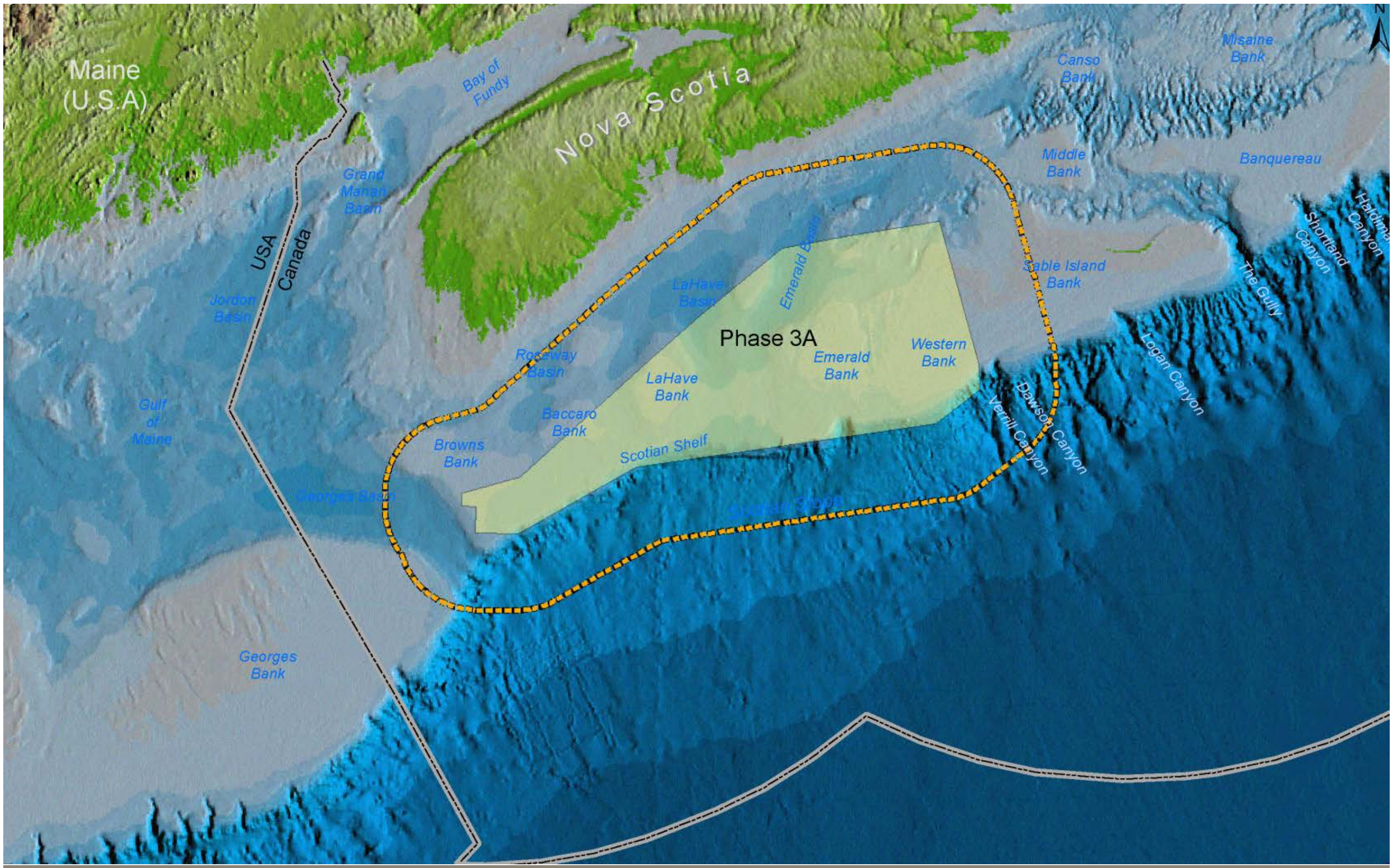
CNSOPB CANADA-NOVA SCOTIA OFFSHORE PETROLEUM BOARD

Final Report



STRATEGIC ENVIRONMENTAL ASSESSMENT FOR OFFSHORE PETROLEUM EXPLORATION ACTIVITIES

Western Scotian Shelf (Phase 3A)

Prepared for:

CANADA-NOVA SCOTIA OFFSHORE PETROLEUM BOARD

Submitted by:

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April 2014

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Design with community in mind

Strategic Environmental Assessment for the Western Scotian Shelf (Phase 3A)

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April 2014

Executive Summary

This report is a Strategic Environmental Assessment (SEA) of potential petroleum exploration activities on the Western Scotian Shelf. This SEA examines potential environmental effects that may be associated with the possible issuance of future exploration rights granted by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) on the Western Scotian Shelf (Western Bank to Browns Bank) and discusses general restrictive or mitigative measures that should be considered during an exploration program application. The SEA is not intended to replace project-specific environmental assessments (EAs) that would be required for any proposed exploration program; rather it is intended to support and facilitate future project-specific EAs.

The scope of exploration activities considered in the SEA includes geophysical survey activities (*e.g.*, seismic programs), seabed surveys (*e.g.*, geohazard surveys, geotechnical surveys), exploratory and delineation drilling (including well testing and well abandonment), and vessel and helicopter traffic. Routine and accidental events were considered as well.

The "Project Area" considered for the SEA includes the potential area within which exploration rights could be issued by the CNSOPB. A larger "Study Area" was established as a buffer around the Project Area to recognize a potential zone of influence of environmental effects from activities that could occur within the Project Area. Although the Project Area is predominantly on the Banks on the Western Scotian Shelf (*e.g.*, Western, Emerald, LaHave and Baccaro Banks), the larger Study Area extends into Browns Bank and Georges Bank and into the deeper waters on the Scotian Slope.

There are several fish, marine mammal, sea turtle and bird species with special conservation status known to occur within the Study Area, including the endangered blue whale, North Atlantic right whale, Northern bottlenose whale, and leatherback turtle. Special Areas within the SEA Study Area include *Species at Risk Act* Critical Habitat (*e.g.*, Roseway Basin critical habitat for the endangered North Atlantic right whale), *Fisheries Act* closure areas (*e.g.*, coral conservation area, Haddock Box), and Ecologically and Biologically Significant Areas (EBSAs). Sable Island National Park Reserve and the Gully Marine Protected Area are located east of the Study Area.

The Study Area, which encompasses portions of Northwest Atlantic Fisheries Organization (NAFO) Divisions 4W, 4X, and 5Ze is heavily fished, particularly on the banks, with invertebrate and groundfish fisheries being the dominant fisheries. Pelagic fisheries are primarily concentrated along the shelf break and in adjacent deeper waters on the Scotian Slope. Other ocean uses in and around the Study Area include commercial shipping, scientific research, military activity and offshore petroleum exploration activity.

In recognition of the existing environmental features, potential exploration activities, key relevant legislation and guidelines, and stakeholder interests, the scope of the SEA was established, focusing on the following Valued Environmental Components (VECs):

- Species of Special Status (species listed by the *Species at Risk Act*, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and migratory birds);
- Special Areas (designated areas of special interest due to ecological/conservation sensitivities); and
- Fisheries (commercial, recreational, aboriginal fisheries and species which support these fisheries).

For each VEC, the SEA explored potential effects of exploration activities drawing on existing knowledge and literature, recommended mitigation and planning considerations, and discussed data gaps and uncertainties. Adherence to standard regulatory requirements/guidelines, including but not limited to, the Nova Scotia Offshore Drilling and Production Regulations and associated guidelines, the Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment (SOCP), Offshore Waste Treatment Guidelines, Offshore Chemical Selection Guidelines, and Compensation Guidelines Respecting Damage Relating to Offshore Petroleum Activity, was taken into consideration as standard mitigation. It should be noted however, that in some cases, these requirements would be considered minimum standards and enhanced mitigation may be required (*e.g.*, enhanced mitigation for seismic surveys beyond minimum requirements stated in the SOCP).

Table E.1 provides a summary of key mitigation and planning considerations for exploration activities in the Phase 3A Study Area.

Table E.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
Seismic and Seabed Surveys	• Avoid Roseway Basin Area Critical Habitat, Northeast Channel Coral Conservation Area (intrusive seabed surveys), and Sambro Bank and Emerald Basin Vazella Closure Areas (intrusive seabed surveys). • Schedule surveying to minimize interaction with peak spawning (*e.g.* haddock spawning in the Haddock Box from April to May). • If beaked whales are detected, enhanced mitigation may be required for seismic surveys (*e.g.*, the 30 minute observation period outlined in the Statement of Canadian Practice with Respect to Mitigation of Seismic Noise in the Marine Environment may be extended to 60 minutes to account for longer diving times. • Use of trained wildlife observers, with experience in identifying all whales listed on Schedule 1 of *SARA*, to visually monitor and record marine mammal, sea turtle and marine bird interactions and to help enforce safe operating distances. • Seabird monitoring to be completed following the CWS pelagic seabird monitoring protocol provided in Appendix C.

Table E.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
	• Detailed acoustic modeling as input to any project-specific EAs for seismic projects in the Phase 3A Project Area that may occur in the June-December period when North Atlantic right whales may be congregating in the Study Area. These modeling results may be used to define appropriate safety zones for shutdown (*e.g.*, 180 dB_{rms} safety zone) and the buffer zone around the Roseway Basin Critical Habitat/Area to be Avoided. • Fisheries Liaison Officer (FLO) familiar with NS offshore fisheries to be present on seismic survey vessels to communicate with fishing vessels in the area and to assist with avoiding potential conflict with fishing activities/gear. For conventional (single vessel) seismic programs, FLOs may be trained as marine wildlife observers and perform both tasks. • Use of Passive Acoustic Monitoring (PAM) as per the "Statement of Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment". • Adherence to the CNSOPB Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity. • Issuance of "Notice to Mariners" on location and scheduling of survey activities. • Commencement of seismic data acquisition only if survey area confirmed to be clear of fixed fishing gear (*e.g.*, lobster traps) or floating longline gear (*e.g.*, for large pelagics such as tuna and swordfish). • Consultation with key organizations representing fishing interests (including commercial and Aboriginal) in the area during the EA planning stage and just prior to commencement of any work to coordinate seismic program activities with fishing industry and to reduce potential conflict with fishing activity during peak fishing times. • Consultation with DFO Science Branch to ensure survey area and timing minimizes potential for conflict with research vessel program plans. • Consultation with the Department of National Defense (DND) to ensure survey area and timing minimizes potential for conflict with exercises and/or training. • Seabird monitoring to be completed following the CWS pelagic seabird monitoring protocol provided in Appendix C.
Exploratory Drilling	• Avoid exploration drilling in Roseway Basin, Northeast Channel Coral Conservation Area, and the Sambro Bank and Emerald Basin Vazella Closure areas. • Conduct pre-drilling ROV investigation to determine presence of corals, sponges, or other sensitive features as required by the CNSOPB. • Areas with known aggregations of cold water coral and other sensitive features shall be avoided during oil and gas drilling activities. If aggregations of cold water coral are found to occur as the result of an environmental assessment that is conducted following an application for drilling or production, the CNSOPB requires mitigation to avoid harming these aggregations (DFO 2006). • Follow Canadian Wildlife Service mitigation measures when finding a dead or injured bird (*i.e.*, Williams and Chardine handling protocol). • Adhere to the CNSOPB Offshore Waste Treatment Guidelines and Offshore Chemical Selection Guidelines to minimize effects of waste discharges during drilling programs.

Table E.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
	• Adhere to Nova Scotia Offshore Drilling and Production Regulations. • Implement bulk transfer and hose handling procedures as per best available practice. • Minimize flaring and ensure the use of high-efficiency igniters as per best management practice. • Focus all area lighting on the work areas of offshore platforms and down shade lights to minimize marine bird attraction. • Conduct a post-drilling ROV survey to verify that the muds and cuttings are within the predicted zone of influence. • Develop emergency contingency measures and response plans to address significant weather scenarios. • Monitor seabird interactions with the drilling rig/platform. • Enhanced mitigation and EEM programs may be required for activities within or adjacent to special areas, such as spawning areas (*e.g.* the Haddock Box), the Roseway Basin Area to be Avoided/Critical Habitat, Northeast Channel Coral Conservation Area and/or Sambro Bank and Emerald Basin Vazella Closure areas. • Develop codes of conduct to guide new exploratory activities in the vicinity of the Roseway Basin Area to be Avoided/Critical Habitat. • Issue "Notice to Shipping" on location and scheduling of drilling activities. • Consult with key organizations representing fishing interests (including commercial, Aboriginal and recreational) in the area during the EA planning stage.
Vessel Traffic	• Adhere to Transport Canada Guidelines for the Control of Ballast Water Discharge from Ships in Waters under Canadian Jurisdiction. • Use existing vessel routes to the extent practical and alternate routes around key fishing grounds particularly when fishing is at its peak. • Seasonal avoidance of the Roseway Basin Area to be Avoided (June 1 to December 31).
Well Abandonment	• Design wells and casings to facilitate effective mechanical cutting and removal of the wellhead; avoiding explosive means of separation where possible. • If use of explosives is necessary, the recommendations set out in the *Guidelines for the use of Explosives in or near Canadian Fisheries Waters* (Wright and Hopky, 1998) will be followed.
Accidental Spills	• Detailed spill probability and behavior modeling as input to any project-specific EAs for drilling projects. • Engineering design and process safety management protocols to prevent spills from occurring and/or reaching the marine environment including but not limited to secondary containment, inspection and maintenance, spill response kits, and blowout safeguards. • Implement Emergency and Oil Spill Response Plan accepted by the CNSOPB to address spill prevention and response including interactions with fishers and other ocean users, and includes spill response exercises.

Table E.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
	• Outline an EEM Plan to address post-spill monitoring effects in the Spill Response Plan, with the scope of the EEM Plan directly related to the severity of potential spills. • Establish ongoing communication with key fisheries stakeholders and other ocean users in the event of a spill and during spill response activities, including but not limited to issuance of a Notice to Shipping/Mariners. • Adhere to CNSOPB "Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity".

Various data gaps and uncertainties exist with respect to the understanding of environmental effects of exploration activities on marine species. In light of these gaps, a precautionary approach to oil and gas exploration should be taken in the vicinity of sensitive areas and the presence of species of special status. This may mean enhanced mitigation (beyond typical regulatory compliance) and monitoring until understanding of potential interactions and effects can be improved and appropriate mitigation developed. Future exploration that may occur in the Study Area offers a potentially valuable platform to conduct further research to address knowledge gaps. Stakeholder consultation will play an important role in mitigating environmental effects on fisheries and other ocean users.

Assuming adherence to applicable standards and regulations and the implementation of mitigation and monitoring as recommended, exploration activities in the Phase 3A Project Area are not expected to result in unacceptable adverse environmental effects such that populations of species of special status or the integrity of special areas would be compromised. Environmental effects of exploration on fisheries are also not expected to result in unacceptable effects provided the implementation of recommended mitigation and ongoing communication with fishery stakeholders occurs. It should be noted that there is the potential requirement for additional or alternative mitigation measures on a case by case basis at the Project level.

List of Acronyms

2D	two-dimensional
2DHR	2D high resolution
3D	three-dimensional
ACCASP	Aquatic Climate Change Adaptation Service Program
AFS	Aboriginal Fishing Strategy
ATBA	area to be avoided
AZMP	Atlantic Zone Monitoring Program
Bbbl	billion barrels
MMbbl	million barrels
BOP	blowout preventer
BP	British Petroleum
CEA	cumulative effects assessment
CEAA, 2012	*Canadian Environmental Assessment Act, 2012*
CEPA	*Canadian Environmental Protection Act*
CFA	crab fishing area
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CNSOPB	Canada-Nova Scotia Offshore Petroleum Board
COPAN	Cohasset-Panuke Project
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPT	cone penetrometer technology
cu.	cubic
CUPE	catch per unit effort
DFO	Fisheries and Oceans Canada
E&P	exploration and production
EA	environmental assessment
EBSA	ecologically and biologically significant area
EC	Environment Canada
ECRC	Eastern Canada Response Corporation
EEM	environmental effects monitoring
EMOBM	enhanced mineral oil-based mud
EPP	environmental protection plan
ESRF	Environmental Studies Research Fund
ESSIM	Eastern Scotian Shelf Integrated Management
FAC	Fisheries Advisory Committee
FLO	Fisheries Liaison Officer
FSC	food, social and ceremonial
GOM	Gulf of Mexico
HADD	harmful alteration, disruption or destruction
ICCAT	International Commission for the Conservation of Atlantic Tuna

IMO	International Maritime Organization
JIP	joint industry program
LFAs	lobster fishing areas
MARLANT	Maritime Forces Atlantic
Mcf	thousand cubic feet
MEG	mono-ethylene glycol
MMcf	million cubic feet
MODU	mobile offshore drilling unit
MOU	memorandum of understanding
MPA	marine protected area
MRI	Marshall Response Initiative
NAFO	Northwest Atlantic Fisheries Organization
NEB	National Energy Board
NAO	North Atlantic Oscillation
NWPA	*Navigable Waters Protection Act*
OBM	oil-based mud
OCMD	Oceans and Coastal Management Division
OCS	outer continental shelf
OCSG	Offshore Chemical Selection Guidelines
OEER	Offshore Energy Environmental Research Association
OGP	Oil and Gas Producers Association
OWTG	Offshore Waste Treatment Guidelines
PAM	passive acoustic monitoring
PERD	Program of Energy Research and Development
RMS	root mean square
ROV	remotely operated vehicle
SARA	*Species at Risk Act*
SBM	synthetic-based mud
SEA	strategic environmental assessment
SFA	scallop fishing area
SOCP	Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment
SOEP	Sable Offshore Energy Project
SSIP	Scotian Shelf Ichthyoplankton Program
TPH	total petroleum hydrocarbon
TTS	temporary threshold shift
VSP	vertical seismic profiling
WAZ	wide azimuth seismic survey
WBM	water-based mud

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1.0 Introduction

This report is a Strategic Environmental Assessment (SEA) of potential petroleum exploration activities on the Western Scotian Shelf (Western Bank to Browns Bank). SEA incorporates a broad-based approach to environmental assessment (EA) that examines potential environmental effects that may be associated with a plan, program or policy proposal and facilitates environmental management considerations at the earliest stages of exploration planning.

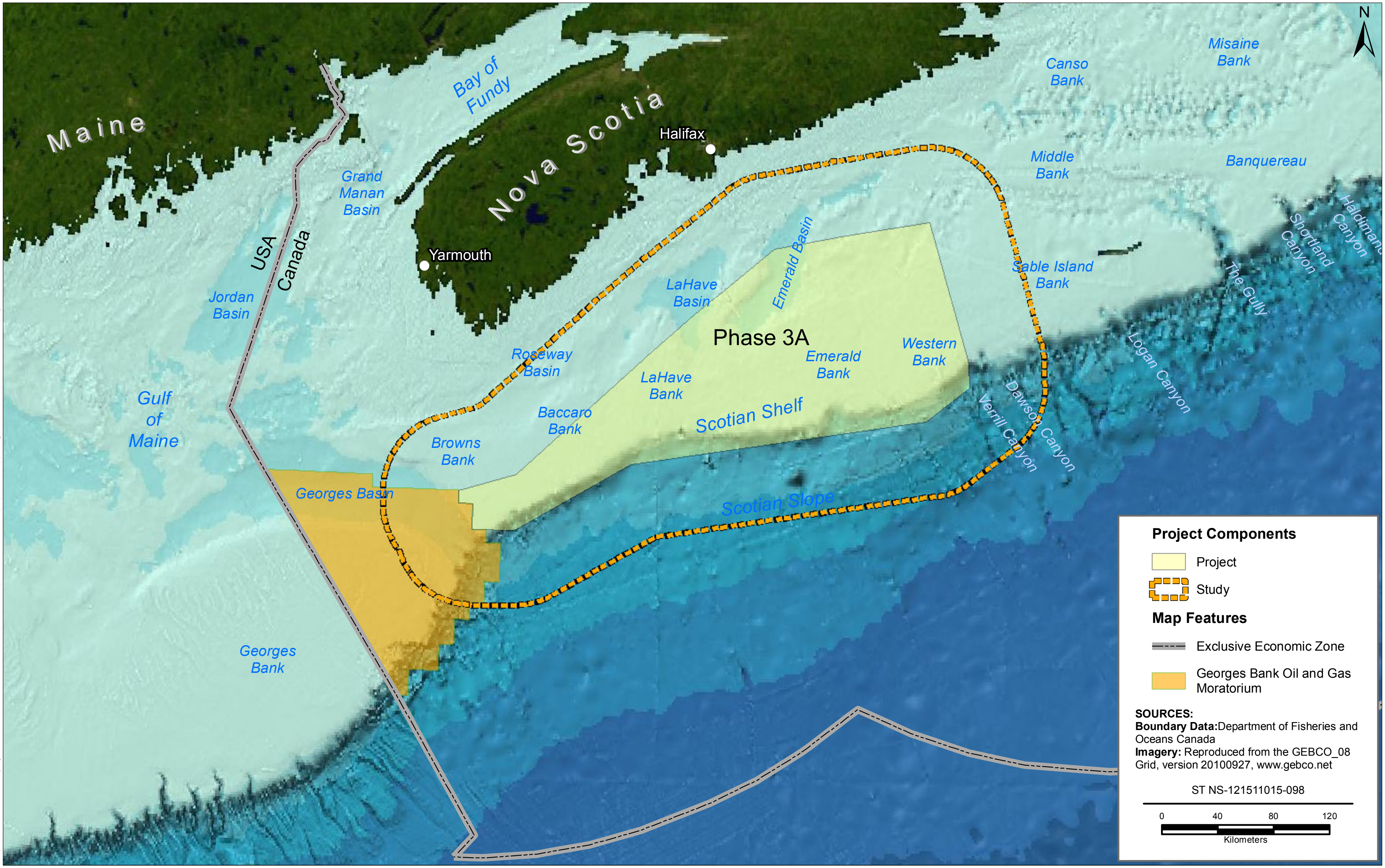
This SEA is intended to assist the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) in its determination with respect to the potential issuance of future exploration rights within the Western Scotian Shelf SEA area including general restrictive or mitigative measures that should be considered during the exploration program application and the program-specific environmental assessment process.

Notable features for environmental management consideration within or directly adjacent to the Phase 3A Project Area include the Roseway Basin Area to be Avoided/Critical Habitat for the North Atlantic right whale, Northeast Channel Coral Conservation Area, Sambro Bank and Emerald Basin Vazella Closure Areas, the Haddock Box, the Georges Bank Moratorium Area, as well as various *Fisheries Act* Closures including LFA 40 and the Browns Bank groundfish closure. Figure 1.1 illustrates the SEA Assessment Area for Phase 3A, which includes the Project Area as defined by the CNSOPB and a larger Study Area that has been delineated in recognition of a potential zone of influence of environmental effects for exploration activities that could potentially occur within the Project Area (refer to Section 4.4 for more information on assessment boundaries).

The SEA:

- defines general exploration activities;
- provides an overview of the existing environment within the Study Area;
- broadly describes potential adverse environmental effects associated with offshore oil and gas exploration;
- highlights relevant knowledge and data gaps; and
- recommends general mitigation measures for offshore petroleum exploration activities.

The SEA therefore identifies key environmental issues for the CNSOPB as well as for prospective future operators with interest in the parcels. The SEA is not intended to replace project-specific environmental assessments (EAs) that would be required for any proposed exploration program; rather it is intended to support and facilitate future project-specific EAs. The CNSOPB has committed to regularly review its SEAs every five years and to update them as required. This SEA has been prepared to meet requirements presented in the Scoping Document (Appendix A) which was subject to regulatory and public review. Additional information on the objectives and scope of the SEA is included in Section 4.



PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C. Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Strategic Environmental Assessment Study Area

FIGURE NO.: 1.1

DATE: Sep 25, 2013

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2.0 Exploration Activities

Since 1960, there have been 400,955 line kilometers of 2D seismic survey work conducted in the Nova Scotia offshore area and 29,512 km^2 of 3D seismic coverage. This does not include Shell Canada Ltd.'s Shelburne 3D seismic survey that was conducted on the southwestern Scotian Slope between June and August 2013 and expected to acquire approximately 8,400 km^2 of additional 3D data.

Since the first exploratory well drilled in 1967 (Sable Island C-67), there have been a total of 207 wells drilled in the Nova Scotia offshore area (including exploratory, delineation and development wells). In the Phase 3A Study Area, there have been 21 wells drilled.

2.1 REGULATORY CONTEXT

Petroleum activities in the Nova Scotia offshore are regulated by the CNSOPB, an independent joint agency of the federal and provincial governments. Under the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act* and the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act,* collectively referred to as the Accord Acts, the CNSOPB is responsible for the management and conservation of the offshore petroleum resources, in a manner that protects the health and safety of offshore workers and the environment while maximizing employment and industrial benefits for Nova Scotians and Canadians. The CNSOPB reports to the federal Minister of Natural Resources Canada and the provincial Minister of Energy.

Offshore petroleum rights are issued through a competitive bidding process (Call for Bids) in which any person or company can submit a Work Expenditure Bid in an effort to secure exploration rights for approved parcels of Crown Reserve Lands. These parcels may be nominated by industry or posted by the CNSOPB. The CNSOPB issues exploration rights to the winning bidder in the form of an Exploration License. An Exploration License has a maximum term of nine years and provides license owner(s) with the right to explore, the exclusive right to develop, drill and test for petroleum, and to obtain a production license. The issuance of an Exploration License does not itself confer authorization for physical exploration activities within the license area. All physical activities related to the exploration for petroleum require specific authorization from the CNSOPB. Before carrying out any activity in the offshore, an operator must obtain an Operator's License and a work authorization from the CNSOPB.

Offshore petroleum activities and the CNSOPB's decision-making processes are governed by a variety of legislation, regulations, guidelines, and MOUs. The CNSOPB enters into memoranda of understanding (MOUs) with government departments and agencies, such as Environment Canada and Fisheries and Oceans Canada (DFO), in order to effectively harmonize their plans, priorities, and activities of mutual interest. Annual work plan projects are developed with each department and implemented under these memoranda. For exploration projects, legislation and regulatory guidance administered by these departments are taken into consideration during environmental assessments where applicable.

As of October 24, 2013, amendments to the Regulations Designating Physical Activities under the *Canadian Environmental Assessment Act, 2012 (*CEAA, 2012) came into force, listing the drilling, testing and abandonment of offshore exploratory wells as a "designated project" under Section 10 of the amended Regulations. Specifically, the amendments include the addition of "The drilling, testing and abandonment of offshore exploratory wells in the first drilling program in an area set out in one or more exploration licences issued in accordance with the *Canada-Newfoundland Atlantic Accord Implementation Act* or the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act*" to the list of designated projects which may require environmental assessment by the Canadian Environmental Assessment Agency (the Agency).

Proponents proposing an exploratory drilling program which meets this criteria must now submit a description of the designated project to the Agency. Following a public comment period on the project description document, the Agency determines whether an EA is required and issues a Notice of Determination. If an EA is required, the Agency prepares Environmental Impact Statement (EIS) Guidelines (which are also subject to public comment) which form the basis for the EA process. Although the CNSOPB is not a federal authority under CEAA, 2012 and cannot lead the EA process, it will participate informally in the process as a technical advisor.

Table 2.1 summarizes key federal legislation and guidelines relevant to exploration activities.

Table 2.1 Summary of Key Relevant Legislation and Guidelines

Legislation/Guideline	Regulatory Authority	Relevance
Nova Scotia Offshore Area Petroleum Geophysical Operations Regulations (and associated Guidelines)	CNSOPB	These Regulations pertain to the geophysical operations in relation to exploration for petroleum in the Nova Scotia Offshore area and outline specific requirements for authorization applications and operations.
Nova Scotia Offshore Drilling and Production Regulations (and associated Guidelines)	CNSOPB	The Regulations outline the various requirements that must be adhered to when conducting exploratory and or production drilling for petroleum.
Offshore Waste Treatment Guidelines	National Energy Board (NEB) / CNSOPB/ Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB	Guidelines to aid operators in the management of waste material associated with petroleum drilling and production operations in offshore areas regulated by the Boards. This document contains key mitigation to be adhered to by operators to allow streamlining of the EA process.
Offshore Chemical Selection Guidelines	NEB / CNSOPB / C-NLOPB	The Offshore Chemical Selection Guidelines (OCSG) provide a framework for chemical selection which minimizes the potential for environmental impacts from the discharge of

Table 2.1 Summary of Key Relevant Legislation and Guidelines

Legislation/Guideline	Regulatory Authority	Relevance
		chemicals used in offshore drilling and production operations.
Compensation Guidelines Respecting Damage Relating to Offshore Petroleum Activity	CNSOPB / C-NLOPB	These Guidelines describe the various compensation sources available to potential claimants for loss or damage related to petroleum activity offshore Nova Scotia and Newfoundland and Labrador. These Guidelines also outline the regulatory and administrative roles which the Boards exercise respecting compensation payments for actual loss or damage directly attributable to offshore operators.
Environmental Protection Plan Guidelines	CNSOPB	Guidelines to assist an operator in the development of an environmental protection plan (EPP) that meets the requirements of the Acts and Regulations and the objective of protection of the environment from its proposed work or activity.
Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment	DFO / Environment Canada (EC) / CNSOPB / C-NLOPB/ Natural Resources Canada (NRCAN)/ Indian and Northern Affairs Canada (INAC)/Provinces of British Columbia/Newfoundland and Labrador/ Nova Scotia/Quebec	Specifies the minimum 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. This document contains key mitigation to be adhered to by operators of seismic programs.
Canadian Environmental Assessment Act, 2012	Canadian Environmental Assessment Agency	The *Canadian Environmental Assessment Act, 2012* (CEAA, 2012) is new legislation aimed at updating the previous CEAA and streamlining environmental assessment of projects where federal authorities are involved. "The drilling, testing and abandonment of offshore exploratory wells in the first drilling program in an area set out in one or more exploration licences" has been recently added to the list of designated activities under CEAA, 2012. As a designated activity, exploratory drilling may require an environmental assessment under CEAA, 2012.
Fisheries Act	DFO EC (administers Section 36, specifically)	The *Fisheries Act* contains provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. Under the *Fisheries Act*, no person shall carry on any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational, or aboriginal fishery, or to fish that support such a fishery,

Table 2.1 Summary of Key Relevant Legislation and Guidelines

Legislation/Guideline	Regulatory Authority	Relevance
		unless this has been authorized by the Minister of Fisheries and Oceans Canada. Section 36 of the *Fisheries Act* pertains to the prohibition of the deposition of a deleterious substance into waters frequented by fish.
Canadian Environmental Protection Act, 1999	EC	The *Canadian Environmental Protection Act, 1999* (CEPA) pertains to pollution prevention and the protection of the environment and human health in order to contribute to sustainable development. Among other things, CEPA provides a wide range of tools to manage toxic substances, and other pollution and wastes, including disposal at sea.
Migratory Birds Convention Act, 1994	EC	Under the *Migratory Birds Convention Act, 1994*, it is illegal to kill migratory bird species not listed as game birds or destroy their eggs or young. (It is legal to kill game birds only during legislated hunting seasons). The Act also prohibits the deposit of oil, oil wastes or any other substance harmful to migratory birds in any waters or any area frequented by migratory birds
Species at Risk Act	DFO/EC/Parks Canada	The *Species at Risk Act* (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. Under the Act, proponents are required to complete an assessment of the environment and demonstrate that no harm will occur to listed species, their residences or critical habitat, or identify adverse effects on specific listed wildlife species and their critical habitat, followed by the identification of mitigation measures to avoid or minimize effects. Proponents are advised that all activities must be in compliance with *SARA*. Section 32 of *SARA* states "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated, endangered or threatened species". For a complete list of prohibitions consult Section 32 of the Act.

Table 2.1 Summary of Key Relevant Legislation and Guidelines

Legislation/Guideline	Regulatory Authority	Relevance
Oceans Act	DFO	The *Oceans Act* provides for the integrated planning and management of ocean activities and legislates the marine protected areas program, integrated management program, and marine ecosystem health program. MPAs are designated under the authority of the *Oceans Act*.
Navigable Waters Protection Act/Navigation Protection Act	Transport Canada	The *Navigable Waters Protection Act* (NWPA) is intended to protect navigable waters by regulating the construction of works on those waters and by providing the Minister of Transport with the power to remove obstructions to navigation. Proposed amendments (likely to come into force in 2014) involve renaming the Act to *Navigation Protection Act* and focusing protection on "Scheduled Waters".

2.2 GENERIC DESCRIPTION OF ROUTINE OIL AND GAS EXPLORATION ACTIVITIES

Generic descriptions of potential exploration activities to be considered in the SEA are presented below. Consideration of routine emissions and discharges have been guided by the scope of the SEA (refer to Appendix A) assuming compliance with applicable regulations and guidelines including: the Offshore Waste Treatment Guidelines (OWTG) (NEB *et al*. 2010), Nova Scotia Offshore Drilling and Production Regulations (and associated guidelines), Offshore Chemical Selection Guidelines (NEB *et al*. 2009), Compensation Guidelines Respecting Damage Relating to Offshore Petroleum Activity (C-NLOPB and CNSOPB 2002), and Environmental Protection Plan Guidelines (C-NLOPB *et al*. 2011).

Table 2.2 Generic Description of Exploration Activities - Geophysical Surveys

Geophysical Surveys (2D Seismic, 3D Seismic, 3D Wide Azimuth Seismic)	

Overview	• Seismic surveys are the first step in oil and gas exploration in which sound waves are used to develop an image of subsurface strata and structure features where hydrocarbons could accumulate and be retained.
	• Sound waves are typically generated by an air source array (*e.g.*, air guns) with reflections from subsurface rock being recorded by hydrophones (streamers) towed behind the survey vessel.
	• Methods of data acquisition can vary depending on level of information that is required:
	  o Two-dimensional (2D) surveys involve a single seismic cable or streamer towed behind a survey vessel with a single sound source (*e.g.*, air gun), giving an image in horizontal and vertical (2D) dimensions. This method is usually used in frontier exploration areas to produce a general understanding of geological structure.
	  o Three-dimensional (3D) surveys typically cover a specific area with known geological targets identified by previous 2D surveys and employ more than one source and streamer from the same survey vessel. Multiple streamer cables and air gun arrays can produce data sets that can be processed with advanced software to reveal the 3D geometry of the surface at high resolutions.
	  o A wide azimuth-seismic survey (WAZ) is a non-conventional seismic survey that involves multiple towed stream/ recording and source vessels, providing a broader range of horizontal direction, thus resulting in enhanced data quality and capacity to resolve complex geological features. The configuration of the survey can vary; typically one or two cable vessels are accompanied by up to four additional vessels towing source arrays only (whereas conventional 3D involves a single vessel towing both a source and receiver array).

Regulatory Context	• A Geophysical Work Authorization is required pursuant to the Nova Scotia Offshore Area Petroleum Geophysical Operations Regulations, and Geophysical and Geological Programs in the Nova Scotia Offshore Area – Guidelines for Work Programs, Authorizations and Reports.
Equipment and Methods	• For conventional seismic surveys, air guns are typically arranged in arrays of 12-48 guns of various sizes distributed over a horizontal area approximately 20 m inline by 20 m cross line. An array typically has 3-6 sub arrays called strings, with each string comprised of up to 6-8 air guns. The array is towed approximately 200 m behind the vessel and suspended by floats at a depth of 3-10 m. The air guns operate at 2000 psi or 137 bar and fire every 10-15 seconds. The hydrophone streamer is also towed behind the vessel (usually 4500-6000 m in length but can be up to 10,000 m in length). Streamers may be solid or contain a fluid (*e.g.*, kerosene). • 2D seismic surveying is the simplest and most inexpensive method, typically using one air gun array and one seismic streamer with distances between survey lines (*i.e.*, ship tracks) spaced at 1 km or greater (refer to Figure 2.1). • 3D seismic surveys use a series of parallel passes through an area with a vessel towing one or more air gun arrays with 6-10 seismic streamers at a speed of 5 knots (refer to Figure 2.1). • WAZ seismic surveys use similar technology as conventional seismic (*e.g.*, air guns, streamers) but employs several source vessels (towing air guns) and make successive passes over the target, each time increasing the offset between the streamers and source vessels by the width of the streamer spread (refer to figure 2.3).

Table 2.2 Generic Description of Exploration Activities - Geophysical Surveys

<table>
<tr><th colspan="2">Geophysical Surveys (2D Seismic, 3D Seismic, 3D Wide Azimuth Seismic)</th></tr>
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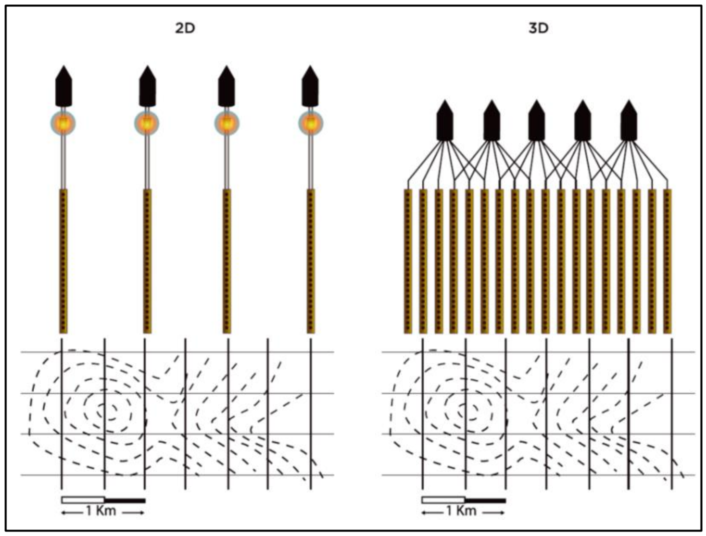
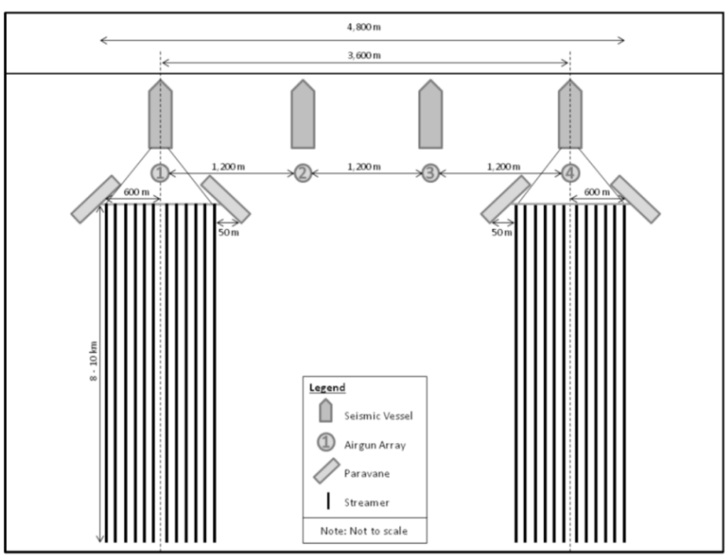


Source: OGP 2011

Figure 2.1 Comparison of Typical 2D Seismic Survey Geometry and 3D Seismic Survey Geometry Showing Spacing between Ship Tracks



Source: Shell 2012

Figure 2.2 Typical 3D WAZ Survey Vessel Configuration
</td></tr>
<tr><td>Spatial Extent</td><td>• 2D data acquisition lines are typically spaced several kilometers apart over a large area (up to thousands of kilometers).</td></tr>
</table>

Table 2.2 Generic Description of Exploration Activities - Geophysical Surveys

Geophysical Surveys (2D Seismic, 3D Seismic, 3D Wide Azimuth Seismic)	
	• 3D data sail line separation is typically in the order of 400 to 800 m depending on the number of streamers deployed and their cross-line separation. A small 3D survey is approximately 300 km^2, with larger surveys covering approximately 1,000 to 3,000 km^2. • WAZ surveys have a larger footprint than conventional seismic surveys given the multi-vessel configuration that is used, although the overall survey area is generally more focused and in the range of 3D surveys. • Propagation of underwater noise increases the spatial extent beyond the physical footprint of the seismic equipment by hundreds of kilometers.
Timing/ Duration	• Conventional seismic surveys (2D and 3D) typically take a few weeks to a month to complete. • 3D WAZ usually occur over a few months, depending on the area being surveyed. 3D WAZ seismic surveys take longer to change survey lines (turn), usually 5-7 hours, compared to 2-3 hours for typical 3D seismic surveys.
Routine Emissions	• Emissions associated with geophysical surveys include routine vessel emissions (*e.g.*, exhaust emissions, lights, sewage/ food wastes, bilge water/ballast water) and underwater noise. • Most of the emitted seismic energy lies within the 10–120 Hz range, with some energy in the 500–1000 Hz range. In shallow waters (25-50 m) air guns can be audible at distances up to 75 km, while in deeper waters they can be audible at distances over 100 km. Typical zero-to-peak source levels for exploration seismic arrays are 245-260 dB relative to 1 μPa at 1m.
Key Environmental Issues	• Effects of seismic noise on marine wildlife • Spills and unauthorized discharges • Interactions with other ocean users, particularly fishing industry • Interactions between seismic ship and gear with marine mammals and sea turtles

Sources: Hurley 2009; DFO 2011a; LGL 2012; OGP 2011; Shell 2012

Table 2.3 Generic Description of Exploration Activities - Seabed Surveys

Seabed Surveys (Geophysical Surveys, Geotechnical Sampling, Environmental Sampling)	
Overview	• Seabed surveys, which can include geophysical, geotechnical or environmental surveys, are undertaken to detect potential hazards (*e.g.*, shallow gas, unstable substrate, wrecks/cables) and characterize surficial geology, bedforms, and benthic habitat in the immediate vicinity of proposed drilling locations.
Regulatory Context	• A Geotechnical/Geological/Engineering/Environmental Program Authorization is required pursuant to the Accord Acts and Regulations and Geophysical and Geological Programs in the Nova Scotia Offshore Area – Guidelines for Work Programs, Authorizations and Reports.
Equipment and Methods	• Geo-surveys are conducted via 2D high resolution (2DHR) digital seismic (low energy) consisting of a small air gun array (160 cubic (cu.) inch versus approximately 3000-6000 cu. inch for typical 2D or 3D seismic survey) and a single

Table 2.3 Generic Description of Exploration Activities - Seabed Surveys

Seabed Surveys (Geophysical Surveys, Geotechnical Sampling, Environmental Sampling)	
	streamer 1200 m or less in length towed 2-4 m below the surface. • Additional equipment that may be used for geophysical sampling can include a sub-bottom profiler, multi-beam echo sounder, sidescan sonar, and/or magnetometer. • Geotechnical sampling can involve a variety of technologies including geotechnical boring (well site locations), vibracores and cone penetrometer technology (CPT). • Environmental sampling (benthic photographs/videos and sediment samples) may be undertaken to corroborate data and characterize benthic habitat.
Spatial Extent	• Seabed surveys are typically focused on targeted drilling locations and do not generally extend more than 1 km from the proposed well site.
Timing/Duration	• The duration of each survey program would be in the order of days, with a total survey program taking a few weeks to a couple of months including port calls and downtime.
Routine Emissions	• Routine emissions include emissions from survey vessels (*e.g.*, exhaust, lights, noise, deck drainage, sewage/food wastes, bilge/ ballast water) and limited noise associated with geophysical and geotechnical sampling.
Key Environmental Issues	• Environmental issues are reduced given the limited duration and geographical extent of the surveys • Effects of underwater noise on marine wildlife • Unauthorized discharges from survey vessels • Interactions with other ocean users, particularly fishing industry

Sources: Hurley 2011; Hurley and Stantec 2010; Corridor Resources Inc. 2010

Table 2.4 Generic Description of Exploration Activities - Drilling Activities

Drilling Activities (Exploration Drilling, Vertical Seismic Profiling, Well Evaluation and Testing, Delineation Drilling, Well Abandonment)	
Overview	• Exploration drilling is conducted to confirm the presence and extent of hydrocarbon resources within a targeted geological structure. • Vertical seismic profiling (VSP) or a check-shot survey is undertaken following completion of drilling to confirm well depth. • If significant hydrocarbons are encountered during drilling, formation fluids are tested (hydrocarbons separated from produced water and analyzed, with produced water sent to the rig's flare or treated for disposal). • Once the exploratory well has been drilled, the wellbore is plugged below the seafloor and suspended for future re-entry or abandoned (wellhead removed from seafloor). A remotely-operated vehicle (ROV) is used to inspect the seabed to ensure no obstructions remain in place. • If hydrocarbons are encountered, the size of the oil and/or gas reserves is assessed through drilling of appraisal or delineation wells.

Table 2.4 Generic Description of Exploration Activities - Drilling Activities

Drilling Activities (Exploration Drilling, Vertical Seismic Profiling, Well Evaluation and Testing, Delineation Drilling, Well Abandonment)	
Regulatory Context	• An Application for Authorization is required pursuant to the Nova Scotia Offshore Petroleum Drilling and Production Regulations and Drilling and Production Guidelines. • After an authorization is issued, each well within the drilling program must be approved by the CNSOPB through an well approval).
Equipment and Methods	• Exploration drilling rigs used off the coast of Atlantic Canada are called Mobile Offshore Drilling Units (MODUs). There are three main types of MODUs, the selection of which is generally dependent on physical characteristics of the well site, including water depth and oceanographic conditions, and logistical considerations (*e.g.*, rig availability). In shallow waters (less than 100 m), a jack-up rig (*e.g.*, Rowan Gorilla II used on Sable Bank) is typically used; in deeper waters a drill ship or semi-submersible rig is used. o A jack-up rig is towed to the drill site. Once on site, the rig's retractable legs are lowered until they rest on the sea floor, at which point the platform is elevated up the legs until it reaches the desired height above the sea surface (refer to Figures 2.1 and 2.2 for examples). o A drill ship is a self-propelled drilling unit that can stay on location using anchors (in waters less than 1,000 m) or a dynamic positioning system (satellite navigation system transmits position to a computer, which controls thrusters direction and power to keep the rig on station). Drill ships generally can carry greater loads (*e.g.*, supplies), making them better suited for remote locations where re-supply is more difficult (refer to Figure 2.3 for example). o A semi-submersible rig can be towed or move under its own power to the site, and is designed to operate in rough seas. Semi-submersibles can be moored using anchors (in shallower waters) or a dynamic positioning system (refer to Figure 2.4 for example). • Drilling muds are used to lubricate the drill bit and flush drilled rock cuttings from the bit, carrying them up to the surface. There are three basic types of drilling muds: water-based muds (WBM), synthetic-based muds (SBM), and oil-based mud (OBM). • Offshore wells are drilled in stages (sections), with a typical well depth ranging from 2,000 to 5,000 m. • The first section of the well is a large diameter conductor hole (approximately 900 mm) being drilled several hundred metres into the seafloor. As there is no way to return the drilling muds and cuttings to the drilling unit before the riser is installed, these muds and rock cuttings are released onto the seafloor. Therefore, WBM is used to drill this portion of the well given its perceived more benign composition (although smothering of the benthos occurs in the immediate vicinity of the well). • The drill string is then removed and a steel casing is run and cemented into place to prevent the wall of the hole from caving in and to prevent the seepage of muds and other fluids. • The casing also ensures that there is adequate pressure integrity to allow a blowout preventer (BOP) and the drilling riser to be installed. The BOP is a system of high-pressure valves that prevent water or hydrocarbons from escaping into the environment in the event of an emergency or equipment failure. • The drill bit and string are then lowered through the BOP and into the surface hole. The bit begins drilling at the bottom of the hole, and extra joints are added to the drill

Table 2.4 Generic Description of Exploration Activities - Drilling Activities

Drilling Activities (Exploration Drilling, Vertical Seismic Profiling, Well Evaluation and Testing, Delineation Drilling, Well Abandonment)	
	string as the drill bit cuts the hole. • When a section of the well is complete, the drill string is pulled out and the sections of the casing are joined together, lowered into the well and cemented into place. • For this portion of the well, the drilling riser connects the casing set at the seafloor up to the drilling unit, which allows the return of cuttings and drilling muds to the surface drilling unit where processing takes place. • SBM is often used in drilling lower well sections, particularly if the use of WBM is technically impractical (*e.g.*, due to formation structure, well orientation). • SBM is transported with the cuttings up the riser to the drilling rig for recovery and reuse. Once onboard, the cuttings are removed from the drilling muds in successive separation stages, with some fluids being reconditioned and reused, and spent fluids returned to shore for disposal. • Cuttings (both WBM and SBM) may be discharged at the drill site provided they are treated (SBM) prior to discharge to meet the OWTG (NEB *et al.* 2010) specified limit of oil on cuttings. Otherwise, cuttings are collected and returned to shore for disposal. • Once the well has been completed, VSP is conducted to obtain accurate "time-to-depth ties". This is necessary as seismic data are recorded in time and wells are drilled in metres. VSP involves placing a string of geophones down the well, with a seismic source (*e.g.*, air guns) suspended from the drilling unit. The seismic source is similar to a seismic survey array, but is usually smaller with a peak output pressure of 240-250 dB (refer to Figure 2.5 for example). • Once drilling and testing is complete wells are typically abandoned. Cement or mechanical devices are used to plug the well. The well casing is cut and removed just below the surface of the sea floor and all previously installed equipment is removed. Wellheads are often removed using a mechanical casing/wellhead cutting device. If the device fails, a chemical/directed explosive method is used to detach the wellhead (with the charge set a minimum of 1 m below the sea substrate). An ROV is used to inspect the seabed to confirm no equipment or obstructions remain in place.

Table 2.4 Generic Description of Exploration Activities - Drilling Activities

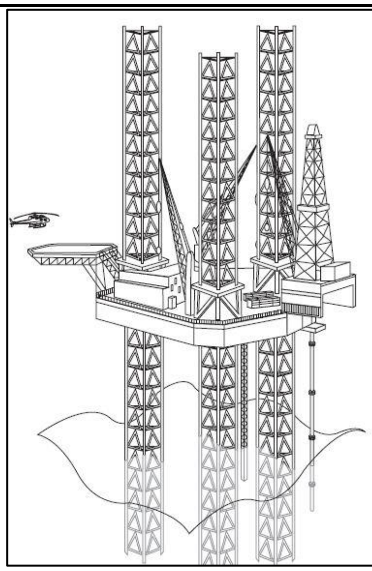
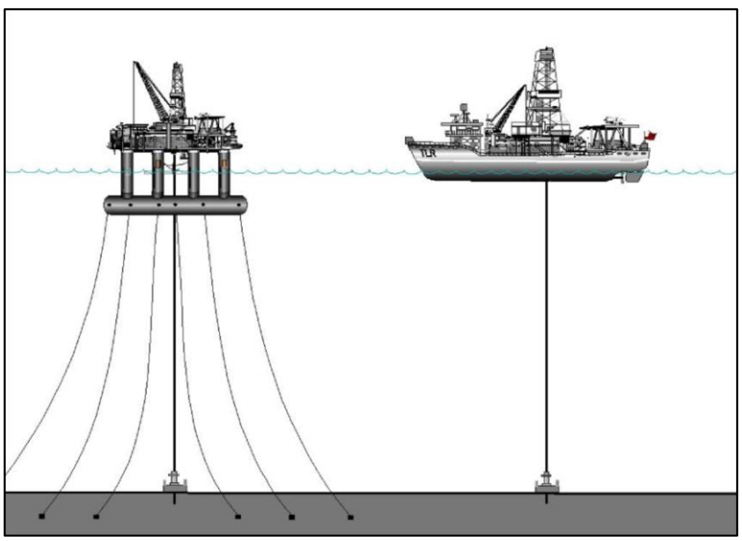
Drilling Activities (Exploration Drilling, Vertical Seismic Profiling, Well Evaluation and Testing, Delineation Drilling, Well Abandonment)	
	 Source: Petroleum Support 2011 **Figure 2.3 Schematic of Typical Jack-up Rig**  Source: MMS 2000 **Figure 2.4 Schematic of Typical Semi-submersible Drilling Rig and Drill Ship**

Table 2.4 Generic Description of Exploration Activities - Drilling Activities

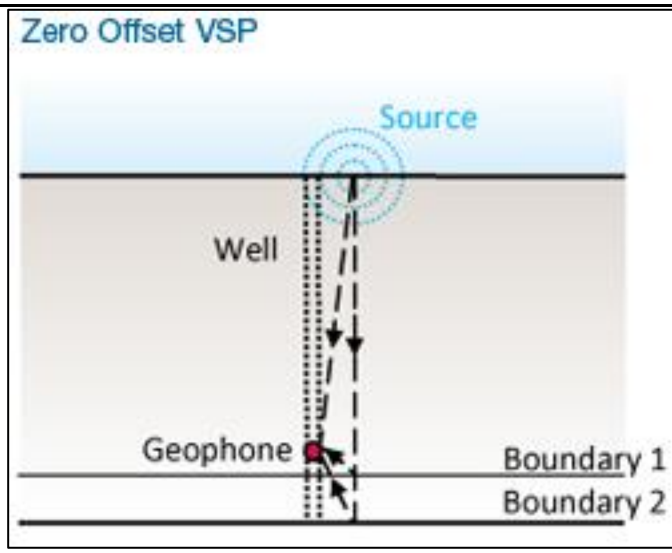
Drilling Activities (Exploration Drilling, Vertical Seismic Profiling, Well Evaluation and Testing, Delineation Drilling, Well Abandonment)	
	 Source: CO2CRC 2011 **Figure 2.5 Schematic of VSP**
Spatial Extent	• A safety zone of 500 m from the rig (or 50 m beyond the edge of an anchor pattern if applicable) is established while a drilling rig is on location. Only ships supporting the drilling program (*e.g.*, supply vessels) are permitted to enter this zone. • Propagation of underwater noise, atmospheric emissions, and routine discharges (including drill wastes) during drilling operations increase the spatial extent beyond the physical footprint of the drilling rig by tens of kilometers.
Timing/ Duration	• The typical duration of exploratory drilling program ranges from 30-90 days, including well testing and completion but can be longer depending on the complexity of the well. • The duration of VSP operations and well testing is in the order of hours to days within this time frame.
Routine Emissions	• Routine emissions include: o Atmospheric emissions such as exhaust and flare emissions (during testing), heat/light emissions from navigation, deck and underwater lights o Drill waste including drilling muds and associated rock cuttings, provided the cuttings do not exceed 6.9 g/100 g oil on wet solids as per the OWTG (release of whole SBM is not authorized for discharge offshore) o Potentially oily water associated with deck drainage, bilge water, and ballast water o Sewage and food wastes o Noise from standby/supply vessels, drilling, and VSP • Levels of radiated drilling noise are dependent on rig type. Jack-up rigs tend to be relatively quiet compared to other rig types. Semi-submersibles are relatively quiet

Table 2.4 Generic Description of Exploration Activities - Drilling Activities

Drilling Activities (Exploration Drilling, Vertical Seismic Profiling, Well Evaluation and Testing, Delineation Drilling, Well Abandonment)	
	themselves although dynamic positioning thrusters are a potential source of noise. Drill ships are noisier than jack-up rigs or semi-submersibles, since heavy machinery is situated close to the hull, thereby radiating more noise into the marine environment. • Miscellaneous solid waste (*e.g.*, paper, domestic waste, scrap metal) is transferred to shore for sorting, recycling, and disposal according to the Nova Scotia Solid Waste-Resource Management Regulations and municipal requirements as applicable. • Whole SBM is not permitted to be discharged offshore and rock cuttings associated with SBM use that do not meet the OWTG after treatment, are shipped to shore for appropriate treatment and disposal.
Key Environmental Issues	• Smothering of benthic habitat and fauna • Effects of drilling noise on marine wildlife • Presence of platform (lights/discharges, loss of access for fishing industry, attraction of wildlife to platform) • Spills and unauthorized discharges (including loss of SBM, blowouts, exceedances of OWTG)

Sources: CAPP 2006; JWEL 2003; Hurley 2009; Encana 2005

Table 2.5 Generic Description of Exploration Activities - Vessel and Helicopter Traffic

Vessel and Helicopter Traffic (Supply and Servicing)	
Overview	• Vessels and helicopters are used to transport personnel and supplies between a shorebase and drilling location, and facilitate liaison with other ocean users (*e.g.*, "chase" or "picket" vessels during seismic surveys).
Regulatory Context	• Vessels and helicopters must meet local (*e.g.*, CNSOPB Offshore Petroleum Occupational Health and Safety Requirements), national (*e.g.*, *Canada Shipping Act*; Marine Occupational Health and Safety Regulations), and international (*e.g.*, MARPOL, SOLAS conventions) requirements. Although support vessels and helicopters are not regulated per se by the CNSOPB, once included in the Declaration of Operator, they are subject to inspection by the CNSOPB prior to authorization.
Equipment and Methods	• During seismic surveys, one or two small chase vessels are used to look for fishing activity in the area and to prevent gear loss and entanglement. • An exploration drilling program would likely require 2-3 supply vessel trips per week, with a dedicated stand-by vessel attending the rig throughout drilling operations. • Supply/support vessels usually range in size from 20 m to 100 m. • Helicopters may be used for resupply, crew changes, or medical emergencies, depending on the length of the seismic survey. • Helicopter flights would be used to transport personnel to and from the drilling rig approximately 4 times per week.
Spatial Extent	• The spatial extent would be related to the transit route between a shorebase on the coast of Nova Scotia to the offshore exploration site.

