which occurred approximately 20 – 21 000 ka. The till at the seabed was deposited during this time.

The prominent shelf break ridges at the seaward end of Romey's Peak and other areas at the mouth of Northeast Channel likely represent terminal moraines deposited at the grounding line of these glaciers. The iceberg furrows and pits were formed as the glaciers receded back up the channel generating large numbers of icebergs.

Outer Northeast Channel Morphology

A description of the morphology of outer Northeast Channel is based on interpretation of multibeam bathymetry (Figure 2.14) collected by the Canadian Hydrographic Service in 1999. The area is described as a deep water shelf break with two major deeper water broad reentrants protruding to the northwest back up the channel. The northernmost reentrant is locally termed the "Hell Hole" by the fishing community. In between these morphological linear depressions are three shallower areas with major ridges at the shelf break. The central northwest trending ridge is locally referred to by the fishing community as "Romey's Peak". Beyond the shelf break in depths greater than 400 m, the seabed morphology becomes canyonized and drops off steeply on the continental slope in a series of submarine canyons with canyon heads, ridges and steep-walled incised valleys. This deep water morphology is in contrast to the more gentle regional slopes within Northeast Channel. As shown in Figure 2.14, most of the seabed is composed of bouldery till. The yellow dots on the image are sites that were side scanned and where bottom photographs and video were collected to assess cold water corals.

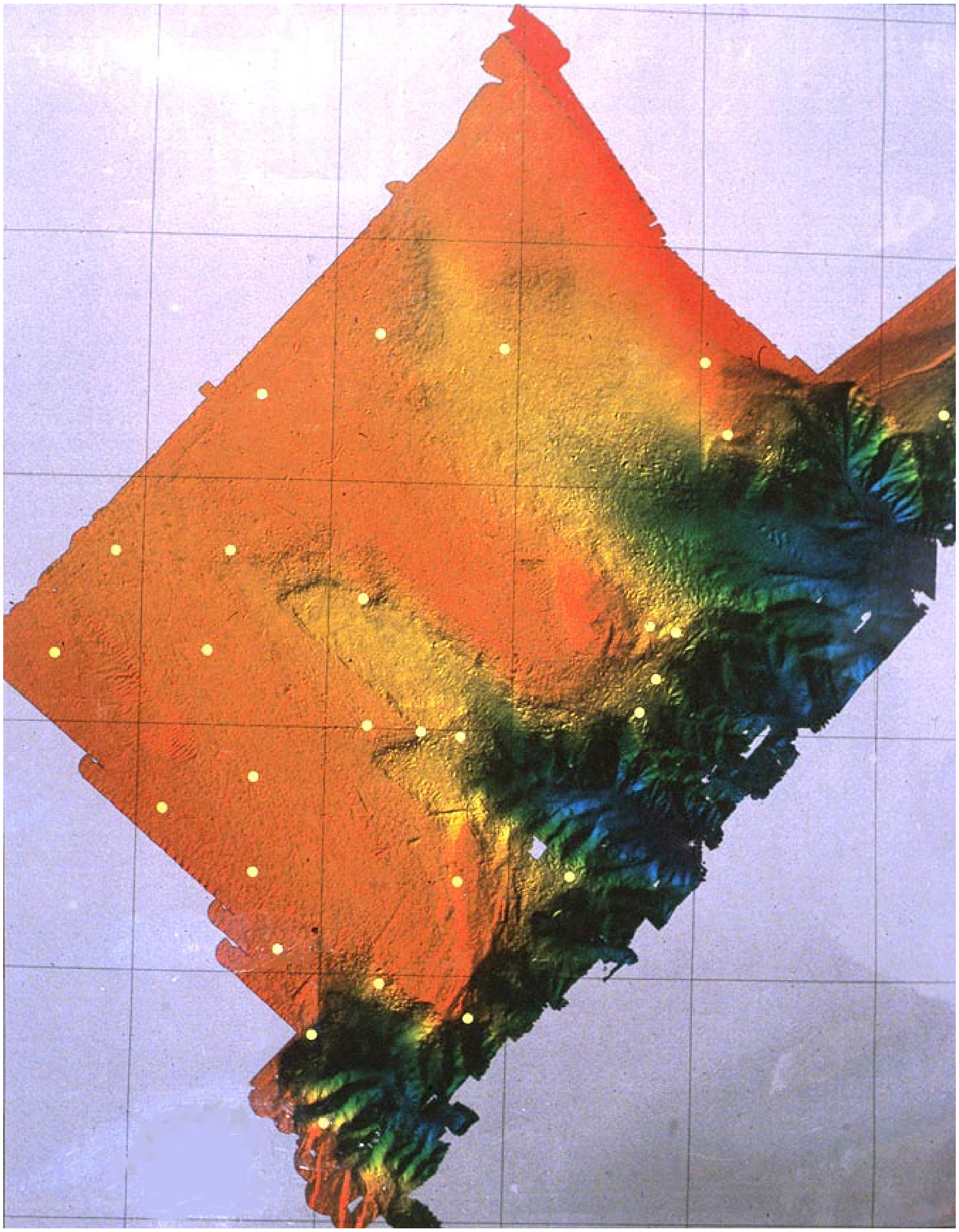


Figure 2.14 A Shaded-relief Multibeam Bathymetric Image of the Outer Part of Northeast Channel (Image courtesy of the CHS)

Outer Northeast Channel Surficial Geology

During the study of deep water coral in Northeast Channel (Mortensen *et al.* 2002), high resolution sidescan sonar data were collected in the deep part of the channel to provide more detailed information on seabed materials and morphology than was provided by multibeam bathymetry. The sonograms clearly depict a rough and irregular seabed of linear iceberg furrows and isolated circular pits. The berms of the furrows and pits are boulder covered whereas the floors of the furrows and pits are generally flat without boulders. In some areas of the channel the seabed is covered with sand ribbons. These bedforms are developed on the till surface and are interpreted as active sand bedforms on the seabed. They trend from northwest to southeast and are moving across the rough glacial terrain without interruption. The sand in these ribbons is interpreted to be thin, less than 1 m in thickness. Video and bottom camera observations (locations of which are shown as yellow dots on Figure 2.14) confirm the occurrence of sand in transport across areas of Northeast Channel. It also appears that when the gorgonian corals grow very large, they may topple over as a result of strong currents and an insufficient foundation (small boulder).

King (2005) conducted an extensive survey of the sand bedforms in the outer part of Northeast Channel and determined that some may be relict. The overall interpretation is that this part of the channel has active sand transport and formation of bedforms overlying an older iceberg furrowed till surface. The general setting of outer Northeast Channel is interpreted as one of high sand mobility even outside of the bedform fields.

2.1.2.5 Benthic Habitat Assessment

Producing functional seabed habitat maps is a very difficult undertaking and often more difficult than some of the other standard mapped products as it is necessary to integrate the results of multifaceted biological and oceanographic research into fixed products. A habitat mapping strategy has been devised that combines community based benthic analysis with numerical modeling to produce an understanding of the potential effects of complex variables on seabed habitat (Pickrill and Kostylev 2007). Using the new information provided by multibeam bathymetry as the underpinning, Kostylev *et al.* (2005) assessed and mapped habitats on the Canadian sector of Georges Bank following the habitat template theory of Southwood (1988).

This is a new approach toward habitat assessment and considers the various environmental conditions that have shaped the existing communities of benthic species and defined the life history traits of species. It utilizes the concepts of habitat disturbance and adversity for assessment. Disturbance is considered a function of sediment type, bottom currents and water depth. Adversity is based on chlorophyll concentration, water temperature, salinity and seasonal variations in temperature. The multibeam bathymetry backscatter information is used as a proxy for sediment type, as well as information on bathymetry and sediment transport. Samples and bottom photographs and video provided the essential ground truth.

The habitat template can be used to define regions that are sensitive to adverse anthropogenic impact. Where natural rates of habitat disturbance are high, then the risk of harmful habitat alteration can be less than in naturally stable areas. Kostylev (pers. comm. 2010) considers that habitat must be an animal-centered term — the conditions that animals need to survive, reproduce, *etc.*, therefore, habitat maps should also be animal-centered, *i.e.*, reflect the ecology and conditions that drive ecosystems.

Maps can be based on distributions of seabed surface characteristics and associated benthic populations and this method can identify large habitat areas. Assuming animal-sediment coupling, maps can be prepared on the assumption that similar groups of species occur on similar substrates but that may not be based on reality. Many of these assessments don't reach the animal-sediment coupling stage and assumptions are implicit.

Information about habitat properties and life history traits can be used by fishery groups seeking higher catches with less effort, and also by regulators and environmental groups to help preserve habitat and biodiversity.

The "habitat template approach" is a new template to address animal habitat coupling utilizing the relationship of life history traits to disturbance and productivity of the environment. It assesses the amount of stress and amount of energy coming into the system. It then evaluates removal due to disturbance; and resulting growth and reproduction due to the energy inputs. Plotting growth against disturbance provides an assessment of the risk of habitat destruction and potential for population recovery from impact.

For the Canadian offshore, Kostylev and Hannah (2007) first constructed maps for the Scotian Shelf where disturbance was assessed through an understanding of the distribution of grain size, bathymetry, and bottom current. This created a map of disturbance. Scope for growth was mapped based on primary production, average temperature, oxygen, and chlorophyll levels. Most productive areas/areas with most scope for growth occur in the Gulf of Maine and Bay of Fundy (Figure 2.15). Growth potential declines toward the east on the Scotian Shelf. The template values were found to explain the distributions.

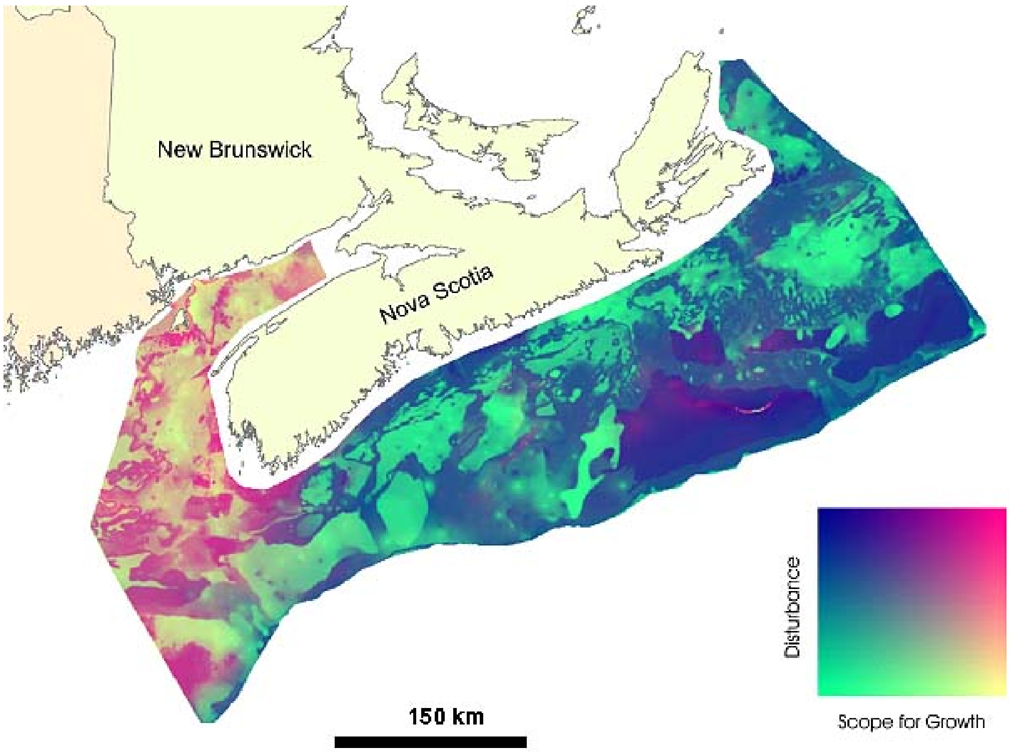


Figure 2.15 Map of the Scotian Shelf Showing the Habitat Template Applied Regionally (Kostylev and Hannah 2007)

A similar approach has been used by American researchers on Georges Bank where the template also explained species distribution well for this area. Most fishing occurs in disturbed habitats where it may be better to fish than in more sensitive areas.

This habitat model can also be used to predict system responses to different environmental changes, such as climate change and increased fishing effort. Increased disturbance due to fishery may predict, for example, more tunicates on Georges Bank. Therefore the habitat model not only helps to assess the current state but can help to predict what would happen if changes occur.

The application of the habitat template to Georges Bank has produced maps of the seabed (Figure 2.16 and 2.17) where regions can be defined according to their degree of stability as well as adversity for life. The resulting map shows the distribution of habitats where organisms with particular life history traits are likely to flourish. In the figures, blue represents adverse and disturbed areas, yellow is benign and disturbed, brown represents benign and stable, and green is adverse and stable. The map also provides an interpretation of habitat sensitivity to adverse effects for integrated management of ocean uses. The maps demonstrate a practical methodology for creating seabed habitat maps using the habitat template approach to integrate multiple environmental fields into a single map.

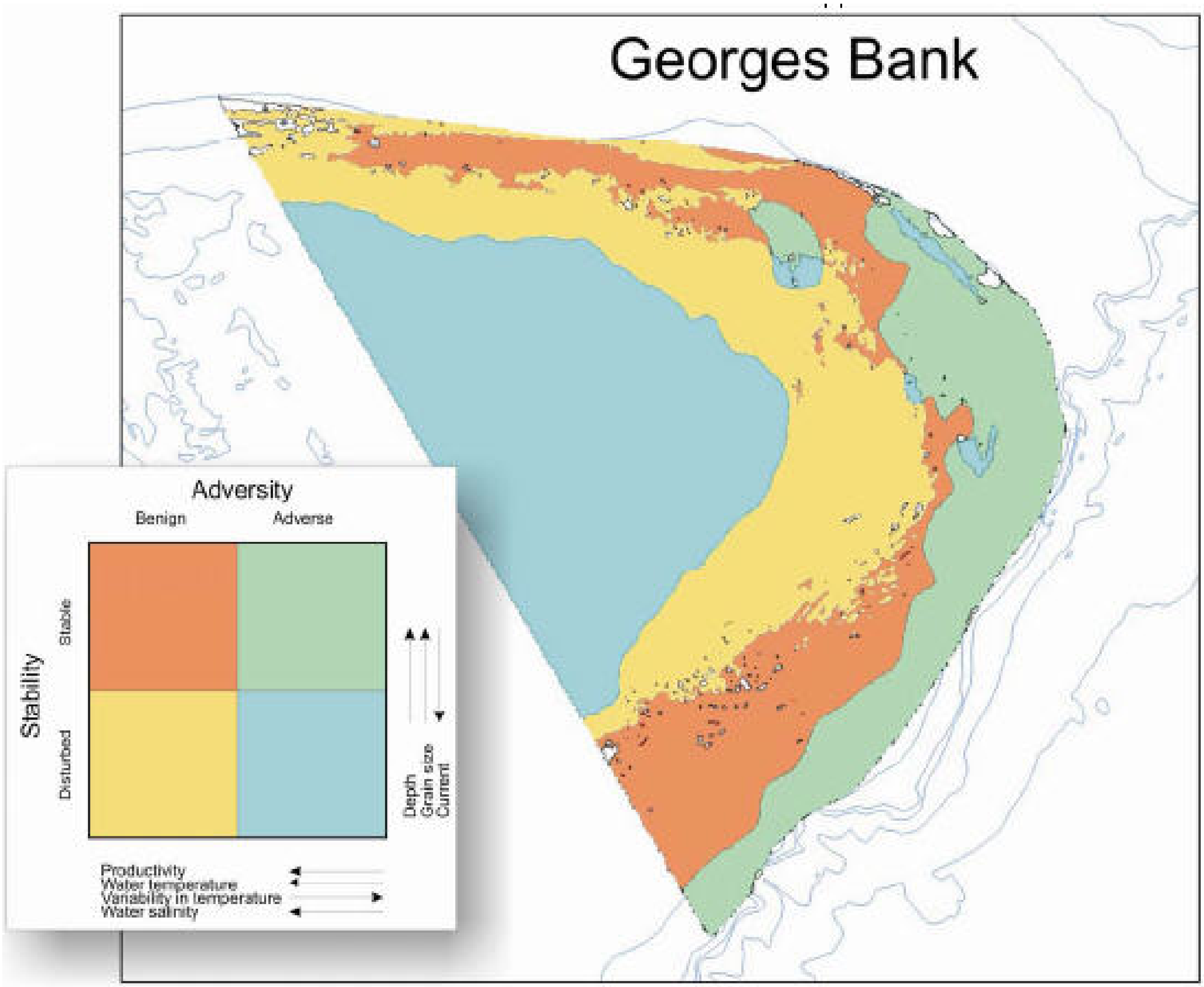


Figure 2.16 Map of the Habitat Template Applied to Georges Bank (Kostylev *et al.* 2005)

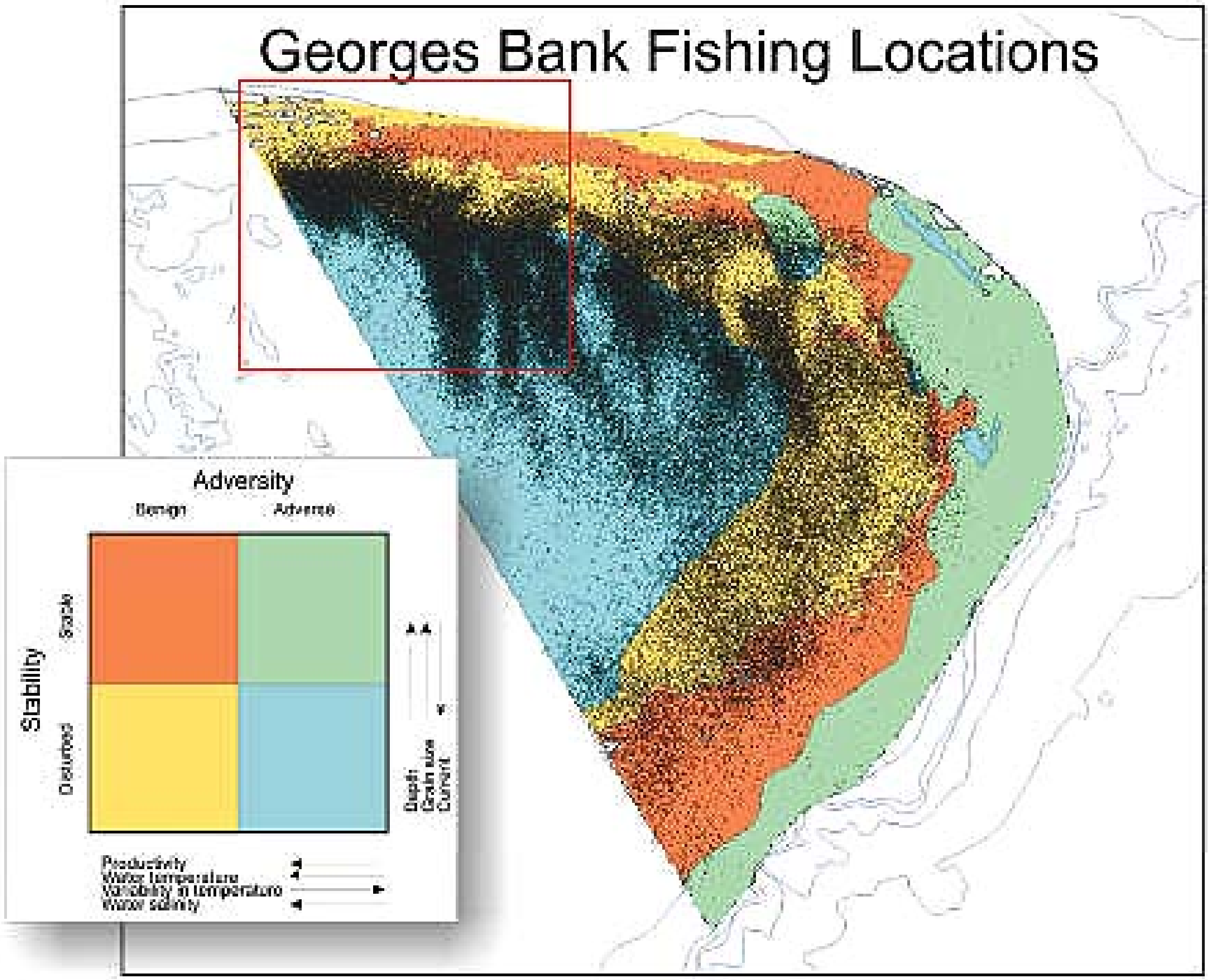


Figure 2.17 Habitat Template for Georges Bank Overlain by Fisheries Information on Scallop Fishing Effort (Kostylev 2009)

Areas of the western central core of Georges Bank clearly show as both adverse and disturbed and correspond on the multibeam bathymetry to areas of active large sandy bedforms. The northern areas of Georges Bank that are primarily composed of gravel, gravelly sand and boulders are both benign and stable. Areas between the northern gravel region and the central sand bedform province appear as benign and disturbed.

Such an assessment of the habitats of Georges Bank has never before been attempted and the results of this assessment clearly have defined regions where benthic communities are more likely to be resistant to anthropogenic activities. This understanding can therefore focus where such activities will have less impact and can be permitted, thus providing science based options for appropriate infrastructure siting.

Summary

Advances in technology and application of new analysis techniques have resulted in a significant advance in understanding of the physical structure of the moratorium study area. Further work on the GSC suite of maps and refinement of the habitat mapping template for Georges Bank will facilitate application of the habitat model to bottom fisheries and potential oil and gas activities in the moratorium area and will serve to protect sensitive habitats and minimize resource conflicts.

2.2 ECOLOGICAL SIGNIFICANCE

2.2.1 Physical Oceanography

2.2.1.1 Panel Context

An overview is provided below of the physical oceanography findings in the 1999 Georges Bank Review Panel Report, which generally support observations of ecological significance. This overview is intended to provide a better appreciation and understanding of our scientific advancement in this area and which is presented in Section 2.2.1.2 since the release of the Panel Report.

At the time of the Panel Report of 1999, knowledge on the physical oceanography, and particularly the driving forces for currents, seasonal water circulation patterns, and contributing factors for the water mass characteristics and structure on the temporal and spatial scale, was relatively well understood for the entire area of Georges Bank including the Canadian moratorium area on the eastern side of the Bank. Currents on Georges Bank are primarily driven by strong tidal currents, with winds, differences in water densities, and storms also contributing on the short and long-term to spatial variations and strengths in currents and water mass characteristics. The Bank's topography and bathymetry also influences the current speeds and directions over the entire Georges Bank.

As a result of the strong tidal currents and the Bank's topography, on the short time scale and within a tide cycle the currents range in speed from approximately 0.2 m s^{-1} in deeper water around the Bank's edge to over 1.0 m s^{-1} in shallower water on top of the Bank. This results in the excursion of water ranging from 2 km in deeper water to over 15 km on the Bank's central plateau. Movement of surface or suspended material released from a fixed point will occur within hours. Water circulation and seasonal currents on a longer time scale flow in a partial clockwise gyre around the edge of Georges Bank. Current speeds of this gyre range from 0.1 to 0.2 m s^{-1} over most of the Bank's edge to 0.2 to 0.4 m s^{-1} along its northern edge. The gyre intensifies and is more closed in the spring and summer because of fresher and more solar-heated water, respectively, and as a result of stronger seawater density gradients in the frontal zones described below.

Three identifiable zones containing unique water mass characteristics are known to occur on Georges Bank, including the Northeast section of the Bank which is the Canadian side and in the moratorium area. The first zone, known as the ‘mixed zone’, contains well-mixed waters with vertically uniform temperature, salinity and density throughout the year above the 60-m depth contour and generally found on top of the Bank. This increases to the 100-m depth contour in the winter because of increased wind mixing and surface cooling. The second zone is the ‘frontal zone’ where the convergence of surface water towards the mixed zone occurs and a noticeable change in the horizontal seawater density is observed. In the summer, the frontal zone is more intense, migrates on-bank and in association with the jet-like flow of the gyre, and where the width varies from 15-20 km over the Bank’s northern edge and up to 40-50 km over the Northeast Peak. The third zone is the stratified water mass of the shelf-slope front on the east slope of Georges Bank that extends from the edge of the Bank and boundary with the frontal zone over to the shelf-edge. The water in this zone is stratified between that of the cooler and fresher shelf water with that of the warmer and more saline slope water beyond the Bank and attributed to the Gulf Stream.

On the basis of drifter and modeling studies carried out and by the time the Panel Report was released, the residence time of water on Georges Bank is estimated as generally ranging from 20 to 80 days on the whole Bank. Furthermore, the residence time is highly dependent on spatial position, season, storms and episodic events such as intrusion of Gulf Stream rings onto the Bank. The highest resident times of passive material (*e.g.,* particles, plankton, eggs and larvae) are expected in the lower water column on the Bank’s central plateau and in the frontal zone in summer for when the gyre circulation tends to be more closed and within the 70-m depth contour. The lowest residence times of the water are expected in near-surface waters in winter and generally around the Bank and in summer over the southern edge of the Bank.

With respect to dispersion and dilution of surface and neutrally buoyant material on the Bank, the high vertical mixing rates should generally contribute to high dilution rates. Strong currents are expected to contribute to relatively high rates of dispersion as well. However, the higher dispersion and dilution potential on the Bank can be offset and dependent on the location and proximity of the material (*e.g.,* spills) to the near-surface convergence in the frontal zone, at the Bank edge, and in the tidally mixed area on the Bank plateau. In addition, the partial gyre around the Bank will likely have retentive features on a larger spatial scale.

2.2.1.2 Advancement in Scientific Knowledge

Boudreau *et al*. (1999), in their summary of water circulation, hydrographic structure and mixing, indicated that “while much is known and understood about its (the Bank) physical regime, the rich complexity of processes and scales on Georges Bank has made it difficult to obtain robust quantitative measures of many important quantities relevant to the fates of materials introduced to the Bank” (p. 11). During the intensive studies conducted by the US GLOBEC program on Georges Bank from 1994 to 2000 and since then, new measurements, observations and modeling work have been undertaken to advance our knowledge in this area, among other physical oceanographic processes, and which have been synthesized and described by Kennedy *et al.* (2010). An overview of this synthesis is presented below.

These new studies (cited within and summarized in Kennedy *et al.* 2010) available since the release of the 1999 Panel Report include near-surface drift patterns and residence time estimates, slope water intrusions over the Bank's edges and onto Georges Bank, exchange across frontal zones (the tidal mixing front and shelf-slope front), cross-overs of Scotian Shelf water onto the Bank (across the Northeast Channel and onto the Northeast Peak of Georges Bank), and interannual and decadal variability. Figure 2.18 provides a schematic summary of many of the physical oceanographic findings from the GLOBEC investigations (taken from Kennedy *et al.* 2010).

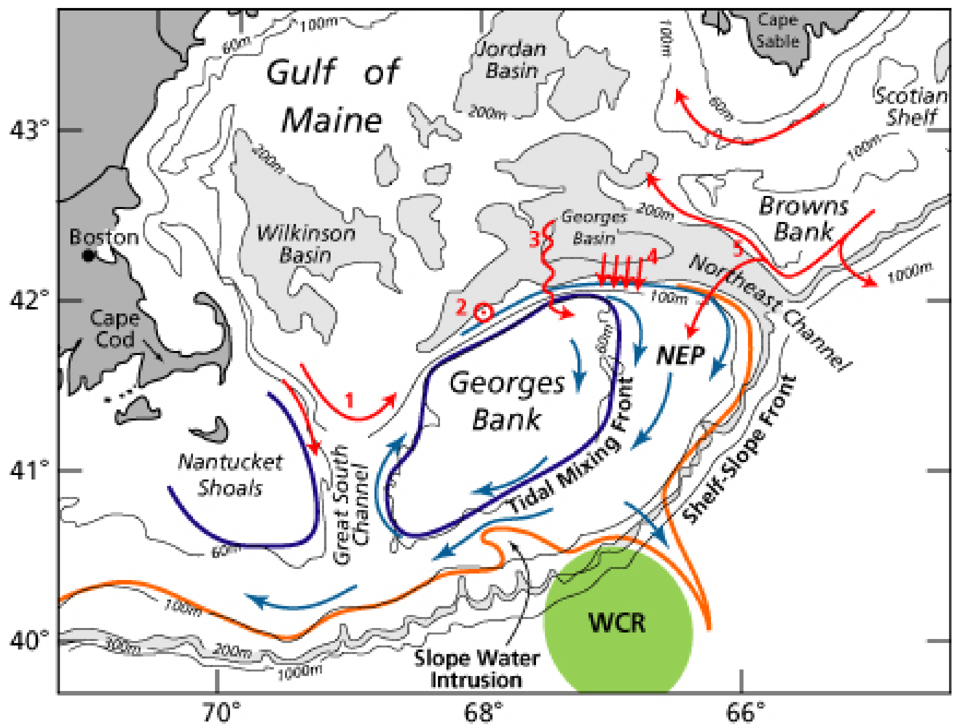


Figure 2.18 Partial Summary of Physical Oceanographic Advancement Since the 1999 Panel Report (taken from Kennedy *et al.* 2010)

The residence time of near-surface water (based on 10-m water depth drifter drogues) measured by Brink *et al.* (2003) (cited in Kennedy *et al.* 2010) on the Bank, and where the flow observed was always clockwise around the Bank and during all seasons, was typically 40 days in winter and 90 days in summer. This difference in residence time is attributed to summer water stratification and topographic rectification of tidal currents. The strong winter/spring storms and entrainment of warm core rings (warm water parcels that break off from the Gulf Stream) are provided as the main factors, besides the gyre, for the shorter residence time in winter.

The quantity of occasional cross-over of Scotian Shelf water across the Northeast Channel and onto Georges Bank was found to be significant during the winter and spring in surface waters above 40-60 m water depth (Bisagni and Smith 1998 cited in Kennedy *et al.* 2010). Mesoscale offshore eddies in the Northeast Channel have been suggested as a possible factor leading to significant interannual variability in the cross-over. The transit time of the cross-over surface water from 15 to 50 m water depth, and based on measurements from current meters, drogues, and satellite imagery, has been provided as ranging from 2 to 26 days (Smith *et al.* 2003 cited in Kennedy *et al.* 2010). The residence time of the Scotian Shelf Cross-over (SSC) water on Georges Bank ranged from 3 to 4 weeks. Smith *et al.* (2003) also attribute SSCs to primarily mesoscale features in the Northeast Channel, with surface winds having a minor role. SSCs have also been shown as a source of zooplankton populations on Georges Bank, using the copepod *Calanus finmarchicus* (Wishner *et al.* 2003, cited in Kennedy *et al.* 2010).

Based on field observations, cross-frontal exchange and mixing across the tidal front on the northern edge of Georges Bank is caused by tidal pumping, rather than mean circulation or other physical factors (Ullman *et al.* 2003, cited in Kennedy *et al.* 2010). The outcome is upwelling of deep water close to the bottom at the Bank edge. Modeling by Chen *et al.* (2003) (cited in Kennedy *et al.* 2010) have shown two pathways for on-Bank movement of water and material. These pathways occur over the northern edge across the front and near the bottom, and on the southern edge of the Bank. In addition, high winter winds can result in significant off-Bank transport that results in “washout” of Bank waters. Wind fluctuations along with tidal mixing have also been shown to be important factors in transporting water and material from across fronts from stratified to mixed regions on the Bank in early summer.

Analysis of interannual and decadal variability has lead to a general conclusion of an increase in temperature and changes in salinity over time that has led to a steady increase in stratification on Georges Bank since the late 1980s (East Coast Aquatics 2009, cited in Kennedy *et al.* 2010). The interannual change in salinity on Georges Bank is attributed to changes in upstream Scotian Shelf sources and the mixing of these waters on the Bank. Freshwater sources contributing to Georges Bank are mainly the Gulf of St. Lawrence water, which is comprised of Labrador Shelf Water and St. Lawrence River Water (Houghton and Fairbanks 2001 cited in Kennedy *et al.* 2010).

In summary, the advancement in scientific knowledge with respect to the physical oceanography has been primarily a refinement of estimates, such as residence time of Georges Bank water, and sources, retention, and losses of water and material on the Bank. Physical forces, processes and spatial locations of water transport on and off the Bank seasonally have also been further understood since the 1999 Georges Bank Review Panel Report.

2.2.2 Productivity and Biodiversity

2.2.2.1 Panel Context

The high productivity and biodiversity of Georges Bank have been major underlying considerations in assessing potential hydrocarbon exploration and production on the Bank (NRCan and NSPD 1999). The 1999 Review Panel suggested that nutrients crossed the tidal-mixing front toward the central area of Georges Bank, allowing phytoplankton production to continue through the summer. Production estimates for various food-web components was provided for Georges Bank and comparable continental shelf ecosystems (Table 2.1).

Table 2.1 Summary of Estimated Levels of Production (kCal·m-2 .y-1) at Various Trophic Levels on Georges Bank Compared With Some Other Continental Shelf Ecosystems (adapted from Cohen and Grosslein 1987)

Component	Georges Bank	Gulf of Maine	Scotian Shelf	North Sea
Phytoplankton	3342	2256	2280	2280
Microzooplankton	202	207	195	186
Macrozooplankton	285	367	216	214
Macrobenthos	98	98	82	100
Microbenthos	13	n.e.	n.e.	25
Fish	52	26	21	24

2.2.2.2 Advancement in Scientific Knowledge

Kennedy *et al.* (2010) revisit the productivity estimates included in the Panel Report and observe that the primary (phytoplankton) production is about 50% higher on Georges Bank compared to other regions, and fish production is about twice as high compared with the other regions. Kennedy *et al.* (2010) attribute the high diversity of fish and shellfish on Georges Bank to “variation in spawning periods that occur (sic) among species and the high level of year-round productivity.” They suggest that the higher fish production may derive from greater use of benthos (not itself more productive on Georges Bank) or that fish obtain a higher fraction of their growth during migrations off Georges Bank.

However, this perceived higher fish production may be open to question based on recent analyses by Link *et al.* (2007), based on (two) mass-transfer network models, which have been increasingly used to derive estimates of production in recent years, although not without controversy. It is difficult to reconcile some of the historical estimates of production of various components summarized by Link *et al.* (2007) with those on Table 2.1, but Link *et al.* estimate that a much higher proportion of the primary production is used by the zooplankton (micro- and macrozooplankton not discriminated), and that the fish production is somewhat diminished compared with the estimate on Table 2.1 and dominated now by small pelagic rather than benthic fishes. Link *et al.* (2007) stress that the strong "bottom-up forcing" (*i.e.,* driven by high phytoplankton production) makes the system highly resilient to effects at higher trophic levels, although possibly more vulnerable to effects like climate change that influence circulation patterns and primary productivity.

Additional detail on relative diversity of species using the moratorium study area is provided in subsequent sections below.

2.2.3 Marine Fish and Invertebrates

2.2.3.1 Panel Context

The 1999 Panel Review recognized two benthic invertebrate species and several groups of fish (cods and hakes, flounders and soles, bottom associated species, and pelagics) known to inhabit the Georges Bank area. Spawning times of the identified species were shown to stagger throughout the year and multiple possible trophic interactions were suggested. It was acknowledged that the understanding of food-web dynamics may have been deficient at the time of the report to allow for a definitive explanation of why fish productivity on Georges Bank was two to two and half times greater than in other comparable areas (NRCan and NSPD 1999).

Species accounts were provided for the key commercial fisheries species including scallop, lobsters, cod, haddock, pollock and yellowtail flounder. Brief life history details were also provided for herring, mackerel, sharks, tuna, swordfish and corals. However, species at risk were not identified, the use of Georges Bank by a large number of diverse invertebrate species was not addressed, and the focus on the commercial fisheries species somewhat overshadowed the presence of the wide variety of fish species that contribute to the ecosystem function of Georges Bank.

The benthos and fish species data collected and presented by the Review Panel contributed to the overall consideration of the ecological significance of Georges Bank. The ecological significance conclusion of the panel was that the Georges Bank ecosystem was highly diverse, highly productive, and exceptional in its combination of special features.

2.2.3.2 Advancement in Scientific Knowledge

Fish Species

A six year collaboration between the Conservation Law Foundation and WWF-Canada yielded a substantial, peer-reviewed report (referred to herein as the Priority Areas for Conservation report) describing a science-based approach to identifying priority areas for conservation in New England and Maritime Canada, including the biogeographic area of Georges Bank (Conservation Law Foundation and WWF-Canada 2006). The authors used the computer programme MARXAN to evaluate and identify the best network of priority conservation areas to meet the three primary network objectives of habitat representation, inclusion of biologically distinctive areas and recognition of biogeographic areas (*e.g.,* Gulf of Maine, Georges Bank and Scotian Shelf). Seven of the 30 individual priority areas making up the recommended conservation network include portions of Georges Bank (Figure 2.19), with three of those seven priority areas including portions of the current moratorium area of Georges Bank (Conservation Law Foundation and WWF-Canada 2006).

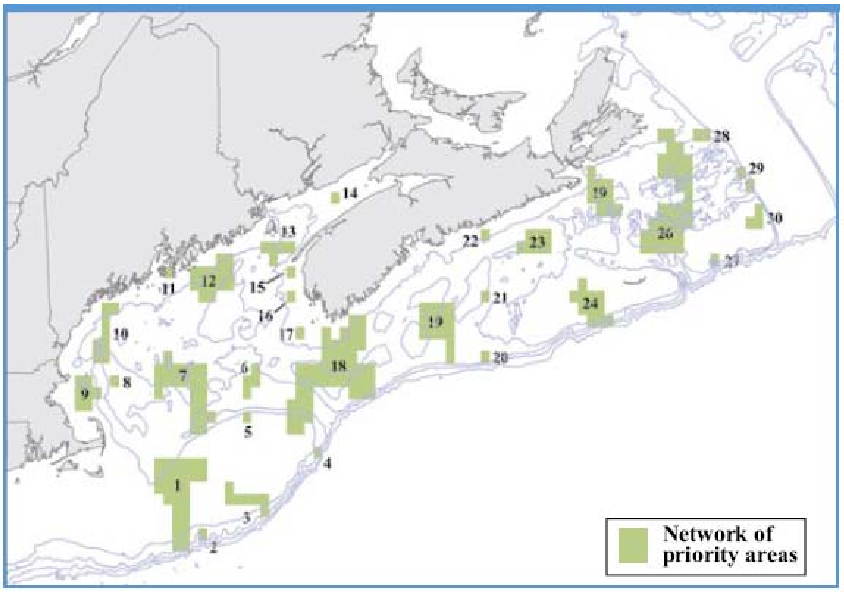


Figure 2.19 Network of Priority Areas for Conservation in the Greater Gulf of Maine and Scotian Shelf (Conservation Law Foundation and WWF-Canada 2006)

Multiple types of information were used to identify the priority areas for conservation including primary production, demersal fishes, cetaceans, and abiotic characteristics of the water and seafloor. The demersal fishes information collected and presented in the 2006 Priority Areas for Conservation report focused on the abundance and richness of resident species for each of the biogeographic areas assessed, including Georges Bank. The species data provides an updated source of information for Georges Bank demersal species. Demersal marine fish are those that live on or close to the ocean floor. A total of twenty-one demersal fish species were identified in the 1999 Panel report. The 1999 Panel Report focused on the four select demersal species that underwent heaviest commercial fishing at the time: Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*) and yellowtail flounder (*Limanda ferruginea*). Updates on these four species and several others were provided by DFO in 2010 (Kennedy *et al.* 2010) as well. Kennedy *et al.* (2010) concluded that Eastern Georges Bank Cod stock productivity is poor as a result of low recruitment and low weights-at-age. Haddock adult biomass was at a record high at the beginning of 2009 following an exceptional year class spawned in 2003, while abundance of pollock has been recovering over the past decade. There has been no directed yellowtail fishery on the Canadian side of Georges Bank in recent years as a result of low quota and a lack of availability of the fish (Kennedy *et al.* 2010).

Kennedy *et al.* (2010) broaden their consideration of the potential Georges Bank fish assemblage and provide a review of nearly one dozen demersal species that are not a focus of commercial fishing. Similarly, the 2006 Priority Areas for Conservation Report took an inclusive ecosystem-approach that included all confirmed demersal fish species on Georges Bank. In this report, a total of 45 demersal fish species (Table 2.2) were classified as residents of Georges Bank according to published records; data used in the analyses were provided by DFO and the US National Marine Fisheries Service (Conservation Law Foundation and WWF-Canada 2006). This species total reflects the full biogeographic area of Georges Bank (since fish do not recognize jurisdictional boundaries) and is not limited to the current moratorium area. The Priority Areas for Conservation report also noted that while Georges Bank was one of the most highly productive areas in their assessment, it exhibited moderate to low-average demersal fish richness compared with the two other biogeographic areas in their study. There was a distinct richness peak at the northeastern tip of Georges Bank, according to the MARXAN analysis (Conservation Law Foundation and WWF-Canada 2006). This richness peak falls within the current moratorium area.

The doubling of the total number of identified demersal fish species contributing to ecosystem function on Georges Bank represents a substantial advancement in ecological significance knowledge since the 1999 Panel Report. The spawning periods accounted for by the 22 demersal fish species identified in 1999 spanned the full calendar year and it was suggested that this temporal staggering of spawning activities contributed to Georges Bank being able to support a high number of co-existing species (NRCan and NSPD 1999). Considering the increased number of demersal fish species now known to inhabit Georges Bank, it is anticipated that spawning period and age class interactions are even more diversified than suggested in 1999. The Priority Areas for Conservation MARXAN assessment of juvenile and adult abundance patterns suggests that the shallow shoal areas of Georges Bank has higher relative density for juvenile fishes than for adults, a trend which was observed in juvenile white hake, silver hake and winter skate abundance patterns (Conservation Law Foundation and WWF-Canada 2006).

An additional two bottom-dwelling fish species, not included in the Priority Areas for Conservation report, were identified in the 1999 Panel Report and DFO's 2002 status report concerning fisheries management planning for the Canadian Eastern Georges Bank groundfish fishery: monkfish or goosefish (*Lophius americanus*), and summer flounder (*Paralichthys dentatus*). Both monkfish and summer flounder were reported in the group of less commonly caught non-quota species in DFO's 2002 status report (DFO 2002a). These species were identified as by-catch associated with the cod, haddock, yellowtail and pollock groundfish fisheries (DFO 2002a). Monkfish have also been a bycatch of the scallop industry, with large landings in Georges Bank (Division 5Zc) throughout the late 1980s and early 1990s (DFO 2002c). Landings continue to fluctuate and the amount of monkish incidentally caught and discarded in the scallop fisheries is unknown but has the potential to be substantial (DFO

2002c). The summer flounder is a lefteye flounder (family Bothidae) that has previously been reported as occurring rarely in the Canadian Atlantic area (Scott and Scott 1988).

Three species of wolffish (spotted wolffish (*Anarhichas minor*), Northern wolffish (*Anarhichas denticulatus*), and Atlantic wolffish (*Anarhichas lupus*)) and three species of redfish (deepwater redfish (*Sebastes mentella)*, Acadian redfish (*S. fasciatus)*, and ocean perch (*S. marinus*) were identified by Kennedy *et al.* (2010) as potentially occurring on Georges Bank. Within these two groups of fish only one species from each group, Atlantic wolffish and Acadian redfish, were included in the Priority Areas for Conservation report as confirmed inhabitants of Georges Bank (Table 2.2). The Atlantic wolffish is considered common in the Gulf of Maine and is generally fished as bycatch. The Atlantic and spotted wolffish are known to inhabit deep waters while the Northern wolffish is understood to inhabit a wide range of water depths (Scott and Scott 1988). Spotted and Northern wolffish are considered rare or vagrant inhabitants of Georges Bank (Kennedy *et al.* 2010). All three species of redfish are considered to be physically similar and are managed together in the fishery (Kennedy *et al.* 2010). Kennedy *et al.* (2010) also identify the black dogfish (*Centroscyllium fabricii*) as a demersal species with a known distribution along the outer continental shelves and slopes of the North Atlantic Ocean. A consideration of the movement of the species in relation to the Georges Bank Moratorium area had not been completed at the time of the current report (Kennedy *et al.* 2010).

Table 2.2 A: Summary of Georges Bank Demersal Fish Species (adapted from Conservation Law Foundation and WWF-Canada 2006)

Family Name	Common Name	Scientific Name
Agonidae (Poachers)	Alligatorfish	*Aspidophoroides monopterygius*
Ammodytidae (Sand lances)	Northern sand lance	*Ammodytes dubius*
Anarhichadidae (Wolffishes)	Atlantic wolffish	*Anarhichas lupis*
Argentinidae (Argentines)	Atlantic argentine	*Argentina silus*
Bothidae (Lefteye flounders)	Summer flounder [1]	*Paralichthys dentatus*
Cottidae (Sculpins)	Hookear sculpin (Genus)	*Artediellus spp*
	Moustache sculpin	*Triglops murrayi*
	Longhorn sculpin	*Myoxocephalus octodecemspina*
	Shorthorn sculpin	*Myoxocephalus scorpius*
Cryptacanthodidae (Wrymouths)	Wrymouth	*Cryptacanthodes maculatus*

Table 2.2 A: Summary of Georges Bank Demersal Fish Species (adapted from Conservation Law Foundation and WWF-Canada 2006)

Family Name	Common Name	Scientific Name
Cyclopteridae (Lumpfishes and snailfishes)	Lumpfish	*Cyclopterus lumpus*
Gadidae (Codfishes)	Cusk	*Brosme brosme*
	Atlantic cod	*Gadus morhua*
	Haddock	*Melanogrammus aeglefinus*
	Red hake	*Urophycis chuss*
	White hake	*Urophycis tenuis*
	Pollock	*Pollachius virens*
Hemitripteridae (Sea ravens)	Sea raven	*Hemitripterus americanus*
Labridae (Wrasses)	Cunner	*Tautogolabrus adspersus*
Lophiidae (Goosefishes)	American angler	*Lophius americanus*
	Monkfish [1]	*Lophius americanus*
Lotidae (Lings/rocklings)	Four beard rockling	*Enchelopus cimbrius*
Merlucciidae	Silver hake	*Merluccius bilinearis*
	Spotted hake	*Urophycis regius*
Myxinidae (Hagfishes)	Atlantic hagfish	*Myxine glutinosa*
Ophidiidae (Cusk eels)	Fawn cusk eel	*Lepophidium cervinum*
Paralichthyidae (Large-tooth flounders)	Gulfstream flounder	*Citharichthys arctifrons*
	Fourspot flounder	*Paralichthys oblongus*
Petromyzontidae	Sea lamprey	*Petromyzon marinus*
Pleuronectidae (Righteye flounders)	Witch flounder	*Glyptocephalus cynoglossus*
	Atlantic halibut	*Hippoglossus hippoglossus*
	American plaice	*Hippoglossus platessoides*
	Yellowtail flounder	*Limanda ferruginea*
	Winter flounder	*Pseudopleuronectes americanus*
Rajidae (Skates)	Thorny skate	*Amblyraja radiata*
	Little skate	*Leucoraja erinacea*
	Winter skate	*Leucoraja ocellata*

Table 2.2 A: Summary of Georges Bank Demersal Fish Species (adapted from Conservation Law Foundation and WWF-Canada 2006)

Family Name	Common Name	Scientific Name
Rajidae (Skates) (Cont'd)	Smooth skate	*Malacoraja senta*
	Barndoor skate	*Raja laevis*
Scophthalmidae	Windowpane flounder	*Scopthalmus aquosus*
Scorpaenidae (Scorpionfish)	Northern searobin	*Prionotus carolinus*
Sebastidae	Acadian redfish	*Sebastes faciatus*
Squalidae (Dogfish sharks)	Spiny dogfish	*Squalus acanthias*
Stichaeidae (Pricklebacks/shannies)	Snake blenny	*Lumpenus lumpretaeformis*
	Daubed shanney	*Lumpenus maculatus*
Zoarcidae (Eelpouts)	Ocean pout	*Macrozoarces americanus*
	Wolf eelpout	*Lycenchelys verrilli*

[1] Species reported in 1999 Panel Report and in DFO 2002a.

In addition to demersal fish species, several pelagic fishes are known to inhabit Georges Bank. Marine pelagic fish are those species that live in the water column rather than close to or on the ocean floor. The 1999, the Panel Report identified the spawning patterns of six pelagic species, including invertebrates (*e.g.,* two squid species) and two fish species that are known to be demersal (*e.g.,* the spiny dogfish, a bentho-pelagic species, and sand lance). Similar to the spawning patterns documented for the demersal species, the pelagic species' spawning periods were staggered throughout the year (NRCan and NSPD 1999). Tuna and swordfish were also identified as frequenters of Georges Bank.

The commercial pelagic fishery on Georges Bank includes herring, tuna and swordfish varieties (Kennedy *et al.* 2010). Kennedy *et al.*'s 2010 review of the Georges Bank marine environment and commercial fisheries identifies species-specific trends amongst pelagic species, which represents a more detailed account than included in the 1999 Panel Report. Atlantic herring (*Clupea harengus*) stocks on Georges Banks have expanded in numbers and distribution since the late 1980s, while swordfish (*Xiphias gladius*) has been reported to experience high feeding success on Georges Bank and improved biomass since the late 1990s (Kennedy *et al.* 2010). Several tuna species inhabit Georges Bank including bluefin (*Thunnus thynnus*), bigeye (*Thunnus obesus*), yellowfin (*Thunnus albacares*), and albacore tuna (*Thunnus alalunga*). Bluefin tuna is under review by COSEWIC for potential listing as a species at risk; Georges Bank is considered a high-use area for this species (Kennedy *et al.* 2010). Bigeye, yellowfin and albacore tuna are commercially fished on the Bank using longline. Swordfish and tuna use Georges Bank for foraging during seasonal migrations; annual variability in nominal tuna biomass catch per unit effort has been observed (Kennedy *et al.* 2010).

Several non-commercial pelagic fish species were also identified in Kennedy *et al.* (2010), which considered the potential interactions associated with offshore petroleum activities on the marine environment and commercial fisheries of Georges Bank. A few of these pelagics, including Atlantic mackerel (*Scomber scombrus*) and sharks were also included in the 1999 Panel Report. However, there are several non-commercial pelagic species presented in Kennedy *et al.* (2010) that did not appear in the 1999 Panel Report. These additional species have been summarized in Table 2.3. The summary includes key species-specific findings reported by Kennedy *et al.* (2010) for Georges Bank non-commercial pelagics.

Table 2.3 Summary of Georges Bank Non-Commercial Pelagic Fish Species (adapted from Kennedy *et al.* 2010)

Family	Common Name	Scientific Name	Species Comments
Alopiidae (Thresher sharks)	Thresher shark	*Alopias vulpinus*	Regularly found on or around Georges Bank. IUCN Red List status: vulnerable. Not listed by COSEWIC or *SARA*.
Anguillidae (Freshwater eels)	American eel	*Anguilla rostrata*	Considered rare or vagrant on Georges Bank. COSEWIC status: Special Concern. *SARA* status: under review. Not on IUCN Red List.
Carcharhinidae (Requiem sharks)	Blue shark	*Prionace glauca*	Regularly found on or around Georges Bank. Atlantic population COSEWIC status: Special Concern. *SARA* status: under review. Near threatened status on IUCN Red List.
Lamnidae (Mackerel sharks)	Porbeagle shark	*Lamna nasus*	Regularly found on or around Georges Bank, . COSEWIC status: Endangered. *SARA* status: under review. Vulnerable status on IUCN Red List.
	Basking shark	*Cetorhinus maximus*	Regularly found on or around Georges Bank. Feed in waters around Georges Bank in summer and fall; form mating aggregations in summer potentially in and around Georges Bank area. Atlantic population COSEWIC status: special concern (COSEWIC 2010). Vulnerable status on IUCN Red List.
	Shortfin mako	*Isurus oxyrinchus*	Regularly found on or around Georges Bank. COSEWIC status: Threatened. *SARA* status: under review. IUCN Red List status: vulnerable.
	White shark - Atlantic population	*Carcharodon carcharias*	Rare in Canadian waters, which represent the northern fringe of its distribution. No abundance trend information available for Atlantic Canada. COSEWIC status: Endangered. *SARA* status: under review. IUCN Red List status: vulnerable.
Myctophidae (Lanternfishes)	Lantern fish	Myctophidae family	Found in stomach contents of Georges Bank swordfish.
Paralepididae (Barracudinas)	Barracudina	Paralepididae family	Found in stomach contents of Georges Bank swordfish.
Percichthyidae (Temperate basses)	Striped bass - Bay of Fundy population	*Morone saxatilis*	Considered rare or vagrant on Georges Bank. COSEWIC status: Threatened. *SARA* status: under review. Not on IUCN Red List.

Table 2.3 Summary of Georges Bank Non-Commercial Pelagic Fish Species (adapted from Kennedy *et al.* 2010)

Family	Common Name	Scientific Name	Species Comments
Salmonidae (Trouts)	Atlantic salmon - Inner Bay of Fundy Population	*Salmo salar*	Endangered status (*SARA* and COSEWIC). IUCN Red List status: lower risk / of least concern
Scombridae (Mackerels)	Atlantic mackerel	*Scomber scombrus*	Spawning biomass reached a record high in 2004
Sphyrnidae (Hammerhead sharks)	Smooth hammerhead	*Sphyrna zygaena*	Regularly found on or around Georges Bank. IUCN Red List status: vulnerable. Not listed by COSEWIC or *SARA*.
Squalidae (Dogfish sharks)	Spiny dogfish	*Squalus acanthias*	Regularly found on or around Georges Bank. Common on the ocean bottom and in the water column. Atlantic population under COSEWIC status review. Not on IUCN Red List. Included as a demersal species in Priority Areas for Conservation report (Conservation Law Foundation and WWF-Canada 2006).

Over the past decade, an increasingly diverse group of demersal and pelagic fish species have been confirmed to inhabit Georges Bank. This diverse assemblage is anticipated to result in complex trophic linkages, spawning and habitat use patterns, age-class dynamics and both inter- and intra-species interactions. Increased attention on adopting an ecosystem science approach to species and environmental management (*e.g.,* DFO 2007a) has resulted in improved documentation of non-commercially fished species, which contributes to the broadening base of Georges Bank scientific knowledge. However, limitations exist concerning the current understanding of the intricate linkages that comprise food-web dynamics on Georges Bank (Kennedy *et al.* 2010) which can have management implications.

Changes in trophic structure and top predator body size have been observed in an adjacent marine ecosystem, where size-selective harvesting under changing climatic conditions has initiated a trophic restructuring of the food chain (Shackell *et al.* 2009). This study in the western Scotian Shelf ecosystem may serve as a cautionary tale for the Georges Bank ecosystem. However, the unique currents and ecosystem structure of Georges Bank may result in a different response to changing environmental conditions and pressures. The inability to describe accurate linkages between primary production and fish species (Kennedy *et al.* 2010) will further complicate the ability to predict changes or responses in the pelagic and demersal fish assemblage.

Benthic Invertebrates

There are multiple commercial fisheries species and non-fisheries species of invertebrates known to inhabit the Georges Bank area. Scallop and lobster were identified in the 1999 Panel Report as key commercial fisheries on the Bank. Kennedy *et al.*'s 2010 review of the marine environment and commercial fisheries of Georges Bank confirmed that the Bank is still one of the few areas in the limited geographic range of the sea scallop (*Placopecten magellanicus*) that supports an abundant population (Kennedy *et al.* 2010). In fact, the 2010 report states that indices of pre-recruits, recruits, and fully-recruited sea scallop abundance are at or above their respective 27-year median levels and that the abundance of pre-recruits specifically is at its highest level observed since 1981 (Kennedy *et al.* 2010).

The Kennedy *et al.* review (2010) reiterated that the highest abundance of American lobster (*Homarus americanus*) on Georges Bank is still found in canyons along its outer slope and, to a lesser extent, along the northeast ridge of the Bank, as reported in 1999. Additional detail concerning the known biology of both the American lobster and the sea scallop is presented in Kennedy *et al.* (2010). However, it is worth noting that DFO identifies ongoing limitations in their own advancement of scientific knowledge in regards to the life history characteristics of Georges Bank lobster, which they continue to work towards addressing:

> *Our understanding of the ecology, life cycle, and population dynamics of the lobster in deep waters near offshore banks is far from complete; for example, the specific locations of settlement and nursery grounds remains unknown. Smaller sizes (in trawl surveys) in the shoal water areas of Georges Bank suggest this is the likely area of settlement, but to date no methods have been developed to test this assumption. Some work is underway with settlement collectors, but so far it is limited to shallow coastal waters with some initial tests in deeper coastal waters* (Kennedy *et al.* 2010).

In addition to the scallop and lobster fisheries identified in the 1999 Panel Report, multiple crab species are fished on Georges Bank. More specifically, jonah crab (*Cancer borealis*) and rock crab (*Hemigrapsus sexdentatus*) have been identified as inhabiting and being fished on Georges Bank (Kennedy *et al.* 2010). No crab species were identified specifically in the 1999 Panel Report, although crabs were included in the list of benthic organisms known to live near, on and in the sediment of Georges Bank. Clams, worms and corals were included in this 1999 list of benthic organisms as well, but no species-specific information was provided. A key development since 1999 in the advancement of knowledge concerning Georges Bank corals is the establishment of a Coral Conservation Area (CCA) in the Northeast Channel within the moratorium boundary (discussed in greater detail below). A broader knowledge base concerning marine worms on Georges Bank is now available as well.

Over the past ten years, advances in marine survey technology have facilitated the gathering of improved data and the development of a greater understanding of the marine ecosystem, including the interesting discovery of tube worm colonies on Georges Bank (refer to Section 2.1). The white calcareous colonizing tube worm *Filograna implexa* has been found in dense colonies on well-rounded gravel substrate located on the northern part of Georges Bank. The dense pattern of protruding tube worm colonies provides habitat for a variety of benthic species including crabs and brittle starfish (ophiuroids). The colonies are easily destroyed by bottom fishing, particularly scallop dragging. The relatively recent discovery of the dense communities of *Filograna implexa* represents the northernmost known occurrence of this species.

Another Georges Bank species discovery made by advancements in marine survey technology is the identification of the invasive sea squirt (or tunicate) species, *Didemnum* cf. *lahillei* (Valentine *et al.* 2007), which has been identified by USGS researchers. Invasive species can threaten ecosystem balance and increase the overall vulnerability of a natural system. *Didemnum* cf. *lahillei* forms dense mats on the ocean floor, which can affect fish that feed on benthic organisms in the gravel, reduce available shelter, and limit space available for settlement of a variety of benthic organisms.

Recent research by the USGS researchers have identified this invasive species on the northern edge of Georges Bank (Valentine *et al.* 2007), on the American side colonizing at least a 6.5 square mile area at a depth of just over 150 feet. *Didemnum* cf. *lahillei* is a siphon-feeding animal that forms dense mats on the seabed, composed of many thousands of individuals, encrusting the hard bottom and organisms attached to it. The colonies appear to have grown substantially in just over a year's time (Figure 2.20). *Didemnum* cf. *lahillei* colonies are yellowish cream, thick sponge-like masses that overgrow themselves and other stationary objects on the sea floor such as gravel, mollusc shells, and possibly other encrusting species. The colonies appear in a variety of shapes often with branched outgrowths or processes projecting from the surface. Some of the outgrowths result from the colony-encrusting worm tubes or other cylindrical objects, but many are solid with a firm gelatinous core. The individuals of the colony are called zooids and many zooids with individual siphonal openings cover the surface of the colony.

Figure 2.20 A Bottom Photograph of the Seabed of Northern Georges Bank Where a Community of Sea Squirt is Seen Moving Across a Gravel Seabed

The area of seabed covered by the colonies has doubled at 75 percent of the sites the USGS observed in both 2005 and 2006 (P. Valentine pers. comm. 2010). Greater density of colonies observed during the survey is evidence that the infestation is persistent, and not a short-lived phenomenon.

Tunicates spread in several ways: by larvae that swim for only a few hours before settling; by colonies that attach onto surfaces such as boat hulls, moorings, fishing gear, and other manmade objects and are carried to new, favorable habitats; and by fragments of colonies that are broken up by human activities and natural events and drift until they settle elsewhere. No other species is known to eat or overgrow them.

Scientists first observed the *Didemnum* colonies in 2003, on the US side of the international maritime boundary separating US and Canadian waters of Georges Bank. Kostylev (pers. comm. 2010) has determined that the colonies have spread to the Canadian eastern side of Georges Bank.

The use of remotely operated vehicles (ROV) further confirmed that the Georges Bank area has the potential to support a wide range of invertebrate species, as is evidenced by a 2005 study of megafauna associated with deep-water corals in the Northeast Channel (Hell Hole East, Hell Hole West, Middle Canyon and The Rips). Nearly one hundred epifaunal species were identified on one type of coral (*Primnoa resedaeformis*) and nearly fifty species were identified on another coral species (*Paragorgia arborea)* (Metaxas and Davis 2005). Epifaunal species are those animal species that live on the surface of the ocean bottom and can also be referred to as epibenthic organisms. The epifaunal species observed in the 2005 ROV survey of gorgonian corals off Georges Bank included hydroids (colonial, plant-like animals), cirripeds (barnacles), foraminiferans (single celled microorganisms), actinarians (anemones), echinoderms and mollusks (Metaxas and Davis 2005).

An additional invertebrate whose presence on Georges Bank should be noted here is squid. The spawning period of squid was included in the 1999 Panel Report, but Kennedy *et al.* (2010) expand upon this consideration of Georges Bank squid, recognizing that squid serve an important role as prey for fish (*e.g.* tuna) and whales that inhabit the Bank. Short-finned (*Illex illecebrosus*) and long-finned (*Loligo pealei*) squid frequent Georges Bank when they migrate to the Gulf of Maine and it has been suggested that the Bank may be an important feeding area for them during their migration (Kennedy *et al.* 2010). Squid also serve the role of predator, feeding intensively on a variety of small-bodied fish (Kennedy *et al.* 2010) which further affirms their inclusion in the Georges Bank food chain.

As observed in the discussion on demersal and pelagic fishes, increased attention has been given to non-commercially fished invertebrate species over the past decade. There has been substantial advancement in the identification of benthic invertebrates and their habitat use within the moratorium area, as described above. The ongoing limitations associated with understanding the intricacies of Georges Bank food-web dynamics (Kennedy *et al.* 2010) will affect the management of invertebrate species facing changing environmental conditions.

However, the enhanced abilities of novel marine survey technologies and the continued focus on ecosystem science management is anticipated to result in continued advancements in Georges Bank marine invertebrate scientific knowledge.

Corals

In 2002, a CCA was established in the Northeast Channel within the moratorium boundary (see Figure 2.5). Deep-water corals like the gorgonian corals located in the Northeast Channel are known to form distinctive habitats in areas of the deep sea that are often otherwise homogenous (Metaxas and Davis 2005). Increasing attention has been paid to corals over the past decade as a result of the improved understanding of the unique habitat they provide in the deep sea and as evidence of coral damage resulting from fishing activity becomes more apparent.

Kennedy *et al.* (2010) include a substantive update on the advances in coral-specific scientific knowledge over the past decade. Their coral distribution mapping within Georges Bank demonstrates clustering of the major groups of corals (Alyconacean, Gorgonian, Pennatulacean, and Scleractinian) located within the moratorium area and associated with the established CCA (Kennedy *et al.* 2010). The presence of thirty-one deep-water coral taxa have been confirmed within the Canadian exclusive economic zone of the Georges Bank moratorium area (Kennedy *et al.* 2010). At least two gorgonian coral species out of these thirty-one species were confirmed to provide habitat for a wide range of epibenthic invertebrates, as discussed above. The high density of these two gorgonian coral species (*Paragorgia arborea* and *Primnoa resedaeformis*) was primarily responsible for the selection of the Northeast Channel CCA location (Kennedy *et al.* 2010).

As stated by DFO, deep-water corals are highly vulnerable to human activities, in particular fishing, and there is a strong international conservation movement for their protection (Kennedy *et al.*2010). The conservation movement has called for closing specific coral areas to fishing and for bans on certain types of fishing gear (Kennedy *et al.* 2010). In 2001 and 2002, DFO and the fishing industry met to address the potential impacts of fisheries on deep-sea corals. An industry working group was tasked to these issues. A proposed coral conservation area was identified which centered on Romey's Peak, in the Northeast Channel (Figure 2.5). Restrictions (and conditions) on bottom fishing gear were put in place to protect deep-sea corals. This action was intended to help provide scientists with an area to study and observe these marine organisms in undisturbed habitats. The conservation area is approximately 424 km^2in size, and is located in NAFO Divisions 5ZE and 4X. Management measures protecting this area became effective as of the 2002 fishing season.

Fishing activity occurs throughout the Northeast Channel region. Through discussions with the industry working group, and at other venues, efforts were made to understand the overlap between fishing activities and areas of coral abundance. The conservation area was designed to protect deep-sea corals, while minimizing the impact on fishing. The conservation area is divided into two zones: a “restricted bottom fisheries zone" and a “limited bottom fisheries zone".

About 90 percent of the area is closed to all bottom fishing gear used for groundfish or invertebrate fisheries (longline, gillnet, trap, mobile)) About 10 percent of the area is only open to authorized fishing. At the present time, the area is open only to longline gear and is closed to all other bottom fishing gear. The effectiveness of this conservation measure will be reviewed over time using information gathered from fishing industry and from research results. DFO works with the fishing industry to develop strategies to reduce the unintentional damage to important coral habitats in other offshore areas. Additionally, DFO also works with other regulators and industries to prevent deep sea coral damage from other marine activities.

2.2.4 Marine Mammals

2.2.4.1 Panel Context

Information presented in the 1999 panel report on marine mammals was derived from one literature source (Backus and Bourne 1987), management documents (COSEWIC), and professional (biological and fisherman) opinion. According to the Panel report (and presumably Backus and Bourne 1987 (more correctly cited as Winn *et al.* 1987), Georges Bank constitutes feeding, nursery and migratory habitat to many marine mammal species. Professional opinion from fishermen supports this assertion concerning Georges Bank marine mammal diversity. Important seasons are reported as summer/fall (grey seal (*Halichoerus grypus*) foraging) and spring (peak abundance of whales relating to productivity); however, input from a professional biologist suggests more complexity in seasonality and annual presence.

The 1999 Panel report suggests that key species inhabiting Georges Bank include the endangered North Atlantic right whale (*Eubalaena glacialis*), humpback (*Megaptera novaeangliae*), sperm (*Physeter macrocephalus*), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), and minke (*Balaenoptera acutorostrata*) whales. Unidentified dolphin and beaked whale species are also mentioned as occurring at Georges Bank. The panel report suggests that the only species of management concern for Canada is the North Atlantic right whale and indicates that Americans view fin, humpback, sei and sperm whales as endangered.

2.2.4.2 Advancement in Scientific Knowledge

An intensive review of available information pertaining to the ecological significance of Georges Bank to marine mammals was conducted. Findings of this review largely supports conclusions of the 1999 panel that Georges Bank constitutes important marine mammal habitat; however, considerable ambiguity between available data sources (pre-1999 and more recent) suggests marine mammal use of the Canadian portion of Georges Bank is not well understood. The majority of data pertaining to this region and marine mammals appears not to have been previously evaluated and was found largely to be greater than 20 years old and hence their use in understanding current conditions may warrant caution. More recent surveys of the area of interest were located and it is possible that further investigation may discover additional data sources.

Review of available information suggests that other sources prior to 1999, and following 1999, merit consideration to better understand marine mammal habitat at Georges Bank. The following is an overview of pre- and post-1999 information, a brief discussion on the state of our knowledge, and recommendations to better understand this habitat.

Contrary to the impression given in the 1999 Panel report, substantial data and information exists on marine mammal habitat specific to the Canadian portion of Georges Bank. The review undertaken for this report was not exhaustive in nature and other studies may exist that pertain to Georges Bank and marine mammals. However, it can be confirmed that prior to 1999 at least 13 separate data sets (some dataset span from 1970s to early 2000's) were in existence (Read *et al.* 2010; Manomet Bird Observatory 1988). Only one of these datasets (CETAP 1987; aerial surveys conducted by the University of Rhode Island) was used by the 1999 Panel. Of the 13 datasets, 10 relate to vessel-based studies, two to aerial based studies and one tagging study (Duke Harbour Porpoise Tracking). The CETAP aerial surveys (CETAP 1987) are the most commonly referenced source of information for marine mammals at Georges Bank (*e.g.,* Winn *et al.* 1987, Panel Report 1999; Kenney *et al.* 1997) though these reports are not solely specific to the Canadian portion of Georges Bank. Noticeably more information on marine mammal habitat at Georges Bank exists from these sources than was reported in the 1999 Panel document. However, given the CETAP 1987 surveys are but one of 13 available datasets (prior to 1999) considerably more information, and confidence in knowledge, is likely gained by mining information from this and other datasets. Brief review of other available data sets suggest considerable differences in species presence, abundance and distribution as compared to information disseminated from the CETAP 1987 surveys (and included in the 1999 Panel report).

Review of more recent (post-1999) marine mammal data specific to Georges Bank found two datasets; however more may be located with additional effort (and consultation with experts). The Northeast Fisheries Science Centre (NEFSC) conducted two aerial surveys; one in 2002 (experimental) and one in 2004 (NEFSC Aerial Circle-Back Abundance Survey) which spanned the area of interest. A brief overview of these surveys follows here. The 2002 experimental survey recorded higher numbers of observations (several species of marine mammals) in the southeastern corner of the Canadian portion of Georges Bank, along the continental shelf. Moderate numbers of observations were recorded along the shelf and in central Georges Bank and low numbers elsewhere. Brief review of the 2004 NEFSC aerial survey results suggests only a few common dolphins were detected along the continental shelf region (though this may in part be due to lack of survey effort and not mammal absence). Again, further data mining of such sources would increase our understanding and confidence in knowledge of marine mammals in the area of interest.

The Department of Fisheries and Oceans recently examined the status of knowledge relating to Georges Bank (Kennedy *et al.* 2010). This examination focused primarily on the CETAP 1987 aerial surveys (as analyzed by Kenney *et al.* 1997 from which a table was adapted) which were not disseminated specifically to the Canadian portion of Georges Bank. The report implies that the significance of Georges Bank to marine mammals was reviewed elsewhere (*e.g.,* Whitehead *et al.* 1998 and Katona *et al.* 1993 (not referenced here) but foundations for this assertion were not located. Largely because emphasis was placed on only one, older, dataset (CETAP 1987), conclusions regarding species diversity (cited as approximately 23 cetaceans and 4 pinnipeds), abundance and seasonality of marine mammal use of the Canadian portion of Georges Bank may not be prudent. For example, data from the Manomet Bird Observatory program (1988) suggest notably fewer than 24 species of marine mammals frequent the eastern (Canadian) portion of Georges Bank. Similarly, brief review of recent NEFSC aerial data (described earlier) also suggests lower species diversity. This review suggests that grey and harbour seals (*Phoca vitulina*) inhabit Georges Bank with grey seal being more common; however supporting evidence for this conclusion was not located. Recent satellite tagging by the Ocean Tracking Network (OTN) shows that the grey seals breeding on Sable Island wander to the Canadian sector of Georges Bank (OTN 2010).

The available marine mammal datasets vary in survey design (*e.g.,* aerial vs. vessel), timing, protocol, transect location, environmental conditions, observer experience, and likelihood of animal detection. Therefore, without further analysis, it is not sensible to summarize or integrate information of marine mammal abundance, seasonality and distribution within the eastern portion of Georges Bank from these ~15 available datasets.

However, from available information, the following advancements in knowledge include the following:

- The eastern portion of Georges Bank does appear to constitute important habitat for several species of baleen, toothed and pinnipeds (though further analysis is required to confidently establish diversity and abundance).

- According to available information, a minimum of fourteen cetacean species have been recorded in the Canadian portion of Georges Bank This estimate was derived from a coarse spatial (attempting to include most of the Canadian portion of Georges Bank) query of the OBIS-SEAMAP database. This is considered a minimum given: i) the coarse nature of the query, ii) not all observations were positively identified; iii) other datasets and observations likely exist; iv) available data for this region was not obtained specifically for the eastern portion of Georges Bank and hence may suffer from lack of coverage; and, iv) the more rare species (*e.g.,* blue whale, beaked whales, northern bottle-nose whales) are less likely to have been observed.

- In 1999 only one Canadian marine mammal of conservation concern was believed to occur at Georges Bank. Presently, three species of Canadian management concern have been recorded in the eastern portion of Georges Bank (North Atlantic right whale, fin whale, humpback whale). Nearby sightings of the Northern bottlenose whale (*Hyperoodon ampullatus*) and presence of deep water canyons (similar to the Gully) suggests that this species also frequents moratorium waters. Hence, four species of Canadian management concern should be considered as occurring in eastern Georges Bank (species-specific status designations are provided in the species at risk section, below).

- Marine mammal presence and abundance likely varies notably by season however further analysis is required to confidently understand this variability. Seasonal presence is likely governed by spring/summer feeding (feeding at Georges Bank or migration to or from other feeding habitat) though a search for information specific to marine mammal behaviour at Georges Bank was not conducted here. Peak abundance appears to be during spring (Winn *et al.* 1987). Evidence supporting assertions made by the 1999 Panel regarding nursery habitat at Georges Bank was not located.
- Relatively little information about seal diversity, abundance, behaviour and distribution on Georges Bank was located. Corroborating evidence to support the presence of four species of seals (as suggested by the 1999 panel report) was not located.

2.2.5 Sea Turtles

2.2.5.1 Panel Context

Very little attention is given to the presence or absence of sea turtles on Georges Bank in the 1999 Panel Review. Anecdotal evidence of sightings of the endangered leatherback turtle (*Dermochelys coriacea*) was given and green turtles (*Chelonia mydas*) were included as one of several species listed with US-based species at risk designations (NRCan and NSPD 1999). No detailed consideration of sea turtle population dynamics on Georges Bank was provided.

2.2.5.2 Advancement in Scientific Knowledge

The status of endangered sea turtles is well reviewed by Kennedy *et al.* (2010). Waters off Atlantic Canada have been discovered as a primary summer foraging habitat for leatherback turtle, which been intensively studied in recent years. James *et al.* (2006) report sightings by fishers and other mariners during June-September 1998-2005. These were mostly from the inner Scotian Shelf, with a concentration of sightings along the northeast flank of Georges Bank, but almost none on the bank proper (James *et al*. 2006, Figure 2). To some extent these sightings may reflect researcher and fishing effort. Less potentially biased may be the summaries of daily positions of 38 leatherback turtles satellite-tagged during 1998-2003 off mainland Nova Scotia and Cape Breton Island (James *et al.* 2005, Figure 1). These subsequently lingered to forage with particular concentrations off Cape Breton Island, the shelf slope off southwest Nova Scotia, and on the shelf south of Cape Cod, before migrating south on widely spaced tracks across the North Atlantic. There were a few foraging days near the Northeast Channel and along the seaward flank of Georges Bank, but none on the bank itself.

Recent records of bycatches of loggerhead turtles (*Caretta caretta*) by pelagic fisheries suggest “that a sizeable part of the western North Atlantic population loggerhead turtle may visit Canadian waters, including Georges Bank, at least seasonally” (Kennedy *et al.* 2010). Extrapolated records suggest that almost 9600 loggerhead turtles were taken by these fisheries during 1999-2006, with little indication of recent decreases (Brazner and McMillan 2008). The species is also a significant bycatch elsewhere in the North Atlantic and Caribbean, and accordingly is under review by COSEWIC (Kennedy *et al.* 2010). Although (Brazner and McMillan 2008, Table 1) do attribute a large fraction of known catches to “Georges Bank,” this has to be interpreted with care, as that area is defined by them to include a large area of Western Bank. Their maps (Fig. 2) of known captures (aggregated by 30 min. squares) indicate that only a few out 701 were near northeast edge of the bank or in the Northeast Channel, and only one was on the bank proper.

It appears that, while the Canadian moratorium area is occasionally visited by leatherback and loggerhead turtles, mostly near the entrance to the Northeast Channel and along the northeast flank, the area is not a primary habitat for them.

2.2.6 Marine Birds

2.2.6.1 Panel Context

Several species groups of birds were identified by the 1999 Panel Review as using Georges Bank at some point during their life history. These species groups included fulmars, auks, shearwaters, storm-petrels, gannets and phalaropes. Seasonal habitat use and migratory paths around Georges Bank were summarized for each species group. Seabird biomass was presented as 13-31 kg/km^2 and peak concentrations were reported to occur in the summer season (NRCan and NSPD 1999).

2.2.6.2 Advancement in Scientific Knowledge

Although there has been little advancement in knowledge of seabirds on the bank since the 1999 Panel Report, species-specific information not included in the 1999 Panel Report is worthy of reconsideration (See Section 1.1.2). The update by Kennedy *et al.* (2010) mentions seabirds only in the contexts of a food source for sharks, and as part of the Georges Bank trophic interaction discussion.

The Revised Atlas of Western Canadian Seabirds (Brown 1986) does not extend to the Canadian sector of Georges Bank. Most accessible knowledge of the distribution and abundance of seabirds on Georges Bank still comes from the account by Powers and Brown (1987), which is based on US seabird surveys. This account is referred to in the Panel Report, but birds are not addressed in the update by Kennedy *et al.* (2010). The Manomet and earlier surveys were carried out in 1978 and 1980-1988. Apparently there have been no quantitative seabird surveys in the Georges Bank region since, although these have been called for (O’Connell *et al.* 2008).

Powers and Brown (1987) express the geographically located seasonal occurrences of seabirds in a series of graphs and tables, with much redundancy. The Canadian sector is encompassed within two regions that they designate GBn (Georges Bank north) and GBe (Georges Bank east). The former includes the northern slope of the Canadian sector to the 200 m level, and the latter includes the very different bank proper and the southern slope to beyond 2000 m

Seabird densities within these two divisions of the Canadian sector are most clearly presented on Table 34.2.4 in Powers and Brown (1987) and are given here on Table 2.4. Densities of the large gulls (Herring and Great Black-backed) are also tabulated by Powers and Brown (1987), and can be quite high during some seasons, but these are predominately inshore species, are attracted to boats, and have been considered to have excessive populations in relation to nesting seabirds of other species, and therefore may not be "valued."

Table 2.4 Summary of Seasonal Abundances (Estimated Nos. km^2) During the 1980s of Regular Seabirds Observed on Two Regions of Georges Bank that Encompass the Canadian Sector

Species	Dec.-Feb.		March-May		June-Aug.		Sept.-Nov.	
	GBe	GBn	GBe	GBn	GBe	GBn	GBe	GBn
Northern Fulmar	70.7	80.5	6.4	28.5			0.7	0.9
Cory's Shearwater					0.7	1.0	0.9	0.2
Greater Shearwater					84.2	20.2	10.4	17.2
Sooty Shearwater			0.1	0.1	19.5	2.8		
Wilson's Storm-Petrel			0.5	0.5	13.7	17.9	0.1	0.1
Leach's Storm-Petrel					0.2	0.1		
Northern Gannet	0.1	0.1	0.1	1.1			0.3	1.0
Black-legged Kittiwake	3.9	6.1	2.6	0.1			0.5	0.3
Red Phalarope			0.1	7.3				

Table 2.4 makes it clear that (during the 1980s) Northern Fulmars predominated in winter and Greater Shearwaters in summer. This predominance doubtless still prevails, although the densities of these and other seabirds in the Canadian sector have probably changed in recent years. There is no evidence for the assertion in the 1999 Panel Report (p. 22) that "the entire North American population of gannets passes across Georges Bank twice yearly on migrations to and from their wintering range." This is only true if the bank region is taken as including the inshore waters along coastal Maine and Massachusetts and deeper waters of the shelf slope and beyond. The pattern of migration by Northern Gannet (the only bird species mapped in Manomet Bird Observatory (1988, figs. 21b, 21e) shows them distributed largely in April along the northern and southern slopes of the Georges Bank, with almost none over the shallows, and only one sighting in the Canadian sector. In November they were largely in the shelf waters, but with very few in the northern end of the bank (two sightings possibly within the Canadian sector), with an indication that most cross to the Gulf of Maine near the Great South Channel. There is also no evidence for the Panel's statement (p. 22) that, along with Northern Fulmars," auks are the main winter residents." Powers and Brown (1987) state that Razorbill, murres and Dovekie have been sighted on the bank, but give no information on numbers.

2.2.7 Species At Risk

The 1999 Panel Review did not provide a detailed discussion of the various risk designations supported by the fish, mammal, turtle and seabird species that inhabit Georges Bank. Species at Risk designations can be made by multiple Canadian and international organizations. In Canada, the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) completes science-based assessments of the status of wildlife species at risk in Canada. In June 2003, the *Species at Risk Act* (*SARA*) established COSEWIC as an advisory body. Under *SARA*, the government of Canada will take COSEWIC's designations into consideration when establishing the legal list of wildlife species at risk.

SARA was implemented in 2002 and is a federal government commitment to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct. The *Act* secures the necessary actions for species recovery, provides for the legal protection of wildlife species, provides for the conservation of their biological diversity and encourages the management of other species to prevent them from becoming at risk. Further, the *Act* creates prohibitions to protect listed threatened and endangered species and their critical habitat. Under *SARA,* it is recognized that compensation may be needed to ensure fairness following the imposition of the critical habitat prohibitions. A public registry of Canadian species at risk data, information and status designations (*i.e.,* the legal list of wildlife species at risk) has also been created as a result of *SARA*.

Internationally, both the IUCN and CITES are involved in protection of species designated as at risk. The IUCN is the International Union for Conservation of Nature, which is a global conservation network that produces a Red List of threatened species. The goals of the IUCN Red List are to: 1) Identify and document those species most in need of conservation attention if global extinction rates are to be reduced; and 2) Provide a global index of the state of change of biodiversity (IUCN 2010). CITES is the Convention on International Trade in Endangered Species of Wild Fauna and Flora and is an international agreement between governments with the aim to ensure that international trade in specimens of wild animals and plants does not threaten their survival. CITES references the IUCN's Red List of threatened species for species at risk designations.

Species status designations made by COSEWIC, *SARA* and the IUCN can differ. These differences in risk designations are primarily a result of the differing geographical focuses of each organization. The IUCN makes species status designations based on global population data and trends, strictly adhering to their own criteria for designations. Both COSEWIC and *SARA* are responsible for making marine species status designations based on populations within Canadian waters. COSEWIC uses the IUCN criteria as guidelines for designation assessments, but also take regional science and knowledge into consideration. *SARA* includes a multitude of factors in their designation assessments, including the science-based, regional recommendations of COSEWIC and the socio-economic implications of designating a species as at risk under the Act. The current review of marine species at risk includes the designations provided by COSEWIC, *SARA* and the IUCN.

Fish Species

Several Georges Bank fish species have received status designations under COSEWIC, *SARA*, or IUCN. The non-commercial, pelagic fish species that are listed by either COSEWIC or *SARA* are included, with their respective designations, in Table 2.3 above. In addition to these pelagic fish species, there are several previously mentioned demersal species (Section 2.2.3.2. and Table 2.2) which have either been designated as being at risk by the IUCN, COSEWIC or *SARA,* or are under consideration. Demersal species undergoing COSEWIC status review include bluefin tuna, Atlantic halibut, white hake, barndoor skate, thorny skate, and smooth skate (Kennedy *et al.* 2010). None of these species currently have a status designation under *SARA*. However, the IUCN Red List has granted endangered status to Atlantic halibut, barndoor skate and smooth skate. They consider the thorny skate to be vulnerable. Two demersal species were found to be included on the IUCN Red List but are not known to be currently under consideration for species at designation through COSEWIC or *SARA.* The little skate has been designated as near threatened on the IUCN Red List, while haddock has been given a vulnerable designation.

The Georges Bank-Western Scotian Shelf-Bay of Fundy population of winter skate and the maritime population of Atlantic cod have been designated special concern by COSEWIC (COSEWIC 2010) and lacked a status designation under *SARA* at the time of the current report (*SARA* Registry 2010). The IUCN Red List designates winter skate as endangered and Atlantic cod as vulnerable. Based on DFO survey data, winter skate are abundant throughout Georges Bank, with the highest concentrations being observed on the USA side of the Bank (Kennedy *et al.* 2010). The Maritime population of American plaice was designated as threatened by COSEWIC in 2009 (COSEWIC 2010), and consultations regarding potential listing under *SARA* are ongoing through 2010 (Kennedy *et al.* 2010). COSEWIC reaffirmed the designation of cusk, a solitary bottom-dwelling species, as threatened in 2006 and the species is being considered under *SARA* (Kennedy *et al.* 2010). Catches of cusk in the Georges Bank area occur mostly in the deeper waters of the Northeast Channel and off the Northeast Peak, but they do occur on the Bank itself in lower amounts (Kennedy *et al.* 2010).

The Atlantic populations of all three wolffish species potentially inhabiting Georges Bank have been given COSEWIC and *SARA* designations, but lack designations on the IUCN Red List. Spotted and Northern wolffish are considered rare or vagrant inhabitants of Georges Bank (Kennedy *et al.* 2010), but both have been designated threatened by COSEWIC and *SARA* (*SARA* registry 2010). Overall landings of the Atlantic wolffish on the Scotian Shelf, Georges Bank and in the Bay of Fundy have declined (DFO 2002b) and the Atlantic wolffish has been determined to be a species of special concern by both COSEWIC and *SARA* (*SARA* registry 2010).

Marine Mammals

Kennedy *et al.*'s 2010 review of Georges Bank included a total of five marine mammal species designated to be at risk by either COSEWIC or *SARA*, or by both organizations. They acknowledged that their list included cetaceans that may be found on Georges Bank, as opposed to those species confirmed present on Georges Bank. As discussed in the Marine Mammal Ecological Significance section above (Section 2.2.4), ambiguity exists amongst the available data sources addressing marine mammal species known or suspected to inhabit Georges Bank. As such, the current assessment of at risk marine mammals will focus on those species that have been recorded in the eastern portion of Georges Bank and have been identified as at risk by COSEWIC, *SARA* or the IUCN.

The North Atlantic right whale has been designated as endangered by COSEWIC, *SARA* and the IUCN. Each of these three species at risk assessment groups has given the humpback whale a different at risk designation. The IUCN has determined the humpback whale to have an at risk status of least concern. COSEWIC and *SARA* have completed assessments of the North Atlantic population of the humpback whale. Under *SARA*, this specific population of humpbacks is considered a species of special concern, while COSEWIC has designated the population as not at risk. The Northern bottlenose whale is likely a vagrant on Georges Bank (Kennedy *et al.* 2010). The Scotian Shelf, or Gully, population of the Northern bottlenose whale has been determined to be endangered by both COSEWIC and *SARA*. The IUCN lists this species as the North Atlantic bottlenose whale and considers data to be deficient, meaning they have not made an at risk designation. The sei whale, on the other hand, has been given an IUCN status designation of endangered, while COSEWIC and *SARA* have reviewed only the Pacific Ocean population of the species.

The IUCN has also given the endangered designation to the fin whale, while COSEWIC and *SARA* consider this to be a species of special concern. Kennedy *et al.* (2010) give a recent estimate for North Atlantic fin whale as almost 3000 individuals (between Georges Bank and the mouth of the Gulf of St. Lawrence) in 1999.

Turtles

The leatherback and loggerhead turtles have been discussed above in Section 2.2.5. The leatherback turtle is listed as endangered by COSEWIC and under *SARA*. The species is considered critically endangered by the IUCN. The status of the loggerhead turtle is being assessed by COSEWIC but at the time of the current report, a designation had not been made. The IUCN has designated the loggerhead as endangered.

Marine Birds

No species of seabird frequenting Georges Bank (per Table 2.4) is listed by *SARA* or COSEWIC. The Roseate Tern (*Sterna dougallii*; designated endangered under *SARA* and by COSEWIC) may well occur there as an occasional migrant, but is much more regular inshore.

2.3 SOCIO-ECONOMIC SIGNIFICANCE

Socio-economic analyses contained in this report were conducted by Gardner Pinfold Consulting Economists Limited. The approach to reviewing the socio-economic issues related to Georges Bank has been multifaceted. The starting point was to review the key points related to socio-economic issues in the 1999 Panel Report. Background work prepared by Gardner Pinfold in 1998 for the Panel as presented in the document, *Georges Bank Resources, An Economic Profile* (Gardner Pinfold 1998) was relied upon heavily in presenting the 1999 context conditions below. Obviously, the fishery underlies the socio-economic issues associated with Georges Bank. The focus herein is to examine what has changed in the fishery has been to both assess the status of commercial fish stocks and to review the landings data and approach to harvesting. The latest findings associated with the various stock status reports have been incorporated into this analysis. In addition, data was requested from Department of Fisheries and Oceans related to value and value of landings and vessel activity. This information has allowed a direct comparison of the most recent scale of fishing industry activity to that reported by the Panel in 1999. In addition, Gardner Pinfold contacted various industry participants to discuss today's Georges Bank fishery.

To review the overall status of the regional economy, the most recently available Census/Statistics Canada data related to the economy was compiled and compared to data reported in the 1998 Economic Profile. To further supplement this, discussions with economic development officials and the South West Regional Development Authority were undertaken. In the course of this study, Gardner Pinfold also drew upon their own professional knowledge related to industry economic research and the regional fisheries in the past number of years.

2.3.1 The Fishing Industry

2.3.1.1 Panel Context

As noted by the Panel in 1998, the fishing industry was the single largest source of industrial employment and income in southwest Nova Scotia. Fish products have consistently been the single largest source of private sector export earnings for Nova Scotia. Fish harvesting and processing sectors in Nova Scotia lead all other private sector industries in employment and economic contribution. To assess changes related to the importance of Georges Bank, it is important to provide an accurate profile of the fishing industry that relies on various Georges' Bank resources. Table 2.5 highlights changes in the Georges Bank fishery since 1998.

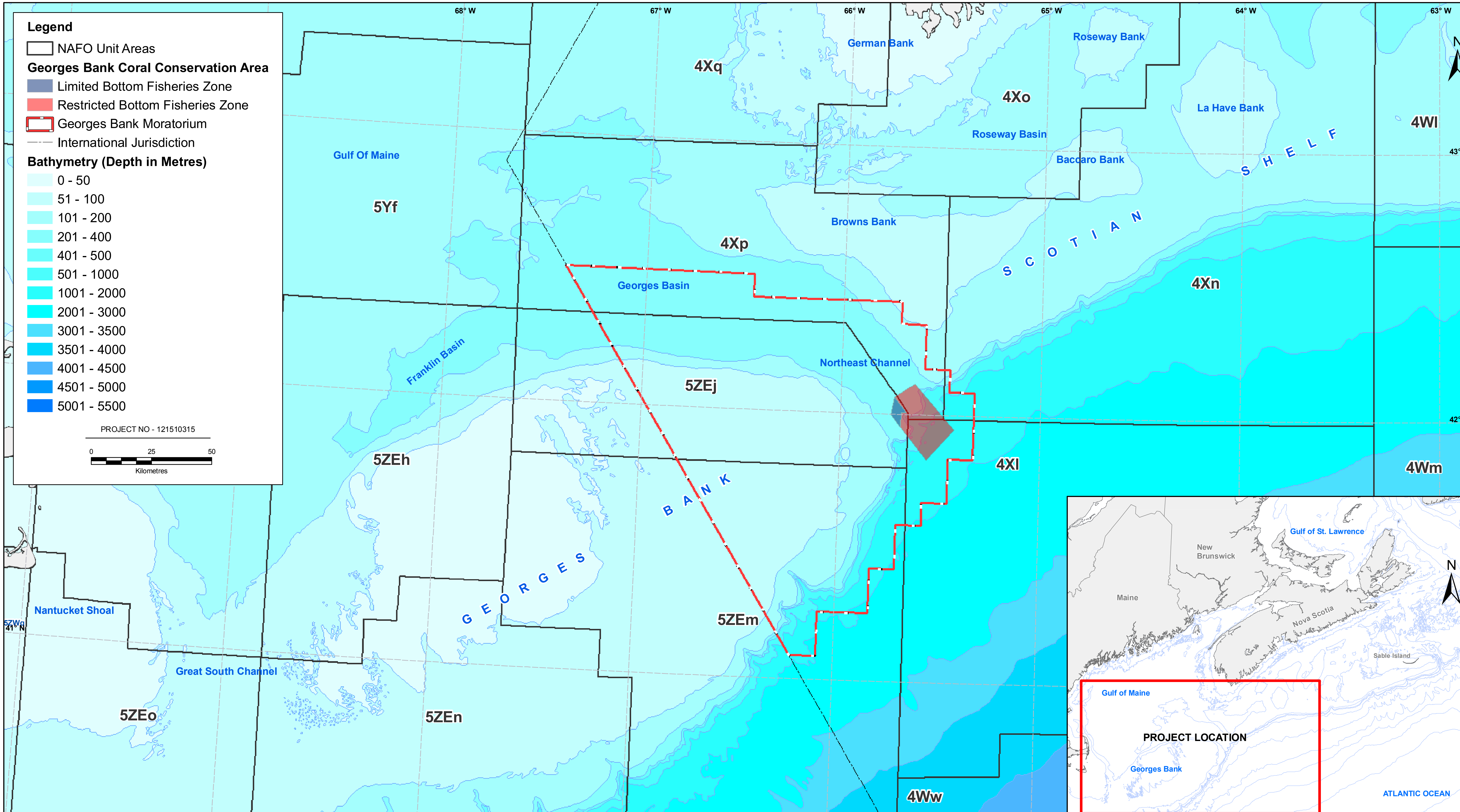
Table 2.5 Highlights of the Changes in the Georges Bank Fishery Since 1998

Fishery	Highlights
Shellfish	• Most important fishery in 1998 at 82% of total value. In 2008 still dominant fishery representing 76% of total value. • Fleet configuration has changed with introduction of freezer scallop vessels. These vessels are state-of-the-art and account for 70% of landings. The introduction of these vessels has resulted in lower employment. • Variation in TAC for scallops do occur depending on year class recruitment to the fishery. • Lobster fishery is very steady in terms of landings from year to year.
Groundfish	• Groundfish fleet operates in a similar manner to how it operated in 1998. • Quota is distributed among various vessel classes. • Groundfish landings have almost doubled since 1998. Haddock accounts for the greatest increase due to the strength of the exceptional 2003 year class. Subsequent year classes have also been strong.
Pelagic	• In terms of value, the pelagic fisheries continues to be relatively small. In 1998, they accounted for 1.7% of landed value and in 2008 they accounted for 3.6%

The Georges Bank fishery in 2008 landed catches in southwest Nova Scotia was valued at $113 million. The shellfish fishery accounted for over 76% of landed value followed by groundfish at 20%. The pelagic fishery accounted for the remainder at about 5%. Over the period 1998-2008, total value peaked in 2000 at $156.0 million. Table 2.6 shows that 2008 has been the best year in the past five years. Also shown in the table is the number of vessels active on Georges Bank by type of fishery and county of landing. In total, 227 vessels were active in 2008. The Georges Bank fishery for purposes of this report includes landings from the Canadian portion specifically Areas 5ZEj and 5ZEm (Figure 2.21).

Table 2.6 Total Landed Value of Georges Bank Fishery by Species 1998-2008 and Number of Vessels Active in 2008

Year	Shellfish (million $)	Groundfish (million $)	Pelagic (million $)	Other (million $)	Total (million $)
1998	95.90	17.07	2.04	0.02	115.04
1999	86.21	18.49	1.33	0.03	106.06
2000	132.84	22.77	0.93	0.03	156.56
2001	107.88	24.16	2.35	0.01	134.39
2002	94.50	21.66	1.32	0.02	117.51
2003	90.76	20.86	2.28	0.01	113.90
2004	60.25	16.11	1.78	0.00	78.14
2005	42.62	23.41	4.32	0.00	70.35
2006	59.54	23.83	3.12	0.00	86.49
2007	59.97	21.00	2.69	0.00	83.65
2008p	86.67	22.62	4.12	0.00	113.40
# of vessels	21	120	114		227



DATE: April 23, 2010

PREPARED BY: G. Mesheau

OEER Offshore Energy Environmental Research Association

PRELIMINARY REVIEW OF ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES ON GEORGES BANK

NAFO UNIT AREAS IN STUDY AREA

FIGURE NO.: **Figure 2.21**

Gardner Pinfold Consulting Economists Ltd. Stantec

Shellfish

Scallops

The scallop fishery on Georges Bank is the most important fishery in terms of landed value in 2008 when $85.4 million in landings occurred. This fishery accounts for 75% of total landed value of all fishing activity on Georges Bank. Figure 2.22 depicts the area on Georges Bank where there is both high catch rates of scallops and low catch rates. In addition, the two sub-management areas “a” and “b” are also illustrated.

Industry Structure

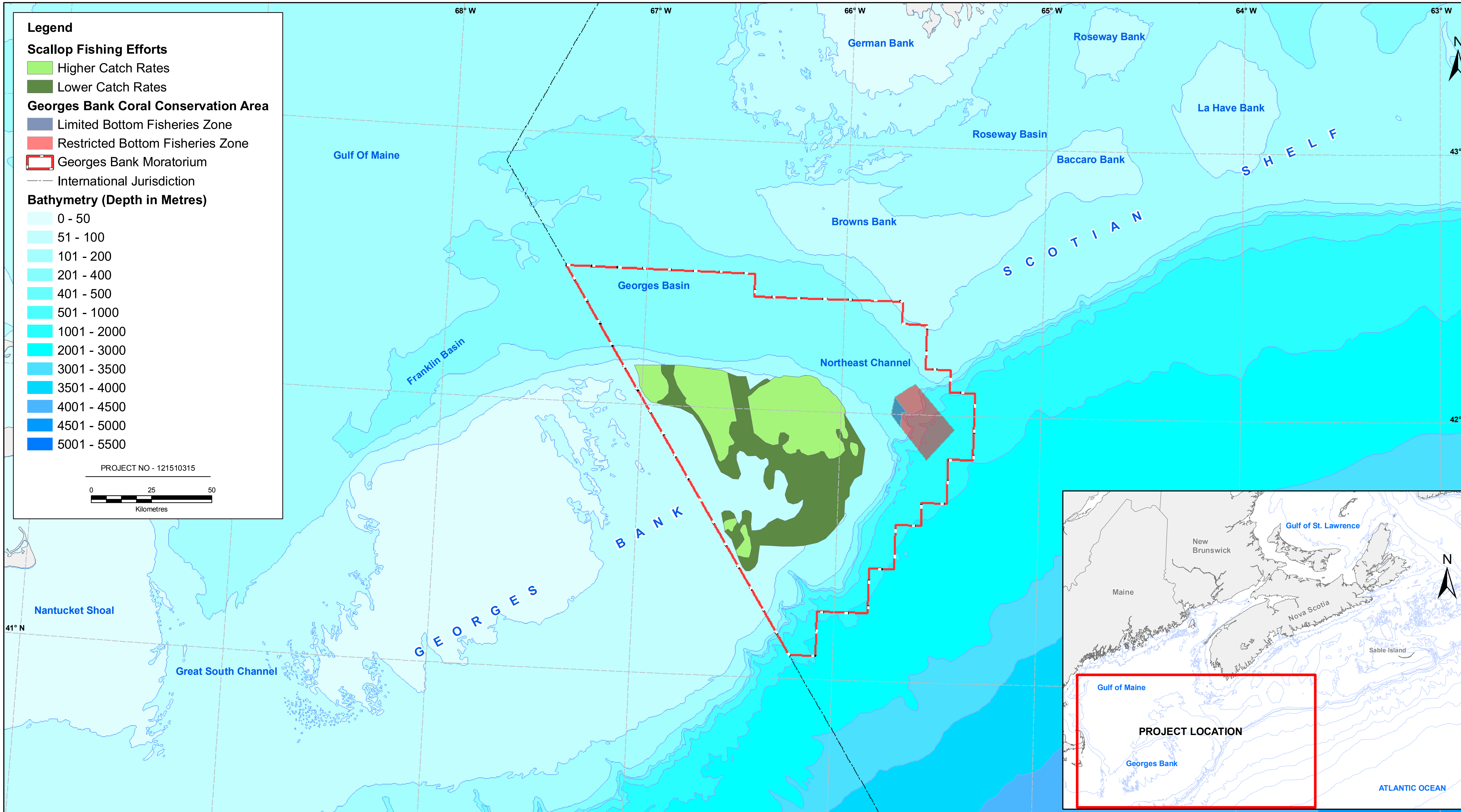
Seven companies were active in the offshore scallop fishery in 1998, down from nine in the late 80s. Presently there are five companies active in the offshore scallop fishery. The companies operate 10 wetfish trawlers and six freezer trawlers. Prior to 1986, a large fleet of inshore vessels also fished on Georges Bank. As a result of an agreement reached in 1986, the fishing grounds are formally divided into exclusive offshore and inshore areas, with the inshore fleet now confined essentially to the Bay of Fundy.

Corporate consolidation and fleet rationalization are attributable to the change in management approach following the Canada-US boundary delimitation in 1984. Among the main elements of the new management regime are a total allowable catch (TAC) and a system of individual company quotas termed enterprise allocations. The latter eliminated competitive fishing and the incentive for companies to operate large fleets in order to maximize shares of the overall TAC. The fleet continues to adjust to the size needed to harvest the available resource efficiently.

The fleet operates from a few main ports in southwest Nova Scotia including:

- Lunenburg;
- Riverport/LaHave;
- Saulnierville;
- Liverpool;
- Lockeport; and
- Shelburne.

Almost half the scallop quota is held directly and indirectly by Clearwater Fine Foods Incorporated and they account for 49% of the total allowable catch in the Atlantic Canada offshore sea scallop fishery. Specific relevant information about Clearwater operations are available in the public domain through the Clearwater Fine Foods Incorporated Income Fund Annual Information Form. The detail below about Clearwater’s specific operations is extracted from that document. It serves to demonstrate the changes introduced by industry over the past ten years and how the scallop fishery is carried out on Georges Bank.



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PRELIMINARY REVIEW OF ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES ON GEORGES BANK

FIGURE NO.: Figure 2.22

AREAS OF SCALLOP FISHING EFFORT ON GEORGES BANK AND THE SCOTIAN SHELF

Gardner Pinfold Consulting Economists Ltd.

Stantec

The harvesting part of Clearwater's sea scallop business is operated from the south shore of Nova Scotia. Since 2002, this company has undertaken a renewal program for its scallop fleet by building two state-of-the-art vessels at an aggregate cost of $26 million (the Atlantic Leader was delivered in June 2002 and the Atlantic Guardian was delivered in February 2003). These two vessels contain facilities on board that permit the sea scallops to be harvested, processed and frozen while at sea. In August 2004, Clearwater acquired two additional vessels, which were converted to factory freezer vessels. The total cost to acquire and convert the vessels, including owner supplied materials and related costs, was approximately $21 million and these vessels entered the fishery in late 2005. The investment in these vessels completed Clearwater's plan to convert the remainder of its scallop fleet to factory vessels. These vessels have enabled the production of a higher quality frozen-at-sea scallop that sells for a premium in the market. In addition, the vessels have enabled the company to increase the efficiency of its harvesting operations by reducing the number of vessels employed, thereby lowering the costs of fishing. There has also been a loss of employment.

In May 2003, Clearwater Fine Foods Incorporated also completed acquisition of High Liner scallop operations, acquiring certain scallop licenses and quotas that increased their ownership in total allowable catch of sea scallops in Atlantic Canada from 36% to the current level.

Sea scallops are processed and packaged at Clearwater's modern facility located in Lockeport, Nova Scotia. Major investments in the latest processing technologies at this facility have reduced production costs, increasing yields. Sophisticated, automated grading machines enable Clearwater to offer customers more consistent and precise size grading.

The market for Canadian sea scallops has been diversified into Europe and Asia from a primarily North American market prior to 1987.

Innovations introduced by industry, bottom imaging technology and vessel tracking systems, have provided the industry and Department of Fisheries and Oceans (DFO) with the ability to better understand the resource and has permitted the harvest of quota more efficiently *e.g.,* the ability to identify particular beds of sea scallops and to target harvesting operations more specifically. This technology also permits identification of areas where the sea scallops are not at full maturity so as to allow operators to defer harvesting in those areas until maturity is reached.

Resource Access

Access to the scallop resource is through enterprise allocations. Each company's enterprise allocation is based on the percentage share of the TAC negotiated in 1986. These in turn are based on each of the original participant's historic share of total landings. The distribution of enterprise allocations in 1998 reflects these shares as adjusted by the consolidation of companies. Under the enterprise allocation rules, the sale of a company and its entire enterprise allocation holding is allowed, though permanent transfers of a portion of an enterprise allocation are not permitted (temporary in-season transfers are). No single company may hold more than 50% of the TAC for any specific scallop stock. Consolidation has continued through 1998-2005.

It is the stated objective of the enterprise allocation approach that each company should invest in the number, size and type of vessel needed to harvest its allocation in the most economically effective manner possible. This has resulted in the move toward freezer trawler utilization. This objective is constrained only by a vessel replacement restriction that specifies the maximum and minimum allowable length. The minimum length finds its rationale in the need to maintain a clear distinction between the inshore and offshore sectors.

The enterprise allocation program is intended to remain in place indefinitely. The program guidelines state that in the unlikely event of a reversion to competitive fishing, the companies would be permitted to operate their original number of licenses (77 vessels).

Management

The primary reference used for the following discussion is the 2009 CSAS Assessment of Georges Bank Scallops. The offshore scallop fleet fished primarily fresh scallop products until 2002, when freezer trawlers were incorporated into the fleet. In the first year of fishing, the freezer trawlers landed 775 t or 12% of the total landings. In 2008, the freezer trawlers landed 3,776 t or 69% of the total landings from zone ‘a’ and 265 t or 74% of the total landings from zone ‘b’.

The commercial catch rates declined from 2007 to 2008 but were still above the long-term average.

In 2008, fully recruited biomass was estimated at 22,540 t (meats). This was a slight decline from the 2007 estimate (22,680 t) but was well above both the 27-year median biomass of 9,960 t and the recent lows in 2004 to 2006.

The 2009 interim TAC is 5,500 t and harvest scenarios evaluated in the historical range of 1,500 to 7,000 t are all predicted to yield increases in commercial biomass. For 2009, a harvest of 7,673 t, representing an exploitation rate of 0.25, is predicted to result in no change in biomass. The extremely large cohort of pre-recruits observed in the 2008 survey will recruit to the fishery in 2010-11, with an expectation of much higher commercial biomass levels at that time.

Prior to 1998, this area was managed as one unit, but since then it has been managed as two zones. Zone ‘a’ is the traditional scallop fishing ground and a more productive area than zone ‘b’, which is marginal scallop habitat.

Table 2.7 2008 Georges Bank Scallop TAC and Catch

Year	Catch (t)		TAC (t)	
	zone 'a'	zone 'b'	zone 'a'	zone 'b'
1998	3,191	800	3,200	800
1999	2,503	1,196	2,500	1,200
2000	6,212	601	6,200	600
2001	6,480	395	6,500	400
2002	6,469	192	6,500	200
2003	5,985	199	6000	200
2004	3,518	200	3,500	200
2005	2,484	201	2,500	200
2006	3,932	162	4,000	200
2007	4,000	401	4,000	400
2008	5,498	358	5,500	400

A TAC and a meat count of 33 meats per 500 grams are used to manage Georges Bank 'a'. Until 2008, Georges Bank 'b' was managed with a meat count of 40 meats per 500 g and a rolling TAC allocated in 200 t increments for a specified fishing period (typically 6 weeks). As of 1 January 2008, Georges Bank 'b' is managed with a conventional TAC and a meat count of 40 meats per 500 g. In March 2010, the Eastern Canada Sea Scallop Fishery achieved Marine Stewardship Council Certification as a sustainable well managed fishery.

Changes to Management

Since November 2004, the offshore scallop industry has implemented voluntary fishery closure areas on Georges Bank to improve commercial yield of large aggregations of juvenile scallops. Three voluntary closures were put in place by the industry in December 2007. The voluntary closure coordinates were modified in October 2008 as a result of available information on size distribution of scallops in the voluntary closed areas and surrounding areas.

The 2008 TAC was 5,500 t for zone 'a' and 400 t for zone 'b'. Total reported landings were 5,498 t for zone 'a' and 358 t for zone 'b'. Based upon preliminary analysis of the 2008 fishery data and the annual stock survey data, an interim TAC of 5,500 t was set for the 2009 Georges Bank zone 'a' fishery and 400 t for zone 'b'.

DFO-Industry Survey

A joint DFO – industry survey takes place annually on Georges Bank, covering both zones. In 2008, all three indices were at or above their respective 27-year median levels. Abundance of pre-recruit scallops is at the highest level observed since 1981. This large increase is due to a large cohort (2006 year-class) in the 25 to 65 mm range, which is primarily in the northwest region of the bank. Moderately high densities of pre-recruits were also found in the extreme southern region.

Fully recruited scallops increased steadily from 2005 and are now nearing the peak observed between 2000 and 2002. The average meat weight of fully recruited scallops in the 2008 survey decreased from 2007, but at 21.1 g it is still well above the 27-year mean of 18 g.

Fully recruited biomass, estimated to be 22,540 t (meats) in 2008, declined very slightly from the 2007 estimate but it is well above both the 27-year median biomass of 9,960 t and the recent lows in 2004 to 2006.

Recent Conclusions and Advice from DFO

Fully recruited (commercial) biomass has been above 10,000 t since 2000. This is due to a combination of two very large recruit cohorts in 1999 and 2000, a shift by industry to generally lower exploitation rates, and adoption of an industry-implemented protocol on a minimum landed scallop size from 1995 onward. The exploitation rates are generally higher than the levels expected due to growth discounted for natural mortality.

The 2009 interim TAC of 5,500 t results in an exploitation rate of 0.18, which is above the replacement line, however, incoming recruitment is expected to be near average and compensate for this level of exploitation. The extremely large cohort of pre-recruits observed in the 2008 survey will recruit to the fishery in 2010-11. Should this cohort recruit successfully, higher commercial biomass levels would be expected than at present.