Table 2.5 Generic Description of Exploration Activities - Vessel and Helicopter Traffic

Vessel and Helicopter Traffic (Supply and Servicing)	
Timing/ Duration	• Chase vessels would be required for the duration of a seismic exploration program (weeks to months). • Supply and servicing by vessels and helicopters would be required for the duration of a drilling program (*e.g.*, 30-90 days, or longer if drilling in deep water).
Routine Emissions	• Routine emissions include: o Atmospheric emissions such as exhaust emissions and light emissions o Potentially oily water associated with deck drainage, bilge water, and ballast water o Sewage and food wastes o Noise • Miscellaneous solid waste (*e.g.*, paper, domestic waste) is transferred to shore for sorting, recycling and disposal according to the Nova Scotia Solid Waste-Resource Management Regulations and municipal requirements as applicable.
Key Environmental Issues	• Vessel collision with marine mammals/sea turtles • Attraction of species to vessel lights and discharges • Noise effects on marine wildlife • Spills and unauthorized discharges

Sources: Thompson *et al.* 2000; Husky 2010

2.3 POTENTIAL ACCIDENTAL EVENTS

Potential accidental events that can occur during petroleum exploration programs are focused on unplanned releases into the marine environment. This can occur as a result of a break of a seismic streamer (*e.g.*, release of kerosene or other streamer fluid), blowouts (continuous uncontrolled release of hydrocarbons during drilling that can occur below or above the sea surface), or platform and vessel leaks, spills and releases (*e.g.*, hydraulic fluid, drilling mud, diesel, release of hydrogen sulphide). Of primary concern, and the focus of this SEA, are well blowouts and batch spills of diesel, although it is recognized that even small amounts of hydrocarbons can have detrimental effects on marine wildlife, particularly marine birds. A worst-case scenario accidental event would be a blow-out resulting in a large spill from a well containing oil on the Scotian Shelf. Although there has not been a blowout involving oil on the Scotian Shelf since exploration activities began in 1968, recent seismic exploration on the Scotian Slope has provided an indication that oil, rather than natural gas, may be the target for future drilling campaigns and should be considered appropriately in accident scenario planning. The following sections provide an overview of petroleum industry-related spills (worldwide and in Atlantic Canada) as well as spill prevention and response measures to provide context for accidental events that could occur during exploration activities.

2.3.1 Spill History of the Offshore Petroleum Industry

On April 20, 2010 a blowout occurred at British Petroleum's exploratory deepwater Macondo well, located in the Gulf of Mexico, killing 11 crew members and spilling what would become approximately 4.9 million barrels (MMbbl) of oil into the Gulf waters. It took 87 days to stop the flow of oil from the well. On September 21, 2010, five months after the blowout event, the United States government finally declared the well "dead". For months following the blowout event, numerous investigations were carried out to determine the cause and better understand the consequences of this event. More than three years later, the residual effects of this catastrophic spill are still evident not only in terms of environmental effects, but also in terms of industry and regulatory-driven changes, and the public perception of risk associated with offshore oil and gas exploration.

The Macondo Prospect well blowout (also widely referred to as the "Deepwater Horizon" incident, named after the drilling installation) was the first uncontrolled deepwater blowout to occur on the United States Outer Continental Shelf (OCS). Since offshore drilling began in the United States mid-1950s, there have been three offshore oil-well blowouts involving hydrocarbon spills greater than 50,000 bbl. In Canada, there have been no large petroleum spills from blowouts. World-wide blowouts involving the spillage of more than 10,000 bbl each are listed in Table 2.6 (Husky 2012).

Table 2.6 Historical Extremely and Very Large Spills from Offshore Oil Well Blowouts

Area	Reported Spill size (bbl)	Year	Operation underway	Durations (days)	Intervention Method
Extremely Large Spills (>150,000 bbl)					
US Gulf of Mexico (GOM) [(a)]	4,000,000	2010	Exploratory Drilling	91	Relief Well
Mexico (*Ixtoc-1*) [(b)]	3,000,000	1979	Exploratory Drilling	293	Relief Well
Iran [(c)]	See note	1983	Production	--	
Mexico	247,000	1986	Workover	??	
Nigeria	200,000	1980	Development Drilling	14	Bridged
North Sea/Norway	158,000	1977	Workover	7	Capped
Very Large Spills (>10,000 bbl)					
Iran	100,000	1980	Development Drilling	8	Unknown
US, Santa Barbara	77,000	1969	Production (platform)	11	Capped
Saudi Arabia	60,000	1980	Exploratory Drilling	8	Capped
Mexico	56,000	1987	Exploratory Drilling	51	
US, S. Timbalier 26	53,000	1970	Wireline	138	Relief Well and Capping

Table 2.6 Historical Extremely and Very Large Spills from Offshore Oil Well Blowouts

Area	Reported Spill size (bbl)	Year	Operation underway	Durations (days)	Intervention Method
US, Main Pass 41	30,000	1970	Production (platform)	49	Capped (three relief wells also initiated)
Australia [d]	30,000	2009	Development Drilling (primarily gas)	74	Relief Well
US, Timbalier Bay/Greenhill	11,500	1992	Production	11	Unknown
Trinidad	10,000	1973	Development Drilling	4	Unknown

Notes:
(A) Varying estimates of spill volume, most recent estimate reported.
(B) Spill volume widely believed to be significantly underestimated.
(C) The Iranian Norwuz oil well blowouts in the Gulf of Arabia, which started in February 1983, were not caused by exploration or drilling accidents, but were a result of military actions during the Iran/Iraq war.
(D) Currently under investigation; spill volume is best estimate and may be subject to revision.

Source: Husky 2012

On a smaller scale, between 1964 and 2010 there have been 33 spills ≥1,000 bbl (159 m^3, 159 kilolitres) from OCS platforms and pipelines. Twenty of these spills were related to leaking or damaged pipelines; eight were associated with well blowouts (including the Macondo well blowout) and three were associated with hurricane events (Anderson *et al.* 2012). Figure 2.6 puts the number of spills into context showing OCS oil production versus petroleum spills >1,000 bbl from 1964 to 2010.

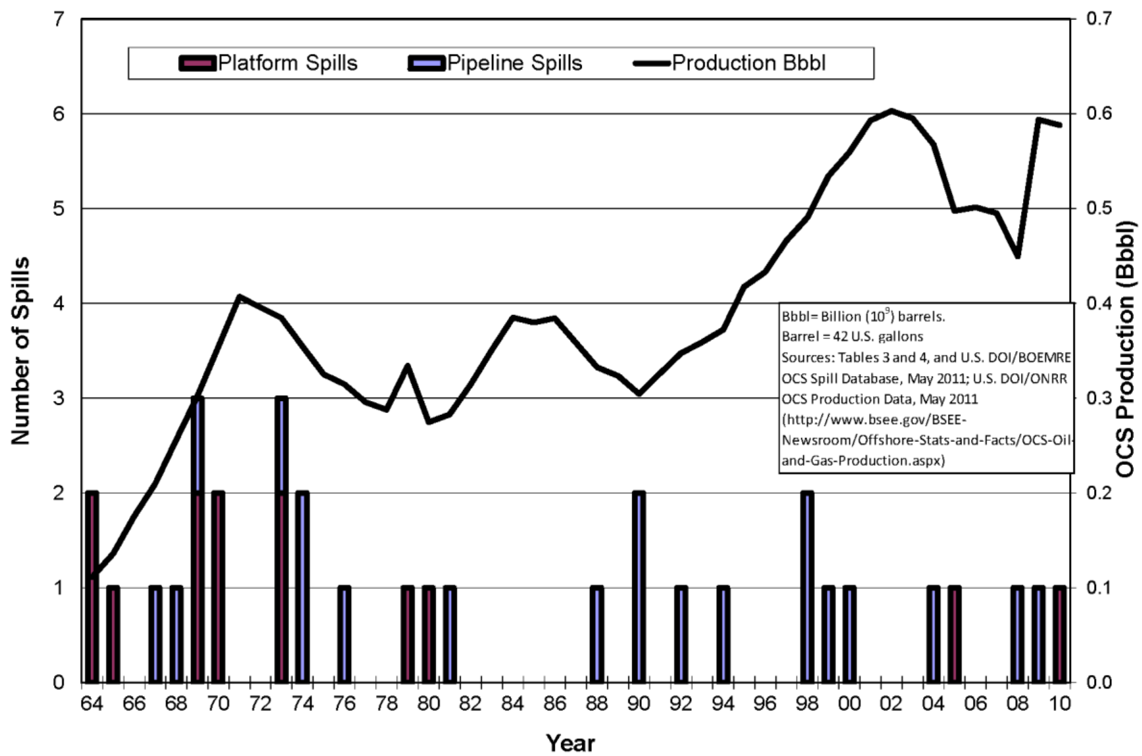


Figure 2.6 OCS Oil Production vs. Petroleum Spills ≥ 1,000 Barrels from OCS Oil and Gas Operations, 1964 through 2010 (Anderson *et al.* 2012)

Spill rate estimates are based on historic spill occurrences and the associated volume of oil produced and transported. A spill rate is an estimate of the mean number of spills of a given size range that is likely to occur over a uniform volume of oil handled. Based on US OCS Platform and Pipeline Spill Data (1964 through 2010), the spill rate for platform spills ≥1,000 bbl is calculated to be 0.25 spills per billion barrels (Bbbl). The spill rate for OCS platform spills ≥10,000 bbl is calculated to be 0.06 spills per Bbbl (Anderson *et al.* 2012).

In spite of recent attention to offshore blowouts in recent years, the probability of a very large spill (*i.e.*, >10,000 bbl) occurring remains extremely low. Compared with other industries that have potential for discharging petroleum into the marine environment, the offshore exploration and production industry has a very good record. A study on marine oil pollution by the US National Research Council (NRC 2002) indicates that accidental petroleum discharges from platforms contribute only 0.07 percent of the total petroleum input to the world's oceans (refer to Table 2.7).

Table 2.7 Best Estimate of Annual Releases [1990 to 1999] of Petroleum by Source

Petroleum Source	North America (in thousands of tonnes)	Worldwide (in thousands of tonnes)
Natural Seeps	**160**	**600**
Extraction of Petroleum	**3.0**	**38**
Platforms	0.16	0.86
Atmospheric Deposition	0.12	1.3
Produced water	2.7	36
Transportation of Petroleum	**9.1**	**150**
Pipeline Spills	1.9	12
Tank Vessel Spills	5.3	100
Operational Discharges [Cargo Washings]	Na[A]	36
Coastal Facility Spills	1.9	4.9
Atmospheric Deposition	0.01	0.4
Consumption of Petroleum	**84**	**480**
Land-Based [River and Runoff]	54	140
Recreational Marine Vessel	5.6	Nd[B]
Spills [Non-Tank Vessels]	1.2	7.1
Operational Discharges [Vessels 100 GT]	0.10	270
Operational Discharges [Vessels <100 GT]	0.12	Nd[C]
Atmospheric Deposition	21	52
Jettisoned Aircraft Fuel	1.5	7.5
TOTAL	**260**	**1,300**

Note:
[A] Cargo washing is not allowed in US waters, but is not restricted in international waters. Thus, it was assumed that this practice does not occur frequently in US waters.
[B] World-wide populations of recreational vessels were not available.
[C] Insufficient data was available to develop estimates for this class of vessels.

Source: NRC 2002

Although the figures on specific contributions vary depending on source (refer to http://oils.gpa.unep.org/facts/sources.htm for reports from various jurisdictions), it remains a consistent conclusion that petroleum extraction constitutes a negligible source of petroleum to the marine environment.

2.3.2 Spills, Blowouts, and other Accidental Events in Atlantic Canada

As of July 2013, there have been more than 600 wells drilled in Atlantic Canada's offshore areas (207 offshore Nova Scotia, 389 offshore Newfoundland and Labrador, 24 in other jurisdictions).

Since the first well was drilled offshore Nova Scotia in 1968, there have been two blowouts. In February 1984, a surface blowout occurred at Shell's Uniacke G-72 exploratory gas well, approximately 16 km from Sable Island. Over the course of the blowout, the well released approximately 70 million cubic feet (MMcf) of gas and 1.7 thousand cubic feet (Mcf) of condensate a day (Angus and Mitchell 2010). Environmental monitoring toward the end of the 10-day blowout revealed a condensate slick that covered 50-90 percent of the water's surface within a radius of several hundred metres of the rig; patches of slick were observed up to 10 km of the rig. Slick trajectory modelling run during the event predicted the slick would affect Sable Island, although monitoring patrols on the Sable Island beach never detected any condensate. While some oiled birds and seals were sighted, the incidence of oiling was not considered exceptional for this area of navigable waters. Monitoring of fish stocks revealed no evidence of tainting and the likelihood of adverse effects on fish stocks was considered to be low (Gill *et al.* 1985).

A year later, in April 1985 a subsurface blowout occurred at the Mobil exploratory gas well N-91 at West Venture. In this case the natural gas was contained underground with no release to the ocean or to the atmosphere (Angus and Mitchell 2010).

There have been no blowouts in the Newfoundland and Labrador offshore area, although the biggest offshore oil spill in Canadian history occurred in 2004 when a total of 1,000 barrels were discharged from the Terra Nova offshore oil production vessel offshore Newfoundland (Angus and Mitchell 2010). As of May 2010, there had been approximately 1,100 barrels of crude oil spilled in the Newfoundland and Labrador offshore area, which represents approximately 1 barrel per 1 million barrels produced (Ruelokke 2010 cited in Angus and Mitchell 2010).

The most tragic accidental events however, have not been spills or blowouts, but safety incidents involving the petroleum industry in which workers' lives have been lost. The most tragic accident of the Canadian offshore petroleum industry was that of the 1982 Ocean Ranger incident in which the semi-submersible drill rig capsized and sank in a storm, killing all 84 crew members while working in the Hibernia oil field, approximately 315 km off the coast of Newfoundland (Angus and Mitchell 2010). In 2009, another tragic accident occurred off the coast of Newfoundland as a helicopter carrying workers to offshore oil fields crashed, killing 17 people (C-NLOPB 2010).

All of these incidents yielded investigations and lessons learned which have resulted in changes to equipment and technology, standard operating procedures, prevention and response procedures, monitoring and reporting processes, and/or regulatory requirements to create a safer offshore working environment in Atlantic Canada.

2.3.3 Spills in the Nova Scotia Offshore Area

Operators are required to report environmental, health and safety incidents to the CNSOPB in accordance with criteria set out in regulations and detailed in the Incident Reporting and Investigation Guidelines. For significant spills (as defined by the Guidelines), hydrocarbon releases and unauthorized discharges, the CNSOPB assesses potential environmental impacts. In addition to examining and following up on these incidents, the CNSOPB also monitors whether trends are occurring.

Table 2.8 presents CNSOPB spill statistics from 1999-2013 (as of March 31, 2013) for spills (including chemical spills) offshore Nova Scotia. Table 2.9 characterizes spills by type, demonstrating types of accidental releases during exploration and production activities offshore Nova Scotia during this time period. Note that this database does not include releases associated with the 1984 Uniacke Blowout as this database commenced in 1999.

Table 2.8 CNSOPB Statistics for Spills to the Marine Environment (1999-2013)

Year	Less Than 1L	1-10L	11-150L	Greater Than 150L	Total Incidents[a]
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
2009-2010	9	1	2	1	13
2010-2011	5	2	0	1	8
2011-2012	3	0	2	1	6
2012-2013[b]	6	0	1	0	7
TOTAL	82	47	46	20	195

Notes:
[a]Does not include exceedences to authorized discharge limits (*e.g.*, oil in produced water or gas releases).
[b]Current to March 31, 2013.

Source: CNSOPB 2013a

Table 2.9 Summary of Spill Types and Volumes as Reported to the CNSOPB

Product Released	Total Approximate Spill Volume (L) (1999-2013)[a]
Chemicals (*e.g.*, freon, NaCl brine, marker dye)	8149
Condensate (includes oil in water over OWTG limits)	414
Diesel	4081 – 4091[b]
Engine Coolant	300
Glycol	23-162
Hydraulic Oil	2083-2094[b]
Mineral Oil (*e.g.*, kerosene from seismic streamers)	1638
Mono-ethylene Glycol (MEG)	155,625 - 283,764[b,c]
Oil (unclassified)	37
Lubricating Oil	101
SBM	355,920 – 355,950[b,d]
WBM	410
Unknown Sheen	1
Other (*e.g.*, grease, hydrocarbon+water, synthetic oil, light oil)	962

Notes:
[a]Based on CNSOPB incident statistics current to March 31, 2013.
[b]Ranges in values shown above reflect ranges shown in incident reporting.
[c]Includes leak of MEG from SOEP flowline in 2006.
[d]Includes SBM release during exploration drilling at Crimson F-81 well in 2004.

The majority of spill events recorded above were associated with the Sable Offshore Energy Project (SOEP) natural gas development, the only petroleum project in production in the Nova Scotia offshore during this reporting period. However, there are some spill events associated with exploration activities including, but not limited to, spills of mineral oil (*e.g.*, kerosene) from streamers during seismic surveys, and releases of drilling fluids during exploration drilling.

Three events during this reporting period were subjected to a formal investigation by the CNSOPB. In 2004, approximately 354 m^3 of SBM was discharged as a result of an equipment failure during well abandonment activities at exploratory well Crimson F-81 in 2,067 m of water, approximately 60 km south of Sable Island. An investigation of the spill led by the CNSOPB concluded that the impact would be minor with no remediation recommended (CNSOPB 2005).

Also in 2004, 3528 liters of diesel fuel spilled into the ocean over a period of 36 hours. On August 22, Exxon Mobil reported a spill of diesel fuel into the ocean from the North Triumph Platform, located 25 km South of Sable Island. A cracked fuel filter on the diesel engine of an electrical generator caused a leak which eventually spilled into the ocean. Exxon Mobil was assessed a penalty of $60,000, a $10,000 fine and $50,000 for the Environmental Damages Fund (CNSOPB 2008).

In 2006, approximately 158 m^3 of monoethylene glycol (MEG) was released through a leak from a SOEP flowline. MEG is an industrial anti-freeze that is used in natural gas pipelines to prevent the formation of hydrates which can cause a blockage of the pipeline. Given the relatively low toxicity of MEG and modelled dispersion of the leak, an investigation concluded that measurable effects on marine species resident in the vicinity of the platform would be unlikely (CNSOPB 2006).

2.3.4 Oil Spill Prevention and Response

The CNSOPB is responsible for the regulation of all spills at offshore drilling operations under the Accord Acts. The CNSOPB holds operators fully accountable and responsible for protection of the environment, ensuring that operators and drilling contractors have the necessary competencies to carry out their work, that they exercise due diligence in incident prevention, and that they demonstrate the capability and capacity to respond to any incidents that may occur (CNSOPB 2013b).

In accordance with the Nova Scotia Offshore Petroleum Drilling and Production Regulations, operators must prepare and submit, prior to initiation of drilling activity, contingency plans to prevent, mitigate and respond to emergencies, which would include, but not be limited to, hydrocarbon spills.

Standard operating procedures to reduce or eliminate the risk of a spill may include schedule of routine maintenance and testing (especially well control); poor weather/sea state drilling practices; sound marine practices and good communications for all vessels supporting a drilling program; regular inspections and audits of the practices and procedures; ongoing training and safety meetings for rig personnel; and reporting near misses and other potential problems to avoid a future spill.

In addition to spill prevention, operators must demonstrate spill response capabilities including the identification of spill response resources on-site and those available locally, nationally and internationally, and describe the arrangements to mobilize the resources to site.

An oil spill is usually classified under three tiers for response planning purposes:

- Tier 1 – poses the least environmental effects and is usually managed offshore/on site
- Tier 2 – requires local shore-based management support and additional resources/ equipment
- Tier 3 – can require local/regional, national and/or international support, as well as a high level of corporate and contract resources (*e.g.*, assistance from Eastern Canada Response Corporation (ECRC) and/or Oil Spill Response (OSRL))

Spill response can include any combination of the following methods:

- Mechanical dispersion (involves use of prop washing or high-pressure water spray and is usually applied to small spills of thinly-layered oil)
- Chemical dispersion (usually applied before the bulk of spill is widely dispersed; requires input from Environment Canada prior to application)
- Containment and recovery (usually the first line of response as most facilities have absorbent booms and skimmers on hand)
- In-situ burning

Each of these methods has advantages and disadvantages and effectiveness of any method depends on several variables including nature of spilled product, size of spill, sea state, and logistical variables. In some cases, the spill response method may have its own environmental effects which need to be considered (*e.g.*, chemical dispersants and in-situ burning). Depending on the size and type of spill, natural dispersion/degradation is a valid option, although it is usually most effective in high winds and sea states.

Spill response also includes surveillance and monitoring (including a spill-specific EEM program), wildlife protection and/or recovery and rehabilitation measures. Compensation of affected parties for associated loss or damage attributed to a spill by the offshore petroleum industry is directed by the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (C-NLOPB and CNSOPB 2002).

Incident reporting occurs in accordance with the Incident Reporting and Investigation Guidelines (C-NLOPB and CNSOPB 2012), which define incidents and specify reporting procedures, including notification of third parties. All spills are to be reported through written notification within 24 hours of the spill event (C-NLOPB and CNSOPB 2012). Investigations of past incidents (including international incidents such as the 2010 Macondo incident in the Gulf of Mexico) have resulted in improvements in technology and safety, environmental, and operational procedures and continue to improve industry performance.

3.0 Key Characteristics of the Environment

This section provides an overview of key features of the existing environment in the Study Area that could potentially interact with or influence elements of a petroleum exploration program.

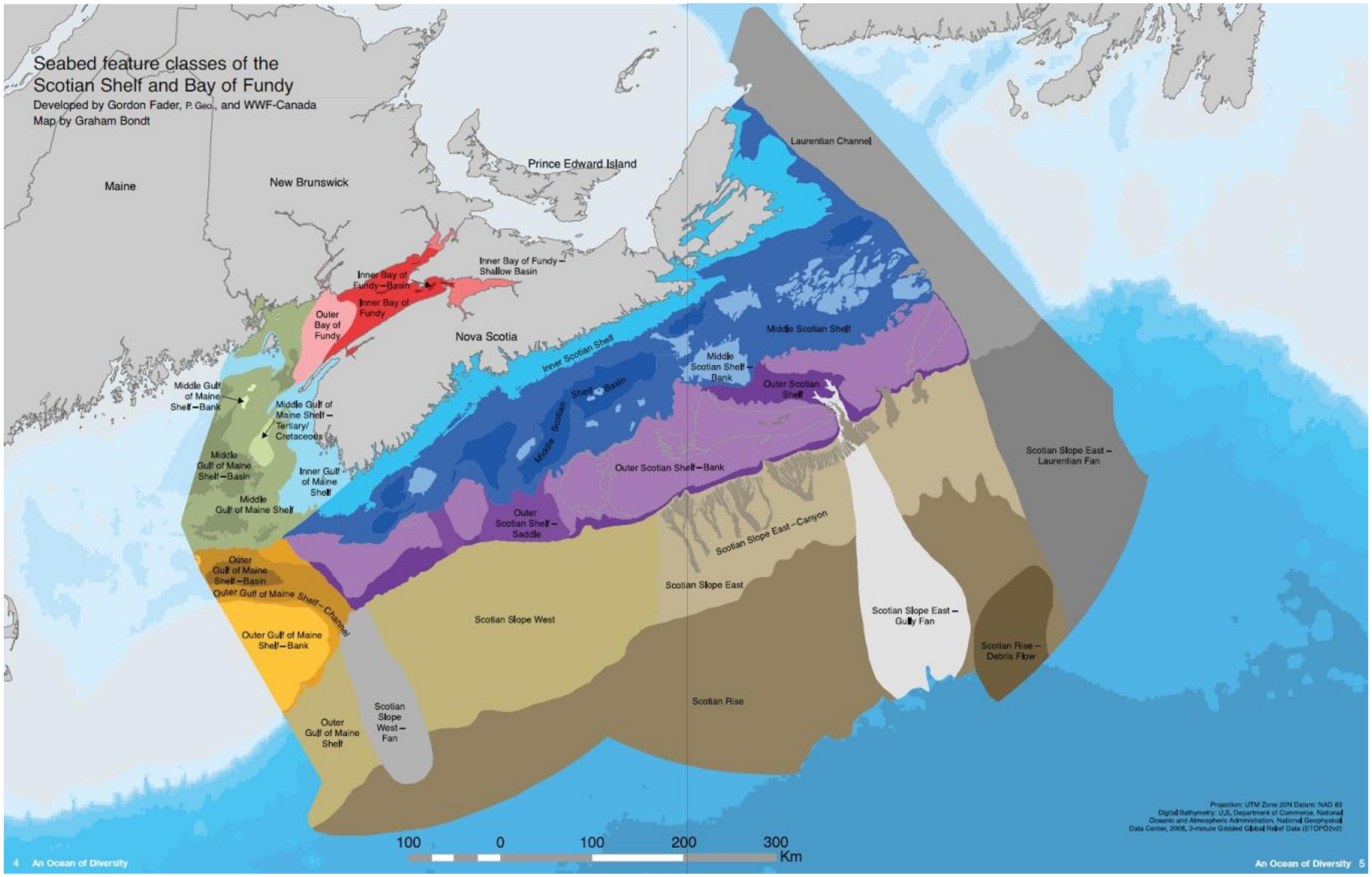
3.1 PHYSICAL CHARACTERISTICS

3.1.1 Oceanography

The Scotian Shelf is part of the North American Continental Shelf off of Nova Scotia. The Scotian Shelf is 700 km long and between 125 and 230 km wide. The northeast channel separates the Shelf from the Gulf of Maine to the southwest, while the Laurentian Channel is the natural boundary between Newfoundland and the Shelf to the northeast (DFO 2011a). The Scotian Shelf is a broad continental shelf made up of a number of shallow offshore banks and inner basins.

The Scotian Shelf can be divided into the inner, middle, and outer shelf regions. The inner portion of the shelf extends from the coast out to approximately 25 km offshore and is an extension of coastal bedrock (Zwanenberg *et al*. 2006). The middle shelf is an area of complex topography containing many small-sized banks and basins resulting from repeat glaciation. The outer shelf is a series of relatively flat shallow banks. In the east, Sable Island is an exposed portion of the Sable Island bank, creating a unique feature on the outer shelf regions. Also within the Study Area are Western, Emerald, LaHave, Baccaro, Browns, and Georges Banks. The average depth of the shelf is approximately 90 m. Georges Bank is located on the outer Gulf of Maine Shelf, on the western edge of the Study Area, and is an oval shaped bank underlain with sandstone and covered in a sand and gravel mixed substrate (WWF 2009). In between Georges and Browns Banks the Northeast Channel connects the Gulf of Maine with the Atlantic Ocean.

At the edge of the shelf at the 200 m isobath the continental slope begins as the shelf becomes steeper to a depth of 2000 m. The western Scotian Slope has a gentle gradient and a relatively smooth seabed. It is an area of low, gentle hills and valleys, sloping towards the Scotian Rise and the abyssal plain. When compared to the eastern Scotian Slope, the western Slope has a less dynamic seabed, with fewer canyons (WWF 2009). Dawson and Verill Canyons are located at the eastern edge of the Study Area. At the depths of 2000 m – 5000 m the slope is more gradual, with this area known as the continental rise (refer to Figure 3.1).



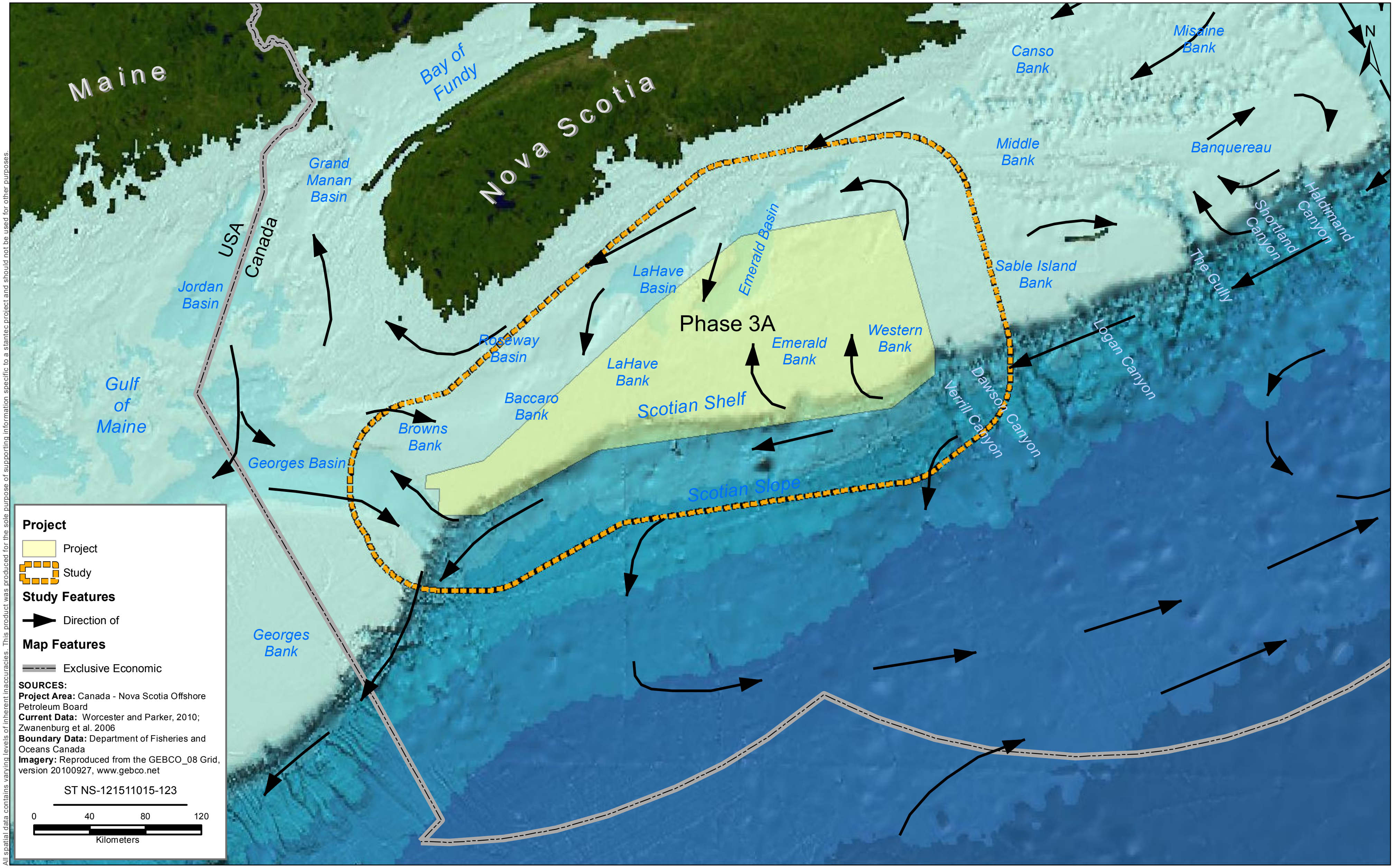
Source: WWF 2009

Figure 3.1 Seabed Features of the Scotian Shelf and Bay of Fundy

The physical environment on the Scotian Shelf is governed by its close proximity to the meeting place of major currents of the northwest Atlantic and its complex bathymetry. The three major currents influencing the movement of water on the Scotian Shelf are: the Nova Scotia Current; the Shelf Break Current (an extension of the Labrador Current); and the Gulf Stream (Zwanenburg *et al.* 2006). Relatively cool, fresh waters flow from the Gulf of the St. Lawrence through the Cabot Strait. A portion of this water turns at Cape Breton to flow southwest along Nova Scotia's Atlantic coast, while the rest of the flow continues through the Laurentian Channel to the shelf break. At the shelf break it turns and joins the Shelf Break Current to flow southwest along the shelf edge. The Shelf Break Currenthas the largest transport along the Eastern Scotian Shelf (Han and Loder 2003). The Gulf Stream flows northeastwards, and its warmer, more saline waters mix with the cool Labrador Current waters over the Scotian Slope, forming a mass of water known as slope water (DFO 2011a). This slope water periodically leaks onto the Shelf through channels and canyons. The shelf bottom consists of a series of submarine banks and cross-shelf channels along the outer shelf and basins and troughs along the central shelf which limit and guide the near-bottom flow. The predominant flow of cold, fresh water from the northeast to the southwest results in a general increase in both temperature and salinity as you move closer to the southwest (Zwanenburg *et al.* 2006). This flow is strongest in the winter and weakest in the summer. For an overview of currents on the Scotian Shelf refer to Figure 3.2.

Further to the south, on the Western Scotian Shelf, the Nova Scotia Current flows in a southwesterly direction close to the coastline. As it reaches the Halifax area it branches in an offshore direction, where it joins the Shelf Break Current and continues to flow southwesterly along the shelf break (Breeze *et al.* 2002.) On the shelf, the influence of the warm waters from the Gulf Stream is felt primarily within the deep channels and basins. The depression between Emerald and LaHave Banks, known as the Scotian Gulf, is a well-known area of warm water infiltration. Significant differences in circulation patterns exist between the western and central Scotian Shelf. The water masses of the central and western Scotian Shelf are more similar to one another than to those found on the eastern Scotian Shelf (Breeze *et al.* 2002.).

The movement of water on Georges Bank is driven primarily by tidal currents, wind, and variations in water density. Georges Bank is shallow in depth, and is located at the mouth of the Gulf of Maine and the Bay of Fundy, which gives rise to strong tidal currents found in the area. In the deeper water perimeter areas of the bank, current speeds can reach approximately 0.2 m/s and can reach upwards of 1.0 m/s in the shallow areas on top of the bank (Kennedy *et al.* 2011). The general circulation pattern on Georges Bank is a partial, anticyclonic grye (water rotates in a clockwise direction). This clockwise circulation is associated primarily with interactions of the tidal currents with the Bank's topography. Higher current velocities occur in the summer months, which are associated with horizontal density gradients in the frontal system. This gyre is 'leaky' year-round, as storms cause an exchange of water with the nearby waters of Browns Bank, the Gulf of Maine, and the continental slope (Kennedy *et al.* 2011).



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CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Overview of Currents on the Scotian Shelf

FIGURE NO.: 3.2

DATE: Apr 21, 2014

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At the shelf edge, outer marginal water masses collide to form a frontal zone which shifts in location from year to year. At this frontal zone, cold slope water mixes with the warm water at the edge of the outer banks, supplying nutrients and promoting phytoplankton growth (WWF 2009). The eddies, which peel off the Gulf Stream, also rework the benthic environment here, disturbing the seabed and bringing nutrients towards the surface waters. This frontal zone is an area of high primary productivity and is also a location where species are deposited after long voyages north on the Gulf Stream (WWF 2009).

The water temperatures on the Scotian Shelf and in the Gulf of Maine are among the most variable in the North Atlantic (Worcester and Parker 2010). The Western Scotian Shelf is generally warmer than the Eastern Scotian Shelf. This is due to the infiltration of warm Gulf Stream water entering in between Browns and Western Banks. The normal temperature on the Western Scotian Shelf is both seasonally and spatially more dynamic than those found on the Eastern Scotian shelf. This is also due to the impact of warm water from the Gulf Stream and increased vertical mixing (Breeze *et al.* 2002). Surface temperatures typically show a large variation over the Scotian Shelf.

Ice cover and sea ice are very rare in the Nova Scotia offshore environment (Worcester and Parker 2010). Sea ice is generally transported out of the Gulf of St. Lawrence through the Laurentian Channel and pushed out to the Scotian Shelf via northwesterly winds and ocean currents. Generally sea ice will only make it as far as the Eastern Scotian shelf and melt before reaching the Central and Western sections of the shelf. Localized sea ice may also form along the coastline of Nova Scotia, but would melt and dissipate after break-up before it has any chance of entering the Study Area.

Salinity is an important characteristic of marine waters. It influences the presence of marine life both directly through salinity preferences and needs or differing species and indirectly through its effect on stratification, which effects the growth of phytoplankton and thus primary production (Breeze *et al.* 2002). The Labrador Current and Gulf Stream (34 – 36 ppt) are both more saline than the Shelf Current (31-33 ppt). It has been found that salinity does not vary systematically with temperature, although periods of low temperatures are generally associated with lower salinities and higher temperatures with higher salinities (Breeze *et al.* 2002).

The density of seawater depends on temperature, salinity, and pressure. Density increases with depth in the ocean (Worcester and Parker 2010). The difference in density between water at two depths is known as the density stratification. The stratification divided by the difference in depths is called the stratification index. High levels of stratification inhibit the vertical mixing of water and as a result can decrease nutrient fluxes to the surface waters, and affect the growth of phytoplankton. Increased stratification can also reduce turbulence, concentrating phytoplankton and thus lead to increased primary production in the surface waters (Worcester and Parker 2010). Under increased stratification, there is a tendency for more primary production to be recycled within the upper mixed layer, reducing the amount available for deeper layers (Hebert *et al.* 2012). On the Scotian Shelf, the 0 to 50 m stratification index increased during the 1990s and from the mid to late 1990s was at its 50 year maximum on record. In the eastern gulf of

Maine and on Georges Bank changes in stratification have also been noted. Stratification has been increasing steadily from the mid-1980s. Highly stratified water can be found in the deep basins of the Study Area including Emerald Basin and Roseway Basin (Worcester and Parker 2010).

Strong stratification has the potential to inhibit the vertical mixing of water to a degree to cause dissolved oxygen levels in the deeper layers to become depressed. The waters in the Study Area do stratify, but not to a degree where low dissolved oxygen levels become an issue for the species inhabiting the area. The lowest dissolved oxygen levels can be found within the deepest basins in the area (Worcester and Parker 2010).

3.1.2 Climatology

The climate of the Scotian Shelf varies between Atlantic, Boreal, and sub-arctic climates. The warm Gulf Stream and the cold Labrador Current influence the climate in the area. Air temperatures in the region are measured on Sable Island and have shown an increase of 1°C over the last century (Worcester and Parker 2010).

The North Atlantic Oscillation (NAO) is the dominant atmospheric pattern in the North Atlantic Ocean, which is the significant large scale abiotic driver of the Scotian Shelf ecozone (Drinkwater *et al*. 1998; Petrie 2007; Worcester and Parker 2010). The Scotian Shelf is primarily affected by advection. The NAO is a back and forth pattern between a high pressure cell over the Azores in the south east Atlantic and a low pressure cell over Iceland. The NAO index is a measure in the difference in sea level pressure between the two locations in winter. A high index brings increased westerly winds, precipitation, and warmer waters to the Scotian Shelf. The opposite forcing occurs with a low NAO index bringing drier conditions, a decrease in storm conditions, and cooler water temperatures as a result of an increase in influence from the Labrador Current.

Wind climate is an important physical force in the generation of currents and waves, which can affect exploration vessels and marine operations. Wind speed and direction are common parameters to describe wind characteristics. Data on percent wind speed by wind direction were acquired from Environment Canada's Meteorological Service of Canada (MSC). The MSC50 hindcast data set (1954-2012) was used for grid point 4457 (43.30° N, 62.9° W; water depth 106 m) within the Study Area, near Emerald Bank. Wind statistics are presented in Table 3.1 and wind roses depicting these data on a seasonal basis are presented in Figure 3.3.

Most wind speeds at grid point 4457 are between 5 and 10 m/s during spring, summer and fall, and between 10 to 15 m/s during the winter season (December to February). Winds are most commonly from the west, except during the summer (June to August) when they are typically from the southwest. There was no wind speed reported during the summer greater than 15 m/s. Wind speeds exceed 20 m/s in the winter only.

Table 3.1 Seasonal Wind Statistics for Grid Point 4457 (1954-2012)

Season	Mean Wind Speed (m/s)	Most Frequent Direction (from)	Maximum Hourly Wind Speed (m/s)
Winter (Dec-Feb)	9.98	West Northwest	28.68
Spring (Mar-May)	7.54	West	26.37
Summer (Jun – Aug)	5.12	Southwest	30.75
Fall (Sep – Nov)	7.98	West	31.85

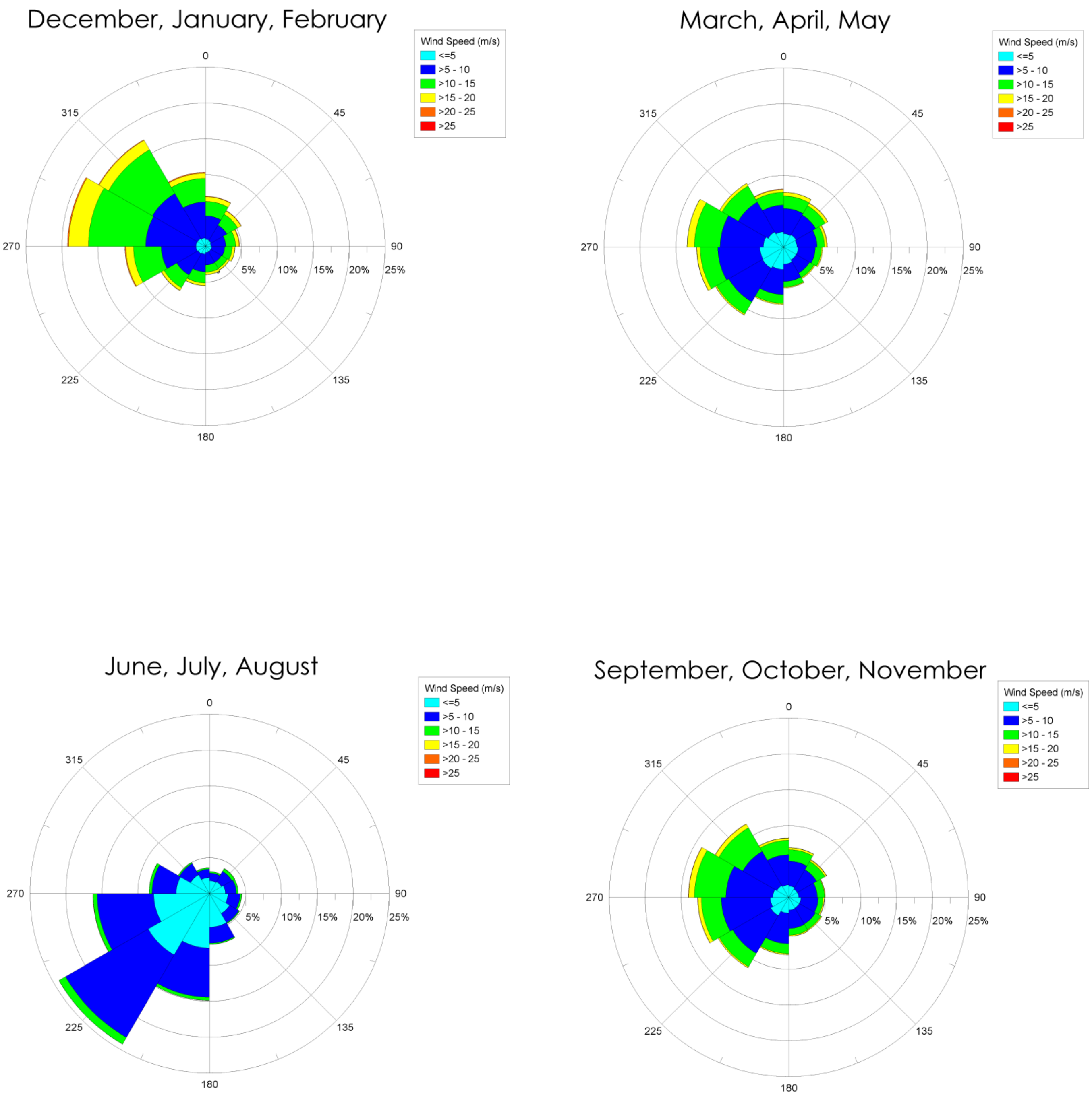


Figure 3.3 Seasonal Wind roses for Grid Point 4457 (1954-2012)

The wave climate in the Study Area was also assessed by means of the MSC50 data set (1954-2012) for grid point 4457 (43.30 N, 62.9 W; water depth 105.87 m) located within the Study Area. The minimum, maximum, mean and standard deviations of significant wave heights for each season are presented in Table 3.2. Significant wave height (Hs) is the mean wave height of the highest 1/3 of all individual waves from trough to crest (NOAA 2011). Maximum significant wave heights were greatest in the summer and fall seasons, although in general, mean wave heights were greatest in the winter season. The percent occurrence of peak wave period against significant wave heights for grid point 4457 for each season is presented in Tables 3.3 to 3.6. Peak wave period (Tp) refers to the period associated with most energetic waves in the nondirectional wave spectrum at a specific point.

The majority of the significant wave heights occurred at 1 to 1.99 m during the spring, summer, and fall. In the winter, the majority of significant wave heights were nearly evenly divided between 1 to 1.99 m and at 2 to 2.99 m. Generally, the fall and winter months experienced the highest wave heights. The typical peak period was approximately 7 seconds for all seasons.

Table 3.2 Standard Deviation of Significant Wave Height at Grid Point 4457 by Season (1954-2012)

Season	Minimum Significant Wave Height (m)	Maximum Significant Wave Height (m)	Mean Significant Wave Height (m)	Standard Deviation (m)
Winter (Dec-Feb)	0.40	10.95	2.80	1.32
Spring (Mar - May)	0.35	12.77	2.13	1.16
Summer (Jun -Aug)	0.39	13.74	1.38	0.58
Fall (Sep - Nov)	0.44	13.03	2.11	1.08

Table 3.3 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 4457: December, January, February (1954-2012)

Significant Wave Height (m)	Peak Wave Period (s)										Total
	1	3	5	7	9	11	13	15	17	19	
0 - 0.99	<0.01	0.13	0.81	0.56	0.73	0.20	0.07	0.11	0.00	0.00	2.61
1 - 1.99	<0.01	0.25	10.76	7.61	7.17	2.48	0.29	0.40	0.00	<0.01	28.96
2 - 2.99	<0.01	<0.01	1.35	18.78	6.65	4.53	0.31	0.16	<0.01	<0.01	31.77
3 - 3.99	<0.01	<0.01	0.01	7.58	7.34	4.26	0.40	0.11	<0.01	<0.01	19.69
4 - 4.99	<0.01	<0.01	<0.01	0.19	6.04	3.03	0.63	0.09	<0.01	<0.01	9.98

Table 3.3 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 4457: December, January, February (1954-2012)

Significant Wave Height (m)	Peak Wave Period (s)										Total
	1	3	5	7	9	11	13	15	17	19	
5 - 5.99	<0.01	<0.01	<0.01	0.00	1.66	2.36	0.52	0.07	<0.01	<0.01	4.60
6 - 6.99	<0.01	<0.01	<0.01	<0.01	0.17	1.15	0.24	0.02	<0.01	<0.01	1.59
7 - 7.99	<0.01	<0.01	<0.01	<0.01	0.01	0.36	0.14	0.01	<0.01	<0.01	0.52
8 - 8.99	<0.01	<0.01	<0.01	<0.01	0.00	0.07	0.10	0.01	<0.01	<0.01	0.19
9 - 9.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.08	0.00	<0.01	<0.01	0.08
10 - 10.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.00	<0.01	<0.01	0.02
11 - 11.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
12 - 12.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
13 - 13.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	**<0.01**	**0.37**	**12.92**	**34.73**	**29.76**	**18.44**	**2.80**	**0.97**	**0.00**	**0.00**	**100.00**

Table 3.4 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 4457: March, April, May (1954-2012)

Significant Wave Height (m)	Peak Wave Period (s)										Total
	1	3	5	7	9	11	13	15	17	19	
0 - 0.99	<0.01	0.31	2.62	4.74	2.07	0.64	0.31	0.19	0.02	<0.01	10.89
1 - 1.99	<0.01	0.23	11.92	16.93	12.70	2.78	0.46	0.27	<0.01	<0.01	45.29
2 - 2.99	<0.01	<0.01	0.82	12.36	7.92	3.78	0.17	0.05	<0.01	<0.01	25.09
3 - 3.99	<0.01	<0.01	0.01	3.15	4.99	2.99	0.15	0.05	<0.01	<0.01	11.33
4 - 4.99	<0.01	<0.01	<0.01	0.05	2.76	1.64	0.22	0.02	<0.01	<0.01	4.69
5 - 5.99	<0.01	<0.01	<0.01	<0.01	0.61	1.00	0.12	0.02	<0.01	<0.01	1.75
6 - 6.99	<0.01	<0.01	<0.01	<0.01	0.07	0.44	0.07	0.03	<0.01	<0.01	0.61
7 - 7.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	0.05	0.01	<0.01	<0.01	0.17
8 - 8.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.05	<0.01	<0.01	<0.01	0.10
9 - 9.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.05
10 - 10.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01

Table 3.4 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 4457: March, April, May (1954-2012)

Significant Wave Height (m)	Peak Wave Period (s)										Total
	1	3	5	7	9	11	13	15	17	19	
11 - 11.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01
12 - 12.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01
13 - 13.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	**<0.01**	**0.53**	**15.35**	**37.23**	**31.13**	**13.44**	**1.64**	**0.65**	**0.02**	**<0.01**	**100.00**

Table 3.5 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 4457: June, July, August (1954-2012)

Significant Wave Height (m)	Peak Wave Period(s)										Total
	1	3	5	7	9	11	13	15	17	19	
0 - 0.99	<0.01	0.25	4.99	16.19	2.32	0.49	0.39	0.04	0.06	0.01	24.72
1 - 1.99	<0.01	0.13	14.01	33.99	12.82	1.45	1.15	0.30	0.07	<0.01	63.92
2 - 2.99	<0.01	<0.01	0.18	5.10	2.92	0.97	0.15	0.13	0.01	<0.01	9.46
3 - 3.99	<0.01	<0.01	<0.01	0.33	0.71	0.33	0.06	0.03	<0.01	<0.01	1.45
4 - 4.99	<0.01	<0.01	<0.01	0.01	0.16	0.11	0.03	0.02	<0.01	<0.01	0.32
5 - 5.99	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.02	0.01	<0.01	<0.01	0.07
6 - 6.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.02
7 - 7.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.02
8 - 8.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
9 - 9.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
11 - 11.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
12 - 12.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
13 - 13.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	**<0.01**	**0.38**	**19.18**	**55.60**	**18.95**	**3.39**	**1.81**	**0.56**	**0.14**	**0.01**	**100.00**

Table 3.6 Percent Occurrence of Peak Wave Period against Significant Wave Height for Grid Point 4457: September, October, November (1954-2012)

Significant Wave Height (m)	Peak Wave Period(s)										Total
	1	3	5	7	9	11	13	15	17	19	
0 - 0.99	<0.01	0.21	2.25	2.51	2.61	0.85	0.29	0.17	<0.01	<0.01	8.90
1 - 1.99	<0.01	0.22	14.81	15.61	9.87	3.95	1.52	0.49	<0.01	<0.01	46.47
2 - 2.99	<0.01	<0.01	0.86	16.35	6.54	2.97	0.75	0.36	0.01	<0.01	27.86
3 - 3.99	<0.01	<0.01	<0.01	3.49	5.01	2.03	0.32	0.13	<0.01	<0.01	10.99
4 - 4.99	<0.01	<0.01	<0.01	0.04	2.18	1.02	0.19	0.11	0.01	<0.01	3.54
5 - 5.99	<0.01	<0.01	<0.01	<0.01	0.48	0.75	0.11	0.06	<0.01	<0.01	1.40
6 - 6.99	<0.01	<0.01	<0.01	<0.01	0.06	0.36	0.09	0.01	<0.01	<0.01	0.52
7 - 7.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	0.04	0.01	<0.01	<0.01	0.17
8 - 8.99	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.05	<0.01	<0.01	<0.01	0.08
9 - 9.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.04
10 - 10.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01
11 - 11.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.02
12 - 12.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
13 - 13.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	**<0.01**	**0.44**	**17.93**	**37.99**	**26.75**	**12.07**	**3.41**	**1.39**	**0.03**	**0.00**	**100.00**

Table 3.7 provides extreme wave conditions for the grid point 4457 for various return periods as determined by Oceanweather's Inc. Gumbel distribution. The largest waves are originating from the south, southwest and west directions, with the most extreme waves coming from the southwest.

Table 3.7 Extreme Wave Conditions at the Grid Point 4457

Direction	S			SW			W		
Return Period (year)	H_s (m)	T_p (s)	H_{max} (m)	H_s (m)	T_p (s)	H_{max} (m)	H_s (m)	T_p (s)	H_{max} (m)
1	5.68	11.13	10.73	6.60	11.44	12.08	6.32	11.04	11.67
2	8.00	12.84	14.45	8.54	12.80	15.47	7.62	11.85	14.00
5	9.45	13.77	16.80	9.76	13.57	17.60	8.43	12.31	15.47

Table 3.7 Extreme Wave Conditions at the Grid Point 4457

Direction	S			SW			W		
Return Period (year)	H_s (m)	T_p (s)	H_{max} (m)	H_s (m)	T_p (s)	H_{max} (m)	H_s (m)	T_p (s)	H_{max} (m)
10	10.42	14.34	18.35	10.57	14.05	19.02	8.98	12.61	16.44
25	11.65	15.02	20.32	11.59	14.63	20.81	9.66	12.96	17.68
50	12.56	15.50	21.78	12.35	15.04	22.14	10.17	13.22	18.59
100	13.46	15.96	23.23	13.11	15.44	23.46	10.68	13.46	19.50

Notes:
[1] Based on 57 years of MSC50 hourly wave data from 1954 to 2010

3.1.3 Summary

Table 3.8 summarizes physical characteristics of the Study Area.

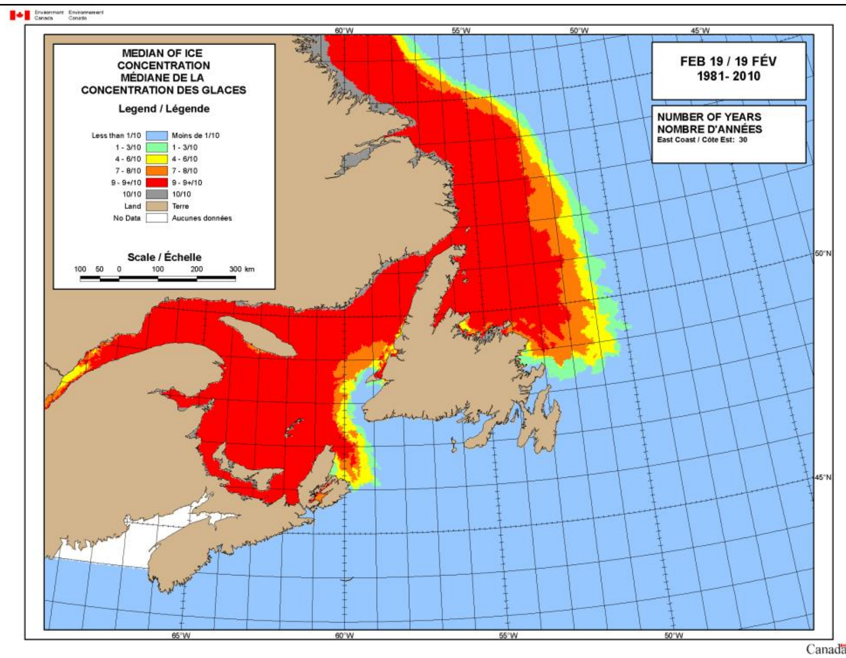
Table 3.8 Overview of Physical Characteristics

Physical Characteristics	
Sea Bed Characteristics (refer to Figure 3.1)	• The middle shelf is characterized by a wide and complex network of valleys, ridges, and small gravel covered banks. • Basins have been smoothed by glaciers and recently filled with the deposition of silt. These basins span across the middle of the Scotian Shelf. In certain areas, boulder-covered till ridges protrude through the mud, silt, and pockmarks. • There are several large and shallow banks that are the defining features of western shelf and outer banks. These include the Sable Island, Western, Emerald, LaHave, Baccaro, Browns, and Georges Banks. • Sable Island Bank is characterized by complex fields of sand ridges with average heights of 12 m and widths of 6.4 km. Sable Island is surrounded by a shore face that extends to 20 m in depth. Sand ridges occur on the lower part of the shore face and extend offshore on both sides of the island. The larger and more extensive ridges lie along the south side of the island and in the deeper water to the west. • The shallow outer banks tend to have sand and/or gravel benthic structure, with some areas having an extensive shell bed cover. Storms and currents constantly shape the tops of the banks forming sand into a wide variety of ridges, waves and ripples. • The deeper basins are covered in fine silt and clay interspersed with coarse glacial material. • Saddles are areas of slightly deeper water that occur between the banks on the outer Scotian Shelf. Saddles are present between Emerald Bank, LaHave Bank, and Browns Bank on the western Scotian Shelf. They occur at depths less than 200 m and are covered by sand which contains minor amounts of clay, silt and gravel. The saddles form an entrance to the basins of the middle Scotian Shelf for deep warmer slope water masses. • The western Scotian Slope has a gentle gradient with a relatively smooth seabed. It is an area of low, gentle hills and valleys, sloping towards the Scotian Rise and

Table 3.8 Overview of Physical Characteristics

Physical Characteristics	
	abyssal plain. Compared to the eastern Scotian Slope, the western Slope has a less dynamic seabed, with fewer canyons. There are a few shallow gullies which reach depths of up to 500 m. The area is extremely productive, hosting many marine mammals and large fish during important life history periods, including feeding and migration. • A series of deep canyons (*e.g.*, Dawson and Verill Canyons) occur along the outer edges of the Scotian Shelf and extend down the slope. These canyons act as transport areas for sand and provide a transition from the outer shelf to the deep ocean. • Between the canyons the seabed is criss-crossed by furrows and pits created by icebergs in the past. This area continues to erode creating a natural disturbance, which may enhance biological productivity. • Georges Bank is located on the Outer Gulf of Maine Shelf. It is a large oval shaped bank, underlain by sandstone bedrock. The surface gently slopes in a south east direction and is covered by a sand and gravel mix. The northern section of the bank has a rougher substrate containing course gravel and boulders. Strong currents and large waves, created by storms, have shaped the sand into dynamic bedforms including waves, ripples, and ridges. Strong currents provide fresh nutrients and oxygen across the benthic environment here, fanning and feeding fish eggs and young, making this an extremely important area for the health of many fisheries. • The Northeast Channel is the largest and deepest channel connecting the open Atlantic Ocean to the Gulf of Maine. It crosses the outer continental shelf between Georges and Browns Banks, connecting the basins of the Gulf of Maine at depths between 200 m to 300 m. Glacial till, a mixture of clay, silt, sand, gravel, and boulders covers large areas of the floor of the Northeast channel. • Georges Basin is located north of Georges Bank, and is a deep, elliptically shaped depression. The basin has a smooth seabed, except for a local high point near the center where bedrock protrudes. Glacial till is exposed on the northern and western portions of the basin, where it is covered by sand, pebbles, and cobble. Source: DFO 2011b; Worcester and Parker 2010; Zwanenburg *et al*. 2006; WWF 2009; Li and King 2007
Climatology	• Climate is strongly influenced by the warm Gulf Stream and the cold Labrador Current • Daily Air Temperature Range: -1.4°C (February) to 17.8°C (August) • Extreme Minimum Air Temperatures: -19.4°C (January) to 4.4°C (August) • Extreme Maximum Air Temperatures: 12.8°C (February) to 29.6°C (July) • Average Monthly Precipitation: 95.2 mm (July) to 147.0 mm (November) • Extreme Daily Precipitation: 66.00 mm (April) to 166.1 mm (November) • Average days per year with fog: 127 days Source: Sable Island, Environment Canada 2012a
Sea Ice and Icebergs	• Ice cover is rare in the offshore of the Scotian Shelf. • Sea ice is generally transported out of the Gulf of St. Lawrence through the Cabot Strait. • Ice can be transported from the Cabot Strait by north westerly winds and ocean currents onto the Eastern Scotian Shelf, although this is very rare. • Sea ice which travels onto the Scotian Shelf from the Gulf of St. Lawrence will dissipate and melt before reaching the Central and Western sections of the Shelf. • Localized sea ice can form in coastal areas, but will dissipate before entering the Study Area. Source: DFO 2011b

Table 3.8 Overview of Physical Characteristics

<table>
<tr><th colspan="2">Physical Characteristics</th></tr>
<tr><td></td><td>


Source: Environment Canada 2012c

Figure 3.4 Maximum Extent of Median Sea Ice Concentration from 1981 – 2010
</td></tr>
<tr><td>Wind</td><td>

Average Wind Speeds: 5.12 m/s (18 km/h) (summer) to 9.98 m/s (36 km/h)) (winter)
Most Common Wind Direction (from): West
Maximum Hourly Wind Speed: 26.37 m/s (95 km/h)(spring) to 31.85 m/s (115 km/h) (fall)

MSC50 (1954-2102) Grid Point 4457
Source: Oceanweather Inc. 2013
</td></tr>
<tr><td>Waves</td><td>

Monthly mean significant wave height, Hs (m): 1.38 in summer to 2.80 in winter
Monthly maximum Hs (m): 12.77 in spring to 13.74 in summer
The highest maximum significant wave heights occur in summer and fall

MSC50 (1954-2102) Grid Point 4457
Source: Oceanweather Inc. 2013
</td></tr>
<tr><td>Ocean Currents</td><td>

Circulation patterns are governed by the complex seafloor topography and by the influence of three major currents:

Cool, relatively fresh (less saline) Nova Scotian Current derived from the outflow of the Gulf of St. Lawrence flowing along the inner, middle, and outer portions of the shelf
Cold Shelf Break Current (Influenced by Labrador Current from the north) flowing along the shelf edge
Warm, higher saline Gulf Stream flowing northeast over the Scotian Slope and mixing with the Labrador Current, creating “slope water”.

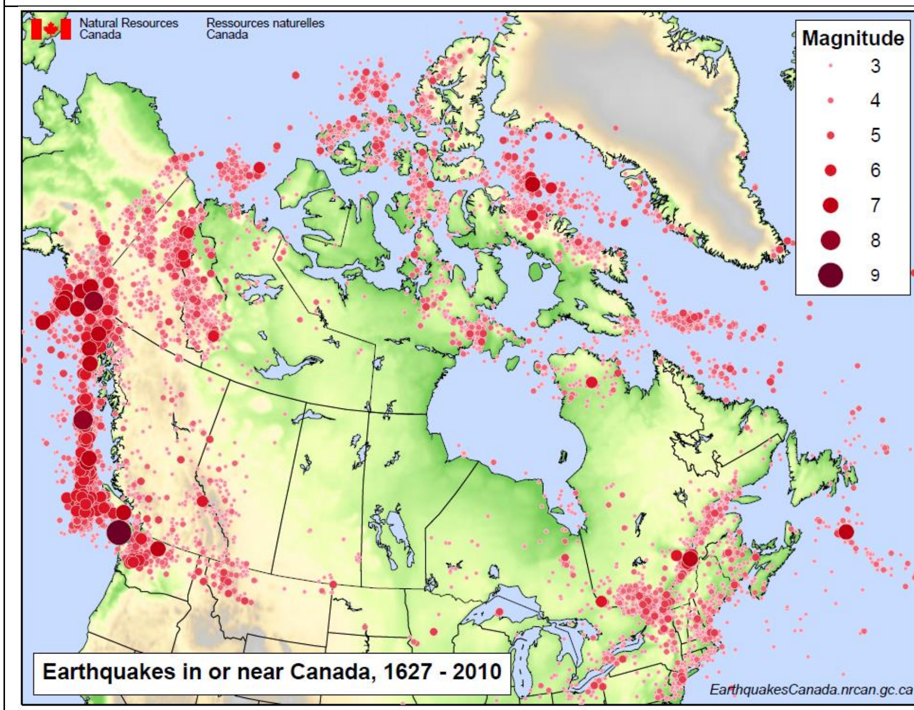
The Nova Scotia Current flows in a southwesterly direction close to the coastline. As it reaches the Halifax area it branches in an offshore direction, where it joins the

</td></tr>
</table>

Table 3.8 Overview of Physical Characteristics

Physical Characteristics	
	Shelf Break Current and continues to flow southwesterly along the shelf break. • Overall flow is from the Northeast to southwest, with speeds ranging from 0.055 – 0.3 m/s. Currents are stronger in the winter and weaker in the summer. • On Georges Bank, the movement of water is primarily driven by tidal currents, wind and variations in water density. The general circulation pattern on Georges Bank is an anticyclonic gyre (water circulates in a clockwise direction). Current speeds reach approximately 0.2 m/s in the deeper perimeter waters and can reach up to 1.0 m/s in the shallow areas on top on the bank. The currents on Georges Bank reach higher velocities in the summer due to the horizontal density gradients created during these months. Source: Worcester and Parker 2010; Zwanenberg *et al*. 2006; Brickman and Drozdowski 2012; Kennedy *et al.* 2011.
Water Temperature	• The water temperatures found in the Western Scotian Shelf and the Gulf of Maine are among the most variable in the North Atlantic Ocean. • The Western Scotian Shelf is generally warmer than the Eastern Scotian Shelf. • Warm water from the Gulf Stream enters the Western Scotian Shelf between Browns Bank and Western Bank. Warm water can also be found entering the Shelf via Verill and Dawson Canyons. • As a result of the influence from the Gulf Stream and from increased vertical mixing in the area, the Western Scotian Shelf has a more dynamic temperature regime than that found in the Eastern Scotian Shelf. • Upper 50 m of water warms in the summer months. • The large variability in the coastal waters of the Scotian Shelf has a significant influence on sound propagation. A strong surface layer condition occurs in many areas during July-October when solar heating has a high effect on surface temperatures. The higher temperature near the surface is often associated with lower salinity produced by runoff that floats on top of the dense ocean water. Sound travels faster in warm water than cold resulting in a net downward refraction of horizontally travelling sound waves. This produces more bottom reflections per kilometer and higher transmission loss. • During November – May, the surface waters are normally colder than the water at depth, resulting in an upward refraction or neutral direction. During these conditions when sound waves are not refracted or are refracted upwards, the effect of the bottom on transmission loss is reduced. Source: Worcester and Parker 2010; DFO 2011b; Davis *et al.* 1998
Salinity	• Coastal waters : 30-32 parts per thousand (ppt) • Nova Scotian Current: 31-33 ppt • Labrador Current: 34-36 ppt • Gulf Stream 34-36 ppt Source: Worcester and Parker 2010
Stratification	• There have been increases in stratification in recent years on the Scotian Shelf. • Strong stratification can inhibit vertical mixing and cause depleted dissolved oxygen levels at depth. Increases in stratification can also concentrate phytoplankton, increasing primary productivity. • Bottom dissolved oxygen concentration is relatively high within the Study Area on the Browns, Baccaro, LaHave, Emerald, and Western Banks. Lower dissolved oxygen concentrations can be found at deeper depths in the LaHave and Emerald Basins. Source: Worcester and Parker 2010; Zwanenburg *et al*. 2006; DFO 2011b

Table 3.8 Overview of Physical Characteristics

<table>
<tr><th colspan="2">Physical Characteristics</th></tr>
<tr><td rowspan="2">Seismic Activity</td><td>Earthquakes occur throughout southeastern Canada with five zones of high earthquake activity, with the closest zone being the Laurentian slope zone.
The area is located off Canada's east coast approximately 250 km south of Newfoundland.
In 1929, a 7.2 magnitude earthquake triggered a large underwater landslide in the Atlantic Ocean, triggering a tsunami that killed 27 people on the Burin Peninsula.
Other earthquakes as large as magnitude 5.3 have been recorded in the area.
Earthquakes in this area are generally associated with fault movement in the ocean floor.
Source: NRCAN 2013</td></tr>
<tr><td>

Source: NRCan 2013
Figure 3.5 Significant Earthquakes in or near Canada, 1627 – 2010</td></tr>
</table>

3.2 BIOLOGICAL CHARACTERISTICS

3.2.1 Plankton

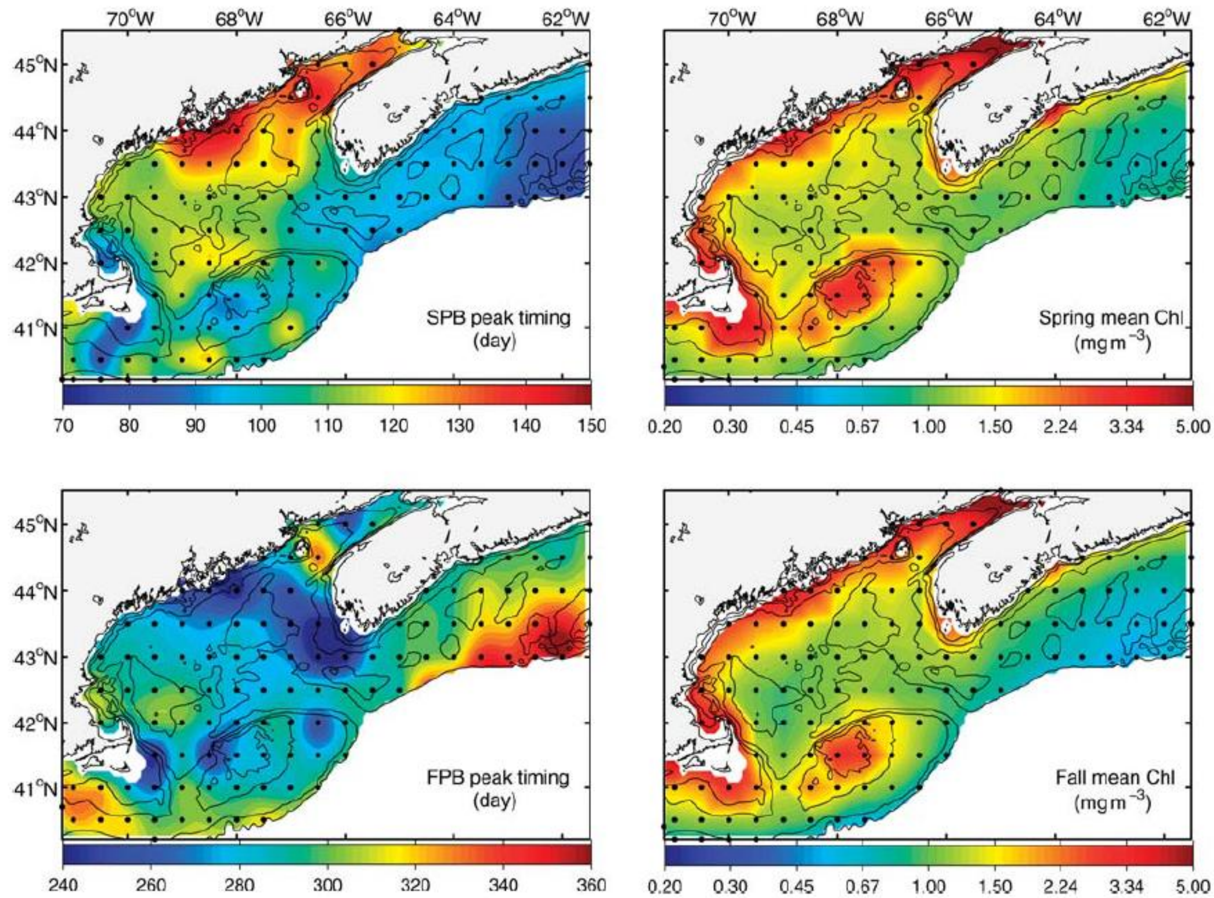
3.2.1.1 Phytoplankton

Phytoplankton are the base of the marine food web and as a result, their production sets an upper limit on the production of all higher trophic levels (Worcester and Parker 2010). Phytoplankton are distinctive among ocean biota in that they derive their energy from sunlight and structural requirements from nutrients in the surrounding water (DFO 2011a). On the Scotian

Shelf diatoms and dinoflagellates are generally the forms with the largest cell size and most commonly recognized types of phytoplankton. Their abundance is based on the balance between growth and mortality, which may be strongly influenced by the complex physical oceanographic features of the Shelf. There is a distinctive cycle to their abundance characterized by widespread spring and fall blooms related to a high concentration of nutrients and sunlight in the water column.

This 12-month seasonal cycle is driven by the earth's rotation around the sun. The annual phytoplankton cycle on the Scotian Shelf begins in the spring as the energy from the sun increases during the changing of the seasons from the winter solstice to the spring equinox (DFO 2013a). During the winter months, the surface waters are mixed upwards by passing storms increasing the amount of nutrients in the surface layer . As the surface begins to warm, the surface waters stabilize creating an ideal area of nutrients and increasing sunlight, allowing for the rapid growth of phytoplankton. Diatoms have evolved to take advantage of these conditions and make up the majority of the spring bloom on the Scotian Shelf. As the spring bloom flourishes, the nutrients in the upper layer begin to dissipate as they are used by the plankton for growth (DFO 2013a). As this progresses into the next season, a summer flora of phytoplankton, which is able to use nutrients regenerated within the ecosystem, begins to take over. The summer season comes to an end with the autumn equinox as water temperatures reach their maximums, which is accompanied by a high abundance of small phytoplankton in a second bloom event. As the fall turns to winter, many phytoplankton communities become inactive, although the occasional winter bloom of well-adapted species can occur (DFO 2013a).

Blooms can vary in temporal and spatial scales. Recent trends in the magnitude and duration of the spring bloom on the Scotian Shelf indicate that blooms are beginning earlier now than they did in the 1960s and 1970s and are more intense and longer in duration (Worcester and Parker 2010). The structure and composition of the phytoplankton community in the Gulf of Maine area, including the Western Scotian Shelf, has been described by Li *et al*. (2011). Diatoms (which have silica shells) and dinoflagellates (which can swim with flagella) are the most taxon rich groups in these waters (Li *et al.* 2011, DFO 2013a). Cyanobacteria as well as 18 classes of other microalgae also occur in the waters of the Western Scotian Shelf. The spring bloom is typically dominated by diatoms, with dinoflagellates contributing significantly to blooms later in the season.



Source: Song *et al.* 2010.

Figure 3.6 The spatial distribution of the Spring Bloom (top panels) and Fall Bloom (lower panels) by day of year and the concentration of chlorophyll during the blooms.

Specifically on the Western Scotian Shelf and in the Gulf of Maine regions, changes in the intensity of low-salinity Scotian Shelf Current inflows can significantly affect the spring blooms in these areas (Song *et al.* 2010). Other environmental factors such as surface winds can influence the spring bloom dynamics by changing the strength and depth of vertical mixing. Figure 3.6 above depicts the peak timing and mean chlorophyll levels associated with the spring and fall blooms on the Western Scotian Shelf and Gulf of Maine areas. In general, the spring bloom occurs earlier in the Eastern regions of the shelf and later on the Western Scotian Shelf and Gulf of Maine. The opposite is true for the fall bloom, with the Western Scotian Shelf peak bloom occurring earlier than the Eastern Scotian Shelf Bloom (Song et al 2010). On the Western Scotian Shelf the average peak bloom occurs from mid-March to mid-April. On Georges Bank the average peak bloom occurs from April to May. On the Northeast peak of Georges Bank, there is a major spring bloom, but no distinctive fall bloom due to the elevated summertime plankton concentrations fueled by a continuous nutrient supply from the deep Gulf of Maine tidal pump.

The spring bloom on the Western Scotian Shelf is strong and short-lived, with a late and weak fall bloom counterpart (Song *et al.* 2010).

3.2.1.2 Zooplankton

Zooplankton are animals that are unable to maintain their horizontal spatial distribution against the current flow (DFO 2011a). The dynamics and abundance of zooplankton determines, in part, how much energy produced from phytoplankton is transferred to higher tropic levels (fish, mammals, birds) (Worcester and Parker 2010). Zooplankton can be divided into three main categories based on size:

- Microzooplankton (20-200 µm in length), which includes ciliates, tintinnids, and the eggs and larvae of larger taxa;
- Mesozooplankton (0.2-2 mm in length), which includes copepods, larvaceans, pelagic molluscs, and larvae of benthic organisms; and
- Macrozooplankton (> 2mm), which includes larger and gelatinous taxa.

The mesozooplankton on the Scotian Shelf is dominated by copepods. Three species of copepods of the genus *Calanus* comprise over 70% of the copepod biomass. *Calanus finmarchicus* appears to be a significant link in the food chain. Food (phytoplankton) and other environmental variables (temperature) are likely the most important variables affecting the abundance of zooplankton on the Scotian Shelf (DFO 2013a). The Scotian Shelf is a dynamic system, where changes in the abundance of long-lived zooplankton species (*e.g. Calanus*) can be influenced by large-scale processes such as the changes in circulation.

The mesozooplankton community on Georges Bank is dominated by a few species (Kennedy *et al.* 2011). Six copepod species make up 80 % of the mesozooplankton community at any given time of the year. These include: *Calanus finmarchicus* and *Pseudocalanus* sp. (winter/spring dominant); *Paracalanus parvus, Centropages typicus,* and *Centropages hamatus* (summer/fall dominant); and *Oithona similis* (abundant year round) (Kennedy et al 2011). The zooplankton community on Georges Bank has a strong seasonal cycle in terms of both biomass and abundance. The total zooplankton abundance peaks from May to June, with average concentrations reaching 1000 individuals/m^3. The lowest concentrations can be found from December to January.

On the Scotian Shelf zooplankton levels have been lower in more recent years than in the 1960s and 1970s, which is the reverse of the recent phytoplankton trend. However they are beginning to recover from the lows observed in the 1990s (DFO 2011a).

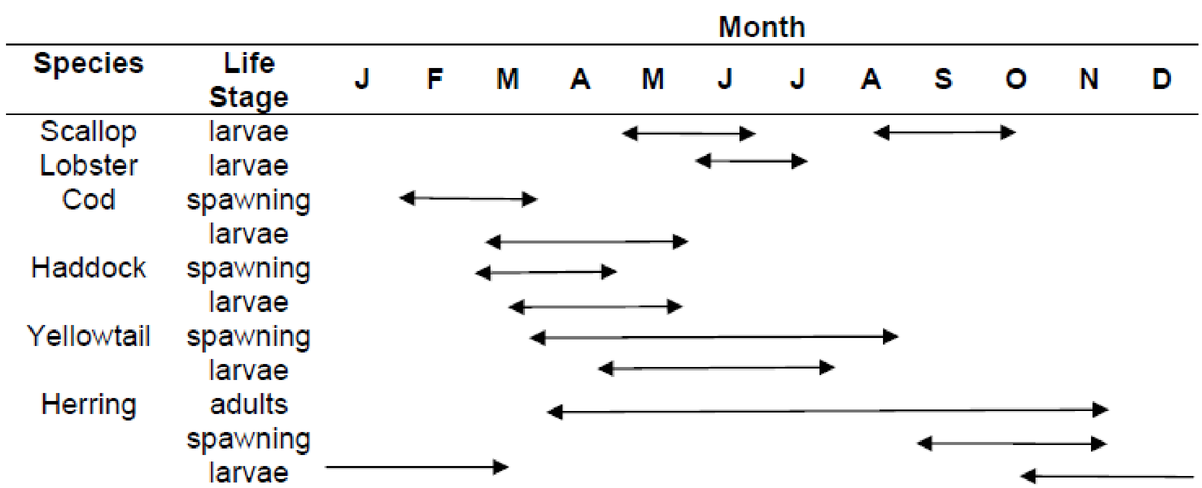
3.2.1.3 Ichthyoplankton

Ichthyoplankton are the eggs and larvae of fish and shellfish. Ichthyoplankton, along with other planktonic early life stages of marine animals, are collectively referred to as the meroplankton because they are planktonic for only a part of their life cycle (NOAA 2007).

One of the major sources of information on zooplankton for the Scotian Shelf is the Scotian Shelf Ichthyoplankton Program (SSIP), which was conducted from 1976-1982. The outflow of the Gulf of St. Lawrence (Nova Scotia Current) is responsible for maintaining high biomass of ichthyoplankton on the northeast half relative to the southwestern half of the Scotian Shelf during June and October. High biomass has been found of various ichthyoplankton communities on the Emerald and Western Banks during the spring and summer (Breeze *et al.* 2002).

Georges Bank plays as an important role in the early stages of a variety of species that are targets of commercially important fisheries (DFO 2011a). Table 3.9 below depicts the periods in which certain commercially important species' eggs and/or larvae can be found in the water column on Georges Bank.

Table 3.9 Timing of various life stages for select invertebrates and commercial fish species which occupy Georges Bank



Source: Kennedy *et al.* 2011

3.2.2 Bacterial Communities

Bacterial communities consist of prokaryotes (single-celled organisms including bacteria and archaea) which make up the smallest free-living cells in any pelagic ecosystem. Bacteria can have a variety of energy sources with some using light as their primary energy source (photoautotrophs), or as an auxiliary source (photoheterotrophs), with the majority of bacteria using organic material as an energy source (heterotrophs) (DFO 2011a). Since the majority of bacteria are secondary producers (rely on organic material for energy) their abundance can be correlated to the abundance of phytoplankton communities. The majority of bacteria rely on material derived from phytoplankton, including waste exuded from plankton cells, cell autolysis, viral lysis, and organic material released from grazers feeding on phytoplankton (DFO 2011a).

Bacteria, specifically heterotrophic bacteria, are natural microbial agents which have the ability to remediate hydrocarbon contamination in the marine environment. Crude oil can be found naturally in the marine environment from natural seeps in the ocean floor (ASM 2011). Crude oil, in essence, is a natural product which has been generated by organisms millions of years ago which used photosynthesis to harness the energy of the sun as their principal energy source. Certain microbes in the marine environment have evolved to harness the energy contained in hydrocarbons or crude oils. These bacteria contain enzymes which allow them to "combust" hydrocarbons as an energy source, much in the same manner as an engine, but at lower temperatures (ASM 2011). There are many different compounds contained within crude oil, some of which can be degraded by many types of bacteria, while some can only be degraded by specific bacteria. As a result, a community of bacteria must work together to fully degrade all of the differing compounds contained within hydrocarbons.

When there is a spill of crude oil or hydrocarbons, the bacteria capable of degrading the substance proliferate and multiply quickly (ASM 2011). The local community of microbes in an area is adapted to the background supply of hydrocarbons. When a spill occurs, there is a lag time during which the microbes replicate and increase their populations in response to the influx of a new energy source. During an oil spill, the volume of oil released into the environment initially out-paces the ability of bacteria to degrade the substance until the community catches up in numbers in response to the increased availability of a hydrocarbon source. In coordination with other physical processes including evaporation, dissolution, dispersion, and photo-oxidation, bacteria will eventually clean up the spill by consuming the hydrocarbon compounds which are biodegradable (ASM 2011). It should be noted that this process occurs over a long time period and depends on a variety of factors including the volume of oil spilled, sea-state, weather conditions.

3.2.3 Algal Communities

Marine plants include both phytoplankton and macrophytic marine algae, with the latter are commonly referred to as "seaweeds". Seaweeds in Nova Scotia can be grouped into three main categories: green algae; red algae; and brown algae.

Green algae need a large amount of light and can generally be found closer to the surface in the intertidal or shallow subtidal areas. Red algae can grow at greater depths and are generally found in the intertidal zone. Brown algae are the dominant seaweeds in Nova Scotia and can also be found in the subtidal zone (DFO 2011b). Table 3.10 provides an overview of marine vegetation.

Table 3.10 Marine Plants

Middle Shelf	• Phytoplankton is the dominant plant in the region, and is found in the upper mixed layer of the ocean. • Coralline algae form pale to pinkish crusts on rock and gravel surfaces on the banks. • Productivity is generally not as great as nearer to shore or closer to the edge of the continental shelf. • Most productivity occurs during the spring and fall phytoplankton blooms. Occasionally drifting seaweeds can be found, from interactions with slope water and the Gulf Stream further offshore. • The basins and shelf areas of the middle shelf are too deep to sustain plant growth.
Outer Shelf (Georges, Browns, Baccaro, LaHave, Emerald, and Western Banks)	• Phytoplankton is the primary marine plant in the region. • Phytoplankton productivity is similar to that found in the middle shelf with spring and fall blooms. • The spring bloom typically occurs earlier on the Eastern regions of the Scotian Shelf and later on the Western regions of the Shelf. The fall bloom occurs in the opposite fashion, with blooms occurring first in the West and later on in the East. • The spring bloom typically peaks from mid-March to mid-April on the Western Scotian Shelf, and from April to May on Georges Bank. • Encrusting algae may occur on hard substrates on the bank. • The outer edge of the shelf has enhanced plankton productivity due to the interaction of shelf and slope waters which brings nutrients to the surface. • Occasionally masses of *Sargassum*, can be found floating in this area.

Source: NSM 1997; Li *et al.* 2011, Song *et al.* 2010.

3.2.4 Corals and Sponges

Corals and sponges provide marine fish and invertebrates with protection from strong currents and predators, and can serve as nurseries for larval and juvenile life stages, feeding areas, breeding and spawning areas, and resting areas (Campbell and Simms 2009).

Cold water corals, which are the type of corals found in the Study Area, are suspension-feeding invertebrates with delicate appendages that capture food particles from the water column. Cold water corals do not contain symbiotic algae and as a result, can live in deeper waters without the influence of sunlight. Most corals require a hard substrate to attach to, while some can anchor themselves into soft sediment (DFO 2011b). The Northeast Channel Coral Conservation area is located within the Study Area on the southeast corner of Georges Bank, in between Georges and Browns Banks (Deller 2012) (refer to Section 3.2.7). In June of 2002, following successive video surveys conducted by DFO and Dalhousie University, the Northeast Channel Coral Conservation Area was established by DFO (Cogswell *et al.* 2009). The area of the conservation area is 424 km^2 and consists of a restricted bottom fishing zone (90% of the area) and a limited bottom fishing zone (10% of the area). The area was chosen based on having the highest density of octocorals, specifically the bubblegum coral, *Paragoria arborea*, and the seacorn coral, *Primnoa resedaeformis*, in the Maritimes. In addition to having the highest concentrations of these corals, there was also evidence of recent disturbances to corals in the area from bottom fishing activities (Cogswell *et al.* 2009). Table 3.11 summarizes characteristics of cold water corals in the Study Area.

Table 3.11 Cold Water Corals

General Characteristics	• Suspension-feeding invertebrates with delicate appendages that capture food particles from the water column. • Do not contain symbiotic algae, and can live at depths without the influence of sunlight. • Most require a hard substrate for attachment; few can anchor into soft sediment. • Occur in many sizes and shapes, with some species forming reef structures. • Slow-growing, some maybe over 100 years old. • Two major groups occur on the Scotian Shelf: Hard/Stony corals (*Scleractinia*) and Octocorals, some of which are solitary while others form reefs. • Octocorals include sea pens, sea whips, sea fans, and "soft corals". • The largest octocorals on the Scotian Shelf are the gorgonian corals, which include bubblegum and seacorn corals.
Locations within the Study Area	• The Northeast Coral Conservation Area is located in the Northeast Channel in between Georges and Browns Bank. • The Northeast Coral Conservation Area has the highest concentrations of bubblegum and seacorn corals in the Maritimes • Large concentrations of large and small Gorgonacea can be found within the Northeast Channel Conservation Area as well as sporadically along the edges of the Banks within the Study Area. • Cup corals (*Flabellum* spp.) can be found on the soft sediments in the basins of the Scotian Shelf and the Gulf of Maine. • Soft corals (dead man's fingers, *Alcyonium digitatum,* and red soft coral, *Gersemia rubiformis*) are widespread on the Scotian Shelf where there is a suitable rock substrate for attachment. • Sea pens and small gorgonians have been found on soft sediments.  Source: DFO 2013e **Figure 3.7 Sea corn (*Primnoa resedaeformis*; to left) and bubblgum coral (*Paragoria arborea*; to right) 900 m below the surface in the Northeast Channel**

Table 3.11 Cold Water Corals

	 Source: DFO 2011e **Figure 3.8 Sea pens (*Pennatula* sp.) in Emerald Basin**

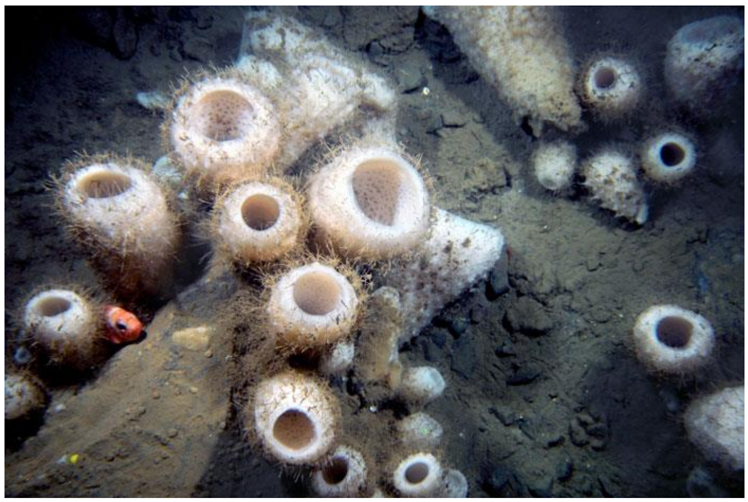
Source: DFO 2011b; Zwanenburg *et al*. 2006; Kenchington *et al*. 2010; DFO 2006

At least 34 species of sponge have been identified off the Atlantic coast. Table 3.12 summarizes the general characteristics of Scotian Shelf sponges and potential distribution in the Study Area.

Table 3.12 Sponges

<table>
<tr><td>General Characteristics</td><td>

Marine invertebrates that attach themselves to bottom substrates.
Filter feeders, which are generally found at water depths below 300 m.
Sponges provide substrate, shelter, and food for many other species.
Russian hat glass sponge (Vazella pourtalesi) is a rare, fragile and barrel-shaped structure forming species of glass sponge.

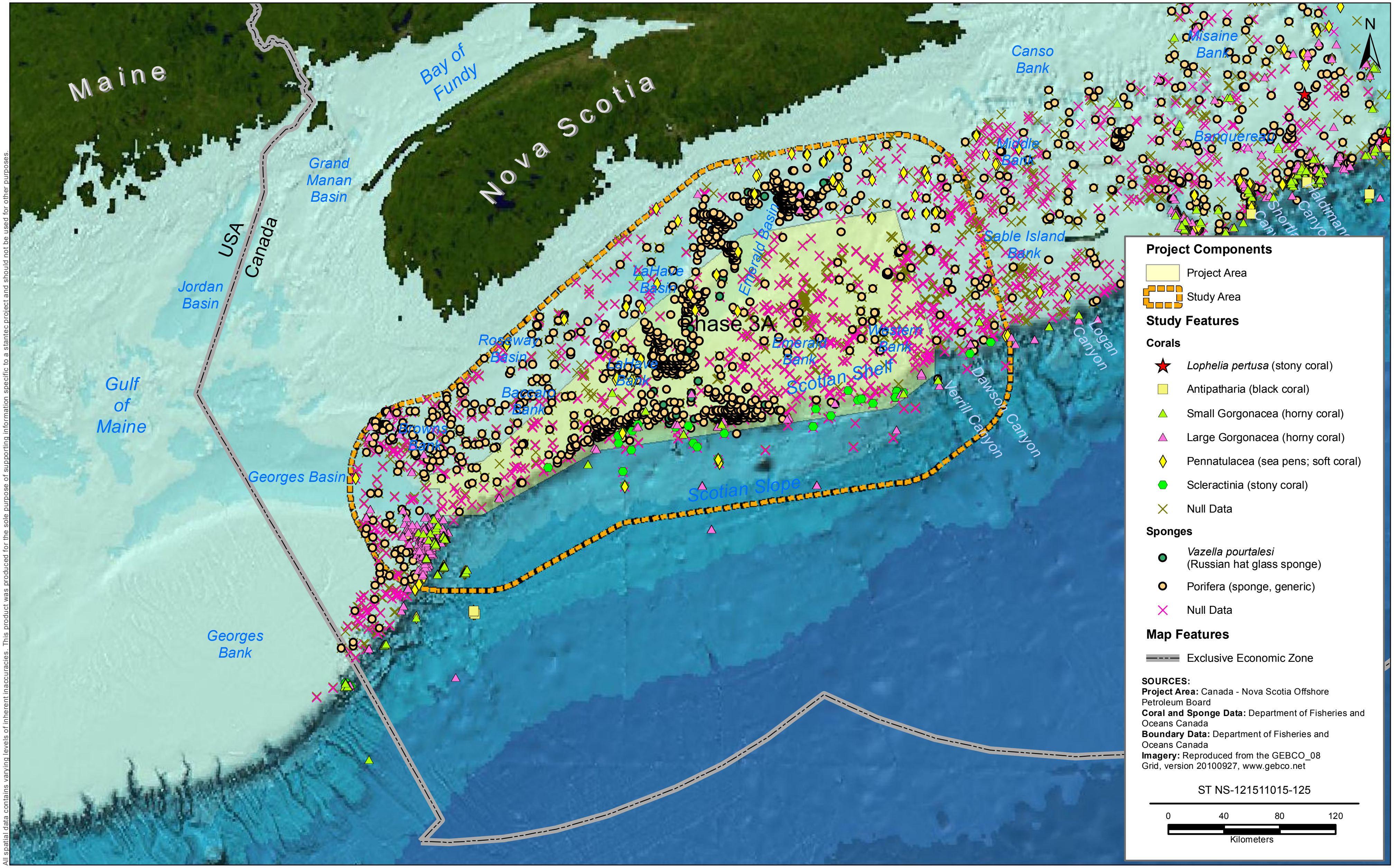

Source: DFO 2013d
Figure 3.9 Vazella pourtalesi (Russian Hats) on the Scotian Shelf
</td></tr>
<tr><td>Locations within Study Area</td><td>

Sponge species (Phylum Porifera) are found on the edges of Georges, Browns, Baccaro, Lahave, Emerald, and Western Banks.
Globally unique sponge grounds containing large aggregations of Vazella pourtalesi are found on Sambro Bank and Emerald Basin. This species is only known to exist in two other locations worldwide – Gulf of Mexico and the Azores - and these two locations only contain individuals or small aggregations.
In 2013, DFO closed areas of Sambro Bank and Emerald Basin to bottom–contact fishing to help protect these sponges.

</td></tr>
</table>

Source: DFO 2011b; Kenchington *et al*. 2010; DFO 2013d

Figure 3.10 displays known distribution of corals and sponges on the Scotian Shelf (data courtesy of DFO).



PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.10
REVIEWED BY: C. Shupe		DATE: Nov 21, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Coral and Sponge Locations**	Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-125_Coral_Phase3A.mxd

3.2.5 Fish and Invertebrates

Key fisheries species on the Western Scotian Shelf are described in three categories: pelagic fish, groundfish, and invertebrates (*e.g.*, shellfish). Pelagic organisms live in the water column and at the surface and can include highly migratory species such as tuna, swordfish, and sharks. Groundfish spend the majority of their life near the bottom of the ocean and include the gadoids (cod, pollock, and haddock), skates, and flatfishes. Groundfish are a major component of the Scotian Shelf fishery. Invertebrates play an important role in the Scotian Shelf fishery with over 28 species that have commercial value including crustaceans, bivalves, snails, squid, and echinoderms.

Table 3.13 summarizes reproductive times (spawning, hatching, mating) for key commercial, recreational or Aboriginalfisheries species that are likely to occur in the Study Area.

Table 3.13 Summary of Spawning and Hatching Periods for Principal Commercial, Recreational, and Aboriginal Fisheries Species with the Potential to Occur in the Study Area

Common Name	Scientific Name	Location of Eggs and Larvae	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Species at Risk														
Acadian Redifish	Sebates fasciatus	Scattered over enitire Scotian Shelf and Slope												
American plaice	*Hippoglossoides platessoides*	Nearshore: Halifax to Liverpool George's to Banquereau Banks and Edge, Roseway Basin												
Atlantic Cod	*Gadus morhua*	Nearshore: Halifax to Yarmouth Georges Bank and scattered throughout the WSS, with higher concentratiosn in ESS												
Atlantic wolffish	*Anarchichas lupus*	*Nearshore: south of Bridewater ans SW NS Roseway and LaHave Basins*												
Blue Shark	*Priomace glauca*	*Not on Shelf or Slope*												
Cusk	*Brosme brosme*	*Georges Basin, Roseway Basin, Browns toWestern Sable Island bank and Edges*												
Deepwater Redfish	*Sebastes mentalla*	Scattered over enitire Scotian Shelf and Slope												
Roughhead Grenadier	*Macrourus berglax*	*Outside of the RAA, Potentially Scotian Slope*												
Roundnose Grenadier	*Coryphaenoi des rupestris*	*Scotian Slope*												
Smooth Skate	*Malacoraja senta*	*Rosway Basin*												
Spiny Dogfish	*Squalus acanthias*	*Roseway, LaHave, and Emerald Basins*												
Spotted Wolffish	*Anarchias Minor*	*Outside of the RAA*												
Throny Skate	*Amblyraja radiate*	*Roseway and LaHave Basins Emerald to Banquereau Banks*												
Winter Skate	*Leucoraja ocellata*	*Browns Bank, Western to Banquereau Banks*												
Pelagic Species														
Atlantic herring	*Clupea harengus*	*Nearshore: Halifax to SW NS Browns to Banquereau Banks, with a few along the Shelf Edge*												
Atlantic Mackerel	*Scomber scombrus*	*Emerald to Banquereau Banks and few along Shelf Edge*												

Table 3.13 Summary of Spawning and Hatching Periods for Principal Commercial, Recreational, and Aboriginal Fisheries Species with the Potential to Occur in the Study Area

Common Name	Scientific Name	Location of Eggs and Larvae	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Black dogfish	*Centroscyllium fabricii*	*Eggs and larvae not present in the area, gives birth to pups*												
Capelin	*Mallotus villosus*	*Nearshore: Halifax* *Eastern Scotian Shelf outside of the RAA*												
Groundfish Species														
Atlantic halibut	*Hippoglossus hippoglossus*	*Browns to Banquereau Banks and Shelf Edge*												
Haddock	*Melanogrammus aeglefinus*	*Nearshore: Halifax to Liverpool* *Georges Bank, Browns Bank to Western Sable Island Bank and Shelf Edge, Roseway Basin*												
Monkfish	Lophius spp.	Gearges to Banquereau Banks and Shelf Edge												
Pollock	*Pollachius virens*	*Nearshore: Halifax to Yarmouth* *Georges Bank, Browns to Western Bank*												
Red hake	*Urophycis chuss*	*Browns to Sable Island Bank and Shelf Edge*												
Sandlance	*Ammodytes dubius*	*Banquereau*												
Silver hake	*Merluccius bilinearis*	Brown's Bank and Slope, Emerald to Banquereau Banks and Shelf Edge												
Turbot-Greenland flounder	*Reinhardtius hippoglossoides*	*Potentially Scotian Slope*												
White hake	*Urophycis tenuis*	*Georges Bank, Roseway Basin, Baccaro Bank and Edge, Western to Sable Island Bank and Edge*												
Witch flounder	*Glyptocephalus cynoglossus*	*Nearshore: Halifax to SW NS* *Georges to Banquereau Banks and the Shelf Edge and Slope*												
Yellowtail flounder	*Limanda ferruginea*	*Nearshore: south of Halifax* *Georges Bank, Browns Bank, Emerald to Banquereau Banks*												
Invertebrate Species														
Lobster*	*Homarus americanus*	*Nearshore Waters*												
Jonah Crab**	*Cancer borealis*	*N/A*												
Scallop	Potential for multiple	Nearshore SW NS												

Table 3.13 Summary of Spawning and Hatching Periods for Principal Commercial, Recreational, and Aboriginal Fisheries Species with the Potential to Occur in the Study Area

Common Name	Scientific Name	Location of Eggs and Larvae	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	species	Georges Bank, Browns Bank, Western to Banquerea Banks												
Northern Shrimp	Pandalus borealis	Nearshore Waters												
Shortfin Squid	Illex illecebrosus	Not completely known - Possibly Continental Shelf South of Cape Hatteras and in the Gulf Stream												
Snow Crab	Chinoecetes opilio	Nearshore SW NS and Bridgewater to Halifax												

*Note: Lobster eggs are extruded by the female from June to September and held until they hatch approximately 9-12 months later.

**Note: Very little biological information exists for Jonah Crab on the Scotian Shelf and Slope.

	Mating period
	Potential Spawing Period
	Anticipated Peak Spawning Period
	Eggs and/or Larvae Present

Source: Campana *et al.* 2003, 2013; Cargnelli *et al.* 1999a,1999b; COSWEIC 2006, 2007, 2008, 2010b,2012a, 2012b; DFO 2001, 2007, 2009a, 2009b, 2010b, 2011a, 2013d, 2013e2013f, 2013h, 2013i, 2013k, 2013l, 2013m, 2013n, 2013o; NOAA 2013b, 2013c; SARA 2013a, 2013b; Horseman and Shackell 2009

3.2.5.1 Pelagic Fish

The following table contains common pelagic species of commercial, recreational and Aboriginal fisheries that are likely to occur within the Study Area. Species of Special Status are discussed in Section 3.2.5.4.

Table 3.14 Pelagic Fish of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in Study Area

Common Name	Scientific Name	Distribution
Albacore tuna	*Thunnys alalunga*	Albacore tuna enter Canadian waters in July and remain until November feeding on forage species. Migration routes are still uncertain. Albacore tuna are distributed sparsely along the Scotian Shelf Edge and Slope, with higher numbers further offshore above the abyssal plain. Spawning takes place in subtropical waters of the Atlantic Ocean and the Mediterranean Sea. Larvae remain in the spawning grounds until the second year when during the spring they begin their migration to the North American Coast.
Atlantic herring	*Clupea harengus*	Atlantic herring are a small schooling fish and are common along the coast of Nova Scotia and offshore banks. Known to be present in the Roseway, LaHave, and Emerald Basins feeding primarily on zooplankton, krill and fish larvae.. Atlantic herring travel from spawning grounds to feeding sites in a seasonal migratory cycle, with spawning locations found in both coastal waters and on offshore banks. Coastal spawning grounds include areas off Southwest Nova Scotia, Bay of Fundy, and off of Grand Manan Island. Offshore spawning occurs on areas of Georges Bank. Spawning begins in August in Nova Scotia and Eastern Maine Regions and in October/November in the Southern Gulf of Maine and Georges Bank.
Atlantic mackerel	*Scomber scombrus*	The Atlantic Mackerel is a pelagic species found on both sides of the Northern Atlantic Ocean. On the western side of the Atlantic Ocean, they can be found from Cape Hatteras, North Carolina to Newfoundland and Labrador. During the spring and summer months, mackerel can be found in coastal waters. During the fall and winter the species moves offshore to the warmer waters along the continental shelf. Atlantic mackerel feed primarily on crustaceans including copepods, krill, and shrimp. They will also feed on squid and small fish species. The species has two major spawning areas which include the Mid-Atlantic Bight from April to May and the Gulf of St. Lawrence in June and July.
Bigeye tuna	*Thunnus obesis*	Bigeye tuna are a tropical tuna species which can be found in temperate to tropical waters from Nova Scotia to Brazil. Spawning takes place in tropical waters throughout the year with a peak during the summer months. Young individuals typically inhabit tropical waters with mature individuals migrating to northern latitudes. Mature bigeye tuna enter Canadian waters including the Scotian Shelf in July and remain

Table 3.14 Pelagic Fish of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in Study Area

Common Name	Scientific Name	Distribution
		until November to feed. Bigeye tuna have a similar distribution as the Albacore with a few fish inhabiting waters along the Scotian Shelf Edge and Slope, with higher numbers further offshore.
Black dogfish	*Centroscyllium fabricii*	The black dogfish is a deepwater species found in temperate to boreal waters over the outer continental shelves and slopes of the North Atlantic Ocean. The black dogfish has been observed at depths of up to 1,500 m but are more common from 550 – 1,000 m. This species has been found along the banks and basins within the Study Area. Reproduction occurs year round. Females are oviviparous and give birth to up to 40 pups which measure 12-19 cm in length. In Canadian waters they have been observed giving birth in parts of the Laurentian Channel.
Swordfish	*Xiphias gladuis*	Swordfish migrate into Canadian waters in the summer as part of their annual seasonal movement, following spawning in subtropical and tropical areas. Swordfish are commonly caught along the slope of Sable Island Bank and is one of the most important pelagic commercial fish species in the Study Area. Swordfish can be found along the Scotian Shelf Edge and Slope as well as on the northeast corner of the Emerald Basin. They can be commonly found feeding on the slopes of the banks in cooler, more productive waters. Swordfish feed on a variety of fish species as well as invertebrates including squid.
White marlin	*Tetrapturus albidus*	In western Atlantic waters, marlin can be found in warm temperate waters and tropical waters. During the summer months marlin migrate into Canadian waters off of Nova Scotia. Marlin can be found along the Scotian Shelf edge and slope. They can often be found in areas with upwelling and distinct geographic features including shoals, drop-offs, and canyons. White marlin feed on squid, mahi-mahi, mackerel, herring, flying fish and bonito.
Yellowfin tuna	*Thunnus albacares*	Yellowfin tuna migrate into Canadian waters, including the Scotian Shelf to feed during the summer months. Yellowfin tuna have similar distributions as the Albacore and Bigeye tunas, sparsely populating the shelf edge and slope with higher numbers further offshore. The species spawns from May to August in the Gulf of Mexico and from July to November in the Southeastern Caribbean.

Source: Scott and Scott 1988; Campana *et al*. 2003; Maguire and Lester 2012; DFO 2006a; DFO 2011a; DFO 2012a; DFO 2013a; NOAA 2013b, 2013c, 2013d, 2013e, 2013f, 2013g, FLMNH 2013a, 2013b; GMA 2014.
Note: For an in-depth overview of important areas for fish, particularly larval distribution maps, refer to Horsman and Shackell (2009).

3.2.5.2 Groundfish

Table 3.15 summarizes the distribution of groundfish of commercial, recreational and Aboriginal fisheries that are likely to occur within the Study Area value likely to occur in the Study Area. Species of Special Status are discussed in Section 3.2.5.4.

Table 3.15 Groundfish of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in the Study Area

Common Name	Scientific Name	Distribution
Atlantic halibut	*Hippoglossus hippoglossus*	Atlantic halibut are distributed from north of Labrador to Virginia. On the Scotian Shelf, halibut are most abundant between 200 – 500 m and can be found on the banks and basins of the continental shelf and are present within the Study Area. They prefer sand, gravel or clay substrates. The Atlantic halibut is the most important groundfish species within the Study Area. The species preys on benthic organisms which range from invertebrates to fish as they grow in size. Females mature at 10 to 14 years and spawn from December to June in deep water ranging from 300-700 m. Females can spawn several million eggs which are pelagic.
Haddock	*Melanogrammus aeglefinus*	Haddock are a demersal gadoid species usually closely associated with the seafloor, preferring broken ground, gravel, pebbles, clay, smooth hard sand, sticky sand of gritty consistency, and shell beds. Haddock can be found from Greenland to Cape Hatteras, and are common in the Study Area on all of the banks and basins. They can be most commonly found at depths ranging from 50 – 250 m. Haddock feed on a variety of benthic organisms including mollusks, polychaetes, crustaceans, echinoderms, fish eggs, and small fish. They are a species which grows at a fast rate and mature from one to four years of age. Spawning takes place from January to July over rock, sand, gravel and mud bottoms on areas of Georges Bank and eastward to Sable Island Bank and shelf Edge. Eggs and larvae are pelagic.
Hagfish	*Myxine glutinosa*	Hagfish can be found from the coast of Florida to the Davis Strait and Greenland.They can be found in depths up to 1200 m at temperatures less than 14 °C and salinities less than 32 ppt. The species prefers soft substrates and areas with low current velocity. As a new fishery in the area, Hagfish are becoming an important source of income within the groundfish fishery. Hagfish spawn year round with each female carrying 1 – 30 horny-shelled large eggs. Females deposit eggs in burros with newly hatched hagfish resembling adults and measure 6 – 7 cm in length. They feed on a variety of infaunal and epifaunal invertebrates.
Monkfish	*Lophius americanus*	Monkfish can be found from the Northern Gulf of St. Lawrence to Cape Hatteras. They have been found inhabiting areas up

Table 3.15 Groundfish of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in the Study Area

Common Name	Scientific Name	Distribution
		to 800 m in depth, but are most commonly found from 70-190 m. Concentrations of Monkfish can be found on the banks and basins and the edge of the shelf in the Study Area. Monkfish typically inhabit areas with benthic substrates consisting of sand, mud and shell hash. They are opportunistic feeders and prey on a wide variety of fish and invertebrates. Monkfish reach sexual maturity between three and four years of age. Spawning typically occurs during the summer months from Georges to Sable Island Bank and Shelf edge. The eggs are spawned in a thin ribbon-like mucous veil which is pelagic in nature.
Pollock	*Pollachius virens*	Pollock is a gadoid species found from southern Labrador to Cape Hatteras, with major concentrations on the Scotian Shelf, including the banks and basins of the Study Area. Pollock can be found inhabiting areas with sand, mud, rock, and various types of vegetation. Pollock travel in schools between the Scotian Shelf and Georges Bank with some fish traveling into the Gulf of Maine. Pollock mature from four to seven years of age with spawning taking place from September to March. Spawning occurs from Georges Bank to Western Bank. Eggs and larvae are pelagic and float in the surface layers.
Red hake	*Urophycis chuss*	The red hake can be found from the Gulf of St. Lawrence to North Carolina from depths of 10 – 500 m at temperatures of 5-12°C. Within the study area red hake can be found in the LaHave and Emerald Basins as well as along the shelf edge. During the spring and summer red hake migrate to shallower waters to spawn, returning to the deeper waters of the shelf edge and slope during the winter months.
Sand lance	*Ammodytes dubius*	In the northwest Atlantic, sand lance can be found from Cape Hatteras to Greenland and are generally found in water depths of less than 90 m (DFO 2013q). They are generally found along coastal zones and on the shallow waters of offshore banks on sand or small gravel benthic substrates. Sand lance do not make extensive migrations, but will travel between resting and feeding grounds Sand lance mature at two years of age and spawn on sand in shallow water depths during the winter months (DFO 2013q). The eggs stick to the substrate and remain there until they hatch. Upon hatching, the larvae become pelagic and remain in the surface waters for a few weeks and are an important food source for predators.
Silver hake	*Merluccius bilinearis*	The silver hake can be found from southern Newfoundland to South Carolina. Within the Study Area, this species can be found in the Lahave and Emerald Basins as well as along the shelf edge.The species can be most commonly found at depths

Table 3.15 Groundfish of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in the Study Area

Common Name	Scientific Name	Distribution
		from 150-200 m feeding primarily on shrimp, krill, and sand lance. Silver hake mature at two years of age. Seasonal migrations occur during the spawning period, from June to September. Spawning occurs from Browns Bank to Sable Island Bank and along the shelf edge. During this time they move from the deeper waters of the LaHave and Emerald Basins up onto the Banks. The eggs and larvae are buoyant for a period of three to five months.
Turbot – Greenland flounder	Reinhardtius hippoglossoides	The Greenland flounder can be found in water depths ranging from 90-1600 m from western Greenland to the southern edge of the Scotian Slope. Within the Study Area, this species is most common along the shelf edge and slope. Females mature at approximately nine years of age with spawning taking place during the winter and early spring.
Witch flounder	*Glyptocephalus cynoglossus*	Witch flounder is a deep-water, boreal flatfish that can be found from Labrador to Georges Bank at depths from 100– 400 m, and can occasionally be found at depths up to 1600 m. They occur most commonly in deep holes and channels and along the shelf edge on muddy bottoms. Spawning occurs from May to October with a peak in July and August. Spawning occurs on the shelf from Georges Bank to Sable Island Bank in the Study Area. Eggs and larvae are pelagic and drift in the currents until settling to the benthos.
Yellowtail founder	*Limanda ferruginea*	Yellowtail flounder is a small-mouthed Atlantic flatfish that inhabits relatively shallow waters of the continental shelf from southern Labrador to Chesapeake Bay. A major concentration of yellowtail flounder occurs on Georges Bank from the Northeast Peak to the Great South Channel. This species prefers sand or sand-mud sediments in water depths ranging from 40-80 m. The species feeds on a variety of invertebrates as well as small fish species. Maturity is reached from two to three years of age. Spawning takes place near the substrate on Georges, Browns, Emerald, Western and Sable Island Banks from May to July. The eggs drift to the surface following fertilization and drift during development.

Source: Scott and Scott 1988; Cargnelli *et al*. 1999a; Cargnelli *et al*. 1999b; DFO 2001, 2006b, 2009b, 2009c 2012.
Note: For an in-depth overview of important areas for fish, particularly larval distribution maps refer to Horsman and Shackell (2009).

3.2.5.3 Invertebrates

Table 3.16 summarizes invertebrate species of commercial, recreational and Aboriginal fisheries that are known to occur within the Study Area.