Fishing Patterns

The fishery could be year-round, though effort is concentrated in the April to August period when about 60 percent of landings are made. In 2008, no landings were reported in November and December. Fishing effort and landings on Georges Bank tend to be concentrated along the northeast peak (above lat. 41.80 N), the area of highest stock density and catch rates.

Table 2.8 Monthly Landings 2008

Month	Round Weight kg	Meat Weight kg
January	1,758,877	211,913
February	2,641,323	318,232
March	2,050,367	247,032
April	5,901,591	711,035
May	6,569,627	791,521
June	4,437,956	534,693
July	6,034,240	727,017
August	5,044,971	607,828
September	1,505,720	181,412
October	578,398	69,687
November	0	0
December	0	0
Total	**36,523,070**	**4,400,370**

Lobster

The primary source of data for the following discussion on the lobster industry was the Clearwater Fine Foods Incorporated Income Fund Annual Information Report (Clearwater Fine Foods Incorporated 2007). Figure 2.23 illustrates areas in the vicinity of Georges Bank where lobster are caught.

Industry Structure

The eight licenses, originally held independently, are now consolidated in one company (Clearwater Fine Foods Incorporated) and this company can harvest 100% of the total allowable catch.

Management

The offshore lobster fishery is managed under a formal plan specifying the objectives, principles and management measures by which the fishery is conducted. The main objective is a viable offshore sector based on a secure stock and habitat. The key principles are conservation through control on effort and the exploitation rate; economic stability through the use of enterprise allocations; habitat protection; and, a strong scientific base for advice on harvest levels.

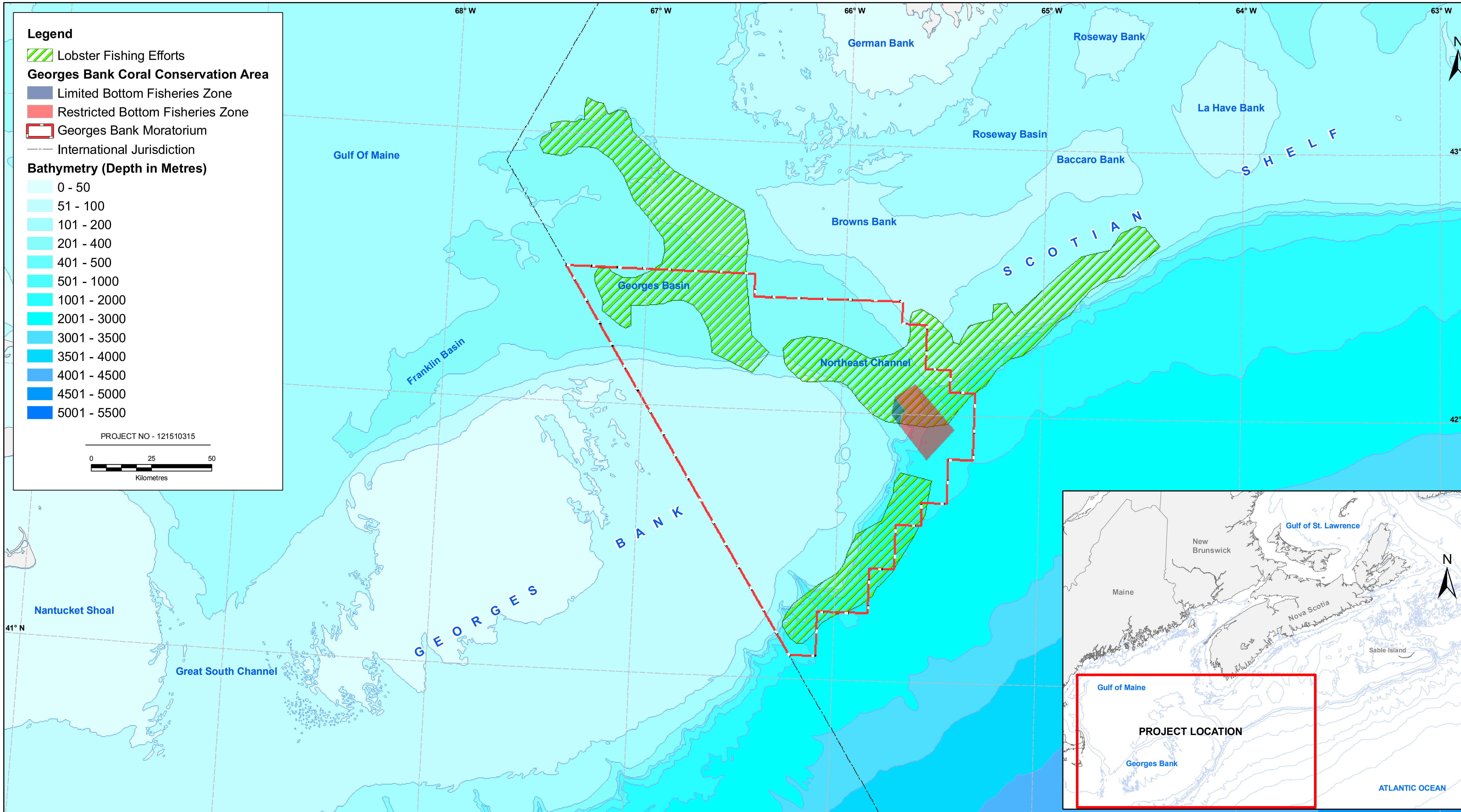
Among the key management measures are:

- Enterprise allocations;
- Legal minimum size of lobster retained using carapace length measurement;
- Gear allowed is restricted to traps;
- Egg-bearing females must be returned to the water; and,
- Traps must have escape vents for under-sized lobster and biodegradable panels to prevent continuous fishing if traps are lost.

It is the understanding of the Study Team that the offshore lobster fishery is in the final stages of Marine Stewardship Council Certification.

Fishing Patterns

Offshore vessels are permitted to fish in the Offshore Lobster Fishing District, an area lying beyond 50 nautical miles of the coast of Nova Scotia between the Laurentian Channel in the north and the mouth of the Bay of Fundy in the south. This line was established in 1971 to separate the inshore and offshore fisheries.



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PRELIMINARY REVIEW OF ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES ON GEORGES BANK

AREAS OF LOBSTER FISHING EFFORT ON GEORGES BANK AND THE SCOTIAN SHELF

FIGURE NO.: **Figure 2.23**

Gardner Pinfold Consulting Economists Ltd. Stantec

Initially, all lobster fishing occurred on Georges Bank, but in 1972 stocks were discovered on the outer edge of Browns Bank. The inshore fishery had traditionally been confined to within about 20 km of the coast, but by the mid-1970s, inshore fishermen were operating right up to the 50 mile line in the Browns Bank area.

The fishery was concentrated initially on western and southeastern Browns Bank and southern Georges Bank. Effort shifted to the southwest and southeast edges of Browns when the Bank itself it was closed to lobster fishing in 1977. Effort also shifted to the northeastern part of Georges Bank as better grounds were discovered closer to port. When the International Court of Justice set the maritime boundary in 1984, American fishing effort was eliminated in Crowell and Georges Basins in the Gulf of Maine, and the Canadian vessels moved into these areas.

This is a year-round fishery, with fishing effort and catches concentrated in the spring (usually, April to June) and fall (usually, October to December) seasons; in some years substantial catches are reported in winter. Most vessels fish about 1,000 traps. They are set on long lines from a single buoy marked with a high-flyer, with 100-125 traps per line.

Resource Status and Prospects

The abundance indicators presented in lobster stock assessment reports suggest that lobster abundance in LFA 41 has been either stable or has trended higher since 1999. The current catch rate model indicates catch rates have trended inconsistently or increased in different areas of LFA 41.

Nova Scotia lobsters take 8-10 years to reach 82.5 mm carapace length (CL), the legal size in LFA 41. Mature lobsters seasonally migrate to shallower waters in summer and deeper waters in winter. Over most of the lobster's range these movements amount to few kilometers; however, in the Gulf of Maine, the offshore regions of the Scotian Shelf and off New England, lobsters can undertake long distance migrations of tens to hundreds of kilometers.

The lobster stock structure in the Gulf of Maine is not fully understood and is viewed as a stock complex, which means that there may be a number of sub-populations linked in various ways by movements of larvae and adults.

The number and distribution of the subpopulations are uncertain. Lobster concentrations are highest in coastal regions and lower concentrations are associated with the offshore Banks of Browns and Georges. Lobsters are found in higher concentrations on the banks migrate to deeper water in winter.

Georges Bank (Corsair Canyon and the slope east of it) has been fished since 1972. There is little area for expansion on Georges Bank as the US lobster fishery lies to the south, and once lobsters move onto the banks they disperse. This is also an area where significant mobile gear activity would interfere with lobster fishing.

The TAC has been caught in 8 of the last 10 years and 5 of the past 5 years. Although landings are not a good indicator of lobster abundance in LFA 41, in part because the fishery is limited by a TAC, an inability to catch the TAC over several years may be an indicator of low lobster abundance and would warrant investigation as to the cause.

US landings from Northeast (NE) Georges Bank have increased dramatically in recent years. US landings from NE Georges Bank increased from 152 t in 2000 to 1,602 t in 2005 and were at 643 t in 2007. During the 1990s, Canadian and USA landings were similar, but over the last 5 years (2003-2007) landings from the US portion of NE Georges Bank averaged 7.9 times that of the Canadian landings on Georges Bank. US landings on the southern portion of Georges Bank have increased slightly over the last 10 years. Landings in adjacent fisheries increased significantly during the last 10 years, indicating additional pressure on the lobster resources in these areas.

The density of lobster gear in LFA 41 (4X + 5Zc) is considered to be low (approximately 12,000 traps over roughly 32,000 km^2) relative to the inshore fisheries (LFA 34 – approximately 386,800 traps over roughly 21,000 km^2).

Based on the current indicators of abundance, fishing pressure and production, the current TAC of 720 t (in place since 1985) does not appear to have had negative impacts on the lobster in LFA 41 overall and is considered to represent an acceptable harvest strategy at this time.

That there has been no change in the TAC in almost 20 years is less a reflection of any evidence of a stable population than it is an affirmation of the influence of the inshore sector. There is considerable resistance among inshore fishermen to allowing an increase in the TAC because they believe there is a link between the inshore and offshore fisheries and that any increase in offshore catches would adversely affect the inshore. The issue remains unresolved.

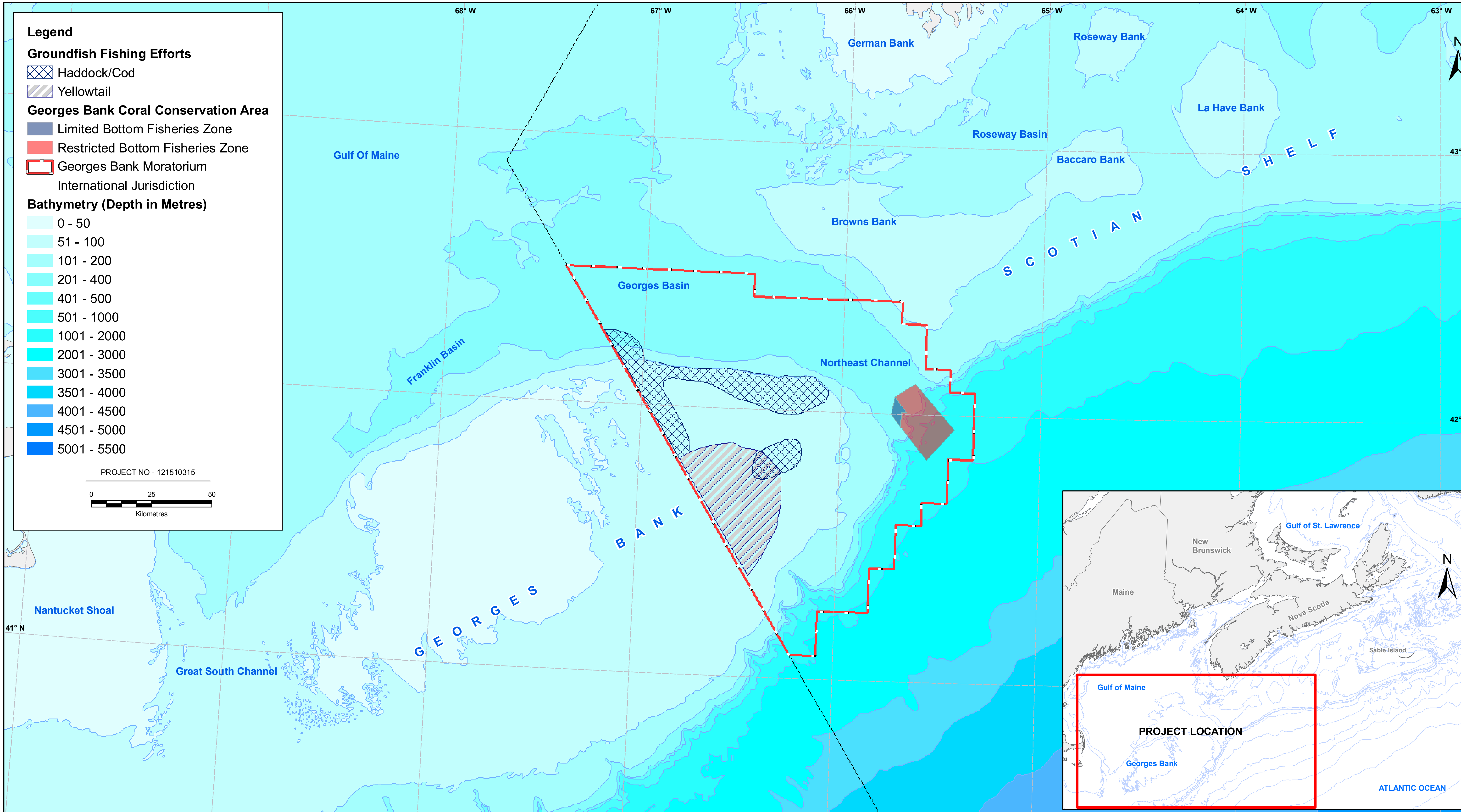
It is worth noting that in recent years, Jonah crab has become an important by-catch of the offshore lobster fishery. Reliable data on the quantity and value of the catch are not available.

Groundfish

Industry Structure

The groundfish fleet operating on Georges Bank is the largest and most diverse of any of the fisheries. Figure 2.24 illustrates the area on Georges Bank where fishing effort for groundfish is concentrated.

Virtually all inshore vessels are under 19.8 m (65’), though a very few fall into the 19.8-30.5 m (65-100’) category. There are several hundred vessels of varying length and gear type in the inshore groundfish fleet in southwest Nova Scotia. In 2008, 120 different groundfish vessels participated in the Georges Bank groundfish fishery.



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PRELIMINARY REVIEW OF ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES ON GEORGES BANK

AREAS OF GROUNDFISH FISHING EFFORT ON GEORGES BANK AND THE SCOTIAN SHELF

FIGURE NO.: **Figure 2.24**

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Inshore vessels tend to be owner-operated, with the shift towards newer management systems including enterprise allocations and individual transfer quotas (ITQs), an increasing proportion of the mobile gear fleet has become integrated into inshore processing companies.

Resource Access

TACs are set for each fish major stock and then allocated through quotas to the different fleet and gear sectors licensed to fish those stocks. All vessels gain access to the resource either through enterprise allocations (offshore vessels) or ITQs (inshore mobile gear vessels). Enterprise allocations and ITQs are set by DFO based on historic landings. Shares for the inshore fixed gear fleets are set by associations to which DFO has delegated responsibility for certain aspects of management. These associations account for just over 90% of the fixed gear allocation on Georges Bank.

Three species of groundfish have allocations specific to Georges Bank (NAFO division 5ZE): cod, haddock and yellowtail flounder. Other groundfish species are caught on Georges, but none is subject to specific allocations. In 2008, the allocations on Georges Bank by fleet sector were as shown in Table 2.9.

Table 2.9 2008 Groundfish Quota Allocations on Georges Bank by Fleet Sector (t)

	Cod	Haddock	Yellowtail
Aboriginal Fishery	69	1,154	
Fixed Gear <45'	791	2,824	
Fixed & Mobile Gear ITQ/Enterprise Allocation Fleet	577	10,378	
By-Catch Reserve	196	150	550
Reserve		444	

Management

Canada has faced considerable difficulty managing transboundary groundfish stocks on Georges Bank (cod, haddock and yellowtail flounder). Before 1977, the area was an international fishery and stocks were heavily over-fished as national quotas tended to be ignored. In 1978, Canadian quotas were set subject to negotiations with the US. From 1979 until the boundary settlement in 1984, the TACs and quotas were also set subject to negotiations with the US, but in effect the quotas were based on the Canadian shares of the 5ZE TACs as set out in an unratified 1979 Fisheries Agreement.

Canada altered its approach in 1985 as the parties were unable to make any progress on an agreement for joint management. Both countries abandoned the practice of sharing the stock according to the Fisheries Agreement. For its part, Canada set a quota for its fishermen as though the whole 5ZE stock were within its jurisdiction. The US adopted a similar approach (though quotas were not used). For much of the next decade, fishing pressure was up to four times higher than the level which would have been consistent with a conservative fishing strategy (generally referred to as F0.1). Not until 1995, with a year-round closure on the US side of the line and a substantial reduction in the Canadian quota, did the exploitation rate drop to an acceptable level.

The overfishing contributed to a sharp decline in stock abundance. From a peak of 25,000 t in 1985, the Canadian quota for cod declined to just 1,000 t in 1995 (reducing it to a by-catch fishery). Similarly, from a 12,000 t peak in 1982, the haddock quota declined to 2,500 t in 1995.

The Canadian experience mirrors what happened on the US side of Georges Bank during the 1990s: stringent management action in response to a steep slide in landings. From an average of some 5,000 t during the 1980s, US haddock and yellowtail landings dropped to the 100 t range by the mid-1990s. Over the same period, cod landings dropped from the 6,000 t range to less than 1,000 t.

Fishing Patterns

The fishery is dominated by draggers and long-liners. Some 120 (down from 145 in 1998) vessels are estimated to be active, though more are eligible to fish based on historic participation. For many vessels, the individual quotas are too low to make the trip economic, so they trade or lease their quotas to others.

Fishing for cod and haddock ranges over the Bank, depending on the location of stocks in any particular year.

Table 2.10 Canadian Groundfish Landings from Georges Bank

Year	Weight kg
1998	9,105,891
1999	9,205,031
2000	12,058,188
2001	14,850,696
2002	13,158,519
2003	12,917,714
2004	13,782,198
2005	17,535,363
2006	14,664,159
2007	13,883,898
2008p	16,802,866

Resource Status and Prospect

Resource status and prospect information was collected from cod, haddock and yellowtail Georges Bank Assessments completed by the Transboundary Resources Assessment committee.

Cooperation on fisheries science and management between Canada and the US has improved over the past few years. Stock assessment information is shared, and each country takes the other's catch expectations into consideration in developing management strategies. The management objective for both is to implement restrictive measures to allow stocks to re-build.

Eastern Georges Bank Cod

Adult population biomass (ages 3+) declined from about 50,000 t in 1990 to below 10,000 t in 1995. Biomass subsequently fluctuated between 6,000 and 13,000 t before decreasing in 2005 to about 3,800 t.

The 2005 and 2006 year classes are close to the post-1990 average. Initial indications are that the 2007 year class is weak. Resource productivity is currently poor due to low recent recruitment and low weights-at-age.

Average weight at length, used to reflect condition, has been stable, but declines in length and weight at age have hampered biomass rebuilding. Resource productivity is currently poor due to low recent recruitment and low weights at age compared to the 1980s.

While management measures have resulted in decreased exploitation rates since 1995, adult biomass has fluctuated without any appreciable rebuilding. The continuing poor recruitment since the early 1990s is an important factor for this lower productivity. The 2003 year class made a substantial contribution to the fishery and population biomass, and it is projected to continue to be an important component in the fishery catch biomass in 2009-2010 (around one third of the catch) and population biomass in 2010-2011. With the passing of the 2003 year class through the population, rebuilding will not occur without improved recruitment.

Cod and haddock are often caught together in groundfish fisheries, although they are not necessarily caught in proportion to their relative abundance because their catchabilities to the fisheries differ. Due to the higher haddock quota, discarding of cod may be high and should be monitored. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

Eastern Georges Bank Haddock

Under restrictive management measures, combined Canada/USA catches declined from 6,504 t in 1991 to a low of 2,150 t in 1995, varied between about 3,000 t and 4,000 t until 1999, and increased to 15,256 t in 2005. Combined catches in 2006, 2007 and 2008 were 12,634 t, 12,488 t and 15,995 t, respectively.

The Canadian catch in 2008 increased to 14,814 t from 11,946 t in 2007. For the combined Canada/USA fishery catch in 2008, the 2003 year class (age 5) dominated by numbers and weight.

The Transboundary Management Guidance Committee has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

Improved recruitment since 1990, lower exploitation and reduced capture of small fish in the fisheries allowed the adult population biomass (ages 3+) to increase from near an historical low of 9,100 t in 1993 to 81,900 t in 2003. Adult biomass decreased to 57,800 t in 2005 and subsequently increased to 155,600. The tripling of the biomass after 2005 was due to the exceptional 2003 year class, that resulted in 291 million age 1 fish. The preliminary estimate for the 2008 year class is below-average at 9 million fish at age 1.

Both length and weight at age have generally declined since about 2000. While size at age increased in 2008 for the younger age groups, weights remained below the 1986 to 2000 average, except for age 1. The size at age for the 2003 year class is smaller than previous year classes, but its rate to growth at length is similar to previous year classes.

Catches for several years into the future will be dependent on the 2003 year class.

With current fishing practices and catch ratios, the achievement of rebuilding objectives for cod may constrain the harvesting of haddock. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

Eastern Georges Bank Yellowtail Flounder

Combined Canada and USA catches in 2008 were 1,275 t. The TAC for a by-catch in Canada is 550 t. Historically, yellowtail was an important commercial species.

Pelagic Fisheries

Swordfish

Industry Structure

The Atlantic Canada swordfish fleet is composed mainly of long-line vessels, all of which also hold groundfish licenses. There are also some 1,400 vessels licensed to harvest swordfish using harpoons. These vessels play a minor role in the fishery, accounting for less than 10 percent of landings. Figure 2.25 illustrates areas of in the vicinity of Georges Bank where sword fishing takes place.

Resource Access

The fishery operates on a competitive basis (*i.e.,* all license-holders compete to maximize their share of the Canadian quota). The Canadian quota has declined sharply over the past decade, dropping from 3,500 t in the late 1980s, to just 1,100 t in 1998 and up to 1,431 in 2008 (this quota is not Georges Bank specific).

Management

Swordfish is a highly-migratory species. The North Atlantic stock is under the jurisdiction of the International Commission for the Conservation of Atlantic Tunas (ICCAT). The Canadian fishery is managed by DFO that controls it within the quota assigned by ICCAT. Management measures include limited entry licensing, at-sea observers, logbook reporting and dockside monitoring.

Fishing Patterns

The swordfish season on Georges Bank opens on August 1 and extends through September and into October as the stock makes its way through its northern range. About 50 longline vessels are active. Swordfish are found on the edge and slope of the Banks, where there is a distinct thermocline (where water depth drops sharply from shallow to deep). They are found throughout the water column, but are caught mainly at night during their migration to feed in surface waters (Figure 2.25). Longlines extend some 65 km. It is the understanding of the Study Team that in recent years swordfish have been harpooned right across Georges Bank.

Resource Status and Prospects

Stocks have declined over the past decade, and further declines are expected. The TAC (and national quotas) is expected to be reduced in the next few years to promote stock re-building.

Tuna

The tuna fishery conducted in waters off Nova Scotia is based on a TAC set by the International Commission for the Conservation of Atlantic Tunas (ICCAT). The fish are very valuable and landings are strictly monitored. Licence holders must purchase tags in advance of catching tuna. All tuna landed, both by directed fishing and by-catch must have a valid tag attached. The “Hell Hole”, the northeast channel off Georges Bank, is the most important area for Nova Scotia tuna landings.

According to DFO, annual landings of tuna have generally increased over the past decade. In 2007, of 114 vessels fishing pelagic species on Georges Bank, 60 reported landing tuna. Preliminary data for 2008 show the best year since 1998 with 102 tonnes being landed with a value of approximately $1.8 million.

Herring

Industry Structure

The herring fleet with access to Georges Bank is composed of purse seine vessels, though only a few have been active in the fishery since it re-opened in 1993. The purse seine fleet had numbered over 40 vessels until the early 1990s, with many vessels independently owned.

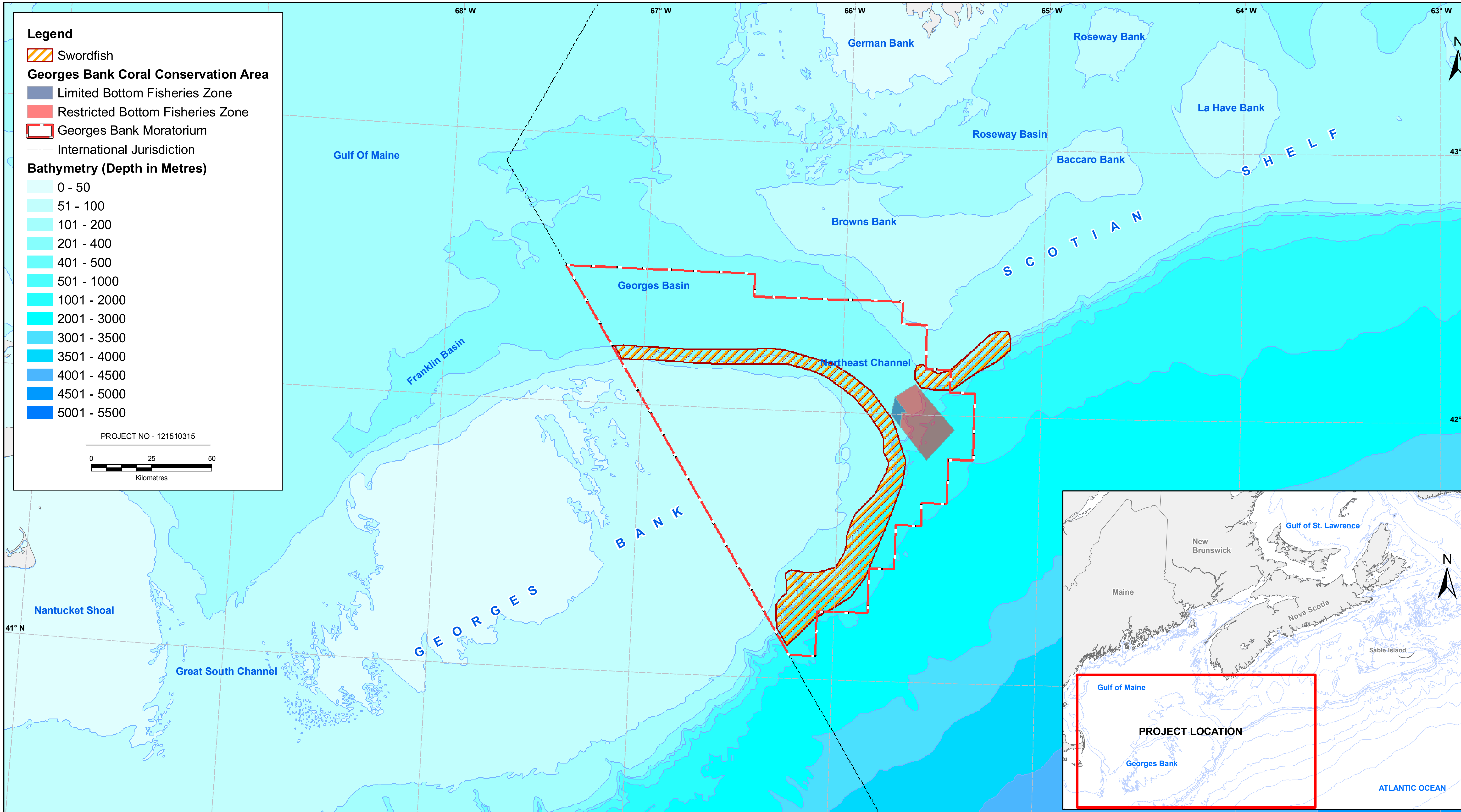

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FIGURE NO.: **Figure 2.25**

Gardner Pinfold Consulting Economists Ltd.

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Declining stocks have led to fleet rationalization. The remaining vessels are now largely company-owned.

Resource Access

The fishery on Georges Bank is open to all licensed vessels on a competitive basis.

Combined Canada and USA herring landings (not isolated to Georges Bank) increased from 106,000 t in 2005 to 116,000 t in 2006, then declined to 90,000 t in 2008.

During 1978-2005, the USA accounted for about 76% of the total landings, but during the most recent decade, this percentage increased to about 85%.

Landings by Canada averaged about 27,000 t during 1978-1994, declined to an average of 19,000 t during 1995-2001, and declined further to 14,000 t during 2002-2005. Landing from 2006-2008 average 16,800 t although landings in 2007 peaked at 31,000 t. Canadian landings have been dominated by the New Brunswick weir fishery.

Management

The Georges Bank fishery is managed using a variety of measures set out in the “1997 Scotia-Fundy Fisheries Integrated Herring Management Plan, NAFO Sub-divisions 4WX, 4VN, and 5Z”. Canadian and US scientists are making efforts to develop a joint management approach.

Resource Status and Prospects

The outlook for the herring stock is relatively stable for the next few years with continued growth of the stock to historic levels. There is optimism that the area will again support a substantial fishery.

2.3.2 Southwest Nova Scotia Economic Profile

Early History

The history of southwest Nova Scotia is one of over 300 years of close association with the sea. The French (Acadian) established settlements in the area early in the 17th century. For many years, the principal economic activities - fishing, trapping, logging and farming - were carried out largely on a subsistence basis. As a consequence, the number of settlements remained small and the area sparsely populated.

The region remained predominantly Acadian until the British began to establish settlements in the area in the mid-18th century. The first of these was Lunenburg, established in 1753. As mainland Nova Scotia passed from French to British hands in the mid-1700s, the Acadians were expelled from the region. Many returned to the area (mainly Digby County) following the end of hostilities between Britain and France in the late 1700s. The Municipal District of Clare remains to this day the largest French-speaking area of the province.

The population of southwest Nova Scotia grew most rapidly in late 1700s following the American Revolution. There was an influx into the area of people who remained loyal to the British Crown. The towns of Shelburne, Liverpool, Yarmouth and Digby were the main areas of settlement.

Nova Scotia entered a period of sustained prosperity late in the 18th century. The main economic activities were fishing, shipbuilding and trade. The ports of Halifax and Yarmouth became important commercial centres. Numerous manufacturing and service operations came into existence to supply and support the expanding fishing and shipbuilding industries. The region's main exports were fish, fish oil, lumber and ships.

Nova Scotia’s fortunes declined in the second half of the 19th century. Three factors accounted for this: the loss of tariff preference for Nova Scotia exports as the British moved to a system of free trade; the introduction of steam-powered, steel-hulled vessels had a devastating effect on the economy of the region, with its heavy reliance on the timber and shipbuilding industries; and, Confederation with Canada meant removal of tariffs and a rapid decline in the competitiveness of local manufacturers. These companies relied on the tariff to protect them from direct competition from larger operations in central Canada.

With these changes, many areas in the province moved out of the mainstream of industrial development and economic growth. These areas, of which southwest Nova Scotia was one, became increasingly dependent on the fishery. This dependence continues in much of the Region to this day.

2.3.3 Key Economic and Demographic Characteristics

2.3.3.1 Changes to Socio-economic Conditions and Overview

The five counties in southwest Nova Scotia share a number of common features and many of the key economic statistics are very similar now to what they were in the late 1990s:

- The fishing industry continues to be the single largest source of industrial employment and income.
- Labour force participation rates about 3.5% lower than the provincial average; they were 4% lower in 1996.
- Official unemployment rates are one-two percentage points higher than the provincial average; this is the same today as in the late 1990s, although the region now has the highest unemployment rate in the province.
- Average incomes are 5-10 percent lower than the provincial average; this is the same today as in the late 1990s.

- A low degree of urbanization, with only about 25 percent of the population living in the nine towns in the area; this also has not changed.
- Concentration of the population in coastal communities, a legacy of the close association with the fishery.
- Population decline continues to be a factor due mainly to high rates of out-migration of persons at the prime age for household formation.
- This, in turn, continues to lead to population decline in which the elderly form a higher proportion of the total population than is the case in Nova Scotia generally.

Though the Region today is characterized by a more diversified economy than 50 years ago, there continues to be a greater dependence on the primary industries – principally fishing and forestry – than in the economy of Nova Scotia generally. The region is facing several economic challenges.

Employment by Industry

The Southern Region's relative dependence on the fishery is best illustrated by the proportion of those employed in the primary fishing industry – about 9% of total employment. This compares with just over 2% for the province as a whole (Table 2.11). A further indication of the importance of the fishing industry may be found in employment in manufacturing (where fish processing is included): proportionately one and a half times as many are employed in this sector in the Region than in the Province (13% vs 9%). We should note that in the past 10 years, the number employed in fish processing has likely declined. Some caution should also be used in comparing these data since they include all manufacturers. In the Southern Region, this includes Michelin and Bowater.

Table 2.11 2008 Labour Force by Industry, Southern Region Compared to Nova Scotia

	NS 000s	%	Southern NS 000s	%
Total employed, all industries	453.2	100	56.8	100
Goods-producing sector	92.6	20	19	33
Agriculture	6.4	1	1.7	3
Forestry, fishing, mining, oil and gas	12.7	3%	5.2	9%
Utilities	3.1	1	X	X
Construction	31.3	7	4.2	7
Manufacturing	39.1	9	7.6	13
Services-producing sector	360.6	80	37.8	67
Trade	79.2	17	9.2	16
Transportation and warehousing	18.6	4	1.4	2
Finance, insurance, real estate and leasing	22.3	5	1.8	3
Professional, scientific and technical services	21.3	5	1.6	3
Business, building and other support services	25.9	6	2.4	4

Table 2.11 2008 Labour Force by Industry, Southern Region Compared to Nova Scotia

	NS 000s	%	Southern NS 000s	%
Educational services	33.9	7	3.3	6
Health care and social assistance	60.5	13	8	14
Information, culture and recreation	19.8	4	2.4	4
Accommodation and food services	29.4	6	3.3	6
Other services	19.4	4	2.1	4
Public administration	30.3	7	2.4	4

Note: Data presented for the forestry, fishing, mining and oil/gas industries are combined due to confidentiality.
Source: Statistics Canada, Table 282-0061.

Average Income

Average income in the Region is lower than the provincial average, with all counties showing lower income levels. In fact, as shown in Table 2.12, all counties have slipped in terms of average income compared to the provincial average. This reflects weaknesses in the economies, including relatively high unemployment rates (Table 2.13).

Table 2.12 Southern Region, Average Income, 1996 and 2006

	Average Income 1996	% of Nova Scotia	Average Income 2006	% of Nova Scotia
Digby	17,828	82.7	25,549	80.3
Lunenburg	20,235	93.9	28,998	91.2
Queens	22,513	104.5	27,159	85.4
Shelburne	20,715	96.1	26,770	84.2
Yarmouth	19,607	91.0	27,740	87.2
Nova Scotia	21,552	100.00	31,795	100

* of population 15 years and over.
Source: Census of Canada, 1996.

Table 2.13 Labour Force Activity Southern Region Compared to Nova Scotia

	2002		2008	
	Southern NS	Nova Scotia	Southern NS	Nova Scotia
Population (000)	103.0	747.5	103.5	768.6
Total labour force (000)	62.0	467.7	62.6	491
Total employment (000)	55.3	422.9	56.8	453.2
Full-time employment (000)			45.8	370.3
Part-time employment (000)			11	82.9
Unemployment (000)	6.7	44.8	5.8	37.8
Not in labour force (000)			40.9	277.6
Unemployment rate (%)	10.8	9.6	9.3	7.7
Participation rate (%)	60.2	62.6	60.5	63.9
Employment rate (%)	53.7	56.6	54.9	59

Source: Statistics Canada, Table 282-0055.

Labour Force Characteristics

The participation rate (the percentage of working age people in the labour force), taken in conjunction with employment growth, are important indicators of economic activity. Both indicators show relative stability over the period 2002-2008. The unemployment rate in southern Nova Scotia has dropped by 1.5% as compared to the province as a whole where the rate has dropped almost 2%. The most recent labour force data released by Statistics Canada for Nova Scotia shows the Southern Region with the highest unemployment rate in the province (9.3%).

The Nova Scotia participation rate is some three percentages points higher than the Regional average, while the unemployment rate is now two percentage points lower. These differences reflect stronger employment creation in the province as a whole. The number employed in Nova Scotia increased by almost 7% between 2002 and 2008, while regional growth was less than 2.5%.

Population

Population trends in the Region reflect the general level of economic activity. Population increased slightly from 1986 to 1991, reflecting moderately improving economic circumstances, including considerable growth in the fishing industry. This trend reversed after 1991 as population started to decline. By contrast, the overall population of the province increased steadily over the 20-year period examined (Table 2.14).

Only Lunenburg County experienced some positive growth over the past 20 years, while all other counties have registered little or no growth. Each county, including Lunenburg, experienced a population decline over the 2001-2006 period.

Table 2.14 Southern Region Population, 1986-2006

	1986	1991	1996	2001	2006
Digby County	21,852	21,250	20,500	19,545	18,995
Lunenburg County	46,483	47,634	47,561	47,595	47,150
Queens County	13,125	12,923	12,417	11,725	11,215
Shelburne County	17,516	17,343	17,002	16,230	15,540
Yarmouth County	27,073	27,891	27,310	26,840	26,275
Southern Region	126,049	127,041	124,790	121,935	119,175
Nova Scotia	873,199	899,942	909,282	908,005	913,465

2.3.3.2 Current Socio-economic Circumstances

Local Economic Situation

In the past two years, the Southern Region of the province has experienced a number of significant blows to its economy. As yet, the impact associated is not reflected in economic indicator data, which lags behind the current year. Although, as noted, the region now does have the highest rate of unemployment in the province. Consultations with regional economic development officials to discuss the current circumstances facing the southwest regional economy substantiate the Study Team's understanding and ongoing economic research in the region.

The inshore lobster fishery, which many argue is the economic driver of Shelburne, Yarmouth and Digby counties, suffered record low prices to fishermen in the past two fishing seasons. These low prices were attributable to the economic recession that occurred in major markets. This has proven to be a very serious hardship for fishermen as this fishery has become quite capital intensive. Many reported that fishing costs were higher than returns and inventories were high. Lobster landings continued to be at average levels experienced over the past 5-10 years.

Recently, it was announced by Bay Ferries that "the Cat" would not operate this coming season (2010) between Yarmouth and Maine. The number of passengers on ferries between Yarmouth and Maine have declined sharply during the past eight years from over 300,000 passengers to 85,000. The loss of "the Cat" will compound issues in the tourism sector which has suffered in recent years due to high gas prices, the increased exchange rate and the reduction in travel that was attributed to 9-11. Community observers suggest the tourism industry in the Southern Region will noticeably contract with the closure of businesses related to the accommodation and restaurant sectors.

Aboriginal Fishery

The Regional Fisheries Management Program of DFO Maritime Region is responsible for managing the regional fisheries resources, which are harvested for Aboriginal, commercial, and recreational purposes in marine and inland waters.

Aboriginal rights to fish were determined by the Supreme Court of Canada's 1999 Marshall decision. In response to the decision and the resulting government obligation to manage with the objective of increased self-reliance for First Nations, DFO has initiated various programs and initiatives aimed at increasing Aboriginal communities' participation in the Atlantic commercial fishery. The Aboriginal community became active in the Georges Bank groundfish fishery in 2003 when, according to DFO quota reports, a quota allocation for both cod and haddock on Georges Bank was designated for the Aboriginal fishery.

In 2007, there were 12 vessels fishing 10 Aboriginal licenses in NAFO Unit Area 5ZE. The 12 vessels landed their catches primarily in Yarmouth County, Nova Scotia with a total value of approximately $1.78 million. This consisted primarily of groundfish with a total landed value of approximately $1.72 million with the balance made up of shark, swordfish and tuna. The 2008 quota allocation for the Aboriginal Fishery on Georges Bank was 69 t for cod and 1,154 t for haddock (Table 2.9).

The Unama'ki Institute of Natural Resources provided the following information about the importance of Georges Bank to First Nations communities (Unama´ki Institute of Natural Resources 2010).

The following Mi'kmaq communities have direct groundfish access to the George Bank fishery:

- Potlotek
- Eskasoni
- Glooscap
- Membertou
- Wagmatcook
- Acadia
- Millbrook
- Waycobah
- Annapolis Valley First Nations

Approximately 9,500 people live in these communities and in 2007 there were approximately 315 people working directly as fishers or crew (9/13 NS bands). In total, Unama'ki First Nations hold 17 groundfish licenses for haddock, cod, halibut, Pollock, white hake, flounder, witch flounder, and yellow tail flounder.

First Nations note the money generated from the fishing enterprises goes directly to those actively fishing including captains and crews but also as salaries to those managing and maintaining the fleets. After operational costs are removed from the income generated for each year the profits are then returned to each community where the Band Administration decides on how to best benefit the community. Revenues generated from fishing enterprises as well as other means goes to community infrastructure, housing, education, public works, social assistance, community services, health services, community recreation, youth and elder outreach, suicide prevention, addiction support, counseling, policing, and job creation.

First Nation communities have concern that offshore oil exploration could jeopardize the financial benefits that Mi'kmaq First Nation communities now have begun to enjoy from the fishery of both the Bay of Fundy and Georges Bank. The fishery has created many opportunities for employment and community benefit that are not being realized and the communities have many concerns over the possible impacts of restrictions to the lucrative fishing area of the Georges Bank (Unama´ki Institute of Natural Resources 2010).

3.0 Regulatory Context

This section describes the regulatory context in which environmental and socio-economic issues associated with offshore petroleum activity are managed, with a focus on changes in the regulatory framework since the 1999 Panel Review. A comprehensive description of oil and gas regulatory approval processes is included on the Offshore Oil and Gas Approvals in Atlantic Canada (ACPI 2001) and the CNSOPB website (www.cnsopb.ns.ca).

3.1 PANEL CONTEXT

3.1.1 Offshore Petroleum Regulation

Established in 1990, pursuant to the *Canada-Nova Scotia Offshore Petroleum Accord Implementation Act* and the *Canada-Nova Scotia Offshore Petroleum Accord Implementation (Nova Scotia) Act* (Accord Acts), the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB, the Board) is the independent joint agency of the Governments of Canada and Nova Scotia responsible for the regulation of petroleum activities and resources offshore Nova Scotia. The Board's activities and decision making processes are guided by a regulatory framework which comprises legislation, regulations, guidelines, memoranda of understanding and other regulatory documents.

During the Panel Review process, there were three main themes of discussion related to the regulatory regime: 1) the stringency or effectiveness of regulatory requirements and the science on which decisions are based; 2) consultation and liaison practices; and 3) compensation issues.

Regulatory Effectiveness

During the 1999 Panel Review process, it was noted by some who opposed the moratorium that the CNSOPB regulatory regime was appropriate “to decide upon and enforce restrictions to protect the productivity and habitat of Georges Bank” (NRC and NSPD 1999, p. 41). Others pointed out that the existing regulatory regime had not been in place very long and a moratorium period would “buy time” for Canadian regulators to gain experience and build public confidence. There was also concern that the mandated responsibilities of the CNSOPB to address safety and environmental protection, as well as requiring plans for industrial benefits from offshore petroleum activities, may represent an inherent conflict. The Panel appeared to dismiss this comment, describing the petroleum regulatory regime as comprehensive and recognizing that the context for the regime is to manage activities with forethought, rather than imposing total bans on activity.

One of the key issues that emerged under the discussion of regulatory effectiveness was the apparent lack of an ecosystem-based approach in the context of making regulatory decisions.

The Panel recognized a need for more ecosystem-based research to develop an integrated conservation planning approach in the marine environment (NRC and NSPD 1999).

Consultation and Liaison

Many presenters during the Panel Review recognized that consultation and liaison processes had improved over the years and that generally, the CNSOPB's approach to consultation and liaison, primarily through the establishment of committees, was acceptable.

Compensation

At the time of the Panel Review, the Canadian Association of Petroleum Producers (CAPP) and fishing industry representatives were still negotiating a voluntary compensation regime for damages from petroleum-related activities. Several unresolved issues remained.

3.1.2 Conservation Approach

As discussed above in Section 3.3.1, marine conservation planning was recognized as being in its early stages in 1999, certainly lagging behind terrestrial ecosystem conservation planning. The *Oceans Act*, intended to provide a framework for ocean management, had just come into force in 1997. The first Marine Protected Area (MPA) in Atlantic Canada (The Gully MPA) was only designated in May 2004.

The Panel recognized that protection of marine ecosystems was an urgent matter that had just recently become a priority and that the relevant ecological science behind the development of protected areas was just beginning to evolve. In this respect, they supported the complementary approach of regulation based on permitting as well as designating areas for banned activities, advocating a protective approach in the absence of definitive scientific proof (NRCan and NSPD 1999).

3.2 CHANGES TO REGULATORY CONTEXT

In the past ten years, there have been numerous developments in the regulatory framework that affect offshore oil and gas activities, either directly or indirectly. Table 3.1 summarizes key regulatory documents which have environmental and/or socio-economic implications to the offshore oil and gas industry, focusing on updates, amendments, and new developments that constitute changes to the regulatory context and could possibly have some bearing on a moratorium decision.

It is recognized that, in addition to the CNSOPB, several other government departments and agencies are involved in the regulatory processes for offshore oil and gas activities. To the extent that these processes and the CNSOPB authorization processes are related to environmental protection or socio-economic issues, they are discussed below.

Table 3.1 Summary of Updates to Legislation and Environmental Guidelines

Regulatory Document	Regulating Agency	Purpose/Objective	Key Update/Development
Acts and Regulations			
Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act (1988 c.28) and *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act (1987 c. 3)* (The Accord Acts)	Canada-Nova Scotia Offshore Petroleum Board	The Accord Acts implement an agreement between the Government of Canada and the Government of Nova Scotia on offshore petroleum resource management and revenue sharing.	Although there have been no key updates to the Accord Acts which would have a bearing on petroleum activities on Georges Bank, this legislation is included as it provides authority to the CNSOPB and it is the key legislation under which the moratorium has been placed.
Canada Oil and Gas Drilling and Production Regulations (SOR/2009-315)	Canada-Nova Scotia Offshore Petroleum Board/Canada-Newfoundland Offshore Petroleum Board/National Energy Board	Regulations amalgamate and modernize Drilling Regulations and Production and Conservation Regulations under the *Canada Oil and Gas Operations Act* and the *Accord Acts*.	These regulations, which came into force in 2009, are written in goal-oriented style and provide more flexibility for regulatory process efficiency. Regulations decrease duplication of previous regulations. Regulations require companies to have a management system to ensure compliance with Act and Regulations. Goal-oriented approach retains regulatory objectives while enhancing regulatory clarity and efficiency (*e.g.,* easier to adapt to technological changes). Rather than prescribing standards in regulation, operators become responsible for identifying appropriate standards, codes and practices to be applied for specific projects.
Fisheries Act (R.S. 1985, c.F-14) and Bill C-32 *(Fisheries Act, 2007)*	Fisheries and Oceans Canada	The *Fisheries Act* includes provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. Under the Act, no one may carry out any work or undertaking that results in the harmful alteration, disruption or destruction (HADD) of fish habitat, unless this HADD has been authorized by the Minister of Fisheries and Oceans Canada.	Bill C-32 repeals and replaces the *Fisheries Act*. It seeks to provide for the sustainable development of Canadian fisheries and fish habitat in collaboration with fishers, the provinces, aboriginal groups and other Canadians. The current Act treats fish habitat protection and pollution prevention as issues separate from fisheries management. Habitat protection is clearly stated in the new Act as an integral element of proper fisheries management. The general prohibition on the harmful alteration, disruption or destruction of fish habitat remains the cornerstone of DFO's fish habitat protection program. Key implications of the new Act include (DFO 2007b) : • the government's ability to focus on activities that have a higher risk of causing harm to fish habitat; • increased transparency and public involvement in development of regulations; • intergovernmental cooperation to eliminate unnecessary duplication of provincial/federal regulations; • increased effectiveness of habitat protection program due to improvements in enforcement of terms and conditions in authorizations; • increased protection from invasive species; and • improved balance and distribution of powers between fisheries officers and habitat inspectors.
Oceans Act (S.C. 1996, c.31)	Fisheries and Oceans Canada	The Oceans Act assigns DFO the lead role in integrated planning and management of ocean activities and legislates three main initiatives: • Marine Protected Areas Program • Integrated Management Program; and • Marine ecosystem health program.	Pursuant to the Oceans Act, in 2002, DFO released Canada's Ocean Strategy (DFO 2002d) which presents a strategic framework for oceans management. Key principles of the Ocean Strategy are: • Sustainable development; • Integrated management; and • Precautionary approach. This Ocean Strategy represents the federal government's commitment to work with stakeholders to promote sustainable use of the ocean resources and protect important features through such mechanisms as designated Marine Protected Areas. Although Georges Bank has not been identified as a priority for a Marine Protected Area, DFO's approach to managing petroleum activities in the offshore, including the moratorium study area, is consistent with the principles in Canada's Ocean Strategy.
Canadian Environmental Protection Act, 1999 (1999, c.33)	Environment Canada	CEPA was enacted in 1988 as pollution prevention legislation. Results of legislated five year review result in new CEPA, 1999 which came into force on March 31, 2000 as "an Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development" (Environment Canada 2004). Among other things, CEPA provides a wide range of tools to manage toxic substances, other pollution and wastes, including disposal at sea.	*CEPA 1999* replaces the Ocean Dumping Regulations, 1988 and prohibits the disposal of wastes and other matter (*e.g.,* dredged material) at sea within Canadian jurisdiction unless the disposal is done under a permit issued by the Minister of Environment.

Table 3.1 Summary of Updates to Legislation and Environmental Guidelines

Regulatory Document	Regulating Agency	Purpose/Objective	Key Update/Development
Species at Risk Act (2002, c. 29)	Environment Canada/Fisheries and Oceans Canada/Parks Canada	*SARA* is intended to protect species at risk in Canada and their critical habitat (as defined by *SARA*). The main provisions of the *Act* are scientific assessment and listing of species, species recovery, protection of critical habitat, compensation, permits and enforcement. The *Act* also provides for development of official recovery plans for species found to be most at risk, and management plans for species of special concern. Only species on Schedule 1 of *SARA* are subject to the permit and enforcement provisions of the *Act*.	*SARA* was proclaimed in 2002 and came fully into force in 2004. Under the Act, project proponents are required to demonstrate that no harm will occur to listed species, their residences or critical habitat. *SARA*-listed species do occur on Georges Bank, although no "critical habitat" for species at risk has been defined in the moratorium area. This legislation is slated for review in 2010.
Canadian Environmental Assessment Act (*CEAA*) (1992 c. 37)	Canadian Environmental Assessment Agency	The *Canadian Environmental Assessment Act* (*CEAA*) ensures environmental effects of projects are reviewed before federal authorities exercise decision making authority in connection with the projects.	*CEAA* came into force in 1995 and was subject to a five-year legislative review which involved an extensive public consultation process. In 2001, amendments were introduced to strengthen the environmental assessment process. These amendments came into force in 2003. Since the 1999 Panel Review, the federal environmental assessment process has evolved to become more rigorous, yet more efficient. Specific amendments to various *CEAA* regulations regarding offshore petroleum activities have led to a more transparent and streamlined environmental assessment approach for these types of projects. In particular, amendments to the Law List Regulations and Federal Authorities Regulation now recognize the CNSOPB as a Federal Authority with responsibilities under *CEAA* to conduct environmental assessments of projects prior to exercising their authority to grant approvals. Amendments to the Comprehensive Study List clarify expectations for level of assessment for certain petroleum activities. This legislation is proposed to be amended in 2010 to further strengthen the role of the Canadian Environmental Assessment Agency and improve timelines for environmental assessment.
Guidelines			
Offshore Waste Treatment Guidelines (August 2002)	National Energy Board/Canada-Nova Scotia Offshore Petroleum Board/Canada-Newfoundland Offshore Petroleum Board	The Offshore Waste Treatment Guidelines outline recommended practices and standards for the treatment and disposal of wastes from petroleum drilling and production operations in Canada's offshore areas, and for sampling and analysis of waste streams to ensure compliance with these standards.	The 2002 Guidelines supersede previous waste guidance documents and prescribe minimum standards to be applied in decision making. These guidelines are subjected to a five-year review, and are currently undergoing another review with an update anticipated to be published in 2010. Key updates to the 2002 version include revised prescribed limits to drill waste and produced water discharges as well as the addition of air emission reporting requirements. The guidelines are reviewed and updated in acknowledgement of advances in industry practice and scientific knowledge of effects of wastes.
Offshore Chemical Selection Guidelines for Drilling & Production Activities on Frontier Lands (April 2009)	National Energy Board/Canada-Nova Scotia Offshore Petroleum Board/Canada-Newfoundland Offshore Petroleum Board	The Chemical Selection Guidelines provide a framework for chemical selection which minimizes the potential for environmental impacts from the discharge of chemicals used in offshore drilling and production operations. The objective of these Guidelines is to promote the selection of lower toxicity chemicals to minimize the potential environmental impact of a discharge where technically feasible.	These Guidelines are formally reviewed (at a minimum) every five years to ensure that they continue to reflect significant gains in scientific and technical knowledge. Updates to other relevant legislation (*e.g., Canadian Environmental Protection Act*, *Pesticides Act*) and international standards (*e.g.,* North Sea chemical notification system) guide the review and updates of these guidelines.
Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (March 2002)	National Energy Board/Canada-Nova Scotia Offshore Petroleum Board/Canada-Newfoundland Offshore Petroleum Board	The purpose of these guidelines is to: describe the various compensation sources available to potential claimants for loss or damage related to petroleum activity offshore Nova Scotia and Newfoundland and Labrador; and outline the regulatory and administrative roles which the Boards exercise respecting compensation payments for actual loss or damage directly attributable to offshore operators.	These guidelines replace previous compensation guidelines developed by the Boards, although there were no substantical changes.
Drilling and Production Guidelines (Draft, December 2009) Safety Plan Guidelines (Draft, December 2009) Environmental Protection Plan Guidelines (Draft, December 2009) Data Acquisition and Reporting Guidelines (Draft, December 2009)	National Energy Board/Canada-Nova Scotia Offshore Petroleum Board/Canada-Newfoundland Offshore Petroleum Board	Draft Guidelines have been prepared to provide guidance on how to achieve regulatory compliance with the new *Canada Oil and Gas Drilling and Production Regulations*.	To reflect the goal-oriented approach of the new Regulations, the Guidelines are intended to reflect lessons learned through audits and assessments, advancements in technology and improvements to best practice. Operators will be required to have management systems in place to proactively evaluate the project-specific hazards and risks and identify the most appropriate technology, design and operational requirements for the circumstances. This management system approach is intended to ensure compliance with the safety, environmental protection and resource conservation requirements of the Regulations.
Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (2007)	Various federal and provincial regulators	The *Statement* is essentially a national code of conduct which sets out minimum standards that will apply in Canada's non-ice covered marine waters to all seismic activities that use air source arrays.	The *Statement* is the culmination of a review of science by federal and provincial regulators and scientific experts regarding effects of seismic noise on the marine environment. As new scientific information and improved mitigation technologies and practices emerge, these will be considered for incorporation into the *Statement*. Surveys must be designed to avoid causing a significant adverse effect for an individual marine mammal or sea turtle listed as endangered or threatened in the Canadian legislation to protect species at risk; or a significant adverse population-level effect for any other marine species.