Table 3.16 Invertebrates of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in the Study Area

Common Name	Scientific Name	Distribution
American Lobster	*Homarus americanus*	Lobster can be found along the Atlantic coastline and on the continental shelf from Northern Newfoundland to South Carolina. Within the Study Area there are two classifications of lobster; inshore and offshore. The inshore component of the population can be found in the Roseway and LaHave Basins as well as in most locations of the nearshore shelf. The offshore component of the population is present in the Northeast Channel and along the edges of the Shelf. Adult lobsters are typically found in water depths of less than 300 m but have been found up to 750 m. They prefer substrate with rock and boulder shelter as they use these surfaces as protection from predators as well as sunlight. They have also been found in areas with sand, gravel and mud substrates. During the summer months lobsters migrate to shallower waters to take advantage of warm water temperatures. In the winter they retreat to deeper water to avoid winter storms, ice, and extreme cold water temperatures. Lobster reproduction takes two years. Immediately after molting females mate with males and store sperm in the undersides of their bodies in a sperm plug. During this time females are developing eggs internally for 12 months. The next summer eggs are extruded and fertilized with the stored sperm. Females carry the fertilized eggs for 9 – 12 months before hatching. Egg bearing females will move inshore to hatch their eggs during the late spring to early summer.
Snow crab	*Chionoecetes opilio*	Snow crabs can be found from the Gulf of Maine to Greenland at depths from 50m to 1300 m. The species prefers temperatures in the range of 3-4 °C. Within the Phase 3A Study Area, snow crab is not a commercially important species; most harvesting occurs east of the Study Area on the Banquereau, Middle, and Sable Island Banks.
Jonah crab	*Cancer borealis*	Jonah crab are found from Newfoundland to South Carolina and in the Bermuda Islands at water depths ranging from intertidal to 800 m. Offshore Nova Scotia they are generally found at water depths of 50-300 m. Jonah crab feed primarily on benthic invertebrates including mussels, snails, barnacles, and dead fish. Within the Phase 3A Study Area, harvesting appears to be concentrated in pockets around LaHave and Roseway Basins and along the shelf break.
Atlantic sea scallop	*Placopecten magellanicus*	Atlantic sea scallop can be found from the Gulf of St. Lawrence to Cape Hatteras, North Carolina and are prevalent on Browns and Georges Bank within the Study Area. Females can reproduce beginning at two years of age, but do not produce many eggs until four years of age.
Northern shrimp	*Panadalus borealis*	The species can be found from Massachusetts to Greenland at water depths from 10 – 350 m. The species prefers soft mud benthic substrates. Northern shrimp are important in

Table 3.16 Invertebrates of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in the Study Area

Common Name	Scientific Name	Distribution
		marine food chains as they are an important prey item for many species of fish and marine mammals. Although a benthic species, northern shrimp will migrate vertically through the water column at night (diel vertical migration) to feed on small crustaceans in the pelagic zone (DFO 2013t). They also prey on phytoplankton and zooplankton as well as benthic invertebrates. The northern shrimp is a hermaphroditic species (possesses the reproductive organs of both sexes). The species first reaches maturity as a male at the age of 2-3 years and by the age of 4-5 years they transform into a female, spending the rest of their lives in this state. In the northwest Atlantic, mating occurs during the late summer to fall in offshore waters, with fertilized eggs remaining attached to the females abdominal appendages until the following spring. Females migrate to nearshore waters during the late fall to early winter. After approximately 7 – 8 months the eggs hatch during April and May. The larvae remain pelagic and drift in the ocean currents feeding on planktonic organisms. After a period of a few months they settle to the benthic zone and start to resemble adults. Juveniles will remain in coastal waters for over a year before migrating to deeper offshore waters and mature as males. Overall northern shrimp migrate with seasonal changes in water temperature spending the fall and winters in nearshore waters when the water is the coolest and migrating offshore during the spring and summer.
Shortfin squid	*Illex illecebrosus*	The life cycle of the shortfin squid is approximately one year in length. The shortfin squid may reproduce during any part of the year although most reproduction occurs during the winter months over the continental shelf south of Cape Hatteras, North Carolina. Females then expel their eggs through jets in their abdomen while at the same time creating one or multiple jelly masses which contains up to 100,000 eggs and measures up to a meter in diameter. The fertilized mass of eggs is pelagic and travels north in the Gulf Stream. When the squid first hatch after 8 – 16 days they are known as paralarvae. Paralarvae are abundant in the convergence zone of Gulf Stream water and slope water where there is an area of high productivity. Once reaching a size of 5 cm the paralarvae become juveniles and feed mainly on crustaceans (Euphausiids) at night near the surface waters; they also feed on nematodes and fish. At this stage juveniles grow at a rate of 1.5 mm per day. Once reaching a size of 10 cm juveniles are at the adult stage and can reach sizes of up to 35 cm. During the spring juveniles and adults migrate onto the Scotian Shelf area from the

Table 3.16 Invertebrates of Commercial, Recreational and Aboriginal Fisheries Likely to Occur in the Study Area

Common Name	Scientific Name	Distribution
		slope frontal zone and feed on fish including: cod, mackerel, redfish, sand lance, herring, and capelin. Adults will also cannibalize smaller squid. Juvenile and adult squid have diel vertical migrations in which they rise vertically in the water column to feed at night and migrate to deeper depths during the day. During the fall months the shortfin squid will migrate off the shelf to spawn presumably in the Gulf Stream and south of Cape Hatteras. Spawning is believed to occur from December to March.

Source: DFO 2002; DFO 2004b; DFO 2007; DFO 2009a, 2009d, 2009e; DFO 2010d; DFO 2012a; DFO 2013g, 2013h, 2013i, 2013j; NOAA 2013h, 2013i, 2013j, 2013k, 2013l

3.2.5.4 Fish Species of Special Status

Table 3.17 lists fish species of special status which may be present in the Study Area. Species of special status are those that are listed as endangered, threatened, or special concern either under the *Species at Risk Act* (SARA) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Populations that are highly unlikely to occur in the Study Area have been excluded (*e.g.*, Atlantic cod Laurentian North population).

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Northern wolffish	*Anarhichas denticulatus*	Threatened	Threatened	Low	Main range is off northeast Newfoundland and across the North Atlantic Ocean with some occurrence on the Eastern Scotian Shelf off Cape Breton. Most commonly found inhabiting the seafloor in water depths of 100 to 900 m. Non-migratory spawning occurs in the fall. Larvae may be present on the seafloor in fall to early winter.
Spotted wolffish	*Anarhichas minor*	Threatened	Threatened	Low	Main range is west of Greenland to the Grand Banks with some occurrence on the Eastern Scotian Shelf off Cape Breton. Most commonly found inhabiting the seafloor in water depths of 50 to 600 m. Non-migratory spawning occurs in the summer. Eggs / larvae may be present on the seafloor in summer to fall.
Atlantic (striped) wolffish	*Anarhichas lupus*	Special Concern	Special Concern	High	Occurs along the Scotian Shelf with a higher concentration around Brown's Bank, along the edge of the Laurentian Channel and into the Gulf of Maine. Most commonly found inhabiting the seafloor in water depths of 150 to 350 m. Short migrations to spawning grounds in shallow waters during the fall. Eggs / larvae may be present on the seafloor in fall to early winter in the Roseway and LaHave Basins.
White shark	*Carcharodon carcharias*	Endangered	Endangered	Low	Rare in north Atlantic Canadian waters (32 records in 132 years), as it is the northern edge of their range. Recorded sightings range from the Bay of Fundy to the Laurentian Channel as well as on the Sable Island Bank. Can range in depth from the surface to 1,300 m, are highly mobile and seasonally migrant.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Acadian redfish (Atlantic population)	*Sebastes fasciatus*	Not Listed	Threatened	High	The Acadian redfish is closely associated with the seafloor commonly found inhabiting waters 150 to 300 m in depth along the Scotian Shelf Edge and Slope. They can be found over a wide range of habitats and are known to use rocks and anemones as protection from predators. Mature individuals expected to occur in the Study Area from year -round. Migratory information for the species is lacking due to the fact that they cannot be tagged. Mating occurs in fall. Larvae may be present in the water column May to August.
American eel	*Anguilla rostrata*	Not Listed	Threatened	Transient/ Low	Adult American eels migrating from freshwater streams to the Sargasso Sea may pass through the Study Area. Mature silver eels spawn in the Sargasso Sea with hatching occurring from March to October, peaking in August. The larvae are transparent and willow-shaped and are transported to North American coastal waters via the Gulf Stream. After approximately 7-12 months, larvae enter the Continental Shelf area and become glass eels taking on an eel shape while remaining transparent. As glass eels migrate towards freshwater coastal streams they are known as elvers. Elvers will run into the freshwater streams with runs peaking from April to June in Nova Scotia. Elvers eventually transform into yellow eels, which is the major growth phase for the species. Yellow eels will spend years maturing in freshwater streams and coastal areas before making a major transformation to return to the Sargasso Sea to spawn. On average, yellow eels will remain in coastal areas or freshwater for 9 to 22 years before metamorphosing both morphologically and physiologically into silver eels. Nova Scotian silver eels will begin their outmigration to the Sargasso Sea in November travelling over 2000 km to spawn for the only time during their life.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
American plaice (Maritime population)	*Hippoglossus platessoides*	Not Listed	Threatened	High	The American plaice is closely associated with the seafloor and commonly found in water depths of 100 to 300 m where soft/sandy sediments are present. The maritime population is common to the Scotian Shelf. Within the Study Area, American plaice can be found along the banks and basins as well as along the Shelf edge year round. Females are batch spawners, spawning batches of eggs for up to one month. Spawning occurs in April/May. Eggs and larve are pelagic and may be present in the water column between May and June. Major spawning areas include Banquereau, Western and Browns Banks.
Atlantic bluefin tuna	*Thunnus thynnus*	Not Listed	Endangered	High	The Bluefin tuna is a highly migratory species which travels over long and varied routes. The species is distributed throughout the North Atlantic Ocean, occupying waters up to a depth of 200 m. Adult Bluefin tuna enter Canadian waters, including the Scotian Shelf from June to October. The bluefin can be found distributed in high concentrations along the the shelf edge and the Northeast Channel (Hell Hole) within the Study Area. The species forages on herring, mackerel, capelin, silver hake, white hake, and squid. Spawning takes place in the Gulf of Mexico and the Mediterranean Sea with females producing upwards of 10 million eggs per year. The eggs are buoyant and are fertilized by males in the water column.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Atlantic cod (Laurentian South population)	*Gadus morhua*	Not Listed	Endangered	Low-Moderate	Atlantic cod can generally be found in coastal, nearshore and offshore areas from depths of a few meters to 500 meters. Atlantic cod can be found from Greenland to Cape Hatteras, and is common on all of the banks and basins within the Study Area. In 1993 a moratorium on northern cod fishing (Newfoundland and Labrador, Gulf of St. Lawrence, and Eastern Scotian Shelf) was put in place on all directed fishing and remains in effect today. Cod remains an important commercial by-catch fishery on the southwest Scotian Shelf. Cod from this population migrate from the southern Gulf to the waters of the Scotian Shelf off Cape Breton between May to October. Eggs and Larvae may be present in upper water column from May to April.
Atlantic cod (Southern population)		Not Listed	Endangered	High	Atlantic cod from the Southern Population inhabit waters from the Bay of Fundy and southern Nova Scotia including the Scotian Shelf to the southern extent of the Grand Banks. This population overwinters in the deeper waters of Browns and LaHave Banks as well as inshore waters near Nantucket. Atlantic Cod have been observed spawning in both offshore and inshore waters year round. Peak spawning has been observed during the spring with pelagic eggs and larvae. Juvenile cod prefer habitats which provide protection and cover such as nearshore waters with eelgrass or areas with rock and coral.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Atlantic salmon (Outer Bay of Fundy)	*Salmo salar*	Not Listed	Endangered	Transient/Low	Atlantic salmon are iteroparous, returning to natal rivers to spawn after the completion of ocean scale migrations. Collectively as a species, adult salmon return to freshwater rivers after a feeding stage at sea from May to November, with some fish returning as early as March. Female salmon deposit eggs in gravel nests in October and November, usually in gravel riffle sections of streams. Spawned-out or spent adults (kelts) return to sea immediately after spawning or remain in fresh water until the following spring. Fertilized eggs incubate in nests over the winter and begin to hatch in April. Hatchlings (alevins) remain in the gravel riverbed for several weeks while living off a large yolk sac. Once the yolk sac has been absorbed, free swimming parr begin to actively feed. Parr will remain in fresh water for one to eight years before they begin a behavioral and physiological transformation and migrate to sea as smolts, completing the life cycle. In general, Atlantic salmon make long oceanic migrations from their over wintering at sea locations to their native freshwater streams. This migration occurs from May to November. Spawned out adults either return to their overwintering location following spawning or wait until the following spring to return to sea. The majority of Atlantic salmon overwinter in the Labrador Sea and Flemish Cap Area. Population extends from the Saint John River westward to the U.S border. Migration patterns to the North Atlantic may cause the population to be present in the Study Area; any presence will be transient in nature.
Atlantic salmon (Inner Bay of Fundy)		Endangered	Endangered	Transient/Low	This population extends from Cape Split around the Inner Bay of Fund to a point just east of the Saint John River estuary. It is believed that some of the Inner Bay of Fundy Salmon overwinter in the Bay of Fundy and Gulf of Maine.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Atlantic salmon (Eastern Cape Breton population)		Not Listed	Endangered	Transient/Low	Population extends from the northern tip of Cape Breton to northeastern Nova Scotia (mainland). Migration to the North Atlantic is not likely to involve crossing the Study Area.
Atlantic salmon (Nova Scotia Southern Upland population)		Not Listed	Endangered	Transient/Low	Population extends from northeastern Nova Scotia (mainland) along the Atlantic and Fundy coasts up to Cape Split. Migration between freshwater rivers and the North Atlantic means the population may pass through the Study Area with a presence being transient in nature.
Atlantic sturgeon (Maritimes population)	*Ancipenser oxyrinchus*	Not Listed	Threatened	Low	Population found throughout the coastal waters of the Maritimes and extends out onto the Shelf. Concentrated in water depths less than 50 m and highly migratory in nature so any presence in the Study Area is likely transient. Adults migrate into estuaries and rivers in the autumn (August-October) or in the spring (May-June) prior to reproduction. Adults will often overwinter in deep channels and pools in rivers and estuaries downstream of the spawning sites. Adults and large juveniles move both inwards and seawards in responses to season and salinity. They can be found in the Bay of Fundy, along the coast of Nova Scotia and offshore as far as Banquereau and Sable Island Banks.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Basking shark (Atlantic population)	*Cetorhinus maximus*	Not Listed	Special Concern	Moderate	Found throughout the North Atlantic with concentrations in coastal waters of Newfoundland and near the mouth of the Bay of Fundy. They have also been observed on Georges Bank, Northwest Channel, and the LaHave and Emerald Banks. During the summer months they can be found in surface waters, particularly the LaHave and Emerald Basins, where they may mate. During the winter months they are believed to be found on the Scotian Slope in deeper waters. It is believed that the basking shark lives primarily in oceanic front locations where their main food source, zooplankton, is found. They have been shown to be sensitive to low frequency (25-200 Hz) pulses.
Blue shark (Atlantic population)	*Priomace glauca*	Not Listed	Special Concern	Moderate-High	The blue shark is a highly migratory species, with its western Atlantic range from Newfoundland to Argentina. The blue shark has been recorded in Canadian waters including the Scotian Shelf, Shelf edges and Slope most commonly from June to October. Blue sharks are opportunistic predators feeding on bony fish, squid, birds, and marine mammal carrion. The species prefers water temperatures ranging from 8 – 16 °C, with water temperature being a primary factor for migration. The blue shark mates during the spring and early summer outside of the Study Area.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Cusk	*Brosme brosme*	Not Listed	Endangered	High	Commonly found between the Gulf of Maine and southern Scotian Shelf. Most common along the southwestern Shelf but have been frequently noted as far up the Shelf as Sable Island. Within the Study Area, cusk can be found along the Scotian Shelf Slope and prefer water depths from 200-600 m. The species feeds on invertebrates and inhabits benthic areas with hard and rocky substrates. They can sometimes be found over gravel and mud substrate as well. Cusk mature from five to seven years of age and spawn from May to August. The eggs and larvae are buoyant and float in the surface layers until reaching a size fo 50-60 mm. Larvae can be found over Georges and Roseway Basin as well as from Browns Bank to Sable Island Bank and respected shelf edges.
Deepwater redfish (Northern population)	*Sebastes mentalla*	Not Listed	Threatened	Low	Closely associated with the seafloor and commonly found inhabiting waters 350 to 500 m in depth from Sable Island to northern Labrador. They have similar life histories to the Acadian redfish which can be seen in Table 3.15.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Porbeagle shark	*Lamna nasus*	Not Listed	Endangered	Moderate-High	Porbeagle sharks are a pelagic shark species commonly inhabiting continental shelves and ocean basins at depths from 1 – 2800 m. Immature porbeagle sharks inhabit the Scotian Shelf with mature individuals migrating along the shelf waters to mating grounds located on the Grand Banks, off the mouth of the Gulf of St. Lawrence, and on Georges Bank during September to November. Females leave the continental shelf in December, travelling to the Sargasso Sea to give birth in March and April. Young of the year porbeagles begin to show up in Atlantic Canadian waters in June and July. There is a population which undertakes extensive migrations. From January to February they can be found in the Gulf of Maine, Georges Bank and the southern Scotian Shelf. During the spring they can be found on the edge of the Scotian Shelf and in offshore basins. They migrate northeasterly and can be found off the southern coast of Newfoundland and in the Gulf of St. Lawrence in the summer and fall.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Roundnose grenadier	*Coryphaenoides rupestris*	Not Listed	Endangered	Moderate	The roundnose grenadier is a continental slope species with the deeper part of its geographic range not well surveyed. It is closely associated with the seafloor and commonly found inhabiting waters 400 to 1,200 m in depth but has been found in water depths of up to 2600 m. The species prefers areas absent of currents and can be found in aggregations in troughs, gorges, and lower parts of the Scotian Slope. Aggregations have been found around the North Atlantic Sea Mounts. Spawning is believed to occur year round with peaks at different times for different areas. Females will spawn 12,000 to 25,000 pelagic eggs. Roundnose grenadier have been observed moving up and down continental slopes, moving to deeper water in the winter and shallower water in the summer. They have also been observed to carry out diurnal vertical migrations of 1,000 m off the bottom. The species feeds in the water column on a variety of prey items including: copepods, amphipods, squid, and small fish.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Roughhead grenadier	*Macrourus berglax*	Not Listed	Special Concern	Moderate	The roughhead grenadier is a benthopelagic species that is closely associated with the seafloor and commonly found in water depths of 400 to 2,000 m on or near the continental slope of the Newfoundland and Labrador Shelves from the Davis Strait to the southern Grand Banks. They have also been observed on Banquereau, Sable Island, Browns and Georges Banks. The species is an opportunistic predator which feeds on invertebrates, small fish, and squid. Roughhead grenadier are a slow-growing and late-maturing fish species with a long life cycle. The species matures on average at 15 years of age. Spawning may occur within the southern Grand Banks during the winter and early spring, although it is possible that the species spawns year round. Females lay over 25,000 pelagic eggs over a lengthy spawning period
Shortfin mako	*Isurus oxyrinchus*	Not Listed	Threatened	Moderate	This species migrates into Canadian waters following food stocks generally in the later summer and early fall, where they are associated with the warm waters of the Gulf Stream. Shortfin makos inhabit similar water as the blue sharks including the Scotian Shelf edge and slope, as well as the banks and basins within the Study Area.

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Smooth skate (Laurentian-Scotian population)	*Malacoraja senta*	Not Listed	Special Concern	High	The smooth skate can be found from the Grand Banks to South Carolina. In Canadian waters It is common from the Grand Banks along the Scotian Shelf and into the Gulf of Maine area. The species is commonly found at depths ranging from 70 to 480 m, up to depths of 1400 m at temperatures ranging from -1.3 to 15.7 °C. Smooth skates prefer soft mud bottom substrate consisting of silts and clay, but they have also been found on sand, shell hash, gravel and pebble substrates. Smooth skates primarily feed on small crustaceans, and will eat fish once they reach later (largest) stages of their life. The smooth skate is a slow-growing, late-maturing and long-lived species that are capable of spawning year-round with no known observed peak in spawning rates. Females mature at an average age of 11 years. Females will lay an egg-capsule on the benthic substrate. A young, juvenile is developed in the egg capsule in 1-2 years before hatching.
Spiny dogfish (Atlantic population)	*Squalus acanthias*	Not Listed	Special Concern	High	Commonly found from the intertidal zone to the continental slope in water depths up to 730 m. Most abundant between Nova Scotia and Cape Hatteras. Highest concentration in Canadian waters is along the Scotian Shelf. The species follows a general seasonal migration pattern between inshore waters during the summer-fall and offshore waters during the winter-spring. Females mature at 15 years and mating occurs during the spring. After a gestation period of 18- 24 months an average of six pups are born which are approximately 25 cm in length (COSEWIC 2010b). Both mating and pupping is believed to occur along the edge of the Scotian Shelf in the spring

Table 3.17 Fish Species of Special Status Potentially Occurring in the Study Area

Common Name	Scientific Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential for Occurrence in the Study Area	Life History Characteristics
Thorny skate	*Amblyraja radiata*	Not Listed	Special Concern	Low to Moderate	Population is common throughout the North Atlantic and is concentrated on the Grand Banks with some occurrence on the Scotian Shelf On the Scotian Shelf the species has the highest concentrations on the Eastern Banks as well as the lower Bay of Fundy. The species can be found in depths ranging from 20-1400 m on substrates including sand, shell hash, gravel, pebbles, and soft muds. They are a slow growing species with maturity being reached at an age of 11 years. It is believed that peak spawning occurs in the fall and winter months.
White hake	*Urophycis tenuis*	Not Listed	Special	Moderate	White hake can be found on the continental slopes, ranging from southern Labrador and the Grand banks to the Gulf of Maine. Within the Study Area, white hake can be found in the LaHave and Emerald Basins as well as along the Shelf edge including Georges Bank. Maturity is reached from two to five years of age. Spawning occurs during the summer months.
Winter skate (Georges Bank-Western Scotian Shelf-Bay of Fundy population)	*Leucoraja ocellata*	Not Listed	Special	High	High concentrations have been found on Georges Bank and the offshore banks of the Scotian Shelf. Non-migratory spawning has been observed in the fall. Eggs / larvae may be present up to 22 months after spawning and are attached to the seafloor.

Source: Scott and Scott 1988; Campana *et al*. 2003; Maguire and Lester 2012; COSEWIC 2006a, 2006b; COSEWIC 2007; COSEWIC 2008; COSEWIC 2009a, 2009b, 2009f; COSEWIC 2010a, 2010b, 2010c, 2010d; COSEWIC 2011a; COSEWIC 2012a, 2012b, 2012c, 2012d; DFO 2006a; DFO 2011a; DFO 2012a; DFO 2013a, 2013c, 2013l, 2013m, 2013n , 2013k, 2013o, 2013p; NOAA 2013m; SARA 2012; SARA 2013a, 2013b

3.2.6 Marine Mammals and Sea Turtles

There are three groups of marine mammals that have the potential to inhabit the Study Area: the mysticetes (toothless/baleen whales), odontocetes (toothed whales), and pinnipeds (seals). In 2007, a large scale aerial survey of marine megafauna was conducted in the Northwest Atlantic (DFO 2011b). During this survey, 20 species of cetaceans were identified on the Scotian Shelf. Common dolphins were the most prevalent species, followed by pilot whales and white-sided dolphins.

Figures 3.11, 3.15 and 3.17 have been prepared by DFO's Oceans and Coastal Management Division, presenting marine mammal and sea turtle sightings data collected between 1966 and 2012. It should be noted that these data have been collected from various sources over the years, including sightings from fishing and whaling in the 1960s and 1970s and more recently from observer programs on fishing vessels. The database also includes data from scientific expeditions by DFO, non-government organizations, and Dalhousie University research teams. Much of the data were collected on an opportunistic basis from vessels in the area, with survey effort not consistent across the Study Area (*e.g.*, lack of sightings does not necessarily represent lack of species presence in a particular area) (DFO, pers. comm. 2013).

3.2.6.1 Mysticetes and Odontocetes

Table 3.18 lists cetacean species known to inhabit the Study Area. Special designations by SARA and/or COSEWIC are included as applicable. Six species of mysticetes (baleen whales) have been reported to occur in the Study Area, predominantly in the summer and fall months, although some have been sighted year-round on the Scotian Shelf (refer to Table 3.18). Critical habitat for the endangered North Atlantic right whale has been identified in Roseway Basin within the Phase 3A Study Area (refer to Section 3.2.7). Figure 3.11 presents the distribution of baleen whale sightings over the Western Scotian Shelf and Slope between 1966 to 2012. Recorded sightings for the North Atlantic right whale, fin whale, blue whale, and humpback whale are presented in Figures 3.12 to 3.15.

Odontocetes includes toothed whales, dolphins and porpoises, all of which occur in the Study Area, particularly along the Shelf Break (refer to Figure 3.16). Critical habitat for the endangered Northern bottlenose whale has been designated in the Gully and Shortland and Haldimand Canyons east of the Study Area, although there have been sightings along the Shelf Break and within Dawson and Verrill Canyons in the Study Area. Recorded sightings for the Northern bottlenose whale and dolphins in the Study Area are shown in Figures 3.17 and 3.18.

These data do not include sightings recorded during the Shelburne Basin 3D seismic survey conducted by Shell Canada Limited between June and August 2013. These data were reported on a weekly basis and posted to the CNSOPB website. A summary of these observations is provided in Figure 3.19, illustrating the overwhelming majority of observations to be dolphin sightings.

Table 3.18 Marine Mammals Known to Occur within the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Mysticetes (Toothless or Baleen Whales)					
Blue whale (Atlantic population)	*Balaenoptera musculus*	Schedule 1, Endangered	Endangered	Low	Has a large range, including along the Scotian Shelf but a low population density. Forages for krill in both coastal and offshore waters, especially in areas of upwelling such as the continental shelf during spring, summer and fall. Found in small migrant herds and surface every 5 to 15 minutes for breathing. On the Scotian Shelf, they can be found from May to October in areas of high primary productivity. Within the Study Area, the species has been more commonly sighted on Sambro, Emerald and Western Banks. They have also been sighted along the Slope and between Roseway Bank and Basin. Blue whales were sighted regularly by whalers on the Scotian Shelf from 1966-1969, although they have been rarely sighted since.
Fin whale (Atlantic Population)	*Balaenoptera physalus*	Schedule 1, Special Concern	Special Concern	High	Concentrated in the northwest Atlantic region during summer months (but seen year round) for feeding, with a high concentration on the Scotian Shelf. The most commonly sighted whale species along the Scotian Shelf. Calving occurs in winter, in lower latitudes. Within the Study Area they can commonly sighted throughout the Scotian Shelf between Western and Roseway Banks and on the Scotian Slope. The estimated population size for the western North Atlantic fin whale stock is 3,985 individuals based on surveys conducted in 2006 and 2007.

Table 3.18 Marine Mammals Known to Occur within the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Humpback whale (Western North Atlantic population)	*Megaptera novaeangliae*	Schedule 3, Special Concern	Not at Risk	Moderate to High	Humpback whales are common in the summer and can be sighted from the Gulf of Mexico to southeastern Labrador. Most sightings occur in coastal waters. Humpback whales undergo extensive seasonal migrations and have a number of distinct feeding aggregations. Newfoundland and Gulf of Maine subpopulations migrate to the Scotian Shelf and Slope during the summer months to forage. One feeding aggregation occurs in the Georges Bank and Gulf of Maine region. Few have been sighted within the area during the winter. The estimated North Atlantic population (including Gulf of Maine and Scotian Shelf stocks) is 7,698 based on genetic tagging data.
Minke whale	*Balaenoptera acutorostrata*	Not Listed	Not at Risk	Moderate	The minke whale can be found from the Davis Strait in the north to the Gulf of Mexico. Minke whales can be found in the Study Area during the spring and summer.

Table 3.18 Marine Mammals Known to Occur within the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
North Atlantic right whale	*Eubalaena glacialis*	Schedule 1, Endangered	Endangered	Moderate to High	Species range is along the Atlantic coast from the southeastern U.S. to the Scotian Shelf, with the *Roseway Basin Area to be Avoided* (also SARA designated Critical Habitat) located on the southwestern Scotian Shelf. They are commonly found feeding and socializing from the western end of Sable Island bank to Browns Bank. They have also been sighted in Dawson and Verrill Canyons on the Scotian Slope. Migration patterns typically bring them to the waters of the Scotian Shelf from July to October. Primarily feeds on copepod and other zooplankton. The western North Atlantic minimum population size was estimated to be 396 individuals in 2007.
Sei whale	*Balaenoptera borealis*	Not Listed	Not Listed	High	In Atlantic Canadian waters sei whales can be found from Georges Bank in the south to Labrador in the north. During the summer and early autumn months, a large portion of the population can be found on the Scotian Shelf.
Odontocetes (Toothed Whales)					
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Not Listed	Not at Risk	Moderate	Atlantic white-sided dolphins are distributed throughout the continental shelf and slope areas of the North Atlantic. Atlantic white-sided dolphins prefer depths of less than 100 m and are spotted most often during the summer and early autumn months on the Scotian Shelf.

Table 3.18 Marine Mammals Known to Occur within the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Harbour porpoise (Northwest Atlantic population)	*Phocoena phocoena*	Schedule 2, Threatened	Special Concern	Moderate	Harbour porpoises are widely distributed over the continental shelves of the northern hemisphere and are generally found within 250 km of shore. They are an occasional visitor to the shallow banks of the Scotian Shelf, although they are rarely sighted. . The estimated population size of harbour porpoises in the Gulf of Maine/Bay of Fundy region is 89,054 based on 2006 surveys conducted in the region.
Killer whale	*Orcinus orca*	Under Consideration	Special Concern	Low to Moderate	Occasional visitor to the area, although rarely seen.
Long-finned pilot whale	*Globicephala melas*	Not Listed	Not at Risk	High	Long-finned pilot whales can be found on the Scotian Shelf and Slope year round. The species can be found frequenting coastal waters of Cape Breton during the summer months, and moving further offshore during the winter.
Northern bottlenose whale (Scotian Shelf Population)	*Hyperoodon ampullatus*	Schedule 1, Endangered	Endangered	Moderate	The Scotian Shelf population is concentrated around the Gully, Shortland and Haldimand Canyons (all designated Critical Habitat under SARA), just east of the Study Area. Within the Study Area, there have been sightings primarily along the Shelf Break, including at Dawson and Verrill Canyons and into deeper waters off the Slope. Non-migratory with mating and calving occurring in August. Known to be extremely curious and will investigate vessels or equipment.

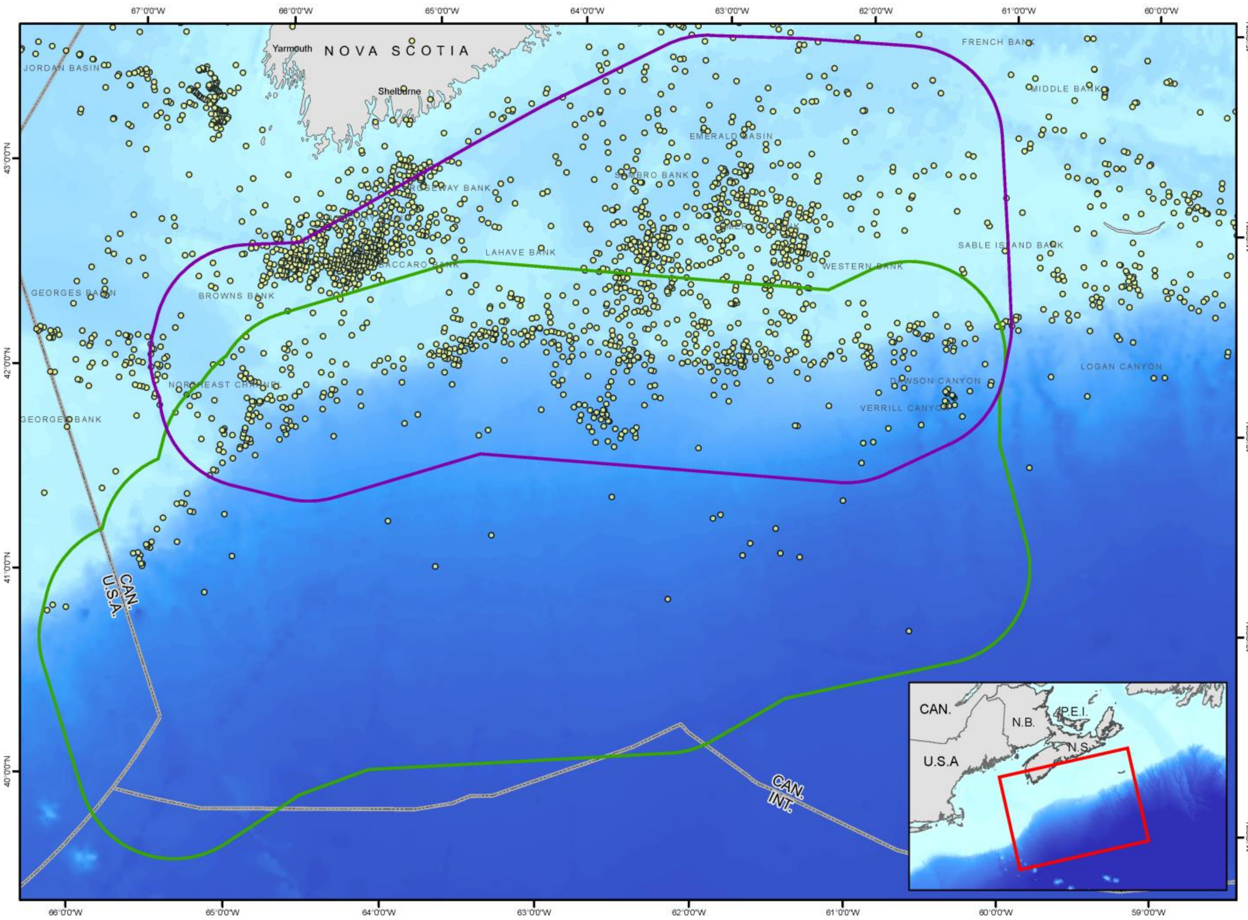
Table 3.18 Marine Mammals Known to Occur within the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Sowerby's beaked whale	*Mesoplodon bidens*	Schedule 1, Special Concern	Not Listed	Low to Moderate	Only found in the North Atlantic with some known occurrence along the Scotian Shelf but not often sighted; have been seen in the Gully MPA. In recent years, sightings have significantly increased in the Gully, Shortland, and Haldimand Canyons, east of the Study Area. There have been sightings within the Study Area along the shelf edge. Habitat tends to concentrate around shelf edges and slopes.
Short-beaked common dolphin	*Delphinus delphis*	Not Listed	Not at Risk	High	The common dolphin may be one of the most widely distributed cetacean species, inhabiting tropical, sub-tropical, and temperate areas. The species can be found on the Scotian Shelf during the summer and autumn months once water temperatures increase above 11°C.
Sperm whale	*Physeter macrocephalus*	Not Listed	Not at Risk	High	The sperm whale can be found along the Scotian Shelf edge and may be more common in the submarine canyons of the shelf, as it is regularly seen in the Gully. Sperm whales can also be found along the edge of the Laurentian Channel and can be commonly found in areas where water mixes to produce areas of high primary productivity. The sperm whale has been sighted more regularly on the eastern end of the Scotian Shelf at depths of 200 m – 1500 m.

Table 3.18 Marine Mammals Known to Occur within the Study Area

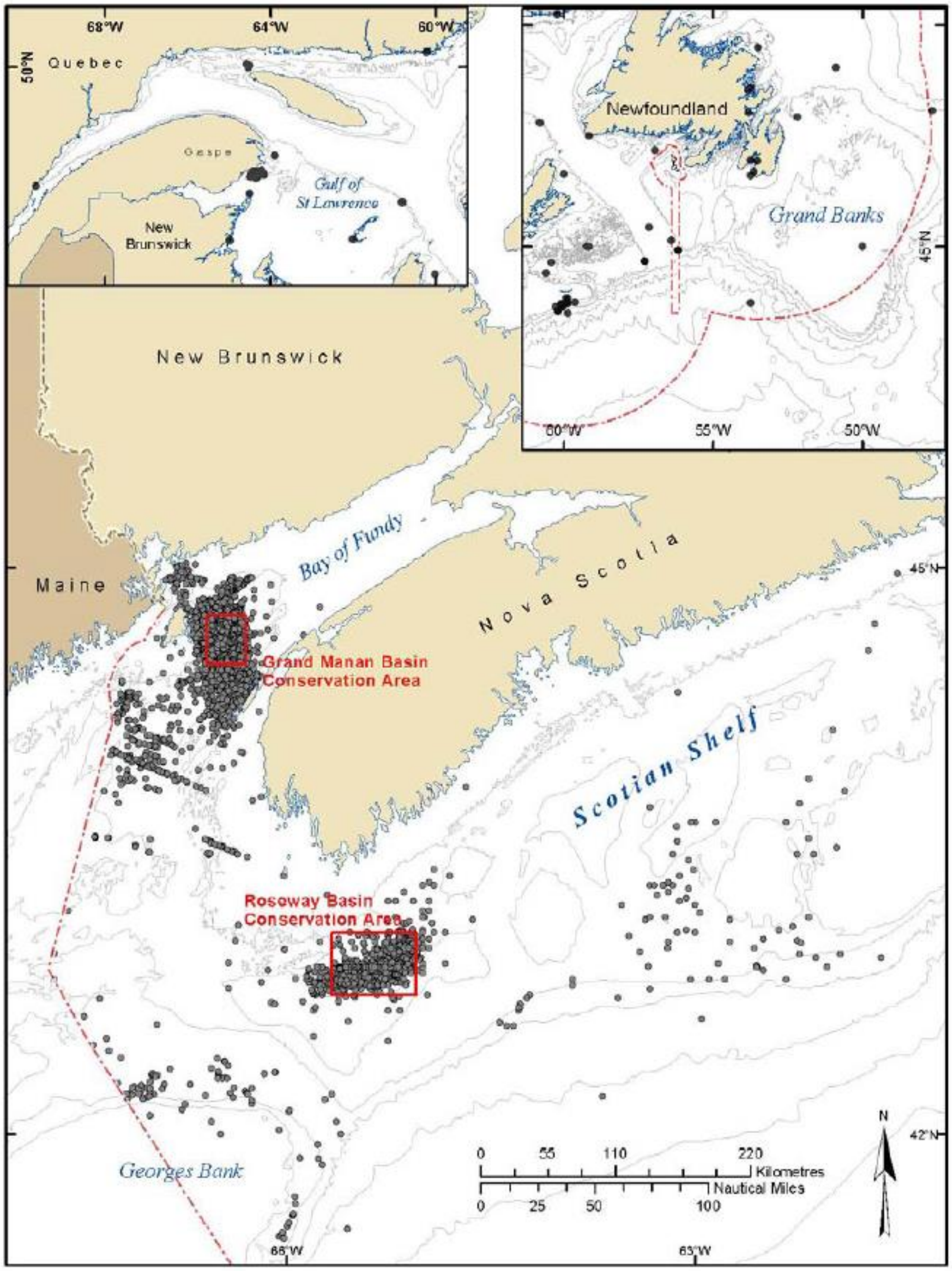
Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Striped dolphin	*Stenella coeruleoalba*	Not Listed	Not at Risk	High	The striped dolphin can be found from Cape Hatteras to the southern margin of Georges Bank and also offshore over the continental slope and rise in the mid-Atlantic regions. They prefer the warm waters found on the Shelf edge and are often seen in the Gully. Few striped dolphins have been sighted on the Scotian Shelf over the winter months.
White-beaked dolphin	*Lagenorhynchis albiorostris*	Not Listed	Not at Risk	Moderate	The species is a year-round resident of the area inhabiting waters from Cape Cod to Greenland.

Source: DFO 2011a, DFO 2011b, SARA 2012, DFO 2013c; Breeze *et al.* 2002; Waring *et al.* 2011



Source: DFO Marine Mammals Sightings Database

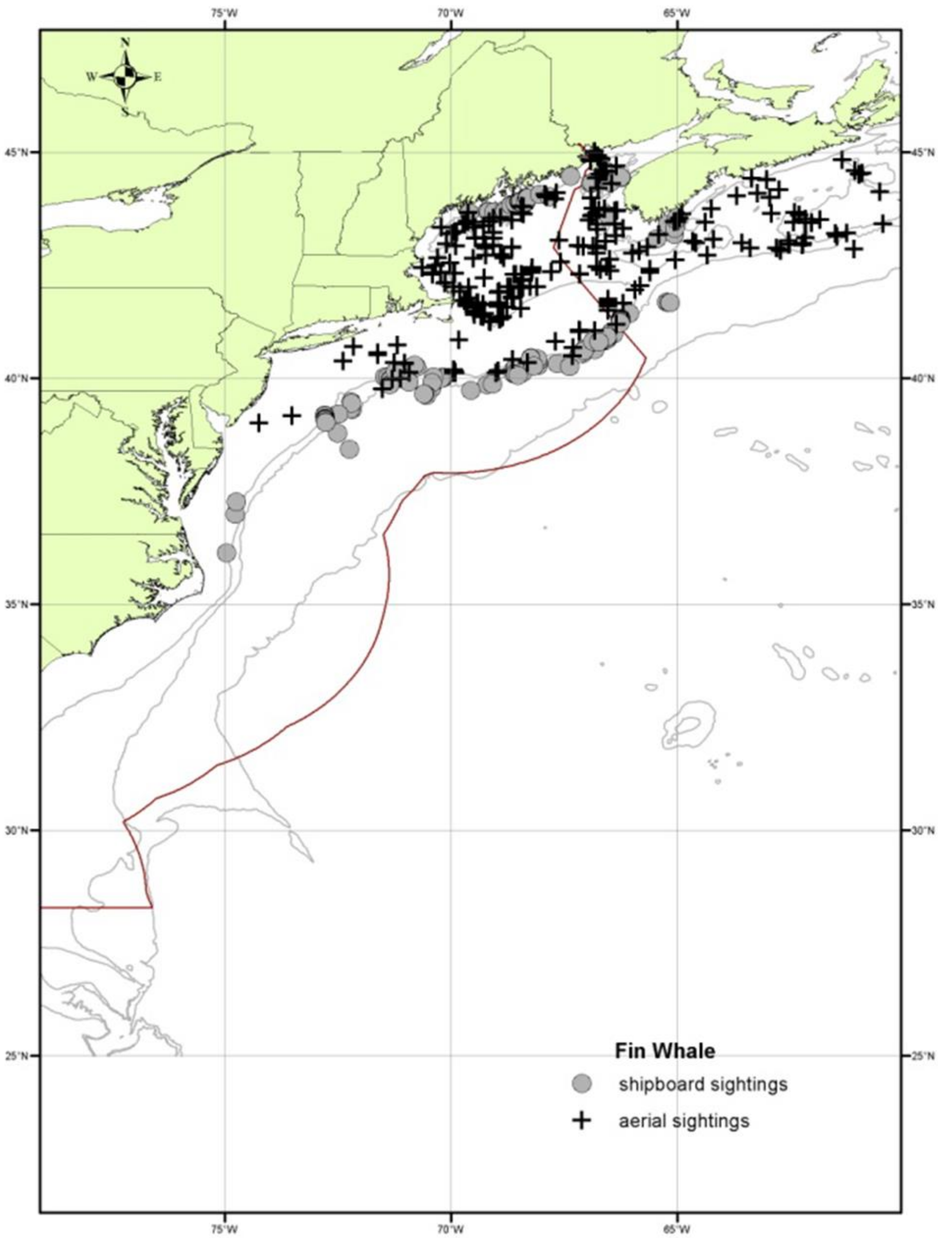
Figure 3.11 Baleen Whale Sightings (1966-2012) within Phase 3A (purple) and 3B (green) Study Areas



Source: Brown *et al.* 2009

Note: Data is based on individual sightings from the North Atlantic Right Whale Consortium 1951-2005, the St. Andrews Biological Station whale sightings database 1992-2005, and the DFO Newfoundland Region whale sighting database 1975-2003.

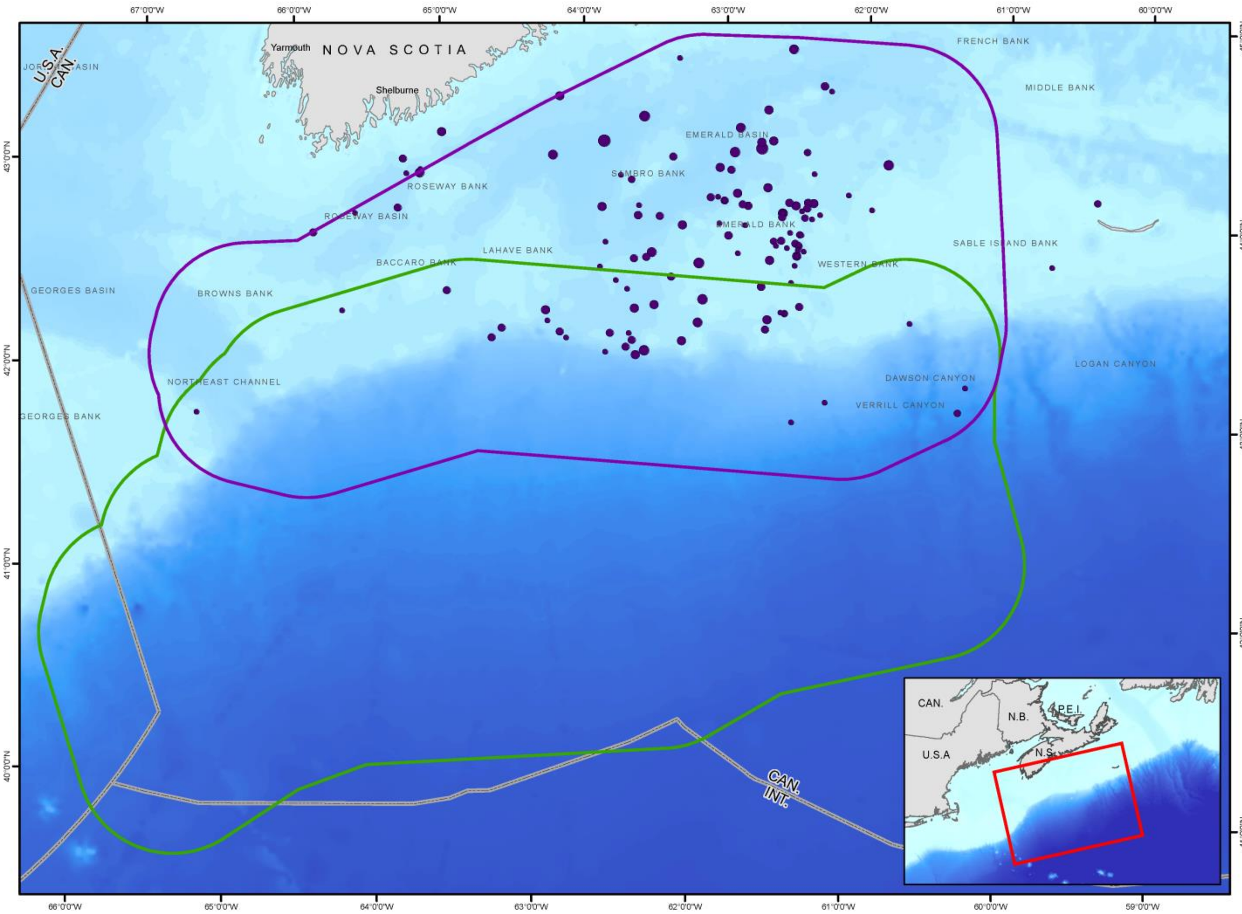
Figure 3.12 Canadian Range of the North Atlantic Right Whale



Source: NOAA 2013n

Note: Based on data collected during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011. Isobaths represent the 100, 1000, and 4000 m depth contours.

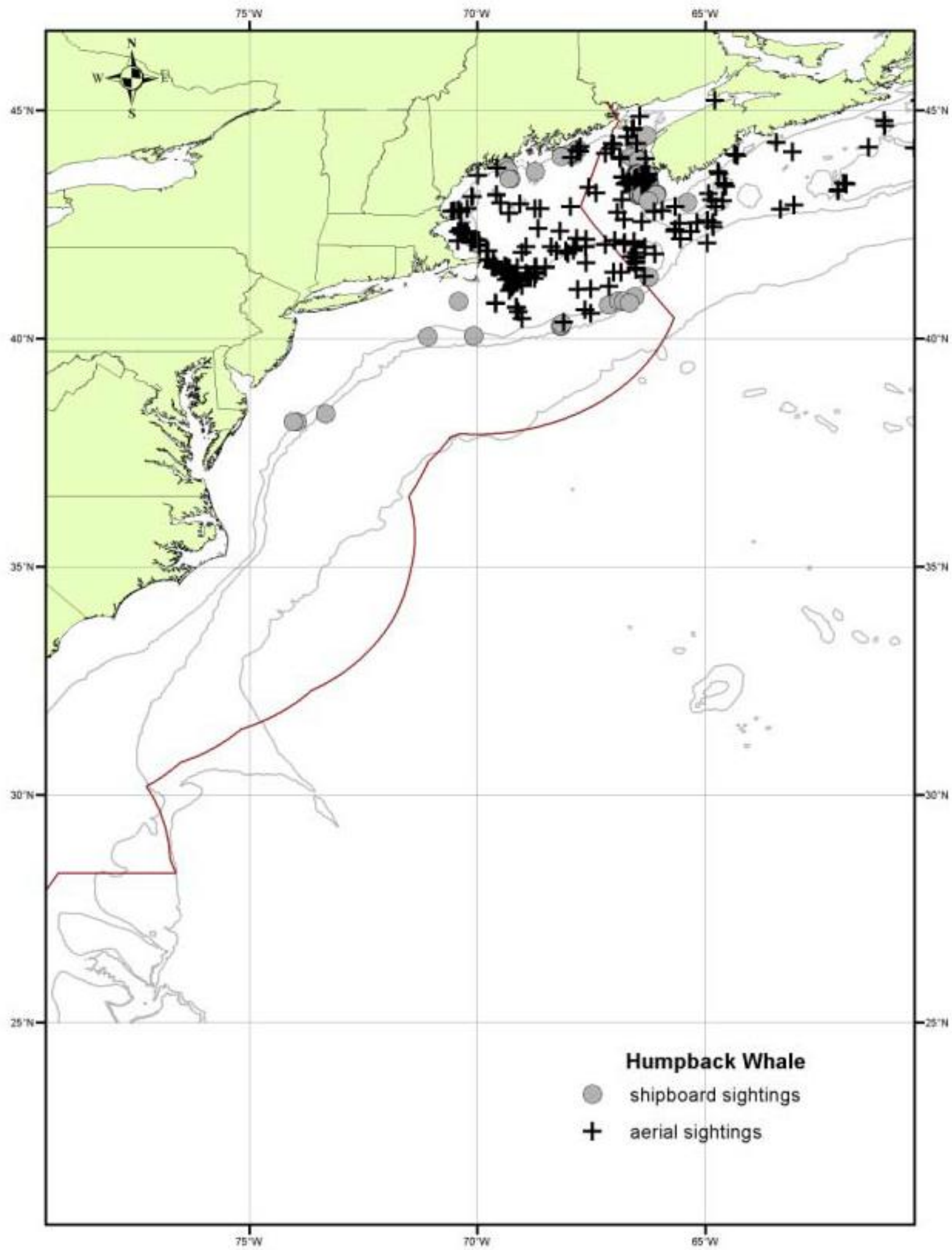
Figure 3.13 Distribution of Fin Whale Sightings from Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) Shipboard and Aerial Surveys



Source: DFO Marine Mammals Sightings Database

Note: Different sized symbols denote various counts with smallest symbol representing a few individuals (~2), medium symbol representing some individuals (~10), and largest symbol representing many individuals (~30).

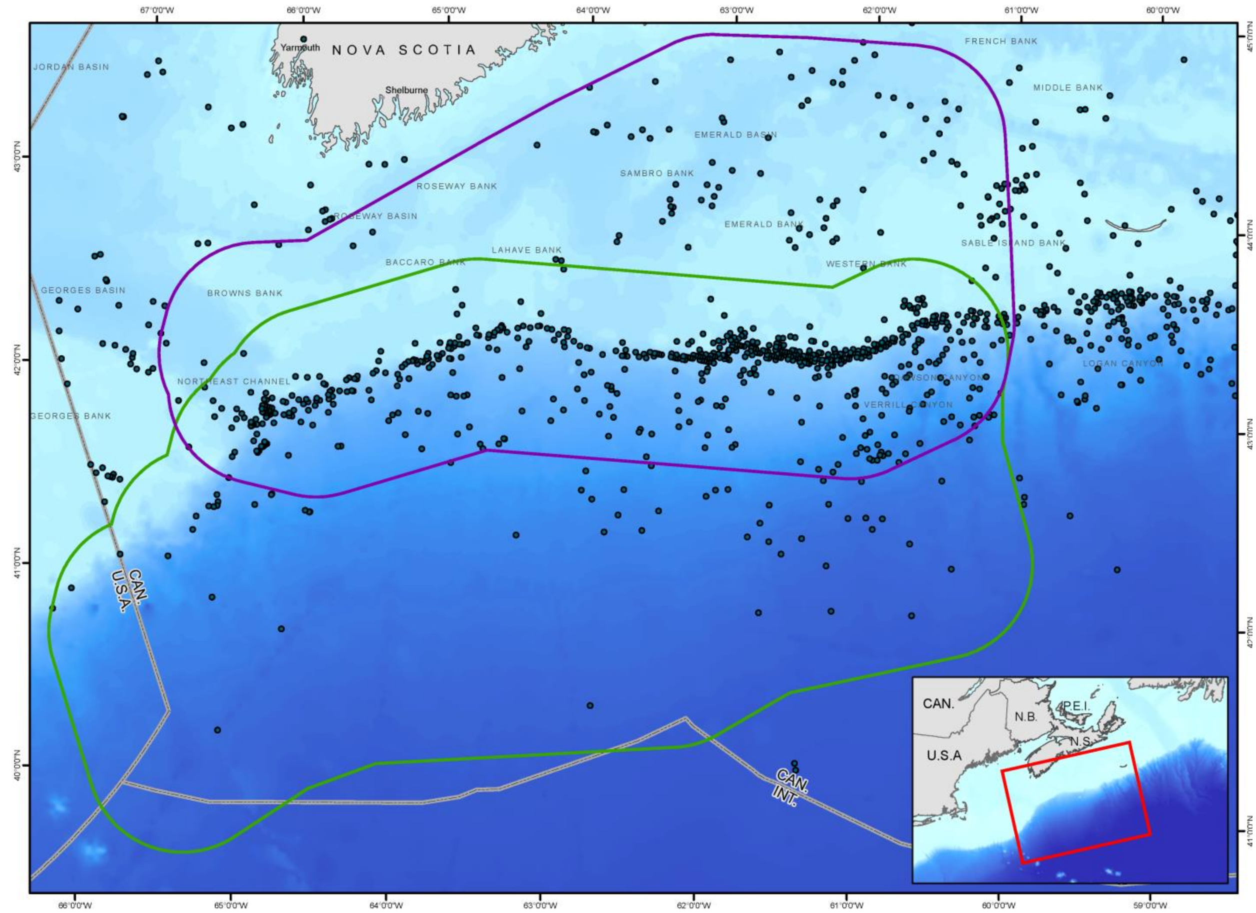
Figure 3.14 Blue Whale Sightings (1966-2012) in the Phase 3A (purple) and Phase 3B (green) Study Areas



Source: NOAA 2013n

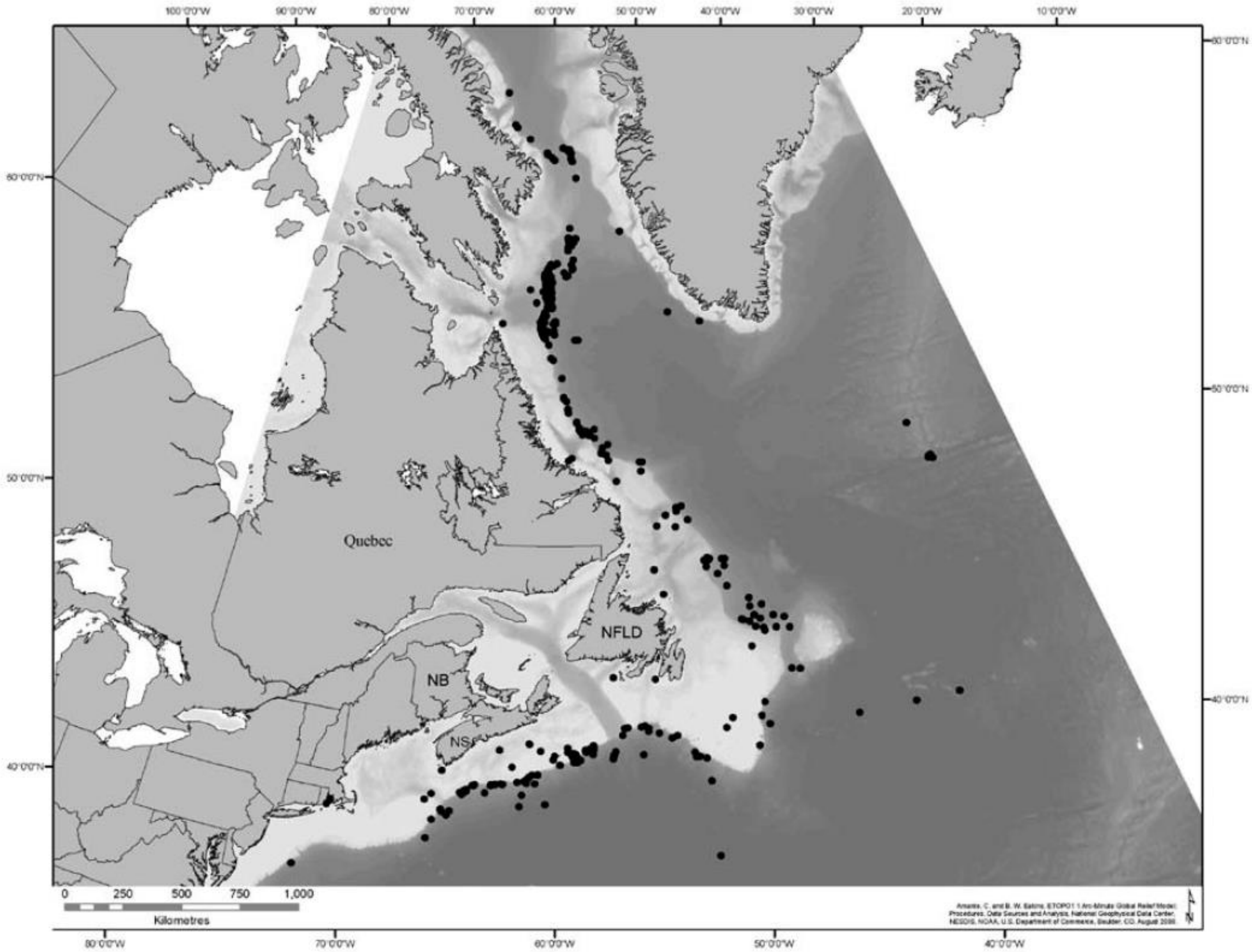
Note: Data collected during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011. Isobaths represent the 100, 1000, and 4000 m depth contours.

Figure 3.15 Distribution of Humpback Whale Sightings from NEFSC and SEFSC Shipboard and Aerial Surveys



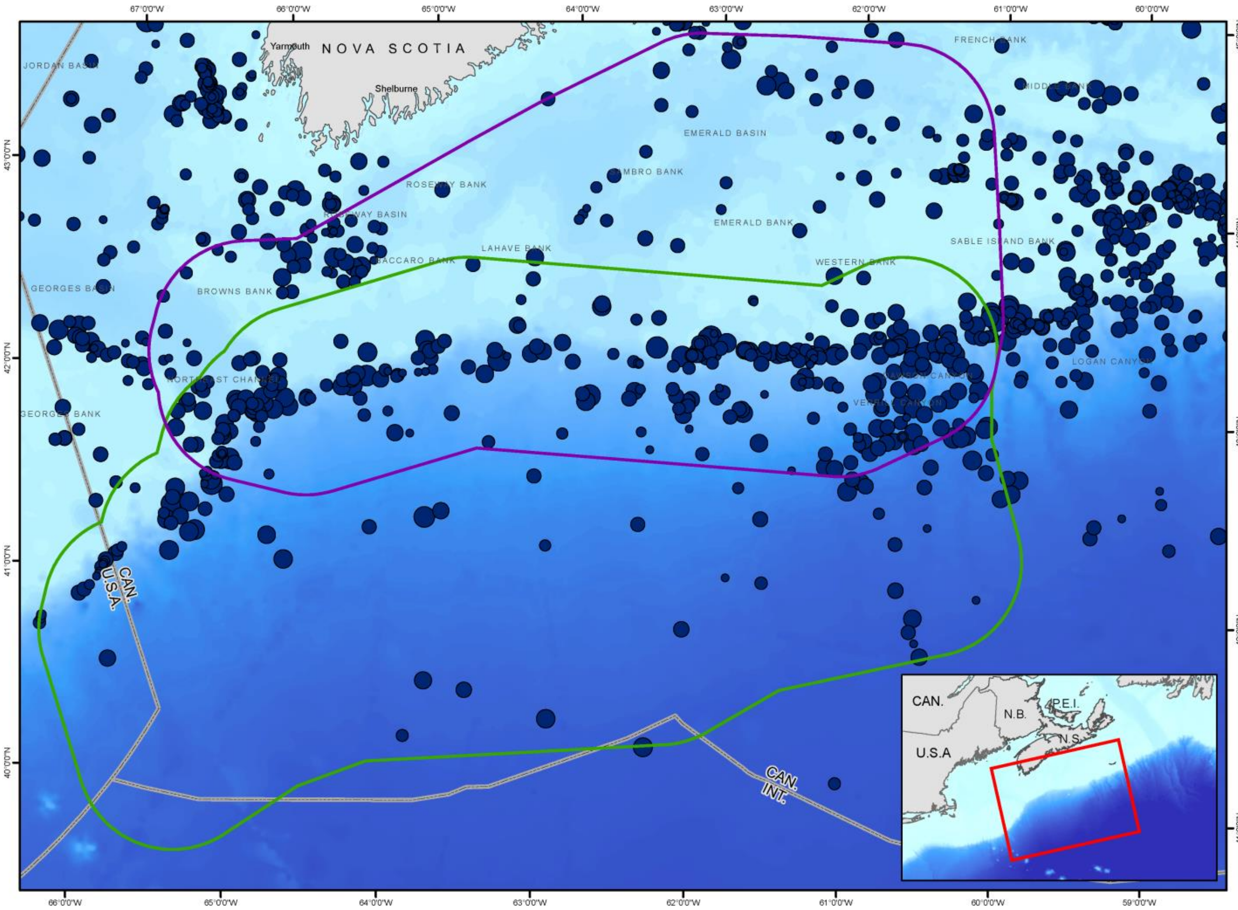
Source: DFO Marine Mammals Sightings Database

Figure 3.16 Toothed Whale Sightings (1966-2012) in the Phase 3A and Phase 3B Study Areas



Source: COSEWIC 2011b

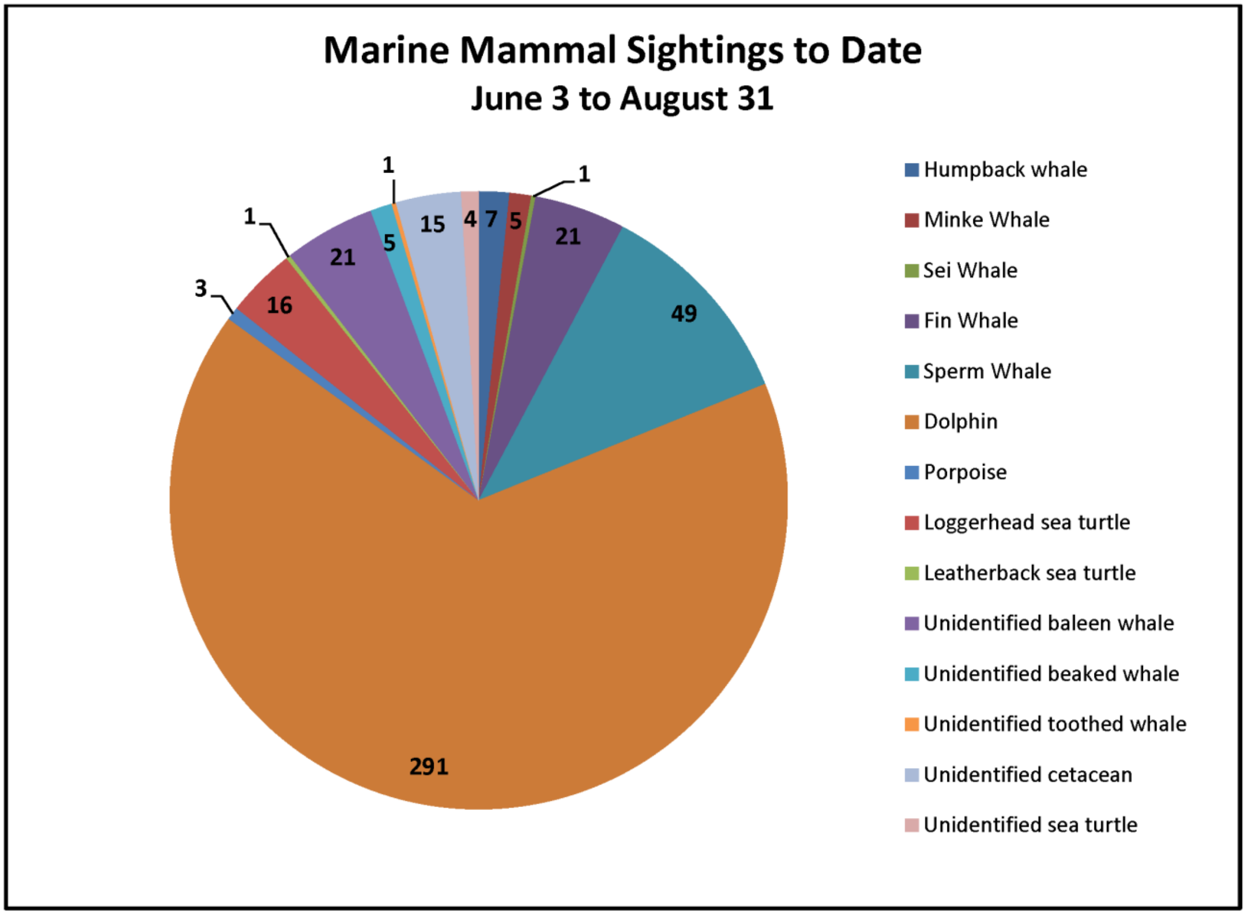
Figure 3.17 Sightings of Northern Bottlenose Whales off Canada and Adjacent Waters (n= 16,808) between 1867 and 2010



Source: DFO Marine Mammals Sightings Database

Note: Different sized symbols denote various counts with smallest symbol representing a few individuals (~2), medium symbol representing some individuals (~10), and largest symbol representing many individuals (~30).

Figure 3.18 Dolphin Sightings (1966-2012) in the Phase 3A (purple) and Phase 3B (green) Study Areas



Source: Shell Canada Limited 2013

Figure 3.19 Marine Mammal Sightings Reported during 2013 Shelburne Basin 3D Seismic Survey in ELs 2423, 2424, 2425, 2426, 2429 and 2430 (June 3-August 31, 2013)

3.2.6.2 Pinnipeds (Seals)

Sable Island is a significant area for seals on the Scotian Shelf. It is important for two breeding populations of seals, containing approximately 80% of the world's largest breeding population of grey seals, as well as a smaller population of harbour seals. Seals feed off Sable Island and in the Gully year-round (DFO 2011b). Table 3.19 lists pinniped species found within the Study Area. No seal populations within the Study Area are designated under SARA or by COSEWIC.

Table 3.19 Pinniped Species found within the Study Area

Common Name	Scientific Name	Potential Occurrence in Study Area
Grey seal	*Halichoerus grypus*	Largest world-wide breeding population, pupping on Sable Island mid-December to late January (approximately 62,054 pups in 2010). Smaller breeding colonies found on coastal islands along Southwest Nova Scotia at Flat, Mud, Noddy, and Round Islands (approximately 417 pups in 2010). Forages in Study Area year-round on a wide range of demersal and small pelagic fishes.
Harbour seal	*Phoca vitulina*	Breeding population uses Sable Island for pupping mid-May to mid-June and forages in the Study Area year-round. Expected that Sable Island may become a non-breeding site for harbour seals owing in part to competition with an increasing grey seal population.
Harp seal	*Pagophilus groendlandica*	Occasionally found foraging in Study Area, although generally not found in waters of the Scotian Shelf
Hooded seal	*Cystophora cristata*	Occasionally found foraging in Study Area, although generally not found in waters of the Scotian Shelf.
Ringed seal	*Phoca hipsida*	Occasionally found foraging in Study Area, although generally not found in waters of the Scotian Shelf.

Source: DFO 2011a, DFO 2011b, Bowen *et al.* 2011; Worcester and Parker 2010

3.2.6.3 Sea Turtles

There are four species of sea turtles that can be found migrating and foraging within the Study Area (Table 3.20), although only the endangered leatherback turtle and the loggerhead turtle are known to regularly forage in Atlantic Canada waters. DFO is currently in the process of using satellite tracking data to define important habitat for leatherback turtles in Atlantic Canada. The information generated by this exercise will be used to propose critical habitat for designation under SARA (DFO 2011d).

Table 3.20 Sea Turtle Species Known to Occur in the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Leatherback sea turtle	*Dermochelys coriacea*	Schedule 1, Endangered	Endangered	High	The leatherback sea turtle is the most widely distributed and largest of all marine turtles. Data comprised of satellite tracking studies as well as sighting information indicate that the species can be found in Atlantic Canadian waters from April to December. James *et al.* (2005) tagged 38 leatherback turtles from 1999 to 2003 with satellite tags and tracked their migration patterns. The Western Scotian Slope was noted as a high area of use for foraging by the species with the highest densities found from July to September. The distribution of the species generally shifts from the southwest shelf and slope to the northeast, as the foraging period progresses in the area. Additional areas where the species is found include: waters east and southeast of Georges Bank, the southeastern Gulf of St. Lawrence including Sydney bight, the Cabot Strait, Magdalen Shallows, waters adjacent to the Laurentian Channel, and waters south of the Burin Peninsula, Newfoundland. The species distribution in Canadian waters is believed to be primarily based on foraging habitat. The leatherback turtle forages on gelatinous zooplankton (primarily jellyfish consuming an average of 330kg/day). While foraging, they spend approximately two-thirds of their time in the top 6 m of the water column. Approximately 50% of day and evening hours are spent at the surface. Leatherback turtles begin a migration south in September and October, although they have been observed to be in the vicinity of Georges Bank as late as November/December. Leatherbacks found in Atlantic Canada originate from nesting beaches in the wider Caribbean, South and Central America, and Florida. The leatherback sea turtle may swim more than 10,000 km between nesting locations in the tropics and foraging areas in the north. One leatherback sea turtle was recorded during the marine mammal observation program for the Shelburne Basin 3D seismic survey on the Scotian Slope between June and August 2013.

Table 3.20 Sea Turtle Species Known to Occur in the Study Area

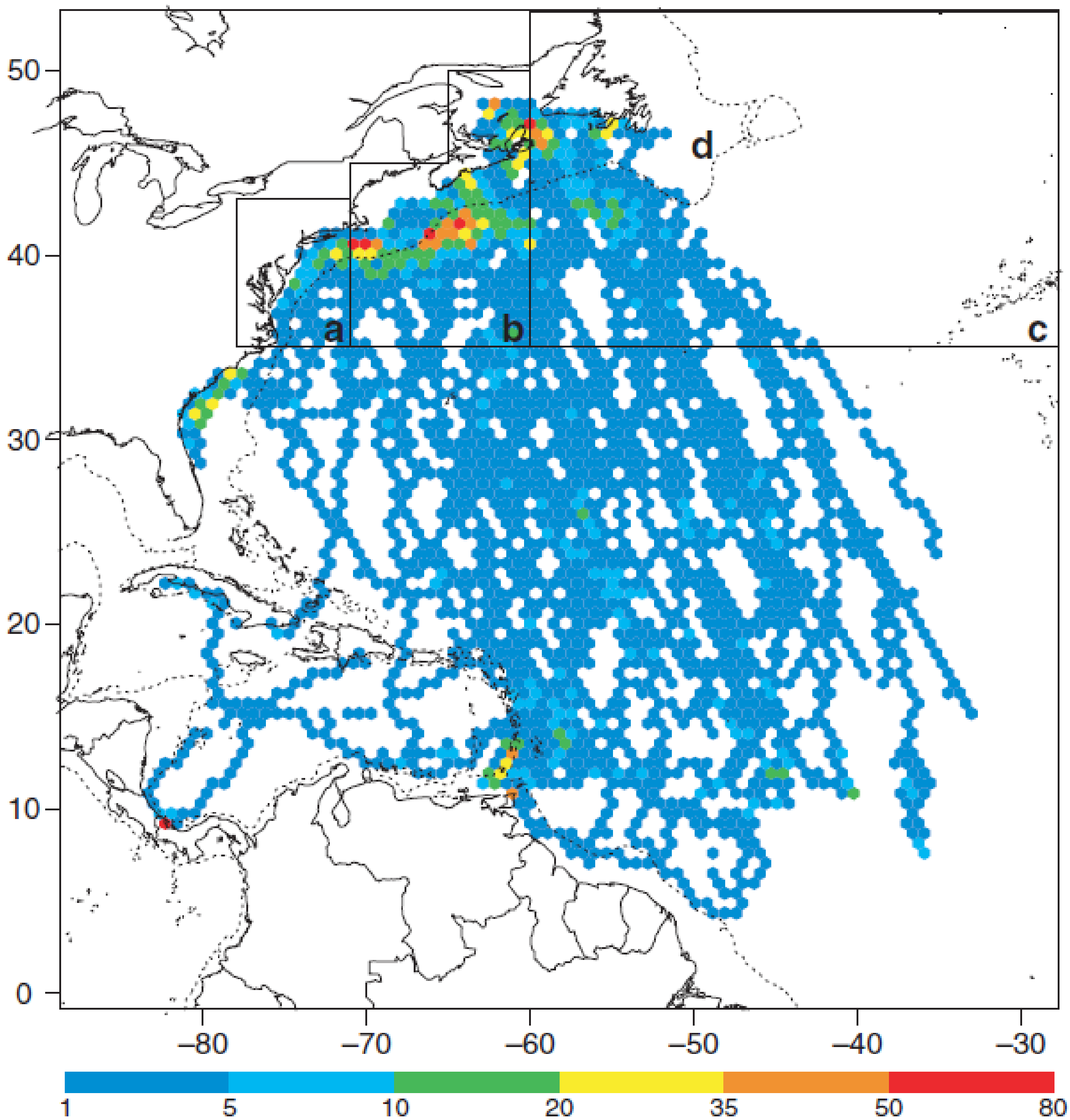
Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Loggerhead turtle	*Caretta caretta*	Not Listed	Endangered	High	Immature loggerhead turtles occur regularly at the edge of the Scotian Shelf and on the Slope and are routinely found foraging on the Scotian Shelf and Slope and Georges Bank in the Study Area. In general, loggerhead sea turtles make predictable migrations from southern breeding grounds in the Southern US (breeding as far north as Virginia), Caribbean, Gulf of Mexico, and South America to temperate foraging grounds in the Northern Atlantic. The largest breeding colony in North America is in Florida. Recent findings have determined that not all loggerhead turtles leave the area during the winter months. Telemetry data has shown that some turtles move east and northeast during the winter. Sixteen loggerhead turtles were observed during the Shelburne Basin 3D seismic survey on the Scotian Slope between June and August 2013.
Kemp's ridley turtle	*Lepidochelys kempii*	Not Listed	Not Listed	Low	Kemp's ridley turtle is the smallest of sea turtles. Occasionally seen in the waters of Nova Scotia, it is generally found further south. The Scotian Shelf is not a regular foraging area.

Table 3.20 Sea Turtle Species Known to Occur in the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Designation	Potential Occurrence in Study Area	Life History Characteristics
Green turtle	*Chelonia mydas*	Not Listed	Not Listed	Low	The green sea turtle is unique among sea turtles in that it is herbivorous, feeding on plants. Green sea turtles are widely distributed in tropical and sub-tropical waters between 30° North and 30° South. In the Western Atlantic they are found from the Gulf of Mexico to Massachusetts. The nesting season of the green sea turtle varies from location to location but females usually nest in the summer months from June to July on beaches throughout their southern range. A green turtle and green turtle—loggerhead hybrid recently documented in nearshore waters off Nova Scotia represent the most northerly confirmed records of green turtle in the Northwest Atlantic. There is some evidence that the green sea turtle occurs regularly on the Scotian Shelf seasonally.

Source: COSEWIC 2010e; COSEWIC 2012e; DFO 2011a, 2011d; DFO 2014; James *et al.* 2004; James *et al*. 2005; James *et al.* 2006; NOAA2013o, 2013p; Shell Canada Limited 2013

Figure 3.20 displays sea turtle habitat usage on the Scotian Shelf and Slope (James *et al.* 2005).



Source: James *et al.* 2005

Note: 38 leatherback sea turtles from 1999-2003 with an average observation period of 218 days. Colour denotes the number of day(s) each turtle was tracked in a particular polygon.

Figure 3.20 Spatial Use of 38 Leatherback Sea Turtles Tagged from 1999-2003

3.2.7 Marine Birds

The waters of the Scotian Shelf are known to be nutrient-rich because of the interaction of a variety of physical drivers (*e.g.*, see Section 3.1, Physical Characteristics) (Fifield *et al*. 2009). These physical drivers include major current systems, bathymetry, and temperature and salinity patterns; the resulting nutrient-rich waters support highly productive marine ecosystems, including the over 30 million seabirds known to utilize Eastern Canadian Waters each year (Fifield *et al.* 2009). The east coast of Canada supports large numbers of breeding marine birds as well as millions of migrating birds from the southern hemisphere and the northeastern Atlantic (Gjerdrum *et al.* 2008, 2012). The combination of northern hemisphere breeding birds and southern hemisphere migrants results in seabird diversity peaking in the spring (Fifield *et al.* 2009). During the fall and winter, significant numbers of over-wintering alcids, gulls, and Northern Fulmars (*Fulmarus glacialis*) use Eastern Canadian waters (Brown 1986). Marine birds are reliant upon land when they are raising their young, but the majority of their lives are spent in the marine environment.

Table 3.21 lists marine bird species found within the Study Area. Shorebirds known to be present on the Scotian Shelf and that could potentially be found in the Study Area are also included. Special designations by SARA and/or COSEWIC are included, as applicable.

Table 3.21 Marine Bird Species Which May Occur in the Study Area

Common Name	Species Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential Occurrence in Study Area
Pelagic Seabirds				
Northern Fulmar	*Fulmarus glacialis*	Not listed	Not at Risk	High potential for occurrence – Majority breeds in eastern Canadian Arctic. Found in deep cold waters, showing preference for shelf break habitats. Common in Study Area between January and March.
Great Shearwater	*Puffinus gravis*	Not listed	Not at Risk	High potential for occurrence – Breeds in South Atlantic and spends non-breeding season in the North Atlantic. Found in relatively high numbers between May and November.
Sooty Shearwater	*Puffinus griseus*	Not listed	Not at Risk	High potential for occurrence – Breeds in southern hemisphere and spends non-breeding season in the North Atlantic. Found in relatively high numbers between April and September.

Table 3.21 Marine Bird Species Which May Occur in the Study Area

Common Name	Species Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential Occurrence in Study Area
Cory's Shearwater	*Calonectris diomedea borealis*	Not listed	Not at Risk	High potential for occurrence – Breeds in the northeast Atlantic and are most common in August and into the fall.
Manx Shearwater	*Puffinus puffinus*	Not listed	Not at Risk	Moderate potential for occurrence – Breeds predominantly in the United Kingdom with small number breeding off southern Newfoundland. Observed in the Study Area during the summer.
Audubon's Shearwater	*Puffinus lherminieri*	Not listed	Not at Risk	Low potential for occurrence –Breeds in the Caribbean and has been sighted on Georges Bank on rare occasion.
Wilson's Storm-Petrel	*Oceanites oceanicus*	Not listed	Not at Risk	High potential for occurrence – Breeds in southern hemisphere and spends non-breeding season in North Atlantic. Observed in large flocks primarily between May and October.
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Not listed	Not at Risk	High potential for occurrence – Breeds in northern hemisphere (southern Labrador to Massachusetts). Species concentrates at fronts and eddies when feeding. Most abundant in Study Area between March and September.
Thick-Billed Murre	*Uria lomvia*	Not listed	Not at Risk	Moderate potential for occurrence – Breeds in southern Labrador, north shore of Gulf of St. Lawrence and in Newfoundland, with largest colonies in the High Arctic. Found mainly in continental shelf waters. Small numbers winter on Georges Bank (December through May).
Common Murre	*Uria aalge*	Not listed	Not at Risk	Moderate potential for occurrence – Most of Common Murres in Atlantic Canada breed in eastern Newfoundland. Observed in Study Area during winter
Dovekie	*Alle alle*	Not listed	Not at Risk	Moderate potential for occurrence – Breeds in Greenland and present in Study Area between October and March.

Table 3.21 Marine Bird Species Which May Occur in the Study Area

Common Name	Species Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential Occurrence in Study Area
Atlantic Puffin	*Fratercula arctica*	Not listed	Not at Risk	Low potential for occurrence – Breeds in North Atlantic. Widely dispersed offshore during the winter and only occasionally observed in the Study Area.
Razorbill	*Alca torda*	Not listed	Not at Risk	Low potential for occurrence – Breeds in boreal and low Arctic regions of the North Atlantic and may be observed in small numbers in the Study Area between January and May.
Northern Gannet	*Morus bassanus*	Not listed	Not at Risk	Moderate potential for occurrence – In North America, breeds in six colonies in Quebec and Newfoundland. Birds dispersed over shelf waters in the winter. May be present in the Study Area during migration between northern breeding colonies and wintering grounds in the south (March through May and October through December).
Black-legged Kittiwake	*Rissa tridactyla*	Not listed	Not at Risk	High potential for occurrence – Widely distributed, with largest breeding colonies in Atlantic Canada found in eastern Newfoundland and Gulf of St. Lawrence. Distributed offshore during migration, often along edge of sea ice, feeding over a variety of water depths. Most likely to occur in Study Area between October and April.
Neritic Seabirds				
Herring Gull	*Larus argentatus*	Not listed	Not at Risk	High potential for occurrence – In eastern North America, breeds along Atlantic coast from Baffin Island to Cape Hatteras. Most commonly observed close to land but also seen regularly offshore outside breeding season. Present in Study Area year-round.

Table 3.21 Marine Bird Species Which May Occur in the Study Area

Common Name	Species Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential Occurrence in Study Area
Great Black-backed Gull	*Larus marinus*	Not listed	Not at Risk	High potential for occurrence – Occur only in North Atlantic and breed from North Carolina to Hudson Strait. Most commonly observed close to land but also seen regularly offshore outside breeding season. Common in shelf waters in spring with significant proportion wintering on Georges Bank.
Common Tern	*Sterna hirundo*	Not Listed	Not at Risk	Moderate potential for occurrence - Breed at colonies in coastal Nova Scotia and along Gulf of Maine coast. May be present in Study Area during migration in May and September. Tend to occur closer to coastline.
Arctic Tern	*Sterna paradisaea*	Not Listed	Not at Risk	Low potential for occurrence – Breed at colonies in coastal Nova Scotia and along Gulf of Maine coast. May be present in Study Area during migration in May and September. Tend to occur closer to coastline.
Roseate Tern	*Sterna dougallii*	Endangered	Endangered	Low potential for occurrence – Primarily a coastal species. Small population breeds almost exclusively on a small number of islands off of Nova Scotia, Sable Island being one of them. Noted to be sensitive to increases in large shipping traffic and any possible beach activity on Sable Island.
Double-Crested Cormorant	*Phalacrocora x auritus*	Not listed	Not at Risk	Low potential for occurrence – Common along coast in summer, breeding in the western Gulf of St. Lawrence and on the Atlantic coast of mainland Nova Scotia.
Great Cormorant	*Phalacrocora x carbo*	Not listed	Not at Risk	Low potential for occurrence – Common resident in Nova Scotia, breeding in colonies on cliff ledges in Nova Scotia. Fall migration begins in September with a substantial portion of the population wintering off New England.

Table 3.21 Marine Bird Species Which May Occur in the Study Area

Common Name	Species Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential Occurrence in Study Area
Black Guillemot	*Cepphus grylle*	Not listed	Not at Risk	Low potential for occurrence – Common resident in Nova Scotia, breeding in coastal waters.
Waterfowl and Divers[a]				
Barrows Goldeneye	*Bucephala islandica*	Special Concern	Special Concern	Low potential for occurrence – A migratory duck that is largely concentrated in the Rocky Mountains with only a small portion of its population extending east to Atlantic Canada, wintering in coastal areas.
Harlequin Duck	*Histrionicus histrionicus*	Special Concern	Special Concern	Low potential for occurrence – Eastern population known to winter in Nova Scotia, along the coast with a preference for coastal islands.
Common Loon	*Gavia immer*	Not listed	Not at Risk	Low potential for occurrence – immature loons are known to frequent coastal waters year round and adults frequent coastal waters in the winter months.
Red-throated Loon	*Gavia stellata*	Not listed	Not at Risk	Low potential for occurrence – Common transient, breeding in arctic and winters along Atlantic coast
Shorebirds[b]				
Red Phalarope	*Phalaropus fulicaria*	Not listed	Not at Risk	High potential for occurrence – Breeds in circumpolar Arctic and migrates to winter in south temperate and subtropical/tropical waters. Generally found in Study Area feeding on the banks during fall and spring migration (particularly during northward migration in spring).
Red-necked Phalarope	*Phalaropus lobatus*	Not listed	Not at Risk	Moderate potential for occurrence – Occur on Georges Bank during spring and fall migration. Western Bay of Fundy was historically an important fall staging area although numbers have been declining.
Piping Plover (melodus subspecies)	*Charadrius melodus melodus*	Endangered	Endangered	Low potential for occurrence – Population inhabits sandy beach ecosystems throughout Atlantic Canada but is not known to inhabit Sable Island. Winters on the southern Atlantic coast of the U.S.

Table 3.21 Marine Bird Species Which May Occur in the Study Area

Common Name	Species Name	*SARA* Schedule 1 Status	COSEWIC Designation	Potential Occurrence in Study Area
Savannah Sparrow (Ipswich Sparrow)	*Passerculus sandwichensis princeps*	Special Concern	Special Concern	Moderate potential for occurrence – Population nests almost exclusively on Sable Island. Winters in the mid-Atlantic U.S. and therefore would migrate across Study Area.

Notes: [a] This is not intended to be an exhaustive list of waterfowl. A number of other waterfowl species could occur (*e.g.*, Common Eider, Black Scoter, White-winged Scoter, Surf Scoter, Long-tailed Duck), although interactions with the Study Area are expected to be low. Those listed in the Table above are species of special status that have a low potential for occurrence.

[b] This is not intended to be an exhaustive list of shorebirds. A number of other shorebird species could occur, although the Table above concentrates on shorebirds most likely to leave coastal waters and/or those which are species of special status that could occur in the Study Area.

Source: SARA 2012; DFO 2011a; LGL 2013; Brown 1986; Fifield *et al.* 1999; Gjerdrum *et al.* 2012

Data on pelagic seabird distribution on the east coast of Canada has been collected through various research programs for nearly 50 years. From 1965-1992, data on pelagic seabirds were collected under the Programme intégré de recherches sur les oiseaux pélagiques (PIROP). The PIROP program was designed to be implemented by professional biologists and interested volunteers and employed a simple survey protocol. A series of atlases were produced from these data to summarize pelagic seabird distribution in the northwest Atlantic (Fiefield *et al.* 2009; Gjerdrum *et al.* 2012). Although this program was discontinued in 1992, the PIROP data are still used in offshore environmental assessments (Gjerdrum *et al.* 2012).

Following the 2004 crude oil spill at the Terra Nova Floating Production, Storage and Offloading vessel on the northeastern Grand Banks and the subsequent identification of a lack of area-specific seabird abundance information, the Environmental Studies Research Fund (ESRF) funded a 3.5-year project to assess seabird abundance and distribution in multiple areas of oil industry activity in eastern Canada, including the Scotian Shelf. This resulted in the ESRF Offshore Seabird Monitoring Program (Fifield *et al.* 2009).

In 2005, the Canadian Wildlife Service (CWS) of Environment Canada reinstated the pelagic seabird monitoring program (Eastern Canadian Seabirds at Sea; ECSAS) with the intent to update information on the abundance, distribution and threats of seabirds occurring offshore, to minimize these threats, and increase awareness and support for seabird conservation (Gjerdrum *et al.* 2012). Although this program relies on ships of opportunity (in addition to DFO's AZMP surveys), it has adopted a more scientifically rigorous data collection protocol than the original PIROP program (Gjerdrum *et al.* 2012). Since 2005, almost 100,000 km of ocean track has been surveyd by CWS trained observers.

Fifield *et al*. (2009), which presents results from the Offshore Seabird Monitoring Program, identifies persistent seasonal and year-round hotspots of high seabird concentration and identifies nine groups of seabirds (Table 3.22) recognized as the most abundant within their study area (*i.e.*, Grand Banks, Scotian Shelf, Flemish Cap, Laurentian Channel, Gulf of Maine, Orphan Basin/Knoll and the Labrador Sea).

Table 3.22 Species Groupings for Fifield *et al*. (2009) Seabird Abundance and Distribution Analysis

Group	Common Name	Scientific Name
Northern Fulmar	Northern Fulmar	*Fulmarus glacialis*
Shearwaters	Greater Shearwater	*Puffinus gravis*
	Manx Shearwater	*Puffinus puffinus*
	Sooty Shearwater	*Puffinus griseus*
	Cory's Shearwater	*Calonectris diomedea*
	Audubon's Shearwater	*Puffinus therminieri*
	Unidentified Shearwater	-
Storm-Petrels	Wilson's Storm-Petrel	*Oceanites oceanicus*
	Leach's Storm-Petrel	*Oceanodromoa leucorhoa*
	Unidentified Storm-Petrel	-
Gannet	Northern Gannet	*Morus bassanus*
Gulls	Herring Gull	*Larus argentatus*
	Iceland Gull	*Larus glaucoides*
	Glaucous Gull	*Larus hyperboreus*
	Great Black-backed Gull	*Larus marinus*
	Lesser Black-backed Gull	*Larus fuscus*
Black-legged Kittiwake	Black-legged Kittiwake	*Rissa tridactyla*
Murres	Common Murre	*Uria aalge*
	Thick-billed Murre	*Uria lomvia*
	Unidentified Murre	*Uria sp.*
Dovekie	Dovekie	*Alle alle*
Other Alcids	Atlantic Puffin	*Fratercula arctica*
	Black Guillemot	*Cepphus grylle*
	Razorbill	*Alca torda*
	Unidentified Alcid	-

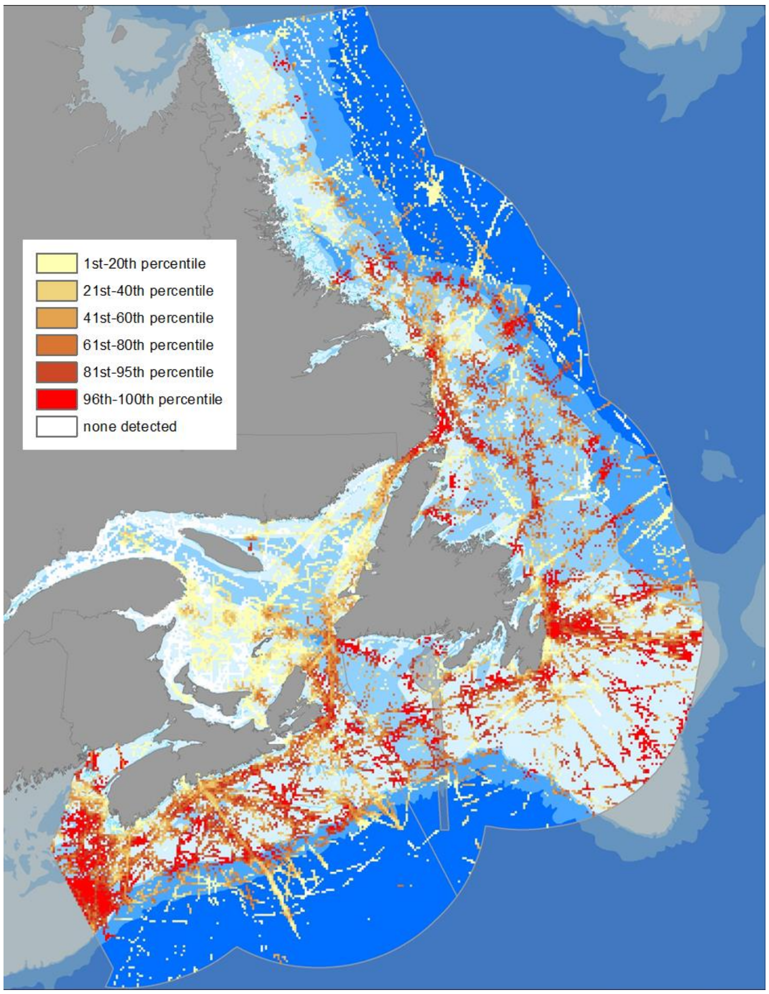
Through their surveying and analysis, Fifield *et al*. (2009) identified several geographical areas that they deemed to be important to one or more species/groups of seabirds in one or more seasons. The Scotian Shelf and Laurentian Channel were grouped and designated as one of the geographical areas recognized as important, using the absolute densities of seabirds reported by Fifield *et al*. (2009). Specifically, they determined this to be one of the more productive regions for seabirds in their study area.

Fulmars were abundant in the Scotian Shelf region throughout the year. Table 3.23 summarizes the seasonal abundances of the nine most abundant groups of seabirds in the area. During the spring season, high numbers of gulls, murres and gannets frequented the area (Fifield *et al.* 2009). The study team found that murres and gannets were joined by large numbers of storm-petrels and shearwaters in the summer. Storm-petrels were particularly abundant on the western Scotian Shelf. Storm-petrels and shearwaters remained in the Scotian Shelf area into the fall season and were joined by gulls (Fifield *et al*. 2009). Fifield *et al*. 2009 observed that winter in this region brought large numbers of gulls, murres and other alcids. Table 3.23 is adapted from Fifield *et al*. (2009) and provides the seasonal weighted median (range in parenthesis) of 1° blocks surveyed of absolute densities (birds/km^2) by species group in the Scotian Shelf – Gulf of Maine ocean region. Individual 1° block density estimates were weighted by block survey effort to compute the overall regional weighted median. Only blocks having at least 25 km of survey effort were included (Fifield *et al*. 2009).

Table 3.23 Summary of Seasonal Abundances in the Scotian Shelf - Gulf of Maine Ocean Region (adapted from Fifield *et al*. 2009, Table 5).

Species	Season	Scotian Shelf - Gulf of Maine (Median Birds/Km^2)
All Waterbirds	Spring	7.92 (0.68 - 25.37)
	Summer	8.30 (1.73 - 148.56)
	Fall	4.23 (0.97 - 21.18)
	Winter	7.67 (4.39 - 29.44)
Northern Fulmars	Spring	0.75 (0 - 4.24)
	Summer	0.15 (0 - 1.64)
	Fall	0.30 (0 - 3.31)
	Winter	1.08 (0 - 12.37)
Shearwaters	Spring	0 (0 - 0.46)
	Summer	1.78 (0.29 - 84.02)
	Fall	2.20 (0 - 18.40)
	Winter	0 (0 - 3.74)
Storm-Petrels	Spring	0 (0 - 1.36)
	Summer	0.78 (0 - 12.74)
	Fall	0.02 (0 - 1.47)
	Winter	0 (0 - 0)
Northern Gannets	Spring	0.40 (0 - 1.03)
	Summer	0 (0 - 1.69)
	Fall	0.19 (0 - 2.83)
	Winter	0.04 (0 - 0.22)
Large Gulls	Spring	1.22 (0 - 21.33)
	Summer	0.08 (0 - 8.39)
	Fall	0.58 (0 - 2.86)
	Winter	0.62 (0 - 2.31)
Black-legged Kittiwakes	Spring	0.06 (0 - 3.74)
	Summer	0 (0 - 0.76)
	Fall	0.11 (0 - 1.39)
	Winter	1.96 (0 - 21.31)
Dovekies	Spring	0.71 (0 - 36.98)
	Summer	0 (0 - 2.68)
	Fall	0 (0 - 0.25)
	Winter	2.13 (0 - 10.93)
Murres	Spring	0.88 (0 - 4.37)
	Summer	0.06 (0 - 2.60)
	Fall	0 (0 - 0.14)
	Winter	0.61 (0 - 7.71)
Other Alcids	Spring	0.14 (0 - 1.53)
	Summer	0.04 (0 - 0.91)
	Fall	0.05 (0 - 0.65)
	Winter	0.37 (0 - 4.69)

The highest density in the entire study area at any time of year was recorded during the summer (May-August) in the Gulf of Maine. This was attributable to large aggregations of Great Shearwaters found there and in the western Scotian Shelf region. Figure 3.21 demonstrates extensive use of Canadian continental shelf areas by shearwaters, notably on George's Bank and within the Gulf of Maine, on the Scotian Shelf and on the Newfoundland and Labrador Shelves (C. Gjerdrum, CWS, pers. comm. 2012).



Source: CWS unpublished data (C. Gjerdrum, CWS, pers. comm. 2012)

Note: *Shearwater distribution map presenting relative linear densities of counts of all shearwater species, across all seasons, for Atlantic waters within Canada's EEZ. Estimates for each 5X5 km cell are classed within 20% quantiles, with the top quantile split to show the top 5% of estimates. Estimates are corrected according to the number of days cells were surveyed. No interpolation was applied to ascribe values to cells in which no surveys occurred. The latter cells are transparent, revealing the underlying bathymetry. It should be noted that this map highlights "hot-spots" or areas where large numbers of birds congregate. The pattern shown is strongly influenced by the most common species observed, and therefore under-represents less common species, including those of conservation concern. Areas that are not highlighted as hot-spots do not necessarily mean those areas are not also important habitats for birds.*

Figure 3.21 Shearwater Distribution Map

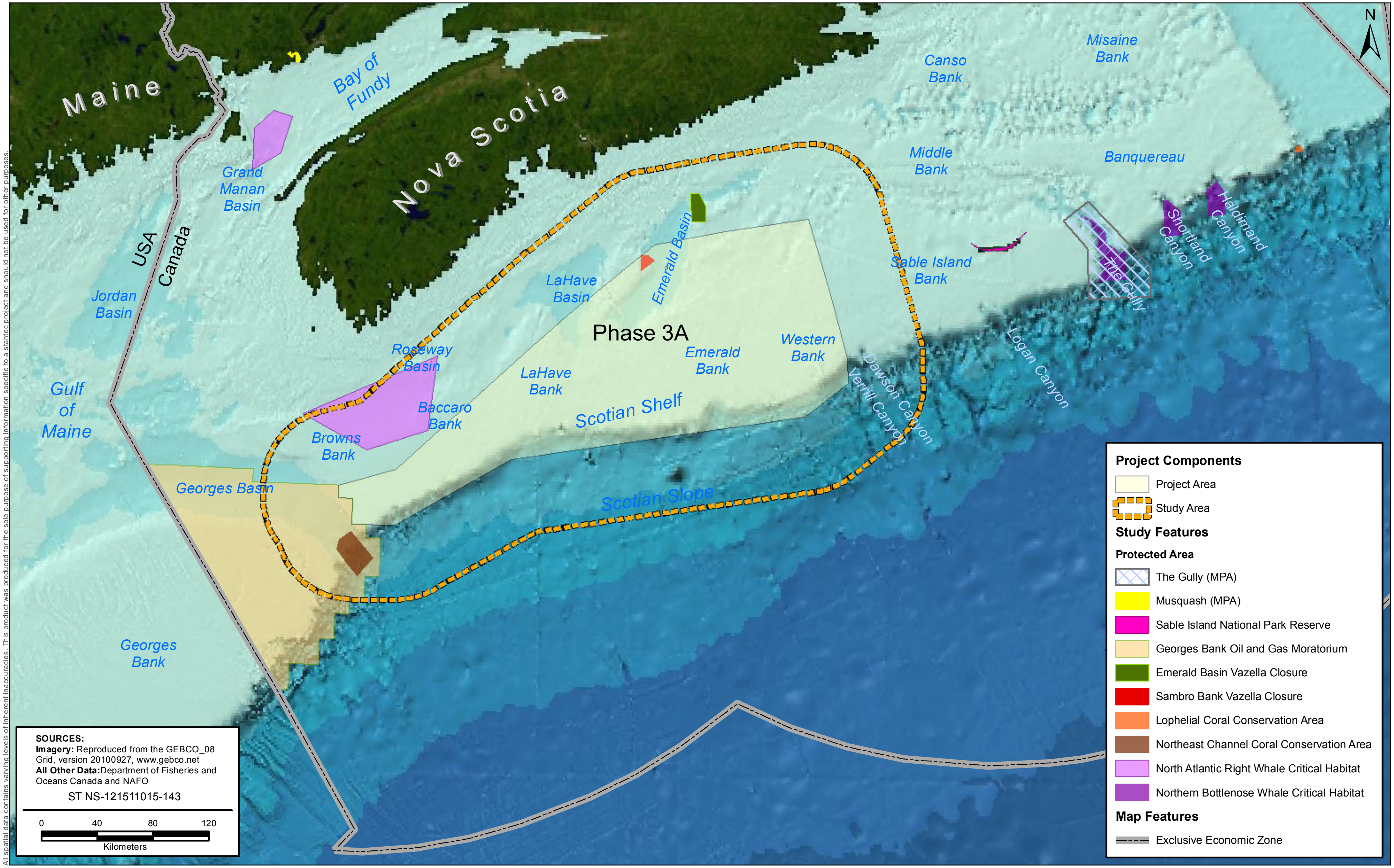
Of the bird species of Special Status that can occur offshore Nova Scotia, only one has a moderate potential for occurrence in the Study Area. The Savannah (Ipswich) Sparrow nests on Sable Island and could potentially occur in the Study Area as it migrates to its overwintering grounds in the mid-Atlantic US. Details on these two species, as well as other marine bird species of special status are included in Table 3.21.

3.2.8 Special Areas

Special Areas within the SEA Study Area include the North Atlantic Right Whale Area to be Avoided/Critical Habitat, the Northeast Channel Coral Conservation Area, the Haddock Box (fisheries closure), the Georges Bank Oil and Gas Moratorium Area, various fisheries closures (to protect fish stocks and benthic habitats), and Ecologically and Biologically Significant Areas (EBSAs). While fisheries closures may not have direct significance to oil and gas activities, they do generally indicate areas of importance for fish spawning and/or protection of juveniles, and therefore have been included for consideration.

Figures 3.22 and 3.23 depict designated Special Areas, including protected areas and fisheries conservation areas, and Figure 3.24 depicts EBSAs found not only within the Study Area but also the larger Scotian Shelf area. EBSAs have been identified based on a compilation of scientific expert opinion and traditional knowledge that was solicited through efforts to support integrated ecosystem-based management efforts on the Scotian Shelf (Doherty and Horsman 2007). Using the criteria of uniqueness, aggregation, fitness consequences, naturalness, and resilience, DFO experts identified EBSAs to address conservation objectives in accordance with the *Oceans Act* (Horsman *et al.* 2011). Although many EBSAs in the Study Area may not yet have official protection under the *Oceans Act*, they warrant consideration for conservation given the ecological and biological significance of the sites. Therefore, EBSAs are considered as Special Areas in the SEA process. The EBSAs as presented on Figure 3.24 are based on Doherty and Horsman (2007) but have been processed further and some EBSA features that overlap have been refined (hence some EBSAs have been combined); this remains an ongoing process as work on the network analysis continues. DFO (2012d) outlines DFO's ocean planning process and objectives and how updated criteria are being used to help build a bioregional network of marine protected areas on the Scotian Shelf.

Table 3.24 describes the designated Special Areas in the Study Area and Table 3.25 describes EBSAs in the Study Area. In some cases designations overlap (*e.g.*, Georges Bank has been declared a moratorium area based predominantly on its ecological significance, as indicated by other designated conservation and EBSAs in and around the Bank). Where this occurs, these designations are described separately in this section as illustrated in Figures 3.22 to 3.23, however they are consolidated in Section 5.2 in the assessment of potential environmental effects.



PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C. Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Special Areas - Protected Areas

FIGURE NO.: 3.22

DATE: Apr 21, 2014

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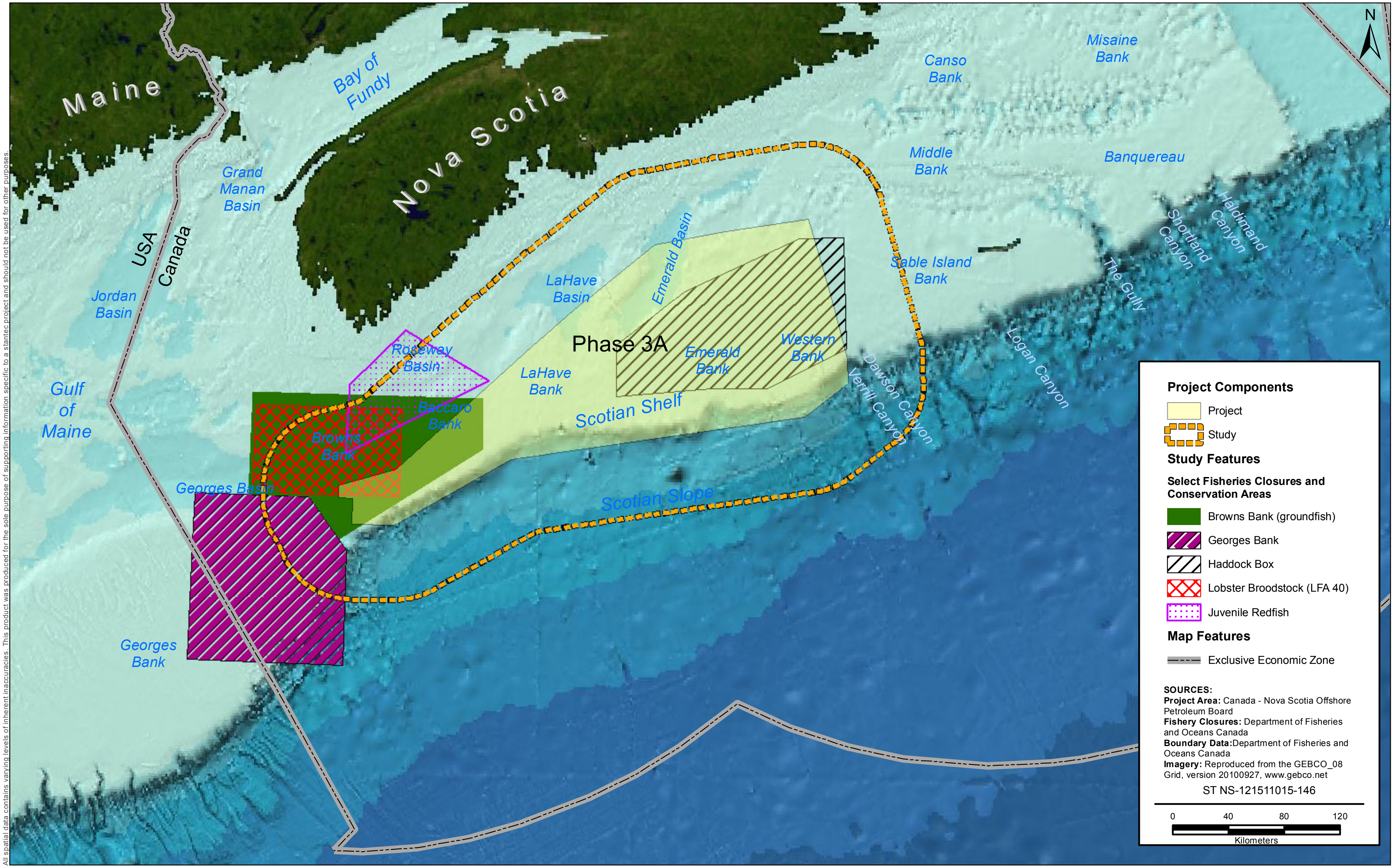

PREPARED BY: M. Huskins-Shupe

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CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Special Areas - Select Fisheries Closures and Conservation Areas

FIGURE NO.: 3.23

DATE: Apr 21, 2014

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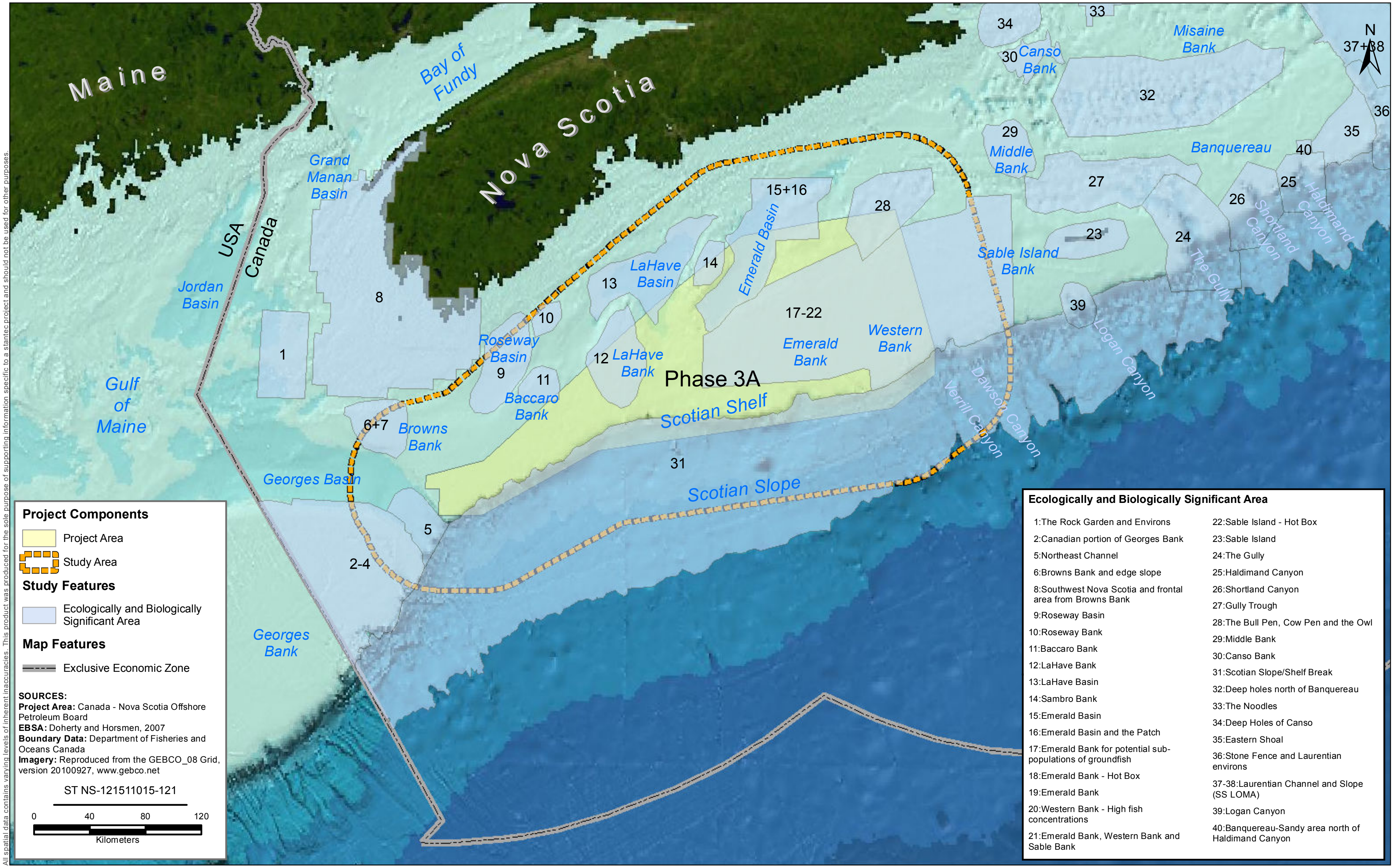

PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.24
REVIEWED BY: C. Shupe		DATE: Apr 21, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Ecologically and Biologically Significant Areas**	Stantec

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Table 3.24 Designated Conservation/Protected Areas

North Atlantic Right Whale Area to be Avoided/Critical Habitat (SARA)	
Location	• Approximately 3318 km^2 located in Roseway Basin between Baccaro and Browns Banks.
Designation and Administration	• In 1993, Roseway Basin was designated as a conservation area for right whales (Brown *et al.* 2009). • In 2007 Transport Canada submitted a proposal to the International Maritime Organization (IMO) for the designation of a recommend seasonal Area to be Avoided (ATBA) by ships 300 gross tonnage and upwards in transit during the period of 1 June through 31 December in order to significantly reduce the risk of ship strikes of the highly endangered North Atlantic right whale. This was adopted by IMO in 2007 and implemented in May 2008 (IMO 2007; Brown *et al.* 2009). • The North Atlantic right whale is listed as an endangered species on Schedule 1 of SARA. The Recovery Strategy for the North Atlantic Right Whale (*Eubalaena glacialis*) in Atlantic Canadian Waters (Brown *et al.* 2009) adopts the designated ATBA as provisional boundaries for a critical habitat designation under SARA.
Ecological Significance	• Right whales have shown an affinity for edges of banks and basins, upwellings and thermal fronts, and appear to be highly dependent on a narrow range of prey (*e.g.*, Calanoid copepods) (Brown *et al.* 2009). • Roseway Basin is an important area of right whale aggregation where right whales have been observed feeding and socializing in the summer and autumn months. Right whale abundance and stage C5 *Calanus finmarchicus* concentrations peak during this time (Brown *et al.* 2009). • Research is ongoing to evaluate prey distribution in Roseway Basin to refine critical habitat boundaries (Brown *et al.* 2009). • On average 17 whales (range 0 - 117) are sighted in the Roseway Basin habitat annually and these remain in the habitat for an average of 136.4 (±70.9) days in any given year (Vanderlaan 2009).
Northeast Channel Coral Conservation Area	
Location	• Approximately 424 km^2 in the Northeast Channel, east of Georges Bank.

Table 3.24 Designated Conservation/Protected Areas

Designation and Administration	• In June 2002 DFO established a Coral Conservation Area in accordance with the *Fisheries Act* and the *Oceans Act* with the objective of protecting high densities of intact octocorals (*Paragoria arborea*, bubblegum coral, and *Primnoa resedaeformis*, seacorn coral). This is one of three areas of significance for cold-water corals offshore Nova Scotia (the Gully and Lophelia Coral Conservation Area in Laurentian Channel being the other two) (ESSIM 2006). • The Northeast Channel Coral Conservation Area is divided into two zones: 1. Restricted bottom fisheries zone - ~ 90 percent of the area is closed to all bottom fishing gear used for groundfish or invertebrate fisheries (*e.g.*, longline, otter trawl, gillnet, trap). The highest density of corals, as observed in scientific surveys, is found in this zone. 2. Limited bottom fisheries zone - about 10 percent of the area is open to authorized fishing activities. At the present time, the area is open only to longline gear for groundfish (with an At-sea Observer) and is closed to all other bottom fishing gear. • In 2006 DFO developed a coral conservation plan (ESSIM 2006) for the Maritimes Region which provides an objective and strategy to protecting and understanding important benthic habitats.
Ecological Significance	• The conservation area was primarily selected on basis of having the highest density of large branching octocorals (gorgonian), *Paragorgia arborea* and *Primnoa resdaeformis,* in the Maritimes and visual evidence indicated vulnerability to bottom fishing damage (Cogswell *et al.* 2009). • The conservation area contains 12 taxa of coral (amalgamating the genus *Primnoa* and *Paragorgia*), including gorgonian corals, sea pens, and stony corals, and is optimally positioned to protect the highest density and least impacted branching gorgonians in the area (Cogswell *et al.* 2009). • Corals provide various ecosystem functions and coral biomass has been shown to be closely correlated to fish biodiversity (Campbell and Simms 2009).
Sambro Bank and Emerald Basin Vazella Closure Areas	
Location	• Sambro Bank Vazella Closure area is 62 km^2 on Sambro Bank, between LaHave Basin and Emerald Basin on the Scotian Shelf. • Emerald Basin Vazella Closure area is 197 km^2 in Emerald Basin on the Scotian Shelf.
Designation and Administration	• In 2013, in accordance with DFO's Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas (DFO 2009c), DFO closed two areas on the eastern Scotian Shelf known to contain the highest density of *Vazella pourtalesi* to bottom-contact fishing. • DFO's Sensitive Benthic Areas Policy is guided by the legal and policy framework designed to manage Canada's fisheries and ocean resources including the *Fisheries Act*, the *Oceans Act* and *SARA* as well as Canada's commitments under several international agreements including Canada's commitment under the United Nations Resolution 61/105 to protect vulnerable marine ecosystems in domestic waters (DFO 2009c).