3.2.1 Petroleum Regulation in Offshore Nova Scotia

CNSOPB Governance

The CNSOPB remains the key regulator of petroleum activities in the Nova Scotia Offshore Area. This regulatory agency has, as predicted would occur, gained valuable experience over the past ten years, resulting in a more efficient and experienced Board. In December 1999, the Cohasset-Panuke Project, Canada's first offshore oil project, ceased production. At the same time, the Board issued an authorization to Sable Offshore Energy Inc. (SOEI) to begin producing gas from the Sable Offshore Energy Project (SOEP), Canada's first offshore natural gas project (CNSOPB 2000). Since then, the CNSOPB has authorized more than 175 applications for work activities and participated in numerous screening, comprehensive study level environmental assessments for offshore seismic, drilling, production and decommissioning projects.

The *Canada Oil and Gas Drilling and Production Regulations*, which just came into force in December 2009, demonstrate a trend toward modernizing regulation of activities through a goal-oriented approach such that regulators can more easily adapt to technological advances in the industry. With an emphasis on environmental management planning, the Regulations are less prescriptive in nature, requiring operators to establish and maintain management plans to meet project-specific standards.

Intergovernmental Cooperation

As noted above, certain aspects of petroleum activities also fall under the regulatory authority of other agencies. To ensure effective coordination of all the regulatory requirements, the Board takes the lead role in coordinating regulatory activities and has entered into Memoranda of Understanding with the appropriate departments and agencies. For example, Memoranda of Understanding have been established with Environment Canada and DFO to provide coordination of environmental and fisheries matters, and with the National Energy Board to improve the efficiency and effectiveness of pipeline regulation. Each year, the CNSOPB, Environment Canada and DFO develop a Work Plan to identify specific projects for collaboration with the objective of enhancing current mechanisms and practices for delivering environmental protection and conservation measures in the Nova Scotia offshore environment (CNSOPB, Environment Canada, and DFO 2009).Collaborative projects may include: joint priority setting and planning; environmental assessment; environmental effects monitoring; marine conservation initiatives; air emissions; and/or reporting on progress. Intergovernmental coordination relating to offshore activities has improved significantly in the last ten years, as an integrated management approach has become the management model (refer to Section 3.2.2).

In addition to cooperation with other Canadian government departments and agencies, the CNSOPB monitors activities of, and interacts with, international regulatory agencies. The CNSOPB is a founding member of International Offshore Petroleum Environmental Regulators Group (IOPER). Founded in 2008, IOPER is a network of regulators exchanging information on offshore environmental trends, industry performance, lessons learned, best practices, regulatory initiatives and measuring effectiveness of regulatory activities. These interactions further advance the CNSOPB's regulatory expertise in environmental protection matters.

Environmental Assessment

The CNSOPB requires an environmental assessment (EA) for all activity authorizations under the Accord Acts. Prior to 2001, an EA under the *Canadian Environmental Assessment Act* (*CEAA*) was only required for production projects. Environmental assessments of all other authorizations for offshore oil and gas projects were conducted according to internal CNSOPB policy and not assessed under *CEAA.*

In 2001, the Federal Authorities Regulations were amended to include the CNSOPB as a Federal Authority. Amendments to the Inclusion List Regulations and Law List Regulations in 2003 expanded the coverage of *CEAA* to include East Coast offshore oil and gas exploration activities (*i.e.,* areas under jurisdiction of C-NLOPB and CNSOPB), making exploration, as well as production projects, subject to the federal EA process (Government of Canada 2003).

Key amendments to the Comprehensive Study List Regulations during this period clarified the requirement for level of assessment for exploration drilling. A drilling project located within the limits of a "study area" delineated in a comprehensive study or review panel under *CEAA* or an Environmental Assessment Review Process Guidelines Order (EARPGO) Panel review of a previous offshore exploratory drilling project would be subject to a screening EA. A proposed exploratory drilling project outside the limits of a study area as defined above would be subject to a comprehensive study (Government of Canada 2003). In 2005, BEPCo's exploration drilling program on EL 2407 became the first offshore drilling project assessed and approved as a *CEAA* comprehensive study under the CNSOPB's jurisdiction, thereby raising the level of assessment for drilling activity.

In 2005, the Comprehensive Study List Regulations were amended again with respect to oil and gas activities, to change the type of environmental assessment of the first exploratory drilling project in an offshore area from the comprehensive study type to the screening type. Based on experience gained in offshore Canada, it was determined that offshore exploratory drilling projects are, in general, minor, localized, short in duration, and reversible, and not likely to cause significant adverse effects. They should therefore be subject to a screening level EA rather than a comprehensive study EA (Government of Canada 2005). This determination was made based on recommendations from a subcommittee of the multi-stakeholder Regulatory Advisory Committee (RAC) that had been formed to develop recommendations on the manner in which offshore exploratory drilling activities should be covered in the federal EA regime. The subcommittee's decision was based primarily on a consultant's study (Hurley and Ellis 2004) that examined EEM information relating to offshore drilling projects. More information on this report is provided in Section 4.

As discussed above, the CNSOPB shares an interest in collaborating with other federal agencies regarding EA. The cooperation of federal agencies as they satisfy their respective obligations under *CEAA*, facilitates exchange of information and improves the EA process. Depending on the project features and specific requirements for authorizations, Environment Canada, DFO, National Energy Board, Transport Canada, and/or Industry Canada may participate as a Responsible Authority (RA) for environmental assessment under *CEAA*. Depending on shore-based facilities (*e.g.,* onshore processing plant), the Province of Nova Scotia may also be involved in the environmental assessment process.

The CNSOPB is currently considering preparing a Regional Environmental Assessment (REA) focused on the environmental effects of hydrocarbon exploration. As a precursor, they have identified EA data gaps and research priorities (see Hurley 2009) and are exploring stakeholder consultation methods for such an REA (CNSOPB, Environment Canada, and DFO 2009).

Environmental Guidelines and Policies

Since 1999, the CNSOPB has developed or updated several key guideline documents in cooperation with the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and National Energy Board (NEB), including the Offshore Waste Treatment Guidelines (NEB *et al.* 2002), the Offshore Chemical Selection Guidelines For Drilling & Production Activities on Frontier Lands (Offshore Chemical Selection Guidelines) (NEB *et al.* 2009), and the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (CNSOPB and C-NLOPB 2002) (Table 3.1). These guidelines, in particular, advance mitigative standards and procedures to minimize environmental effects, thereby framing oil and gas activities on Georges Bank in a new context.

The Offshore Waste Treatment Guidelines (NEB *et al.* 2002) outline recommended practices and standards for the treatment and disposal of wastes from petroleum drilling and production operations in Canada's offshore areas, and for sampling and analysis of waste streams to ensure compliance with these standards (NEB *et al.* 2002). These Guidelines are reviewed and updated approximately every five years and are currently under review by the three Boards with input from stakeholders. The key updates in the 2002 revision included a concentration limit of 6.9 g/100 g or less oil on wet drill solids. At the time of the Georges Bank Panel Review, the 1996 version of the Guidelines were being used, which included a requirement of treatment of drill waste to reduce oil concentrations to 15 g/100 g or less of dry solids (NEB *et al.* 1996).

Between the 1996 and 2002 versions of the Offshore Waste Treatment Guidelines, a 1% discharge limit was implemented in 2000. This 1% discharge limit essentially represented a zero discharge regime for oil-based muds, resulting in operators “skipping and shipping” the drill waste to shore for land disposal. The limit was changed to 6.9% in 2002 based on an understanding of best available technology and environmental effects monitoring results which had demonstrated a lower impact level than previous assumed during environmental assessments of drilling projects (refer to Section 4.2 for more information on scientific advancements related to drill waste).

Another important revision to the *Offshore Waste Treatment Guidelines* was the limit established for produced water discharges. Production installations commencing operation in 2002 or later need to ensure that the 30-day weighted average of oil in discharged produced water does not exceed 30 mg/L and that the 24-hour arithmetic average of oil in produced water does not exceed 60 mg/L. The 1996 version of the Guidelines had limits of 40 mg/L (averaged over a 30 day period) and 80 mg/L (averaged over a 48 hour period) (NEB *et al.* 1996). Installations which had started production previous to 2002 (*e.g.,* SOEP) were expected to achieve a 30-day weighted average of oil in discharged produced water of 30 mg/L no later than December 31, 2007 (NEB *et al.* 2002).

In addition to changes in prescribed limits for specific discharges, the revised Offshore Waste Treatment Guidelines also introduced reporting requirements for air emissions. Recognizing the significance of cumulative greenhouse gas emissions, the Guidelines request that annual quantities of greenhouse gas emissions are calculated and included in development applications, along with a plan to control and reduce these emissions. Drilling and production operators are expected to calculate and report, on an annual basis, greenhouse gas emissions emitted from their installations. Volatile organic compounds (VOCs) are also included in reporting expectations. The *Chemical Selection Guidelines* (NEB *et al.* 2009) outline the minimum requirements associated with the selection of chemicals for use in offshore drilling and production operations. These Guidelines will be formally reviewed every five years to ensure that they continue to reflect significant gains in scientific and technical knowledge. The objective of these Guidelines is to promote the selection of lower toxicity chemicals to minimize the potential environmental impact of a discharge where technically feasible. Updates to these Guidelines are related to changes in other Canadian legislation (*e.g.,* Canadian Environmental Protection Act, 1999; Pesticides Act) as well as international standards and processes such as the chemical notification system used in the North Sea (E. Theriault, pers. comm. 2010).

In 2007, a *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* was released. This document, prepared with the cooperation of various provincial and federal government agencies, specifies the mitigation requirements that must be met during the planning and conduct of marine seismic surveys, in order to minimize impacts on life in the oceans. Currently, all seismic operators must adhere to this Statement of Practice. The Statement, which is founded on best global knowledge and practices, is considered a ‘living’ document and is intended to be reviewed and updated on a regular basis.

Environmental Effects Monitoring

The CNSOPB requires operators to implement programs to assess, mitigate and manage environmental risks. Environmental Effects Monitoring (EEM) improves the understanding of the relationship between potential effects and the ecosystem, thereby allowing operators and regulators to incorporate findings into subsequent management decisions (i.e,, adapative management) (CNSOPB 2009).

The number of EEM programs has increased, the length of the programs lengthened, and the results have become more accessible. EEM programs are evolving from a compliance-driven exercise to an adaptive management strategy. Adaptive management is described by the CNSOPB as a "'learn by doing' approach that incorporates changing science, methods, results, and industrial practices into subsequent management decisions. As a result, management processes that adhere to adaptive principles not only focus on achieving objectives but also add to the collective knowledge base about an ecological system, improving the precision and efficacy of future decision making and the regulatory process" (CNSOPB 2009).

In 2005, the CNSOPB, DFO, and Environment Canada developed the *Environmental Effects Monitoring Coordination Framework* (April 2005), with the objective of strengthening cooperation and coordination between government, regulators and industry when designing, implementing and reviewing EEM programs with respect to the oil and gas sector offshore Nova Scotia.

Recognizing the value of EEM in adaptive management and advancing scientific knowledge, petroleum industry operators are collaborating with scientific experts and regulatory agencies to conduct EEM programs for various offshore activities, many on a voluntary basis. As one of the responsibilities defined under the EEM Coordination Framework (CNSOPB, DFO and Environment Canada 2005), the CNSOPB has prepared a synopsis of Nova Scotia's Offshore EEM Programs (CNSOPB 2009). This synopsis provides a comprehensive overview of EEM results from the SOEP and COPAN EEM programs, as well as various seismic and drilling programs (refer to Section 4 for a discussion of EEM results).

The EEM Coordination Framework also specifies that EEM conducted as part of a *CEAA* follow-up program must be made available through the Canadian Environmental Assessment Registry. Furthermore, reports older than five years are no longer considered to be proprietary and can also be released, regardless of a *CEAA* requirement (E. Theriault, pers. comm. 2010)

Regardless of whether their project was assessed under *CEAA*, some operators are voluntarily releasing their EEM reports, recognizing the value in sharing of the data to adaptive management of the industry. The C-NLOPB also just recently made available EEM program data for Terra Nova, Hibernia, and White Rose development projects on the Grand Banks.

The value of using EEM results in a *CEAA* review process is demonstrated by the EEM data and literature review conducted by Hurley and Ellis (2004). This Report, which examined environmental effects of exploratory drilling offshore Nova Scotia, Newfoundland and in the Beaufort Sea, was used by the CEA Agency Regulatory Advisory Committee to downgrade EA requirements for exploratory drilling from a comprehensive study (if proposed to occur in a previously unassessed study area) to a screening level assessment.

As offshore EEM programs become more transparent and available, there becomes less uncertainty around the activities and their effect on the ecosystem and adaptive management strategies are able to prevent and/or reduce known environmental effects.

Consultation and Liaison

Consultation and liaison with stakeholders in the Nova Scotia offshore area is achieved through various channels, although one of the most effective means is the Board's Fisheries Advisory Committee (FAC) which includes representatives from various fishing groups and associations, Fisheries and Oceans Canada (DFO), the Nova Scotia Department of Agriculture and Fisheries, Natural Resources Canada, and the Nova Scotia Department of Energy. FAC members provide advice and suggestions to the Board for consideration in work authorization applications, regulations and guidelines (CNSOPB website: http://www.cnsopb.ns.ca/stakeholder_involvement.php). Although this forum has been in place for quite some time and does not represent an update for this review, it is worth noting its continued role in offshore petroleum regulation.

With drilling and seismic projects now subject to *CEAA*, consultation efforts have increased and authorizations have become more transparent.

Compensation

In 2002, the CNSOPB and C-NLOPB jointly issued the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (CNSOPB and C-NLOPB 2002). These Guidelines, which updated a previous version, were prepared to describe the various compensation sources available to potential claimants for loss or damage related to petroleum activity offshore Nova Scotia and Newfoundland and Labrador; and outline the regulatory and administrative roles which the Boards exercise respecting compensation payments for actual loss or damage directly attributable to offshore operators. In addition, the petroleum industry (led by CAPP), in association with the fishing industry, established a fisheries compensation program for loss resulting from non-attributable gear and vessel damage. The *Canadian East Coast Offshore Operators Non-attributable Fisheries Damage Compensation Program* (CAPP 2007) is an alternative to making a claim through the courts or other regulatory authorities (*e.g.,* through the CNSOPB process).The intent of this program is to demonstrate the commitment of CAPP's members who operate in the Atlantic Canada offshore area to the efficient and fair resolution of claims proven to be attributable to upstream oil and gas activity and not attributable to any one particular operator (CAPP 2007).

As in 1999, fisheries compensation continues to be an important issue and frameworks continue to evolve as the petroleum and fishing industries work together to share overlapping resources.

3.2.2 Conservation Approach and Management Tools

Since 1999, the approach to marine conservation has become more informed, and has evolved beyond sustainable development and precautionary principles to include concepts such as ecosystem science and integrated management. Canada's Ocean Strategy, developed in 2002 in response to the *Oceans Act*, provides policy direction for an integrated approach to ocean management, coordination of policies and programs across governments, and an ecosystem approach to ocean resource management and environmental assessment (DFO 2002d). These principles guide the establishment of protected areas and protection of species at risk. Recent developments in marine conservation are discussed below.

Ecosystem Approach to Management

Ecosystem science takes a broad approach to studying relationships and interactions in the ecosystem, focusing efforts on identifying and understanding the key relationships in nature, and their links to human needs and actions. Ecosystem science provides the foundation for integrated management of diverse human activities. In 2007, DFO published *A New Ecosystem Science Framework: in Support of Integrated Management*, to provide scientific support for ecosystem-based management. The document provides context for this approach, outlines benefits and challenges to the approach, and describes the framework in detail. Examples of DFO activities set in an ecosystem context include: assessing the slow pace of Atlantic cod recovery; considering the entire lifecycle of wild west coast salmon stocks in developing the wild salmon policy; and taking an ecosystem perspective to a cost-benefit analysis when assessing oil and gas exploration and development in the North.

Integrated Management

Integrated management is an approach to management whereby decision-makers responsible for ocean-based activities manage these activities in consideration of other ocean users and in a manner that will sustain a healthy marine environment. The Eastern Scotian Shelf Integrated Management (ESSIM) Initiative is an example of the integrated management principle in practice. ESSIM is lead by DFO and takes a collaborative and integrated planning and management approach to addressing broad scale ocean use and interests of the Eastern Scotian Shelf. Key interests in ocean use and activities include fisheries, offshore oil and gas, shipping, maritime defence operations, submarine cables, science, research and development, recreation and tourism, potential offshore minerals development, and marine conservation (DFO 2002d). This approach represents a significant shift in the management of offshore resources, recognizing various stakeholders, beyond fisheries and petroleum operators. The updated *Fisheries Act, 2007* (Bill C-32) which has not yet received royal assent, embodies an integrated management approach, integrating the fish habitat protection with fisheries management, issues historically addressed separately under the current *Fisheries Act*.

Federal Marine Protected Areas Strategy

The *Oceans Act* provides the Minister of Fisheries and Oceans with a leadership role for coordinating the development and implementation of a federal network of marine protected areas. The responsibility for the network of protected areas is shared by three federal government departments: DFO, Environment Canada, and Parks Canada.

As of January 2010, DFO has designated seven Marine Protected Areas (MPAs) under the *Oceans Act*, including the Gully MPA, which was established on the Scotian Shelf in 2004. An

MPA is a coastal or marine area given special status to conserve and protect its natural habitat and marine life. There are no other MPAs established offshore Nova Scotia.

National Marine Conservation Areas (NMCAs) are established by Parks Canada and are marine areas managed for sustainable use and containing smaller zones of high protection. Amendments to the *Wildlife Act* in 1994 allow Environment Canada to extend provisions for National Wildlife Areas to be identified as Marine Wildlife Areas (MWAs). There are no NMCAs or MWAs established offshore Nova Scotia.

Pursuant to the *Fisheries Act*, DFO has established Coral Conservation Areas in the Maritimes Region as the offshore of Nova Scotia hosts many unique species of cold water corals. One of these Coral Conservation Areas is the Northeast Channel Coral Conservation Area near Georges Bank. Surveys conducted in 2000 and 2001 revealed signs of fishing impacts on corals, prompting the designation of a conservation area (Kennedy *et al.* 2010). In June 2002, DFO established a Coral Conservation Area (424 km^2 in size) in a portion of the Northeast Channel (parts of NAFO Divisions 5ZE and 4X), with the objective of protecting high densities of intact octocorals. Approximately 90 percent of the area is closed to all bottom-fishing gear, with 10 percent open to authorized fishing activities (*e.g.,* longline gear for groundfish with an observer on board).

Species at Risk Management

Species at risk are federally protected under the *Species at Risk Act* (*SARA*), administered by Environment Canada, Parks Canada and DFO. *SARA* is intended to protect species at risk in Canada and their critical habitat (as defined by *SARA*). This Act was proclaimed in June 2003. The main provisions of the Act are scientific assessment and listing of species, species recovery, protection of critical habitat, compensation, permits and enforcement. The Act also provides for development of official recovery plans for species found to be most at risk, and management plans for species of special concern.

Only species on Schedule 1 of *SARA* are subject to the permit and enforcement provisions of the Act. The list includes species of special concern, extirpated, endangered and threatened species. Schedules 2 and 3 of *SARA* identify species that were designated at risk by COSEWIC prior to October 1999 and must be reassessed using revised criteria before they can be considered for addition to Schedule 1.

Proponents are required to demonstrate that no harm will occur to listed species, their residences or critical habitat. *SARA* has been linked to *CEAA* through requirements in both Acts. Section 79 of *SARA* requires that a Responsible Authority (RA) must notify the competent minister (of DFO or Environment Canada) in writing if a Project being assessed is likely to affect a listed wildlife species or its critical habitat. The RA must identify the adverse effects of the project on the species/critical habitat and, if the project is carried out, must ensure that measures are taken to avoid or lessen the effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and action plan. *CEAA* specifically includes within its definition of “environmental effect” any change a project may cause to a listed wildlife species (*i.e.,* listed under *SARA*), its critical habitat (*i.e.,* the habitat that is necessary for the survival or recovery of a listed species and that is identified in the recovery strategy or action plan for the species) or the residences of individuals of that species (*i.e.,* a dwelling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating).

SARA does allow for issuance of Incidental Harm Permits under specific conditions. If affecting the species is incidental to the activity being carried out, it must be shown that all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted, all feasible measures must be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals, and the activity must not jeopardize the survival or recovery of the species. It is inferred that Incidental Harm Permits are applicable to planned/intended activities and would not be required for or applicable to an unplanned and unforeseen event, such as an accidental oil spill or blowout.

The Deep Panuke Project is an example of a recent development project on the Scotian Shelf that could has *SARA* species within the study area considered for the environmental assessment (EnCana Corporation 2006). One *SARA*-listed species, the endangered Roseate Tern has “critical habitat” as defined in its species recovery strategy under the Act in the vicinity of EnCana’s subsea pipeline to shore. The implications of this designation resulted in EnCana observing buffer zones around the designated critical habitat and implementing a monitoring program during pipelaying activities in the vicinity of the Roseate Tern critical habitat and foraging areas.

As discussed in Section 2.2, there are several *SARA* listed species that occur in the Georges Bank study area, although no critical habitat has been designated for these species within the moratorium boundaries.

3.2.3 National and International Experience

3.2.3.1 International Standards and Protocols

International standards and regulations for seismic surveys, drilling mud discharges, and produced water discharge are summarized below for key countries. These standards not only demonstrate acceptability and tolerance for oil and gas activities around the world, but also demonstrate the extent of industry capabilities where regulations may be more stringent than in Canadian jurisdiction (*e.g.,* zero harmful discharge).

Seismic Exploration

In many respects, international standards for seismic exploration are quite consistent. Table 3.2 (adapted from Tsoflias and Gill 2008) lists the regulation, including consideration of species of concern, and ramp up and shut down procedures for seven countries. In addition to the information in the table, the following procedures are required for all seven countries:

- qualified observers, or in the case of New Zealand a marine mammal coordinator;
- a pre-survey observation period;
- a soft-start ramp up procedure;
- a shut-down procedure when a species of concern enters the shutdown zone;
- except for New Zealand, nighttime or low-visibility procedures; and
- passive acoustic monitoring, although only required in the United Kingdom in sensitive areas, is encouraged in all jurisdictions, except for Ireland.

Table 3.2 Summary of Mitigation Measures for Seismic Operations in Key Countries (Modified from from Tsoflias and Gill 2008)

Country	Regulation	Species Protected by the Regulations	Ramp up Restrictions	Shut down Requirements
Australia	• EPBC Act Policy Statement 2.1- Interaction between offshore seismic exploration and whales (2007)	• Whales excluding smaller dolphins and porpoises	• 30 min. pre-survey observation period • Initiate soft-start with lowest energy-output/volume airgun • Gradually add airguns over 30 min • Continuous visual observations required	• 500 m shutdown zone
Brazil	• Guide for monitoring marine biota during seismic data acquisition activities (2005)	• Marine mammals and sea turtles	• 30 min. pre-survey observation period • Initiate soft-start with lowest energy-output/volume airgun • Gradually add airguns over 20-40 min	• 500 m shutdown zone
Canada	• Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (2007)	• Marine mammals and sea turtles	• 30 min. pre-survey observation period • Initiate soft-start with lowest energy-output/volume airgun • Gradually add airguns over 20-40 min	• 500 m shutdown zone
Ireland	• Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters (2007)	• All cetaceans	• 30 min. (depth<200 m) and 60 min. (depth>200 m) pre-survey observation period • Initiate soft-start with smallest airgun • Gradually add airguns over 20-40 min	• 1,000 m shutdown zone
New Zealand	• Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (2006)	• Marine mammals	• 30 min. pre-survey observation period • Initiate soft-start with single airgun • Gradually add airguns over 20-45 min	• Shutdown zone varies from 200-1,500 m

Table 3.2 Summary of Mitigation Measures for Seismic Operations in Key Countries (Modified from from Tsoflias and Gill 2008)

Country	Regulation	Species Protected by the Regulations	Ramp up Restrictions	Shut down Requirements
New Zealand (Cont'd)			• Continuous visual observations required	
United Kingdom	• Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys (2004)	• Seals, whales, dolphins, porpoises	• 30 min. pre-survey observation period • Initiate soft-start with smallest airgun • Gradually add airguns over 20-40 min	• 500 m shutdown zone
United States-Gulf of Mexico (GOM)	• Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program (2007)	• Marine Mammals and Sea Turtles	• 30 min. pre-survey observation period • Initiate soft-start with lowest energy-output/volume airgun • Gradually add airguns over 20-40 min • Continuous visual observations required	• 500 m shutdown zone

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
Australia	• Discharge allowed subject to 1% oil limit, including free oil & diesel oil, and 17% KCI content of muds for exploratory drilling. Sampling required predischarge. • Other drilling wastes can be discharged as long as they meet the 1% oil limit. • Risk assessments required by regulator. • Operators describe the types of muds to be used and may make commitments for additional testing or monitoring in Environment Plans which are submitted to the government and once accepted become binding requirements. • Flow rate monitored but not reported or limited. • Some dischargers monitor Hg/Cd.	• 1% oil limit effectively eliminates discharge. In W A, operators were allowed approx. 15% oil limit for low tox OBM cuttings 2-3 years ago. This exception would most likely not be allowed now. • Restriction on fluids with aromatics >1%. • At present, in Western Australia (WA) over 80% of all wells are drilled using WBF in all hole sections. The remaining wells are drilled using WBF for the top hole sections and non-WBF in the 311 mm (12 1/4 inch) and/or 216 mm (8 1/2 inch) bottom hole sections. The use of low toxicity OBF in the bottom hole sections has reduced from 10% of all wells drilled in 1994 to 0% (as of mid-1998). The use of SBF has remained essentially the same over the same period with increasing proportion of EBFs. Since the late 1980s there has been a trend towards the increased use of more technically advanced WBFs.	• No specific regulatory language concerning SBM. • WA regulator sets a 10% dry weight limit on SBM cuttings discharges under environmental plan regulations. • Operators have discharged esters and IO cuttings with requirements for monitoring programs determined on case by case basis. • Esters seem to be acceptable but more general acceptability of SBM not resolved. • Environmental regulations for offshore E&P being overhauled and may become more detailed and specific. • Enhanced-mineral-oil-based cuttings have been used in the past in WA and discharged. • Where the use of SBF is accepted, discharges to the • seabed are limited to a maximum amount of 10% by dry weight of base fluid on drilled cuttings for a 311 mm (12 1/4 inch) hole size	• Monitoring not required but may be in the future. • Operators may make commitments for monitoring in environment Plans which are submitted to the government and once accepted become binding requirements.

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
Brazil	• No specific regulatory language concerning WBF. • Current practice is to allow discharge.	• All drilling discharge plans need to be approved through IBAMA,; IBAMA has made it clear that there will be greater scrutiny of NAF discharges (than those of WBFs) • OBM not permitted for discharge. • Unlikely that low tox mineral oils would be approved- Enhanced Mineral Oil-based fluids possible. • Petrobras presently discharging a highly refined paraffin mud.	• SBM cuttings have been discharged by Petrobras. • Industry workgroup formulated guidelines for discharge approval (laboratory testing protocols-biodegradability, sediment toxicity, and bioaccumulation) and worked with government to develop a framework for gaining approval for use of synthetics. • Zero discharge in <60m water depth and environmentally sensitive areas; Monitoring requirements that vary by depth; >1000 m: no monitoring required; 60 - 1000 m: comprehensive water column and seabed monitoring; NADF (SBM) cuttings permitted for discharge in water depths >60 m subject to pre and post drill toxicity tests on organisms from four different phyla and lab tests of NABF for biodegradation (OECD 306 method), total PAH concentration, and bioaccumulation potential (log Pow).; average <9.4%ROC for ester, average <6.9%ROC for paraffin/olefin, Hg/Cd in barite <1/3 mg/kg; <1% formation oil (by RPE).	

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
Canada	• The 2002 Offshore Waste Treatment Guidelines allow the discharge of water-based muds without restrictions but encourage operators to reduce the need for bulk disposal of drilling fluids. • Discharge of drill cuttings associated with WBMs are also permitted.	• 2002 Offshore Waste Treatment Guidelines require approval by the Chief Conservation Officer for the use of OBMs, when it is not technically feasible to use WBMs or SBMs. • This only occurs under exceptional circumstances and at no time can whole OBMs be discharged to sea. • The Chief Conservation Officer may grant approval for the use of enhanced mineral oil-based muds (EMOBM) provided it's environmental and safety performance can be demonstrated to be equivalent or better than SBM. • Whole EMOBM are not permitted to be discharged at sea, instead they must be recovered and recycled, re-injected, or transferred to shore to be treated and disposed of using an approved method. • Drill cuttings associated with OBM are not permitted to be disposed of at sea, however drill cuttings associated with EMOBM	• 2002 Offshore Waste Treatment Guidelines require SBMs to have a PAH concentration of < 10 mg/kg and be able to biodegrade under aerobic conditions. • Whole SBM are not permitted to be discharged at sea, instead they must be recovered and recycled, re-injected, or transferred to shore to be treated and disposed of using an approved method and must have a PAH content of < 10 mg/kg. • Drill cuttings associated with SBMs are to be re-injected and where this option may not be technically feasible the cuttings may be discharged at sea provided they have been treated first with the best available technology (BAT) first to achieve a oil on cuttings retention limit of 6.9% wet weight.	• Environmental Effects and Compliance Monitoring are required for production drilling per the Offshore Waste Treatment Guidelines.

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
Canada (Cont'd)		are permitted to be disposed of at sea provided they have been treated with best available technology to achieve an oil on cuttings retention limit of 6.9 % wet weight.		
North Sea	• Discharge of WBM is permitted given that the oil content is less than 1% by weight and that it has passed toxicity testing under OSPAR 2000/3. • Persistency (P): Half-life (T½) of 50 days and • Liability to Bioaccumulate (B): log Kow>=4 or BCF>=500 and • Toxicity (T) Taq: acute L(E)C50=<1 mg/l, long-term NOEC=<0.1 mg/l	• The discharge of OBM on cuttings is limited to 1% by weight.	• The discharge of SBM on cuttings exceeding 1% SOC is only permitted under exceptional circumstances.	
Norway	• Discharge allowed subject to pre-approval requirements for all drilling fluid chemicals. • Monitoring of discharge sites may be required. Preapproval requirements include toxicity testing according to OSPAR protocols. • No KCl limits. • Flow rate not monitored or limited, but calculation is made of cuttings discharged based on well dimensions and wash out factor. • Sampling is daily.	• Under OSPAR 2000/3, discharge is subject to limit of 1% oil on cuttings with is not operationally attainable with current technology.	• Permitting discharge of a range of synthetics for development drilling only. • SBM discharge allowed only where technical/safety considerations preclude use of WBM. • SBM content of cuttings limited to 8-18%; operator is required to set limit based on properties of formation. • Chemical monitoring of cuttings required annually, biological monitoring required every 3 years.	• A baseline survey is required prior to initiation of production drilling activities. • Monitoring activities are thereafter required to be performed every 3 years. Surveys involve sampling of sediment and analysis for biological and chemical properties. • Guidelines for monitoring are provided in the 1999 SFT document "Environmental monitoring

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
Norway (Cont'd)	• Discharge of other drilling wastes not prohibited as long as pre-approval occurs. • A discharge permit is required for cementing and completion chemicals. • Drilling must makeup is monitored and reported.		• Applications for approval require testing according to OSPAR format. • OSPAR decision 2000/3 permits Group III cuttings discharge only under exceptional circumstances (for Norway, likely to mean only at those sites where SBFs have been previously discharged.	of petroleum activities on the Norwegian shelf; guidelines" (in Norwegian) • Guidelines for characterizing drill cuttings piles have been prepared by the Norwegian oil industry association (OLF)
United Kingdom	• Discharge allowed subject to pre-approval requirements for drilling fluid chemicals. Pre-approval requirements include toxicity testing according to OSPAR protocol.	• Limit of 1% oil on cuttings- effectively prohibits discharge • Practice is to inject cuttings or return to shore and recover oil.	• Phasing out use of all but ester based synthetics. Industry expects further restrictions on esters. Discharge of non-ester fluids will likely ceased at end of 2000. • Although OSPAR 200/3 decision permits Group III cuttings discharge only under exceptional circumstances. • The UK government has made it clear that there will be no exceptional circumstances arising that would lead to discharge of SBM cuttings.	• OSPAR requirements • Requirements for seabed monitoring following discharge of SBM cuttings; data used in conjunction with laboratory data to determine fluid acceptability.
United States	• **Coastal Waters:** (*e.g.* inland canals and enclosed bays). Discharge prohibited except for Alaska. Alaskan coastal waters subject to same regulations as offshore waters. • **Offshore Water (California):** • Discharge allowed beyond coastal waters (3 mi).	• **California:** Discharge of enhanced-mineral-oil-based mud/cuttings prohibited. Practice is to inject OBM cuttings. • **GOM:** Discharge not allowed. OBM cuttings are typically landfilled. Exxon typically rents OBM pay for	• **GOM:** Only SBM associated with cuttings may be discharged. Subject to the essentially the same restrictions as WBM. Currently, spills of SBM are treated as oil spills. Additional restriction of no discharges within 544 m of Areas of Biological Concern	**GOM:** Compliance monitoring as detailed. No requirements for routine scabbed monitoring.

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
United States (Cont'd)	• 50lb/bbl in EPA generic mud #1. • Flow rate is monitored and maximum annual discharge cannot exceed 215,000 bbl. • 96hr LC50 SPP >3%. Weekly sampling; at least 1 tox. Test of each mud system. Mud sample must be at 80% or greater of final depth for each mud system. • Hg/Cd <1/2 ppm. • No free oil/diesel/waste oil as by static sheen test. • No chrome lignosulfonate. • Spotting fluids must meet toxicity requirements. • Drilling mud makeup monitored and reported. • Special restrictions for environmentally sensitive areas. • **Offshore Water (GOM):** • Discharge allowed >3 miles, not allowed <3 miles. • Flow rate is estimated hourly during discharge. • Toxicity testing monthly. By Exxon choice, testing every time mud system changed. Static sheen testing is performed weekly. • Toxicity: 96 hour LC50 of suspended particulate phase >30,000 ppm. • Toxicity limit effectively limits	the volume that is not returned. Cuttings are treated to carrying degrees onshore and either injected or landfilled.	(Central and Western GOM) and within 1000 m of Areas of Biological Concern (Eastern GOM). • **California:** Not specifically mentioned in current permit. Under discussion for regional permit. • EPA is developing specific guidelines for SBM cuttings discharge.	

Table 3.3 Summary of Requirements for Discharge of Drilling Mud and Cuttings in Key Countries (Modified from Stantec 2009a)

Country	Water-Based Drilling Fluids and Cuttings	Oil-Based Drilling Fluid Cuttings	Synthetic-Based Drilling Fluid Cuttings	Environmental Monitoring Requirements
United States (Cont'd)	KCl content. • 1/3 ppm Hg/Cd in barite; tested in stock barite. • No free oil as measured by static sheen test. • Spotting pills may not be discharged. • Must keep a chemical inventory and track mass/volume of all mud constituents. • No other components regulated. • Flow rate is limited in environmentally sensitive areas			

Table 3.4 Summary of Produced Water Regulations/Guidelines in Key Countries

Country	Oil in Water Limit
Australia	The concentration of petroleum (dispersed) in any produced water discharged to the sea is not to exceed 50 mg/L at any one time and average less than 30 mg/L during each period of 24 hours.
Brazil	Oil in water content recommend to be a maximum of 20 mg/L.
Canada	The Offshore Waste Treatment Guidelines for Atlantic Canada (NEB 2002) recommend that oil concentrations in produced water not exceed a monthly average of 30 mg/L and a daily average of 60 mg/L.
North Sea[1]	The Oslo–Paris Commission (OSPAR 2001) set recommended waste treatment guidelines for produced water discharges of hydrocarbons in the OSPAR signatory states at a monthly average of 30 mg/L, effective beginning in 2006 (no exceptions threshold noted).
Norway[1]	The Oslo–Paris Commission (OSPAR 2001) set recommended waste treatment guidelines for produced water discharges of hydrocarbons in the OSPAR signatory states at a monthly average of 30 mg/L, effective beginning in 2006 (no exceptions threshold noted).
United Kingdom[1]	The Oslo–Paris Commission (OSPAR 2001) set recommended waste treatment guidelines for produced water discharges of hydrocarbons in the OSPAR signatory states at a monthly average of 30 mg/L, effective beginning in 2006 (no exceptions threshold noted).
United States	The offshore sub-category effluent guidelines limit oil and grease in produced water discharges to an average of 29mg/Land a maximum of 42mg/L, based on best available technology.

[1] The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) governs the discharge of offshore discharges wastes in the waters of the OSPAR signatory states: Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland. This was first set to 40 mg/L oil in water content for produced water discharges, however as of 2006, it was lowered to 30 mg/L.

3.2.3.2 Offshore Oil and Gas Moratoria

Various jurisdictions have instituted moratoria on oil and gas activities in an attempt to preserve sensitive environments and/or valuable offshore resources. A brief discussion follows on the United States and Province of British Columbia offshore oil and gas moratoria as both processes offer interesting perspectives that may have implications (in the case of the United States moratorium decision) and/or lessons learned for the Georges Bank moratorium.

United States Offshore Oil and Gas Moratorium

As indicated in Section 1.2 of this report, the United States had enacted a moratorium on oil and gas exploration on the portion of Georges Bank under their jurisdiction, until 2012. Unlike the process in Canada, this moratorium was established and extended by various executive orders, without public participation. Beginning in 1982, the United States Congress restricted more and more offshore areas through annual appropriations. At no time, was a law passed to permanently put these areas out of reach from exploration; these appropriations had to be renewed annually. In 2008, President Bush lifted an executive order restricting offshore drilling and the US Congress allowed a 27-year-old ban on most offshore oil and gas drilling to expire, thereby opening up the US outer continental shelf for petroleum exploration. Since then, bills have been introduced in the House of Representatives and Senate that would serve to protect Georges Bank from exploration activities, but have yet been passed to become law. For example, a provision to protect Georges Bank from “exploration, development or production of oil or natural gas in…the fishing grounds known as Georges Bank in the waters of the United States" was included in an energy bill passed by the House of Representatives in 2008. This bill (H.R.6899) never became law.

In March 2010, President Obama released a five-year drilling plan for the Outer Continental Shelf (OCS) that excluded any new oil and gas leasing activities in the north Atlantic, effectively reinstating the presidential ban on drilling on Georges Bank for the time being. However, seismic exploration is not currently prohibited in the US moratorium area.

British Columbia Offshore Oil and Gas Moratoria

Perhaps less relevant geographically, but pertinent nonetheless, are the federal and provincial moratoria on oil and gas activities offshore British Columbia which have been undergoing review for several years. In 1972, a policy decision by the federal government "to not approve any new exploration permits or programs in the west coast offshore and to suspend all work obligations under existing permits" essentially became a federal moratorium. In 1989, the Province of British Columbia made a policy announcement that there would be no offshore drilling for at least five years.

In 2001, the Province of British Columbia began a review of the provincial moratorium on offshore petroleum activity, commissioning various reports considering the engineering, science and socio-economic aspects of offshore oil and gas activity. An independent scientific panel concluded: "there is no inherent or fundamental inadequacy of the science or technology, properly applied in an appropriate regulatory framework, to justify a blanket moratorium on offshore oil and gas activities" (Strong, Gallagher and Muggeridge 2002). However, several recommendations were put forward to carry out additional scientific and technical research.

The Government of Canada initiated a review of its moratorium in 2003, acknowledging the process would involve a scientific review, public review and First Nations engagement process. Similarly to the provincial scientific review, the federal scientific panel identified a number of science gaps and made various recommendations, but concluded that "provided an adequate regulatory regime is in place, there are no science gaps that need to be filled before lifting the moratoria on oil and gas development" (Royal Society of Canada 2004). The public review panel reported on strongly polarized views that were demonstrated at various public meetings, suggesting that these views did not provide a basis for a public policy compromise to lifting or keeping the moratorium. The First Nations engagement process found that all participating First Nations interests felt that lifting the moratorium would not be in their best interests (Province of British Columbia 2007). As of January 2010, the federal government is still in the process of reviewing its moratorium.

In addition to the provincial and federal governments, the First Nations groups are also directly involved in determining if the moratorium should be lifted due to unresolved land claims in the Province. The Province of British Columbia continues to reaffirm its commitment to offshore exploration in its 2007 BC Energy Plan while waiting for the federal government to lifts its moratorium (Province of British Columbia 2007).

4.0 Review of Key Panel Decision Factors

This section of the report revisits key decision factors in the 1999 Georges Bank Review Panel Report, and discusses advancements in scientific knowledge and progress in mitigation relative to these key issues and decisions. Residual issues (*i.e.,* remaining data gaps) and recommendations for further work are also discussed.

Key environmental aspects of petroleum activity considered by the 1999 Georges Bank Review Panel included physical (lethal and sublethal) and behavioural effects of seismic noise on fish, fish larvae, and mammals, effects of mud and cuttings discharges, and accidental discharges (spills and blowouts). Each of these is discussed below in Section 4.1. In addition, recent developments in air emissions and produced water discharges are also discussed below, although these issues were given less attention in the 1999 Review as they pertain mainly to development activities; whereas the focus of the review was mainly on exploration. Socio-economic aspects from the Panel Report are discussed in Section 4.2 and focus on effects on commercial fisheries, including loss of access and effects on marketability (*e.g.,* tainting). Safety and assistance at sea as a result of potential petroleum activity is also discussed.

4.1 SEISMIC EXPLORATION

Seismic surveys are conducted in the preliminary phases of exploring for hydrocarbons in the marine environment. Pressure waves are generated from airguns mounted on a vessel equipped for seismic exploration. Airguns fire at regular intervals, typically each 25 m, as the vessel follows the survey course, and creates sound pressure levels with peak values of over 230 dB re 1 μPa in the immediate vicinity of the airguns. This peak noise level drops off with increasing distance from the source. For context, this sound pressure is approximately 100 times greater than the sound pressure emitted by container ships. The pressure waves bounce off the layers of rock which make up the ocean floor. The returning wave signatures are received by hydrophones attached to streamers which drag behind the seismic vessel and can be 3-8 km in length. These wave signatures are then analyzed and interpreted to determine whether hydrocarbons are likely present.

Seismic exploration is an issue in the marine environment as the pressure waves have the potential to, in the worse case, be lethal to fish larvae, and can injure fish with swim bladders. Seismic noise also has the potential to disrupt behavioural patterns of fish and marine mammals by startling them, changing their feeding, migration and spawning behaviours. A report by the Royal Society of Canada (Addison *et al.* 2004) indicated that for a single gun with a source magnitude of 232 dB, a signal level of 230 dB would be received at 1.5 m. Organisms closer than 1.5 m to an airgun would likely be killed. Those closer than 4 m would suffer immediate significant internal injury, which might ultimately kill biota or, possibly prevent reproduction. Presence within 100 m might cause transient stunning of fish or marine mammals.

This section reiterates the Panel comments with respect to seismic effects, reviews the advancements in scientific knowledge of seismic effects on invertebrates, fish and marine mammals, describes the progress in impact mitigation and discusses residual issues. Seismic activities can result in behavioural and physiologicaleffects on invertebrates, fish and marine mammals.

4.1.1 Panel Comments

With respect to effects of seismic surveying on fish and fish larvae, the Panel highlighted the following areas of agreement:

- the lethal zone for fish eggs and larvae is within about 6 m of airguns is and it is also an area where fish swim bladders are damaged;
- significant effects have not been observed beyond this zone; and
- there is an insufficient number of studies to provide confidence limits and statistical power.

The Panel heard divergent perspectives regarding the effect of seismic surveying on fish and fish larvae. Some participants stated that seismic surveying should proceed because the risks are acceptable and others indicated that caution should be exercised because the risks are too high. The Panel recommended that there is a need to reduce uncertainty of effects of seismic surveying on species of larvae on Georges Bank. Participants did not present specific information or studies with respect to potential effects of seismic surveys on fish spawning behaviour and on the behaviour of adult lobsters, scallops and pelagic fish. Again, the Panel heard divergent perspectives regarding the potential effects of seismic surveys on fish behaviour—that an acceptable level of risk exists in terms of affecting fish behaviour and that the risk is too high. The Panel concluded that there is some credible evidence, which may be applicable to Georges Bank, of a “significant adverse effect of seismic on fish behaviour” (NRCan and NSPD 1999).

The 1999 Review Panel commented on potential effects to marine mammals (relating to underwater seismic noise) and expressed uncertainty; both in terms of the mechanisms (pathways) of effect and overall risk to this group and key species at Georges Bank (*e.g.,* endangered north Atlantic right whale). Assertions of potential effects to marine mammals (auditory damage, long range detection, short and long-term avoidance) were generally described as unlikely, short-term, minor, and local; but were discussed with the caveats that evidence for (or studies on) most of these potential effects on species inhabiting Georges Bank was lacking. The Panel did not review, discuss, or recommend mitigation measures to reduce or eliminate the potential effects of seismic activity on marine mammals.

Other uncertainties included in the 1999 Panel Report include potential attraction of marine mammals by underwater sound, uncertainty in results (which were noted as often contradictory) of short-term studies that have been conducted, and abilities to know if impacts actually occur (given challenges to effectively monitor such species at sea in variable weather/wave conditions).

The Panel identified that many available studies pertaining to potential effects of underwater noise on marine mammals comes from species occurring elsewhere and that several species at Georges Bank are listed as endangered by the US (In Canada, only the northern right whale was considered endangered by COSEWIC).

4.1.2 Advancement in Scientific Knowledge

Advancements in scientific knowledge, organized around the key Panel comments, are discussed below. Additional advancements, beyond the areas of concern expressed by the Panel, are also discussed.

Effects on Invertebrates and Fish Larvae

Since 1999, there has been considerable work pertaining to effects of seismic noise on invertebrates and fish larvae, including a substantial body of research conducted by DFO.

In March 2003, DFO organized a workshop to develop a "Decision Framework for Seismic Survey Referrals" which produced an inventory of ecological factors that should be considered when dealing with referrals for seismic surveys in Canadian waters (DFO 2004). Conclusions regarding invertebrates echoed the Panel comments and are summarized as follows:

- Information is lacking to evaluate the likelihood of sub-lethal or physiological effects on crustaceans during pre-molt, molting and post-molt periods.
- The ecological significance of seismic effects is expected to be low, except if effects of exposure to seismic sounds were to influence reproductive or growth activities.
- The potential for seismic sound to disrupt communication, orientation, and detection of predator/prey, locomotion and other functional uses of sound has not been studied.

To begin to address these uncertainties, a preliminary study to determine the effects of seismic energy on the health of the resident snow crab population was funded by the Environmental Studies Research Funds (ESRF). This study reported that there were no apparent effects on adult crab behaviour, health or catch rates but there was a significant effect on egg development from a female exposed to seismic signals at a very close range (2 m) (Christian *et al.* 2003).

In late 2003 and early 2004, studies were conducted on short notice by DFO to coincide with an operations seismic survey taking place off the western coast of Cape Breton. A two-dimensional (2D)seismic survey was being conducted in December 2003 by Geophysical Service Incorporated (GSI) for Corridor Resources Inc. 20 km off western Cape Breton. Monitoring for possible effects of the seismic program was conducted in consideration of an abundant and lucrative snow crab population found in this area, which is also part of the larger spawning and nursery area provided by the southern Gulf of St. Lawrence.

The study was a partnership of private and public sectors and included a cage study and laboratory experiments on potential effects of seismic energy on the reproductive biology of female snow crabs. Female snow crabs were caged, for short (12 days) and medium (5 months) duration, at the seismic survey site and at a control site located 41 km away. Exposed snow crabs were then brought to the laboratory to assess differences in their behaviour, morphology and physiology. Crabs were also held in captivity in the lab over a six-month period to measure mortality, condition and behaviour. Initial results of this study showed:

- no acute or mid-term mortality of the crab exposed to seismic activity;
- no evidence of changes to feeding in the laboratory;
- survival of embryos being carried by female crabs and locomotion of the resulting larvae after hatch, were unaffected by the seismic survey;
- in the short-term, gills, antennules and statocysts were soiled in the test group but were found to be completely cleaned of sediment when sampled five months later; and
- significant differences existed between the experimental and control groups (which subsequently led to further studies).

Because the working papers presented at the meeting did not produce any new scientific knowledge and also because further statistical analyses were required to draw definite conclusions on the histopathological evaluation, the outcome of the meeting was presented as an ESRF report and a proceedings document (Boudreau *et al.* 2009). Lee and Wright (2009) conducted a statistical analysis of the data from the proceedings and concluded that no significant correlations could be made with seismic exposure and observed histopathologies in the crab hepatopancreas and gonad tissues. They observed a high degree of correlation between the degree of pathological abnormalities and caging time. Therefore, it was concluded that chronic damage/recovery was difficult to assess due to the confounding effects of crowded caging and limited food supply.

In addition to the DFO work described above, a recent laboratory experiment was conducted to determine the potential effect of seismic noise on monkfish (*Lophius americanus*) eggs and larvae (Payne *et al.* 2009). Seven trials were carried out with sound pressure levels at 205 dB peak to peak and no significant differences were observed between control and exposed larvae examined 48-72 hours post exposure. The authors concluded that, given the results obtained on larval and egg exposures in this study, modeled estimates of pressure levels at the water surface, and literature on levels reported to effect mortality in eggs and larvae, it is unlikely that seismic surveys pose any real risk to either monkfish eggs or near hatch larvae that may float in veils on the sea surface during monkfish spawning.

There have been several other advancements in scientific knowledge with respect to the marine environment in the areas of:

- effect of seismic noise on the mortality rate of adult scallops;
- lethal and sub-lethal effects of seismic noise on American lobster; and
- damage to fish hearing or ear structures (several species of finfish) due to exposure to seismic noise.

ESSO Australia commissioned a study in 2001 to investigate the impacts of seismic testing on adult scallops by comparing the mortality and adductor muscle strength of scallops deployed in an area subject to seismic testing with those in a control area. The study found that the mortality rate and adductor muscle strength of scallops suspended 19 m below the surface in the path of the airgun array was not significantly different from those of scallops placed on a control plot (Esso Norge AS 2001).

A field- and laboratory-based pilot study examined the effect of seismic noise on American lobsters (*Homarus americanus*) (Payne *et al.* 2007). The study was designed to explore changes in biological endpoints and identify those that might require more detailed study. The following endpoints were assessed in lobsters exposed to seismic noise ranging from 202 to 227 dB peak-to-peak:

- survival;
- food consumption;
- turnover rate (as a measure of equilibrium); and
- serum protein, enzymes and calcium.

Seismic noise had no effect on delayed mortality or damage to mechano-sensory systems. There was no evidence of loss of appendages. Sublethal effects were observed with respect to feeding and serum biochemistry with effects sometimes being observed weeks to months after exposure. Comprehensive studies are needed to confirm the results. The authors also recommended studies on moulting and effects on egg development and animal behaviour.

Popper *et al.* (2005) investigated the effects of seismic noise on the hearing of three fish species in the Mackenzie River Delta, northern pike (*Esox lucius*), broad whitefish (*Coregonus nasus*) and lake chub (*Couesius plumbeus*). Fish were caged and exposed to 5 or 20 airgun shots. Threshold shifts were found in exposed fish compared to the control fish for northern pike and lake chub, with recovery within 24 hours of exposure, while there was no threshold shift in the broad whitefish. The authors concluded that the three species are not likely to be substantially impacted by exposure to an airgun array used in a river seismic survey.

An environmental effects monitoring (EEM) program was conducted during a seismic survey conducted by Hunt Oil Company of Canada, Inc. in Sydney Bight in November of 2005 (CEF 2005). This report specifically addressed the potential sublethal damage to the sensitive ear structures of fish, in this case Atlantic cod (*Gadus morhua*) and aimed to identify the distance at which such effects could occur. Suspended and bottom moored fish cages with juvenile cod were used to monitor the effects of the seismic survey vessel as it passed as close as 55 m from the nearest test cage. Five cages were used at the test site, equipped with hydrophones and video surveillance gear. A control site consisting of two cages was also part of the survey. All cages were collected as soon as possible following exposure to the seismic noise and samples were transported to the University of Maryland for dissection and further study. Video analysis noted a slight behavioural reaction when test cages were nearest to the seismic vessel and both test and control sites observed similar levels of fish mortality upon retrieval, possibly due to the stress of handling, exposure to large temperature changes, and erratic currents of the surrounding area. The most important finding of this study was that there appeared to be no detectable damage to sensitive fish ear structures or any other organs as a result of exposure to seismic airguns at ranges as close as 55 m.

Effects on Invertebrate and Fish Behaviour

Several invertebrate and fish behavioural studies were conducted to study the effects of seismic noise. Several studies have been conducted out of Australia at the time of the Panel Report. An experimental program was conducted by the Centre for Marine Science and Technology of Curtin University from March 1996 to October 1999 to study the implications of offshore seismic survey noise (McCauley *et al.* 2000). Ten fish trials (species not specified but they were finfish) were conducted with caged fish and a nearby airgun. Study results included:

- a startle response to short range start up or high level airgun signals;
- a greater startle response from smaller fishes and with an increase of received airgun level above 156–161 dB re 1 μPa rms;
- the tendency in some trials for faster swimming and formation of tight groups correlating with periods of high airgun levels;
- a general behavioural response of fish to move to bottom, centre of cage in periods of high airgun exposure (~ >156–161 dB re 1 μPa rms);
- a return to normal behavioural patterns some 14–30 minutes after airgun operations ceased;
- no significant physiological stress increases which could be attributed to airgun exposure; and
- for constrained fish, some preliminary evidence of damage to the hearing system of exposed fishes in the form of ablated and damaged hair-cells, although an exposure regime required to produce this damage was not established and it is believed such damage would require exposure to high level airgun signals at short range from the source.

Three trials were carried out with caged squid (*Sepioteuthis australis*) to gauge their response to nearby airgun operations. In the first trial several squid showed a strong startle response to a nearby airgun starting up by firing their ink sacs and/or jetting directly away from the airgun source at a received level of 174 dB re 1 µPa rms. Throughout this trial the squid showed avoidance of the airgun by keeping close to the water surface at the cage end furthest from the airgun. The airgun level never fell below 174 dB re 1 µPa rms throughout this trial. During two trials with squid and using a ramped approach (rather than a sudden nearby startup), the strong startle response was not seen but a noticeable increase in alarm responses were seen once the airgun level exceeded 156–161 dB re 1 µPa rms.

Studies have been conducted in the North Sea to determine the effects of seismic noise on fish behaviour (measured in terms of catchability). Engas *et al.* (1996) measured changes to catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) due to seismic activity in the Barents Sea by measuring catchability seven days prior to conducting a seismic program, five days during the program and five days following the program. They found that catchability decreased by about 50% once the seismic program began. The greatest effect occurred within the area of the seismic program although effects were observed up to 33 km from the area of seismic activity. Catch rates did not return to starting levels within the five days following the seismic program. Dalen *et al.* (2007) conducted a review of the effects of seismic surveys on fish catches. They found that there have been several studies conducted to investigate potential effects and all of the studies demonstrated catch reductions during a seismic survey compared with catches prior to seismic activity. Dalen *et al.* (2007) also noted that the scare effects result in catch reductions which vary among species and fishing-gear types.

More recently, a fishing and acoustic survey of the distribution of fish and plankton was undertaken in connection with the Norwegian Petroleum Directorate's seismic survey off the coasts of Vesterålen in summer 2009 to study the degree to which commercial fishes were affected by seismic noise (Løkkeborg *et al.* 2009). The results of this study demonstrated that fish reacted to the sound of airguns in that catch rates changed (increased or fell) during the seismic shooting. Fish appeared to raise their level of swimming activity, thus making the Greenland halibut, redfish and ling more liable to be taken in gillnets, while saithe likely migrated out of the area. No changes in plankton distribution or the distribution of other demersal fishes were observed. Løkkeborg *et al.* (2009) concluded that this rise in swimming activity could lead to reduced longline catch efficiency.

Gillnet catches of Greenland halibut and redfish rose during seismic shooting and remained higher after the end of the campaign than they had before the start of seismic activity. Longline catches of Greenland halibut fell during the seismic campaign, but rose again in the course of the following 25-day period.

DFO found that there have been no documented cases of fish mortality upon exposure to seismic sound under field operating conditions. However, there is potential for short term impacts on certain fish species—startle response, changes in swimming patterns (*e.g.,* speed and direction), and changes in vertical distribution (Worcester 2006).

Effects on Marine Mammals from Georges Bank

Since 1999, notable advancement in knowledge has been made regarding potential effects of underwater noise to marine mammals. For example, the subsequent year saw the adoption of underwater noise criteria relating to seismic sound by American regulators (NMFS 2000). These criteria, which are still used today, were designed purposely to provide a precautionary approach to the conduct of seismic operations and form the basis for mitigation measures (*e.g.,* shut-down zones around active arrays; described more fully in Section 4.1.3). More recently, newer science-based acoustic thresholds have been developed (Southall *et al.* 2007, an overview of which is provided below) and integrated by some recent Canadian seismic programs.

In general, much of the increase in knowledge relating to underwater sound (and hence potential effects from seismic sound) has stemmed from increased deployment of sophisticated underwater recorders, sometimes over large areas, as well as increased knowledge of the physics of underwater sound travel and predictive modeling of this phenomena. However, as related by the Panel in 1999, much of the information on the potential effects of seismic sound is specific to other species and regions, and the reader is directed to Agbrall and Moulton 2008 for a useful review of this important information (relevant material from this report to the Georges Bank region is included below). It is also important to note that considerably more is known about the hearing of toothed whales (owing primarily to the captivity and experimentation on this group) than baleen whales and this represents a consistent information gap relating to potential effects of seismic sound.

For the purposes of this report, advancements relating to the following three categories are of particular relevance to key species inhabiting Georges Bank:

1. Establishment of new marine mammal noise injury criteria and their implications on effects from seismic noise;

2. Results from studies of seismic surveys conducted at in the Gully and outer Scotian Shelf (which are relevant to Georges Bank); and

3. Influence of communication masking to northern Atlantic right whales from low frequency sound.

The following discussion provides an overview of the above three advancements (and direction to further detailed supporting studies).

In some cases, noise exposure criteria, which are commonly used to determine appropriate ‘marine mammal safety radii’ during seismic operations, developed by the National Marine Fisheries Service in 2000 (typically endorsed by DFO), relating to potential auditory damage to marine mammals from seismic sound, have been described as overly precautionary (see Agbrall and Moulton 2008). New science-based noise exposure criteria for marine mammals were published in early 2008 (Southall *et al.* 2007). These new criteria suggest thresholds for acoustic injury (and behavioural change) should be specific to the types of sound being emitted (*e.g.,* pulse or continuous) and differences in hearing abilities among marine mammal groups (*e.g.,* low frequency cetaceans, mid-frequency cetaceans, high frequency cetaceans and pinnipeds in water and air).

In addition to the separation of marine mammals according to their hearing abilities, Southall *et al.* (2007) proposed that new sound metrics, which address the cumulative sound energy received by marine mammals, be used to evaluate potential effects relating to noise. Hence the use of sound exposure levels may replace, or accompany, previous approaches (*e.g.,* root mean square metric) to describing sound impacts. At the time of writing, American (*e.g.,* National Marine Fisheries Service (NMFS)) and Canadian (DFO) regulators have not formally adopted use of these new sound criteria. Evidence from recent seismic projects elsewhere in Canada (Beaufort Sea and Pacific Coast of British Columbia) suggests that the older criteria (NMFS 2000) are still used by DFO.

The sound exposure level metric and acoustic thresholds defined by Southall *et al.* (2007) were recently applied to a 3D seismic survey in the Canadian Beaufort Sea (Kavik-AXYS 2008). Results suggest that for shallow waters (~65 m, similar depth to the flattish top of Georges Bank) sounds causing temporary hearing loss to marine mammals (*e.g.,* 198 dB_{SEL} re: 1 μPa^2-s as per Southall *et al.* 2007) would occur within less than 500 m of the array. Application of older acoustic criteria (NMFS 2000; *e.g.,* 180 dB_{rms} re 1µPa-m) indicates that for the same array temporary or permanent hearing damage may extend to 1620 m. At greater depths (750 m) little difference between acoustic injury criteria (NMFS 2000 and Southall *et al.* 2007) was found. Hence, there is some evidence (as determined through use of newer science-based acoustic criteria), in certain circumstances, that the potential for auditory damage to cetaceans from seismic sound may be less than what has been regulated since 2000. It is important to note that Southall *et al.* (2007) suggest that seals are likely more sensitive to underwater noise than previously believed and that their new criteria were not applied to potential changes in behaviour.

Our understanding of how marine mammals may be disturbed to some biologically important degree by seismic sound continues to be based on behavioural observations (primarily visual) of some species (Agbrall and Moulton 2008). Hence uncertainties described by the Panel in 1999 on this effect to Georges Bank marine mammals remain today (*e.g.,* conflicting results from short-term studies). However, a review of findings from recent seismic programs on the Scotian Shelf, which interacted with similar species and environmental conditions, is useful.

Marathon Canada Petroleum and EnCana undertook 3D seismic surveys near the Gully submarine canyon (a Marine Protected Area; approximately 500 km from Georges Bank) in the spring, summer and fall of 2003. In response to concerns regarding potential effects from underwater seismic sound to the endangered northern bottlenose whale Scotian Shelf population (for which the Gully was designated an MPA) an extensive monitoring study (including vessel-based observations and acoustic recordings) was conducted before and during the seismic operations (Lee *et al.* 2005). Much useful information was collected during these studies and the reader is directed to the previous citation for further detail. Conclusions regarding the effects of seismic operation on whales, as determined from these monitoring studies, indicate:

- Cetaceans (except dolphins) avoided relatively small areas around the arrays;
- Some dolphins swam as close as 150 m from the airguns;
- Baleen whales and sperm whales likely avoided seismic operations;
- Marine mammals were observed in larger groups during seismic operation (than when guns were quiet) and appeared to become less vocal during seismic operation; this suggests that seismic surveying can apparently have a behavioural effect at a higher level of statistical significance without visual observers seeing fewer animals;
- Seismic sounds were detectable above background levels at distances greater than 100 km from the guns;
- Changes in abundance or distribution could not be attributed to the influence of seismic operation or natural variability (seasonality); and
- Likely more survey effort would be required to better detect changes in abundance and distribution and future techniques should include use of additional technology (satellite tags) to detect more subtle changes in behaviour at the individual scale.

Hence, in many ways the findings from these recent (2005) studies reconfirm the 1999 Review Panel statements on the short-term, localized nature of marine mammal avoidance of seismic sound and that marine mammals up to 100 km away are likely to hear seismic sound. Potential evidence of reduced vocalization during seismic operations as reported by Lee *et al.* (2005) suggests that behavioural effects are likely more notable than previously understood in 1999 and as described by Agbrall and Moulton (2008).

Evidence emerging from studies specific to the effects of vessel-based underwater noise on the endangered north Atlantic right whale may hold relevance for understanding effects of seismic operations to this species. Though vessel and seismic noise are typically categorized differently (continuous and pulse respectively), and hence may evoke different responses in marine mammals, at great distances (*i.e.,* 100 km) the separation between seismic noise pulses are decreased and are nearly continuous in nature (D. Hannay pers.comm. 2010).The north Atlantic right whale is categorized as a low-frequency cetacean and hence noise from vessels and seismic arrays largely falls within their preferred hearing range. Increases in low-frequency noise from vessels have recently been shown to result in the masking of right whale communication. Researchers have demonstrated that right whales adapt to this masking by increasing the intensity of their calls (Clark *et al.* 2009). Given that seismic noise is within the hearing range of right whales communication masking may also occur during seismic operation. At closer ranges to the seismic source, communication masking may be less likely given the pulse nature of this noise and the likely ability of marine mammals to hear and vocalize during these inter-pulse intervals (Agbrall and Moulton 2008). The biological implications of this potential effect (*e.g.,* reduced communication between individuals, identification of food sources) have not been quantified and longer-term implications (for all marine mammals) are not well understood.

The potential for other behaviour-related effects such as reduced echolocation efficiency, hampered avoidance of human-induced threats (*e.g.,* fishing gear, vessel traffic), deflections in migration, reduced parental care, chronic and indirect effects are similarly not well studied or understood.

4.1.3 Progress in Mitigation

Seismic experience gained from all three marine regions in Canada, and advances in science and technology, suggests recent and future progress in the field of seismic mitigation. The following discussion provides a brief overview of these core mitigation measures and monitoring techniques, Canadian policy relating to seismic mitigation, some recent developments in mitigation across Canada and advances in science and technology.

The core mitigation measures commonly employed by industry to minimize or avoid potential effects of seismic sound to marine species include:

1. Planning to: i) ensure only the minimum amount of energy necessary for the seismic program is used; ii) identify any significant adverse effect on a marine species' population or on any individual marine mammal that is listed as threatened or endangered (*SARA*); and iii) avoid displacing threatened or endangered species from breeding, feeding, or nursing, or diverting them from a known migration route or corridor.

2. Establishment of a safety zone (typically 500 m radius) around the array that is continuously observed by a Marine Mammal Observer (MMO) for up to 30 minutes prior to activation of the array, during a mandatory array ramp-up (typically of 20 minutes duration; required after periods of inactivity exceeding 30 minutes), and throughout seismic activity;

3. Ramp-up of seismic arrays (from airguns of lower to larger capacity) after periods of inactivity;

4. Immediate shut-down of arrays if a marine mammal that is endangered, threatened, or has otherwise been identified as requiring protection, is observed within the safety zone; and

5. When seismic surveying ceases during line changes, maintenance, or any other operational reason, the array must be shut down completely or reduced to a single source element.

Commensurate with a heightened awareness in the potential effects of seismic sound to marine species in recent years a group of Canadian experts initiated the development of the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (SOCP). The SOCP is largely built from the core mitigation measures outlined above and sets out the minimum standards that must be met during the planning and conduct of all marine seismic surveys which propose to use an air source array(s) in all non-ice covered marine waters in Canada.

A thorough review on the implementation of the SOCP by seismic projects in Canada is not warranted here, however recent experiences suggest consistent application of the core measures (above) with considerable (inter and likely intra-) regional variability in planning (e.g., incorporation of advanced acoustic predictive modeling; restrictions in seismic operation relating to local marine mammal habitat), monitoring effort (number and training of MMOs and passive acoustic techniques), rationale for, and size of, the marine mammal safety zone (ranging in extent from 500 m to ~7 km). For example, for a 2009 seismic program in northeastern Pacific ocean DFO recommended a safety zone for the 160 dB isopleth distance from point source (i.e., NMFS' behavioural criteria) (P. Cottrell, pers. comm. 2010).

Operators may be required to put in place additional or enhanced environmental mitigation measures to further reduce the risk of harm to marine life beyond the mitigation included in the Statement of Canadian Practice. Hurley (2009) lists examples of such enhanced mitigation measures that have been used in the Nova Scotia offshore notably when operating near sensitive marine areas. These include:

- Acoustic modeling and monitoring to verify seismic noise zone of influence predicted in the EA report;
- Controlling vessel speed and orientating seismic lines to reduce sound energy;
- Developing contingency measures and a response plan to address significant weather scenarios and accidental events; and
- Developing a Code of Conduct for operating near sensitive marine areas that specifies the minimum safe working distances for aircraft and vessels from these special areas.

Recently (May 2009), the Canadian Science Advisory Secretariat hosted a peer review meeting to examine the operational mitigation measures set out in the SOCP. The draft proceedings from this workshop were distributed by DFO to attendees in August 2009. At the time of writing, finalized proceedings were not available from the CSAS website. Key elements identified in this review relating to mitigation effectiveness include:

- Influences affecting MMOs (number, fatigue, efficacy, training, dedicated effort, use on supply vessels, equipment use, height of observation, potential DFO MMO standards, etc,) and visual detection of marine mammals (*e.g.,* darkness, wave states, visibility, variability in species behaviour and likelihood for detection), *etc.*;

- Advantages in the use of sound propagation models to determine marine mammal safety zones (to account for variability (*e.g.,* bottom conditions, salinity, depth, species communication, m-weighting), challenges in standardizing measurements and comparisons between models, use of the Southall *et al.* (2007) sound exposure criteria as the 'best science' for initial modelling), *etc.*;

- Advancement in science of mitigation through consistent collection of monitoring data;

- Advantages and limitations of passive acoustic monitoring (airgun reverberations and call masking (by vessels and airguns), differences in vocalization types and detection, use during ramp-up, blind zones due to presence of vessels, location of hydrophones (towed or other vessels), need for further development, training of acoustic monitors, accuracy and limits in detection ranges; challenges in localizing vocalizing animals); and

- Improved planning: most effective mitigation is proper planning in advance of surveys; to reduce or avoid impacts on marine mammal life functions; need for good baseline surveys of marine mammal distribution and habitat modeling, need for good communication between all stakeholders, *etc.*

Some potential technological advances that may increase the effectiveness of seismic mitigation measures include active acoustic monitoring, automated passive acoustic monitoring, underwater and aerial unmanned monitoring drones/gliders, alternatives to airguns, and better tools to standardize MMO reporting and predictive modeling. Stantec (2010a) provides a discussion of emerging technologies to address environmental issues from seismic exploration.

With specific regard to monitoring techniques, Lee *et al.* (2005) include details regarding the use of monitoring techniques for seismic programs on or near the Scotian Shelf. The following is a generalized summary of available whale survey monitoring methods in relation to seismic programs.

- **Dedicated vessel-based monitoring** typically involves surveys by marine mammal observers (MMOs) of pre-designed transects spanning the study area. This approach is not widely used in Canada primarily due to high daily operational costs for suitable offshore vessels.
- **Vessel-based monitoring from seismic vessel** is the most typical and common form of monitoring. MMOs conduct observations of a 'marine mammal safety zone' when conditions allow (e.g., daylight, low waves, etc.) and may also collect information farther afield.

- **Acoustic monitoring** exists in two broad forms in relation to seismic programs: Passive Acoustic Monitoring (PAM) and bottom-mounted recorders (sometimes called ‘pop-ups’). PAM is presently considered in research and development, has had limited use in Canada to date, and is conducted from a support vessel or from the main seismic vessel.
- **Aerial surveys** are typically conducted by twin engine, fixed wing aircraft. Flight paths (transects) are pre-designed to allow researchers to estimate abundance and spatial density across the study area, with moderate to high statistical confidence. This monitoring approach is widely used in the Beaufort Sea.

4.1.4 Residual Issues

Many of the studies and literature reviews since the 1999 Georges Bank Review Panel Report discuss areas of continuing concern and needed research on the effects of seismic noise on fish species. These include:

- Overall lack of quantitative studies;
- Potential sublethal effects on individual fish; and
- Concern at the stock or sub-stock level.

The following studies elaborate on each of these points.

In a literature review by Moriyasu *et al.* (2004), the effects of seismic surveys using airguns were examined in 20 articles of which there were nine quantitative studies. Five of these showed immediate lethal or physical impacts, four showed no effects. The authors noted a lack of scientific documents on the possible effects of seismic noise on marine invertebrates and found that it was often concluded that invertebrates are robust to noise from explosions and airguns without support from empirical evidence. Dalen *et al.* (2007) also found that little research has been conducted in the field of seismic effects on planktonic organisms. The primary study that is cited in numerous literature reviews is the experiment on snow crabs by Christian *et al.* (2003) where egg development exhibited definite developmental differences between the control groups and the test groups for eggs exposed at a distance of 2 m from a single, small 0.7 L airgun. Both the test and control groups were examined over a 12-week period in the laboratory. Other than this, there was no indication of immediate or delayed mortality or other effects.

Payne (2004) also conducted a literature review on the potential effect of seismic surveys on fish eggs, larvae and zooplankton. He found that limited data indicate that some fish eggs and larvae may be damaged at a distance of approximately 5 m from a seismic discharge. In the absence of studies on a wider variety of species and lack of attention to long-term survival and sub-lethal effects, it is premature to suggest that 5 m is the approximate injury zone for effects on the eggs and larvae of finfish and shellfish, zooplankton, or planktonic life stages in general. The author recommends a few representative studies on keystone species such as those of commercial importance would be helpful in shedding light on whether a distance of 5 m s a reasonable approximation as the zone of injury for eggs and larvae of finfish and shellfish and other planktonic organisms.

Hurley (2009) found that a residual gap is the potential sublethal effects on individual fish in the immediate vicinity of the seismic array despite mitigation of scheduling of seismic activities to avoid sensitive periods and areas (*e.g.,* spawning, egg and larval concentrations, migrations, *etc.*) particularly for commercially-important fish species and species at risk.

Payne *et al.* (2008) concluded that the primary concern for producing effects from seismic activities is at the stock or sub-stock level such as in a shallow coastal environment like a bay. There is some evidence suggesting a potential for seismic activities to have sublethal effects at the individual level both physiological and histopathological. However, with respect to ambient ocean noise and animal behaviour, the authors were of the opinion that the level of noise associated with general marine traffic could be of greater importance.

With respect to marine mammals, at the time of writing, potential improvements relating to mitigation measures (as outlined earlier from the 2009 CSAS draft proceedings), were not in final form and it is not presently known how this information may be applied to the SOCP and related policy. Note is also made that present Canadian seismic mitigation measures (*e.g.,* SOCP) are considered as policy and their implementation is not specifically legislated. Though improvements to the core mitigation measures described above hold promise for increasing mitigation effectiveness, several aspects likely warrant further attention.

- There is no evidence that seismic surveys have resulted in temporary or permanent changes to marine mammal hearing. However this conclusion must be accompanied by the caveat that associated monitoring studies are unlikely to detect such effects. Though this may constitute a residual issue, it is believed that such effects are likely to be rare. Marine mammals are unlikely to remain in an area for any duration if received noise levels are uncomfortable (140+ dB; Richardson *et al.* 1995).

- Visual observation of safety zones during seismic operation, though effective under the appropriate conditions (daylight, calm wave states, presence of trained MMOs, *etc.*), cannot ensure full-time protection of the zone (night time, fog, *etc.*). Passive acoustic and other monitoring techniques are currently considered as ‘in development’; therefore safety zones presently cannot be effectively monitored for large portions of time. Fortunately passive acoustic monitoring holds significant promise over the next years and hence may assist greatly in addressing this residual issue. Important caveats relate to the variability, and large lack of knowledge, of calling rates and influence of seismic sound on calling rates – if marine mammals don’t vocalize they would not be detected by passive acoustic means. Note is made that the production of sound by seismic arrays is largely a mitigation measure unto itself, given that marine mammals generally tend to avoid such noises.

- Baseline data is typically of insufficient spatial and temporal resolution to confidently determine if seismic sound results in changes to natural marine mammal abundance and distribution. In its present form, ecological knowledge of marine mammal habitat on Georges Bank must also be considered as insufficient at detecting potential change in abundance and distribution resulting from future seismic programs. As explained in Section 2.2.4, further data mining of available databases, habitat modeling and possibly more field studies would resolve this residual issue for Georges Bank.

- Similar to the above point, available baseline data rarely enables resource managers and environmental assessors to identify biologically important habitat. Increased quality (spatial and temporal) of baseline data on marine mammals on Georges Bank may identify some areas, and/or times, of greater biological significance to key species. Consequently, planning of seismic surveys may incorporate such information and effectively avoid, or mitigate effects. A good example of such baseline data and effective planning comes from the Canadian Beaufort Sea where seismic operation is restricted in known bowhead feeding aggregations during periods of low visibility (to MMOs). Hence a lack of adequate ecological information for Georges Bank may constitute a residual issue.

- A further complication regarding the collection of robust baseline data on marine mammal abundance and distribution relates to biases induced by the presence of anthropogenic activities during baseline studies. To understand true baseline conditions the collection of marine mammal related data must be undertaken well in advance of seismic programs and ideally when little other human activity is taking place.

- The majority of present knowledge underpinning mitigation measures (specifically the evidence and rationale used to identify safety zones) comes from a limited number of toothed whale species and restricted visual monitoring studies based from seismic vessels. Hence potential effects to baleen species (for which hearing is less understood and whose communication frequencies are more likely to be masked by seismic sound) may represent a residual issue. Vessel-based survey results suggest that baleen whale species, similar (if not the same) to those likely found on Georges Bank do exhibit minor avoidance of active seismic arrays. Application of frequent aerial survey monitoring of seismic operation, over larger areas (adjacent to development licenses), would assist in better understanding the significance of this residual issue.

- Though toothed whale hearing is better understood than baleen whale hearing, not all toothed whale species have been studied. For example, beaked whales tend to be less understood. Evidence exists to suggest that beaked whales may be more sensitive to anthropogenic underwater sound (Schrope 2002). The *SARA* listed Sowerby's Beaked whale, for example, has been recorded in the Canadian portion of Georges Bank. Consequently, safety zones designed on the basis of knowledge gained from other species, may not be appropriate for beaked whales.

- The core seismic mitigation measures in Canada (described above) are primarily related to avoiding temporary or permanent hearing loss. Effects relating to changes in marine mammal behaviour (direct and indirect) and communication masking therefore can largely be considered a current residual issue. In the near future it is possible that advances in acoustic knowledge and increased behavioural studies of marine mammals may help to address this issue.

- A need to further understand cumulative effects from seismic sound (over years) to marine mammals; merits of including the sound exposure level as a biologically relevant metric in conjunction with previous metrics (root mean square);

- Further information is needed on whether ramp-ups are effective and if there are some circumstances when animals may not avoid sound sources;

- Other relevant mitigation-related aspects brought forward in 2009 include the need for mitigation measures that are operationally feasible and practical; a need to evaluate the effectiveness of mitigation measures themselves; potential use of seasonal closures of specific areas; use of multiple mitigation measures together; and a need to measure and manage cumulative effects of multiple noise sources.

The Exploration and Production (E&P) Sound and Marine Life Joint Industry Programme (JIP), whose membership comprises leading exploration and production companies as well as a global industry association, has recognized knowledge gaps pertaining to underwater noise and physiological and behavioural effects on marine mammals and have commissioned a broad range of studies to be carried out by independent agencies around the world (E&P Sound and Marine Life JIP 2008, http://www.soundandmarinelife.org/Site/Basics/AnnRep2.pdf). As of July 2008, projects are underway in the following research categories with committed funding as shown:

- $6.1 million in funding for sound source characterization and propagation studies;

- $2.9 million in funding for physical, physiological and hearing effects of sound;

- $2.9 million in funding for behavioural reactions and biologically significant effects; and

- $3.0 million in funding for mitigation and monitoring.

For a detailed list of specific studies and researchers, refer to the E&P Sound & Marine Life JIP Annual Report for 2007/08 (E&P Sound and Marine Life JIP 2008). Although many residual issues exist, the *Statement of Canadian Practice with respect to Mitigation of Seismic Sound in the Marine Environment*, to which all seismic operators must adhere, addresses many areas of uncertainty by improving mitigation practices. Also, ongoing research, including the JIP research described above, will also serve to improve the understanding of the potential effects of seismic exploration on the marine environment.

4.2 DRILL MUDS AND CUTTINGS

Drilling muds are fluids that are circulated in oil and gas wells to clean and condition the drill (NEB *et al.* 2002). During exploration drilling, the drill bit penetrates the rock, and drilling mud is pumped around it to cool and lubricate the drill bit, balance subsurface hydrostatic pressure, and carry drill cuttings up to the surface through the drilling pipes (Hurley 2009).

The types of drilling fluids used are well-specific. Typically, the two types of drilling fluids used in offshore drilling operations are water-based mud (WBM) and/or synthetic-based mud (SBM). WBMs are used in most offshore oil and gas wells; direct discharge into the sea of the cuttings produced with WBMs is permitted. SBM cuttings can also be discharged into the sea following treatment with best available technologies. WBM drilling muds are most likely to be used on Georges Bank, although there is potential for SBMs to be used depending on volumes to be treated, variability in geological formation, and production rate.

In recent years, SBMs have been developed to provide the oil and gas industry with an environmentally-improved alternative to non-aqueous oil-based muds (OBMs) such as diesel, mineral oils, and low-toxicity mineral oils (LTMOs) (Hurley 2009). In addition, barite and/or bentonite (weighting agent) and chemical additives (emulsifiers, biocides, lubricants, wetting agents, corrosion inhibitors, surfactants, *etc.*) are often used in drilling muds to enhance: the mud operational properties such as viscosity, which aids the removal of rock chippings; and/ the weight, which balances the pressures being encountered in the well (Hurley 2009).

SBMs are distinguished by their use of a synthetic-based fluid (SBF) instead of water or oil. SBMs are prepared synthetically, their properties are well characterized, and they are free from substantial impurities. Metal concentrations in SBMs are expected to be similar to those in WBMs. With the exception of barium, these concentrations are typically similar to the range measured in uncontaminated marine sediments (Neff *et al.* 2000). SBM based drilling fluids typically do not contain polynuclear aromatic hydrocarbons (PAHs). The base fluids in SBMs are synthesized organic compounds that do not contain the toxic components found in refined oils, such as aromatics and cyclic structures . According to Hart *et al.* (2007), the most common SBM types include esters, ethers, iso-alkanes, poly-alpha-olefins, detergent alkylate, linear alpha-olefins, isomerized olefins, and dimethyl siloxane-based oligomeric siloxanes.

SBMs provide the same essential drilling mud functions with significant improvements in environmental performance (Hurley 2009). For example, the use of WBMs generates between 1100 and 2000 m^3 of muds and cuttings, depending on the depth and diameter of the well; the use of SBMs generates between 300 and 1300 m^3 of drill waste (Veil *et al.* 1995).

Once on the drilling rig, the cuttings and muds are separated and disposal options must be considered. The discharge of drilling mud and rock cuttings into the marine environment is an issue because of the potential adverse effects on benthic organisms or seabed fauna, including growth inhibition, mortality, and smothering (*e.g.,* Gordon 1988; Gordon *et al.* 2000; Cranford and Gordon 1992; Cranford *et al.* 1999). However, research prior to the 1999 Georges Bank Review Panel Report and advancements in scientific knowledge in the past decade can provide a basis for practical decisions that minimize both real and perceived adverse effects (Hannah and Drozdowski 2005).

4.2.1 Panel Comments

The 1999 Review Panel identified that there was uncertainty as to whether the discharge of muds and cuttings from a drilling rig on or near Georges Bank would have significant, harmful effects on the marine environment. Varying (and often contradicting) perspectives from the fishing industry, the petroleum industry and scientific researchers were presented. Key issues were related to the potential sub-lethal and chronic long-term effects of drilling wastes, as well as bioaccumulation. For example, it was identified by some presenters that even if WBM and SBM were used, the potential exists for smothering of benthic organisms; however, other sources (*e.g.* scientific research by Cranford *et al.* 1998) found the effects to be localized. Data gaps were also discussed, such as the need for chronic toxicity data on the many additives in drilling muds, as well as the need to investigate the potential lethal and sub-lethal effects on marine resources other than scallops, lobster and haddock, and the overall ecosystem structure and function on Georges Bank.

The 1999 Review Panel commented that presentations from the petroleum industry were based on an assumption that used drill muds and cuttings would be discharged from the rig to the marine environment, but the possibility was raised that they could be disposed of remotely either offshore or onshore. This was not a specific regulatory requirement in 1999, nor is it now; however, in the past decade significant advancements have been made in offshore treatment and disposal, cuttings re-injection and transporting discharges to shore for disposal.

4.2.2 Advancement in Scientific Knowledge

The 1999 Review Panel's key issues with drill muds and cuttings were categorized into general concerns and biological effects (potential lethal effects, potential sublethal effects and bioaccumulation). Advances in scientific knowledge pertaining to these issues, as well as advances in transport modeling of drilling waste are the focus of this discussion.

General Concerns

This section describes the general process and issues associated with drill muds and cuttings. Biological issues (lethal, sublethal and bioaccumulation) are discussed in the following section.

The processes that drilling muds and cuttings undergo once they are discharged in marine environments include: advection; dispersion; aggregation; settling; deposition; erosion; re-suspension; and re-entrainment (Crawford *et al.* 2002). The relative effects of these processes on the fate of drilling wastes in marine environments is dependent upon the type of drilling waste and physical parameters such as water depth, currents (tidal and residual), waves and storms.

The physical characteristics of Georges Bank were discussed in Sections 2.1 and 2.2.1 above. The Bank is characterized by strong tidal currents, with current speeds and directions being further influenced by topography and bathymetry in the moratorium zone and in surrounding areas. The high energy nature of the system can prevent the accumulation of drilling muds and cuttings; accumulation of muds and cuttings can be characteristic of lower energy or shallow water systems. The risk to benthic organisms is thereby decreased when drilling muds are dispersed quickly over a larger area instead of accumulating at the point of discharge (which can smother certain benthic organisms) (Neff 2005). The ability of the strong Georges Bank bottom currents to rapidly disperse settling materials from drill sites has been confirmed by the American Georges Bank Monitoring program (Phillips *et al.* 1987; Neff *et al.* 1989). Advancements have also been made in scientific dispersion and transport modeling; modeling advancements are discussed next in the Biological Effects section.

Biological Effects

Discharge of drilling mud and cuttings can result in lethal and sublethal biological effects. These effects may include: toxic exposure (depending on drilling fluid components); smothering effects (due to accumulation of discharges on the seabed); and physical effects on tissues (*e.g.*, reduction in growth and reproduction of scallops) as a result of chronic exposure to very low concentrations (>0.05 mg/L) of bentonite and barite (Cranford 2006).

While the release of both WBM and SBM drill cuttings can cause potential effects on the environment, there are differences in the level and extent of the various effects. WBM drill cuttings are finer than SBM drill cuttings, therefore they can spread further in the water column before settling to the sea floor. This results in the potential for WBM drill cuttings to have smothering effects over larger areal extent (JWEL 2001). SBM cuttings fall to the sea floor sooner and have a low solubility in water. They can create physical piles of accumulated material and potentially concentrate any toxic effects of the drill cuttings or increase organic enrichment (JWEL 2001). Recent DFO studies show SBMs as being readily biodegradable in Atlantic marine sediments under ambient environmental conditions (Li *et al.* 2009). However, limitations associated with the biodegradable potential of SBM include elevated metals ions in recycled and reused muds can interfere with hydrocarbon degradation resulting in a need to balance the trade-off of potential risks. This need to balance risks in relation to the biodegradation of SBMs is further discussed in the upcoming Residual Effects Section.

Recent attention has been focused on the potential for effects of drilling muds and cuttings on fish and shellfish to address knowledge gaps considered important to the fishing industry, and to address general environmental concerns (ICES 2002; Hurley and Ellis 2004). However, effects from drill muds on sediment conditions and associated benthic communities are likely subject to the greatest potential effects from drilling operations (Cranford 2006).

Potential Lethal Effects

Acute effects usually result from the smothering of slow-moving or sessile benthic organisms near the point of discharge rather than toxic exposure since acute toxicity thresholds for muds and their components are much higher than concentrations expected under field conditions (Cranford and Gordon 1992). Dose-response studies on fish demonstrated that sediments contaminated with cuttings containing SBMs from the Grand Banks (Hibernia) had a very low toxicity potential (Payne *et al.* 20001a; 2001b; 2006). However, sublethal effects at concentrations as low as 1 ppm have been observed in flounder that have had chronic exposure to aromatic hydrocarbons (Payne *et al.* 1988).

Cranford *et al.* (1999) followed up on a study by Cranford and Gordon (1992) in which they found that prolonged exposure (*e.g.,* on the order of a month) to high concentrations (*e.g.,* 10 mg/L) of bentonite and barite can cause tissue weight loss, cessation of gonad development or mortality of sea scallops.

Because of expected rapid dispersion rates due to the high energy environment on Georges Bank and the likely use of low-toxicity WBM on Georges Bank (should drilling be permitted to occur), it is likely that the affected zone around drilling rigs would be limited to less than 500 m. Monitoring studies have shown that toxic effects (if any) on marine life from drill muds and cuttings discharges occur only in the immediate vicinity of the drilling rig (*i.e.,* within 500 m safety zone of the drilling platform), due primarily to the development of low-toxicity drilling fluids (Hurley and Ellis 2004). One study by Sayle *et al.* (2002) from offshore Brunei (South China Sea) found that WBM discharges were more widely dispersed than ester-based SBM sites (>1,200 m vs. 200 m). However, the report also noted that the dispersion of organic inputs from drilling muds appears to be accelerated in shallow water characterized by high wave and current energy, due to increased oxygenation of sediments (Sayle *et al.* 2002). Overall, the ecological consequence of acute interactions from drilling muds and cuttings discharges is expected to be low.

Potential Sublethal Effects

Sublethal or chronic, long-term interactions are usually associated with the benthic community since the majority of drilling mud wastes descend to the seafloor and therefore sessile benthic organisms become exposed (Cranford *et al.* 2005). Prior to the 1999 Georges Bank Review Panel Report, laboratory studies conducted at the Bedford Institute of Oceanography by DFO had linked detrimental sublethal effects in sea scallops with both barite and bentonite. Concern has been expressed in the past that we are limited in our ability to quantify and predict potential sublethal effects from drilling muds (NRCan and NSPD 1999).

In the past decade, significant advancements have been made to help address the above concern. To understand the fate and effects of particles and chemicals associated with drilling wastes discharged into the sea during drilling, a number of numerical models of different types and complexities have been developed (Cranford *et al.* 2003; Cranford 2006). One of these models is the Benthic Boundary Layer Transport (BBLT) model. The BBLT model was developed to study the dispersion and transport of suspended sediment in the benthic boundary layer of the continental shelf (Hannah *et al.* 1995).

BBLT modeling has been used to predict the zone of influence of the drilling wastes and the effect on scallop growth to chronic exposure to drilling waste discharges on the northeastern part of Georges Bank (Cranford 2006, Cranford *et al.* 2003). BBLT modeling has shown that chronic effects on scallop growth were predicted to be greatest in the vertically stratified region around the side of Georges Bank (>100 m depth), which supports relatively low numbers of scallops (dense aggregations can be found in some areas) (Cranford 2006, Cranford *et al.* 2003). As well, the potential effect of drilling mud discharges on scallop growth has been reported to be in the order of a few days of lost growth over spatial scales of a few kilometres, depending on environmental parameters (Hannah *et al.* 2006).

BBLT simulations have also been used as the basis for characterizing the drift and dispersion of drilling mud on northeast peak of Georges Bank, as well as on Sable Island Bank (North Triumph SOEP site) and on Grand Bank (Hibernia) (Hannah *et al.* 2003). These three locations have similar water depths (65-85 m) and provide a dramatic contrast in drift, dispersion, and potential concentration levels. The drift rates and diffusivities were found to be the greatest on Georges Bank (northeast peak), intermediate at North Triumph and least at Hibernia (Hannah *et al.* 2005). The differences in magnitude and seasonal cycle can be explained in terms of the regional oceanography and meteorology. The strong tidal currents and mean flows at the northeast peak of Georges Bank result in conditions where expected near-bottom concentrations from drilling discharges are the least likely to accumulate (Hannah *et al.* 2005).

In addition to Hannah and Drozdowski (2005), other studies including (Tedford *et al.* 2001; Cranford *et al.* 2003, Hannah *et al.* 2003, Tedford *et al.* 2003) have estimated the area where effects on benthic organisms could occur as a result of discharges of drill muds on Georges Bank, Sable Island Bank, and the Grand Banks. At Sable Island Bank, for example, the model results were in agreement with the very low concentrations (generally < 1 µg/L) of barium observed in the water column during a corresponding EEM program (Hannah *et al.* 2003).

While the BBLT model represents a key step in predictive modeling of environmental effects of offshore oil and gas activities (Drozdowski *et al.* 2004), there are limitations associated with any model. In the case of BBLT simulations, application of the results to Georges Bank is dependent upon the waste release site location and timing, as well as on benthic organism stock distribution.

Several different dispersion and transport models exist in addition to the BBLT model including the Offshore Operator's Committee (OOC) and MUDMAP models, both of which follow the Koh and Chang approach (1973) to predicting the transport and dilution of drilling fluid discharges, and the numerical model, SizeCUT. These transport models have undergone recent (*i.e.,* since 1999) development, application and/or validation.

Both the PROTEUS (Sabeur and Tyler 2004) and Dose-related Risk and Effect Assessment Model (DREAM) (Durell *et al.* 2006) are examples of models developed to predict the fate of chemicals associated with drilling waste discharges. These two physico-chemical models have been developed since the 1999 Panel Report. Risk assessment models are typically modules included in either physical transport models or physico-chemical models that enable the calculation of potential risks to an area (like Georges Bank) from drilling waste discharges.

In addition to modeling exercises, several laboratory studies have been conducted to further evaluate the potential chronic effects of drilling muds and cuttings. DFO acknowledged that laboratory studies on the chronic impacts of waste drilling muds on major benthic organisms are concisely summarized in Cranford *et al.* (2005). Chronic toxicity tests in which scallops were exposed to drilling muds showed that low levels (0.05 to 2 mg/L) of all major types of muds (*i.e.,* WBM, SBM and LTMO) may affect growth and reproduction (Cranford and Gordon 1992; Cranford 1995; Cranford *et al.* 1999; Armsworthy *et al.* 2005). From ecological and fisheries perspectives, growth and reproductive effects are considered to be the most important sublethal effects on adult scallops (Capuzzo 1988). The fine particulates in drilling muds (*i.e.,* bentonite and barite) were the major cause of the observed effects from WBM and SBM, as a result of their interaction with feeding and digestive processes (Armsworthy *et al.* 2005). Barlow and Kingston (2001) detected similar physical effects in other bivalve species (the suspension feeder *Cerastoderma edule* and the deposit feeder *Macoma balthica*). A Georges Bank modelling study by Cranford *et al.* (2003) found that the routine discharge of WBM may affect scallop growth over an area exceeding 200 km^2, under certain hydrographic conditions.

One issue brought up in the 1999 Panel Report was the need for more studies on the sensitivity of other organisms to the various fluids in drilling mud formulations. In 1995, Payne *et al.* studied organ and body condition, energy reserves, liver and gill histopathy, and MFO enzymes in fish to assess effects of contaminated sediment. Sediment contaminated with aliphatic hydrocarbon based drilling fluid showed little potential to affect fish health in any of the indices listed above (Payne *et al.* 1995). This study represents continued development in the assessment of potential drilling mud effects on the environment by differentiating between aliphatic hydrocarbon contaminated materials and aromatic hydrocarbon contaminated materials. Sub-lethal effects have been observed in flounder exposed to aromatic hydrocarbon containing sediments (Payne *et al.* 1995; Payne and Fancey 1989), but SBM based drilling fluids do not typically contain PAHs.

Andrews *et al.* (2004) exposed snow crabs (by mouth) to drilling fluids and examined hepatopancreatic enzymes, haematology, and heaptopancreatic histology. The only difference noted between the control and experimental group was an induction of palmityl Co-A oxidase (enzyme involved in metabolism of fatty acids) in the experimental group. Hamoutene *et al.* (2004) conducted a similar study, injecting lobster with relatively high concentrations of drilling fluid. Different aspects of lipid and protein metabolism were assessed and the only recordable effect was an increase in protein content in lobster claw muscle.

Also in 2004, Hurley and Ellis reviewed environmental effects resulting from exploratory drilling offshore in Canada. Their review represents a significant advancement since 1999 in the understanding of potential effects from exploratory drilling operations. Amongst other findings, Hurley and Ellis (2004) determined that changes in the diversity and abundance of benthic organisms were most common within 50 to 500 m of drill sites and that benthic communities typically returned to baseline conditions within one year after drilling operations ceased. They also found that results of laboratory and field studies reviewed during their assessment suggested a low potential for toxicity or health effects.

Bioaccumulation

In the 1999 Georges Bank Review Panel Report, bioaccumulation was identified as a concern and was discussed mainly in regards to heavy metals in scallops and in large pelagic species such as tuna, but it was generally concluded that the potential was low. The 1999 Panel identified that a monitoring report from the American side of Georges Bank found no heavy metal uptake in clams or flounder, and that it would not likely be a problem in such a dispersive environment. The 1999 Panel also noted that barium in the barite that is used in drilling muds would not likely bioaccumulate or biomagnify, but heavy metals associated with barium deposits could be of concern. However, the 1999 Panel then noted that selecting a high grade of barite would avoid the potential problem.

Studies from Thouzeau *et al.* (1991) and Neff (1987) indicated that the benthos on Georges Bank would be highly sensitive to bioaccumulation of trace metals and hydrocarbons discharged in the course of oil and gas drilling. Hurley's 2009 review of environmental assessment biophysical data gaps included chronic toxicity studies focused on bioaccumulation potential. Hurley (2009) concluded that the studies showed limited bioaccumulation of PAHs in flounder exposed to PAH contaminated sediments.

Using the BBLT model or other similar models, it is possible to estimate the area where effects on benthic organisms could occur as a result of discharges of drill muds on Georges Bank (refer to the previous sections on lethal and sublethal effects for studies using BBLT modeling and the potential effects of drill muds on marine organisms).

As previously discussed, the 2002 OWTG encourage operators to use WBM or SBM. The drilling muds that are likely to be considered in Georges Bank petroleum exploration activities would be mainly low-toxicity WBM because of the relatively shallow water depth of the bank, with potential use of SBM. Due to current regulations, it is extremely unlikely that OBM would be considered at all. Metal concentrations in SBMs are expected to be similar to those in WBMs. With the exception of barium, these concentrations are typically similar to the range measured in uncontaminated marine sediments (Neff *et al.* 2000). SBM base fluids typically do not contain PAHs. The base fluids in SBMs are synthesized organic compounds that do not contain the toxic components found in refined oils, such as aromatics and cyclic structures (Stantec 2009).

SBMs are not expected to bioaccumulate significantly in marine organisms because of their extremely low water solubility and consequently low bioavailability which reduces the likelihood that exposures will be long enough that a significant bioaccumulative hazard will result (OGP 2003). Cuttings discharged with SBMs have resulted in smaller zones of impact on the seafloor, and a more rapid recovery of the biological community (OGP 2003). Laboratory and modeling studies (*e.g.,* those discussed above) support this argument, as do EEM field studies conducted in eastern Canada (discussed in the next section). Overall, toxic effects (if any) on marine life from drill muds and cuttings discharges have been shown to occur only in the immediate vicinity of the drilling rig (*i.e.,* within 500 m safety zone of the drilling platform), due primarily to the development of low-toxicity drilling fluids (Hurley and Ellis 2004).

Environmental Effects Monitoring (EEM)

A key advancement in the past decade is the extensive and valuable information that has been gathered through EEM programs. EEM for offshore petroleum activities in Nova Scotia involves scientific monitoring of the effects of petroleum activities on specific components of the surrounding environment (CNSOPB 2009). EEM programs are conducted throughout each year, and the program design changes yearly. EEM is required for all development projects, and occasionally for certain exploration activities (CNSOPB 2009).

EEM programs, which are designed to collect data on the known relationship between activities and the receiving environment, arise as a follow-up and monitoring requirement under the *Canadian Environmental Assessment Act* (*CEAA*) to validate environmental assessment (EA) predictions. In Nova Scotia, the CNSOPB is a federal authority under the *CEAA*, and requires all offshore oil and gas activities to undertake an EA. EAs assess the environmental effects of proposed activities. Although all offshore oil and gas activities in Canada are required to undertake an EA, only production projects but still most developments in recent years have committed to EEM programs. It is also important to note that both industry and DFO have used the BBLT model for the preparation and review of EAs and EEMs.

An EEM process framework was developed jointly in 2005 between the CNSOPB, the Canadian Environmental Assessment Agency, DFO and Environment Canada. The purpose of the framework is to strengthen cooperation and coordination among government, regulators and industry when designing, implementing and reviewing EEM programs with respect to the oil and gas sector offshore Nova Scotia (CNSOPB 2009). Given that many aspects of drilling are common between offshore exploration and development drilling, comparisons of EEM data sets can be made if program/project-specific differences such as single well and multi-well scenarios are taken into account (Hurley 2004).

A review of primary literature and industry reports on the effects of SBM and WBM drill mud and cuttings found that EEM programs at Hibernia, White Rose and Terra Nova have confirmed, their respective EA predictions of no significant effect on the marine environment for those production projects (Stantec 2009). Mathieu *et al.* (2005) and Deblois *et al.* (2005) both concluded the Terra Nova project demonstrated no significant effects on fish health and fish habitat after a three-year period where six wells were drilled using a combination of WBM and SBM.

The literature review conducted by Stantec (2009a) found that with some exceptions (*e.g.,* Sayle *et al.* 2002), the environmental effects on benthic communities from SBM drill cuttings discharge appear to be generally limited to within 500 m of the discharge point for exploration drilling. This finding is consistent with Hurley and Ellis (2004) who determined that changes in the diversity and abundance of benthic organisms were most commonly within the 50 to 500 m range of drill sites, as outlined above. This zone of influence is consistent for literature review case studies and for Canadian EEM data; it applies to wells discharging SBM or WBM, and for multiple or single wells drilled at the same site (Hurley and Ellis 2004, cited in Hurley 2009).

The Stantec (2009) review also found that changes to benthic communities were not severe, even at the sites that were the most heavily contaminated with drill cuttings, and were likely mainly caused by organic enrichment of sediments from the deposition of biodegradable SBM cuttings (CSA 2004). Where effects were observed, progress toward physical, chemical, and biological recovery appeared to occur within one to five years from cessation of discharges (*e.g.,* OGP 2003; CSA 2004; Sayle *et al.* 2002; Tait *et al.* 2004; Hurley and Ellis 2004). Possible mechanisms included microbial biodegradation (breaking down of materials by microorganisms) and burial by natural sediment deposition or bioturbation (reworking of sediments by marine organisms) (CSA 2004).

Previously confidential, SOEP EEM reports (1998-2008) have been recently summarized by the CNSOPB. The CNSOPB (2009) reports that observed effects from the offshore EEM program are consistently less than original EIS/EA predictions. For example, a predicted plume of drilling waste was only detected once and appeared lighter and shorter lived than modeled (CNSOPB 2009). One of the most notable differences between observations and EA predictions was in SOEP EEM sediment quality monitoring where sediment chemistry studies found only elevated TPH and barium levels, not the full range of 24 metal chemical test parameters. TPH and barium levels were only found in elevated concentrations to a distance of 500 m (CNSOPB 2009).

Hurley (2009) noted other key EEM findings, including:

- The areal and temporal extent of discharged drill wastes appears to be related to differences in the number of wells/volume of discharges, oceanic and environmental conditions such as current speed and direction, water depth or sediment mobility at the drilling location;
- Elevated body burden concentrations of drill waste indicators were generally detected over larger scales (1600- 2600 m) in a wide range of taxonomic groups than the spatial area detected for benthic community change (within 1000 m);
- Results of laboratory and field studies suggest a low potential for toxicity or health effects on commercial finfish and shellfish species. Chronic toxicity studies showed limited bioaccumulation of polycyclic aromatic hydrocarbons (PAH) in flounder exposed to sediments containing high levels of petroleum hydrocarbons (*e.g.,* studies by Payne *et al.* 2001a; 2001b and 2006). Although reported to occur in fish around some rig sites, no early warning health effects have been observed in east coast EEM programs using biochemical and/or histopathological indicators of chemical stress in American plaice and a variety of shellfish species (*e.g.*, from Terra Nova, Hibernia and White Rose).
- Similarly taint (described in further detail in Section 4.5 (with respect to spills) was not detected for any of the species tested within the Canadian EEM programs where SBM or WBM were used for drilling; however, taint was observed during Cohasset Panuke Project (1992-99) where Low Toxicity Mineral Oil (LTMO) drilling muds were used to drill some wells.

Results of EEM studies conducted in Atlantic Canada have demonstrated that the effects of drill waste on the benthic community varies with the volume of muds and cuttings discharged and also varies with proximity to the point of discharge (CNSOPB 2009). Not surprisingly, benthic organisms closest to the discharge area and platform are most likely to suffer the effects of smothering by cuttings piles, but beyond the cuttings piles species diversity and abundance can either increase or decrease and a return to baseline levels is generally observed within one year after drilling discharges have ceased (Hurley and Ellis 2004; CNSOPB 2009). EEM studies have shown the potential for physical dispersion of contaminants originating from anthropogenic or natural activities to be extensive and that dispersion is directly related to the bottom energies of receiving waters. They further determined that evidence suggests only minor effects on fish health from drilling discharges (Hurley and Ellis 2004; CNSOPB 2009).

4.2.3 Progress in Mitigation

Section 3 summarizes the regulatory requirements for drilling waste disposal including the 6.9% concentration of oil on cuttings specified in the OWTG (NEB *et al.* 2002). Through the combination of treatment system technologies and other management controls, such as ship to shore, the 6.9% target has been reached in Nova Scotia (Stantec 2009). This discharge limit may be modified in individual circumstances where more challenging formations and drilling conditions are experienced or areas of increased environmental risk are identified (NEB *et al.* 2002). It is anticipated that performance will improve in the future as further improvements in technology and operating procedures are developed.

In addition to meeting or exceeding the most recent version of the OWTG, oil and gas drilling operators may be required to place additional or *enhanced* environmental mitigation measures to further reduce the risk of harm to marine life (Hurley 2009). With respect to drill muds and cuttings, the following enhanced mitigation measures have been used in the Nova Scotia offshore (Hurley 2009):

- Conducting a post-drilling survey (including chemical analysis of sediments and benthos) to verify muds/cuttings plume dispersion modeling estimates included in EAs to accurately predict the zone of influence; and
- Use of heavy brine in place of barite as a weighting agent to reduce input of mercury compounds in the marine environment.

Measuring SBM and cuttings compliance is also an important component of the *Offshore Waste Treatment Guidelines.* For example, in eastern Canada, the concentration of oil on drill solids is measured every twelve hours using the Procedure for Field Testing of Oil-Based Drilling Muds; a 48-hour rolling average in grams per 100 grams of wet solids is calculated. Stantec (2009a) found that there have been no reported exceedances of the OWTG pertaining to discharge of mud and cuttings since they came into effect in September 2002.

In Canada, discharge guidelines for SBM drill cuttings are based on Best Available Technology (BAT). This guideline evolved from the USEPA results obtained from the Gulf of Mexico; however the Gulf of Mexico also has additional limitations, including toxicity testing and biodegradation (Dorn *et al.* 2007).

Best Management Practices

For the Gulf of Mexico, the USEPA worked closely with industry to develop a Best Management Practices (BMP) approach, and this approach essentially requires the operator to devise a program to keep better track of SBM at all stages of handling (Johnston *et al.* 2004). Specific pollution prevention activities under this BMP approach can include (Johnston *et al.* 2004) improved SBM equipment programs, operation and maintenance procedures for the solids control system, minimizing contamination of drilling fluids when switching between WBMs and SBMs, improved monitoring of SBM cuttings during well intervals, inclusion of SBM cuttings data in permit reports, establishing mud pit and equipment cleaning methods that effectively minimize drill cuttings build-up, and increasing information collection requirements.

Johnston *et al.* (2004) showed that implementation of BMPs on Gulf of Mexico drilling programs significantly reduced SBM retention on cuttings and can therefore provide operators with an opportunity to realize benefits for both the environment and their drilling operations. Using data for comparable well intervals from 72 non BMP wells and 12 BMP wells, retention was reduced from 4.30% (with a standard deviation of 1.18%) to 3.53% (with a standard deviation of 0.96%) (Johnston *et al.* 2004).

4.2.4 Residual Issues

Li *et al.* (2009) found that SBMs were readily biodegradable in Atlantic marine sediments under ambient environmental conditions. However, Li *et al.* (2009) did identify that the volume of drilling muds used in commercial operations may result in the alteration of environmental conditions associated with “burial” of spilled muds, and therefore further research is needed to assess the persistence of SBM under anoxic conditions and the biological impact of the drilling materials on benthic organisms.

4.3 PRODUCED WATER

Produced water, in its most general sense, is the wastewater generated during the production and processing of oil and gas at the well or platform level. Produced water can be made up of several compounds, including (i) formation water (briny or fresh water that is naturally found with oil and gas in sedimentary rock formations); (ii) various hydrocarbons, metals, other organic and inorganic chemicals, and naturally occurring radioactive material (NORM) which are associated with formation water; and (iii) various chemicals and injected water which have been used in the extraction and recovery process (PRAC 2006; Durell *et al.* 2006).

Produced water represents the largest volume of any waste product generated in oil and gas production (Clark and Veil 2009) and therefore is of concern with respect to disposal and potential environmental effects. This concern will only increase over time since the amount of produced water increases proportionately with the age of the well (Henderson *et al.* 1999). However, produced water volumes and chemistry are also well or platform specific, depending on deposit characteristics, recovery system specifications, and treatment methods used (reference).

4.3.1 Panel Comments

The potential impacts of produced water disposal on Georges Bank ecology was not discussed to any great extent in the 1999 Review Panel Report (NRCan and NSPD 1999). The focus at that time was on exploratory drilling which would result in only minor amounts of produced water being generated and discharged into the environment. However, Section 4.2 of the Panel Report (*Cumulative and Remote Impacts)* recognized that produced water would be a major by-product of any commercial drilling program and therefore had the potential to significantly impact marine ecology.

A study by Cranford *et al.* (1998), which was commissioned by the Review Panel, reported that produced water discharges could be deleterious to the survival of haddock eggs and lobster/scallop larvae at concentrations ranging from 0.9% to 22%. This study was apparently cited by many as a cause for concern since these are important commercial species for Georges Bank (NRCan and NSPD 1999). In reply, oil and gas industry representatives indicated that produced water discharges could be monitored and treated or re-injected as needed, based on regulatory requirements.