Table 3.24 Designated Conservation/Protected Areas

Ecological Significance	• The glass sponge *Vazella pourtalesi* is known to exist in only three locations worldwide – the Gulf of Mexico, the Azores, and in Canada. • The locations on the eastern Scotian Shelf are the only instances where large aggregations have been found and thus are regarded as being globally-unique aggregations; the Gulf of Mexico and the Azores populations exist as individuals or in small aggregations (DFO 2013c). • Slow growth rates, longevity, variable recruitment, and habitat-limiting factors make the sponges particularly vulnerable to physical impacts and limit recovery (DFO 2013c).
Georges Bank Oil and Gas Moratorium Area	
Location	• Georges Bank is an offshore bank located on the outer continental shelf straddling the Canada-United States maritime boundary, with the northeast portion of the Bank in Canadian waters. • The moratorium area covers approximately 15,000 km^2 and includes the Canadian portion of Georges Bank and much of the Northeast channel to the southwest edge of Browns Bank (DFO 2011a).
Designation and Administration	• 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 extended until 2012 following an independent panel review in 1999. • Schedule IV of the Accord Acts delineates the Canadian portion of the moratorium area. • In early 2010, the moratorium was extended by both governments to 2015 and in December 2010, the Province of Nova Scotia passed the *Offshore Licensing Policy Act* which prohibits the exploration or drilling for or the production, conservation, processing or transportation of petroleum on George Bank indefinitely. A public review, no earlier than December 31, 2022, may be ordered at the discretion of the Minister of Energy to re-examine the moratorium. There is currently no mirror legislation for the federal government. • Exploration rights issued to leaseholders on the Canadian portion prior to the moratorium are suspended while the moratorium remains in effect. • The Government of the United States established a moratorium on the United States portion of Georges Bank in 1990; this moratorium has been extended to 2017.
Ecological Significance	• Georges Bank is recognized internationally as a unique ecosystem that exhibits high levels of biological productivity and biodiversity. • Georges Bank is at the northern edge of southern assemblages of plankton and fish and at the southern edge of northern assemblages, therefore biodiversity is very high in this area (of both subpolar and subtropical assemblages), with the Northeast Peak being the most productive part of Georges Bank (NRC and NSPD 1999). • Georges Bank supports a highly productive, diverse, and economically valuable fishing industry with landings of scallops, lobster, groundfish and large and small pelagics. Fish productivity has been reported to be two to two and half times that in other comparable areas such as the Gulf of Maine or the Scotian Shelf (NRC and NSPD

Table 3.24 Designated Conservation/Protected Areas

	1999). • The high and persistent productivity of phytoplankton and fish and the co-occurrence of spawning and nursery areas on the Northeast Peak are biological features that contribute to Georges Bank uniqueness and ecological significance (NRC and NSPD 1999). • Strong and persistent tidal currents (dominant physical factor on the Bank) result in high mixing rates, nutrient supply and overall dispersion (Boudreau *et al.* 1999). • Georges Bank serves as a feeding ground, nursery, and migration corridor for more than two dozen whales (including SARA-listed species) and four seal species (NRC and NSPD 1999). • Georges Bank serves as an important feeding area for birds owing to high mixing rates and nutrient supply.
Select Fisheries Closure Areas for Fisheries Conservation	
Lobster Fishing Area 40 (Georges Bank)	• A closure of LFA 40 area on Browns Bank to all lobster fishing has been in place since 1979 as a measure to protect lobster broodstock. • It has been surmised that the LFA 40 closure may also be beneficial to the protection of North Atlantic right whales and leatherback turtles given the proximity of the Roseway Basin (critical habitat for North Atlantic right whales) and decreased risk of entanglement in fishing gear (O'Boyle 2011).
Georges Bank (5Z)	• Since 2005, a scallop fishery area/time closure (February – March) has been implemented to reduce bycatch and minimize disturbance to spawning aggregations of cod by the offshore scallop fishery on Georges Bank. The time restrictions (February – March) coincides with cod spawning season and the area corresponds with density of cod abundance and overlap with scallop catches on Georges Bank (DFO 2012b).
Browns Bank (Haddock Spawning Closure)	• Seasonal fishery closure area to protect 4X cod and haddock during spawning season and reduce exploitation rates in Southwest Nova Scotia. Closure terms and area has evolved since the 1970s but currently prohibits fishing gear capable of catching demersal species (*e.g.*, hook gear, scallop dredges) during March - May (O'Boyle 2011).
Haddock Nursery Closure, Emerald/Western Bank (Haddock Box)	• The Haddock Box is an important nursery area for the protection of juvenile haddock, and is closed year-round by DFO, pursuant to the *Fisheries Act*, to the commercial groundfish fishery. Scallop fishing continues to occur on the easternmost part of the closed area (O'Boyle 2011). • Established to protect juvenile haddock in Northwest Atlantic Fisheries Organization (NAFO) Division 4VW (no considerations for biodiversity or habitat protection) (O'Boyle 2011). • Adult haddock aggregate to spawn within the Haddock Box, including Emerald Bank, from March-June, with peak spawning in March/April (BEPCo. 2004). • Closed area may be playing role in increasing haddock stock and abundance of other non-target species (*e.g.*, winter flounder, plaice, silver hake) (O'Boyle 2011).

Table 3.24 Designated Conservation/Protected Areas

Hell Hole (Northeast Channel)	• The Hell Hole is an important area for bluefin tuna. Longline fisheries are not permitted to fish within the Hell Hole from July to November to reduce bluefin tuna bycatch (Breeze and Horsman 2005).
Redfish Nursery Closure Area (Bowtie)	• Located on Browns Bank, extending into Roseway Basin, this special management area (known informally as the "Bowtie") is closed January to June to fishing using small mesh gear (mesh <130 mm) to protect small redfish (Breeze and Horsman 2005; LGL 2013).

Table 3.25 Ecologically and Biologically Significant Areas (Doherty and Horsman 2007)

Ecologically and Biologically Significant Areas	
2-4 Canadian portion of Georges Bank, Northern Edge of Georges Bank (herring spawning area), and Northern Edge of Georges Bank (tube worm habitat)	• Very strong tidal currents over steep topography resulting in a tidal mixing front along the northern flank of Georges Bank. • Nutrients are upwelled into the frontal zone as a result of the frontal dynamics. This nutrient pump feeds a very productive ecosystem which continues to support active fisheries. • The primary production has been estimated to be about 40% greater than the surrounding shelf regions and the fish production is twice that of the surrounding areas. • The Georges Bank tidal mixing front is likely the largest in Canada and one of the largest in the world. Arguments for the ecological and biological significance of Georges Bank have been made many times. • The bank is highly productive with diverse communities; it is a spawning, breeding and feeding area for a myriad of species and a migration route for many more. • The area provides spawning and nursery grounds for cod and haddock, spawning and settling area for scallops, spawning and summer residence for deep water lobster. • This is a well-documented herring spawning area; herring go back to this area every year to spawn. • This may be unique tube worm (*Filograna implexa*) habitat, at least regionally. Tube worm colonies cover the gravel in this area and have not been seen on the rest of the Scotian Shelf to the north. • The area also has interesting geological features.
5 Northeast Channel (corals, whales)	• A highly productive area where corals are found in densest aggregations in Atlantic Canada. Three species of deep water Gorgonian corals are found: *Paragorgia arborea and Primnoa resedaeformis* [the two dominant species] and Acanthogorgia species. • Juvenile redfish are associated with the corals. The area should include all areas of high coral densities at the mouth of the NEC. This area includes the "Hell Hole" which is an area of aggregation of pelagic species. • High diversity of whales in entrances of channels.

Table 3.25 Ecologically and Biologically Significant Areas (Doherty and Horsman 2007)

	• There are likely a variety of species of dolphins to deep diving whales (*e.g.*, sperm whales). • This is a well-known swordfish aggregating area.
6-7 Browns Bank and edge slope Fundian Moraine (Browns Bank)	• Known concentration of large lobsters; these lobsters may produce larvae which seed areas off southwestern Nova Scotia. • The area supports major cod and haddock spawning (seasonal closure on Browns Bank), gadoid nurseries, lobster protected area, aggregation of scallops, and natural refugia on the north side. • Unique geology. • Highly productive area with strong currents and local turbulence.
9 Roseway Basin	• Key feeding area for migrating, highly endangered North Atlantic right whales. • Highly productive area, persistent upwelling feature, high level of surface chlorophyll year-round, krill and *Calanus* concentrations. • High concentrations of juvenile redfish.
10 Roseway Bank	• Fish species fitness could be enhanced by protecting an array of suitable habitat such as Roseway Bank. • Roseway Bank (<100 m) was also chosen as an area of interest requiring further research because it may be good habitat for fish due to the rough bottom (mostly boulders, untrawable). • In the areas of the bank that are trawled (approximately 1/3) there are good catch rates of groundfish, including juvenile fish.
11 Baccaro Bank	• Fish species fitness could be enhanced by protecting an array of suitable habitat such as Baccaro Bank.
12 LaHave Bank	• Fish species fitness could be enhanced by protecting an array of suitable habitat such as LaHave Bank. • The area is covered in boulders/gravel with a lot of attached biological growth. • This area could be an important spawning area.
13 LaHave Basin	• Fields of pockmarks that likely have chemosynthetic cold seep communities. • Unique benthic diversity on bottom of pockmarks that is fed by venting hydrocarbon gas. • Krill and overwintering *Calanus*.
14 Sambro Bank	• Fish species fitness could be enhanced by protecting an array of suitable habitat such as Sambro Bank.

Table 3.25 Ecologically and Biologically Significant Areas (Doherty and Horsman 2007)

15-16 Emerald Basin and The Patch	• Emerald Basin is a hotspot for large glass sponges, *Vazella pourtalesi* (Class Hexactinellida, Family Porsillidae), also known as Russian Hats, and is the only known monospecific population of *Vazella pourtalesi* on the Scotian Shelf. They are globally unique with 100% of the known population found in this area. These sponges are vulnerable to fishing disturbance (*e.g.*, trawling). • Primary residence and spawning ground of silver hake. • Overwintering ground of basking sharks (primary) and porbeagle sharks. • Residence for whales and dolphins. • Summer residence of tuna and swordfish. • Important overwintering area of *Calanus*. • Important aggregation for krill. • High species richness. • Fields of pockmarks that likely have chemosynthetic cold seep communities. • Unique benthic diversity on bottom of pockmarks that is fed by venting hydrocarbon gas.
17-22 Emerald, Western and Sable Bank (including Emerald Bank Hot Box and Sable Island Hot Box	• Seasonally high diversity of copepods. • The combination of gravel and sandy seabeds supports higher concentrations of fish, particularly juvenile fish. • Area of highest larval fish diversity perhaps due to a gyre. • Area of concentration of spawning fish (*e.g.*, gadoids). • Juvenile nursery area for haddock, cod, monkfish, yellowtail, skate, flounder. • Includes the defined 4W Haddock Box Nursery Area. Important overwintering area in the slope waters. • Confirmed diversity of species (*e.g.*, haddock, sea cucumbers, possible mussel beds). • Hard gravel/boulder seabed.
28 The Bull Pen, the Cow Pen and the Owl	• Highly diverse and productive area with mix of cold and warm water a large number of both southern and northern fish species. • Possible white hake spawning area.

Table 3.25 Ecologically and Biologically Significant Areas (Doherty and Horsman 2007)

31 Scotian Slope/Shelf Break	• Includes areas of unique geology (iceberg, furrows, pits, complex/irregular bottom). • High finfish diversity due to habitat heterogeneity provided by depth. • Primary residence for mesopelagic fishes. • Inhibited by corals, whales, porbeagle shark, tuna, swordfish. • Endangered leatherback turtles foraging habitat (summer and fall) – the area supports concentrations of salps which are a source of food for turtles. • High diversity of squid. • Overwintering area for number of shellfish species. • Halibut overwintering, lobster overwintering. • Seabird feeding/overwintering area. • Greenland sharks.

3.3 SOCIO-ECONOMIC CHARACTERISTICS

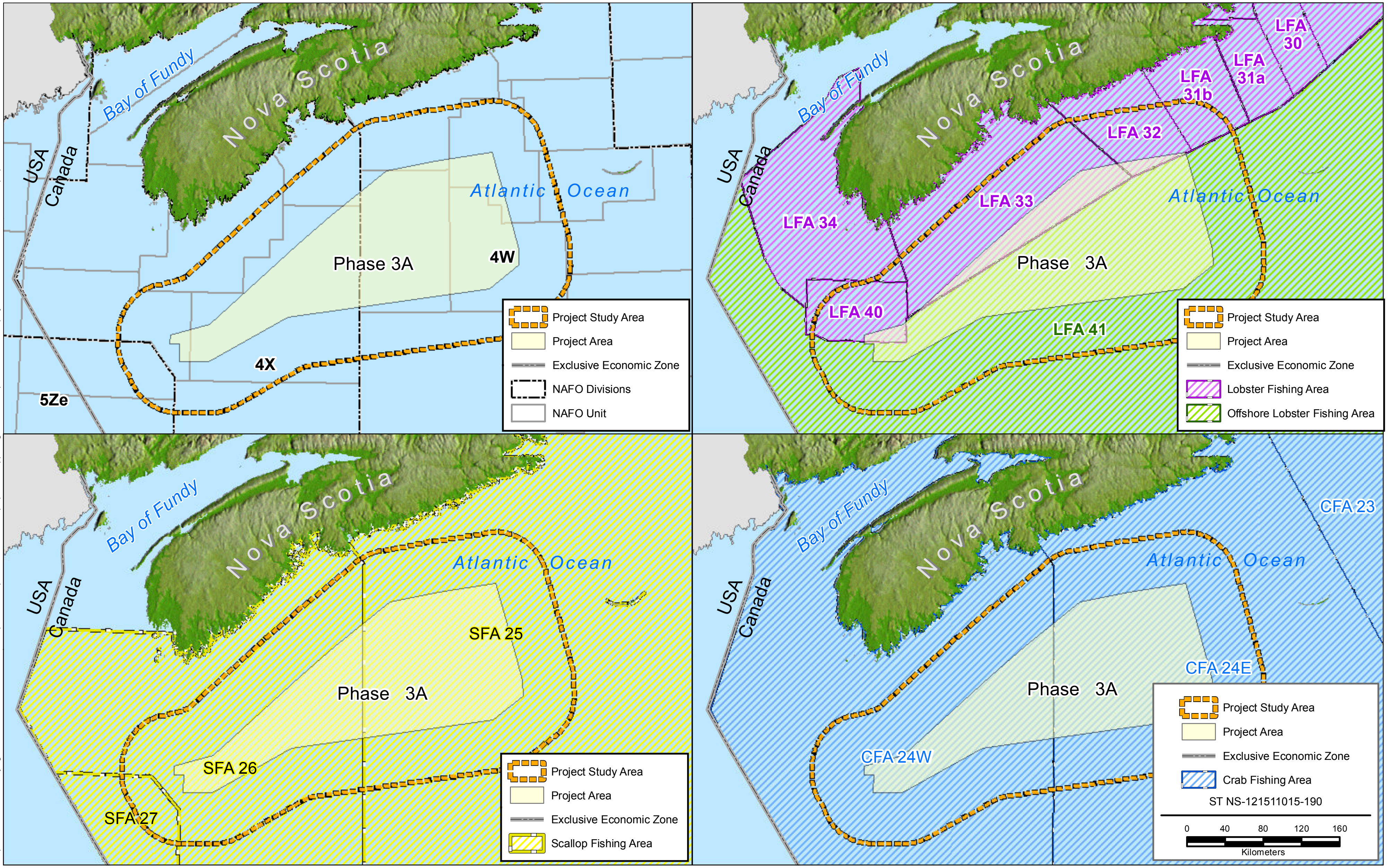
3.3.1 Commercial Fish and Fisheries

Commercial fishing in offshore Nova Scotia waters started in the mid-1500s and by 1700, Nova Scotia was exporting cod, mackerel, and herring. In 1973, the total landings of fish on the Scotian Shelf peaked, with catches exceeding 750,000,000 kg (750,000 t) (DFO 2011b). In 1977-1978 the overall landed value of fish increased dramatically with the declaration of a 200-mile exclusive economic zone, greatly reducing foreign fishing on the Scotian Shelf.

Throughout most of Nova Scotia's history, groundfish fisheries dominated the commercial catch, although landings reached a historic low with the collapse of groundfish stocks and in 1993, a moratorium on the groundfish fishery, particularly for cod, was imposed on the Eastern Scotian Shelf (NAFO Divisions 4W, 4Vs, 4Vn, and 3Ps) and remains in effect today (Worcester and Parker 2010).

The Phase 3A Study Area falls primarily within NAFO Divisions, 4W, 4X, and 5Ze and contains some of the most important fishing areas in the Northwest Atlantic Ocean. Figure 3.25 displays the NAFO Division boundaries as well as other management areas used to manage other fishing areas including Scallop Fishing Areas (SFAs), Crab Fishing Areas (CFAs) and Lobster Fishing Areas (LFAs). Shellfish fisheries (*e.g.*, sea scallop, lobster, crab), pelagic (*e.g.*, shark, swordfish, tuna, mackerel), and groundfish (cod, halibut, flatfish, haddock, hake) fisheries occur throughout the Study Area, with shellfish fisheries dominating the commercial catch value.

Table 3.26 outlines the number of fishery licenses (commercial and communal commercial) that may fish in the Western Scotian Slope and Shelf Region within which SEA Study Areas 3A and 3B are located. This data, provided courtesy of DFO, is meant to demonstrate the relative context of fisheries operating in the vicinity of the Phase 3A and 3B Study Areas, based primarily on licensing data from NAFO 4W, 4X and 5Ze. The number of licenses and tonnage of landings are determined from fisher-submitted documents and landings totals may not add up due to rounding. It should be noted that the data in Table 3.26 is representative of 2012 license counts and contains preliminary landings data as of August 16, 2013. This data represents a snapshot in time of fishing activity and this activity may vary between years. For an overall depiction of fishing activity over longer time periods refer to landings maps in Appendix B as well as landing values in Table 3.27.



PREPARED BY: C. Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.25
REVIEWED BY: M. Huskins-Shupe		DATE: Apr 21, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Commercial Fisheries Management Areas - Phase 3A**	Stantec

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Table 3.26 Fishery Licence and Landing Information of the Southwest Scotian Slope and Shelf Region

Fishery	Total Number of Licences (*i.e.* Commercial and Communal Commercial) (2012P)	Number of Communal Commercial Licences (2012P)	Total Number of Licences with Landings (2012P[1])	Number of Communal Commercial Licences with Landings (2012P)	Landings for all Licences in tonnes (t, 2012P)	Landings for Communal Commercial Licences in tonnes (t, 2012P)
Crab CFA 24 NAFO 4X	 CFA 24 – 53 4X – 9	 CFA 24 – 24 4X – 3	 CFA 24 – 47 4X – 6	 CFA 24 – 12 4X – 2	Total landings for all licences –5,581 t	Total landings for all Communal Commercial licences – 1,477 t
Groundfish (All Gear) (Includes cusk, dogfish, flatfish, red hake, white hake, silver hake, halibut, redfish, wolfish) NAFO 4W NAFO 4X NAFO 5ZE	Total licences for all areas (some licences may fish multiple areas) = 2,329 4W – 921 4X – 2,063 5Ze – 596	Total Communal Commercial licences for all areas (some licences may fish multiple areas) = 26 4W – 12 4X – 25 5Ze –11	Total Licences with landings for all areas (some licences may have landings from multiple areas) = 439 4W – 119 4X – 355 5Ze – 64	Total Communal Commercial Licences with landings for all areas (some licences may have landings from multiple areas) = 5 4W – 1 4X – 5 5Ze – 2	Total landings for all areas = 38,947 t 4W-10,994 4X- 20,640 5Ze- 7,314	Total Communal Commercial landings for all areas = * t[2] 4W - * 4X- 833 5Ze - *
Hagfish NAFO 4W NAFO 4X NAFO 5ZE	Total licences for all areas (some licences may fish multiple areas) = 7 4W – 6 4X – 4 5Ze – 1	Total Communal Commercial licences for all areas = 1 4W – 1 4X – 0 5Ze – 0	Total Licences with landings for all areas (some licences may have landings from multiple areas) = 7 4W – 6 4X – 4 5Ze – 1	Total Communal Commercial licences with landings for all areas = 1 4W – 1 4X – N/A 5Ze – N/A	Total landings for all areas = 2359 t 4W- 1,996 4X – * 5Ze- *	Total Communal Commercial landings for all areas = * t 4W- * t 4X – N/A 5Ze – N/A
Large Pelagics (Vessel-based licences that are valid to fish all of DFO Maritimes	Shark – 3 Swordfish (harpoon + longline) – 901	Shark – 0 Swordfish – 14	Shark – 0 Swordfish (harpoon & longline) – 68	Shark – N/A Swordfish(harpoon & longline) – 4	Shark – N/A Swordfish Total – 642 t	Shark – N/A Swordfish Total – * t

Table 3.26 Fishery Licence and Landing Information of the Southwest Scotian Slope and Shelf Region

Fishery	Total Number of Licences (*i.e.* Commercial and Communal Commercial) (2012P)	Number of Communal Commercial Licences (2012P)	Total Number of Licences with Landings (2012P[1])	Number of Communal Commercial Licences with Landings (2012P)	Landings for all Licences in tonnes (t, 2012P)	Landings for Communal Commercial Licences in tonnes (t, 2012P)
Region. Some licences are issued out of DFO Gulf Region). NAFO 4W NAFO 4X NAFO 5ZE	 Tuna (Bluefin) – 54	 Tuna (Bluefin) – 4	4W – 24 4X – 59 5Ze – 45 Tuna (Bluefin) – 58 4W – 31 4X – 33 5Ze – 8	4W – 2 4X – 4 5Ze – 1 Tuna (Bluefin) – 4 t 4W – 1 4X – 2 5Ze – 1	4W – 345 t 4X – 193 t 5Ze – 105 t Tuna (Bluefin) – 159 t 4W – 42 t 4X – 98 t 5Ze – 20 t	4W – * t 4X – * t 5Ze – * t Tuna (Bluefin) – * t 4W – * t 4X – * t 5Ze – * t
Lobster (Inshore and Offshore) *LFA 31b-34* *LFA 41*	LFA 31B – 71 LFA 32 – 159 LFA 33 – 700 LFA 34 – 979 LFA 41 – 1	LFA 31B – 0 LFA 32 – 6 LFA 33 – 15 LFA 34 – 29 LFA 41 – 0	LFA 31B – 71 LFA 32 – 144 LFA 33 – 604 LFA 34 – 931 LFA 41 – 1	LFA 31B – N/A LFA 32 – 3 LFA 33 – 10 LFA 34 – 21 LFA 41 – N/A	31B – 1,080 t 32 – 924 t 33 – 5,149 t 34 –21,846 t 41 – * t	31B – N/A 32 – * t 33 – 46 t 34 – 276 t 41 – N/A
Mackerel (Vessel-based licences that are valid to fish all of DFO Maritimes Region) *NAFO 4W* *NAFO 4X* *NAFO 5ZE*	1844	12	63 4W – 10 4X – 54 5Ze – 0	0	423 t 4W – 174 t 4X – 249 t 5Ze – N/A	N/A
Scallop (Vessel-based licences that are valid to fish all of	6 (Offshore)	0	6	N/A	Total landings for all areas = 39,399 t	N/A

Table 3.26 Fishery Licence and Landing Information of the Southwest Scotian Slope and Shelf Region

Fishery	Total Number of Licences (*i.e.* Commercial and Communal Commercial) (2012P)	Number of Communal Commercial Licences (2012P)	Total Number of Licences with Landings (2012P[1])	Number of Communal Commercial Licences with Landings (2012P)	Landings for all Licences in tonnes (t, 2012P)	Landings for Communal Commercial Licences in tonnes (t, 2012P)
DFO Maritimes Region) *SFA 25* *SFA 26* *SFA 27*			SFA25 – 3 SFA26 – 6 SFA27 – 6			

Notes:
[1]Data for reporting 2012 is preliminary (denoted by 2012P) and as such, may be incomplete and/or subject to change without notice.
[2]To protect confidentiality, landings totals are denoted by an asterisk (*) in instances where less than five separate license holders have been active.

Source: DFO, pers. comm. 2013

Table 3.27 summarizes landings weight and values for each of the three NAFO divisions (4W, 4X, and 5Ze) for pelagic, groundfish, shellfish and other (*e.g.*, marine plants) fisheries for 2007-2012. Detailed data per NAFO Unit are provided in Appendix B. Table 3.28 summarizes fishing seasons for key commercial fisheries occurring in the Study Area. Additional details on the pelagic, groundfish, and shellfish (invertebrate) fisheries are provided in the following sections. Spatial data for fisheries landings 2006 to 2010 are provided in Appendix B to illustrate a regional context of fisheries activities in and around the Study Area.

Table 3.27 Landed Weight and Value of Commercial Fish Species in NAFO Divisions 4W, 4X, 5Ze (2007-2012)

	2007		2008		2009		2010		2011		2012	
	Landed Weight (t)	Landed Value ($'000)	Landed Weight (t)	Landed Value ($'000)	Landed Weight (t)	Landed Value ($'000)	Landed Weight (t)	Landed Value ($'000)	Landed Weight (t)	Landed Value ($'000)	Landed Weight (t)	Landed Value ($'000)
Groundfish												
4W	12,792	12,789	13,667	13,649	11,059	10,678	10,597	10,747	11,204	13,024	13,280	14,354
4X	26,431	35,692	23,965	32,192	24,239	33,865	22,281	31,695	21,023	32,177	21,034	33,976
5Ze	13,884	20,517	16,803	22,749	19,322	30,605	19,160	24,902	14,276	22,544	7,468	14,917
Total Groundfish	**53,107**	**68,998**	**54,435**	**68,590**	**54,619**	**75,148**	**52,039**	**67,345**	**46,504**	**67,746**	**41,782**	**63,248**
Pelagics												
4W	9,642	9,465	3,944	6,285	15,412	7,968	10,865	9,346	12,293	9,739	2,731	10,773
4X	80,424	21,956	58,889	18,439	55,136	21,928	58,181	22,786	52,803	22,938	52,731	22,409
5Ze	302	2,626	472	3,572	455	3,300	529	4,381	307	2,427	313	2,642
Total Pelagics	**90,368**	**34,047**	**63,305**	**28,296**	**71,003**	**33,197**	**69,575**	**36,512**	**65,402**	**35,105**	**51,150**	**55,002**
Shellfish												
4W	9,642	65,064	11,224	67,265	13,164	58,989	14,182	62,106	13,476	77,517	13,269	74,222
4X	48,316	305,369	47,062	321,148	40,817	281,650	49,642	329,402	58,559	361,654	58,038	360,782
5Ze	36,779	49,977	48,807	65,453	48,189	64,466	44,801	60,891	37,879	59,910	33,926	73,488
Total Shellfish	**94,737**	**420,410**	**107,093**	**453,866**	**102,170**	**405,104**	**108,625**	**452,398**	**109,915**	**499,080**	**105,232**	**508,492**
Other Species												
4W	1	8	1	19	0	6	0	1	0	0	-	-
4X	15,900	1,703	16,572	2,228	43,292	1,408	41,123	3,367	16,989	1,355	11,812	799
5ZE	43	467	15	163	16	177	6	66	22	-	-	-
Total Other Species	**15,943**	**2,178**	**16,588**	**2,410**	**43,309**	**1,590**	**41,129**	**3,433**	**17,012**	**1,356**	**11,812**	**799**
Grand Total	**254,156**	**525,634**	**241,421**	**553,161**	**271,102**	**515,040**	**271,367**	**559,689**	**238,833**	**603,286**	**209,976**	**627,541**

Source: DFO, pers. comm. 2013

Table 3.28 Summary of Fishing Seasons for Principal Commercial Fisheries Species Potentially Within Study Area

Common Name	Latin Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Pelagic Species													
Albacore tuna	*Thunnys alalunga*												
Bigeye tuna	*Thunnus obesus*												
Bluefin tuna	*Thunnus thynnus*												
Mackerel	*Scomber scombrus*												
Porbeagle shark	*Lamna nasus*												
Swordfish	*Xiphias gladuis*												
White marlin	*Tetrapturus albidus*												
Groundfish Species													
American plaice	*Hippoglossoides platessoides*												
Atlantic cod	*Gadus morhua*												
Atlantic halibut	*Hippoglossus hippoglossus*												
Cusk	*Brosme brosme*												
Greysole-Witch flounder	*Glyptocephalus cynoglossus*												
Haddock	*Melanogrammus aeglefinus*												
Monkfish	*Lophius spp.*												
Pollock	*Pollachius virens*												
Redfish (deepwater and Acadian)	*Sebastes mentella / Sebastes fasciatus*												
Red hake	*Urophycis chuss*												
Silver hake	*Merluccius bilinearis*												
Stripped catfish (wolfish)	*Anarchichas lupus*												
Turbot – Greenland	Reinhardtius hippoglossoides												

Table 3.28 Summary of Fishing Seasons for Principal Commercial Fisheries Species Potentially Within Study Area

Common Name	Latin Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
flounder													
White hake	*Urophycis tenuis*												
Invertebrate Species													
Lobster*	*Homarus americanus*												
Scallop	potential for multiple species												
Snow crab	*Chionoecetes opilio*												

*Note: The Study Area falls within multiple Lobster Fishing Areas (33, 34, 40, and 41) with different fishing seasons. See below for the various Lobster fishing seasons:

LFA 33: Last Monday in November – May 31

LFA 34: Last Monday in November – May 31

LFA 40: Closed year round.

LFA 41: Open year round.

Open Fishing Season * Note all large pelagic fisheries are open year round.

Closed Fishing Season

High Fishing Activity within the Season

Low Fishing Activity within the Season

Data sources: Breeze and Horsman 2005

3.3.1.1 Pelagic Fisheries

During the period from 1980-2000 pelagic species have shown fluctuations in catch and have ranged from 8 % to 15 % of the total landed value on the Scotian Shelf (Worcester and Parker 2010). In 2012 pelagic species accounted for approximately 9% ($55 million) of the total landed value of commercial landings in the Maritimes Region (DFO 2013b). On the Scotian Shelf, bigeye tuna, yellowfin tuna, swordfish and blue shark stocks are considered to be in a healthy state, while bluefin tuna, albacore tuna, shortfin mako, porbeagle, blue marlin, and white marlin stocks are in a critical state as determined by DFO (DFO 2012a).

Figures 1 to 5 in Appendix B demonstrate pelagic fisheries in the Study Area are concentrated primarily along the shelf break (*e.g.*, swordfish) or in deeper waters off the Scotian Slope (*e.g.*, tuna). Table 3.29 summarizes information regarding fishing seasons and gear types.

Table 3.29 Pelagic Fishery Seasons and Gear Type

Species	Fishing Season and Gear Type
Bluefin tuna	• Season is open year round with the main season taking place during the summer and fall months • Catch limits are governed by the International Commission for the Conservation of Atlantic Tuna (ICCAT) • Gear used is either direct fishing by angling (rod and line), tended line trap, or electric harpoon and indirect fishing by longline
Albacore tuna Bigeye tuna Yellowfin tuna	• Season is open year-round with the main season taking place from July to November • Gear used is pelagic (floating) longline, with some trolling using rod and line • Mainly fished for along the shelf edge and slope
Swordfish	• Season is open year-round with the main seasons taking place from June to July for harpoon, and July to November for longline • Catch limits are governed by the ICCAT • Gear used includes pelagic longline and harpoon • Mainly fished for along the shelf edge and slope
Porbeagle shark	• A large proportion of sharks are caught as bycatch in the swordfish longline fishery. • There is a direct fishery for porbeagle sharks using pelagic longline gear and angling. • The main commercial fishery occurs along the Scotian Slope.

Source: DFO 2011 d

3.3.1.2 Groundfish Fisheries

Groundfish landings dominated the Nova Scotia fishery until the early 1990s. Between 1991 and 1995, groudfish landings dropped by 80% (DFO 2012a). In 2012 groundfish species accounted for approximately 10% ($63 million) of the total landed value of commercial landings in the Maritimes Region . The collapse in groundfish stocks in the 1990s and the moratorium for cod and haddock fishing in 4W, 4Vs, 4Vn, and 3Ps has had a profound effect on the Scotian Shelf ecosystem and fisheries. Within those fisheries management areas, the longline fishery for Atlantic halibut is presently the major groundfish fishery in operation (Worcester and Parker 2010).

Landings of Western Scotian Shelf/Bay of Fundy cod averaged 20,000 t annually over several decades, but declined after 1990 to a range of 3,000-5,000 t since 2000 (DFO 2012a). Atlantic cod as well as witch flounder stocks on the Western Scotian Shelf are considered to be at a critical state. Haddock, halibut, winter flounder, and sculpin are considered to have healthy stock status (DFO 2012a).

Figures 6 to 21 in Appendix B depict locations of groundfish species catches within and around the Study Area. Table 3.30 summarizes information regarding fishing seasons and gear types.

Table 3.30 Groundfish Fishery Seasons and Gear Type

Fishing Seasons and Areas	• Groundfish fishery is open during all seasons. • Fishing occurs in NAFO subdivisions 4W, 4X and 5Ze. • Within the Study Area, the cod and haddock fisheries have been closed in 4W since 1993, and species can only be caught and kept through by-catch. • Some seasons are more important than others based on the seasonal movement of fish species. • Most intensive fishing occurs in the summer from July to September where fishing activity is widespread on the Scotian Shelf. • The central shelf basins and valleys yield high landings year-round. • In the fall months there is less fishing pressure and landings, as many fishermen fishing for groundfish switch to lobster in late November. • Halibut catch is concentrated along the shelf break, Roseway Basin, and Browns and Baccaro Banks. Cod, haddock, and pollock landings are concentrated on the LaHave, Baccaro and Brown Banks and Georges Bank and Basin.
Gear Type	• The main gear types used are trawls and longlines. • Longlines are used most frequently on the shelf edge and deep water channels and basins. • Handlines and gillnets are rarely used.
Other Information	• The collapse and closure of the cod and haddock fisheries has resulted in a switch from groundfish as the main target to invertebrates (shellfish) in 4W. Groundfish remain an important fishery in 4X.

Source: Breeze and Horsman 2005

3.3.1.3 Shellfish Fisheries

Since the 1990s, the total value of the shellfish fishery has surpassed that of groundfish fishery in Nova Scotia. In 2012, shellfish species accounted for approximately 81% ($508 million) of the total landed value of commercial landings in the Maritimes Region (DFO 2013b). Within the Western Scotian Shelf region, there are no invertebrate stocks considered to be at a critical health level (DFO 2012a).

LFA 34 has the highest landings of lobster of any area in Canada, accounting for 40% of Canadian landings and 23% of the world landings (Worcester and Parker 2010). Commercial fishing for lobster and crab in the Study Area is concentrated on Georges Bank outer shelf and upper slope, Georges Basin, Southeast Browns Bank outer shelf and upper slope east of the Northeast Channel, and West Browns Bank (DFO 2011b). The scallop fishery, concentrated on Georges Bank and Browns Bank in the Study Area, accounts for approximately 70-80% of the annual scallops landed in Canada (DFO 2011a).

Figures 22 to 26 in Appendix B depict locations of shellfish landings within and around the Study Area. Table 3.31 summarizes information regarding fishing seasons and gear types.

Table 3.31 Shellfish Fishery Seasons and Gear Type

Species	Fishing Season and Gear Type
Crab	• Crab Fishing Area 24 is located within the Study Area. • Jonah crab is the primary crab species harvested in the Study Area, although rock crab, stone crab, porcupine crab and spider/toad crab are also caught. Jonah crab are harvested in the same areas as the offshore lobster fishery. • The fishing season for CFA 24 runs from April 2- September 30. • Gear used are crab traps, which are either conical or rectangular in shape.
Lobster	• Inshore and offshore lobsters are fished within Lobster Fishing Areas 31b to LFA 34 and LFA 41. • Has been historically fished with traps and trawls although use of trawls has been significantly reduced in recent years. Trawls for lobster are multiple traps attached on one line which is the preferred method used in offshore areas. • Fishery season is open year round subject to Total Allowable Catch.
Sea Scallop	• Scallop Fishing Areas 25 to 27 are located within the Study Area. • The fishing season is open year-roundThere is a lull in fishing activity during the winter months. • The gear used for fishing is mainly scallop drags.
Exploratory	• There is the possibility of exploratory fisheries occurring in the Study Area. • Potential exploratory whelk fishery in 2014.

Source: Breeze and Horsman 2005; DFO 2011a; DFO 2014

3.3.2 Aboriginal Fisheries

In 1990, the Supreme Court of Canada issued a landmark ruling in the Sparrow Decision. This decision found that the Musqueam First Nation had an Aboriginal right to fish for food, social and ceremonial purposes. The Court found that where an Aboriginal group has a right to fish for food, social and ceremonial (FSC) purposes, it takes priority, after conservation, over other uses of the resource. The Supreme Court also indicated the importance of consulting with Aboriginal groups when their fishing rights might be affected (DFO 2008b). In response to this decision, DFO developed an Aboriginal Fishing Strategy (AFS). The AFS assists DFO in managing the fishery in a manner consistent with Sparrow and subsequent Supreme Court of Canada decisions.

The Minister of Fisheries and Oceans issues communal fishing licenses to Aboriginal groups, which allows for fishing for FSC purposes. In the DFO Maritimes Region, communal FSC licenses are held by 16 First Nations (11 in Nova Scotia and 5 in New Brunswick) and the Native Council of Nova Scotia. These communal FSC licenses are for inland and inshore areas, however, as DFO does not provide access for FSC purposes in offshore areas (DFO, pers. comm. 2012).

In 1999, the Supreme Court of Canada issued the Marshall Decision, which affirmed a Treaty right to hunt, fish, and gather in pursuit of a moderate livelihood, stemming from Peace and Friendship Treaties of 1760 and 1761. The Decision affected 34 Mi'kmaq and Maliseet First Nations in New Brunswick, Prince Edward Island, Nova Scotia, and the Gaspé region of Quebec. In response, DFO implemented the Marshall Response Initiative (MRI), to provide increased First Nations access to the commercial fishery through issuance of communal commercial licences. Communal commercial licences are held under the name of the First Nations community and not under the name of a specific individual.

There are 134 communal commercial licenses for commercial fishing within the Western Scotian Shelf and Slope region. These licenses are for crab, groundfish, hagfish, swordfish, bluefin tuna, and lobster (DFO, pers. comm. 2013). The communal commercial licenses listed in Table 3.26 are held by Aboriginal groups in the DFO Maritimes Region, and do not include those communal commercial licenses held by the Pictou Landing First Nation and Paq'tnkek First Nation. These two First Nations are located in Nova Scotia, but fall under the jurisdictional authority of the DFO Gulf Region.

3.3.3 Recreational Fisheries

Recreational offshore fisheries in the SEA Study Area may include fishing charters and tournaments for large pelagics (*e.g.*, sharks, tuna, *etc*.) (DFO, pers. comm. 2013).

3.3.4 Other Ocean Uses

In addition to the fisheries described above, there are several other ocean activities and uses occurring within and around the Study Area, including commercial shipping, military exercises, petroleum exploration and development, telecommunication cables, and scientific research (refer to Table 3.32).

Table 3.32 Other Ocean Uses In and Around the Study Area

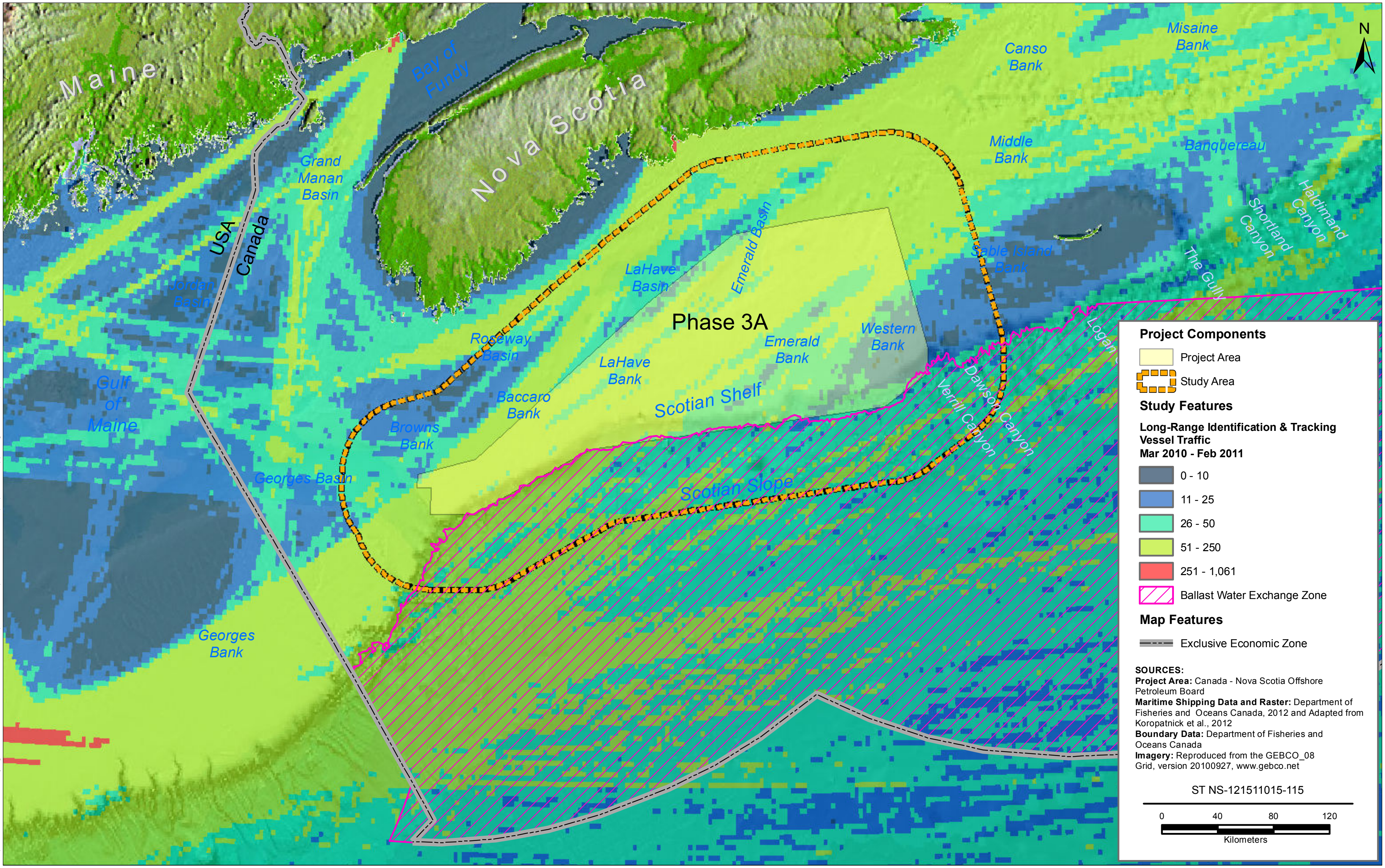
Use	Description
Commercial Shipping (refer to Figure 3.26)	• The Study Area is heavily used for domestic and international commercial shipping consisting of mostly tankers and bulk and containerized cargo carriers, as well as a range of fishing vessels, cruise ships and various government vessels. • There are four distinct regional traffic patterns including: international shipping over the Scotian Shelf as part of the "great circle route" (*i.e.*, shortest distance over the earth's surface) between Europe and the eastern

Table 3.32 Other Ocean Uses In and Around the Study Area

Use	Description
	seaboard of the United States and Canada; international and domestic shipping along the coast of Nova Scotia bound to and from the United States, Bay of Fundy, Gulf of St. Lawrence and Newfoundland; shipping through the Cabot Strait, a major sea route linking trans-Atlantic shipping lanes to the St. Lawrence Seaway and the Great Lakes; and traffic associated with the major ports of Halifax, Saint John, Port Hawkesbury (Strait of Canso) and Sydney (DFO 2011a). • Fishing vessels account for over 70% of marine traffic volume southeast of Nova Scotia (essentially between Cape Breton and Yarmouth out to the EEZ) (Pelot and Wootton 2004). • A designated ballast water exchange zone exists in the Study Area, extending from the Scotian Slope to the EEZ (refer to Figure 3.26), providing ships the opportunity to exchange ballast waters mid-ocean to reduce the risk of alien species introduction and transfer.
Military Activity (refer to Figure 3.27)	• Canada's east coast naval presence is provided through Maritime Forces Atlantic (MARLANT), which has its headquarters in Halifax. • MARLANT engages in a range of operations and activities including sovereignty patrols, maritime surveillance, naval training and combat readiness, search and rescue, humanitarian relief and aid to civil authorities, and operational support to other government departments, including fisheries and environmental protection (DFO 2011a). • MARLANT also conducts naval training activities in designated exercise areas off Nova Scotia. Exercise areas may also be used by foreign vessels or aircraft during periodic multinational exercises or with permission from the Government of Canada. Maps, coordinates and descriptions of military activities permitted in these exercise areas are provided in the Canadian Coast Guard's Annual Notice to Mariners (DFO 2011a). • Operators are requested to consult with DND during Project-specific EAs to present project locations and timing to confirm no adverse interactions with military activity.
Offshore Petroleum Activity (refer to Figure 3.28)	• The Sable Offshore Energy Project and the Deep Panuke Offshore Gas Development Project are located less than 10 km from the Phase 3A Study Area. • There is no current petroleum activity in the SEA Project Area. Several exploratory wells have been drilled in the Study Area, all of which have been plugged and abandoned. • In 2013, Shell Canada Limited conducted a 3D WAZ seismic survey over their deepwater exploration licenses on the Scotian Slope (ELs 2424, 2425, 2426) and is currently planning an exploration drilling program to commence in 2015. • BP Exploration Operating Company is proposing to conduct 3D seismic survey over ELs 2431, 2432, 2433 and 2434 in 2014 and/or 2015.
Seabed Cables (refer to Figure 3.29)	• There are numerous inactive cables on the Scotian Shelf and Slope, some of which are more than 100 years old (Breeze and Horsman 2005). • Several active submarine telecommunications cables make landfall in Nova Scotia, many of which cross through the Phase 3A Study Area (including Hibernia Atlantic Sections A, D and E).

Table 3.32 Other Ocean Uses In and Around the Study Area

Use	Description
Shipwrecks and Legacy Sites (refer to Figure 3.30)	• As illustrated on Figure 3.29 there are several shipwrecks existing within the Study Area. • There are two explosive dumpsites within the Phase 3A Study Area.
Scientific Research (refer to Figure 3.31)	• There are several ongoing scientific research programs on the Scotian Shelf, some of which occur in the Study Area. Figure 3.31 presents locations of some of the ongoing research initiatives but may not capture short-term research initiatives. • The Gulf of Maine Ocean Observing System and Environment Canada owns and operates buoys on the Scotian Slope. The Halifax Line and the Browns Bank line of the Atlantic Zone Monitoring Program (AZMP) runs through the Phase 3A Study Area. There is also a fixed station (Halifax Station 2) in the Study Area, on the Halifax Line. These transects and stations are sampled by DFO on a bi-weekly or monthly schedule during the ice free season. The AZMP is a comprehensive environmental monitoring program designed and implemented by DFO in 1999. The program was introduced to increase DFO's capacity to understand, describe, and forecast the state of the ocean environment and to relate these changes to the predator-prey relationships of marine resources. • The Continuous Plankton Recorder Survey, run by the Sir Alister Hardy Foundation for Ocean Science, has been using vessels of opportunity to collect plankton samples since 1931 (Sir Alister Hardy Foundation for Ocean Science, 2005) (DFO 2011a). • Scientists at DFO monitor fish populations of the Scotian Shelf, Bay of Fundy, and Gulf of Maine on an ongoing basis. Some of the most important sources of information on the state of marine fish populations are bottom trawl surveys (DFO 2011a) which are generally conducted in the winter and summer within the Study Area. • Scientists from Dalhousie University (Whitehead Lab) conduct cetacean studies every 3-4 years within the Study Area. • The Ocean Tracking Network (OTN based at Dalhousie University) and DFO jointly operate a fixed and semi-permanent series of almost 200 acoustic receivers along the ocean bottom of the Halifax Line. There is the potential that these receivers could be impacted by seismic surveys in the area.



PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C. Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Shipping Traffic

FIGURE NO.: 3.26

DATE: Apr 21, 2014

Stantec

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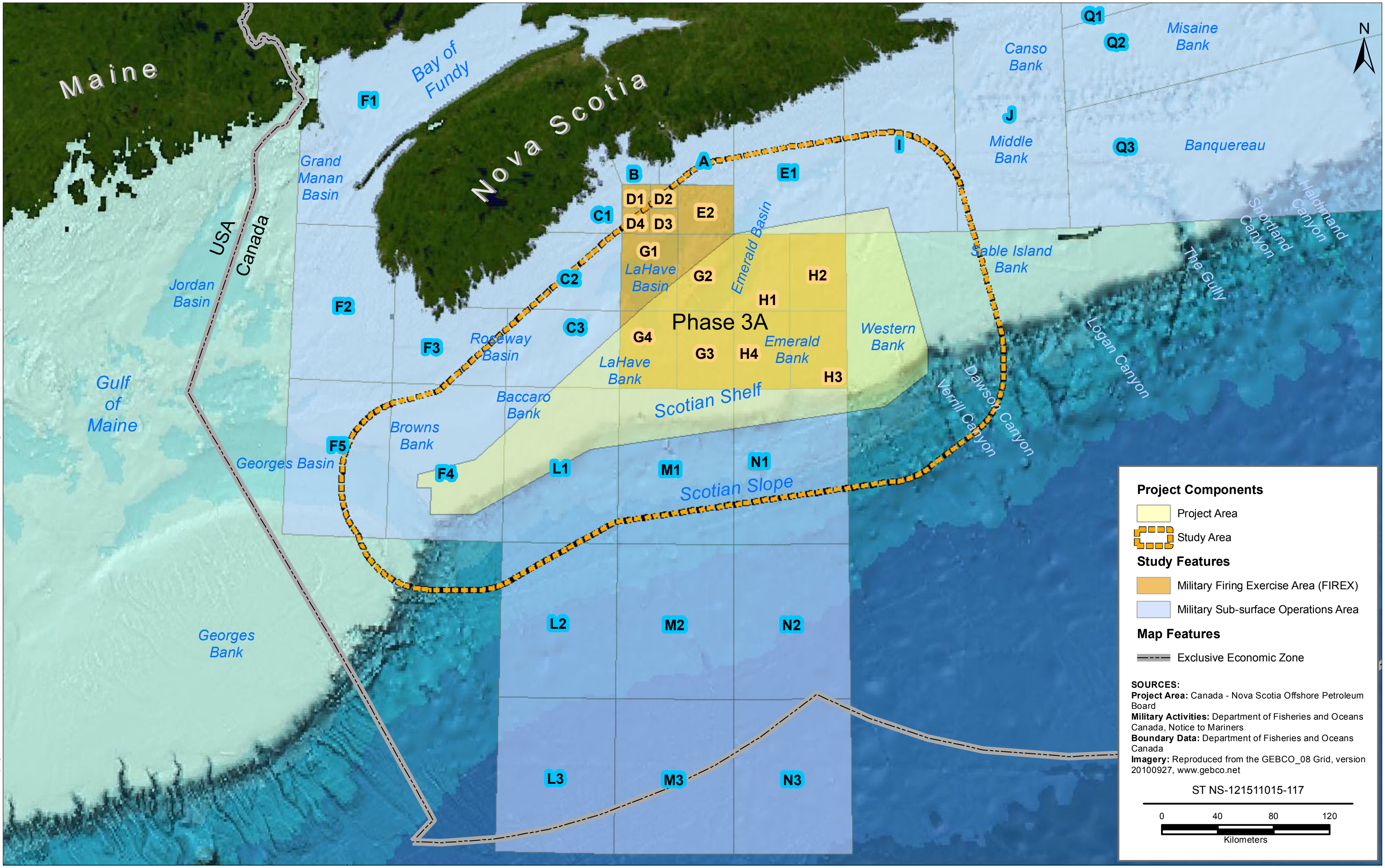
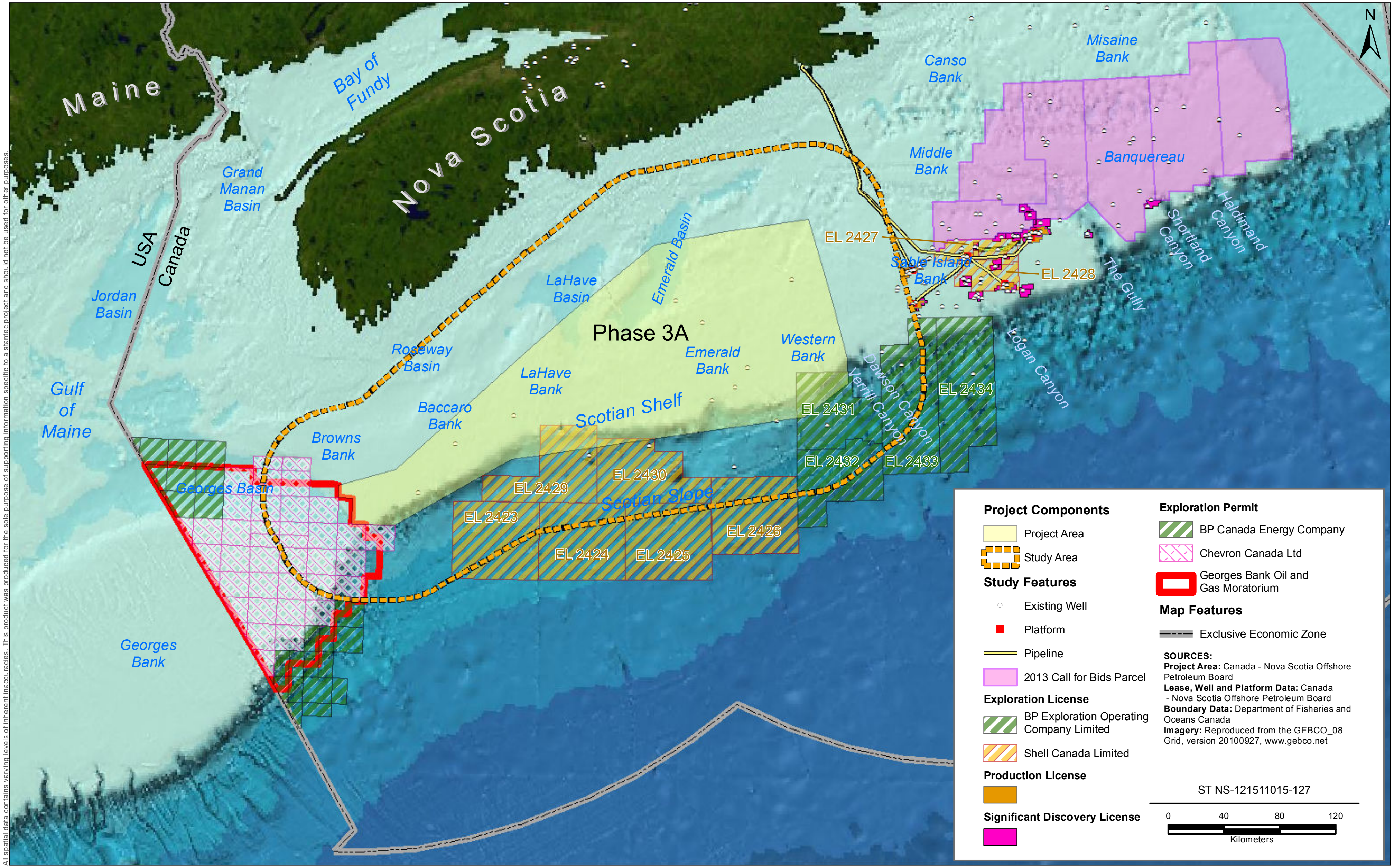


All spatial data contains varying levels of inherent inaccuracies. This product was produced for the sole purpose of supporting information specific to a stantec project and should not be used for other purposes.