4.3.2 Advancement in Scientific Knowledge

Over the last few decades there has been considerable research interest in produced water, in both offshore and inshore settings. This work has revolved around (i) understanding the potential effects and risks associated with produced water disposal; (ii) developing technology to better handle, monitor, and treat produced water; and (iii) analyzing the risks and economic implications of managing produced water to meet regulatory requirements.

Although there are various options for disposing of produced water (including re-injection and transport to land based treatment facilities), the most common means of offshore disposal is currently ocean discharge (Clark and Veil 2009). Before being legally discharged, produced water must be treated to remove contaminants such as dispersed oil, corrosive gases, suspended solids, and various other chemicals. Although the quality of produced water is greatly improved by on-site treatment, it is impossible to remove all contaminants before discharge (Lystad and Nilssen 2004). The following summarizes the current state of knowledge on various contaminants in produced water and potential effects on the marine environment.

Chemical Composition and Biological Effects

Hydrocarbons and Alkylphenols

Petroleum hydrocarbons, particularly polycyclic aromatic hydrocarbons (PAHs), are the organic components of greatest environmental concern in produced water (Frost *et al.* 1998). Aromatic hydrocarbons are a family of compounds which can be grouped into three main classes based on typical levels found in produced water and their potential environmental effects (OGP 2002):

- **BTEX**: benzene, toluene, ethylbenzene, and xylene (ortho, meta, and para isomers). These are monocyclic aromatic compounds.

- **NPD**: naphthalene, phenanthrene, and dibenzothiophene, including their C1-C3 alkyl homologues. These are 2-3 ring aromatic compounds. (Note: naphthalene and phenanthrene are technically PAH compounds).

- **PAH**: Polycyclic aromatic hydrocarbons including acenaphthylene, acenaphthene, fluorene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. These are 3-6 ring aromatic compounds.

The aromatic fraction in produced water is dominated by BTEX and NPD compounds which are the most soluble in water. PAHs, having greater molecular weight, are less soluble in water and are mainly associated with dispersed particulates and oil droplets (OGP 2002). Once discharged, much of the BTEX and some of the NPD in produced water will evaporate if near the surface (OGP 2002). Lighter BTEX and NDP compounds also tend to biodegrade faster than heavier PAH compounds (OGP 2002). A study by Berry and Wells (2004) on the fate of BTEX and NPD on the Scotian Shelf indicated these compounds were also rapidly diluted to background levels after discharge.

In contrast, heavier PAH compounds will generally follow the dispersion plume or be retained at various depths based on the buoyancy of associated particulate matter (OGP 2002). It is the increased persistence of PAHs (relative to other aromatic compounds), as well as their varied toxicity, that has caused particular attention to be placed on PAHs in produced water.

A range of toxicity mechanisms have been linked to PAHs including mutagenicity, carcinogenicity, and teratogenicity. PAHs may also act as endocrine disruptors (*i.e*. influence hormone regulation) in various organisms (OGP 2002). Alkylated phenols (or alkylphenols) are a family of organic compounds which can be found naturally in petroleum products as well as in treatment chemicals used in oil and gas recovery. Alkylphenols (APs) are known endocrine disruptors (estrogen mimics), especially the longer chain (C8-C9) compounds (Ekins *et al.* 2005). However, as discussed below, concentrations at which these effects can be observed are not realized as a result of the dispersion of produced water in open water environments (as opposed to laboratory environments).

In a study looking at PAH impacts on sheepshead minnow (*Cyprinodon variegatus*), Bechmann *et al.* (2004) showed PAH biomarker responses (*i.e.* physiological early warning signs of possible impacts) in experimental fish at North Sea oil concentrations of 0.1 mg/L (equivalent to parts per million, ppm), but no clear effect on fish reproduction below oil concentrations of 0.4 mg/L. It was noted in this study that dispersion models suggest produced water oil concentrations are typically less than 0.1 mg/L around North Sea platforms (*i.e.* lower than that found to disrupt fish reproduction under experimental conditions). However, biomarker response at lower concentrations suggested additional research on PAH contamination was warranted.

Aarab *et al.* (2004) added 0.5 mg/L of North Sea oil, with and without 0.1 mg/L concentrations of unspecified PAHs and APs to a continuous flow-through water system containing blue mussels (*Mytilus edulis*). Results suggested oil contamination alone could produce an endocrine disruptive effect in mussels and that the addition of other contaminants (in this case PAHs and APs) could produce pathological effects. However, a later study by Durell *et al.* (2006) showed PAH concentrations to be in the range of 20-100 ng/L (equivalent to parts per trillion, ppt) near oil platforms in two North Sea regions, concentrations a thousand times lower than that used by Aarab *et al.* (2004) in their study. Also, as noted above, oil concentrations in produced water are typically less than 0.1 mg/L around North Sea platforms (Bechmann *et al.* 2004). These data highlight the importance of dispersion and dilution in offsetting potential effects of discharged produced water.

Meier *et al.* (2002) also studied the effect of APs on fish. Two series of experiments were conducted. In the initial experiment, two-year-old cod (spawning for the first time) were fed pellets containing selected C_4-C_7 alkylphenols. One group received a daily dose of 500 µg/kg (equivalent to parts per billion, ppb), based on total fish weight, of each phenol; a second group a daily dose of 5 µg/g. The low dose was intended to represent a realistic exposure concentration while the high dose represented a positive control. Another control group was fed uncontaminated pellets. Exposure was carried out over a 14-week period, with spawning occurring between one to three months after the exposure period. A second experiment was carried out over a four-week period during which five different groups of cod received weekly doses of 5 µg/kg, 0.5 mg/kg, 5 mg/kg, 10 mg/kg and 20 mg/kg of each of four APs. A control group and an estrogen positive control group dosed with 5 mg/kg 17β-estradiol were also included.

Overall results showed effects on both female and male fish even at low exposure levels. In female fish, gonads of exposed females developed slower than control females and it was estimated that exposed females would commence spawning 21 days later than control fish. In male fish, testosterone and sperm levels were reduced in exposed fish. In addition, maturation of testes was affected and in some cases abnormal production of vitellogenin (an egg yolk protein) was observed.

Based on the findings of Meier *et al.* (2002), the Norwegian Oil Industry Association commissioned a confirmation study (Sundt and Baussant 2003) using the same 5 µg/kg low dose AP concentrations and a water equivalent concentration of 0.008 µg/L, based on a bioconcentration factor (BCF) of 600 as stated by Meier *et al.* (2002). In this study, Sundt and Baussant concluded that only about 10% of ingested alkyphenols are likely absorbed by fish, suggesting that the equivalent water concentration of the Meier *et al.* 2002 experiment was actually about 0.0008 µg/L for each AP.

Although the results of Meier *et al.* (2002) and Sundt and Baussant (2003) suggest fish can be negatively affected by relatively low water concentrations of APs, extended exposure times used in laboratory studies may not be representative of actual environmental conditions. Exposure to produced water plumes and their associated chemical constituents under natural conditions are highly variable over time and space (Neff 2002). In addition, these compounds are usually diluted and/or rapidly degraded by photolysis and bacterial degradation after discharge (Neff 2002).

For example, in a more recent study, Harman *et al.* (2009) used passive samplers and an empirical uptake model to estimate exposure levels to PAHs and APs around oil platforms and other reference locations in the North Sea. Exposure levels were found to be relatively similar within 1-2 km of produced water discharge points, with levels dominated by short chained C1-C3 alkylphenol isomers (concentrations of 19-51 ng/L) and alkylated NPDs (concentrations of 29-45 ng/L). Exposure stations showed significant differences to reference sites for NPDs, but not always for more hydrophobic PAHs. The authors noted that estimated concentrations were several orders of magnitude lower than those reported to give both acute and sub-lethal effects, although their potential long term impacts remain unknown (refer to Section 4.3.4 for a discussion on residual issues).

Heavy Metals

In addition to hydrocarbons, produced water may also contain various metals which are potentially toxic, including barium, cadmium, copper, lead, mercury, nickel, silver, strontium, and zinc (Lee *et al.* 2005). However, due to rapid dilution upon discharge, heavy metals are generally considered to be of less of an environmental concern than hydrocarbons. In a detailed summary of the effects of produced water on marine environments, Neff (2002) concluded that metal contaminants do not generally pose a hazard to organisms in either water or sediment.

NORM

Another produced water contaminant of concern is NORM associated with formation water. The most abundant NORM isotopes in produced water are radium-226 and radium-228 (Neff *et al.* in press). Preliminary studies on produced water samples recovered in Atlantic Canada have shown radium isotope levels significantly higher than natural seawater levels. However, due to effective natural dispersion, only normal background levels were detected in seawater samples taken around platforms on the Grand Banks and Scotian Shelf (Nelson 2009).

Treatment Chemicals

Produced water may also contain a range of chemicals used in the extraction, production, and recovery of oil and gas. However, treatment chemicals are only used in direct response to a problem and demonstrated need. As a result, treatment regimes (and chemical use) are platform specific. The most common types of problems encountered in offshore oil and gas production operations, and the types of treatment chemicals used to treat them, are listed in Table 4.1 (CAPP 2000a).

Table 4.1 Common Treatment Chemicals Used in Offshore Oil and Gas Production

Problem	Treatment Chemical
Hydrate formation	Hydrate inhibitor
Water vapor	Dehydrator
Mineral deposits	Scale inhibitor
Chemical corrosion	Corrosion inhibitor
Bacterial corrosion	Bactericide
Emulsions (normal or reverse)	Emulsion breakers, coagulants, flocculants
Foaming	Defoamer
Paraffin	Paraffin inhibitor, solvent

Although many treatment chemicals are oil-soluble and will remain with the oil, some are water-soluble and a fraction of them will remain and be discharged with produced water. The most potentially toxic treatment chemicals are biocides, corrosion inhibitors, and detergents.

Environmental concerns associated with the use of treatment chemicals are generally managed and addressed through the use of best management practices (*e.g.* Produced Water Waste Management, CAPP 2000a; Chemical Selection Guidelines, NEB *et al.* 2009) and by effluent monitoring and treatment (*i.e.* best available technology).

Biomarkers

Concern over chronic effects of low contaminant concentrations in produced water (and other sources) has focused research into ways of detecting early responses of organisms and communities to chemical stressors (so-called biomarkers). A biomarker is defined as a change induced by a chemical stressor in the biochemical or cellular components of a process, structure or function that can be measured in a biological system (NRC 1989).

Biomarkers currently being used to assess the effects of chemical stressors include, but are not limited to, mixed function oxygenase (MFO) induction and related ethyresorufin o-allthylase (EROD) activity, bile metabolites, vitellogenin activity, acetylecholine esterase inhibition, metallothioein induction, DNA adduct formation, and lysosomal membrane assessment.

For example, EROD enzyme activity can be influenced by compounds such as PAHs, polychlorinated biphenyls (PCBs), and dioxins; whereas vitellogenin (an egg yolk precursor protein) can be used as a biomarker for effects of estrogenic mimics such as APs.

In theory, biomarker responses can be used to identify the presence of adverse conditions in advance of population level responses and serve as an early warning of problem identification and adverse health effects. However, in an in-depth review of the use of biomarkers (and fish bioaccumulation) in environmental risk assessment, van der Oost *et al.* (2003) concluded that the measurement of biomarker responses in organisms from contaminated sites offers great promise, but in some cases, it still has to be demonstrated that biomarkers respond to chemical stressors in a regular and predictable manner. In addition, field data can be hard to interpret, as biomarkers provide an integrated response to stressors from all sources, not just those of specific interest within a given study. Furthermore, the use of biomarkers for risk assessment at the community and ecosystem level is still rather ambitious.

Based on continuous development, application, and validation of produced water models, as well as other related research (including EEM results), the general consensus of the 2007 International Produced Water Conference (Lee and Neff in press) was that any acute effects of produced water on individual development sites in the open ocean are likely to be minor. This is mainly due to the effectiveness of natural dispersion (dilution) processes in the ocean environment (*e.g.* tides, currents, *etc.*). However, there are still many unanswered questions related to the fate and potential chronic or cumulative effects of low contaminant concentrations in discharged produced water (PRAC 2006; Neff *et al.* in press).

Fate and Transport Models

Linked to our improved understanding of biological effects from produced water discharges, is the advancement of fate and transport modeling. Several simulation models have been developed and refined over the years to predict the dispersion of produced water in ocean environments. These include, but are not limited to:

- the ASA™ MUDMAP model for modeling drilling mud and produced water transport (Spaulding 1994);
- the buoyant plume (BJET) dispersion model (Skåtun 1996);
- the Offshore Operators Committee (OOC) mud and produced water discharge model (Brandsma and Smith 1996);
- the US EPA Visual PLUME dispersion model (Frick *et al.* 2003);
- the Princeton Ocean Model (POM) (Mellor 2004);
- the CORMIX dispersion and mixing model (Doneker and Jirka 2007);and
- the PROMISE composite dispersion model (Niu *et al.* 2009).

While generally effective and easy to use, most dispersion models do not include uncertainty analyses and therefore may give misleading results in some situations, especially as distance increases from the discharge source. However, more advanced models like PROMISE include probabilistic analysis to help reduce uncertainties in estimated dispersion of produced water (Niu *et al.* 2005).

Dispersion models are important tools for understanding and predicting produced water movement in ocean environments, but they do not by themselves allow assessment of the potential environmental effects of produced water. Other models have been developed for this purpose, which are generally run in conjunction with dispersion models. These models include PROVANN (Reed *et al.* 1996), DREAM (Reed *et al.* 2001), FUGACITY (MacKay 2001), and PROTEUS (BMT Cordah 2008) to name a few. For example, DREAM (Dose-related Risk and Exposure Assessment Model) can account for releases of chemically complex produced water and compute associated impacts on organisms of interest in the water column or on the sea floor. Laboratory test data can then be used to estimate possible lethal and sub-lethal effects and risks (SINTEF 2009).

Neff *et al.* (in press) acknowledge advancements regarding fate/transport models and understanding of biological effects of produced water discharges to the ocean but contend that there is need for further improvement in fate/effect modeling in order to better predict the ecological effects of all chemicals in the rapidly-diluting produced water plumes. Many of the contaminants of concern in produced water cannot be detected in the ocean environment with standard analytical protocols therefore is it not possible to validate modeling results.

4.3.3 Progress in Mitigation

Progress has been made on several fronts with respect to mitigation of produced water effects on marine environments. As discussed in Section 4.3.2, several dispersion and chemical fate models have been developed and refined over the years which improve understanding and predictability of produced water movement and related impacts.

Along with modeling research, on-going EEM provides information used to assess long-term effects of contaminant discharge. EEM data are also used to validate and/or calibrate models used to predict contaminant movement, fate, and bioavailability. EEM involves using various technologies to monitor contaminants from produced water and other sources. For example, semi-permeable membrane devices (SPMDs) and polar organic chemical integrative samplers (POCIS) are both used to estimate low concentrations of dissolved and finely dispersed organic contaminants in water (Durell *et al.* 2006; Harman *et al.* 2009). Autonomous underwater vehicles (AUVs) are also used to monitor and collect samples from the water column associated with offshore platforms (Husain *et al.* 2008). In addition, benchmark data collection is used to help researchers and regulators assess short-term and long-term effects of oil and gas development in the marine environment. For example, Hellou *et al.* (2005) collected benchmark PAH concentration data in small finfish as part of the Hibernia development of the southeast coast of Newfoundland.

Of course the best way to mitigate against contaminants in discharged produced water is to remove the contaminants before the water is discharged, or to not discharge the water at all. Various technologies have been developed to treat produced water prior to ocean discharge and/or to reduce produced water volumes (Table 4.2). Any or all of these techniques can be used as part of an overall produced water treatment regime. Actual methods used are site and platform specific and depend on regulatory requirements, economics, and risks associated with produced water discharge (Ekins *et al.* 2005).

Table 4.2 Methods Used to Management Produced Water Chemistry and Volume (from Ekins *et al.* 2005)

Physical Separation Techniques	Enhanced Separation Techniques	Alternative Techniques	Preventative Techniques
Hydrocyclone	Mare's Tail ®	Non-regenerative absorption	Down hole separation
Skimmer tank and plate interceptor	Centrifuge	Regenerative absorption	Onshore biodegradation
Dissolved gas / induced gas floatation (DGF/IGF)	Compact Floatation Units (CFU)	Membranes	Produced water re-injection (PWRI)
		C-Tour Process System	Onshore biodegradation
		Steam stripping	

A description of these techniques can be found in Stantec (2010a), Section 4.

In addition to treatment methods described by Ekins *et al.* (2005), there have been other recent developments in produced water treatment and management, some of which may be applicable to offshore conditions. These include:

- The use of sponge gourd (*Luffa cylindrica*) to remove heavy metals through bio-absorption (Oboh *et al.* 2009);
- The use of reverse osmosis technology as a secondary treatment to reduce salt content in produced water (Franks *et al.* 2009);
- The use of pressure-assisted ozonation and sand filtration to remove hydrocarbons from produced water (Hong *et al.* 2009);
- Electrodialysis (ED) and electrodialysis reversal (EDR) technology which uses an electrical field along with ion selective membranes to remove dissolved salts in produced water (WRI 2008); and
- The use of walnut shell filters to remove hydrocarbons from produced water (BONO Artes no date).

The Produced Water Management Information System (PWMIS), sponsored by the US Department of Energy through its National Energy Technology Laboratory (NETL) system, provides information on many treatment technologies for both offshore and inshore oil and gas wells (http://www.netl.doe.gov/technologies/PWMIS/).

4.3.4 Residual Issues

As noted above, the general consensus of researchers is that any acute effects of produced water on individual development sites in the open ocean are likely to be minor (Lee and Neff In press). It would only be in site specific cases where acute hazards may exist. However, potential chronic and/or cumulative effects of produced water contaminants on marine ecosystems are still being debated (PRAC 2006). Improved analytical technology and protocols are required to measure specific contaminants in the rapidly diluting produced water plume. This would help to further refine fate/effects models and support model validation (Neff *et al*. In press).

The main focus of present research is on the potential effects of polycyclic aromatic compounds (PAHs) and alkylphenols (APs) on the marine environment. Standard separation treatments are relatively effective at removing “heavy” PAHs and APs associated with dispersed oil in produced water, however these techniques do not remove “lighter” PAHs and APs (and other hydrocarbons) which are dissolved in water (Ekins *et al.* 2005). Other treatment and management techniques are needed to address these and other dissolved contaminants. However, it is important to note that regulations in Canada only address total oil and grease in produced water (NEB *et al.* 2002); levels of other contaminants not associated with dispersed oil are not currently under regulation.

The use of biomarkers and laboratory experiments to study the potential effects of hydrocarbons, PAHs, and APs on marine organisms are important initiatives, but as pointed out by Neff (2002) and van der Oost *et al.* (2003), care must be taken when interpreting results of these studies with respect to actual conditions around oil and gas platforms. Contaminant concentrations and exposure times are often much lower than those created in laboratory experiments and biomarkers reflect an integrated response to all stressors in the environment, not just those of specific interest in a given study.

Caution also needs to be applied when interpreting produced water dispersion and risk model outputs. Although the development and use of these models has greatly enhanced produced water management, they may not be representative in all cases. For example, contaminant partitioning between the surface micro-layer, water column, and seabed sediments may not be well described by current models, and changes in produced water toxicity are correlated with partitioning of chemical components (Azetsu-Scott *et al.* nd).

Finally, it is important to remember that potential hazards associated with offshore produced water, and the management/treatment regime needed to address these hazards, are always site and platform specific (*e.g.,* the volume of produced water varies greatly between the SOEP and Hibernia projects). Also, produced water management must be compatible with management of other waste products, such as drill muds and cuttings and atmospheric emissions.

4.4 ATMOSPHERIC EMISSIONS

Offshore petroleum hydrocarbon exploration and development can result in certain well-understood emissions:

- Emissions from support vessels;
- Turbine, diesel engine and other power sources on drilling and production platforms;
- Flaring emissions from well-testing, or from process control or emergency depressurization of production platforms; and
- Emissions from blowouts, spills or other accidental events.

Atmospheric emission from offshore installations has not been a major regulatory concern due to the distance from populated areas and dispersal from offshore winds. Safety controls to protect workers on offshore installations inherently contribute to protection of farther afield receptors from air contaminants in emissions.

The focus on air emissions from an environmental perspective is the contribution to cumulative effects regarding greenhouse gas emissions, an issue that has received increasing attention in the past decade.

4.4.1 Panel Comments

Atmospheric emissions received little attention in the 1999 Review Panel Report with the focus primarily being on greenhouse gas emissions and climate change. Acknowledging that greenhouse gas emissions are a complex problem, the Panel noted that natural gas has a lower greenhouse gas intensity than coal, or oil, and that it might serve a useful purpose as a "transitional fuel". Further comments were in support of overall reduction in energy use, improvement in efficiency, and stimulation of the use of renewable energy sources.

The Panel Report additionally noted comments from presenters on "Natural Gas Use, Flaring, and Environmental Toxicity". The notes on use refer to comments regarding increases in indoor air pollutants such as "nitrogen dioxide, carbon monoxide, fine particulates, polycyclic aromatic hydrocarbons, and volatile organic compounds including formaldehyde", further citing potential effects to sensitive parts of the population. The panel offered no comments on this.

The noted comments on environmental effects of flaring referred to the effects of flare emissions on ocean ecosystems and "pointed to recent concerns about animal and human illness and miscarriages in Alberta, which some feel are associated with sour gas wells and the flaring of natural gas". The panel did not provide comments on this.

To put these comments into perspective, it is useful to understand that the perspective on atmospheric emissions had begun to change when the Panel Report was prepared. The major issues of the previous two decades had been the Criteria Air Contaminants (CACs), particularly sulphur dioxide. These contaminants were referred to as CACs because the federal objectives, under *CEPA,* and most provincial legislation provided limits on hourly, daily and annual averaging periods. Sulphur dioxide was at the forefront because of the "acid rain" problems that surfaced in the 1970s and resulted in continent-wide limits to acidifying emissions. Acidification was a long-term phenomenon that the CAC limits did not adequately address, as their objective was to control air quality on a relatively short time scale. It is axiomatic that if air quality is controlled to acceptable (*i.e.,* non-perceptible) levels in the short-term, it will easily meet long term standards.

By 1999, the issue of "acid rain" had established that long-term anthropogenic effects were of concern, and the global warming through climate change was being debated in the scientific community as another long-term effect of excessive use of fossil fuels. Although the same level of scientific consensus had not been achieved, there was enough evidence that, in combination with the recurring issues of energy shortages, the panel, as most of the scientific community, held the view that the excessive use of fossil fuels and the emission of greenhouse gases was not acceptable, and that there was a potential for significant damage to the climate.

The other aspect of air quality that had achieved some measure of public importance was that of health risks due to contaminants that were not CACs, and that were bio-accumulated or carcinogenic, such as polychlorinated biphenyls (PCBs), and PAHs. A number of international incidents, including energy-from waste incinerators, and provincial issues, such as the Sydney Tar Ponds, had served to sensitize the public to the threat of long-term health damage.

4.4.2 Advancement in Scientific Knowledge

Since the 1999 Panel Review, the concern over greenhouse gas emissions has intensified. The Kyoto agreement, as referenced in the Panel Report, did not achieve all its objectives, but did serve to help focus public opinion and political discussion.

At the present time, Canada is committing to an emission reduction following the 2009 Copenhagen climate change summit. If this commitment provides quantitative targets for emissions by industrial sectors, the potential for any offshore energy development on Georges Bank will have benchmarks against which they must be measured. The future of energy exploration and development will likely occur in the context of such benchmarks, such as the carbon intensity. Through lifecycle analysis, it is possible to compute a number reflecting the emission of carbon dioxide-equivalent per unit of energy recovered. Such measures have been used by the Canadian Association of Petroleum Producers, among others, and can be applied to the offshore and the oil sands to provide directly comparable performance measures. At the present time, this methodology exists, but the value of the carbon dioxide is still undecided. At such time that a tonne of carbon dioxide equivalent is given a dollar value, it will be possible to compare project costs and benefits, and it will also be possible to do more thorough analyses of the mitigation methods that are applicable to greenhouse gas emissions.

A recent review by Stone (2010) provides a succinct account of the international progress toward the December 2009 Copenhagen meetings and the prospects for the future control and reduction of greenhouse gas emissions. Stone's review shows that the political and scientific paths have not necessarily been on a converging course, and shows that the interests of China, the United States, and the members of the EU are diverse. Stone refers to the recognition in the Copenhagen Accord of "the scientific view that increases in global temperatures should be kept below 2° C", but notes that it does not endorse the target. Scientists diverge somewhat on that target, some arguing for 1.5° C limit. In Canada, the federal legislative vehicle for reduction of greenhouse gases is the Climate Change Accountability Act, now Bill C-311, but which had been first introduced as Bill C-377 in 2006. It is a Private Member's Bill and as of February 2010 has been delayed for further consideration. In the hearings on the Deep Panuke Project and other recent projects, activists have focused on the greenhouse gas emissions as the most significant issue in the assessment, and have demanded full accountings of the emissions and measures to control them. This issue is evolving quickly politically and scientifically and it will remain a major component to be addressed in offshore energy projects.

Carbon dioxide, and other gases that act as greenhouse gases are not CACs, and had not until recent years been viewed as contaminants. All combustion processes of hydrocarbon fuels involve the production of carbon dioxide, and carbon dioxide is accepted to be the main agent in changing the properties of the earth's atmosphere leading to climate change. The ecological effect of regional pollution and climate change is potentially more widespread and of greater concern. The exhaust from turbines, diesel engines and flares comprises about 13% carbon dioxide, substantially more than the CACs that typically occur in exhaust at levels in the parts per million range. Dillon (2003) summarized the emissions of carbon dioxide by offshore operations in the North Sea as 70% from fuel gas, 22% from flaring, 7% from diesel consumption, and the remainder from vented gas, well testing, and other sources. This report provides a survey of emission reporting requirements from other jurisdictions which are on an inventory basis.

There are two approaches to the monitoring of ongoing air quality effects. An inventory provides the emissions on, for example, a tonne per year basis. This allows calculation of benchmarks such as the carbon intensity of fuel, that is, the tonnes of carbon dioxide equivalents per tonne of hydrocarbon fuel recovered. Such figures of merit are useful in determining the energy efficiency of a project. The other method is the calculation or monitoring of the maximum concentration of pollutant in the environment where humans, animals, or valued parts of the ecosystem are exposed. These concentration maxima are typically calculated on the one hour, twenty-four hour and annual average basis. This approach has been the conventional one for the CACs. For emissions such as carbon dioxide and its equivalents, the concentration is not the risk to the environment, but it is the aggregate contribution to the global balance that is of concern. For CACs, the concentrations with respect to their respective limits are the performance indicator; for greenhouse gases, it is the inventory and derived figures, such as the energy intensity that constitute the performance indicators. Given that technology exists to maintain acceptable levels of the CACs, and that the world is challenged to cope with the driving forces of climate change, the latter will be the more important consideration in the atmospheric impacts for the forseeable future.

Relatively recently, another effect of air emissions has come to light which rivals the issue of greenhouse gas and climate change. It has now been shown that the dissolution of carbon dioxide and subsequent conversion to carbonic acid in the ocean waters has resulted in acidification that threatens ocean ecosystems. In May 2004, the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission of UNESCO (UNESCO-IOC) co-hosted an international symposium, "The Ocean in a High-CO_2 World". The Royal Society published an important milestone report on the subject in 2005, and by 2009, reviews of the issue, such as that by Christian (2009) of DFO showed the recognition of the potential problem and the substantial gaps in knowledge of the problem in Canadian waters. Christian cites, for example, the problems of the Arctic Ocean where the acidification may exacerbate the problems of receding ice. Coral reefs and molluscs, as well as crustaceans and echinoderms have carbonate shells or exoskeletons with carbonate minerals that are vulnerable to acidification. Climate change is recognized as an indirect effect of greenhouse gas emissions through the mechanisms that govern Earth's climate; ocean acidification is a direct and clear effect of increased concentrations of acidifying gases in the atmosphere. The clarity of the link and the magnitude of the potential risk make this an issue that will further underline the need to reduce greenhouse gas emissions wherever possible.

The comments from presenters about indoor air quality reflect the fact that Nova Scotians had no experience with the domestic use of natural gas at that time. Since then, the use of natural gas in commercial establishments has become common, and the domestic market has grown. It is unlikely that the same level of concern would persist.

Similarly, the allegations of the effects of flared emissions on ocean ecosystems may have been countered by the experience from the Sable Offshore Energy Project. Although this gas source contains virtually no sulphur, the flaring emissions have not resulted in ecosystem damage. The comments to the Georges Bank Panel on the sour gas wells of Alberta are not relevant, as the gas finds offshore have been consistently very low to negligible in sulphur content. The analogy between cattle that are relatively immobile, in close proximity to low level flares of gas with perhaps 38% hydrogen sulphide content to the mobile and transient animals that may be exposed to highly dispersed emissions from the higher level flares of gas with fractions of a percent of hydrogen sulphide is not well founded.

4.4.3 Progress in Mitigation

One of the key updates in the redraft of the 1996 Offshore Waste Treatment Guidelines was the inclusion of requirements for air emissions (NEB *et al.* 2002). Under the current version of the Guidelines (NEB *et al.* 2002), each operator of a production installation is expected, as part of its development application, to provide an estimate of the annual quantities of greenhouse gas that will be emitted from its offshore installation and as well as a description of its plans to control and reduce these emissions. Operators of drilling and production installations are expected to calculate and report greenhouse gas emissions on an annual basis in accordance with the Canadian Association of Petroleum Producer's (CAPP) Global Climate Change Voluntary Challenge Guide (CAPP 2000b). Also under the Offshore Waste Treatment

Guidelines, operators of drilling and production installations are expected to report the type and significance of VOC emissions and report them in accordance with best management practices for oil and gas operations in Canada (*e.g.,* CAPP 1999; CAPP 2000b).

The control of greenhouse gas emissions is a focus of research around the world. Mitigation measures that avoid the emission of greenhouse gases are being developed, but the technology is much newer than that for the removal of sulphur dioxide, for example. Offshore energy producers are reluctant to use experimental or unproven technology in the offshore environment.

The technological issues surrounding carbon capture are substantive. Because exhaust from combustion systems contains approximately 78% nitrogen by volume, but only perhaps 13% carbon dioxide, much of the capacity of air handling systems is used simply to pass through the inert nitrogen fraction. One approach to this issue is to use pure oxygen to sustain combustion, limiting the exhaust volume by a factor of about 5, and reducing the size and energy consumption of the air pollution control systems. Natural gas often contains quantities of carbon dioxide that must be removed to meet commercial sales specification, and this technology is well developed. Another approach is to use chemical stripping agents to absorb and desorb the carbon dioxide from the exhaust. These approaches have different strengths and weaknesses, and pilot to full-scale projects are underway. Given that the technology will evolve to a level where the carbon dioxide can be removed and contained in a concentrated exhaust stream, the question of disposal of the gas remains.

Substantial resources have addressed the potential for re-injection of carbon dioxide into the reservoir to enhance yields, and to sequester the greenhouse gas on a permanent basis. In the west, this technique has long been used for enhanced production from reservoirs. A “clean coal” technology research project in Alberta will have carbon capture from the combustion gases, and the carbon dioxide will be sold to a US energy company for injection into a reservoir to enhance recovery. In the offshore, the EnCana Deep Panuke project, now underway, comprises a plan for the injection of the carbon dioxide and the sulphur dioxide emissions into a reservoir deep below the seabed. The injection concept, such as that selected by EnCana remains the most promising current technology for storage of the carbon dioxide.

IEAGHG, the greenhouse gas section of the International Energy Agency (www.ieaghg.org) is one of several international consortiums sponsoring research into the area of greenhouse gas sequestration in wells and reservoirs. The first meeting of the Oxyfuel Combustion Conference occurred in September 2009, and other conferences, such as the Electrical Utilities Environment Conference (www.euec.com) have had sessions focusing on carbon dioxide removal and clean combustion since 2007.

On the domestic front, in 2009, the Carbon Capture Storage Research Consortium of Nova Scotia (CCS Nova Scotia) was formed. CCS Nova Scotia is a not-for-profit corporation whose members include the Province of Nova Scotia, Nova Scotia Power Inc. and Dalhousie

University. CCS conducts multidisciplinary research into the issues involved in the capture, transport, storage and monitoring of stationary sourced carbon dioxide emissions.

In summary, advances in mitigative measures pertain mainly to the management of GHG, with the focus on carbon capture technology (*e.g.,* capturing carbon, and of disposing it in sedimentary rock reservoirs). As issues of climate change and ocean acidification continue to rise in importance, further technological advancement in this area is expected.

4.4.4 Residual Issues

The capture and storage of greenhouse gas in the reservoir remains one of the few alternatives for reducing the effects on climate by facilities that process fossil fuels. The substantial interest in injection as a carbon removal technology has resulted in investigation by numerous researchers that will provide valuable guidance in the future.

4.5 SPILLS AND BLOWOUTS

While the probability of a spill or blowout (*i.e.,* continuous, uncontrolled release of hydrocarbons above or below sea surface) is low (and continues to decrease at an industry level), the potential for harmful effects can be high, depending on various circumstances (*e.g.,* chemical properties, spill volume, environmental and oceanographic conditions, time of year, sensitivity of receptors,). The definition of a spill can range from a small platform-based spill (*e.g.,* spill from transfer operations, spill of lubricating oil on the platform) to a large batch spill of oil (*e.g.,* related to bulk storage or transfer of oil/gas during production). Although more attention is generally given to large hydrocarbon spills, there is growing concern regarding platform spills production chemicals. A blowout is defined as a continuous, uncontrolled release of hydrocarbons (which can mixture of gas, gas condensate and/or oil) and can occur above or below the sea surface (*i.e*., at the well head). Depending on the composition and phase of the hydrocarbon, these products will exhibit different fate and behaviour and therefore result in different potential environmental effects. It should be noted, that, in the discussions of spills, the term “oil” is used generically to mean hydrocarbons and should not be interpreted to mean only crude oil.

This section addresses advances in our understanding of potential environmental effects of spills and blowouts, as well as advances in spill modeling, and spill prevention and response.

4.5.1 Panel Comments

Concern regarding potential effects of spills and blowouts on the Georges Bank ecosystem and fisheries was arguably the most substantial issue with which the 1999 Review Panel had to contend in their review. Although it was recognized that the probability of a large blowout would be low, presenters including DFO and Environment Canada stressed that even small spills could trigger international concerns and result in population effects on marine species. Consultants for the petroleum industry, on the other hand, argued that the most serious risk from spills was to seabirds, with risks to marine mammals, pelagic fish, demersal fish, shellfish, phytoplankton and zooplankton being negligible. The Panel took a precautionary stance, acknowledging that these assessments are based on “first principles” and extrapolations.

Potential effects on fisheries were considered to be “slight” with exception of the perception of tainting. The “perception of tainting” of fish products was identified as a major concern whereby there could be a potential loss of market due to consumer perception that fish products are tainted and/or contaminated by petroleum and waste discharges. Although the issue of taint is not restricted to spill events and is often addressed in EEM programs for routine drilling and production activities (refer to Section 4.2), the Panel appeared more concerned with potential tainting following a spill event, and therefore taint is discussed briefly below in a spill context.

4.5.2 Advancement in Scientific Knowledge

Oil Spill and Blowout Probability

The 1999 Panel Report acknowledges the probability of an oil spill on Georges Bank as being low. A review of recent industry performance corroborates this statement and demonstrates a declining trend in spill events. The average annual oil spillage from petroleum industries, shown in Figure 4.1, has decreased 46% from 1997 to 2007 and 77% from 1969 to 2007 (API 2009).

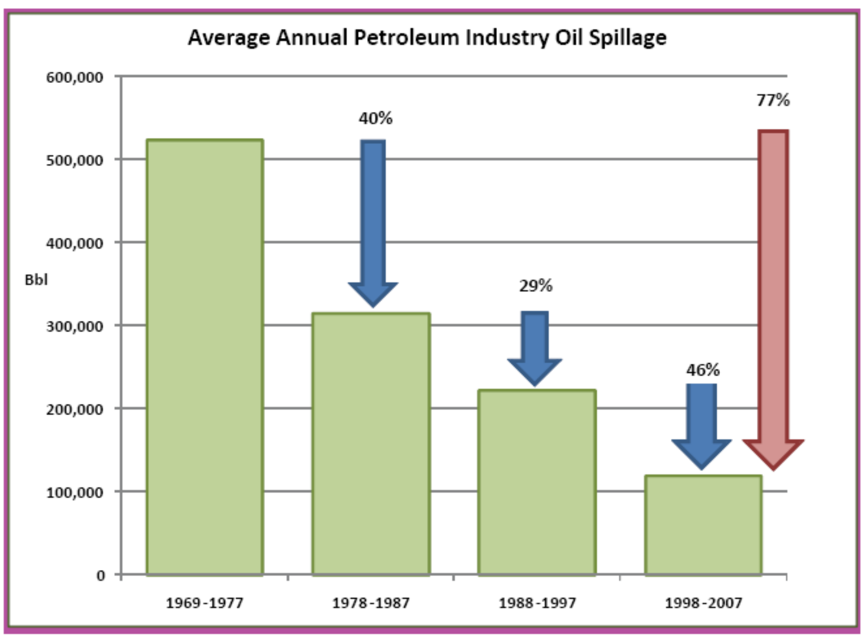

Figure 4.1 Average Annual Petroleum Industry Oil Spillage by Decade (American Petroleum Institution 2009)

In spite of this declining trend, large blowout and spill events can still occur. On April 20, 2010, a fire and explosion occurred on Transocean's Deepwater Horizon drilling rig, killing 11 workers, while drilling an exploration well on BP's Mississippi Canyon Block 252, approximately 66 km offshore Louisiana in the Gulf of Mexico. At the time of writing this report, the cause of this incident was under investigation; initial efforts were focused on spill response and countermeasures. It is likely that monitoring programs will be conducted for years to come before the effects of the spill are fully understood.

Despite this recent event, the overall trend of spills and blowouts is decreasing worldwide. A blowout of the magnitude of the Deepwater Horizon blowout is extremely rare. An investigation will most likely result in lessons learned in terms of improved technology and procedures. However, in spite of potential further improvements and advancements, there still remains an element of risk.

The probability of a blowout occurring during exploration is 1 in 1,800 years (assuming two wells drilled per year) with shallow blowouts occurring more frequently than deep well blowouts (Hurley and Ellis 2004). Blowouts involving 400 barrels or less make up about 50% of the well blowouts (API 2009). Since 1964 there have been 17 marine blowouts in the United States, totaling 248,963 barrels spilled (API 2009). In 1969 the largest blowout occurred from the Alpha Well 21 off Santa Barbara, California releasing 100,000 barrels of oil. Until the Deepwater Horizon blowout event in April 2010, there had been no exploration drilling blowout spill greater than 10,000 bbl anywhere in the world since 1987, suggesting an improvement in technology and/or practice in the last 20 years (Hurley and Ellis 2004).

There is a higher chance of a small (1 barrel) oil spill occurring than a large (>1000 bbl), very large (>10,000 bbl) or an extremely large (>150,000 bbl) oil spill occurring (Table 4.3). Based on Nova Scotia's previous oil spill incident history, the possibility that a small oil spill will occur is once every two years (Hurley and Ellis 2004). Using the rate of two wells per year, the probability of an extremely large oil spill, very large oil spill, and large oil spill is 1 in 17,500 chance per year, 1 in 5,800 chance per year, and 1 in 4,400 chance per year, respectively (Hurley and Ellis 2004).

Table 4.3 Predicted Number of Blowouts and Spills for Exploration Drilling (2 Wells/Year) (Hurley and Ellis 2004)

Event	Historical Frequency (per well drilled)[1]	Predicted No. of Events per year	Frequency (assumes two wells/year)[2]
Deep blowout during exploration	2.85×10^{-4}	5.7×10^{-4}	One every 1,800 yrs
Exploration drilling blowout with oil spill >1000 bbl	1.14×10^{-4}	2.28×10^{-4}	One every 4,400 yrs
Exploration drilling blowout with oil spill >10,000 bbl	8.57×10^{-5}	1.71×10^{-4}	One every 5,800 yrs
Exploration drilling blowout with oil spill >150,000 bbl	2.86×10^{-5}	5.72×10^{-5}	One every 17,500 yrs
Platform oil spill, 0 to 1.0 bbl	0.263	0.53	One every 2 yrs

Table 4.3 Predicted Number of Blowouts and Spills for Exploration Drilling (2 Wells/Year) (Hurley and Ellis 2004)

Event	Historical Frequency (per well drilled)[1]	Predicted No. of Events per year	Frequency (assumes two wells/year)[2]
Platform oil spill, 1.1 to 49.9 bbl	0	5.7×10^{-2}	One every 17 yrs
Platform oil spill, 50 to 999 bbl	0	1.2×10^{-3}	One every 800 yrs

[1]Blowouts and blowout-spills (first four rows of data) are based on worldwide, US OCS, and North Sea experience;
[2]Platform-based spills (last three rows of data) are based on Nova Scotia experience, 1994 to 2002.

The total petroleum input from petroleum discharges on platforms (referred to in Table 4.3 as "platform oil spill") is 0.07% of average annual releases of petroleum by source in North America. By comparison, land-based (river and run-off) spills account for approximately 21% (National Research Council 2003).

Oil spills can occur during any phase of an offshore petroleum project; however, in the unlikely event that an oil spill was to occur, there is a greater chance that an oil spill will occur in the production phase. According to the C-NLOPB, from 1997 to 2007 there were a total of 337 incidents where hydrocarbons were released totaling 429,787 liters of oil from activities offshore Newfoundland and Labrador. Of the 337 incidents, 40 were from exploration and drilling where the other 297 were from development drilling and production. The CNSOPB annual incident reports that the majority of spills offshore Nova Scotia are a result of production projects; coinciding with the C-NLOPB report. Table 4.4 presents CNSOPB spill statistics from 1999 to 2009 for spills (including chemical spills) offshore Nova Scotia. Overall, spill incidents have decreased over the last ten years.

Table 4.4 CNSOPB Statistics for Spills to the Sea (1999-2009)

Year	Less Than 1L	1-10L	11-150L	Greater Than 150L	Total
1999-2000	0	8	3	2	13
2000-2001	11	8	11	2	32
2001-2002	11	9	4	0	24
2002-2003	10	3	4	3	20
2003-2004	6	5	9	5	25
2004-2005	6	0	2	2	10
2005-2006	7	2	3	1	13
2006-2007	4	2	4	2	12
2007-2008	1	3	1	0	5
2008-2009	3	4	0	0	7
TOTAL	59	44	41	17	161

Source: CNSOPB website http://www.cnsopb.ns.ca/environment_incident_statistics.php

On the Scotian Shelf, there have been two investigated spill events related to the Sable Offshore Energy Project (SOEP). In 2004 CNSOPB was informed that there had been a diesel spill from the North Triumph platform with a total volume of 3.5 m^3 released into the ocean (CNSOPB 2009). Environmental surveillance on Sable Island indicated that no effects on wildlife were observed. A day after the spill event the oil had naturally dispersed and/or evaporated removing the oil sheen from the surface of the water (CNSOPB 2009). In 2006 ExxonMobil reported a monothylene glycol (MEG) spill occurred on a flowline extending from the Thebaud platform to the Alma platform. MEG is an industrial anti-freeze used to prevent formation of hydrates and is considered to have low toxicity. Approximately 158 m^3 of MEG was spilled into the ocean, but no measurable impact was identified (CNSOPB 2009). In both situations mitigation measures have been put in place to prevent the reoccurrence of a similar incident.

Recently, spill predictions in environmental assessments for major oil and gas projects in Atlantic Canada have come under scrutiny. Fraser and Ellis (2008) compared environmental assessment spill predictions for Hibernia, Cohasset-Panuke, SOEP, Terra Nova, White Rose and Deep Panuke to the observed spills that had occur thus far. Three projects (SOEP, Terra Nova, and White Rose) were found to have exceeded lifetime predictions for small spills. SOEP, for example, had a total of 57 small spill events in the first six years of production; exceeding the lifetime prediction of 8.5 spills <50 bbl (Fraser and Ellis 2008). These estimates were based on best available information at the time. Each spill event is followed up by the respective regulatory board (CNSOPB, C-NLOPB). These apparent prediction discrepancies will no doubt serve to improve future environmental assessments and spill predictions in Atlantic Canada. Nonetheless, it remains that spill frequency and volumes are showing a decreasing trend.

Most oil spills occur during transportation of oil. Since the 1970s the number of large (>700 tonnes) tanker oil spills has been decreasing significantly. There has been a one third decrease from the 1970s to the 1990s and further decrease in the 21st century, as seen in Table 4.5 (ITOPF 2008). The largest oil spill in the 21st century (also the 20th largest spill since 1967) was in 2002 when the *Prestige* oil tanker released 63,000 tonnes of oil off the coast of Spain. Single large oil spill events distort figures for a particular year. Between 1990 and 1999 there were 358 spills over 7 tonnes, equaling 1,138 thousand tones. Of the 1,138 thousand tones spilled, approximately 830 thousand tonnes (73%) were spilled in just 10 incidents (just under 3%; ITOPF 2008). The majorities of tanker oil spills are small in volume and yet make relatively small contribution to the total quantity tanker oil spills (ITOPF 2008).

Table 4.5 Annual Quantity of Oil Spilled (ITOPF Oil Tanker Spill Statistics 2008)

Year	Quantity (Tonnes)	Year	Quantity (Tonnes)
1990	61,000	2000	14,000
1991	430,000	2001	8,000
1992	172,000	2002	67,000
1993	139,000	2003	42,000
1994	130,000	2004	15,000
1995	12,000	2005	17,000
1996	80,000	2006	13,000

Table 4.5 Annual Quantity of Oil Spilled (ITOPF Oil Tanker Spill Statistics 2008)

Year	Quantity (Tonnes)	Year	Quantity (Tonnes)
1997	72,000	2007	18,000
1998	13,000	2008	2,000
1999	29,000	2009	N/A
Total	1,138,000	**Total**	196,000

http://www.itopf.com/information-services/data-and-statistics/statistics/documents/Statpack2008_001.pdf

With respect to Georges Bank, a tanker spill would only be a relevant consideration in the event of a production project that employed tankers to export product (as opposed to an export pipeline).

From 1998 to 2007 oil spills related to petroleum activities represented 0.9% of the amount released from natural seepage (9,938 bbls versus 1,123,000 bbls) (API 2009). Natural seepage is responsible for an estimated annual discharge of 4.2-14 million barrels annually (Wilson *et al.* 1974; Kvenolden and Harbaug 1983).

Spill Behaviour

With the accuracy of oil spill fate and transport models continuously improving, the capacity to predict spill trajectory and effects on Georges Bank has also improved. Recent emphasis on the evaluation of fate and effects of spills that are entrained in the water column as a result of high mixing energy in the water column or due to application of a dispersant represents a scientific advancement over historical surface trajectory and weathering models.

Based on our current understanding of fate and behaviour of oil spills, and observations from previous spills, predictions for spill behavior on Georges Bank as reported in Boudreau *et al.* (1998) remain valid. It is expected that the bulk of any oil released on Georges Bank would initially concentrate at the surface to form a slick which would be subject to evaporation. Evaporation would likely remove 40-50% of the oil in the first 24 hours with the remaining oil disappearing through various processes (*e.g.*, dispersion, dissolution, photo-oxidation, biodegradation) after one to two weeks. High rates of vertical mixing observed on Georges Bank would likely increase the concentration of oil entrained in the water column, with stratified regions around the perimeter of the Bank experiencing substantially lower concentrations in deeper water (Boudreau *et al.* 1998)).

Environmental Effects

Effects to Plankton

Oil concentrations on the order of 100 ppb have been demonstrated to cause lethal and sublethal effects on plankton organisms. However, phytoplankton and zooplankton have the capability to metabolize hydrocarbons which may reduce the environmental effects on the pelagic system (Varela *et al.* 2006). Despite many studies, it is difficult to demonstrate that spills and releases have any irreversible effects on planktonic communities. Recent research, including a study conducted following the 2002 spill of the *Prestige* oil tanker off the Spanish coast appear to substantiate claims that effects of spills on plankton are negligible.

In 2002 the *Prestige* oil tanker released 63,000 tonnes of oil. Varela *et al.* (2006) documents a study that was undertaken to identify effects of the spill on plankton. The study showed no signs of variation in the phytoplankton or zooplankton productions and biomass; however, the zooplankton copepods were found to be externally and internally contaminated with oil. The spring bloom after the *Prestige* spill found no significant differences in the phytoplankton, including no changes to the dominance of phytoplankton groups (Varela *et al.* 2006). Other oil spills such as the *Torrey Canyon*, the *Santa Barbara*, the *Argo merchant* and the *Tseis* could not demonstrate any major effects to phytoplankton production and/or biomass (Varela *et al.* 2006).

Similarly to other marine organisms, the effects of an oil spill on plankton are varied and depend on the natural environment conditions. The natural variability of the plankton is dependent on the season, the mobility of water masses and the patchiness in spatial and temporal distribution of plankton (Varela *et al.* 2006).

Ecosystem level effects on Georges Bank are expected to be low due to rapid dispersion and weathering, rapid rates of regeneration of planktonic organisms, and mixing of replacement of phytoplankton and zooplankton from surrounding water.

Effects on Fish, Fish Eggs, and Larvae

Fish eggs and larvae generally are unable to avoid an oil contaminated area and have yet to develop detoxification mechanisms. Effects to eggs and larvae include reduced growth, abnormal development and localized mortality. The type of oil, yolk sac stage and feeding conditions affect the sensitivity of fish larvae to an oil spill (LGL *et al.* 2000). Spawning events occur on Georges Bank every month (Kennedy *et al.* 2010) and any hydrocarbon release to the marine environment could have lethal or sub-lethal effects to fish eggs and larvae. However, high natural mortality rates make it difficult to determine the effects of an oil spill on eggs and larvae (Boudreau *et al.* 1999; Varela *et al.* 2006).

Effects to adult fish tend to be minimal for the reason that they can move away from an oil contaminated area depending on the extent of an oil spill event. Extensive research, analysis and monitoring of pink salmon mortality, incubation success, viability of spawners, and record return performances of pink salmon over a 10-year period following the *Exxon Valdez* oil spill in Prince William Sound in 1989 are seen as important indicators of the lack of a significant oil spill effect on the local pink salmon population. Biological studies have documented low level of risk to pink salmon and support the conclusion that specific, oil-related effects on the population were undetectable (Wiens *et al.* 2000).

The extent of effects of a spill or blowout on fish and invertebrates depends on the timing and location of the spill relative to spawning events. All major commercial species on Georges Bank have pelagic eggs and/or larvae, with at least two species spawning every month of the year on Georges Bank, therefore any hydrocarbon release has the potential to affect fishery resources (Boudreau *et al.* 1999). There remains difficulty in determining a cause and effect relationship between reduced population size and oil contamination due to high levels in natural variability. This represents a residual issue that has not been resolved with advances in scientific knowledge.

Interactions with the benthic environment are most likely to occur in the shallow well-mixed central area and convergence areas of the Bank. However, hydrocarbons would not be expected to persist on the Bank longer than a few months because of the strong current that continually transport fine sediment particles out to deeper water (refer to Section 2.2.1). Widely distributed species such as scallops would likely be subjected to little risk except in localized areas of high oil concentrations (Boudreau *et al.* 1999). Of greater concern would be potential effects on the fishery related to the perception of tainting in the unlikely event of a spill.

Tainting

Tainting is defined as an off-taste or odour detected in a fish product. Seafood products that are tainted (or perceived to be tainted by consumers) can have serious market implications including a measurable loss of market value of products originating (or perceived to be connected to) the affected area. That loss of market value can translate to downward pressure on revenue, wages, employment, and social welfare in communities with economic ties to the fishery in question.

In the last ten years, the public's awareness of food safety and the interaction between the food supply and the environment from which it is derived has increased dramatically. This may be due, in large part, to intense media coverage of food safety issues including the bovine spongiform encephalopathy (BSE) in beef products and the 2008 *Listeria* outbreak in processed meats. Although these issues represent extreme cases of food safety and should not be compared to potential effects of petroleum activity on fisheries, they have served to increase consumer awareness and sensitivity around tainting.

Since the 1999 Panel Review, there have been no tainting issues in Atlantic Canada associated with oil and gas activities, and, as discussed above, effects on fish stocks are not expected to be significant. However, in the unlikely event of a spill, a tainting incident in a fishery on Georges Bank could potentially have a greater effect than a decade ago as a result of increased public sensitivities.

Effects on Marine Mammals and Sea Turtles

Accurate data on the effects of oil on mammals and sea turtles is limited due to public and scientific concerns about controlled laboratory experiments on mammals and the vulnerability of turtle species worldwide. Data from actual spills therefore seem to provide the only evidence of effects, and, since these marine animals are not commonly considered as part of oiled wildlife responses, observational data is limited.

There is no evidence linking acute or chronic effects as a result of hydrocarbon contamination to cetaceans (Short 2000). Higher than normal mortality rates, however, are generally observed following an oil spill event. After the *Exxon Valdez* oil spill in 1989 a reported 26 Grey whales, 5 Harbour porpoises, 2 Minke whales, 1 Fin whale and 3 unidentifiable whales were found washed ashore (Short 2000).

Geraci and St. Aubin (1980; 1982) found whales are unlikely to ingest enough oil to cause serious internal damage when exposed to contaminated waters. Inhalation of vapours from an oil spill may cause irritation of respiratory membranes and absorption of hydrocarbons into the bloodstream (Geraci 1990). There is indication; however, that dolphins try to minimize contact with the surface by decreasing respiration rates and increasing dive duration (Smultea and Wursig 1995). Temporary displacement can occur because of oil contamination, boat disturbance or displacement of food (LGL *et al.* 2000). Monitoring studies after an oil spill in the Guanabara Bay showed that the population of *Sotalia fluviatilis* (a dolphin species) avoided the contaminated area from the oil spill and return to the area prior to the completion of the cleanup avoiding primary effects of contamination (Short 2000).

Oil spills and blowouts have shown seal mortality may have occurred as a result of oil contamination (St. Aubin 1990). Adult and juvenile grey and harbor seals have blubber to provide insulation and therefore are at no risk of thermal regulatory effects (Kooyman *et al.* 1976, 1977; St. Aubin 1990). Young pups on the other hand rely on their birth coat and brown fat stores for insulation and may be at risk of the harmful effects of oiling (St. Aubin 1990). Seals, along with cetaceans, can void ingested oil through vomit, feces or metabolize at rates that prevent significant bio-accumulation (Neff 1985, cited in Hartung 1995). Minor kidney, liver and brain lesions may occur from toxic absorption but as seals return to clean water internal oil can depurate (Engelhardt 1985). Following the *Exxon Valdez* spill, 15 dead harbor seals were recovered. Based on this finding, it is assumed that seals moved away from the spill area (Wiens *et al.* 2000).

Follow-up monitoring studies that will be undertaken for more recent spills including the 2009 southeast Queensland oil spill, in which more than 230 tonnes of fuel oil (and 30 tonnes of other fuel and 620 tonnes of ammonium nitrate) were spilled from a cargo ship, will serve to further advance our understanding of effects of spills and countermeasures on marine mammals.

Effects to Seabirds

Seabirds are the most vulnerable marine animals to a spill or blowout and most susceptible to lethal and sublethal effects. Birds that become oiled can no longer regulate body temperature and flying becomes difficult. Excessive preening can lead to ingestion of oil from their feathers. Oil can have a lethal or sub-lethal effect once a sea bird becomes oiled. The initial exposure to an oil slick, when thermal insulation and buoyancy is damaged, there is a high mortality rate (LGL *et al.* 2000).

The morality rate of birds affected by oil spills is dependent on timing and location. In November 2004 1,000 barrels of crude oil was spilled from the Terra Nova vessel on to the Grand Banks with an estimate of 4,000-16,000 birds at risk (Wilhelm *et al.* 2006). Compared to the 1970 *Irving Whale* spill and the 1986 Apex Houston spill, Terra Nova had double the volume of oil spilled; however, the same projected mortality (Wilhelm *et al.* 2006).

There are no bird species at risk known to occur in the Georges Bank area, but migratory birds are protected under the *Migratory Birds Convention Act, 1994*. In the unlikely event of a spill on Georges Bank, wildlife response plans would address oiled birds.

4.5.3 Progress in Mitigation

Advancements in platform design and materials, along with new regulations for petroleum activity, decrease the probability of an oil spill or blowout. In the unlikely event that an oil spill or blowout does occur, recovery plans have been implemented.

Design, Materials and Operations

Through the use of design, inspection, integrity assurance programs and engineering techniques, the risk of an accident is minimized. Environmental and safety precautions may include equipment inspections and maintenance, pipeline leak prevention, blowout prevention safeguards, flowline protection and subsea protection structures. Stantec (2010a) discusses various technologies that have been designed to minimize accidental events.

The development and of the double hulled tanker reduces the impact and environmental risks if a collision was to occur. For instance, there have been three tanker incidents Lake Maracaibo Channel in Venezuela; Nissos Amorgos, Olympic Sponsor and Icaro. Nissos Amorgos was a single hulled tanker and spilled a considerable amount of crude oil into the channel. Olympic Sponsor and Icaro were double hulled tankers and had no oil spilled (Australian Maritime Safety Authority 2001). Amendments to Regulation 13G of Annex I of MARPOL were put in force in 2005 to phase out single hulled tankers. A timeline, which extends to 2010 for ships delivered in 1984 or later, is established to have single hulled tanks replaced and inspected. Improvements, such as maintenance, operation, construction, salvage, design, stability, ventilation and access, mitigate issues regarding probability of an oil spill event.

Regulations

Since 1999, there have been various regulatory changes which serve to minimize spill events and/or improve emergency response in the unlikely event of a spill. The 2009 Canada Oil and Gas Drilling and Production Regulations are supported by environmental protection guidelines which provide mitigation measures in the event that a spill or blowout occurs. Operators are required to include in their application for authorizations, a project-specific emergency preparedness plan which includes:

- potential abnormal situations;
- emergency situations;
- incidents and accidents that could have a harmful effect on the environment;
- process for reporting incidents and near misses
- investigation procedures in the event of an incidents to determine the root cause; and
- remedial actions to prevent reoccurrence of incidents similar in nature including implementing plans, policies and procedures.

Also applicable to offshore Nova Scotia, the CNSOPB and Environment Canada work together to ensure timely reporting of accidental spills and follow up (including spill response actions) in order to mitigate environmental effects (CNSOPB and EC 2007).

Recovery and Cleanup

Despite improvements in spill prevention, there is still probability that an oil spill or blowout could occur. The first line of defence is physical recovery of oil, even though limitations occur due to spreading rate of oil spills, weather, and operational limitations for containment booms. Recent research has focused on the use of dispersants, including their effectiveness of hydrocarbon dilution, as well as potential increased bioavailability of toxic components to pelagic organisms. DFO scientists have been involved in various research studies to determine effectiveness of various oil spill countermeasures.

In the United States, the Minerals Management Service (MMS) has maintained a comprehensive, long-term research program for more than 25 years to improve the knowledge and technologies used for the detection, containment and cleanup of oil spills that may occur on the U. S. Outer Continental Shelf. The Oil Spill Response Research (OSRR) program is a cooperative program which brings together expertise and funding from government, industry and international (including Canada) partners. Current OSRR projects cover a wide spectrum of oil spill response issues and include, but are not limited to major topic areas including: remote sensing and detection; physical and chemical properties of crude oil; mechanical containment and recovery; and chemical treating agents and dispersants (MMS 2009).

Chemical dispersants are likely to be effective in the Georges Bank area in the event of an oil spill. Another option, for smaller spills, may involve microbial biodegradation to enhance physical dispersion of oil in the water column. For a discussion on technological advances regarding oil spill recovery and cleanup, refer to Section 4 of Stantec (2010a).

4.5.4 Residual Issues

Considerable research has been conducted on the potential effects an oil spill or blowout on the marine environment. However, there are recurring issues that remain the focus of ongoing research. Fish eggs, larvae and fish have high natural mortality rates making it difficult to distinguish between natural mortality and lethal effects from hydrocarbons. The major concern is a spill event that would coincide in time and place of a spawning event on Georges Bank.

In many cases, outstanding issues are related to incomplete baseline data. Without adequate baseline information for an ecosystem affected by a spill, including knowledge of number and diversity of species, determining loss due to an oil spill is often challenging. Varela *et al.* (2006) advocate there is a lack of adequate monitoring prior to an oil spill as well as inadequate historical data when studying the *in situ* evaluation of the effects of oil on the marine ecosystem. In the case of Georges Bank, where considerable study has been undertaken on the marine ecosystem, this issue is less of a problem.

The recent focus on possible shortcomings in spill prediction techniques historically used in Atlantic Canada environmental assessments for offshore oil and gas projects serve to increase knowledge and awareness of spill events, which will undoubtedly improve future environmental assessments, including those which would be required for a potential exploration or production project in the moratorium area should these activities be permitted.

The key residual issue, which is not unique to Georges Bank, is the ongoing research related to spill countermeasure techniques, including the biodegradation of hydrocarbon compounds and bioavailability of toxic components in dispersants. As noted in the 2004 Workshop on Dispersant Use in Eastern Canada (Trudel 2004), environmental trade-offs must drive dispersant use/non-use decisions. Future research will serve to inform operators, regulators and emergency responders on appropriate response actions.

4.6 LOSS OF ACCESS AND CROWDING

One potential interaction between the petroleum and fishing industries is the increased density of activity in shared ocean areas. To oil and gas companies, shared use poses potential threats associated with damage to equipment and infrastructure, as well as the safety and security of personnel. To the fishing industry, oil and gas exploration and production can potentially result in loss of access to valuable fishing grounds.

Diminished freedom of movement through fishing grounds results from the regulated establishment of safety zones around oil and gas infrastructure as well as the need for safe navigation areas around operating seismic vessels. Safety zones (sometimes referred to as “exclusion zones”) are established to prevent damage to oil and gas infrastructure, minimize the likelihood and effects of environmental incidents, and maintain the safety and security of industry personnel. Safety zone radii around drilling rigs usually range from 500 m to 1 km. A rig with a 1.5 km safety zone radius would exclude approximately 7 km^2 from fishing activity which is about 0.2% of the total Canadian area of Georges Bank having a water depth less than 100 m (4,500 km^2) (Boudreau *et al.* 1999). It was reported by a fishing industry source that safety zones are enforced with increasing intensity as the perception of threats to security have risen over the past decade.

Georges Bank is a highly concentrated fishing ground in which stocks are fully utilized. The potential socio-economic effects of overcrowding and the loss of access can be attributed primarily to the decrease in landings and/or higher cost of harvesting the resource. As fleets must follow the very mobile supply of fish through the Bank, it can be assumed that the presence of oil and gas infrastructure and associated safety zones would result in lost opportunity and a fleet competing on an oceanographically smaller fishing ground. While it is impossible to provide a definitive answer in the abstract, it is possible to put the matter in perspective in a general way. Much depends on the species in question, and the location and timing of the exclusion:

- **Scallop:** This is a sedentary species. The fishery is conducted over the whole of the Bank where scallops occur in commercial quantities. Any scallops in an exclusion zone are lost to the industry as long as the zone is in effect. It may be possible to shift effort to other areas of the Bank if the exclusion zone is short term (a few months). This strategy has its limitations if the scallops in the exclusion zone are needed to achieve minimum meat size regulations.

- **Lobster:** The fishery occurs in a well-defined area along the edge of the Bank as the lobsters migrate during spring and fall. An exclusion zone in the preferred area would cause effort to be redirected to other areas potentially resulting in crowding and reduced harvesting efficiency. The catch usually falls short of the TAC, indicating economic limitations on the scope for shifting effort. Shifting the fishery in time may avoid catch losses, though if the exclusion coincides with the spring and fall peaks, shifting may not be possible.

- **Swordfish:** This is a migratory species. The fishery occurs in a well-defined area (slope of the Bank) and time (August-October). An exclusion zone in this area and at this time could result in non-recoverable losses. An exclusion zone outside this window would have little or no effect.

Stakeholders also identified the possibility of oil and gas infrastructure altering the migration patterns of pelagic species, diverting them away from Georges Bank entirely. Broadly speaking, socio-economic effects could include:

- Decreased landings and production values.
- Increased cost of production to fishing industry.
- Downward pressure on fishing industry employment.
- Social welfare losses associated with lower tax revenues and increased social transfers.

Finally, where petroleum-fishing industry interactions occur, damage to infrastructure and fishing equipment is inevitable. To address this reality, compensation processes and guidelines have been established.

4.6.1 Panel Comments

The 1999 Review Panel acknowledged overlapping demand for access from the fishing and petroleum industry and considered loss of fishing access as a result of seismic and exploration drilling activities as an inconvenience and disruption to patterns of fishing. While some panel participants believed the degree to which fishing fleets and petroleum industry operators can coexist successfully depends on effective consultation and planning, others maintained that the Bank is so heavily utilized now that displacement of vessels from the area would result in overcrowding in other areas. The loss of access was a real concern particularly due to the uncertainty surrounding potential petroleum activity scenarios, each of which could result in different exclusion requirements.

4.6.2 Evolution of Socio-economic Conditions

Over the past decade, little has changed on Georges Bank from a socio-economic perspective. While the fishing industry has weathered cyclical variation in production and revenue, Georges Bank has remained an important and intensely harvested fishing ground with major socio-economic importance to communities in Nova Scotia. The potential effect of diminished access to this resource remains the same as it was a decade ago. As noted in Section 2.3, the value of the fishery can fluctuate in a given year depending on the status of the various resources.

4.6.3 Progress in Mitigation

Mitigation strategies for lost access and overcrowding are limited. While there are explicit compensation guidelines for damages related to offshore petroleum activity in place, damage is mostly limited to that caused by debris, spill, or discharge (C-NLOPB and CNSOPB 2002). Demonstrating damage caused by restricted access or lost opportunity is often difficult to determine.

Mitigation remains relatively unchanged, with the focus on effective stakeholder consultations to fully understand potential overlaps in time and space. Environmental assessments of proposed projects are required to consider temporal and spatial overlaps in activity and address effects of fisheries exclusion. Seasonal avoidance may be a potential option, scheduling seismic and exploratory drilling activities to avoid peak fishing periods. While the Study Team is not aware of a specific protocol being proposed, it can be generally noted that stakeholder engagement and community consultation have played increasingly prominent roles in petroleum industry development in recent years.

An example of this is the organization of “ONE OCEAN”, an inter-industry organization providing a forum to enhance communications and information exchange between Newfoundland and

Labrador's fishing and petroleum industries. ONE OCEAN is comprised of an advisory board consisting of representatives from each industry, including members of the Fish, Food and Allied Workers union; the Fisheries Association of Newfoundland and Labrador; and the Canadian Association of Petroleum Producers. Recognizing that the continued growth of the fishing and petroleum industries is critical to the economy of Newfoundland and Labrador, ONE OCEAN provides a practical forum to discuss how these industries can co-exist in a sustainable manner. ONE OCEAN serves as a medium for information exchange regarding industry operational activities between the fishing and petroleum industries in Newfoundland and Labrador, initiates research and industry specific activities to meet industry challenges, and promotes cooperation, transparency and information dissemination between these industry sectors. They also coordinate and attend meetings between the operators and fish, food and Allied Workers Union with respect to environmental assessments (refer to http://www.oneocean.ca).

One of the undertakings of ONE OCEAN was to send a delegation representing the Advisory Board to participate in a study tour of Norway and the United Kingdom to explore how similar inter-industry groups in other parts of the world operate where fisheries and oil and gas industries co-exist. In the regions visited by the delegation, it was obvious that the petroleum industry was much more mature than it was offshore Atlantic Canada. Fishing and petroleum representatives in Bergen, Norway, for example shared that the relationship between the two industries was once antagonistic but over time the groups have developed a relationship and now share an appreciation for each other (ONE OCEAN 2003).

As reported by ONE OCEAN, it became apparent from the tour that while conflict may always exist in some form between the sectors, a good working relationship has developed. The key to co-existence seemed to be focusing on striking a balance to minimize adverse impacts and maximize shared opportunities. This tour confirmed to ONE OCEAN "that a 'solid' working relationship between these two vital industries is not only achievable, but also that a 'committed effort' by both groups can and will accomplish much" (ONE OCEAN 2003).

Although there is no such organization established in Nova Scotia, ONE OCEAN could potentially serve as a model for the future, particularly if oil and gas activities proceed on Georges Bank. Unrelated to industry liaison, but also potentially effective in addressing access and overcrowding issues are the technological advances in sea bed mapping that have benefited fisheries in Georges Bank over the past decade, where detailed images have been used in planning the scallop harvest. Through the use of detailed bottom mapping, it is possible that the siting of infrastructure and selection of a safety zone could be made with a more accurate identification of economically important fishing grounds.

4.6.4 Residual Issues

There are no specific residual issues with respect to loss of access and exclusion of fisheries that would require additional research and consideration. It remains that successful coexistence of fisheries and petroleum interest requires effective consultation and coordination of activities.

4.7 ADDITIONAL ISSUES

In addition to the key issues discussed above, the Georges Bank Review Panel considered other environmental effects of offshore oil and gas activities. These include other drill rig discharges, including domestic discharges, light and sound emissions from exploration drilling, and potential effects related to transportation. These issues and advancements in scientific knowledge and mitigation are addressed below, as applicable.

4.7.1 Panel Comments

Little attention was given by the 1999 Review Panel, to incidental wastes associated with offshore drilling. These incidental wastes include, but are not limited to: fluids such as salt solutions, polymers, test fluids and various additives; bilge and ballast water; cooling water; deck drainage; and domestic sewage. Noise, lights and flaring residues were also identified as other operational discharges. The Panel noted that some workshop participants expressed concern about potential change in species migration patterns to avoid areas of increased activity caused by noise, lights, and/or chemical discharge.

The Panel also noted that presenters frequently expressed concerns about cumulative effects related to transporting oil or gas by pipeline or tanker. Spills associated with tankers and pipelines are addressed in Section 4.5. Concerns related to interference of laying pipelines (*e.g.,* benthic damage, loss of fishing access, barriers to lobster movement) are discussed below.

4.7.2 Advancement in Scientific Knowledge

4.7.2.1 Operational Discharges

For other non-drilling related discharges, Hurley and Ellis (2004), in their review of oil and gas EEM programs in Atlantic Canada and the Beaufort Sea, found no indication of specific effects of non-drilling related discharges or synergistic effects in combination with drill waste. These discharges, treated to comply with applicable regulatory standards prior to release (*e.g.,* OWTG), are diluted quickly upon discharge and difficult to measure. These discharges, therefore, have not been the focus of assessment, monitoring, or mitigation and there are no significant advances in scientific knowledge regarding these discharges.

Underwater Noise

In addition to noise generated by seismic surveys (refer to Section 4.1), underwater noise is also generated by exploration (*e.g.,* drilling noise), construction, production and decommissioning phases of offshore oil and gas development. Although these noises may not induce physical injury to marine organisms, chronic exposure may interfere with normal communication and behavioural functions (Payne 2004).

Research on the effects of underwater noise associated with oil and gas activities is generally dominated by seismic noise. In comparison, there are much fewer published studies on drilling noise and other noise generated by construction, production and decommissioning. An assessment of underwater background noise near the Sable Gully, Laurentian Channel, and Sable Bank found the noise field to be dominated by vocalizing fin whales (at 20 Hz), shipping (from 50 to 200 Hz), and wind stress on the ocean surface (above 200 Hz) (Desharnais and Collison 2001). Acoustical monitoring near a SOEP platform during active drilling in 2005 demonstrated that observed noise levels were primarily influenced by noise generated by supply boat thrusters (SOEP 2006, cited in Hurley 2009). When vessel contributions are removed, drill ships and semi-submersibles have the highest source levels, with fixed platforms and gravel islands having the lowest source levels of any oil and gas industry activity (Hurley 2009).

EEM observation data for behavioural reactions of the bowhead whale around a drill site in the Beaufort Sea suggested a zone of influence within 4-10 km from the drillship (Hurley and Ellis 2004). Hurley and Ellis (2004) also found that scientific literature suggests that underwater noise from drilling activities will not likely exceed ambient noise levels from 1-10 km from the source (Green 1985; Richardson *et al.* 1995), with behavioural reactions of marine mammals predicted to be limited to within this radius (LGL *et al.* 2000). The literature indicated that the sensitivity of whales to noise levels differed, where some whales exhibited behavioural changes during playback tests; however, these results were specific for one species whose main activity was feeding. In their review, Hurley and Ellis (2004) noted that no information on habituation was available which would be relevant when assessing potential interactions for migrating whales. The extent to which anthropogenic noise sources may interfere with normal communication and behavioural functions of marine mammals remains unclear.

Lights

The attraction of birds to lights and flares is not a new development. EEM data of exploratory drilling offshore Canada reviewed by Hurley and Ellis (2004) confirmed previous studies that the attraction of seabirds to lights and flares can result in injury or mortality. However, Hurley and Ellis (2004) consider the issue of the timing of drilling activities with respect to critical lifecycle stages, reporting, for example, that the period of greatest risk of attraction to offshore lights for Leach's Storm-Petrels is in September, when young birds are dispersing from nesting colonies and moving to offshore wintering grounds. There are no known bird species at risk in the Georges Bank area. The effect of lights on seabirds is not unique to Georges Bank and therefore potential effects can be assumed to be similar to that observed on the Scotian Shelf.

Pipelines

Since the 1999 Review, there have been several technological advances in relation to pipeline routing and studies about the potential environmental and socio-economic effects of pipeline installation and operation.

As noted in Section 2.1, advances in seabed mapping (multibeam mapping, in particular) allow for more precise routing of pipelines such that they may avoid important habitats and engineering constraints. The “sound images” of the seafloor are the marine equivalent of aerial photography, a technology which has revolutionized our understanding of the earth’s land surface for planning. This data is being used by the fishing industry to focus fishing efforts and may also serve to minimize environmental (*e.g.,* benthic disturbance to sensitive habitats) and socio-economic (interference with commercial fishing) effects during the planning phase of pipeline routing.

With respect to environmental effects on the marine environment as a result of pipeline installation, evidence has shown that effects are short-lived, with recovery of the habitat occurring shortly after pipeline installation. EEM surveys conducted in the nearshore showed kelp and other seaweeds reestablishing shortly after pipeline installation with full recovery of habitat over the buried pipeline observed within three years of pipeline installation (SEEMAG 2001). In 2009, EnCana installed a 172 km offshore export pipeline for the Deep Panuke offshore gas development project currently under construction and planned for commissioning in 2010. Deep Panuke EEM studies will further contribute to our understanding of benthic effects of pipeline construction in the marine environment offshore Nova Scotia.

As has been evidenced in numerous studies, including the SOEP EEM program, oil and gas installations, including pipelines, exhibit a reef effect shortly after installation (SEEMAG 2001); with several species of benthic invertebrates colonizing the structures.

Concerns raised by the fishing community in the vicinity of the landfall of the SOEP pipeline in Goldboro, Nova Scotia prompted an ESRF study (Martec *et al.* 2004) which examined potential effects of the SOEP pipeline on lobsters. This study found there to be a measurable low intensity, but highly localized, magnetic field about the pipeline (extending some two to three metres outwards) and low frequency tonals (within the hearing range of lobster) that appear to emanate from the pipeline; neither of which had an effect on the experimental lobster catch near the pipeline as compared to the reference sites. Laboratory-based lobster mobility experiments demonstrated the ability of lobsters to scale an exposed underwater pipeline with varied success depending on degree of pipeline exposure, coating of the pipeline (smooth versus rough) and diameter of pipeline (32” and 48” diameter pipelines were tested) (Martec *et al.* 2004).

4.7.3 Progress in Mitigation

In the past decade, there have been no significant advancements in mitigation regarding the issues described above. This may well be due to the relatively low level of concern regarding these issues and negligible effects they are predicted to have on the marine environment. Updates to the Offshore Waste Treatment Guidelines (NEB *et al.* 2002) and Chemical Selection Guidelines (NEB *et al.* 2009) provide for progress in mitigation regarding incidental emissions.

4.7.4 Residual Issues

There are no significant residual issues regarding effects from incidental discharges, light and sound emissions, and potential effects related to transportation effects. As indicated in a recent environmental assessment biophysical data gap study (Hurley 2009) limited information is available to assess how the timing of exploration activities may affect interactions with migratory bird and marine mammal species. The Exploration and Production (E&P) Sound and Marine Life Joint Industry Programme (JIP), whose membership comprises leading exploration and production companies as well as a global industry association, has recognized knowledge gaps pertaining to underwater noise and physiological and behavioural effects on marine mammals. They have commissioned a broad range of studies to be carried out by independent agencies around the world (E&P Sound and Marine Life JIP 2008) to address these gaps (refer to Section 4.1.4).

4.8 CUMULATIVE EFFECTS

4.8.1 Panel Comments

The subject of cumulative effects was primarily discussed in two chapters in the 1999 Panel Report. Chapter 3 presented a brief discussion of cumulative effects in the context of Exploration and Drilling using an example of one to three wells in the Georges Bank area over a three to four year period. That section of the report reflected the divergent views of industry, a regulatory body (Environment Canada) and other participants.

Section 4.2 of the 1999 Panel Report discusses the issue in somewhat more detail and provided an overview of cumulative effects in the context of environmental assessment practice at the time. The report noted that Canadian practice generally requires that proponents of a major project are obliged to prepare an environmental impact statement which predicts the effects of a project including cumulative effects. The report also acknowledged this was not the case with Georges Bank since no actual project was being considered and as a result, “cumulative impacts were not discussed systematically”. The remainder of the section summarizes the information gathered during the hearings in relation to bioaccumulation, formation or produced water, transportation and infrastructure and green house gas emissions and climate change. The Panel did comment that “in the absence of any specific project proposal, precise quantification ... of cumulative effects from further development would necessarily be theoretical or speculative.”

4.8.2 Advancement in Approach

A workshop, sponsored by the Environmental Studies Research Funds, on Cumulative Environmental Assessment and monitoring on the Grand Banks and the Scotian Shelf was held in May, 2000 (Hatch Associates Limited and Griffiths Muecke Associates 2000). The workshop presented various approaches to undertaking Cumulative Effects Assessment (CEA) based on experience gained throughout Canada and internationally. The importance of monitoring data has been recognized by regulatory agencies and the industry and efforts expended on the collection of this type of information off Canada's east coast. This information can also contribute to the assessment of cumulative effects of oil and gas activities and these reports are now becoming more readily available through the CNSOPB and C-NLOPB with the results of over a decade of Environmental Effects Monitoring (EEM) programmes from the respective boards for both exploratory drilling (*e.g.,* Hurley and Ellis 2004) and development (CNSOPB 2009).

Horvath and Barnes (2004) discussed the application of Strategic Environmental Assessment (SEA) to offshore oil and gas development and noted that SEA is a process which allows for the systematic evaluation of a policy, plan or program at the earliest appropriate stage of the planning process and is normally undertaken by or on behalf of a regulator or government. They reviewed practice and experience in Canada in the early 2000s noting the examples of the CNSOPB and C-NLOPB in areas offshore Nova Scotia and Newfoundland and Labrador which consisted of SEAs for geographic areas (*e.g.,* Laurentian Subbasin; Jacques Whitford 2003, Orphan Basin; LGL 2003 and areas of the Scotian Shelf; CNSOPB 2003) or for various activities or phases such as seismic activities (LGL and Malme 1998) and drilling off of Nova Scotia (LGL *et al.* 2000). This approach has since continued with the release of other SEAs in the region (*e.g.,* CEF 2005; LGL 2005 and 2007; Sikumiut 2008; and LGL 2010). These SEAs generally provide an overall description of the existing biophysical and socio-economic environment; including identification of Valued Environmental Components, sensitive areas, potential issues, data gaps and recommendations for addressing those where appropriate, planning considerations and mitigation measures that could be implemented in the geographical area in question. It is recognized that this is done in the context and understanding that project specific environmental assessments would be undertaken for exploration and development phases of any future oil and gas related projects.

Davey *et al.* (2001) addressed linkages between SEA and CEA and noted challenges in the Canadian context (*i.e., CEAA*) including those associated with scoping, determination of significance and clarifying the roles and responsibilities of regulators. They presented guiding principles for using SEA to establish a framework for addressing CEA pointing out that a project proponent could refer to the SEA when assessing cumulative environmental effects. They further indicated that SEA could establish the current state of the environment and articulate the level of cumulative environmental effects as a result of all past and present activities. This in turn would facilitate the consideration of project specific and future project environmental effects that are acting in combination with past and present activities. The use of SEA is also evolving and Wagner and Jones (2004) suggested various approaches which are best applied on a case by case basis.

The practice of Cumulative Effects Assessment has also been evolving since the Panel Report. Guidance from the Canadian Environmental Assessment Agency (CEA Agency) has been available since 1994, and has subsequently been refined with the most recent update from the CEA Agency being in 2007 (CEA Agency 2007). As well, the actual practice and methodology, in terms of assessing cumulative environmental effects from a practitioner's perspective, has also evolved and improved in the intervening time period.

In summary, the application of CEA continues to evolve and there have been advances over the past decade both from a methodological perspective and in the availability of information and data to further support CEA. Both the CNSOPB and the C-NLOPB have used SEA for various activities and several geographic areas of East Coast offshore associated with oil and gas exploration and development. One natural extension of this regulatory approach would be to carry out a SEA specifically in relation to potential oil and gas activities on the Georges Bank. This would benefit future decision makers and provide a basis on which to further assess specific project environmental assessment and provide a context for the enhanced assessment of cumulative environmental effects.

4.8.3 Residual Issues

As indicated above a next logical step in the environmental assessment of oil and gas activities on Georges Bank, either to assist in a decision or subsequent to a decision be made to proceed with activities, would be to complete a strategic environmental assessment specific to that area. Subsequent EA of individual projects being evaluated would need to consider cumulative environmental effects which would include consideration of other potential projects on Georges Bank and on the Scotian Shelf (which currently has three producing fields). To put this in context, the Grand Banks has five major petroleum fields; three of which are currently in production. In comparison, the Gulf of Mexico has 37,564 applications to drill with 3559 active platforms (http://www.gomr.mms.gov/homepg/fastfacts/WaterDepth/WaterDepth.html) as of March 1, 2010. Information becoming available from environmental assessments done in this area will help inform the practice of cumulative effects offshore Nova Scotia.

5.0 Economics of Georges Bank

5.1 ECONOMICS OF THE GEORGES BANK FISHERIES

By generating employment and income on vessels, in plants and in support services, the Georges Bank fisheries have helped to sustain the economies of fishing communities in southwest Nova Scotia and southern New Brunswick for over 150 years. The scale of the contribution has fluctuated over the years, responding to the frequent shifts in resource conditions, technology and markets. The mix of communities supported by the fisheries has also changed with time, responding to the rise and fall of particular fish stocks, fleet rationalizations and consolidation and investment by the fishing industry.

In trying to assess the economic significance of Georges Bank, or any fishing area for that matter, it is important to maintain an historical perspective. Relying on a single year's data, or data covering only a brief period, could produce misleading conclusions.

In this section we examine what the Georges Bank fisheries mean in economic and social terms to communities mainly in southwest Nova Scotia. We look back over the past 10 years and assess the contribution in terms of the quantity and value of landings, number of vessels, employment and income at sea and on shore; and, we look forward to anticipate what a well-managed fishery with stocks at long-term potential levels could mean. We do note that earlier work was done by Gardner Pinfold on the Economic Significance of the Georges Bank Fishery up to 1997. This project focuses on the period 1998-2008.

To set the Georges Bank fishery into overall provincial fishing industry context, we draw on the results of a study on the "Economic Impact of the Ocean Sector in Nova Scotia" (Gardner Pinfold 2009) prepared for variety of federal and provincial government departments and the Nova Scotia Fisheries Sector Council. That study, which was recently updated to include 2008 statistics, estimates that the total product value of fish processed in Nova Scotia was approximately $789 million in 2008. Later in this chapter (Table 5.5), we show that the final product value of Georges Bank processed fish in 2008 is $179 million, accounting for 23% of total provincial product value. Total landed value of all fisheries in the province was $661 million in 2008.

For clarification, "landed value" is the value of fish landed at the wharf - usually the price paid to fishermen by buyers. "Product value" or "commercial value" is the value of the fish products as it leaves processing plants or for fresh product could reflect mark-up by buyers. Analysts use these terms to try to distinguish between the primary value of the resource (landed value) and the value added by processing (product value). It should be noted, however, that product value does not reflect retail pricing.

Table 5.1 shows the summary economic impact tables for both the fish processing industry and the commercial fisheries (harvesting sector). As can be seen in the table, fish processing accounts for 3,242 person-years of direct employment, with spin-off jobs adding an additional 5,466 person-years of employment. It is important to note that many people working in fish processing have seasonal jobs, which would mean employment levels would be higher than what is suggested by the person-year estimates. Also in Table 5.1, fish harvesting accounts for 3,487 person-years in direct employment with an additional 3,685 in spin-off jobs. The seasonality of work is also a characteristic of the harvesting sector.

Table 5.1 Economic Impact of the Provincial Fishing Industry (2008)

	Direct	Spin-off*	Total
Fish Processing			
GDP ($000s)	153,143	351,519	504,662
Employment (P-Y)	3,242	5,466	8,709
Household Income ($000s)	117,638	225,179	342,818
Fish Harvesting			
GDP ($000s)	332,054	205,191	539,628
Employment (P-Y)	3,462	3,685	7,172
Household Income ($000s)	232,427	125,573	359,668

* Includes impact on fishing industry.

For landed value, Georges Bank landings were $113 million in 2008, accounting for 17% of provincial industry totals.

The ratio of Georges Bank to total provincial data for both landed value and commercial production is indicative of the economic value of the Georges Bank fishery. Estimating the specific full economic impact of the Georges Bank fishery including economic spin off estimates is beyond the scope of this assessment.

5.1.1 Landings and Production

In 1998 the Panel noted that Georges Bank was widely regarded as one of the world's most productive fishing grounds. The significant role played by Georges Bank in Canadian fisheries history can be traced at least as far back as the mid-1800s and that it continues to support a very diversified and valuable fishery. The Canadian Georges Bank fishery in 1997 provided employment for approximately 1,000 people at sea harvesting, generating direct income of $32 million, and 650 people in processing ashore, with direct income of $6 million. Support services are also provided for the 180 active vessels and the processing sector. The value to the regional economy, the product value, has ranged from $57 million to $148 million annually in the period 1990 – 97 (Gardner Pinfold 1998). Overall, the Panel concluded that, "Georges Bank has a significant and fully-exploited fishery and is heavily used.

Our review of the socio-economic circumstance associated with the fishery in Georges Bank would lead observers to make an identical concluding statements the Panel arrived at in 1999.

The fishing industry has evolved in terms of fishing technology that ensure the fishery will continue to be conducted reflecting modern management approach based on improved enterprise economics. Although fewer fishermen and vessels are active on Georges Bank now than was the case in 1998, the overall importance of the Georges Bank fishery is as important to the economy of southwest Nova Scotia today as it was in 1999.

Table 5.2 compares key economic data related to the fishery between 1997 and 2007. At sea employment has risen from 1,000 to 1,055. However, onshore employment has dropped mainly due to the at-sea processing of scallops.

Table 5.2 Comparison of Key Economic Data Related to Georges Bank Fishery, 1997 and 2007 ($2008)

	1997	2007
Employment - at Sea:		
Person-Years*	n/a	720
Persons	1,000	1,055
Employment - Onshore Processing:		
Person-Years*	650	375
Persons**	n/a	575
Income at Sea	$40 million	$33.55 million
Processing Income	$7.5 million	7.4 million
Number of Vessels	180	226
Product Value Range ($1998)	$62.5 - $185 million (1990 – 1997)	$114 – 245 million (1998 – 2007)

* Estimate derived by Gardner Pinfold for this study based on fishing activity by month.
** Person-Years to Persons ratio for fish processing and fish harvesting taken from "Economic Impact of the Ocean Sector in Nova Scotia, 2002 – 2006" study.

Value of Landings

The past 10 years alone have witnessed wide swings in fishing activity on Georges Bank leading to substantial shifts in the impact on the regional economy. These swings, as reflected in the quantity and value of landings, are set out in Table 5.3. The data show that landed value can swing from $66 to $130 million, depending on resource and market conditions. This pattern serves to illustrate the point that fluctuation continues to be one of the few constants in the fishery.

The landed value data in Table 5.3 are based on information provided by DFO. These values reflect DFO's best estimate of market value. They have made adjustments to reflect the integrated nature of some of the fisheries. Some prices are those agreed to between vessel-owners and buyers. Where vessel-owners and buyers are one and the same (*e.g.,* integrated companies), the significance of price is related to determining crew incomes; prices do not necessarily reflect competitive conditions (they are generally lower, thus the need to adjust to market prices).

During the 1998 – 2008 period, Table 5.4 shows that shellfish landings were at their peak from 2000 – 2003. A period of decline followed with bottom happening in 2005, however the resource recovered significantly by 2008.

Groundfish landings over the same period have been increasing at a fairly steady rate. They have almost doubled between 1998 at 9.1 million tonnes to 17.5 million tonnes in 2005 and in 2008 almost 17 million tonnes were landed.

Pelagic lands have been more volatile with an extreme low of 200,000 tonnes in 1999 and an extreme high of 3.5 million tonnes in 2001.

Table 5.3 Value ($) of Georges Bank Fishery 1998-2008 by Major Species Groups

	Value			
Year	Shellfish	Pelagic	Groundfish	Total
1998	$76,737,669	$1,632,360	$13,661,660	$92,031,689
1999	$70,191,463	$1,086,219	$15,052,266	$86,353,712
2000	$111,065,095	$773,117	$19,036,742	$130,898,610
2001	$92,464,152	$2,014,032	$20,704,813	$115,187,346
2002	$82,822,715	$1,160,581	$18,987,213	$102,985,151
2003	$81,773,381	$2,049,271	$18,790,075	$102,620,302
2004	$55,285,124	$1,630,760	$14,783,787	$71,699,969
2005	$39,968,609	$4,048,597	$21,954,619	$65,971,825
2006	$56,928,794	$2,981,315	$22,784,812	$82,694,920
2007	$58,600,319	$2,630,077	$20,517,070	$81,747,793
2008	$86,657,114	$4,119,409	$22,614,829	$113,391,351

Table 5.4 Quantity of Georges Bank Landings 1998-2008 by Major Species Groups (t)

	Quantity			
Year	Shellfish	Pelagic	Groundfish	Total
1998	33,312,323	295,074	9,105,891	42,713,288
1999	30,930,585	203,976	9,205,031	40,339,592
2000	56,728,486	395,521	12,058,188	69,182,195
2001	57,233,327	3,506,064	14,850,696	75,590,087
2002	55,448,613	1,727,294	13,158,519	70,337,727
2003	51,469,784	1,955,140	12,917,714	66,344,030
2004	31,028,067	223,720	13,782,198	45,034,026
2005	22,554,181	457,914	17,535,363	40,547,458
2006	34,219,544	355,185	14,664,159	49,238,888
2007	36,778,583	302,260	13,883,898	50,964,763
2008	48,803,909	469,639	16,802,866	66,076,413

Product Value

The value to the regional economy is based not just on landed value, but on the value of the final product. Adding value through processing and shipping contributes to regional employment, and individual and corporate income.

Processing typically adds 50-100 percent to landed value at the wholesale level, though the figure could be higher in some market conditions. This varies by species, ranging from 70-100 percent for scallops and lobster to as little as 50 percent for some groundfish products. DFO has provided their best estimates of product value for the Georges Bank fishery over the 1998 – 2008 period. Their estimate indicates that in the best year (2000), the Georges Bank fisheries contributed as much as $245 million to the local economy; in the poorest year (2005), the contribution was as low as $115 million (Table 5.5). Most recently, in 2008, the value is $180 million. It is understood that industry participants believe the DFO estimates of product value are understated. Unfortunately, a comprehensive database is not available to confirm this observation.

Table 5.5 Final Product Values in Millions of Dollars for the Four Major Fisheries that Operate in NAFO Zone 5Z

Year	Shellfish (million $)	Groundfish (million $)	Pelagic (million $)	Other (million $)	Total (million $)
1998	143.45	34.15	2.28	0.02	179.90
1999	128.65	36.97	1.49	0.03	167.15
2000	198.90	45.54	1.21	0.03	245.67
2001	161.47	48.31	5.29	0.01	215.08
2002	141.44	43.33	2.46	0.02	187.24
2003	135.84	41.71	3.53	0.01	181.09
2004	89.94	32.22	1.97	0.00	124.13
2005	63.16	46.82	4.75	0.00	114.74
2006	88.73	47.66	3.43	0.00	139.82
2007	89.25	41.99	2.96	0.00	134.20
2008p	129.58	45.23	4.53	0.00	179.34

Note: The final product values are expressed in 2008 dollars. A ‘p’ refers to preliminary data

5.1.2 Employment and Income

Vessels

Prior to 1998 Gardner Pinfold reported that as many as 300 vessels participated annually in one or more of the Georges Bank fisheries. Changes in stock abundance and access arrangements caused the fleet mix to change from year to year, and also led to a general decline in the number of trips made. But the overall number of active vessels remained fairly stable. In Table 5.6 DFO estimates 226 vessels were active in 2007.

Table 5.6 Estimated Number of Individuals Employed in Select NAFO Zone 5ZE Fisheries in 2007

Fishery	Number of Specialist Vessels	Average Crew Size	Estimated Employed Individuals
Shellfish	21	21	440
Groundfish	117	3	351
Pelagic	88	3	264
Total	**226**		**1,055**

This changed in 1997, as declining quotas coupled with management mechanisms aimed at promoting harvesting efficiency (*i.e.,* ITQs and community management) contributed to a drop in vessel numbers.

Harvesting Employment and Income

The Georges Bank fisheries provided harvesting employment for an estimated 1,055 persons in southwest Nova Scotia in 2007 (see Table 5.7). The work is year-round for many (those on scallop and lobster vessels and in associated on-shore activities); and contributes to year-round or seasonal employment for many others involved in the groundfish and swordfish fisheries. This level of crew employment is very similar to that estimated in 1997. DFO has estimated the income earned from fishing by the 1,055 persons crew. They did this by looking at share arrangements. In 2007, crew income attributable to the Georges Bank fishery is $33.5 million.

Table 5.7 Estimated Total Income in Millions of Dollars Generated by Vessels Fishing in NAFO Zone 5ZE in 2007

Fishery	Estimated Employed Individuals	Estimated Vessel Crew Income (million $)
Shellfish	440	23.4
Groundfish	351	9.23
Pelagic	264	0.92
Total	**1,055**	**33.55**

Depending on the fishery and the vessel in question, the duration of employment may range from a few days to year-round. For most offshore scallop fishermen (who represent about 40 percent of the total involved), the season is roughly ten months, though some of the time is spent on Browns where in a typical year 20-30 percent of the offshore scallop catch is taken.

Fishing effort for groundfish and swordfish is highly seasonal for the approximately 500 fishermen involved. The fishery is concentrated in the June-August period, with limited activity after October. The lobster fishery is less seasonal, though landings tend to be concentrated in the April to June period, and also in the November to January period.

It continues to be the case for all participating vessels and fishermen, there are no alternatives to Georges Bank. All fisheries on the east coast are fully utilized. Shifting to alternative grounds is not possible (even if licences permitted) without displacing others due to quota or space limitations.

Processing Employment and Income

Again, DFO has done work to estimate the processing sector employment and income impacts associated with the Georges Bank fishery. The results of their work are shown in Table 5.8. Fish landed from Georges Bank is processed in plants throughout the five counties in southwest Nova Scotia. The form and extent of processing, and hence employment, vary by species.

- Scallop: The major part of processing – shucking – occurs at sea and is included in vessel employment. It is this sector that has undergone the greatest transformation with the advent of freezer vessels. On shore processing for some of the landings still involves washing, freezing and packing. Product is sold fresh or frozen, with the bulk shipped mainly to the US.
- Lobster: On shore processing involves grading, storage and packing. Product is sold live, with the bulk shipped to the US.
- Groundfish: The catch is generally headed and gutted at sea. Further processing on shore involves one or more of the following: packing for the dressed fish market; filleting; splitting and salting (cod); or, further processing into products such as sticks, portions and entrées. We understand that more products such as fresh and frozen fillets are now sold in a more processed form than was the case in 1999. This could suggest the processing hours used in this study are underestimated. Several processing plants have invested in their processing facilities to take advantage of the high quality haddock being landed from Georges Bank.
- Swordfish: The catch is generally sold whole fresh to retail outlets or restaurants, but may be processed into steaks before shipping.

Table 5.8 Estimated Number of Full-time, Full-year Equivalent Employment Positions Associated with Seafood Processing of Select Fishery Landings Caught in NAFO Zone 5ZE in 2007

Fishery	Annual Landings (t)	Processing Rate (t/h)	Annual Processing Hours (h)	Annual Full-time Employment Equivalents Person-Years
Sea Scallops	4,400	0.04	110,000	61
Offshore Lobster	256	0.05	5,120	3
Groundfish	13,884	0.025	555,360	309
Swordfish	224	0.045	4,978	3
Total	**18,764**		**675,458**	**375**

Note: The number of hours an average employee works per year was assumed to be 1800.

Table 5.8 shows the annual full time employment equivalents for the processing of Georges Bank landing to be 375 persons. This compares to 254 person-years estimated in 1997. These estimates are based on labour requirements by species provided by industry. Data are presented in full-time equivalents (FTE) to allow comparisons with annual measures. Table 5.9 sets out the calculations.

Income

The processing income attributable to Georges Bank fisheries is estimated to have generated about $7.5 million in direct payment to plant workers (Table 5.9). This compares to $6 million estimated in 1997.

It should be noted that the total income figures in this section should be seen as a minimum. In addition to personal income, the fishery generates profits for many enterprises and companies. It is not possible to develop accurate profit measures because operating cost data at the enterprise level are unavailable. Including this would add several million dollars to total income for both harvesting and processing.

Table 5.9 Estimated Total Annual Income Earned in Seafood Processing of Select Fishery Landings Caught in NAFO Zone 5ZE in 2007

Fishery	Annual Processing Hours (h)	Labour Wage (h)	Total Annual Income Earned ($000)
Scallops	110,000	11.00	1,200
Offshore Lobster	5,120	11.00	56
Groundfish	555,360	11.00	6,100
Swordfish	4,978	11.00	55
Total	**675,458**		**7,411**

Note: The hourly wage for labour was assumed to be $11.00.

Regional Dependence on Georges Bank

Vessels active on Georges Bank land catches in several ports in southwest Nova Scotia. These communities are not the only ones to benefit from the Georges Bank fisheries, but they are the most obvious ones. Others include communities where vessel crews and plant workers live, and where processing plants are located. These are not necessarily the same as the ports of landing.

Landings data by community are not available for all ports because confidentiality restrictions prohibit publication where particular enterprises could be identified. For this reason, data are aggregated to the county level.

Georges Bank accounted for about 23 percent of the total value of landings in 2007 in the five counties comprising southwest Nova Scotia. Historically, this ranges between 10 and 20 percent, depending largely on the relative performance of the offshore scallop and inshore lobster fisheries. In 1997 it was reported at 16 percent.

Table 5.10 Georges Bank Landings by County, 2007

County	District Total	Total from NAFO Zone 5Ze	%
Shelburne	$160,373,701	$37,598,602	23.4
Yarmouth	$142,423,322	$18,535,192	13.0
Digby	$51,886,545	$4,435,695	8.5
Lunenburg	$37,820,942	$16,992,037	44.7
Queens	$14,861,107	$4,002,569	27.0
Other		$183,698	
Total	**$360,667,727**	**$81,647,793**	**22.6**

Before reviewing the relative importance of Georges Bank in the context of the fisheries in the region, it is worth noting:

- In some counties, Shelburne and Yarmouth in particular, though Georges Bank landings are significant, they tend to be obscured by the rich inshore lobster fishery, one of the most valuable in Atlantic Canada.

The dependence on Georges Bank varies widely by county (Table 5.10).

- Lunenburg: Overall dependence is greatest in Lunenburg (45 percent of the total landed value). Almost all landings from Georges Bank are scallops.
- Queens: The scallop fishery is also a substantial contributor in Queens County, where Georges Bank accounts for 27 percent of landed value.
- Shelburne: The dependence in Shelburne County arises mainly from groundfish and lobster. The county is home to much of the fixed gear and offshore lobster fleets, dependence on Georges Bank stands at 23 percent.
- Yarmouth: The dependence in Yarmouth County arises mainly from groundfish and scallops. The county is home to much of the inshore mobile gear fleet. Overall dependence is about 13 percent. We do note that an increase in groundfish processing from Georges Bank has been occurring in the West Pubnico area.
- Digby: At about 9 percent, the dependence in Digby arises almost exclusively from the scallop fleet. Groundfish makes a more modest contribution.

5.2 VALUE OF GEORGES BANK REGION ASSOCIATED WITH PETROLEUM ACTIVITY

The 1999 Review Panel noted the economic benefits that can be associated with offshore petroleum exploration:

> *A three to four year exploration and drilling program has been credibly estimated to generate about $53 million to $70 million in direct economic benefits, and create 240 to 320 jobs for Nova Scotians. In addition, there would be indirect benefits and some opportunity for further economic diversification* (NRCan and NSPD 1999, p. 38).

In this section of our report, we provide an analysis of the Nova Scotia experience as a whole, with all phases of the offshore oil and gas industry. The benefits of both exploration and production are presented.

The assessment of the overall value of the Georges Bank region associated with petroleum can only be done in the abstract as there is currently no industry activity due to the moratorium. In this section, we will demonstrate the potential scale of value of petroleum activity drawing on Nova Scotia offshore energy projects, and consider potential opportunities and economic benefits to the region.

5.2.1 Potential Opportunities

Offshore activity is usually divided into four phases:

- Exploration (seismic surveying, exploration drilling);
- Development (engineering, design and construction of production facilities and export mechanisms);
- Production; and
- Abandonment.

Opportunities for local interests to participate in offshore activities arise during each phase, with the development phase likely offering the most economic opportunities. Opportunities fall into three general categories:

- employment
- services
- materials and equipment.

Of the three, employment and services hold the greatest potential. Materials and equipment requirements tend to be highly specialized, with capability in eastern Canada has increased markedly due to the establishment of the offshore oil and gas industry in both Newfoundland and Labrador and Nova Scotia.

Given the uncertainties surrounding the scale and timing of any offshore activity, it is difficult to do much more than list the general categories of opportunity. This is provided in Table 5.11. Each category would contain a number of more specific occupations and business opportunities.

What seems clear from the experience in Nova Scotia and Newfoundland and Labrador is that seizing these opportunities requires initiative. In the case of jobs, it also requires the right mix of skills and abilities. In the case of services, it also requires an ability to produce a product meeting industry standards of quality, price and delivery. Developing joint ventures with established companies has proven to be an effective strategy for entrepreneurs wishing to enter the industry.

Recently, a 12-year Retrospective of Natural Gas Production in Nova Scotia was completed (Stantec Consulting Limited 2009b). This report provides a summary of economic benefits attributable to the existing industry and, on a case study basis, documents many business success stories. Any potential development on Georges Bank will benefit from the industry experience established in the province through the existing projects and in all likelihood would achieve higher rates of provincial benefits. An important conclusion of the Stantec report is as follows:

> *Nova Scotia's experiences in the offshore to-date can be used to continue to succeed in this competitive industry, both here and abroad. The amassed knowledge and experience is a benefit and a value that cannot be quantified, but that will surely continue to be used to operate and compete successfully in the offshore industry around the world.*

Table 5.11 Offshore Oil and Gas Employment and Service Opportunities

	Exploration	Development	Production	Abandonment
Employment	• seismic vessel crew • support vessel crew • drill rig crew • shore base staff • catering staff	• support vessel crew • drill rig crew • shore base staff • catering staff • project mgt staff • engineers/consultants • divers • fabrication trades – plate/pipe fitters – welders – instrument fitters – electricians – construction trades – fitters – welders – electricians – civil trades • barge/crane crews	• project administration staff • offshore platform staff • gas plant staff • shore base staff • support vessel crew • well maintenance	• barge/crane crews • support vessel crew • fabrication trades – plate/pipe fitters – welders • divers
Services	• marine transportation • air transportation • drilling services • catering • vehicle leasing • equipment rental • warehousing • consulting • wholesale trade • retail trade	• engineering • fabrication • construction • transportation • maintenance • marine transportation • air transportation • catering • vehicle leasing • equipment rental • warehousing • consulting • wholesale trade • retail trade	• office services • well services • transportation • marine transportation • air transportation • catering • warehousing	• marine transportation • fabrication

Specific examples of how employment and service opportunities could potentially benefit the Southern Nova Scotia region are discussed in Section 5.2.5.

5.2.2 Nova Scotia Offshore Energy Projects

Cohasset and Panuke Oilfields

The first offshore petroleum project was the development of the Cohasset and Panuke (COPAN) oilfields. Production began in June 1992 and continued to mid-December 1999. This facility consisted of a production platform on the Cohasset site connected by a subsea pipeline to a satellite platform at the Panuke well site. Light crude oil was transferred through a subsea pipeline to a storage tanker moored at a Calm Buoy near the production platform. This facility produced 7.1 million cubic metres of oil during its life span.

Sable Offshore Energy Project

The Sable Offshore Energy Project (SOEP) was formed by a consortium of five companies:

- ExxonMobil Canada Properties Ltd,
- Shell Canada Limited,
- Imperial Oil Resources,
- Pengrowth Energy Trust (Emera Inc.) and
- Mosbacher Operating Limited.

Following regulatory approval in 1998, SOEP undertook the development of natural gas production from discoveries near Sable Island. Production began in late 1999 in what is referred to as the Tier I project. Subsequently, Tier II saw the development of the Alma Field in late 2003 and South Venture in late 2004.

SOEP constructed a pipeline to bring natural gas from the Sable area to Goldboro, NS. A natural gas processing plant was constructed at Goldboro to prepare the raw gas for market, and Maritime and Northeast Pipeline (M&NP) constructed an onshore pipeline to carry natural gas to the principle consumer market in the northeast US, with laterals to Point Tupper, Halifax, Amherst and Saint John. This project is still operating. A detailed analysis of the economic benefits associated with the SOEP is included in Section 5.2.4.

Deep Panuke

In 1999, the Deep Panuke gas was discovered below the former Panuke oil field. The project received regulatory approvals in 2007.

The offshore production facility will process sour gas creating “sweet” market gas which will be transported to Goldboro in a subsea pipeline that is adjacent to the existing SOEP pipeline.

The offshore pipeline will be connected to the M&NP onshore pipeline through a metering station at Goldboro for market distribution. Present activities include the construction of production facilities and preparations for the installation of the pipeline, to be completed in 2009. Natural gas production is scheduled to begin in 2010.

5.2.3 Entitlement to Economic Benefits for the Offshore

According to the 12-Year Retrospective (Stantec 2010b), Federal legislation requires parties that wish to undertake offshore gas or oil related work or activity to submit development plans for approval. These development plans must contain Canada-NS benefits plans with provisions for (*Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act* 1988):

- The employment of Canadians, especially members of the provincial labour force;

- A program shall be carried out and expenditures made to promote education and training in the province in relation to offshore petroleum resource activities; and
- Giving first consideration to services provided from within NS and to goods manufactured in the province, where those services and goods are competitive in terms of fair market price, quality and delivery.

The rights of the Province as the principal beneficiary of its offshore petroleum resources are recognized under the Canada-Nova Scotia Offshore Petroleum Resources Accord, an agreement entered into by the Government of Canada and the Government of NS in 1986.

The agreement entitles the Government of NS to manage revenues from its offshore petroleum resources as if these resources were located on the land portion of the province. The Province therefore receives the proceeds of all fees and provincial-type taxes from offshore gas and oil activity, including royalties, bonus payments, rental and license fees, provincial corporate income tax, and sales tax. These revenues are extremely valuable to the Province. In fact, after personal income tax and sales tax, the gas and oil industry is the largest single source of provincially-generated revenue for NS (CAPP 2008; NSDE and NSE 2009). Offshore royalties contribute to all core government program areas, including education, health care, infrastructure, and debt reduction (CAPP 2008; NSDE and NSE 2009). The Government of NS estimates that $2.2 to $3 billion in royalties are expected to be paid to the Province over the life of SOEP alone (CAPP 2008).

In 2005, the benefits received by the Province were enhanced by the signing of an agreement requiring the federal government to make offset payments to reimburse NS for 100% of any reduction in federal transfer payments (*i.e.,* the Equalization Program) caused by offshore revenues. The arrangement included an advance payment of $830 million to give the Province immediate flexibility to reduce its outstanding debt (Government of Canada and Government of Nova Scotia 2005). The 1986 Offshore Accord also provides the Province with a statutory right to a portion of revenue Ottawa collects from our offshore developers. These revenues to the provinces are called the Crown Share Adjustment Payments. In 2008, an agreement was reached between the Province and the Government of Canada regarding payment to Nova Scotia for a portion of the crown share of offshore revenues. Based on the recommendation of an independent panel, Canada provided $234.4 million crown share adjustment payments to Nova Scotia in 2008. The two governments committed to work together to calculate future payments. It is estimated the total value of future payments related to the Sable Island and Deep Panuke Offshore Energy Projects will be approximately $633 million.

5.2.4 Economic Benefits

In Gardner Pinfold's 2009 study on the "Economic Impact of the Ocean Sector in Nova Scotia", the impacts associated with offshore oil and gas industry were documented for 2006. This analysis was recently updated to reflect 2008 statistics.

Table 5.12 shows the impacts for both development and production activities that took place in 2008. The data presented in this table is derived using the same methodology as used for the fishing industry in Table 5.1 and permits comparison of the relative economic scales of the two industries.