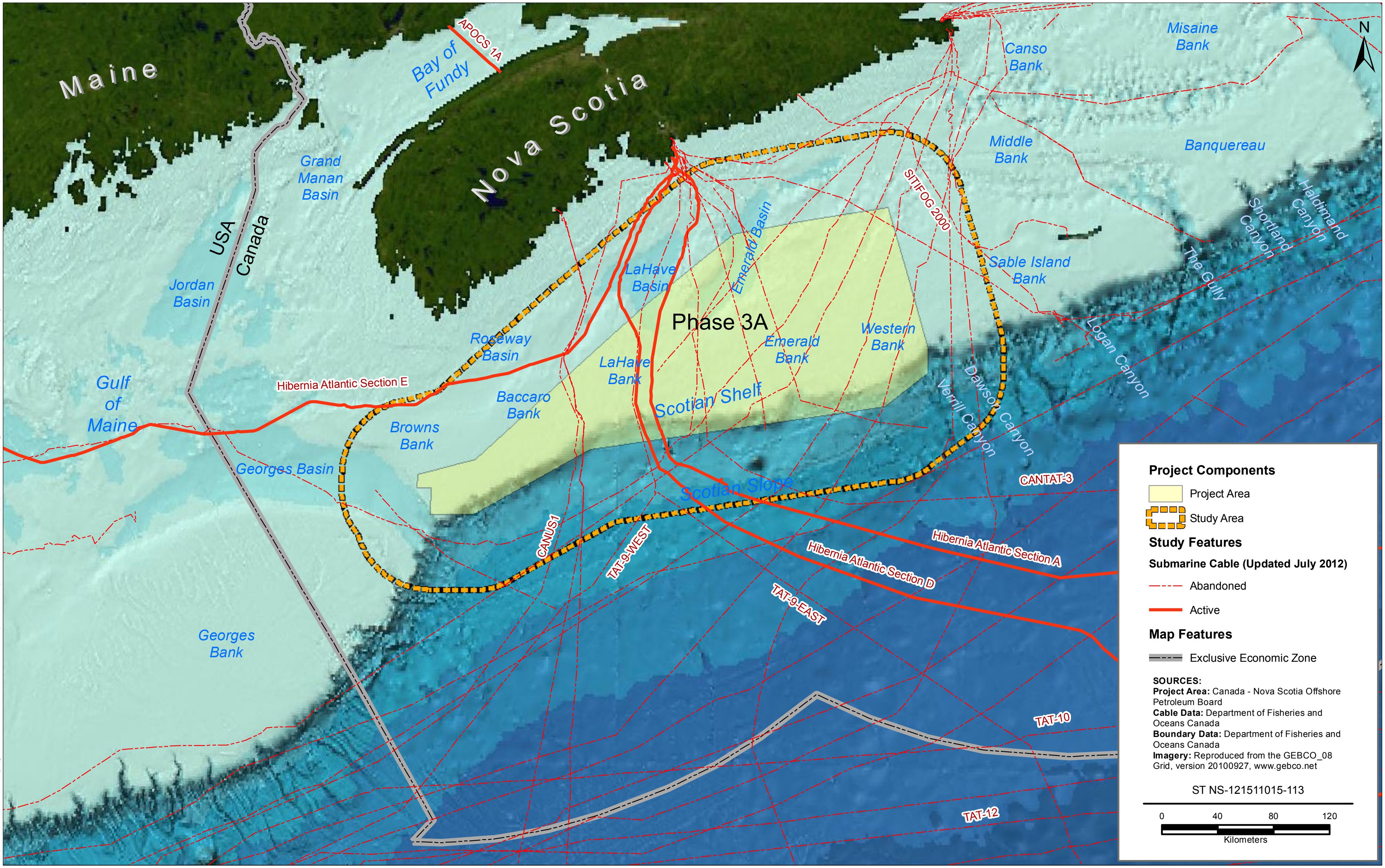
PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.27
REVIEWED BY: C. Shupe		DATE: Apr 21, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Military Exercise Areas**	Stantec

File Path: \\Cd1213-f02\workgroup\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-117_Military_Areas_Phase3A.mxd



PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.28
REVIEWED BY: C. Shupe	**Offshore Petroleum Activities**	DATE: Apr 21, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: \\Cd1213-f02\workgroup\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-127_Hydrocarbons_Phase3A.mxd



PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.29
REVIEWED BY: C. Shupe		DATE: Apr 21, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Subsea Telecommunications Cables**	Stantec

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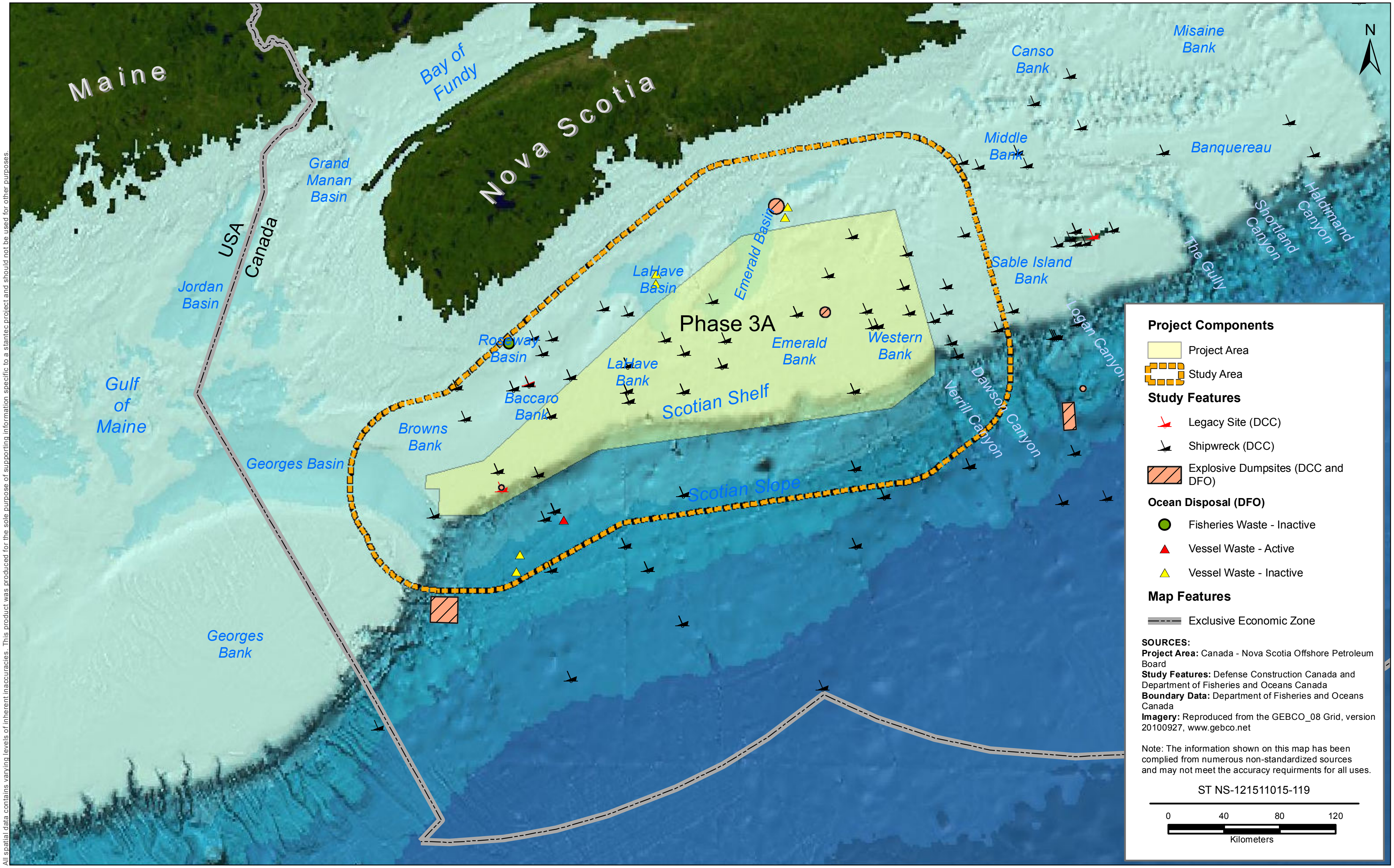

PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 3.30
REVIEWED BY: C. Shupe		DATE: Apr 21, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Shipwrecks and Legacy Sites**	Stantec

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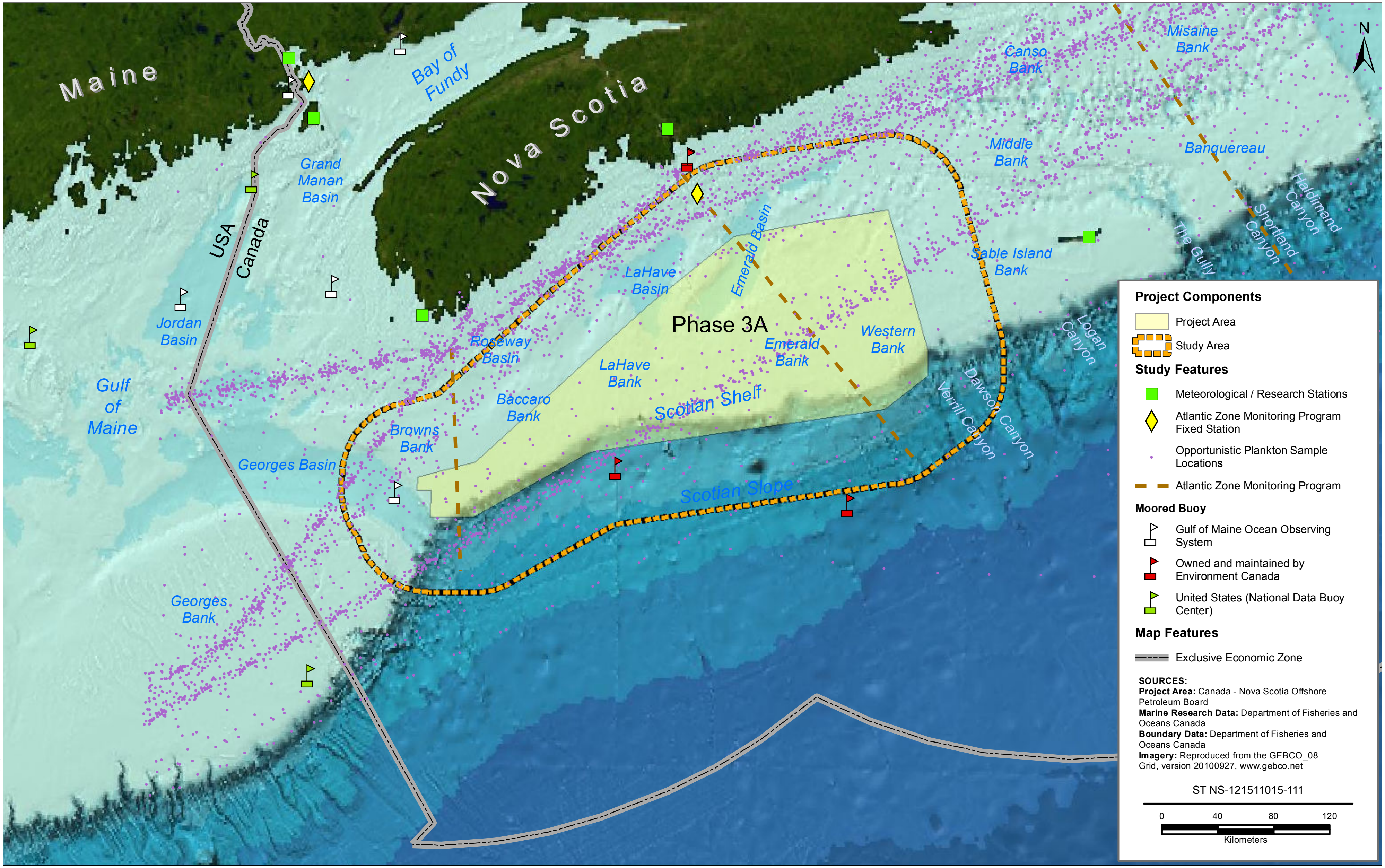

PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C. Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Marine Research Locations

FIGURE NO.: 3.31

DATE: Apr 21, 2014

Stantec

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4.0 Strategic Environmental Assessment Approach

4.1 OVERVIEW OF SEA APPROACH

Environmental assessment is a systematic process for analyzing and evaluating the potential environmental effects of proposed development activities, and is an important means of incorporating environmental considerations into decision-making. Although environmental assessment has traditionally been applied primarily to individual projects, recent years have seen increased interest in its application to policies, plans and programs. SEA expands the scope of environmental assessment to include these earlier stages of the planning process. SEA has been defined by Therivel *et al.* (1992) as:

[T]he formalized, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives...and using the findings in…decision-making.

The federal government's approach to SEA is set out in the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals. The SEA approach is broader and more proactive in assessing and managing environmental effects than traditional project-specific EAs which focus on site-specific issues with defined geographic boundaries. A SEA:

- allows environmental issues to be identified and addressed at the earliest stages of planning, and typically focuses on "regional-scale" environmental concerns;
- can facilitate the consideration of stakeholder issues and concerns early in the planning process, and demonstrates accountability and due diligence in decision-making.; and
- can also help to define the environmental components and potential effects which may require consideration in subsequent project-specific EAs by identifying the key environmental issues associated with a particular sector and/or region.

The CNSOPB's approach to SEA is less broad than the Cabinet directive and more sector-specific (oil and gas exploration). In this particular case, information from the SEA will assist the CNSOPB:

- with respect to potential issuance of future exploration rights within the CNSOPB SEA Project Areas outlined on Figure 1.1; and
- to identify general restrictions or mitigation measures that should be considered for application to consequent exploration activities within this area.

The approach and methods used in this SEA were chosen to help deliver a focused SEA which is useful to both the CNSOPB in its decision making, but also for operators in their future project planning and approval processes.

4.2 SCOPING CONSIDERATIONS

The scope of environmental assessment, including definition of components and activities to be assessed as well as spatial and temporal assessment boundaries, must be established at the outset of the analysis to ensure the analysis remains focused and manageable. A scoping exercise for this SEA was based primarily on knowledge of existing environmental conditions (refer to Section 3), applicable regulatory guidance, results of stakeholder engagement, review of relevant publications and experience of the study team and government reviewers.

4.2.1 Regulatory Considerations

Section 2.1 provides an overview of the regulatory context for exploration activities.

4.2.2 Stakeholder Engagement

Table 4.1 summarizes the regulatory agencies and stakeholder groups which were consulted during the preparation of the SEA either individually or through the CNSOPB Fisheries Advisory Committee (FAC) and key issues or interests raised during discussions.

Table 4.1 Summary of Stakeholder Engagement During SEA Preparation

Name of Organization	Representative	Issues/Comments
Maritime Aboriginal Peoples Council	Roger J. Hunka	Raised issue of Aboriginal Treaty Rights and recommended use of traditional knowledge from Aboriginal fisheries. Also discussed effect of climate change on distribution of pelagic fish species and suggested climate change should be incorporated into the cumulative effects assessment. Recommended SEAs stay high level and serve as a guide, rather than focusing on too much detail that would need to be updated for a project-specific EA anyway.
Fisheries Advisory Committee (FAC)	FAC members	A presentation to introduce the Phase 3 SEAs was made in January 2013. Another presentation was made to discuss the Phase 3A and Phase 3B SEAs in September 2013.
DFO (Maritimes Region)	Melanie MacLean/ Glen Herbert/ Grieg Oldford	Provided spatial and numerical data held by DFO regarding fisheries, marine mammals/sea turtles, and other ocean uses. Comments were provided on the Draft Phase 3A and 3B SEAs, with edits incorporated in the final SEAs as applicable including limitations in scientific data, updated species distributions, forthcoming science reviews, and a cautionary approach to cumulative effects at the SEA level.
Department of National Defence	Kyle Penney/ Nick Sanders	Verified accuracy of operations areas within the Study Area and recommended CNSOPB/operators contact DND on an as required basis for project-specific EAs for review of activities and potential interactions.

4.2.3 Relevant Publications

In addition to relevant regulations and guidelines and stakeholder input, there are several key documents which were reviewed during the preparation of this SEA and informed issues scoping and effects analysis (refer to Section 10 for a complete list of references consulted):

- Strategic Environmental Assessment – Petroleum Exploration Activities on the Southwestern Scotian Shelf (Hurley 2011)
- Environmental Assessment Biophysical Data Gap Study – Petroleum Exploration Activities on the Offshore Scotian Shelf and Slope (Hurley 2009)
- The Marine Environment and Fisheries of Georges Bank, Nova Scotia: Consideration of the Potential Interactions Associated with Offshore Petroleum Activities (DFO 2011a)
- A Synopsis of Nova Scotia's Offshore Oil and Gas Environmental Effects Monitoring Program Summary Report (CNSOPB 2011b)
- Deep Panuke Environmental Assessment Report (Encana 2006)
- Ecologically and Biologically Significant Areas of the Scotian Shelf and Environs: A Compilation of Scientific Expert Opinion (Doherty and Horsman 2007)
- Western Newfoundland and Labrador Offshore Area Strategic Environmental Assessment Update (Draft Report) (AMEC 2013)
- Environmental Assessment of Shell Canada Ltd.'s Shelburne Basin 3D Seismic Survey in Exploration Licenses 2423, 2424, 2425 and 2426 (LGL 2013)

4.3 SCOPE OF THE ACTIVITIES TO BE ASSESSED

The scope of the activities to be assessed in this SEA includes reasonably foreseeable offshore oil and gas exploration activities in the Study Area (refer to Section 2). In particular, the scope of activities to be considered includes:

- seismic surveying (2D, 3D, and 3D WAZ);
- seabed surveying (*i.e.*, geophysical, geotechnical data collection);
- exploratory and delineation drilling and associated activities (*e.g.*, VSP, well abandonment); and
- vessel traffic (supply vessels, seismic vessels, helicopters).

Accidental spills, which may include a seismic streamer break, accidental large spill of diesel, blowout of condensate/oil or SBM release during drilling are considered separately from routine exploration activities.

4.4 SPATIAL AND TEMPORAL BOUNDARIES

Temporal assessment boundaries consider the temporal extent of project activities (*e.g.*, time of year, frequency and duration of project activities). Temporal boundaries for this SEA include consideration of all components and activities that may be associated with exploration programs as described in Section 2. Oil and gas production activities are not addressed in the SEA except to the extent that they may contribute to cumulative effects.

The spatial assessment boundary for exploration activities to be considered in the Phase 3A SEA is shown in Figure 1.1. The Project Area boundary represents the area within which exploration activities could occur. However, it is also important to consider the extent of zones of influence (spatial and temporal extent of effects) when defining assessment boundaries. As outlined in the Operational Policy Statement entitled "The Process for Defining the Spatial Boundary of a Study Area During an Environmental Assessment of Offshore Exploratory Drilling Projects" (CEA Agency 2003), defining a study area requires consideration of the cause-effect relationships between project components or actions and environmental components and the location at which the potential for environmental effects (including cumulative effects) becomes insignificant.

In order to define these extents of influence, it is necessary to consider ecological boundaries on a case by case basis. Ecological boundaries are determined by temporal and spatial scales over which environmental components or populations function. Temporal ecological boundaries take into consideration relevant characteristics of environmental components or populations including:

- trends in natural variation of a population;
- time required for a biological, physical and/or chemical response to an effect to become evident;
- effect recovery time;
- timing of sensitive life history periods; and/or
- timing whereby the species or component remains in the Project zone of influence (Jacques Whitford 2004).

Spatial ecological boundaries are determined by the distribution and movement patterns of the environmental component in relation to the potential zones of influence of the project.

For the purpose of this SEA, the Study Area is defined as a 54 km buffer around the proposed Project Area (refer to Figure 1.1). This buffer was determined primarily by the estimated zone of influence from the worst case scenario of an accidental spill modeled for the Deep Panuke Offshore Gas Development (54 km predicted distance for dispersion of oil cloud from 100 barrel diesel spill) (Encana 2006). Spill trajectory modeling conducted for BEPCo. Canada Company's Environmental Assessment Report for Exploratory Drilling on EL 2407 (deepwater exploration well on Western Scotian Slope) predicted a distance of 37 km for the dispersion of an oil cloud from a

100 barrel diesel spill (BEPCo. 2004). Therefore the 54 km buffer is considered to be a conservative buffer around the proposed Project Area. The Deep Panuke modeling assumed a blowout scenario involving Panuke condensate (density= 775 kg/m^3) and the BEPCo. modeling assumed a Cohasset condensate (density = 790 kg/m^3). Given the physical properties of condensate, the spilled product from a condensate blowout was not predicted to persist or extend as long as was predicted for a batch spill of diesel from the platform, therefore the distance to dispersion for diesel was considered the most appropriate and conservative distance on which to base the Study Area boundaries.

There are no recent modeling results available for a blowout scenario involving crude oil on the Scotian Shelf or Slope as recent exploration drilling and development projects have focused on natural gas. However, a blowout involving crude oil would be considered a worst case scenario (instead of a diesel spill). In the absence of dispersion modeling results for this scenario (a data gap as noted in Section 8), the spatial boundaries for the SEA Study Area are based on the diesel spill modeling described above. As future project-specific oil spill modeling on the Scotian Slope may provide insight on the expected zone of influence from a crude oil spill, this Study Area boundary may be revisited for future SEA updates.

The Deepwater Horizon spill in the Gulf of Mexico has illustrated that worst-case scenarios can result in spills extending much further than 54 km. However, the ocean current profile in the area affected by the Deepwater Horizon spill is very different than that known to occur on the Scotian Shelf and Slope. The Gulf of Mexico currents are much stronger than those documented for the Phase 3 Study Area, including the area of the strongest current speeds where the water travels southwest along the shelf edge. Ocean currents in the Gulf of Mexico can reach speeds of up to 2 m/s (Chang and Oey 2010) while the currents documented around the shelf edge range from 0.05 – 0. 3 m/s (Brickman and Drozdowski 2012). Outside of the Project Area, the currents on Georges Bank range from 0.2 m/s along the edge of the Bank, to 1 m/s over the Bank itself. The 54 km buffer established for the Phase 3A Study Area using the Deep Panuke Offshore Development spill modeling is considered sufficient to include other expected zones of influence (*e.g.*, blowout spills, and behavioral effects of marine mammals, sea turtles or fish associated with seismic noise), and also encompasses Special Areas in the vicinity of the proposed Project Area.

4.5 SELECTION OF VALUED ENVIRONMENTAL COMPONENTS

It is generally accepted that an environmental assessment should focus on those components of the environment that are valued by society and/or which can serve as indicators of environmental change and thus, which have the most relevance to the final decision regarding the environmental acceptability of a proposal (JWEL 2003).

Table 4.2 presents a preliminary screening of issues that was undertaken to identify appropriate Valued Environmental Components (VECs) for the assessment. In cases where an environmental component has not been carried forward as a VEC for assessment, it is generally because experience and research has shown that they are unlikely to be adversely affected by petroleum exploration activities, particularly given implementation of standard mitigation.

Table 4.2 Selection of Valued Environmental Components

Environmental Component	Scoping Considerations	VEC Selected
Atmospheric Environment	It is anticipated that emissions from routine exploration-related operational activities will not cause an exceedence(s) of applicable air quality standards or guidelines. Since there are limited emissions sources and few receptors in the SEA Study Area, and given the short duration of exploration projects, assessment of potential effects on air quality can be excluded from the SEA provided that future licenses holders/operators adhere to: • MARPOL Annex VI, Regulations for the Prevention of Air Pollution from Ships; and • Air Emissions provisions of the Offshore Waste Treatment Guidelines, including provisions for greenhouse gas emissions. However, malfunctions and accidental events (*i.e.*, blowout) may have an environmental effect on air quality. An environmental assessment of the potential effects of air quality as a result of a blowout on selected VECs is the appropriate focus for this assessment rather than "Atmospheric Environment" per se.	Not further assessed as a VEC. Considered in terms of accidental events for Special Areas VEC.
Water Quality	Assessment of the potential environmental effects of discharges from platforms/vessels on water quality during routine exploration activities can be excluded from the SEA provided that future leaseholders/operators adhere to: • Nova Scotia Offshore Area Petroleum Geophysical Regulations; • Offshore Waste Treatment Guidelines; • Offshore Chemical Selection Guidelines; • *Fisheries Act* (Section 36); and • MARPOL 73/78. Compliance with the above requirements involves implementation of standard mitigation and will prevent adverse environmental effects on water quality for routine operations. However, malfunctions and accidental events (*i.e.*, oil spills) may have an environmental effect on water quality. An environmental assessment of the potential effects on water quality as a result of oil spills is considered as applicable for other VECs.	Not assessed further as a VEC. Considered as applicable for accidental spills on other VECs.

Table 4.2 Selection of Valued Environmental Components

Environmental Component	Scoping Considerations	VEC Selected
Fish	Fish species of special status, important feeding, nursery, and/or spawning grounds for fish (*e.g.*, Emerald and Browns Banks), and commercial and Aboriginal fisheries resources are addressed under relevant VECs (Species of Special Status, Special Areas, and Fisheries VECs). Fish species which are not species of special status, don't support fishery resources or other fish species of special status, and are not present in such abundance for a special area to be designated for that species, are excluded from the effects assessment section of the SEA provided that future licenses holders/operators adhere to: • Statement of Canadian Practice with Respect to the Mitigation of Seismic Noise in the Marine Environment (SOCP). The SOCP was developed as a result of an extensive review by federal and provincial government advisors and scientific experts of the most effective and appropriate mitigation measures used world-wide to minimize adverse environmental effects on marine life. Compliance with the SOCP will result in minimization and/or avoidance of adverse residual environmental effects on marine fish and other marine life.	Species of Special Status Special Areas Fisheries (including commercial, recreational and Aboriginal fisheries and species which support these fisheries)
Marine Benthos	Discharges of drilling mud and rock cuttings during exploration drilling can result in burial or toxic effects on the marine benthos. Based on past environmental effects monitoring results and other research studies, these effects are understood to be limited spatially and temporally. However, in recognition of sensitive and/or commercially important benthic species that may occur within the SEA Study Area (*e.g.*, sponges, corals, scallop, and lobster), these effects will be assessed in the Special Areas and Fisheries VECs.	Special Areas Fisheries (including commercial, recreational and Aboriginal fisheries and species which support these fisheries)
Marine Mammals and Sea Turtles	The potential for environmental effects on marine mammal and/or sea turtle Species of Special Status that may occur within the SEA Study Area, as well as those species that may occur in nearby designated environmentally sensitive areas will be assessed under the Species of Special Status VEC and Special Areas VEC respectively. Provided that appropriate mitigation is applied for species of special status, it is not anticipated that exploration activities will have an adverse environmental effect at the population level for secure populations of marine mammals or sea turtles.	Species of Special Status Special Areas
Marine Birds	It is recognized that the attraction of any avian species to lights on platforms/vessels or to flares during drilling operations/well testing, may cause injury or death from collisions or may disrupt migrations. Increased vessel presence may also result in the physical displacement of marine bird species as well as increase the attraction and number of predator species as a result of waste disposal practices. Noise disturbance from seismic equipment may cause direct (*e.g.*, physiological) or	Species of Special Status Special Areas

Table 4.2 Selection of Valued Environmental Components

Environmental Component	Scoping Considerations	VEC Selected
	indirect (*e.g.*, foraging behavior) effects on marine birds. There is also the potential for exposure to contaminants from accidental spills (*e.g.* fuel, oil, streamer fluids) and operational discharges (*e.g.* deck drainage, gray water, and black water). An environmental assessment of the potential adverse environmental effects on avian species of special status (including migratory birds) will be carried out under the Species of Special Status VEC. Population level effects on seabirds, however, are not anticipated. No further assessment of environmental effects on seabirds shall be required, provided that: • The SEA considers the potential impacts of vessel lights/flares and vessel presence on avian species of special status (including migratory birds) and identify any necessary mitigation measures (*i.e.*, should birds land on vessels involved with the project, then implementation of the Williams and Chardine handling protocol brochure entitled "The Leach's Storm Petrel: General Information and Handling Instructions" should be carried out. A permit is required from the Canadian Wildlife Service of Environment Canada to implement this protocol.	
Species of Special Status	Species of Special Status includes consideration of the following species and their critical habitat which may be present in the SEA Study Area and determined to be potentially affected during exploration activities: species designated as at-risk under the *Species at Risk Act* (SARA); species assessed as endangered, threatened, or of special concern by the Committee on the Status of Endangered Wildlife of Canada (COSEWIC) and/or migratory birds protected by the *Migratory Birds Convention Act, 1994*.	Species of Special Status
Special Areas	Designated areas of special interest due to their ecological and/or conservation sensitivities (*i.e.*, marine protected areas, existing or future coral conservation zones, fish conservation areas, *etc.*) could be potentially affected by exploration activities in the SEA Study Area. This VEC includes consideration of the Roseway Basin Area to be Avoided/North Atlantic Right Whale Critical Habitat designation under SARA, the Northeast Channel Coral Conservation Area, fish conservation areas, and ecologically and biologically significant areas (EBSAs) (*e.g.*, nearby canyons, corals and sponges). This VEC also considers the Georges Bank Moratorium Area. The scope of the VEC also includes the inhabitants of the special areas which may not be covered under the Species of Special Status VEC.	Special Areas
Fisheries	Commercial, recreational and aboriginal fisheries (including relevant fish species) that could be affected by exploration activities in the SEA Study Area will be considered. The focus of the assessment of this VEC is on potential disruptions to commercial fishing activities, including aboriginal fisheries	Fisheries (including commercial, recreational and Aboriginal fisheries and species which

Table 4.2 Selection of Valued Environmental Components

Environmental Component	Scoping Considerations	VEC Selected
	interests as applicable, through environmental effects on fisheries resources, displacement from current or traditional fishing areas, or gear loss or damage resulting in a demonstrated financial loss to commercial fishing interests. Key fisheries to consider in the area include groundfish such as cusk, cod, haddock, pollock, halibut, hake (white, red, silver), monkfish, and redfish. Inshore and offshore lobster, crab, and scallop fisheries will also be considered as relevant. Key fisheries on the Slope consist primarily of large pelagics including tunas, swordfish, and sharks.	support these fisheries)
Other Ocean Uses	Other ocean uses (*i.e.*, marine shipping, military use, research surveys, and other petroleum development activities, *etc.*) could potentially be affected by exploration activities. Other than petroleum development activities, other ocean users are expected to have intermittent overlap with potential exploration activities in the SEA Study Area, and effects can be minimized through liaison and early communication of activities to other ocean users. With respect to other petroleum activities in the area which would experience longer term occupation of the area, exploration activities are not expected to interfere with these uses. Communication of planned exploration activities would be considered sufficient mitigation. Other Ocean Uses is considered to be more appropriate for consideration of potential cumulative effects with exploration activities (refer to Section 3.3.4). To the extent that fisheries research surveys may interact with exploration activities, these interactions are addressed under the Fisheries VEC.	Not further assessed as a VEC. Other Ocean Uses considered in cumulative effects assessment (Section 7). Fisheries VEC used to capture interactions with fisheries research surveys.

In summary, the VECs to be assessed in this SEA include:

- Species of Special Status;
- Special Areas; and
- Fisheries.

4.6 POTENTIAL EXPLORATION ACTIVITIES - ENVIRONMENT INTERACTIONS

Table 4.3 considers potential interactions between selected VECs and exploration activities. These interactions are explored in greater depth for each VEC in Section 5, drawing on existing literature and professional knowledge of the Study Team to provide a current understanding of environmental effects and mitigation, indicating data gaps and uncertainties where applicable.

Table 4.3 Potential Environmental Interactions of Petroleum Exploration Activities and Selected VECs

Exploration Activity	VEC			Nature of Interactions
	Species of Special Status	Special Areas	Fisheries	
Seismic surveying	✓	✓	✓	• Interference with fisheries and other ocean uses during routine operations • Underwater noise issues (*e.g.*, hearing loss, behavioural effects, *etc.*) on species of special status, commercial, recreational, and Aboriginal fish species and spawning areas, and species which may be inhabiting Special Areas (*e.g.*, Roseway Basin Area to be Avoided/North Atlantic Right Whale Critical Habitat) • Underwater noise can also result in degradation of habitat quality of Special Areas
Seabed surveying (*i.e.*, geophysical, geotechnical data collection)	✓	✓	✓	• Localized disturbance to marine benthos, potentially affecting benthic species of special status and commercial fish species
Exploratory/delineation drilling, testing (*e.g.*, VSP) and well abandonment	✓	✓	✓	• Attraction (due to lights and/or flares) of bird species of special status and fish species (*e.g.*, swordfish) to platform structures or support vessels • Effects (*e.g.*, smothering, toxicity, reduced growth or reproductive potential) of operational discharges (*i.e.*, drill wastes) on species of special status and commercial fish species, particularly bottom-dwelling fish and invertebrates • Underwater noise issues (*e.g.*, hearing loss, behavioural effects, *etc.*) on species of special status and commercial fish species • Interference with fisheries and other ocean uses (*e.g.*, loss of access due to safety zone)
Vessel traffic (*e.g.*, supply vessels, helicopters)	✓	✓		• Noise disturbance to Special Areas and species of special status depending on proximity of traffic. • Effects on fisheries and other ocean users expected to be negligible given infrequency and short-term nature of traffic
Accidental events	✓	✓	✓	• Effects of accidental events (*e.g.*, large condensate or diesel spill) on all VECs (*e.g.*, contamination, oiling and mortality of biological VECs and fouling of other ocean users' gear)

5.0 Potential Effects of Exploration Activities

This section discusses potential effects of routine exploration activities with accidental events assessed as a separate component. Mitigation and planning considerations are proposed to address potential effects, and data gaps and uncertainties are acknowledged.

5.1 SPECIES OF SPECIAL STATUS

5.1.1 Potential Effects and Existing Knowledge

Potential effects of exploration activities on species of special status include effects on the change in mortality risk (*e.g.*, increases in mortality, impacts on species population level success) and effects on the change in habitat (*e.g.*, displacement from critical spawning, feeding, nursery areas) of fish, marine mammals, sea turtles, and birds of special status (as defined in Section 4.5).

5.1.1.1 Seismic and Seabed Surveys

Seismic surveys use seismic impulses created from a burst of compressed air composed of a positive pressure pulse followed by a negative pressure pulse to gather information about geological structures lying beneath the seafloor (Davis *et al.* 1998; DFO 2011a). The difference in pressure between the positive and negative pulse is peak-to-peak pressure. The average pressure recorded over the course of the pressure pulse is known as the root mean square (rms) or the average pressure. Typical zero-to-peak source levels for exploration seismic arrays are 245-260 dB relative to 1 µPa at 1m. Seismic emissions are categorized as pulsed noise (discharged approximately every 10 seconds at intervals of about 25 m along the survey track) (DFO 2011a).

The rise time is the amount of time required for a sound pulse to reach peak pressure from zero. Physical damage is caused by both peak pressures and rise time. The severity of damage is often related to peak pressure (Davis *et al.* 1998). The intensity of sound weakens as it travels through water as a result of spreading, absorption, scattering, reflection, and rarefaction which is known as transmission loss (TL). When taking about transmission loss underwater it can occur in one of two forms; spherical or geometric spreading loss or cylindrical spreading loss. Spherical spreading loss assumes a uniform environment which is typically found in deep (>2000 m) or mixed waters. Spherical spreading occurs where the range of the receiver from the source (R) is less than the depth of the water column or density layer (R_1). Sound will spread out from a point source as spherical waves and sound will decrease by 6 dB as distance is doubled and by 20 dB when the distance increases by a factor of 10 (WDCS 2004).

Cylindrical spreading loss occurs when a water body is non-homogenous such as in shallow coastal waters (< 200 m) or in stratified water bodies where seasonal thermoclines occur. Under cylindrical spreading loss, sound is reflected or refracted off the sea surface, seabed or off layers of differing densities. Under cylindrical spreading reflected waves combine constructively to form a cylindrical wave front. Cylindrical spreading occurs where the range of the receiver from the source (R) is greater than the depth of the water column or density layer (R_1). Under cylindrical loss, sound intensity decreases by 3dB if distance doubles and by 10 dB when distance increases by a factor of 10. As a result, if there are density gradients in the water column sound can travel much farther than when the water column is mixed and homogeneous (WDCS 2004).

The speed of sound will vary with water temperature, salinity, and pressure (depth), resulting in reflection and/or refraction at water mass discontinuities such as thermoclines or haloclines (Davis *et al.* 1998). The ability to detect sounds produced by seismic exploration depends on the amount of natural or anthropogenic ambient background noise in the surrounding waters. If the background noise is high, the seismic noise will not be as detectable at greater distances than when compared to quieter background levels. In general the open ocean is a naturally noisy environment with sources including wind, surf, thermal noise, precipitation, ship traffic and biological sources contributing to background noise levels.

Key issues of concern related to effects of seismic and seabed surveys on species of special status include potential physiological and behavioral effects on fish and marine mammal species, which may affect mortality risk or have negative population level effects.

Physiological and Behavioral Effects on Fish Species

At very close range, seismic noise can affect the fitness and survival of fish and invertebrates causing abnormal development and possibly mortality to eggs and larvae (refer to Section 5.1.1.1). These acute effects have only been observed at distances less than1 5 m from the air gun, with more frequent and severe effects occurring at the distances less than 1.5 m (Dalen *et al.* 2007; Payne 2004). Payne *et al.* (2009) exposed capelin and monkfish eggs to seismic sound with SPLs of 199 to 205 dB re 1 µPa. Conclusions from this study determined that there was no difference in mortality between control and exposed eggs. Booman *et al.* (1996) exposed various life stages (egg to fry) of commercially important North Atlantic fish to SPLs of 220-242 dB re 1 µPa which corresponded to distances of 0.75 to 6 m from the airgun. The study showed that some injury and mortality occurred, but only at distances which were close to the sound source (<15 m). Since the majority of the fish species of special status that are likely to be present in the Study Area are demersal, the likelihood of seismic sound impacting fish in the developmental stage due to close proximity is expected to be minimal due to large distance between the air gun and any young fish and or eggs/larvae. Although a large portion of the species at risk in the area have eggs and or larvae which are found on the sea floor or close to it, a few species have eggs and larvae which are pelagic in nature (DFO 2011a). Redfish species have eggs which are pelagic in nature and are usually found at mid-depths within the water column. Cod and cusk also have pelagic eggs which can be found in the mid to upper water column and have the potential, although slight, to be impacted by seismic exploration.

Saetre and Ona (1006) used a mathematical model,study applying a “worst-case scenario” to investigate the effects of seismic noise on the eggs and larvae of fish and concluded that the mortality rates caused by the exposure to seismic noise were so low in comparison to the natural mortality, that the impacts of seismic noise on the recruitment of a fish stock is insignificant.

There is evidence that damage could be done to fish from lower sound levels. Damage to fish hearing organs in adult fish has been reported by McCauley *et al.* 2003 (DFO 2011a). McCauley experimented on caged fish and subjected them to repetitive firing of air guns (similar to seismic surveys), which resulted in damage of the sensory hair cells of the inner ear after 18 hours of exposure. Damage to these animals was severe, and they did not regain damaged cells after 58 days (DFO 2011a). The peak noise levels involved were 180-190 dB root mean square (RMS), which corresponds to sound levels that would be encountered less than 500 m from the source. The animals in this experiment were caged and could not act upon their natural avoidance response, which would reduce exposure levels. Due to the fact that most fish species will swim away from the sound source as a natural flight avoidance response, it is unlikely that any noise damage from seismic surveys would be permanent or severe.

To date, there have not been any documented cases of large-scale fish mortality due to exposure to seismic sound under regular operating conditions. Seismic noise does have the potential to elicit short term impacts on fish including startle responses, changes in swimming patterns, and changes in vertical distribution (Worcester 2006, cited in DFO 2011a). These short term effects have been observed up to a radius of 30 km. If these fish are swimming to a spawning ground or are spawning during the time of seismic exploration, spawning success could be impacted. If a seismic program is underway, fish may expend more energy on travel and avoidance than on spawning activities or may even delay spawning, which could impact year class sizes and recruitment.

The study of noise and how elasmobranchs hear auditory cues has been limited, to five species (none of which are found in the Study Area): nurse shark (*Ginglymotoma cirratum*), yellow stingray (*Urobatis jamaicensis*), lemon shark (*Negaprion brevirostris*), horn shark (*Heterodontus francisci*), and the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) (Casper *et al.* 2012). Elasmobranchs do not possess a swim bladder or air-filled cavities. As a result of this, it is assumed that they are incapable of detecting sound pressure. They are only thought to be able to perceive the particle motion portion of sound (Casper *et al.* 2012). The hearing threshold for elasmobranchs is in the range of 20 – 1000 Hz, with similar thresholds in species above 100 Hz (Casper and Mann 2009). It is thought that the pelagic species have more sensitive hearing which is important for prey detection, as compared to demersal species which likely use lateral line detection and electroreception to find buried prey (Casper *et al.* 2012.) It has been discovered that elasmobranchs are not as sensitive to sound when compared to teleosts (bony fish). The hearing range of elasmobranch species falls within the output range of seismic arrays. Although their hearing abilities are less sensitive to those of teleost fish. As a result, any effects from seismic and seabed surveys would be expected to be less than those experienced by most fish species.

Elasmobranch fish have been around for hundreds of millions of years with very little evolutionary change, although the extent of their hearing abilities are limited to a few species. The general understanding of their hearing abilities suggests that they have a relatively narrow hearing range, with a relatively poor hearing sensitivity, when compared to teleosts (Casper *et al.* 2012). As a result, there is a limited knowledge pertaining to the hearing abilities of elasmobranch species, which makes it difficult to evaluate the potential effects associated with exposure to anthropogenic nose.

Physiological and Behavioral Effects on Marine Mammals

The effects of seismic noise on marine mammals are not fully understood, although possible effects are thought to include: masking of conspecific sounds; increased stress levels; change in vocalizations; change in behavior which may include avoidance of affected habitat; and temporary and/or permanent hearing damage (Richardson *et al.* 1995; Hildebrand 2005; Weilgart 2007; DFO 2011a; Dalen *et al.* 2007). Temporary Threshold shift (TTS) can occur when an animal is briefly exposed to loud sounds which temporarily increase the hearing threshold of an animal (Davis *et al.* 1998). Normally this effect is temporary and reversible. Prolonged exposure to continuous loud sound can cause permanent hearing damage. TTS is important to consider due to the fact that some marine mammals, particularly seals, do not avoid seismic arrays.

Alterations in swimming behaviour including diving and foraging behaviours could potentially produce acute physiological effects from gas exchange problems as a result of repetitive shallow dive patterns (Zimmer and Tyack 2007). The extent of each of these effects varies depending primarily on species type, noise level/proximity to seismic source, and pre-disturbance activity of the marine mammals when exposed to the seismic sound (Dalen *et al.* 2007).

Mysticetes (*e.g.*, blue, fin and North Atlantic right whales) produce a variety of communication sounds in the very low frequency range (<100 Hz) and can hear sounds in the low frequency range (<1000 Hz), which falls within the range of seismic activity (Clark and Gagnon 2006, cited in DFO 2011a). Low frequency noise associated with seismic activity may interfere with vocalizations in areas of ecological importance and/or biological significance. Blue whales have been documented changing vocalization patterns and frequencies during seismic surveys (Di Loro and Clark 2009, cited in DFO 2011a). Although little is known about the hearing of mysticetes (baleen) whales, it is assumed they are sensitive to low to medium frequency sounds (Dalen *et al.* 2007).

A recent study on the West coast of Canada conducted by Williams et al. (2013) demonstrated how anthropogenic noise can greatly reduce the ability and range of cetacean communication. Most substantially affected, were cetaceans that rely on low and mid frequency communication. Under natural chronic ocean noise fin whales only lose less than one percent of their communication space. Humpback whales can lose 80 to 94 percent of their communication space within the 71 to 708 Hz communication range in the noisiest environments and 35 to 52 percent in moderate environments (Williams *et al.* 2013). Killer whales in British Columbia were shown to lose up to 97 percent of their communication space compared to the quietest natural conditions in the mid frequency range (1.5 to 3.5 kHz).

A study on the effects of seismic noise on humpback whales was conducted in which the distribution of whales was documented during seismic activity (McCauley *et al*. 2000b). Pods of humpbacks were monitored aerially and were found to be distributed uniformly across depth contours, with no evidence that whales were displaced by seismic activity. Recorded observation data showed no differences between the number of whales sighted per observation block with or without the air guns turned on. Although when this data is broken down by range, it was noted that there was an increased number of whales found within 3 km of the seismic ship when its guns were turned off than when they were turned on. As a result there seemed to be some avoidance of seismic ships when they were operational. This avoidance and displacement from continuously operating seismic vessels could have varying effects based on whether the animal is simply migrating or situated in important habitat (McCauley *et al*. 2000b). For example, if seismic activity is occurring in areas where calves are feeding when they are young as well as relatively weak and vulnerable, the avoidance response could be considerably more serious than when whales are simply migrating.

Malme *et al.* (1985), found that humpback whales occupying their summer feeding grounds in Alaska did not show persistent avoidance patterns when exposed to air gun arrays. Some of the whales displayed startle responses at received levels of 150-169 dB re 1 μPa. The study concluded that there was no clear avoidance, although there were some subtle behavioural side effects at received levels up to 172 dB re 1 μPa. In the Northwest Atlantic, Moulton and Holst (2012) reported that there were significantly lower sighting rates and reported whales swimming away from active air guns, as compared to when the airguns were not active. In this study, blue, minke, and fin whales where all noted to keep a greater distance from seismic ships while the airgun arrays were operational.

Blue, sei, and minke whales, have often been seen in areas where seismic surveys are ongoing and operational (Stone and Tasker 2006). Studies conducted during seismic surveys in the U.K. from 1997 to 2000 suggest that under good visibility, sighting rates for mysticetes (primarily fin and sei whales) were similar when air gun arrays were operational versus silent (Stone 2003; Stone and Tasker 2006). These whales did however, show localized avoidance and remained at significantly farther distances when the array was operational.

Odontocetes (toothed whales) (*e.g.*, long-finned pilot whale, Northern bottlenose whale, Sowerby's beaked whale, and sperm whale) appear, in general, to be more sensitive than mysticetes to seismic sound and tend to show the strongest lateral distance/avoidance, moving out of the immediate area (Stone and Tasker 2006, cited in DFO 2011a) while mysticetes and killer whales demonstrated more localized avoidance to seismic noise (*i.e.*, orient themselves away from the noise but do not leave the area). However, there have also been observances of dolphins swimming close to air gun arrays (*e.g.*, 50 m and 2 km of seismic vessel during shooting) (Duncan 1985, Stonach 1993, cited in JWEL 2003).

Studies have shown that the harbour porpoise displays avoidance behaviour to seismic operations. During seismic operations in Washington state, the harbour porpoise was the species affected by the lowest received airgun sound (< 145 dB re 1 μPa_{rms} at a distance of > 70 km)

(Bain and Williams 2006). During seismic operations from 1997-2000 in the U.K., harbour porpoises showed statistically significant differences in directions traveled during periods when the airguns were operational than when they were not (Stone 2003; Stone and Tasker 2006).

There are practically no specific data on responses of beaked whales to seismic surveys, but it is likely that they exhibit strong avoidance patterns. Most beaked whales avoid approaching vessels (Würsig *et al.* 1998) in general and may also dive for extended periods of time when approached by a vessel (Kasuya 1986). As a result, it is likely that beaked whales would show avoidance to seismic vessels, although this has not been documented to date. There is increasing evidence that strandings of beaked whales can be caused by sonar (Barlow and Gisiner 2006; D'Amico *et al.* 2009; Filadelfo *et al.* 2009). It is unknown if seismic surveys can cause the same effect as there is no conclusive evidence of this (LGL 2013).

Proposed thresholds for behavioral responses and auditory damage or other physical injury for cetaceans have been identified at sound pressure levels of 160 dB rms (root mean squared) and 180 dB rms, respectively (Compton *et al.* 2007). An assessment of seismic noise on cetaceans conducted for the Shelburne Basin 3D Seismic Survey predicted that baleen whales (including the North Atlantic right whale) and odontocetes (including the Northern bottlenose whale) would have to occur within less than 30 m from the operating airgun array to experience hearing impairment (198 dB SEL criterion for Permanent Threshold Shift). Behavioral or disturbance effects were predicted to occur within approximately 8-26 km from the operating air gun array, based on a 160 dB rms isopleth (LGL 2013).

The Study Area contains critical habitat for the North Atlantic right whale and hosts several other cetacean species at risk (refer to Section 3.2.5). Although there is a lack of data on right whale response to seismic noise, based on predicted noise modeling results and expected avoidance behavior, hearing impairment effects on the endangered North Atlantic right whale are not likely to occur. Depending on the proximity of the air gun array to the critical habitat and the timing of the survey, disturbance effects (*e.g.*, displacement from feeding and socialization area) could occur, having negative effects on this endangered population if not managed. Mathews *et al.* (2014) have confirmed that the North Atlantic right whale uses the Roseway Basin for critical life periods including feeding and mate selection. More than 30 percent of all right whales use the Roseway Basin throughout the year. This area is critical for population success. The displacement of right whales from the Roseway Basin, for prolonged periods, due to anthropogenic influences could have potentially significant adverse environmental effects on individuals and the population as a whole.

Although critical habitat for the endangered Northern bottlenose whale is located outside the Study Area, this species does occur in the Study Area, primarily along the shelf break, and could be affected by air gun array noise. The maximum acoustic energy from seismic arrays is in the 20-160 Hz frequency range, which is substantially lower than the peak hearing range for Northern bottlenose whales (which has been predicted and assumed from their vocalization range). Seismic arrays produce significant acoustic energy in the 1-20 kHz range which overlaps with the hearing range of beaked whales (DFO 2010c). Deep diving species may be more sensitive to seismic noise due to the fact that sound may concentrate in water layers at depth and as a result travel farther. Further study is needed on the responses of deep diving cetacean species such as the Northern bottlenose whale in response to anthropogenic sound sources. There have been no documented cases of harm or mortality to Northern bottlenose whales in Canadian waters due to ocean noise (DFO 2011c).

An indirect effect on odontocetes in the Study Area, particularly the Northern bottlenose whale, and Sowerby's beaked whale is the effect of seismic exploration on their main prey item, squid. Trials with caged animals showed a startle and avoidance response in the squid (McCauley *et al*. 2000). When the air guns were activated, the squid emptied their ink sacs and jetted away from the sound source, staying in the furthest part of the cage from the source as possible (McCauley *et al*. 2000). The responses in caged squid suggest that behavioural changes and avoidance to seismic operations would occur at some range of sound pressure. As an important part of the food chain for many top predators in the Study Area, the avoidance of squid could have impacts on many whale populations in the area, depending on how long they avoid a given area (McCauley *et al*. 2000).

In 2003 the Gully Seismic Research Program was undertaken by multiple Canadian and international agencies to observe marine mammals before, during and after exposure to seismic exploration in the Gully and adjacent shelf edge (Lee *et al.* 2005). Marine mammals including endangered species such as the blue whale or Northern bottlenose whale were still observed during the Marathon or Encana seismic programs that took place during this study (Lee *et al.* 2005), although marine mammals avoided the seismic arrays at close ranges (<100 m) and appeared to be less vocal when seismic sources were active (Potter *et al.* 2005). It should be noted that that the results from Lee *et al.* (2005) provide data on species presence and behaviour during seismic surveys, however data was not collected before or after the seismic vessels were present. As a result, direct comparisons of cetacean behaviour before, during, and after the seismic operation could not be made. Several peer-reviewed papers resulted from this monitoring study (Cochrane 2007; Gosselin and Lawson 2004; Lee *et al*. 2005; McQuinn and Carrier 2005; Potter *et al.* 2007; Thomsen *et al.* 2011), although it remains that very little was learned about whale behavior in the presence of active seismic programs.

There have been no documented cases of marine mammal mortality or injuries as a consequence of seismic surveys (Dalen *et al.* 2007). However, as noted by DFO (2011a), detrimental effects suffered by one species at risk can translate into detrimental effects on the population therefore behavioral effects noted above should not be overlooked as inconsequential. To prevent species and population level effects on marine mammals, mitigation measures for any seismic activities in proximity of cetacean critical habitat should be evaluated during project-specific EAs. Season-specific acoustic modeling and/or other enhanced mitigation measures at the project-specific level may be identified.

Physiological and Behavioral Effects on Sea Turtles

There is relatively little research on effects of seismic activities on sea turtles. Available information indicates that turtles hear at low frequency range similarly to seals (*e.g.*, 100-900 Hz (Office of Naval Research website 2002; Environment Australia 2003; Ketton and Bartol 2005), with measureable age and species variations in response to underwater sound (Ketton and Bartol 2005). Ketton and Bartol (2005) observed a size/age difference in hearing range for loggerhead and green sea turtles, with smaller younger individuals having a greater hearing range than larger, older individuals. Martin *et al.* (2012) demonstrated the loggerhead turtle to have low frequency hearing with the best sensitivity between 100 and 400 Hz. Dow Piniak *et al.* (2012) determined that leatherback sea turtle hearing sensitivity overlaps with frequencies and source levels that are produced by low-frequency anthropogenic sources including seismic source arrays, offshore drilling, and vessel traffic.

Studies to date indicate that seismic surveys have short term effects such as a change in hearing sensitivity (Moein *et al.* 1994; McCauley *et al*. 2000), behavioural effects (*e.g.*, increased and erratic swimming behavior; McCauley *et al*. 2000) as well as physiological responses. Certain levels of exposure to low frequency sound may cause displacement from areas near the sound source and increased surfacing behaviour. This exposure could potentially lead to displacement from preferred foraging areas (Atlantic Leatherback Turtle Recovery Team 2006).

There remains however, a lack of research on the acoustic sensitivity of sea turtles and on the importance of the acoustic environment on sea turtles. There is little evidence to suggest that sea turtles would be more sensitive to seismic sound than cetaceans or fish. Therefore, mitigation implemented to protect those marine animals would also serve to protect sea turtles from harmful effects (DFO 2011a). It should also be noted that sea turtles are slow swimmers, meaning that the time taken to avoid seismic exploration vessels is greater than other species in the Study Area.

As noted by DFO (2011a), an added risk for sea turtles is potential entanglement in seismic gear. Although some work has been conducted to develop mitigation measures (*e.g.*, turtle exclusion devices), the effectiveness of these measures is not well known.

Physiological and Behavioural Effects on Marine Birds

There is sparse baseline data available for the evaluation of effects of oil and gas activity on seabirds at sea in the Northwest Atlantic (Wiese *et al.* 2001). Available studies focus primarily on established drilling platforms, with a lack of data specific to exploration-based seismic surveys. The exploration phase of oil and gas activities is shorter than fixed platform operations and therefore, the effects are likely to be relatively short in duration. Additionally, seismic surveys use moving vessels, not stationary platforms. Therefore, the greatest potential for effects on marine birds from seismic and seabed surveys results from noise disturbance (*e.g.*, underwater noise from air guns).

The sound created by air guns is focused downward below the surface of the water. Above the water, the sound is reduced to a muffled shot that should have little or no effect on birds that have their heads above water or are in flight. The nature of a seismic and seabed survey program will result in only temporary incremental increases in ambient noise and disturbance from the vessel in any one area. While it is possible that diving birds within close range of the seismic activity associated with surveys could be startled by the sound, the presence of the ship and the associated seismic equipment in the water will have already indicated unnatural stimuli to any birds in the vicinity (LGL 2005b). As well, the air guns will undergo a ramping-up process, which encourages birds to move away from the noise source before it reaches maximum volume. It is unlikely that non-diving birds would be affected by the underwater noise of air guns.

There have been reports of no effects from seismic surveys on certain seabird behaviours. For example, a study on the effects of seismic surveys on moulting long-tailed ducks in the Beaufort Sea found no effects on their movement or diving behavior (Lacroix *et al*. 2003); however, the authors did note that their study did not have the ability to detect more subtle disturbance effects. Overall, a precautionary note must be applied to any environmental interactions and effects discussion with respect to the effects of sound emissions on marine birds. Scientific and data gaps associated with the environmental effects of sound emissions limit the degree of certainty associated with environment effects predictions.

There is a small potential for attraction of seabirds to vessel lights during the relatively short operation period of seismic vessels. Birds stranded on seismic vessels as a result of attraction and/or disorientation should be handled using the instructions outlined in Williams and Chardine's protocol, "The Leach's Storm Petrel: General Information and Handling Instructions", including the associated permit. Adhering to the permit conditions and following the established stranded bird handling protocol should help to mitigate effects associated with vessel lighting. The potential interaction between seabirds and vessel lighting is further discussed in Section 5.1.1.2.

5.1.1.2 Exploratory Drilling

The main concerns related to routine exploratory drilling are related to: discharges of drilling mud and rock cuttings and their burial and toxic effects on seabed fauna; seabird attractions with highly-illuminated drilling rigs and incineration during flaring/well testing; and drilling noise effects on marine mammal species of special status (accidental spills are discussed separately). Project-specific EAs will take into consideration drill waste dispersion.

Potential effects of drilling discharges on fish relate to potential lethal or sublethal effects. Discharge of drilling muds and cuttings can result in smothering of benthic species and health effects as result of chronic exposure of bentonite, barite or other drilling fluid components. Effects of drilling waste discharges on commercial fish species are discussed in Section 5.3.1.2. There is predicted to be negligible effects of drilling waste discharges on fish species of special status which may occur within the Study Area.

Compliance with Section 36 of the *Fisheries Act* prohibits the deposition of a deleterious substance into waters frequented by fish, which also serves to protect seabirds in the marine environment. Further, Section 5.1 of the *Migratory Birds Convention Act* prevents the deposition of oil, oil wastes and other substances harmful to migratory birds. Attraction can result from food and sanitary discharge as birds are drawn by an increase in attracted prey (Burke *et al.* 2012).

Artificial light has also been known to attract and influence seabirds, which are highly visually oriented and can become disoriented at night in the presence of artificial light. Artificial light from drilling rigs and flares can attract birds depending on the weather, season, age of the birds and the lunar phase, which can lead to collisions, incineration and mortality (Montevecchi 2006). Night-flying birds such as storm-petrels can be particularly attracted to vessel lighting (LGL 2005b). Birds may become disoriented and fly into vessel or platform lights or infrastructure, injuring themselves and therefore becoming stranded. To help mitigate this effect, lighting can be limited primarily to nighttime operations, when lighting is used for both navigational purposes and for safety. Other low-light conditions will also prompt vessel lighting, leading to increased potential for seabird attraction. For example, it has been suggested that seabird disorientation occurs most frequently during periods of drizzle and fog (Wiese *et al*. 2001). Moisture droplets in the air, during conditions of drizzle and fog, refract the vessel's light and greatly increase the illuminated area, thus enhancing the attraction (Wiese *et al*. 2001).