Table 5.12 Economic Impact of the Offshore Oil and Gas Industry (2008)

	Direct	Spin-off*	Total
Development			
GDP ($000s)	4,296	12,421	16,717
Employment (P-Y)	67	222	289
Household Income ($000s)	3,232	8,130	11,362
Production			
GDP ($000s)	1,166,618	206,771	1,373,388
Employment (P-Y)	614	3,392	4,006
Household Income ($000s)	42,939	137,399	180,338

Table 5.13 provides a summary of the economic benefits associated with the offshore petroleum industry over the period 1996 – 2007. As part of the Stantec report an input-output economic analysis was completed jointly by the Nova Scotia Department of Energy and the Department of Finance. It is important to note that Table 5.13 was derived in a separate analysis from that used to generate the information presented in Table 5.12. The information for Table 5.13 was taken from the 12-year Retrospective of Natural Gas Production (Stantec 2010b). Also, Table 5.13 covers multiple years from 1996 – 2007. The economic impact modeling provides estimates of employment, both direct and spinoff (which includes indirect and induced employment) and impacts on household income, as well as the resulting provincial government tax revenue from these personal incomes.

Note that the government revenue estimates in Table 5.13 below do not include direct revenue from offshore royalties and related revenues, nor does it include corporate income tax revenue from project partners (information that is confidential). The provincial government revenue includes both HST and income tax. Impact estimates are separately reported for all offshore exploration/development and production between 1996 and 2007.

Table 5.13 Socioeconomic Impacts from the Offshore, 1996-2007

		Offshore Exploration, Development & Production	Other Related Construction	Total	Annual Average
Expenditures ($ million)		**$1,935**	**$868**	**$2,803**	**$234**
Employment (person years)					
	Direct	16,650	2,802	19,452	1,621
	Spinoff	13,345	5,728	19,073	1,589
	Total	**29,995**	**8,530**	**38,525**	**3,210**

Table 5.13 Socioeconomic Impacts from the Offshore, 1996-2007

		Offshore Exploration, Development & Production	Other Related Construction	Total	Annual Average
Household ($ thousands)					
	Direct	$598,000	$151,039	$749,039	$6,242
	Spinoff	$454,000	$202,982	$656,982	$54,749
	Total	**$1,052,000**	**$354,021**	**$1,406,021**	**$117,168**
	Direct	$64,300	$22,720	$87,020	$7,252
	Spinoff	$47,000	$23,833	$70,833	$5,903
	Total	**$111,200**	**$46,553**	**$157,753**	**$13,146**

Source: Stantec 2010b

As reported in Stantec (2010b), "From 1996 to 2007, total employment (direct and spinoff) has been approximately 38,500 person years, or an average employment of about 3,200 per year (full-time equivalent). In the same period, total household income from the offshore has been approximately $1.406 billion, or an average of about $117 million per year. This income produced government tax revenues of approximately $158 million, or about $13 million per year."

Table 5.14 Nova Scotia Offshore Highlights

Project	Operational Status	Expenditures to 2007		Employment	
		$	% Spent in NS	Total person years	% Nova Scotians
Cohasset (Oil)	1996 - 2000	Total 2.6 billion	37.9%	2,150	84.3%
Sable Offshore Energy Project (Natural Gas)	1996 - ongoing	Total 5.3 billion	36.3%	15,185	58.8%
Deep Panuke (Natural Gas)	2007 +	Total 32.8 million	Unknown	128	42.3%

5.2.5 Detailed Analysis of the Sable Offshore Energy Project (SOEP)

As noted in the introduction to this section, a detailed assessment of the economic value of a petroleum industry development on Georges Bank can only be done in the abstract. To further illustrate the type and rate of economic benefits that can occur on an annual basis of an offshore development, we have assembled annual economic data for SOEP and have presented our findings in a summary table (Table 5.15).

By reviewing this table, the reader can gain an appreciation for annual economic activity associated with such a development. The data is not available to distinguish between pure project development and operational impacts. However, in the first column we show the key activities taking place each year. The greatest impacts associated with the project occur during years the greatest activity related to development was taking place. For instance in 1999, $510 million of project expenditures took place in the province of Nova Scotia. The peak employment occurred in the same year in terms of person-hours worked by Nova Scotians. At peak in 1999, 955 different people were working on the project. Following 1999, development did continue with work related to Tier II activity, however the economic activity was occurring at a lower rate than occurred in 1999. Total head count in employment stayed quite consistent between 1999 and 2004 with numbers ranging between 828 and 1,082.

Table5.15 Summary Table of Annual Activity Associated with the Sable Offshore Energy Project Showing Annual Expenditures and Employment Levels

Year	Activity	Total Expenditure	Total NS Expenditure	Total Employment	Total NS Employment	Head Count NS
		millions (2008)		million person hours		At Dec 31
1998	• Tier 1 Project Development – 60% complete • Increased onshore activity at Sheet Harbour pipe coating, Goldboro gas plant, and Point Tupper fractionation. • Thebaud, Venture, and North Triumph platforms progressing. • Drilling conducted at Venture Field.	**$1,081**	**$242**	**5.4**	**2.4**	**1,895**
1999	• Construction, installation, and commissioning of all platforms, pipelines, and plants. • Received regulatory approval to operate all facilities.	**$1,347**	**$510**	**6.1**	**3.5**	**955**
2000	• Drilling work wound down as 10th well was completed. • Natural gas production began through Maritimes and Northeast Pipeline.	**$443**	**$209**	**2.7**	**2.3**	**828***

Table5.15 Summary Table of Annual Activity Associated with the Sable Offshore Energy Project Showing Annual Expenditures and Employment Levels

Year	Activity	Total Expenditure	Total NS Expenditure	Total Employment	Total NS Employment	Head Count NS
		millions (2008)		million person hours		At Dec 31
2001	• Completion of second full year of production. • ExxonMobil becomes operator of SOEP. • Preliminary engineering on Tier II gas fields.	**$330**	**$166**	**1.4**	**1.7**	**953**
2002	• Project achieves highest average monthly sales and daily production. • Construction and upgrades complete at Goldboro plant. • Tier II development on two fields progresses. • Compression Project preliminary engineering completed.	**$510**	**$205**	**1.8**	**0.98**	**900**
2003	• Upgrades at Point Tupper and Goldboro complete. • Tier II production at Alma field authorized and underway. • Tier II construction on Venture platform continues. • Compression project contracts awarded.	**$610**	**$240**	**3.0**	**1.9**	**974**
2004	• Improvements to Goldboro and Point Tupper initiated. • Production license granted	**$560**	**$199**	**2.5**	**1.6**	**1,082**

Table5.15 Summary Table of Annual Activity Associated with the Sable Offshore Energy Project Showing Annual Expenditures and Employment Levels

Year	Activity	Total Expenditure	Total NS Expenditure	Total Employment	Total NS Employment	Head Count NS
		millions (2008)		million person hours		At Dec 31
	for Tier II South Venture field. • Tier II drilling at SV commences. • First gas at SV achieved in December. • Compression Project ongoing.					
2005	• Additional SV wells brought into production. • Upgrades to Thebaud, Venture, North Triumph cranes completed. • Drilling of Venture V-7 completed. • Tier II modifications to Thebaud initiated. • Compression project ongoing.	**$490**	**$153**	**2.3**	**1.0**	**733**
2006	• Drilling activities completed on Alma 3 well. • Commissioning and startup of Compression Project. • Tier II Thebaud modifications ongoing. • Tie-ins brownfield work initiated.	**$486**	**$186**	**2.2**	**1.4**	**697**
2007	• Marks decade of continuous operation. • Production from North Triumph platform re-established. • Commissioning of Thebaud compression	**$249**	**$110**	**1.2**	**1.1**	**411**

Table5.15 Summary Table of Annual Activity Associated with the Sable Offshore Energy Project Showing Annual Expenditures and Employment Levels

Year	Activity	Total Expenditure	Total NS Expenditure	Total Employment	Total NS Employment	Head Count NS
		millions (2008)		million person hours		At Dec 31
	platform continued. • Compression facilities operating.					
2008	• Drill rig secured and materials ordered for Alma 4 well. • Internal inspections of two pipelines completed. • No new project development work occurred. • Planning of a maintenance campaign scheduled for the summer of 2009.	**$197**	**$106**	**0.94**	**0.86**	**336**

* As at January 30, 2000.
Source: Sable Offshore Energy Project, Canada – Nova Scotia Benefit Report. 1999 – 2008 CNSOPB.

By 2005 employment levels began to drop until 2008 when 336 people worked on the project. At this point the project is pretty well purely operations with little or no development work being undertaken.

5.2.6 Potential Economic Benefits to Southern Nova Scotia

Petroleum exploration and production activities can offer potential economic benefits to the Southern Region of Nova Scotia in the form of employment and business opportunities realized from the range of services required in the support of offshore operations (refer to Section 5.2.1). Geographic location and proximity to infrastructure are key elements of support activities related to both the exploration and production phases of petroleum sector development.

In the 12-Year Retrospective of Natural Gas Production (Stantec 2010b), Stantec identifies key economic elements of the petroleum industry which play a significant role in the provinces economy. Amongst these elements, Nova Scotia firms have demonstrated economic benefits through supporting offshore operations in the areas of marine expertise, ship building and repair, port and harbour operations, transportation and the provision of other services and expertise required to sustain personnel and equipment operating 24-hours per day, seven days per week in remote locations.

Economic benefits to the region would include employment opportunities, provision of services including transportation services and vessel maintenance, increased demand for accommodation and hospitality services and an enhanced commercial tax base. These services have a regional focus as support operations are time dependant and reducing time for logistics operations can lead to significant cost savings and enhanced safety. This can be illustrated through particular linkages between shore-based supply operations, helicopter support services and offshore operations.

Shore-base Support Operations

In the case of operations on Georges Bank, a marine supply base near the site would likely be established to reduce travel times and offer quick turn around on materials supply. For the Sable and Deep Panuke projects shore-base support services are provided out of Halifax as the closest shipping port and airport to the production areas. The relatively long transit time for vessels out of Halifax to Georges Bank would provide a case to establish a marine supply base in southwest Nova Scotia.

The requirements for shore-based operations for exploration include several key facilities. The wharf must be suitable for the supply vessels and dock must have sufficient area and strength to handle a heavy crane for loading and offloading the vessels and place containers and equipment loads. Typically, an area for bulk tanks for the storage of fuel, barite and other consumables used in drilling operations is located near the wharf where these materials can be pumped onto the supply vessels. The offshore supply base would require a lay down area nearby for the storage of drill pipe and casing which could easily be moved to the wharf for load out to the drilling operation. Office space for supply-base personnel and communications equipment would be required at the wharf. The base operation requires sufficient power for the electric pumps used in bulk materials transfer, office services, security lighting and shore power for supply vessel when in port. A supply of freshwater is typically purchased from the local municipality to support both drilling operations and crew needs on the offshore platform and vessels. The supply base relies on highway transportation of bulk products and therefore road transport is an important element of regional infrastructure.

With some consideration to the specific needs of the petroleum industry, many of these services are similar to the services required by the fishing industry which is well established in the region. As a major fishing centre, Southern Nova Scotia has a number of ports with facilities which could meet these requirements.

Air Services

There are potential economic benefits to the region related to increased air transportation services. Air services to support offshore operations include requirements for personnel and cargo transport. The transportation of crew is typically by fixed wing carrier service to the supporting airport and helicopter service from this airport to the offshore platform. The helicopter services are provided by a private company under contract to the oil company. The fixed wing service is typically provided by a commercial air carrier.

Crews rotate on a routine basis and with limited seating capacity on the aircraft, a number of helicopter flights are required for each change. Offshore personnel come from diverse geographic regions and therefore, commercial flights are usually between the supporting airport and a hub terminal such as Halifax Airport. Yarmouth International Airport would logically offer a potential role as the support base for air services to operations on Georges Bank. Presently, there is passenger service between Yarmouth and Portland, Maine; however, passenger service to Halifax was curtailed in 2009.

The transport of cargo by air to offshore operations is typically for specialized instruments or repair parts needed on a rush basis for specialized services during drilling or production. Limitations of the carrying capacity of helicopters and the high cost of helicopter flight time require that transportation of equipment by air is only done when there is an urgent need. Nonetheless, connection with air transport carriers is an important part of air services required by the offshore industry.

Land Transportation Services

There are potential benefits to the region in the transportation sector. The offshore industry relies heavy on road transportation for many of the consumables used in offshore operations. Drill pipe, well casing, barite and fuel oil are just some of the important bulk commodities routinely consumed by offshore drilling programs which are transported by truck to the supply base. The demand by the offshore industry for these services could provide increased opportunities for direct employment in trucking and indirect employment in supply service to this sector in the region.

Ship Building and Repair

Shelburne Ship Repair is undergoing upgrades to its shipway and other facilities. Offshore petroleum activity in the region could increase the demand for vessel repair and maintenance service to the supply vessel fleet. The proximity of these services to the operations site can provide an advantage in reduce travel times and fuel costs for supply vessel operators which may be an important factor due to strong competition with other yards in the province.

Hospitality Services

Petroleum development would increase the number of people coming into the area and requiring services from the hospitality sector. Shore-based petroleum workers would require long term housing and accommodation and could be expected to consume goods and services thereby providing an economic stimulus to the region. Offshore workers, travelling to and from the offshore platform would stimulate demand for temporary accommodations and food services in local hotels and motels and restaurants. This increase in demand may provide employment opportunities in this sector which has shown a decline in the region in recent years (see Section 2.3.3.2).

Summary

In summary, based on experiences from other offshore petroleum projects in Nova Scotia, there are various potential regional economic benefits which could be realized if oil and gas activities are allowed to occur on Georges Bank.

6.0 Summary of Residual Issues and Research Recommendations

An important part of revisiting the 1999 Panel Report decision factors in light of current information is determining the residual issues which may remain in spite of technological advances made in the last ten years. New information focuses on those updates which may allow environmental and socio-economic risks to be effectively mitigated and those which currently have residual uncertainties.

Information presented in this report, including the professional opinion of Study Team authors on residual issues and research recommendations, has been provided to help inform upcoming decisions regarding the status of the Georges Bank moratorium. Any determination of the significance of potential environmental effects associated with these issues would presumably be the subject of a future environmental assessment of oil and gas activities on Georges Bank which is outside the scope of this evaluation.

Table 6.1 summarizes the key comments from the 1999 Panel Report and relevant updates which reflect:

- new scientific knowledge of the Georges Bank ecosystem;
- changes to the socio-economic environment;
- new scientific knowledge of environmental and socio-economic effects pertaining to offshore petroleum activities;
- updates to the regulatory framework which governs offshore petroleum activities; and
- progress in mitigation of potential effects.

Residual issues which remain in spite (or in some cases originate from) these advancements are presented. The majority of these residual issues are not specific to Georges Bank, but rather are issues facing offshore petroleum projects globally. However, in some cases, baseline studies directed in the Georges Bank region are recommended in order to provide a solid foundation on which subsequent monitoring studies could be undertaken should petroleum-related activities be permitted to occur in the future.

Table 6.1 Summary of Updates to Key Panel Comments and Residual Issues

Issue	1999 Comment/Concern	Update	Residual Issues	Research Recommendation
Physical Environment	• Based on seismic data, estimates of oil and natural gas potential in the moratorium area are considerably more than that predicted for existing projects in Atlantic Canada. • Panel recommended further study on physical characteristics, including mapping.	• Multibeam data represents a substantial advancement in technology since 1999 resulting in seabed mapping which can revolutionize fishing activities and planning for offshore infrastructure. This data has various applications including habitat mapping which can provide an assessment of the risk of habitat destruction and potential for population recovery from benthic impact. • Interpretation of seismic has advanced greatly in last 10 years (3D). • Seismic data for Georges Bank is currently being reprocessed.	• Geological Survey of Canada is in the interpretation and preparation stage of a suite of maps for the Georges Bank region, based on new multibeam data, although the maps will not be publically available until 2013 due to proprietary agreement.	• Further work on the GSC suite of maps and refinement of the habitat mapping template for Georges Bank will facilitate application of the habitat model to bottom fisheries and potential oil and gas activities in the moratorium area and will assist in the protection of sensitive habitats and minimize resource conflicts.
Ecological Significance	• Ecosystem is highly diverse, productive and exceptional in its combination of special features. • Fish productivity is two to two and a half times higher on Georges Bank than in other comparable areas. • Georges Bank serves as a feeding ground, nursery and migration corridor for more than two dozen whale and four seal species (including the endangered northern right whale). • Study by Kerr (1999) indicated that the Georges Bank community remained stable over 1987-1998 period while its components did not (*i.e.*, biomass remained stable while species composition changed). • Georges Bank requires special consideration for measures to ensure its conservation and protection.	• Georges Bank is still considered to be a diverse ecosystem with high productivity (Kennedy *et al.* 2010). • Canada's Ocean Strategy (2002) provides for integrated ecosystem management approach to ocean management and guides the process for establishing protected areas. • Conservation Law Foundation and WWF-Canada collaborated to identify priority conservation areas (CLF and WWF 2006) in New England and Maritime Canada; three of 30 priority areas occur in moratorium area (although they are afforded no legal protection). This study has contributed to the body of knowledge of non-commercial fish species in Georges Bank region. • DFO's ecosystem science approach to management has improved documentation of non-commercially-fished species, contributing to scientific knowledge of Georges Bank ecosystem. • The majority of information pertaining to marine mammal presence on Georges Bank appears to be nearly 30 years old. A review of available data suggests one newer survey (2004) included Georges Bank and it did detect north Atlantic right whales there. • *Species At Risk Act* came into effect in 2002, giving legal protection to several species at risk which could occur in the moratorium area. • Coral Conservation Area was established in Northeast Channel in 2002. • The North Atlantic right whale was reassessed by COSEWIC in 2003 and placed on Schedule 1 of *SARA*. A national Recovery Strategy was finalized in 2009 and two areas of Critical Habitat (as defined by *SARA*, potentially affording notable protection) were identified in Canadian waters. One Canadian critical habitat is of particular relevance to seismic programs in Georges Bank: Roseway Basin (approximately 50 km NE of moratorium boundary). • Bottlenose whales (endangered; focus of the 'Gully' near Sable Island), humpback whales (special concern; known feeding ground on Georges Bank) sperm whales (not at risk) and fin whales (special concern) are also known to occur at or near Georges Bank.	• Availability of recent marine mammal data on Georges Bank is limited.	• Conduct field survey to document spatial and temporal distribution of marine mammal species (particularly for species at risk) on Georges Bank and determine areas and/or times of greater biological significance to key species.
Socio-economic Significance	• Georges Bank has a significant and fully-exploited fishery and is considered as one of the world's most productive fishing grounds. • The value to the regional economy (product value) has ranged from \$57 million to \$148 million annually in the period 1990-1997. • Georges Bank accounted for about 16% of the total value of landings in the Southwest Nova region in 1996. • The fishing industry was the single largest source of industrial employment and income for Southwest Nova (Gardner Pinfold 1998).	• Area remains an important fishing area. • Total landed value for Georges Bank Fishery was estimated to be \$113 million in 2008. • Georges Bank accounted for about 23% of the total value of landings in the Southern Nova Scotia region in 2007. • The fishing industry continues to be the single largest source of employment and income for Southern Nova Scotia.	• No residual issues identified.	n/a

Table 6.1 Summary of Updates to Key Panel Comments and Residual Issues

Issue	1999 Comment/Concern	Update	Residual Issues	Research Recommendation
Regulation of Development	• Petroleum regulatory regime is quite comprehensive with focus on mitigation and reduction of adverse effects rather than imposing total bans. • Concern was expressed that the CNSOPB's responsibilities constitute an inherent conflict.	• Since 1999, the CNSOPB has authorized more than 175 applications for work activities including more than 16 drilling program authorizations and 34 authorizations for seismic surveys. DFO, Environment Canada, and CNSOPB Fishery Advisory Committee are involved in review of all offshore work applications. • Regulatory approach is more focused on cooperation with other government regulators to modernize regulatory environment • More emphasis on an integrated planning and management approach to addressing ocean use and interests (*e.g.,* ESSIM) • In the past decade, there have been notable environmental regulatory updates respecting petroleum activities including o Offshore Waste Treatment Guidelines (2002) o Chemical Selection Guidelines (2009) o Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment (2007) • Strategic environmental assessments (SEAs) are conducted on areas to be opened up for bidding by operators. These SEAs characterize the baseline environment and identify sensitive features/issues. This information is then considered during Project-specific EAs.	• No residual issues identified.	n/a
Potential Effects of Seismic Surveys	• There are opposing perspectives on risk of seismic surveys and level of information needed to determine risk. • There is a need for more data on the effects of seismic exploration as applied to the species of larvae on Georges Bank. • No studies were presented on the effects of seismic surveys on spawning behaviour of fish. • There is evidence of adverse effects on fish behaviour. • Information on effects on marine mammals is limited and conclusions are based on other species at other locations.	• Numerous studies have been conducted offshore Nova Scotia (including monitoring of seismic surveys on Scotian Shelf) and elsewhere to better understand effects of seismic surveys on marine organisms. In summary, effects of seismic noise on fish, shellfish and other pelagic marine invertebrates are expected to be low with no serious or long term harm at the population level; observed zones of avoidance by marine mammals ranged from small to none. • The most frequent and serious injuries occur at distances out to 1.5 m from seismic source and fish in the early stages of life are most vulnerable. • The Statement of Canadian Practice with respect to Mitigation of Seismic Sound (SOCP) was developed to mitigate seismic effects in the marine environment; this document is reviewed regularly to incorporate new scientific knowledge and improved mitigation. • Seismic surveys may cause temporary effects on catchability, but mitigation can be implemented to minimize effects (*e.g.,* SOCP). • Advances in underwater noise detection technology since 1999 have improved understanding of effects on marine mammals. • Comprehensive review was published in 2007 (Southall *et al.* 2007) relating to noise exposure criteria and findings largely indicate that the potential for auditory damage (permanent or temporary) to marine mammals from seismic operations is restricted to regions relatively close to the array (<500m). • Numerous studies have been conducted recently regarding the masking of north Atlantic right whale communication by low frequency sound (*i.e.,* a large component of seismic noise) and this will likely be a key issue in the Georges Bank region. Low frequency sounds from seismic (and vessels) can travel great distances (10's to 100's km) and hence larger assessment areas may be required for seismic programs. This may be pertinent given the identification of proximate north Atlantic right whale critical habitat at Great South Channel (US) and Roseway Basin (Canadian). • A monitoring and mitigation program for Marathon Canada Petroleum's 3D seismic program on the Scotian Slope in 2003 showed relatively small zones of avoidance around the operational area for baleen and toothed whales, with little or no avoidance by dolphins (CNSOPB 2009).	• Potential sublethal effects on individual fish in the immediate vicinity of the seismic array despite mitigation of scheduling of seismic activities to avoid sensitive periods and areas (*e.g.,* spawning, egg and larval concentrations, migrations, *etc.*) particularly for commercially-important fish species and species at risk has been identified as a data gap (Hurley 2009). • Biological implications of potential communication masking have not been quantified and longer-term implications (for all marine mammals) are not well understood. • Visual observation of safety zones during seismic operation cannot ensure full-time protection of marine mammals in the zone. Passive acoustic and other monitoring techniques are currently being considered and may assist in addressing this residual issue. • The potential for other behaviour-related effects such as reduced echolocation efficiency, hampered avoidance of human-induced threats (*e.g.,* fishing gear, vessel traffic), deflections in migration, reduced parental care, chronic and indirect effects are similarly not well studied or understood. • In its present form, ecological knowledge of marine mammal habitat on Georges Bank is considered insufficient for detecting potential change in abundance and distribution resulting from future seismic programs. • Increased quality (spatial and temporal) of baseline data on marine mammals on Georges Bank may also identify some areas, and/or times, of greater biological significance to key species.	• Conduct detailed health evaluations of key individual fish and benthic invertebrate species exposed to seismic-level noise pressures (Hurley 2009). • Conduct additional cetacean monitoring programs during seismic operations in Atlantic Canada focusing on communications masking and behavioural effects. • Continue to develop passive and other monitoring techniques to complement visual observation of safety zones. • Conduct aerial monitoring surveys during seismic surveys to assist in understanding of effects of seismic surveys on baleen whale species.

Table 6.1 Summary of Updates to Key Panel Comments and Residual Issues

Issue	1999 Comment/Concern	Update	Residual Issues	Research Recommendation
			• Majority of knowledge underpinning mitigation measures is based on toothed whale studies and restricted visual monitoring studies. Potential effects on baleen species may represent a residual issue. Frequent aerial monitoring surveys during seismic survey would assist in understanding the significance of this residual issue.	
Muds and Cuttings	• Two basic types of drilling muds are used: water-based (WBM) and oil-based (OBM). Synthetic-based mud (SBM) is new and not widely used due to cost. • Laboratory experiments suggest sublethal effects of bentonite and barite on scallops could be experienced up to 40 km from discharge point. • Dispersion of drilling mud is not fully understood. • Probability of significant harmful effects from disposal of drilling discharges near Georges Bank cannot be discounted.	• WBM and SBM are used for offshore drilling in Atlantic Canada; OBM is not used. • The revised Offshore Waste Treatment Guidelines (OWTG) (NEB *et al.* 2002) regulate concentration of 6.9 g/100 g or less oil on wet solids. It has become common industry practice to ship SBM waste to shore, virtually eliminating any ocean discharge of oil from mud and cuttings. • Upgrades to dispersion model allows for more site specific modeling in different regions of the moratorium area. • Based on exploration drilling EEM results in Canada, environmental effects on benthic communities are sometimes detected within 1000 m of a drilling site, but most commonly detected within the 50 m to 500 m range (Hurley and Ellis 2004). • Acute effects experienced in the near-field (*i.e.,* within 500 m) are related primarily to smothering rather than toxicity.	• Degree of impact of drilling waste is highly dependent on several variables.	• Integrate risk assessment models with physical transport/fate and effect models to calculate potential risks of drilling waste discharges on Georges Bank. This information could be included in a Strategic Environmental Assessment for the region and should also be refined in project-specific EAs.
Formation and Produced Water	• Naturally occurring contaminants present in formation and produced water in high concentrations can be toxic to marine species including important commercial species on Georges Bank.	• Revised OWTG (NEB *et al.* 2002) has reduced limit for hydrocarbon content in produced water to 30 mg/L (30-day weighted average). • Field measurements confirm the predictions of modeling studies, that dilution is usually rapid. • Based on concentrations of chemicals in produced water and predicted dispersion rates for sites of concern, it is envisioned that there would be only limited potential for acute toxicity beyond the immediate vicinity of rigs in Atlantic Canada. • Advancements in plume dispersion models and chemical fate/transport models have improved accuracy of predictions although improved sample recovery and analytical methods are needed to support model validation needs (Neff *et al.* In press).	• Dilution is usually very rapid, making it very challenging to monitor toxicity after release to ocean. Chronic toxicity studies are being conducted by DFO to support the development of cost-effective and sensitive monitoring protocols for regulatory use. • As a result of chemical kinetics following dispersion, toxicity may change over time.	• Continue development of chronic toxicity studies to support development of cost-effective and sensitive monitoring protocols for regulatory use in EEM programs. • Continue EEM of development projects on Grand Banks and Scotian Shelf, using improved monitoring equipment and protocols to detect whether there are changes in toxicity of produced water over time.
Greenhouse Gas Emissions and Climate Change	• Canada undertook international obligations in the Kyoto Protocol to reduce greenhouse gas emissions by 6% below its 1990 levels by 2008-2012. • Natural gas can be seen as a useful transition fuel away from coal and oil although it still results in greenhouse gas emissions.	• Issue of climate change due to GHG emissions is well documented and generally accepted worldwide, with increased emphasis on GHG reduction. • The Kyoto agreement did not achieve all its objectives, but did serve to help focus public opinion and political discussion. At the present time, Canada is committing to an emission reduction following the 2009 Copenhagen climate change summit. • Updated OWTG (NEB *et al.* 2002) include reporting requirements for GHG emissions and volatile organic compounds. • New and emerging issues, not specific to Georges Bank or offshore petroleum, but nonetheless are applicable include acidification of oceans and carbon capture/storage technologies. • The recent Deep Panuke Project involves capturing and injecting CO_2 and H_2S into a deep aquifer disposal well thereby reducing GHG and atmospheric emissions.	• Ocean acidification is an emerging issue which is receiving stakeholder and regulatory attention, however this is not necessarily related to oil and gas exploration.	• Continue ongoing research on cause and effect of ocean acidification related to oil and gas development.
Accidental Discharges – Spills and Blowouts	• The probability of a large blowout is low based on experience to date. • Blowouts and spills could result in contamination of the marine environment and damage to	• Annual spillage from exploration and production has decreased from 30,400 bbl/yr between 1969-1977 to 3,900 bbl/yr between 1998-2007(API 2009). • Production oil spillage accounts for less than 0.9% of amount released from natural seeps (9,938 bbls vs 1,123,000 bbls from seeps annually from 1998 to 2007) (API 2009). • Concern has been raised that EAs for Atlantic Canada offshore projects underestimate volume of small spills (<50 bbl) (Fraser and Ellis 2008) although this research has been contested by industry. Follow-up is conducted	• Effects of oil on adult fish and marine mammals are difficult to study and therefore knowledge is incomplete. • Adequate baseline information for an ecosystem affected by a spill, including knowledge of number and diversity of	• Research marine wildlife monitoring programs following spill events world-wide to better understand behavior and physiological effects (including tainting of fish) of marine biota.

Table 6.1 Summary of Updates to Key Panel Comments and Residual Issues

Issue	1999 Comment/Concern	Update	Residual Issues	Research Recommendation
	marine populations. • The transportation of petroleum products by tanker may increase the risk of accidents and spills. • The perception of tainting is a major concern for the fishing industry.	on all spills and information is used in preparation of future EAs. • Difficult to demonstrate spills have irreversible effects on planktonic communities. • Major concern related to a spill event is timing and location of spill relative to spawning events. • Fate and effect models are being continuously improved and can be used to support risk assessment studies, contingency planning, and clean-up operations. • CNSOPB requires operators to implement an Emergency and Oil Spill Response Plan. • There is renewed interest in the application of chemical dispersants to promote dilution of oil in the water column. • Tanker spills have decreased from 1,138,000 tonnes of spilled oil between the years1990 and 1999 to 196,000 between 2000 and 2008 (ITOPF 2008). • Single-hulled tankers are being phased out and replaced with double-hulled tankers which reduce environmental risk. • Taint effects have essentially failed to materialize as they had been predicted in the SOEP EIS (CNSOPB 2009)	species, determining loss due to an oil spill is often challenging. • Spill predictions, particularly for small platform spills, must take into account recent regional statistics. • Use and selection of dispersants to reduce effects on receptors is an event-specific decision, depending on several variables including spill material and location of spill.	• Research efficacy of existing oil spill countermeasures and develop potential countermeasure strategy for potential spills on Georges Bank.
Loss of Access and Crowding	• Seismic exploration vessels will disrupt fishing patterns and can negatively affect catchability of groundfish. • The presence of a fixed exclusion zone would disrupt fishing activities and potentially lead to overcrowding in other areas.	• Advancements in sea mapping can lead to more targeted fishing effort as well as better informed infrastructure siting to minimize extent of overlap of activity and effect of exclusion zones. • Effects of seismic on catchability can occur and can be minimized through seismic survey planning to avoid fishing areas and further avoided by adherence to SOCP. • Improved stakeholder engagement mechanisms has led to successful coexistence of fisheries and petroleum projects on Scotian Shelf and Grand Banks over the past decade.	• No residual issues identified.	n/a
Additional Issues (Operational Discharges and Transportation Impacts)	• Participants expressed concern over operational discharges (noise, light, traffic, flaring residues, formation water, ballast water, and chemical fluids) and potential changes to species migration patterns to avoid areas of increased activity. • Pipelines may pose a barrier to migration pathways for lobster and other species. • Fishing access may be reduced in the area of pipelines.	• Oil and gas EEM programs in Atlantic Canada and the Beaufort Sea found no indication of specific effects of non-drilling related discharges or synergistic effects in combination with drill waste (Hurley and Ellis 2004). These discharges, treated to comply with applicable regulatory standards prior to release (*e.g.,* OWTG), are diluted quickly upon discharge and difficult to measure. • Underwater noise from drilling activities will not likely exceed ambient noise levels from 1-10 km from the source (Greene 1996, Richardson *et al.* 1995), with behavioural reactions of marine mammals predicted to be limited to within this radius (LGL *et al.* 2000). • Since 1999, two offshore pipelines have been constructed from the Sable Bank to onshore Nova Scotia, through active fishing areas. • Considerable research has been conducted in Atlantic Canada regarding pipeline issues related to Blue Atlantic (proposed), Sable Offshore Energy Project, and Deep Panuke pipelines. • Improved seabed mapping capabilities will improve pipeline routing to avoid sensitive areas. • Studies indicate no effects on catchability of lobsters near pipelines and lobsters can navigate pipelines of varying sizes and materials (Martec 2004). • Full benthic recovery has been observed within 3 years of pipeline installation (SEEMAG 2001). ROV survey conducted along SOEP pipeline in 2008 found large numbers of sea cucumbers thriving on the pipeline which was also found to support various other species across several tropic levels (CNSOPB 2009).	• The extent to which anthropogenic noise sources (*e.g.*, drilling noise) may interfere with normal communication and behavioural functions of marine mammals remains unclear. • Limited information is available to assess how the timing of exploration activities may affect interactions with migratory bird and marine mammal species (Hurley 2009).	• Conduct wildlife monitoring programs during routine drilling and production activities to improve knowledge of effects of non-seismic noise on communication and behaviour functions of marine mammals. • Conduct research to determine effectiveness of timing of activities to avoid critical periods for wildlife.
Cumulative Effects	• If exploration activities overlap with production, additive and cumulative effects from exploration activities would be difficult to separate from development and production impacts.	• Between 1967 and 2009, there have been 208 wells drilled offshore Nova Scotia (52 since January 1999). Between 1966 and 2009, there have been 349 wells drilled offshore Newfoundland and Labrador (190 since January 1999). • EEM results are demonstrating smaller spatial and temporal footprints of disturbance with less potential for overlap than once previously assumed. • CNSOPB and C-NLOPB are conducting strategic environmental assessments to examine the environmental effects which may be associated with each Call for Bids in a specific area, thus allowing for the incorporation of environmental considerations at the earliest stages of program planning. SEA typically involves a broader-scale EA that considers the larger ecological setting, rather than a project-specific environmental assessment that focuses on site-specific issues with defined boundaries. • The application of Cumulative Effects Assessment (CEA) continues to evolve and there have been advances over the past decade both from a methodological perspective and in the availability of information and data to further support CEA	• No residual issues identified.	n/a

A considerable amount of research has been conducted on the potential environmental and socio-economic effects of offshore oil and gas activities. The last decade has brought considerable oil and gas experience to Atlantic Canada in the form of exploration and production activities, none of which have demonstrated, based on the results of EEM, population level effects to the marine ecosystem, or on species at risk and their critical habitat (CNSOPB 2009; Hurley and Ellis 2004).

In spite of these findings, there are some knowledge gaps which remain and research recommendations which could serve to further advance the knowledge and understanding of the ecosystem and environmental and socio-economic effects of oil and gas activities. In some cases, the recommendations involve research that is ongoing or will be undertaken by the scientific community separate from directed Georges Bank research. They are provided here nonetheless to help provide context to the current state of scientific knowledge on those issues. Referring back to the precautionary principle, as discussed in Section 1, monitoring and regular review are important to examine whether knowledge and understanding has improved and to examine effectiveness of the precautionary measure addressing the potential threats. Any new information gained through monitoring and further research (such as those studies recommended in Table 6.1) can then be used to inform further management and decision-making, using an adaptive management approach.

The key issues identified by the 1999 Review Panel remain relevant ten years later. However, it is the professional opinion of the Study Team that based on advances in scientific knowledge and advances in mitigation and regulatory requirements, these issues identified in the 1999 Review Panel report could be reasonably mitigated in the event that oil and gas activities are permitted to occur on Georges Bank. Further research will serve to enhance the understanding of environmental and socio-economic effects and improve future environmental performance. As previously noted, the review does not take into consideration the recent Deepwater Horizon incident as the research was substantially completed prior to this major environmental incident occurring.

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APPENDIX A
Terms of Reference

Project # OEER 300-180-Oct9A

Invitation for Commercial Proposals
A Preliminary Review of Environmental and Socio- Economic Issues - Georges Bank

for the

Offshore Energy Environmental Research Association (OEER)

I. OEER MANDATE AND SITUATION OVERVIEW

1.1 Mandate

The OEER was established in March 2006, to promote and fund research on energy and the marine environment. Current membership includes St. Francis Xavier University, Cape Breton University, Acadia University and the Nova Scotia Department of Energy.

The mission of OEER is to foster research and development related to offshore petroleum and renewable energy resources and their interaction with the marine environment, and the diffusion of that knowledge, including the assessment of the potential impacts of:

(i) petroleum exploration, development and production; and
(ii) renewable energy technologies - exploiting ocean currents, wind, tides and waves, on the marine environment and, where consistent with these goals, to encourage building research capacity in Nova Scotia.

1.2 The Need for a Preliminary Review of the Environmental and Socio-Economic Issues pertaining to Georges Bank

Georges Bank is a large submarine bank (250km by 150km – 40,000 km^2) at the edge of the Atlantic continental shelf between Cape Cod and Nova Scotia. It is within the Bay of Fundy and Gulf of Maine tidal system, and is located approximately 100km offshore.

Georges Bank is a very biologically productive region. It is an area of high concentrations of Plankton and as a result, Georges Bank has historically sustained large stocks of fish such as herring, haddock and cod, as well as scallops. In the 1960s and 1970s, it was severely overfished by foreign trawling fleets from the former Soviet Union and Poland, depleting the stocks. In 1984, a boundary decision awarded 5/6 of Georges Bank to the U.S., with the easternmost 1/6 (7000 km^2 rich in ground fish and scallops) being awarded to Canada. Properly managed, it is estimated that the entire Georges Bank can sustain annual fishery yields of about 420,000 t, with easy access to ports.

Oil exploration companies in the 1960s and 1970s, along with the Geological Survey of Canada, estimated that the seafloor beneath Georges Bank possesses large amounts of petroleum reserves. The Canadian portion has been thought to be more prospective than the U.S. portion. Estimates on potential for discoveries vary and research efforts to update reserve estimates are expected to be undertaken shortly using modern software to interpret historical seismic data.

Georges Bank represents an important ocean area to Canada from a broad social, economic and environmental perspective. On December 22, 1999, the Minister of the Nova Scotia Petroleum Directorate and the Minister of Natural Resources Canada announced that the Georges Bank moratorium would be extended until December 31, 2012. This decision was based on the recommendation of a three-member Public Review panel. **Click here to download a copy of the 1999 Georges Bank Review Panel Report.**

In March 2008, the Nova Scotia Department of Energy provided OEER with a $500,000 grant to support OEER research on matters specific to Georges Bank.

1.3 Purpose of the Project

The purpose of this project is to conduct an independent third party preliminary review to outline the current state of the knowledge on the science and issues that led to the 1999 Panel's recommendation to extend the moratorium. In addition, the consultant will undertake a preliminary review of issues related to potential environmental and socio-economic impacts pertaining to offshore petroleum activities on Georges Bank if such activities were to be permitted.

II. REQUIREMENTS

2.1 Time-Frames

The following schedule is presented for guidance:

(a)	**Deadline for Proposal Submission:**	**4:00 pm AST, October 23, 2009**
(b)	**Preferred commencement date:**	**November, 2009**
(c)	**Completion date:**	**February, 2010**
(d)	**Submission of the written report:**	**February, 2010**
(e)	**Session to present research findings**	**Spring 2010**

2.2 Objective

The objective of this Invitation for Commercial Proposals is to obtain the services of a consultant(s) to prepare a report to assist governments in their decision as to whether they should order a Public Review of the moratorium on petroleum activities on Georges Bank and if they should so order, to provide a preliminary body of information for use in the Public Review.

2.3 Scope of work

Scope: Geographic Location

The main study area will be the Canadian portion of the Georges Bank region. The scope includes impacts on ecosystem areas outside the main study area if there is a linkage between the two ecosystems.

Scope: Activities

The preliminary review will incorporate the following:

1. Based on available information from multiple sources, the history and findings of the previous Georges Bank review.
2. Identify relevant existing environmental and socio economic studies.
3. Examine the results of Fisheries and Oceans Canada and others' current science and socio-economic assessments of potential impacts from petroleum activities on Georges Bank.
4. Using the DFO science review results and the 1999 Georges Bank Review Panel Report and previous impact assessments; generally identify factors that led to the decision to extend the moratorium which:
   a. could now be mitigated; or
   b. could not now be mitigated; or
   c. might be mitigated pending additional research.
5. Using available temporal data, analyze trends between 1998 and the present in endpoints that contributed to the extension of the moratorium on petroleum activities on Georges Bank. Has the physical, chemical and biological context changed over the last decade in the absence of petroleum development in ways that may affect future decisions on the development of activities.
6.
   a. Identify new environmental, fisheries and all other relevant legislation and policies that have been enacted since the 1999 Panel Hearings and to consider all environmental and socio-economic factors in the context of the newest legislation in effect.
   b. Identify any and all new environmental and socio-economic issues which have arisen during the time since the Panel Hearings taking into consideration point 4 sub-clauses a., b. and c.
   c. Identify any new problem areas or risks that have arisen since the 1999 Panel hearings and to take these into consideration as well as those identified in the Panel Report.
   d. Identify issues related to potential seismic acquisition on Georges Bank through a conventional multiple array 3-D seismic program.

   e. Identify issues surrounding the conduct of exploratory drilling through conventional drilling activities for a normal exploratory program.

7. Examine the economic value of the Georges Bank region to existing stakeholders (e.g. fishing, transportation etc.) and assess what the impact would be to the economy in the event that oil and gas activities took place. The contractor will also identify measures that would mitigate any or all of the potential adverse impacts and risks.
8. The contractor will incorporate science-based conclusions on the effects of offshore petroleum activities and apply that science to the Georges Bank ecosystem to assess the possible environmental impacts on the area. The contractor will also identify measures (if any) that would mitigate any or all of the potential adverse impacts and risks.
9. Identify questions that could be the subject of short, medium and longer-term research.

2.4 Deliverables

The main deliverable is the written report to OEER which must encompass all components as listed in the scope of work.

The successful bidder will be required to submit monthly progress reports to OEER including the following:

- Work completed to date;
- Accounting of expenditures - percentage of budget expended;
- Estimated time remaining to complete overall work;
- Identification of any issues to be resolved; and
- Input required from other parties to enable the work to progress on time and on budget.

The successful bidder will be required to meet with the OEER steering committee at regular intervals (at least three meetings will be required during the term of the contract).

The successful bidder will be required to give a presentation to OEER and its stakeholders on the findings in the report. **This will take place in the in the spring of 2010.**

2.5 Level of Effort

The suggested level of effort for this project is a maximum of $150,000.

2.6 Enquiry Contacts

Proponents requiring further information on this Invitation for Commercial Proposals should contact:

Name:	Jennifer Matthews
Address:	OEER Association c/o 5151 George Street, Suite 400 Halifax, NS B3J 3P7
Telephone:	902-424-2493
Fax:	902-424-0528
Email:	oeer@offshoreenergyresearch.ca

III. EVALUATION CRITERIA

The following criteria, shown in order of importance, form the basis upon which evaluation of proposals will be made.

3.1 Mandatory Criteria

The following are mandatory requirements. Proposals not meeting them will receive no further consideration during the evaluation process:

- All information requested in this Invitation for Commercial Proposals must be provided;
- All proposals must be submitted in Canadian Dollars (CDN) exclusive of all taxes;
- The consultant must be able to demonstrate experience with the requirements identified in Sections 2.2 and 2.3;
- The consultant must be able to demonstrate relevant knowledge and experience relating to Nova Scotia; and
- The consultant must be able to demonstrate that they can meet the required completion date.

3.2 Desirable Criteria

The following criteria will be evaluated for all proposals that satisfy the mandatory criteria. Please include this table in your proposal and insert references to the appropriate pages or sections of your Proposal that deal with the subjects under evaluation.

Factor	Weight	Reference Proposal Page/Section
Experience and Capability • Experience conducting environmental and socio-economic assessments related to petroleum industry activities • Knowledge of the Georges Bank moratorium and related issues • Experience with Nova Scotia stakeholders and regulatory processes • Proponents have the necessary qualifications and capacity to undertake the prescribed work.	25	
Approach and Methodology • Demonstrates a clear understanding of OEER's needs and has proposed an approach and methodology that will enable the successful completion of the objectives • The proponent has identified potential challenges to meeting objectives, and has provided a plan for overcoming risks.	25	
Project Management • The proponent has outlined a clear and effective management plan that will ensure timely delivery of results and proper accountability for all project tasks.	25	
Cost • The project will offer very good value for the proposed budget. • The project budget is complete and well described (i.e. includes salaries, travel and accommodations, report preparation, other associated costs).	20	
Other • The proposal is well-written. • The reviewers are overall satisfied with the proposal,	5	

attention to needs, expected deliverables, deadlines and cost.		

IV. PROPOSAL CONTENT AND RESPONSE GUIDELINES

In order to receive full consideration during evaluation, proponents must adhere to the following:

4.1 Submit in Electronic Form

Proposals are to be written using the attached OEER proposal form (see **Schedule "A"**).

Proposals must be submitted in electronic form only by **4:00 pm AST, October 23, 2009, to Jennifer Matthews, oeer@offshoreenergyresearch.ca.**

Late proposals will be rejected.

4.2 Proposal Content

Proposals must be submitted on the proposal form in Schedule A and in order to receive full consideration proposals should address the following:

- **Understanding of the Requirements**
  Proposal must demonstrate understanding of the OEER requirements.

- **Definition of the Research Objectives to be addressed**
  Generally describe how the proposal addressed the specific and relevant research objectives of OEER.

- **Experience and capabilities**
  Provide details of work and experience as outlined in Schedule A.

- **Outline of the Approach and Methodology**
  Describe the proposed project approach and methodologies that will used to enable the successful completion of the objectives.

- **Proponent Profile and Team**
  Identify all personnel who will be assigned to the project and who will contribute to (a) the routine management and/or (b) the performance of the required services.

- **Work Plan**
  A work plan should be presented which ties in with the research approach and specifies both begin and end dates, as well as key delivery dates for specified deliverables. Outline a clear and effective management plan that will ensure timely delivery of results and proper accountability for all project tasks.

- **Proposal Pricing**
  Pricing values must be included as outlined in Schedule A.

VI. PROPONENT CHECKLIST

This checklist has been provided solely for the convenience of the proponent. Its use is not mandatory and it does not have to be returned with the proposal.

- The requirements of the Invitation for Commercial Proposals have been read and understood by everyone involved in putting together the proposal.
- The proposal explicitly addresses everything asked for in the Invitation for Commercial Proposals.
- The proposal meets all the mandatory requirements of the Invitation for Commercial Proposals.
- The proposal clearly identifies the proponent, the project, and the Invitation for Commercial Proposals number.

APPENDIX B
Concordance with Terms of Reference

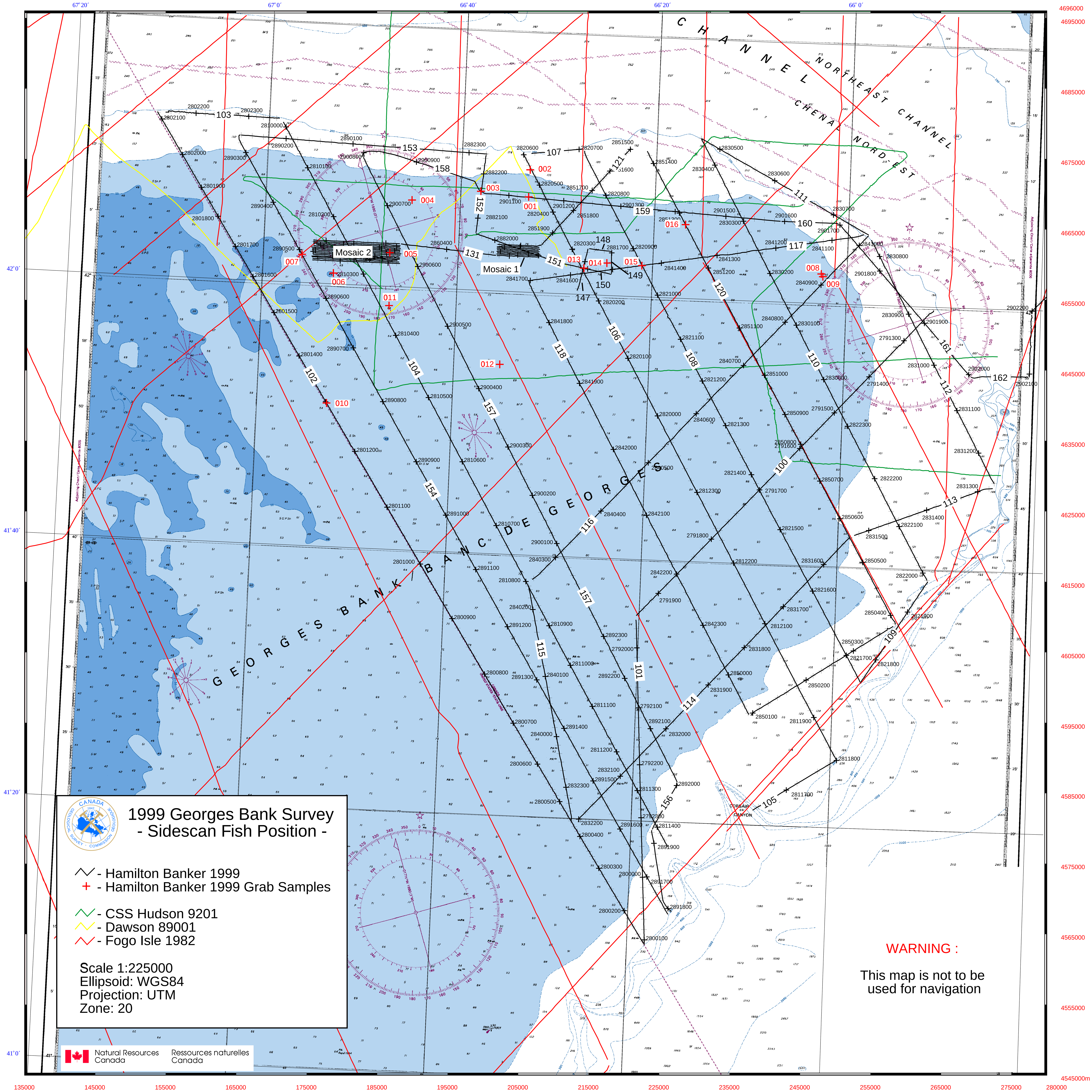
Appendix B. Table of Concordance

Concordance with RFP Activities (Invitation for Commercial Proposals: A Preliminary Review of Environmental and Socio- Economic Issues - Georges Bank for the Offshore Energy Environmental Research Association (OEER) (Project # OEER 300-180-Oct9A)

RFP REQUIREMENTS	STANTEC REPORT
Section 1.3 RFP: Purpose of the Project	
The purpose of this project is to conduct an independent third party preliminary review to outline the current state of the knowledge on the science and issues that led to the 1999 Panel's recommendation to extend the moratorium. In addition, the consultant will undertake a preliminary review of issues related to potential environmental and socio-economic impacts pertaining to offshore petroleum activities on Georges Bank if such activities were to be permitted.	Section 1.1
Section 2.3 RFP Scope: Geographic Location	
The main study area will be the Canadian portion of the Georges Bank region. The scope includes impacts on ecosystem areas outside the main study area if there is a linkage between the two ecosystems.	Section 1.2, Section 2
Section 2.3 RFP Scope: Activities	
RFP Activity 1. Based on available information from multiple sources, the history and findings of the previous Georges Bank review.	Section 2 "Panel Context" sections and Section 4 " Panel Comments" sections
RFP Activity 2. Identify relevant existing environmental and socio economic studies.	Section 2 Characterization of Georges Bank
RFP Activity 3. Examine the results of Fisheries and Oceans Canada and others' current science and socio-economic assessments of potential impacts from petroleum activities on Georges Bank.	Section 4 "Advancements in Scientific Knowledge" sections
RFP Activity 4. Using the DFO science review results and the 1999 Georges Bank Review Panel Report and previous impact assessments; generally identify factors that led to the decision to extend the moratorium which: a. could now be mitigated; or b. could not now be mitigated; or c. might be mitigated pending additional research.	Section 4 "Advancements in Scientific Knowledge" and "Residual Issues" sections, Section 6"
RFP Activity 5. Using available temporal data, analyze trends between 1998 and the present in endpoints that contributed to the extension of the moratorium on petroleum activities on Georges Bank. Has the physical, chemical and biological context changed over the last decade in the absence of petroleum development in ways that may affect future decisions on the development of activities.	Sections 2 and 4 "Advancements in Scientific Knowledge" sections
RFP Activity 6. a. Identify new environmental, fisheries and all other relevant legislation and policies that have been enacted since the 1999 Panel Hearings and to consider all environmental and socio-economic factors in the context of the newest legislation in effect.	Section 3 "Regulatory Context"

RFP REQUIREMENTS	STANTEC REPORT
RFP Activity 6. b. Identify any and all new environmental and socio-economic issues which have arisen during the time since the Panel Hearings taking into consideration point 4 sub-clauses a., b. and c.	Section 4 “Advancements in Scientific Knowledge” sections, Section 6
RFP Activity 6. c. Identify any new problem areas or risks that have arisen since the 1999 Panel hearings and to take these into consideration as well as those identified in the Panel Report.	Section 4 “Advancements in Scientific Knowledge” sections, Section 6
RFP Activity 6. d. Identify issues related to potential seismic acquisition on Georges Bank through a conventional multiple array 3-D seismic program.	Section 4.1 Seismic Exploration
RFP Activity 6. e. Identify issues surrounding the conduct of exploratory drilling through conventional drilling activities for a normal exploratory program.	Section 4.2 Drill Muds and Cuttings Section 4.3 Produced Water Section 4.4 Atmospheric Emissions Section 4.5 Spills and Blowouts Section 4.7 Additional Issues
RFP Activity 7. Examine the economic value of the Georges Bank region to existing stakeholders (e.g. fishing, transportation etc.) and assess what the impact would be to the economy in the event that oil and gas activities took place. The contractor will also identify measures that would mitigate any or all of the potential adverse impacts and risks.	Section 4.6 Loss of Access and Crowding Section 5.0 Economics of Georges Bank
RFP Activity 8. The contractor will incorporate science-based conclusions on the effects of offshore petroleum activities and apply that science to the Georges Bank ecosystem to assess the possible environmental impacts on the area. The contractor will also identify measures (if any) that would mitigate any or all of the potential adverse impacts and risks.	Section 4 Review of Key Panel Decision Factors Section 6 Summary of Residual Issues and Research Recommendations
RFP Activity 9. Identify questions that could be the subject of short, medium and longer-term research.	Section 6 Summary of Residual Issues and Research Recommendations

APPENDIX C
Map of Georges Bank to be Used to Interpret the Multibeam Bathymetric Data (courtesy of Todd *et al.* 2000)


1999 Georges Bank Survey
- Sidescan Fish Position -
- Hamilton Banker 1999
- Hamilton Banker 1999 Grab Samples
- CSS Hudson 9201
- Dawson 89001
- Fogo Isle 1982
Scale 1:225000
Ellipsoid: WGS84
Projection: UTM
Zone: 20
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WARNING :
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