A Norwegian study on bird impacts associated with offshore drilling has shown that the impact of flaring on flocks of birds is small and is only considerable at night during migration periods (Ospar Commission 2007). It was found that sound associated with drilling did not affect bird migrations and that 10% of birds were affected by light emitted from the main deck of offshore oil installations. With proper mitigation (minimization of flaring and reduction in horizontal light emission) the impacts of exploratory drilling on birds at risk is considered to be minimal. Seabird monitoring as part of the SOEP EEM has shown little to no effect on birds transiting to and from Sable Island or the Scotian Slope (CNSOPB 2011b). A standardized protocol for monitoring seabirds is provided in Appendix C.

Drilling noise can potentially cause a temporary avoidance of an area by marine species of special status. Continuous noise generated by a drill rig may cause prolonged avoidance by some demersal fish species from the immediate area (*e.g.*, up to 400 m) (ICES 1995, cited in JWEL 2003). Thompson *et al.* (2000) reports avoidance from a drill rig is expected to be limited beyond 100 m whereas avoidance from a drill ship may range from 1 to 10 km. The North Atlantic right whale is one species known to exhibit long distance avoidance behavior. The effect of drilling noise on marine mammals of special status is considered to be temporary and reversible (Davis *et al.* 1998). To prevent adverse effects on marine mammals, mitigation measures for any drilling activities in proximity of cetacean critical habitat (the Roseway Basin) will be evaluated during project-specific EAs. Season-specific acoustic modeling at the project-specific level may be required on a case by case basis.

5.1.1.3 Vessel Traffic

Vessel traffic is likely to increase as a result of seismic and exploratory drilling operations. An increase in vessel traffic may have impacts on marine mammals and bird species.

An increase in vessel traffic has the potential to increase the amount of artificial light within the Study Area which could potentially attract migrating seabirds. Nocturnal disturbance from light may lead to increased opportunities for predators, collisions due to attraction to vessels, exposure to vessel based threats and the disruption of natural conditions (CWS, pers. comm. 2012). Increased vessel presence during seismic surveys and exploratory drilling may physically displace migratory birds from foraging grounds for short periods of time (CWS, pers. comm. 2012). Increased vessel presence may also lead to the increase in and/or the attraction of predator species due to waste disposal practices from vessels. Sanitary and food wastes disposed in the marine environment could attract species which prey on migratory birds. The number of additional vessels associated with exploration should not substantially affect mortality rates due to collisions with lit vessels as the vessel increase will be temporary and nominal compared to existing traffic in the Study Area. With proper mitigation, including adherence to CWS protocols for handling stranded birds (*e.g.*, *Migratory Birds Convention Act* permit conditions, and Williams and Chardine's protocol), the effect of additional vessels within the Study Area should be minimal on bird species of special status.

Historical data has been examined from 1885 to 2002 with regards to vessel strikes on marine mammals. Vessel strikes have been known to be a large cause of marine mammal mortality. As a result, an increase in vessel traffic due to oil and gas exploration could potentially increase the number of mortalities of marine mammals due to vessel impacts. The most frequent species affected by vessel strikes are:

- Fin whales;
- Humpback whales;
- Gray whales; and
- North Atlantic right whales.

The North Atlantic right whales are the species most affected by vessel strikes, with mortalities being twice as frequent as any other whale species (Vanderlaan and Taggart 2006). It is expected that the species will be extinct within 200 years unless anthropogenic induced mortalities are reduced. Right whales tend to be easily injured because they are slow moving, and have a low profile in the water. Results have shown that reducing vessel speed can reduce the number of deaths by vessel impact. As a result, speed limits may be warranted in highly populated and important habitat areas.

Increased vessel presence will increase levels of noise below the 1 kHz range (Wright 2008). Increased ambient noise can mask biologically significant sounds. For example, masking can result in the disruption of breeding in animals that use sound during mating and reproduction, and disruption of foraging in animals that use sound to detect prey. Increased noise can also mask important acoustic environmental cues that animals use to navigate and to detect predators (Wright 2008). The greatest potential for masking exists for marine mammals that produce and perceive sounds within the range produced from vessels. Baleen whales will be the most susceptible to increased levels of noise below the 1 kHz range. Recent studies on North Atlantic right whales indicate that these species will adjust their vocalizations in the presence of vessel noise (Wright 2008). Some species can alter their communications to avoid being masked by anthropogenic sounds, although these alterations are not optimal behaviour for these species. It is thought that these alterations are costly for the survival and reproductive success of marine mammals.

The Study Area falls within feeding and migratory paths of some marine mammal species; however, the increase in number of vessels due to exploratory operations is not expected to be substantial. With proper mitigation (avoidance of the Roseway Basin Area), the impact of vessel traffic on marine mammals is not expected to be a major concern.

5.1.1.4 Well Abandonment

There is little predicted interaction with species of special status during the mechanical separation of wellheads from the seabed. However, if blasting is required for wellhead removal there could potentially be serious effects, including mortality, on fish, marine mammals, and sea turtles. However, these effects can be avoided with the implementation of mitigation which involves monitoring of the blast site and delay of detonation until observed marine mammals and sea turtles are more than 1 km away from the blast site. A charge detonated below the seafloor will have an initial rate of increased pressure that is more attenuated than an explosion in the water column. Most of the initial shock pulse and energy from the explosion will be absorbed by the seafloor. It is not expected therefore that well abandonment activities will have a substantial effect on Species of Special Status in the Study Area.

5.1.1.5 Accidental Spills

Accidental spills, although unlikely to occur, are the most likely element of exploratory activities to result in significant adverse effects on marine life. Spill scenarios can include, but not necessarily be limited to: a spill from a broken streamer during a seismic survey; subsea or surface blowout during drilling; loss of drilling fluid during drilling; or batch spill of diesel or condensate from a drill rig or vessel. Although a batch spill of crude oil or diesel is most likely to have the most far-reaching detrimental effects, even a small spill can result in adverse effects on marine life, particularly for bird species of special status.

In the event of a spill, chemical dispersants are often used to remove oil from the water's surface (Adams *et al.* 2014). The dispersion of oil increases the concentration of petroleum hydrocarbons in the water column and at the same time increases the rate of decomposition through dilution and biodegration. Advancements in dispersant formulas have decreased their toxicity, but have shifted the concern from the toxicity of the dispersant itself to the toxicity of the dispersed oil mixtures. Adams *et al.* (2014), exposed both Atlantic herring embryos as well as rainbow trout embryos to chemically dispersed crude oil. Atlantic herring embryos exposed to dispersed oil experienced delayed development as well as edema. Embryos which have delayed development may be less viable in a natural environment and as a result subject to high rates of predation. Similar responses were also found for the embryos of rainbow trout. The study concluded that the toxicity of the petroleum hydrocarbons did not change with chemical dispersion. In fact, chemical dispersion of oil increases the bioavailability of petroleum hydrocarbons by increasing the surface area to volume ratio of oil droplets and the rate of partitioning of hydrocarbons from droplets into aqueous solution (Adams *et al.* 2014).

With respect to fish, alterations in fish larvae mortality have been documented with increasing concentrations of oil contaminants in the surface microlayer (DFO 2011a). Sublethal effects on fish can include changes in biochemical responses of enzyme systems, increased frequency of histopathological changes and diseases in bottom fish, and degradation of ichthyoplankton communities in response to oil contaminants. Spawning events of fish are generally restricted in time and place; as a result there can be impacts on year class strength if a spill coincides with a spawning event. A number of studies have shown that the presence of oil can have both lethal and sublethal effects (reduced growth and abnormal development) in eggs, larvae and juveniles. The effects of oil on mature fish are difficult to study in the field as they have the ability to avoid a spill, provided the area is small enough. As a result, fish can mainly be affected by spills from the egg stage until maturity and full mobility is reached.

Marine mammals can be affected by an accidental spill in several ways depending on the scale and nature of the spill (Marine Mammal Commission 2011) including:

- The oil (or other product), its metabolites or dispersants through direct contact, ingestion or inhalation;
- Injury and/or disturbance from spill response activities; and
- Short and long-term ecological changes resulting from the spill and response efforts.

The exposure to oil and its metabolites is known to be harmful to marine mammals. Inhalation of by-products can cause respiratory irritation, inflammation, or emphysema (Marine Mammal Commission 2011). The ingestion of oil may cause gastrointestinal inflammation, ulcers, bleeding, diarrhea, or maldigestion. Certain inhaled or ingested by-products may cause damage to organs such as the liver, kidneys, adrenal glands, spleen or cause reproductive failure. Chemical contact can cause skin and eye irritation, inflammation, burns to mucous membranes, mouth and nares, or increased susceptibility to infection. Oil can also physically foul the baleen of mysticetes whales, which can inhibit feeding.

Response activities to contain and remove oil can also impact marine mammals. The increased marine and air traffic associated with a large spill can disrupt foraging, habitat use, daily and migratory movements and behavior. The increased vessel traffic as mentioned above can have the potential to increase vessel strikes. Oil spills can indirectly affect marine mammals in the area by altering the marine ecosystem and the key features of their habitat such as contamination, shifts and reduction in prey biomass (Marine Mammal Commission 2011).

Marine birds are extremely vulnerable to the effects of oil pollution. Feathers readily absorb oil, decreasing their ability to insulate birds from the cold, and reduce their waterproofing and buoyancy abilities. Contact with a small amount of oil can lead to death through hypothermia and starvation. Seabirds can also die from ingesting petroleum products while preening their feathers. During certain times of year large numbers of birds congregate while migrating. If an oil or fuel spill were to occur in these locations at times where large numbers of birds are congregated (*e.g.*, Georges Bank), the global population of the species could be greatly affected (DFO 2011a).

Site specific spill probability and fate modeling would be required for a project-specific EA to determine the risk of potential effects on species of special status.

5.1.2 Mitigation and Planning Considerations

Table 5.1 summarizes mitigation and planning considerations to mitigate potential effects of exploration activities on species of special status such that residual effects would be considered to be minor, short-term and localized.

An important mitigation measure is adherence to the SOCP for seismic surveys. However, it should be noted that the SOCP specifies minimum requirements and enhanced mitigation may be required, particularly with regard to protection of species of special status. Furthermore, DFO has indicated that they will work in collaboration with the CNSOPB to identify and develop enhanced mitigation requirements beyond the SOCP, as required.

Project-specific EAs will need to address the issue of compliance with section 32 of SARA for listed species under SARA and include mitigation specific to their proposed exploratory activities and/or location to prevent these effects. DFO may be consulted to help assess this risk and identify appropriate mitigation.

Table 5.1 Mitigation and Planning Considerations for Species of Special Status

Seismic and Seabed Surveys	• Adherence (at minimum) to the SOCP and consideration of additional enhanced measures for seismic activities planned in proximity to the Roseway Basin Critical Habitat for North Atlantic right whales. • Use of trained wildlife observers, with experience in identifying beaked whales listed on Schedule 1 of *SARA*, to visually monitor and record marine mammal, sea turtle and marine bird interactions and help enforce safe operating distances. • Sea turtle observers on vessels can be ineffective. A more appropriate mitigation tool with respect to marine turtles may be considering the temporal distribution of these species and schedule development surveys /activities to occur at these times of year when turtles are not present in the area. • Continuous passive acoustic monitoring (PAM) in combination with marine mammal observers, provides the best probability of detecting beaked whales

Table 5.1 Mitigation and Planning Considerations for Species of Special Status

	present in the seismic program study area prior to ramp-up. • If beaked whales are detected, enhanced mitigation may be required for seismic surveys (*e.g.*, the 30 minute observation period outlined in the SOCP may be extended to 60 minutes to account for longer diving times). • Use of trained wildlife observers, with experience in identifying beaked whales listed on Schedule 1 of *SARA*, to visually monitor and record marine mammal, sea turtle and marine bird interactions and to help enforce safe operating distances. • Seabird monitoring to be completed following the CWS pelagic seabird monitoring protocol provided in Appendix C. • Detailed acoustic modeling as input to any project-specific EAs for seismic projects in the Phase 3A Project Area that may occur in the June-December period when North Atlantic right whales may be congregating in the Study Area. These modeling results may be used to define appropriate safety zones for shutdown (*e.g.*, 180 dB_{RMS} safety zone) and buffer zone around the Roseway Basin Critical Habitat/Area to be Avoided. • Use of non-fluid filled streamers for seismic surveys where possible.
Exploratory Drilling	• Conduct a pre-spud survey to verify characterization of benthic habitat, in particular the absence of coral formations. • Adherence to the OWTG with regard to waste streams such as drilling muds and cuttings, deck drainage, desalinization brine, sewage and grey water. • Chemicals will be screened through the most recent version of the CNSOPB Offshore Chemical Selection Guidelines (OSCG) for Drilling and Production Activities on Frontier Lands. • Adherence to CNSOPB Drilling and Production Regulations. • Environmental Protection Plans will be required for exploratory drilling activities. • Bulk transfer and hose handling procedures as per best management practice. • Minimize flaring and ensure the use of high efficiency igniters as per best available practice. • Focus all area lighting on the work areas of offshore platforms and down shade lights as feasible to minimize marine bird attraction. • Conduct a post-drilling ROV survey to verify that the muds and cuttings are within the predicted zone of influence. • Emergency contingency measures and response plans will be developed to address significant weather scenarios.
Vessel Traffic	• Adherence to Transport Canada Guidelines for the Control of Ballast Water Discharge from Ships in Waters under Canadian Jurisdiction. • Use of existing vessel routes to the extent practical. • Seasonal avoidance of the Roseway Basin Area to be Avoided (June 1 to December 31).
Well Abandonment	• Mechanical separation of wellhead to the extent practical. • If use of explosives is necessary, the recommendations set out in the Guidelines for the use of Explosives in or near Canadian Fisheries Waters (Wright and Hopky, 1998) will be followed.
Accidental Spills	• Detailed spill probability and behavior modeling as input to any project-specific EAs for drilling projects in the Phase 3A Project Area. • Implement Emergency and Oil Spill Response Plan to address spill prevention and response, including routine spill response exercises. The type of product spilled can

Table 5.1 Mitigation and Planning Considerations for Species of Special Status

	affect decisions on the response options. • Engineering design and process safety management protocols to prevent spills from occurring and/or reaching the marine environment including but not limited to secondary containment, inspection and maintenance, spill response kits, and blowout safeguards. • Outline an EEM Plan to address post-spill monitoring effects in the Spill Response Plan, with the scope of the EEM Plan directly related to the severity of potential spills.

5.1.3 Data Gaps and Uncertainties

The specific distribution of species of special status in the Study Area is a data gap in this assessment. While some species have been studied extensively, with critical habitat known to exist in the Study Area (*e.g.*, North Atlantic right whale), less is known about other species and how they may be using the Study Area. Although Lee *et al.* (2005) provide information on species presence and behavior during seismic surveys on the Scotian Shelf, data on cetacean presence and behavior was not collected prior to the seismic vessels operating in the study area nor after they left, therefore comparisons of cetacean behavior before, during and after the seismic operations could not be made. Concerns regarding potential effects of seismic on beaked whales (*e.g.,* Northern bottlenose whale) remain a data gap.

Continued research and wildlife monitoring during oil and gas activities may further knowledge in this area, particularly if monitoring surveys are standardized and data is shared for future use. The most relevant studies are those that are conducted while the species are exposed to actual seismic surveys. Future seismic surveys on the Western Scotian Shelf and Slope would present a research opportunity to fill knowledge gaps regarding seismic noise and cetacean and sea turtle species at risk. The use of a trained marine mammal observer onboard during seismic and drilling activities is particularly important in this Project Area given the proximity of species at risk and critical habitat for these species. Similarly, use of a trained marine bird observer onboard during seismic and drilling activities should be considered to address the substantial gap in quantified effects on seabird distribution from oil and gas exploration activities. A recent study on the Grand Banks determined that systematic observations by independent biologists on vessels and platforms are needed to generate reliable assessments of risks to marine birds as opposed to the industry-based self-reporting of seabird monitoring currently undertaken (Burke *et al.* 2012). Seabirds are relatively easy to survey, given that they are conspicuous marine organisms (Wiese *et al*. 2001). As such, an onboard marine bird observer program could work well to address the existing data gap related to quantifiable effects on seabird behavior from exploration activities.

There is a lack of information regarding the deeper areas of the marine benthic environment on the Scotian Slope. The ongoing erosion of Dawson and Verill Canyons and areas in between may enhance the biological productivity in the area, which would attract species, including those of special status. Data gaps also exist for the hearing abilities of sea turtles and many shark species. There have been a limited number of studies focused on a few species of sharks, limiting our understanding of how they interpret sounds and if they can be impacted by anthropogenic noise effects. A similar story is true for sea turtles with relatively little data to rely on to determine if noise impacts turtle species and to what degree.

With respect to effects of exploration activities on species of special status, most of the data gaps and uncertainties are related to effects and monitoring of seismic noise. This gap in knowledge is widely recognized and seismic related research is the focus of various research funding initiatives including the Exploration and Production (E&P) Sound and Marine Life Joint Industry Programme (JIP) and Environmental Studies Research Fund (ESRF) Program. In particular, these research programs have studies underway which are addressing sound source characterization and propagation; physical and physiological effects and hearing; behavioral reactions and biologically significant effects; and mitigation and monitoring.

Site-specific acoustic and spill modeling as input to project-specific EAs will further inform potential environmental effects analysis and appropriate mitigation (including delineation of buffers from critical habitat) as necessary. Seismic operators will adhere to the SOCP, which includes a shutdown zone and use of Passive Acoustic Monitoring (PAM) under conditions of low visibility.

5.2 SPECIAL AREAS

Several Special Areas have been identified in the Phase 3A Study Area. In cases where Special Areas overlap with each other or with EBSAs, information on these areas are consolidated under one overarching area, using the boundaries that cover the largest surface area. For example, the Georges Bank Moratorium Area overlaps with the Georges Bank EBSA. Information pertaining to the Georges Bank EBSA is included in the description of the Georges Bank Moratorium Area.

All Special Areas within this report are not equally ecologically significant or sensitive. Some Special Areas are fisheries closure areas to help protect stocks or sensitive benthic habitat. While these designations indicate ecological sensitivities which should be regarded in environmental assessment for petroleum exploration, they may not require enhanced mitigation by the petroleum industry which may be required in proximity to critical habitat for endangered species (*e.g.*, Roseway Basin Critical Habitat for the North Atlantic right whale).

DFO is in the process of identifying a network of MPAs in the Scotian Shelf / Bay of Fundy region (DFO 2009a). As part of this process, DFO is undertaking a review of EBSAs identified in the offshore Scotian Shelf (Doherty and Horseman 2007). This effort will refine boundaries (using the Convention on Biological Diversity EBSA criteria), further describe ecological features of these areas, and may result in the identification of different EBSAs than those identified in this report. DFO is also undertaking a project to assess EBSAs against current/potential human activities and management measures to provide management and mitigation information for these areas.

The Georges Bank Moratorium Area specifically prohibits the exploration, drilling, production, conservation, processing or transportation of petroleum in recognition of the biological and socio-economic value of the area.

5.2.1 Potential Effects and Existing Knowledge

Exploratory oil and gas activities may have long or short-term environmental effects on Special Areas, affecting the biodiversity, abundance and/or presence of species within these areas, ecological integrity and habitat value, and/or socio-economic value. The analysis of potential environmental effects on Special Areas is closely linked to effects on Species of Special Status (Section 5.1) and Fisheries (Section 5.3).

5.2.1.1 Seismic and Seabed Surveys

Although seismic surveys will not affect the physical structure of the Special Areas themselves, they may affect the quality of habitat and the species found within these areas, thereby affecting the biodiversity and integrity of these areas. Seismic surveys have a greater impact on some species than others (particularly marine mammals) and the effects can vary according to oceanographic conditions. For example, depth is an important consideration where sound attenuates more rapidly with range in shallower water depths.

Effects of Seismic Noise on Areas of Significance for Fish and Invertebrates

As described in the assessment of Species of Special Status (Section 5.1.1.1), seismic noise can affect the fitness and survival of fish and invertebrates at very close range, although this is not determined to be significant compared to natural mortality.

Considering the limited knowledge on these effects of seismic noise, a precautionary approach should be applied by exercising caution in spawning and juvenile areas for fish or invertebrates when conducting seismic surveys, in particular, those that occur in the water column. Long-term and/or permanent effects on larvae and eggs (*e.g.*, mortality) have been observed at close range only, however larvae and eggs for some species are found in the water column where seismic surveying occurs (*e.g.*, redfish, American plaice, Atlantic cod). Horsman and Shackell (2009) provide an in-depth overview of important areas for fish, particularly larval distribution within the Study Area. Important larval areas for herring, witch flounder, silver hake, American plaice, Atlantic cod, haddock, red hake, cusk, Atlantic wolfish, redfish, and monkfish can be found within the Phase 3A Study Area (Horsman and Shackell 2009). In addition to effects on larvae and eggs, seismic surveys may displace adult fish from their spawning grounds (Worcester 2006). Georges, Browns, LaHave, Emerald, Western and Sable Banks are all recognized as important spawning and/or nursery areas for commercially important fish species.

Although seismic exploration would not be permitted to occur within the Georges Bank Moratorium Area, there is potential for underwater noise to migrate within the Moratorium boundaries, thus potentially affecting juvenile fish and larvae.

Effects of Seismic Noise on Areas of Significance for Marine Mammals and Sea Turtles

Section 5.1.1.1 describes potential effects of seismic noise on marine mammals and notes that although mysticetes (*e.g.*, fin, blue, and North Atlantic right whales) are assumed to be sensitive to sound frequencies similar to those emitted by seismic surveys, odontocetes (*e.g.*, Northern bottlenose whales) appear to be more sensitive, particularly within a 1 km radius of the array. Based on data on effects of sound pressure levels on cetaceans, an isopleth of 160 dB_{RMS} has been identified for the inducement of behavioral responses (*e.g.*, avoidance) and 180 dB_{RMS} for the likely inducement of auditory damage and other physical injury (Compton *et al.* 2007). Acoustic modeling conducted for the Shelburne Basin 3D Seismic Survey Environmental Assessment (LGL 2013) predicted that sound pressure levels of 180 dB_{RMS} could propogate approximately 1 km from the source, depending on water depth and season. Critical habitat for the endangered Northern bottlenose whale has been designated in the Gully and Shortland and Halimand Canyons to the east of the Study Area, although Northern bottlenose whale has been observed in the Phase 3A Study Area, including in Dawson and Verrill Canyons.

Critical habitat for the North Atlantic right whale has been designated within Roseway Basin. Depending on the proximity of the air gun array to the critical habitat and the timing of the survey, the quality of habitat could be degraded by underwater noise and disturbance effects could occur (*e.g.*, displacement from feeding and socialization area), having serious effects on this endangered population if not managed.

Although monitoring of marine mammals was conducted during seismic programs in the vicinity of the Gully (Cochrane 2007; Gosselin and Lawson 2004; Lee *et al*. 2005; McQuinn and Carrier 2005; Potter *et al.* 2007; Thomsen *et al.* 2011), there is still much to be learned about whale behavior in the presence of active seismic programs and therefore precautionary measures should be undertaken when seismic operations are planned to occur in the vicinity of the Special Areas designated to protect cetaceans.

The importance of the Scotian Slope/Shelf Break (EBSA 31) for whales is uncertain, however their presence has been observed and it is likely that these species are transiting this area during the summer months. Sea turtles are known to use the Scotian Slope and Shelf Break as foraging areas during the summer and fall.. As mentioned in Section 5.1.1.1, sea turtles may become entangled in seismic gear. As seabirds do not appear to be affected by seismic surveys (refer to Section 5.1.1.1), this activity is not likely to affect any Special Areas containing seabirds.

Effects of Seabed Surveys on Sensitive Benthic Areas

Seabed surveys involve localized disturbance of seabed substrate and benthos, using a variety of tools and techniques such as 2D high-resolution digital seismic (low-energy) using air gun arrays surveying 2-4 m below the surface of the seabed, multi-beam echo-sounders, and seabed core sampling (Hurley 2011). The most sensitive benthic communities are those with high vulnerability and low recovery rate (*e.g.*, deep-sea coral and sponge communities) and the least sensitive benthic communities have a low vulnerability and high recovery rate, for example communities dominated by scavengers and mobile species (DFO 2005; Burbidge 2011).

Although geared for fisheries management, DFO's Sensitive Benthic Areas Policy (DFO 2009c) emphasizes the importance of these sensitive benthic areas and outlines protection mechanisms to protect these habitats.

Irreversible damage including mortality to corals and sponges or other sensitive areas by removal of entire organisms or physical alteration may be caused by seabed surveys. Sensitive benthic areas include those that contain high densities or diversity of corals and sponges and should be avoided when conducting seabed surveys (*e.g.* Northeast Channel Coral Conservation Area, Sambro Bank and Emerald Basin Vazella Closure areas). Similar to seismic surveys, seismic noise from seabed surveys may affect juvenile fish and invertebrates near the seabed (refer above for discussion of sensitive areas for juvenile fish and larvae).

The Scotian Slope/Shelf Break (EBSA 31) contains corals and overwintering areas for shellfish which may be affected by seabed surveys, however more detailed information regarding their distribution and abundance is not known.

5.2.1.2 Exploratory Drilling

Special Areas containing sessile benthic species (corals and sponges) and other benthic species (haddock, Atlantic cod, wolffish, surf-clam, winter skate, and others) are more susceptible than pelagic species to effects from exploratory drilling (Hurley 2011). These effects could potentially include direct physical impact or mortality (see above regarding relative sensitivity and recoverability of benthic environments). Drilling mud and cuttings discharges can smother benthic species and result in toxic effects, causing acute and chronic long-term impacts such as reduced growth or reproductive potential (see Section 5.1.1.2). However, Environmental Effects Monitoring (EEM) results at drilling sites off Atlantic Canada have demonstrated that changes in the diversity and abundance of benthic organisms have been generally limited to within 1000 m of the drill site and returned to baseline conditions within 12 months of cessation of drilling discharges using SBM or Enhanced Mineral Oil Based Mud (EMOBM) in combination with WBM (Hurley 2011; CNSOPB 2011b).

Special Areas potentially affected by exploratory drilling are also those that tend to be vulnerable to seabed surveys: Northeast Channel, Sambro Bank and Emerald Basin, and the Scotian Slope/Shelf Break. Drilling would not be permitted within the Georges Bank Moratorium Area, the Roseway Basin Area to be Avoided/Critical Habitat, Northeast Channel Coral Conservation Area, and Sambro Bank and Emerald Basin Vazella Closure areas. However, underwater noise and discharges from drilling outside these areas could potentially migrate into these Special Areas, affecting the aquatic species that rely on these areas.

Migratory birds using Georges Bank could potentially interact with illuminated vessels or MODUs outside the Moratorium Area and become exposed to contaminants from waste disposal, operational discharges, and spills, or be incinerated by flaring (Hurley 2011; DFO 2011a). The risk of these interactions is expected to be low due to the exclusion of drilling within Georges Bank and short periods of flaring during well testing (8-24 hours) when hydrocarbons are present (Hurley 2011).

5.2.1.3 Vessel Traffic

Potential effects on marine habitats and communities resulting from the high volume of shipping activity and vessel traffic on the Scotian Shelf include ship-source pollution, shipboard wastes, noise, and collisions between vessels and marine life (Burbidge 2011). Vessel traffic from oil and gas exploration activities is expected to be minimal with minor environmental effects on Special Areas in the Study Area (refer to Section 5.1.1.3).

The Roseway Basin Area to be Avoided is well documented on navigation charts and achieves high voluntary compliance. Supply and servicing vessels would comply with the seasonal avoidance of this area.

Surveys conducted under the Cohasset-Panuke Project (COPAN) and Sable Offshore Energy Project (SOEP) EEM programs suggest that offshore oil and gas activities have had little to no impact on benthic communities, fish health, or seabird populations (CNSOPB 2011b). However, it is estimated that ship-source oil pollution results in the oiling of thousands of seabirds in the Scotian Shelf region each year, and the number of oiled seabirds in the region increased 3.2% annually between the early 1970s and 2000 (Coffen-Smout *et al.* 2001; DFO 2009b; Burbidge 2012). Beached bird surveys have been conducted on Sable Island by a resident researcher since 1993 and have become part of the EEM program for the Sable Island Bank region. Between 1993 and 2002, more than 7000 seabird corpses were recovered, 40% of which had experienced some oiling. Most of the contamination was weathered crude and heavy fuel oil mixed with varying amounts of lubricants and diesels (Sable Island Green Horse Society 2004). While most of these fatalities were primarily attributable to large ocean-going vessels and not petroleum exploration and development on the Scotian Shelf, these results do demonstrate the vulnerability of bird species in the area and prevalence of hydrocarbon contamination.

5.2.1.4 Well Abandonment

The effects of well abandonment on Special Areas are similar to those of other exploration activities that can affect benthic organisms through physical alteration, mortality or contamination, with impacts being worse on juvenile fish and invertebrates (JWEL 2003). There is typically little interaction with fish and fish habitat during the mechanical separation of wellheads from the seabed; however, in cases where blasting is required for well-abandonment there would be mortality at the site of blasting, mainly to the infauna community (JWEL 2003). Effects of well abandonment are not expected to extend beyond the previous zone of influence affecting the marine benthos during drilling unless blasting is required in which case there would be increased mortality over a larger area.

5.2.1.5 Accidental Spills

Accidental spills can range from small to large-scale resulting in short or long-term contamination and toxicity of the water column, sediments, and biota, causing both lethal and sub-lethal effects depending on the severity. Although the risk of accidental spills is low due to several mitigation measures in place by the oil and gas industry, the consequences of an accidental spill can be severe and/or far reaching as evident in the 2010 Deepwater Horizon blowout in the Gulf of Mexico. The severity of an accidental spill depends on the site and well-specific characteristics, oceanographic conditions, location and timing of the spill, and particularly the hydrocarbon product and quantity being released: gas, gas condensate, or crude oil, with crude oil being the most severe (DFO 2011a; JWEL 2003).

Environmental assessments for exploration drilling and development projects on the Scotian Shelf and/or Slope over the last two decades have modeled blowout scenarios involving condensate. There are currently no modeling results available for a blowout scenario involving crude oil. However, if oil is the suspected product for an exploration or development well, appropriate modeling would be conducted as necessary. Crude oil will have different fate behaviours than those found for diesel or condensate spills (NOAA 2013). Diesel is a highly volatile fuel and will evaporate from the sea surface in 1-2 days. Crude oils are moderately to non-volatile with some crude oils displaying characteristics of evaporating 1/3 of the spilled volume within a few days, while some crude oils do not evaporate at all (NOAA 2013). The effects of a blowout of a well containing oil would have far greater impacts than a well containing gas. However, the likelihood of a spill of diesel to the sea surface from a platform or vessel spill is far greater than a blowout (Lee *et al.* 2011).

Spill trajectory modeling conducted for the Deep Panuke Offshore Gas Development Project on the Sable Bank predicted spill probabilities and dispersion behavior for various spill scenarios. Although project-specific spill modeling would be conducted for each EA of an exploration project in the SEA Study Area, the Deep Panuke modeling results gives an indication of the potential extent of a spill on the Sable Bank. As indicated above, the severity of spill effects will vary depending on a variety of factors. Modeling conducted for Deep Panuke (a natural gas development project) identified a 100-barrel batch spill of diesel as the worst-case spill scenario, predicting the diesel could persist as a slick for about 19 hours and travel about 18 km prior to the complete loss of surface oil, with a dispersed oil cloud in the water column potentially extending up to 54 km. It is predicted that subsea or surface gas blowouts would result in a much smaller area of influence (1-2.5 km) (Encana 2006). Spill modeling for BEPCo.'s proposed deepwater drilling program on EL 2407 predicted a potential distance of 37 km to reach 0.1 ppm concentration of oil for a 100-barrel diesel spill (summer conditions/average winds).

All Special Areas in the SEA Study Area are considered to be vulnerable to accidental spills that may occur as a result of exploration activities due to potential far-reaching effects. Exploratory drilling is not permitted within the Georges Bank Moratorium Area, although this area could potentially be affected in the event of a spill (*e.g.*, blowout or platform spill) outside the Moratorium boundaries. The severity of effects from a spill is greatly influenced by the time of year. If an oil spill were to coincide with a spawning event, there could potentially be considerable loss of fish eggs, larvae and juveniles that could potentially affect fisheries resources and potentially population viability. Most major commercial species on Georges Bank have pelagic eggs and/or larvae and therefore would be vulnerable to a spill. Convergence zones on the Bank would like concentrate oil and early life stages together in surface waters, thereby magnifying deleterious effects (DFO 2011a). Where there are high rates of vertical mixing, it may increase the amount of petroleum product entrained in the water column. (DFO 2011a). In addition to Georges Bank, there are several other important spawning and nursery areas in the Study Area which could be vulnerable to the effects of a spill.

Seabirds are particularly vulnerable to spills, as coming in contact with even small amounts of oil can have serious health effects. Seabirds feeding on Georges Bank would therefore be vulnerable to deleterious health effects and potentially mortality, in the event of a spill reaching the Bank.

Although the Scotian Slope/Shelf Break EBSA is not well studied and covers a very large area, it is thought to be an area of high biodiversity, containing several ecologically important features including corals, pelagic species such as sharks and tuna, whales, seabirds, and many others (Doherty and Horsman 2007). Given the potential ecological importance of this area and the fact that it has not been identified as being resilient (Doherty and Horsman 2007), it is likely highly vulnerable to an accidental spill.

As indicated in Section 5.1.1, oil spills can indirectly affect marine mammals in the area by altering the marine ecosystem and the key features of their habitat such as contamination and shifts and reduction in prey biomass (Marine Mammal Commission 2011). If a spill were to reach the Roseway Basin, there could be adverse environmental effects on North Atlantic right whales as the quality of their habitat and prey could be degraded.

5.2.2 Mitigation and Planning Considerations

Avoidance is the most effective mitigation measure in consideration of Special Areas in the Study Area that are deemed to be highly sensitive to oil and gas activities. Limiting or minimizing the extent of exploration activities within a Special Area may be considered should application of the suite of other mitigation measures described in Table 5.2 not significantly reduce the potential risk of adverse environmental effects to an acceptable level.

In consideration of the presence of identified critical habitat for the endangered North Atlantic right whale in the Study Area, operators should be reminded that the minimum mitigation requirements specified in the SOCP may not be sufficient and that enhanced mitigation measures may be required in order to avoid environmental effects on listed species and critical habitat to avoid contravention of *SARA*.

Legislation ensures avoidance of Georges Bank for all oil and gas activities within the Moratorium Area boundaries, and therefore no mitigation is required to address exploration in this area.

A Code of Conduct can be an important and useful mitigation measure for operating in proximity to or within protected or Special Areas. For example, industry codes of conduct exist for the Gully Marine Protected Area (MPA) and Sable Island, which specify minimum safe working distances for aircraft and vessels near these areas, among other mitigation measures. Operators who may wish to conduct activities in the vicinity of Roseway Basin should also be expected to develop and implement codes of conduct which would be reviewed by, at a minimum, the CNSOPB and DFO.

Special Areas that are particularly important and/or sensitive to oil and gas activities are those that provide important habitat for Species of Special Status and are important for life cycle stages (spawning, breeding, nursery areas, *etc.*) of fish, invertebrates, and marine and migratory birds. Avoiding these areas during these critical life cycle stages is an appropriate mitigation measure, especially in spawning and juvenile areas. Current spatial and temporal information of these critical life history stages will be required for the application of most mitigation measures.

It is advised to maintain regular communication with DFO to obtain up to date information on Special Areas and the MPA network, as related to project-specific EAs. It is further recommended to work collaboratively with DFO on mitigation measures regarding Special Areas identified in this report.

Table 5.2 summarizes mitigation and planning considerations for Special Areas for each of the key exploration activities.

Table 5.2 Mitigation and Planning Considerations for Special Areas (additional to those identified in Section 5.1.2)

Seismic and Seabed Surveys	• Apply mitigation measures required as per the Statement of Canadian Practice with Respect to Mitigation of Seismic Sound in the Marine Environment (at minimum) such as increasing safety zones near gun arrays and shut down when whales are present or during limited visibility. Enhanced mitigation measures may be required, particularly in proximity to the Roseway Basin Critical Habitat. A Code of Conduct should be developed by operators working in proximity to Roseway Basin. • If beaked whales are detected, enhanced mitigation may be required for seismic surveys (*e.g.*, the 30 minute observation period outlined in the Statement of Canadian Practice with Respect to Mitigation of Seismic Noise in the Marine Environment may be extended to 60 minutes to account for longer diving times. • Use of trained wildlife observers, with experience in identifying beaked whales listed on Schedule 1 of *SARA*, to visually monitor and record marine mammal, sea turtle and marine bird interactions and help enforce safe operating distances. • Detailed acoustic modeling as input to any project-specific EAs for seismic projects in the Phase 3A Project Area that may occur in the June-December period when North Atlantic right whales may be congregating in the Study Area. These modeling results may be used to define appropriate safety zones for shutdown (*e.g.*, 180 dB rms safety zone) and buffer zone around the Roseway Basin Critical Habitat/Area to be Avoided.

Table 5.2 Mitigation and Planning Considerations for Special Areas (additional to those identified in Section 5.1.2)

	• Schedule surveying to minimize interaction with peak haddock spawning (*e.g.*, in the vicinity of the Haddock Box (April/May)). • Seabed surveys using extractive methods should avoid areas with known concentrations and/or high diversity of corals or sponges, including but not limited to the Northeast Channel Coral Conservation Area and Sambro Bank and Emerald Basin Vazella Closure areas. • Use of non-fluid filled streamers during seismic surveys where possible.
Exploratory Drilling	• Avoid exploration drilling in Roseway Basin, Northeast Channel Coral Conservation Area, and the Sambro Bank and Emerald Basin Vazella Closure areas. • Enhanced mitigation and EEM programs may be required for activities within or adjacent to special areas, such as spawning areas (*e.g.*, the Haddock Box), the Roseway Basin Area to be Avoided/Critical Habitat, Northeast Channel Coral Conservation Area and/or Sambro Bank and Emerald Basin Vazella Closure areas. • Known aggregations of cold water coral and other sensitive features shall be avoided during oil and gas drilling activities. If aggregations of cold water coral are found to occur as the result of an environmental assessment or seabed survey, the CNSOPB requires mitigation to avoid harming these aggregations (DFO 2006). • Conduct pre-drilling ROV investigation to determine presence of corals, sponges, or other sensitive features as required by the CNSOPB. • Follow Canadian Wildlife Service instructions outlined in Williams and Chardine's protocol, "The Leach's Storm Petrel: General Information and Handling Instructions", including the associated permit when finding a dead or injured bird. • Adhere to regulatory guidelines (MARPOL and Offshore Waste Treatment Guidelines) for the treatment and disposal of various operational waste streams and emissions.
Vessel Traffic	• Seasonal avoidance of the Roseway Basin Area Critical Habitat (June 1 to December 31). • Minimize discharges in accordance with the *Canada Shipping Act* and other relevant regulations and apply best practices when transiting through or in the vicinity of all Special Areas.
Well Abandonment	• Apply standard mitigation measures during well abandonment (*e.g.*, mechanical separation of wellhead whenever possible).
Accidental Spills	• Detailed spill probability and behavior modeling as input to any project-specific EAs for drilling projects. • Apply standard preventative measures to avoid accidental spills. • Implement Emergency and Oil Spill Response Plan accepted by the CNSOPB, which includes routine spill response exercises. • Outline an EEM Plan to address post-spill monitoring effects, with the scope of the EEM program directly related to the severity of the spill.

5.2.3 Data Gaps and Uncertainties

Several data gaps and uncertainties have been identified in this section and for the other VECs identified in this assessment. Despite the uncertainties pertaining to environmental effects from oil and gas activities, it is important to take a precautionary approach in the vicinity of Special Areas, particularly those of well-known ecological importance, while research continues.

The key source of uncertainty pertaining to the Special Areas VEC is the identification of areas within the Scotian Shelf / Bay of Fundy MPA Network planning process being led by DFO. This planning process may result in the identification of EBSAs other than those discussed in this report. Some of the EBSAs presented in this section require further investigation of their ecological importance. Although the Scotian Slope/Shelf Break appears to have ecological significance, it is a very large area with few surveys to confirm its ecological importance. There are large data gaps associated with the understanding of areas and timing of critical life-cycle stages of various species. More research should be conducted to investigate the importance of this area and to more accurately delineate key areas of ecological importance within this large area. Attention should therefore be given in project-specific EAs to review and update the knowledge and status of these EBSAs and other Special Areas as additional mitigation and planning may be required.

Predicting received sound levels in Special Areas is a significant data gap, in which more definitive modeling is required. Until such time that more definitive sound propagation modeling thresholds (or guidelines) are established for activities in and near sensitive areas, proponents are directed to relevant sections of the Scoping Documents prepared for environmental assessments on past Exploration Licenses 2409, 2415, and 2416 (available from the CNSOPB Public Registry Archive).

While the environmental effects of fishery activities on corals and sponges on the Scotian Shelf and Slope are understood and becoming better documented, little research has been conducted on the effects of seismic or drilling activities on corals and sponges.

5.3 FISHERIES

5.3.1 Potential Effects and Existing Knowledge

Potential environmental effects of exploration activities on fisheries include effects on the fisheries resource (*e.g.*, direct effects on fished species indirectly affecting fishing success) and effects on fishing activity (*e.g.*, displacement from current or traditional fishing areas, gear loss or damage resulting in a demonstrated financial loss to commercial fishing interests). Although this VEC focuses primarily on commercial, recreational and Aboriginal fisheries, research-related fishing activities are also considered as applicable.

5.3.1.1 Seismic and Seabed Surveys

Key issues of concern related to environmental effects of seismic and seabed surveys on fisheries include:

- potential physiological and behavioral effects on fisheries resources (*i.e.*, commercial and recreational fish species) which may affect catchability; and
- fisheries gear loss and damage due to an interaction with seismic equipment.

Physiological Effects on Fisheries Resources

The environmental effects of seismic exploration on fish and invertebrates have been the subject of numerous studies around the world. Injuries and mortality of fish and invertebrates will occur within immediate proximity of an operating air gun (*e.g.*, 1.5 to 5 m depending on species and development stage), with eggs and larvae being the most vulnerable (Payne 2004; Dalen *et al.* 2007; DFO 2011a). Effects of seismic-induced mortality on eggs and larvae at the population level are considered to be insignificant compared to natural mortality (Saetre and Ona 1996; Dalen *et al.* 1996). To date, there have not been any well-documented cases of acute post-larval fish or invertebrate mortality as a result of exposure to seismic sound under normal seismic operating conditions (DFO 2011a). Likewise, studies on physiological effects of seismic noise on fish and invertebrates have not revealed significant adverse environmental effects. While sublethal effects (*e.g.*, reduction in feeding, growth or reproduction rate, histochemical changes) have been measureable in some studies (*e.g.*, Payne *et al.* 2007; Lagardere 1982), other studies have detected no significant differences between exposed and control individuals (*e.g.*, McCauley *et al.* 2000a, 2000b; Exxon Norge AS 2001; Christian *et al.* 2003; Payne *et al.* 2008; Harrington *et al.* 2010), or effects have been shown to be measurable but temporary (*e.g.*, DFO 2004b; Sverdrup *et al.* 1994).

Behavioural Effects of Fisheries Resources Affecting Catchability

Effects of seismic noise on invertebrate and fish behavior (*e.g.*, startle response, changes in swimming speed and direction, and changes in vertical distribution (Worcester 2006)) can affect catchability. Several studies have been conducted, most notably in the North Sea, demonstrating behavioral responses of fish to seismic noise leading to catch reductions. Scare effects can entail catch reductions that will vary from species to species and between various types of fishing gear (Dalen *et al.* 2007).

Dalen and Raknes (1985) observed a change in the distribution of fish at 100-300 m water depth along the course lines of a seismic vessel, with the averaged measured volume of bottom fish (mainly cod and pollock) reduced by 36% after seismic surveying compared with measured values prior to the survey. Quantity of small pelagic species was reduced by 13%. It was concluded in this research study, as in others, that some fish move to greater depths during seismic exposure. A study of seismic exploration effects on cod and haddock behavior in the Barents Sea found that seismic surveying severely affected fish distribution, local abundance, and catch rates. Trawl catches of cod and haddock and longline catches of haddock declined approximately 50% after the survey started and longline catches of cod were reduced by approximately 21%. Reductions in catch rates were observed 18 nautical miles from the seismic surveying area with most pronounced effects observed within the survey area (3 x 10 nautical miles) where trawl and longline catches of cod and haddock ranged from a reduction of 45% to 70%. Abundance and catch rates did not return to pre-survey levels during the 5-day period after the seismic survey ended. Conversely, Gausland (2003) reported higher catches in the immediate track of a seismic survey where bottom trawling was used. Løkkeborg *et al.* (2009) demonstrated that differences in species reactions with Greenland halibut, redfish and ling increasing their level of swimming activity, thus making them more liable to be taken in gillnets and reducing efficiency of longline catch.

Sedentary benthic species (*e.g.*, lobster) are not likely to disperse, therefore catch rates are less likely to be affected (DFO 2011a). LGL *et al.* (2003) monitored snow crab on the ocean bottom, 50 m below seismic air gun arrays. One set included crab in a trap located below the air guns, which showed no visible reaction to seismic activity. Another group of crab was tagged with telemetric tags and did not demonstrate large scale movement out of the study area. Unlike fish, no literature has been found documenting major startle or movement responses upon exposure of crustaceans to sound (Payne *et al.* 2008).

Parry and Gason (2006) investigated the effects of seismic exploration on catch per unit effort (CUPE) of rock lobster in Victoria, Australia and found no evidence that catch rates of rock lobsters in western Victoria declined in areas near surveys in the years or weeks following any of the 33 seismic surveys conducted in western Victoria between 1978 and 2004.

Depending on the relative location of the seismic survey air gun, the fish being harvested and the fishing gear, effects on fish behavior can vary. Effects of seismic noise in displacing fish from their usual habitat is of most concern during spawning season, on nursery and foraging grounds and possibly during seasonal migrations.

Gear Loss and Damage

Damage to fishing gear or vessels can occur as a result of physical contact with seismic vessels and equipment. In general, fixed gear (*e.g.*, crab pots, lobster traps, longlines, gill nets) pose a greater potential for conflict with seismic surveys since it is hard to detect and can be set out over long distances in the water (LGL 2005). Groundfish and pelagic longline fisheries can have gear that can extend more than 60 km in length behind the vessel. Both seismic and longline fishing activities result in large areas of influence associated with each activity as well as the turning radii associated with each type of vessel. Changing wind, waves and tides can also result in considerable drift of longline fishing gear (DFO 2011a). Mobile gear (*e.g.*, trawls, seines) is towed behind vessels and has a lower risk of conflict since the activity is more visible and seismic survey ships and fishing vessels can communicate with each other and exchange information about operating areas and activities (LGL 2005). There have been no seismic/longline gear entanglements offshore Nova Scotia to date.

If WAZ seismic exploration methods are chosen, the path and length of time of the possible interaction between seismic vessels and fishers will be expanded. Multiple seismic vessels are used in parallel to tow sound arrays, resulting in a much greater vessel footprint. These seismic programs also run for longer periods of time as compared to traditional 2D and 3D seismic programs.

5.3.1.2 Exploratory Drilling

Exploratory and delineation drilling and ancillary activities can affect fisheries primarily through potential effects on fisheries resources and loss of access.

Physiological Effects on Fisheries Resources

Potential effects of drilling discharges on fisheries relate to potential lethal or sublethal effects on fisheries species. Discharge of drilling muds and cuttings can result in smothering of benthic species and health effects as a result of chronic exposure of bentonite, barite or other drilling fluid components. Laboratory studies have linked prolonged exposure of bentonite and barite to sublethal effects affecting scallop growth and reproduction at bentonite concentrations as low as 2 ppm (Cranford and Gordon 1992; Cranford *et al.* 1999, 2001; Barlow and Kingston 2001). However, these studies did not take into account active wind and tidal mixing and changes in biophysical benthic conditions. Laboratory studies involving exposure of snow crabs (Andrews *et al.* 2004) and lobster (Hamoutene *et al.* 2004) demonstrated minor metabolic differences between experimental and control group individuals, neither of which would be expected to impact fisheries success. It is noted that all of these experiments involved exposure concentrations much higher than would be realized in an open ocean environment where drilling fluids and cuttings would be diluted and dispersed.

The concentration of drilling mud constituents as well as metals was monitored in surf clams near exploratory drill rigs in cold water environments (Neff 2010). It was found that there was no correlation between the concentration of drill mud constituents and metals in surf clams near drill rigs and in those found in reference sites. The concentration of PAHs was measured in tissues of invertebrates and fish species in a drilling area in the Alaskan Beaufort Sea. It was found that there were no regional differences in PAH levels in amphipod, clam, and fish tissues (Neff 2010). There is no predicted effect on fishing success in the Study Area due to routine drilling discharges.

A review of environmental effects resulting from offshore exploratory drilling in Canada determined that changes in 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 (Hurley and Ellis 2004). Sediment quality monitoring and toxicity testing as part of the SOEP Environmental Effects Monitoring (EEM) program found above background concentrations of total petroleum hydrocarbon (TPH) and barium associated with drill waste and cuttings piles at all drilling platforms in 1999. Since then, these concentrations have decreased at different rates at different locations, with the greatest persistence at Thebaud showing elevated barium concentrations out to 250 m in 2007. No toxic responses (as demonstrated by amphipod mortality testing) have been observed at any site since 2003 (CNSOPB 2011b). Benthic habitat monitoring as part of the SOEP EEM demonstrated no obvious effect on fauna or habitat beyond the drill waste piles. Each year since 1998 the EEM program has demonstrated an increase in biomass and potential growth related to maturing communities of marine species (CNSOPB 2011b). Taint and body burden monitoring demonstrated no tainting effects between the 250 m and 1000 m sampling sites. Tainting was only encountered once in Jonah crabs collected directly from the platform structure at Venture (within safety zone). The results of the SOEP EEM program are consistent with EEM programs conducted elsewhere in Atlantic Canada (*e.g.*, Hibernia, White Rose, Terra Nova), concluding no significant effects on fish health and fish habitat. Fisheries are therefore not likely to be affected by drilling discharges.

Loss of Access

Drilling programs generally last one to three months, during which time access to marine space by fishers or other ocean users is excluded from a 500 m radius (0.8 km^2) safety exclusion zone around the drilling project. For certain fisheries that use longline gear, a larger exclusion zone would be in effect to ensure gear did not drift into drilling rigs (Thompson *et al.* 2000).

The issue of safety zone and loss of access is not so much a project-specific issue as it is a cumulative effects issue whereby cumulative loss of access due to drilling (and production activity where applicable) could potentially result in a displacement and demonstrated financial loss to fishing interests. There is typically no more than two exploratory wells drilled per parcel and exploration licenses generally last for five years.

Safety zones are established to prevent damage to oil and gas infrastructure, minimize likelihood and effects of environmental incidents, and maintain the safety and security of industry personnel (Stantec 2010). However, they may also represent lost fishing opportunity, particularly for sedentary species (*e.g.*, surf clam) or migratory species with a well-defined area and timing. Fisheries that are concentrated within specific areas on the Scotian Shelf (*e.g.*, red hake, silver hake, offshore lobster) would be most affected by an exclusion zone. Any drilling program activities that displace fishing activity in these concentrated areas will result in a temporary direct loss of access to the fishery. Commercial fishers cannot move to alternative fishing grounds if exploration activities prevent them from accessing key fishing locations. Restrictions on invertebrate, pelagic or demersal fishing activity in certain areas can also potentially result in overcrowding of other areas and can potentially affect net income of commercial fishers.

Given the temporary and localized nature of exploration and delineation drilling programs, loss of access from safety exclusion zones is expected to be minimal on a project-by-project basis. However, if a cumulative loss of access is experienced as a result of numerous drilling programs on the Scotian Shelf, particularly where this area represents key fishing grounds for specific fisheries, it will be important to consider timing of drilling programs relative to fishing seasons.

5.3.1.3 Vessel Traffic

Supply vessels travel back and forth between the MODU and the shorebase two to three times a week during an active exploration program and potentially interact with fixed fishing gear that could be present within the travel route. Interactions with seismic vessels and drilling equipment are discussed above.

5.3.1.4 Well Abandonment

Well abandonment may involve mechanical means (*i.e.*, well is plugged and well casing is cut and removed just below the surface of the seafloor) or explosive means (explosive charge set in the well casing and detonated approximately 1 to 10 m below the seabed floor). If mechanical means are used for well abandonment, it is predicted not to have any interaction with fisheries. If explosive means are used, it could potentially result in the injury or mortality of fish, particularly in juvenile fish and invertebrates due to shock waves produced by the explosion. Environmental effects from underwater explosions range from light hemorrhaging of juvenile body cavities to temporary dispersion of adults in the immediate vicinity of an explosion, with tissue damage occurring up to 600 m from a blast site (Nedwell 2001, cited in JWEL 2003). Goertner (1981) found that for a 25 kg severance explosion buried at 4.6 m in a mud bottom in 61 m water depth, measurable fish kills can occur near the surface out to a horizontal range of 27 m, with larger fish considered less vulnerable to injury. Near the bottom, significant fish kills of all sizes of fish were predicted to be limited to a maximum horizontal range of approximately 21 m. As water depth increases, the hazard is reduced. There is no predicted interaction with fisheries following well abandonment.

5.3.1.5 Accidental Spills

Accidental releases through a streamer break, well blowout, batch spill, or SBM release during drilling could potentially occur during exploration activities and affect fisheries through effects on fisheries resources, fishing exclusion (*e.g.*, during spill and clean-up), fouling of gear (*e.g.*, through oiling), or reduced marketability (*e.g.*, real or perceived taint). The severity of effects of a spill on fish (including eggs, larvae, juvenile and adult fish) depends on the properties of the spilled product, and magnitude (*e.g.*, volume), timing, and location (*e.g.*, water depth, temperature, wind and wave energy; proximity to sensitive locations) of the spill. The potential environmental effects on fisheries from a large scale spill could be great, particularly given the global significance of fishing grounds found within the Study Area.

Although spills can result in biophysical effects on fish, which could in turn result in a subsequent loss of fish catch or fish value, there is higher potential for effects on fisheries to occur as a result of perceived fish taint. Following the Uniacke blowout (involving condensate) near Sable Island in 1984, a no-fishing zone was established in spite of no evidence of taint (Zitko *et al.* 1984). Negative public perception of fisheries resources in the event of a spill could affect marketability and therefore result in reduced income for commercial fishers harvesting in proximity to the affected area.

The only hydrocarbons currently produced on the Scotian Shelf are natural gas and condensate, both of which are highly volatile and have reduced impacts compared with crude oil (Zwanenburg *et al.* 2006). A diesel spill would be more likely to occur than a blowout and would have greater potential for environmental effects. Oil spills other than from blowouts can occur during drilling due to the presence of increased marine traffic (Lee *et al.* 2011). Spills commonly include diesel spills, spills from transfer operators, and spills from similar operations needed to run drilling activities. Statistical data from offshore Nova Scotia indicates that the highest frequencies of oil spills are from small platform based spills including diesel.

Environmental assessments for exploration drilling and development projects on the Scotian Shelf and Slope over the last two decades have modeled blowout scenarios involving condensate. There are currently no modeling results available for a blowout scenario involving crude oil. However, if oil is the suspected product for an exploration or development well, appropriate modeling would be conducted as necessary. Crude oil will have different fate behaviours than those found for diesel or condensate spills (NOAA 2013). Diesel is a highly volatile fuel and will evaporate from the sea surface in 1-2 days. Crude oils are moderately to non-volatile with some crude oils displaying characteristics of evaporating 1/3 of the spilled volume within a few days, while some crude oils do not evaporate at all (NOAA 2013). The effects of a blowout of a well containing oil would have far greater impacts than a well containing gas. However, the likelihood of a spill of diesel to the sea surface from a platform or vessel spill is far greater than a blowout (Lee *et al.* 2011).

Spill modelling conducted for the Deep Panuke Offshore Gas Development Project on the Sable Bank predicted spill probabilities and dispersion behavior for various spill scenarios, with a 54 km predicted dispersion distance from a 100-barrel diesel spill. Spill trajectory modeling conducted for BEPCo. Canada Company's Environmental Assessment Report for Exploratory Drilling on EL 2407 (deepwater exploration well on Western Scotian Slope) predicted a distance of 37 km for the dispersion of an oil cloud from a 100-barrel diesel spill (BEPCo. 2004).

Although project-specific spill modeling would be conducted for each environmental assessment of an exploration project in the SEA Study Area, these modeling results give an indication of the potential extent of a spill on the Scotian Shelf and Slope. As indicated above, the severity of spill effects will vary depending on a variety of factors, although the predicted worst-case scenario would involve a 100-barrel batch spill of diesel that could persist as a slick for about 19 hours and travel about 18 km prior to the complete loss of surface oil, with a dispersed oil cloud in the water column potentially extending up to 54 km. It is predicted that subsea or surface blowouts would result in a much smaller area of influence (1-2.5 km) (Encana 2006). All fisheries operating in these areas of influence could be affected through effects on fisheries resources (particularly sessile or slow moving benthic species), fishing exclusion, fouling of gear, or reduced marketability of seafood.

5.3.2 Mitigation and Planning Considerations

Table 5.3 summarizes mitigation and planning considerations to mitigate potential environmental effects of exploration activities on fisheries such that residual effects would be considered to be minor, short-term and localized. Mitigation as presented below is primarily intended to be implemented by individual operators. The CNSOPB will also take into account, when considering work authorization applications, potential cumulative effects associated with concurrent exploration activities, particularly where safety (exclusion) zones are established. Many fisheries occurring in the Phase 3A Study Area are quota-based and can be fished almost any time of year; therefore, it is difficult to prescribe specific seasonal avoidances. Stakeholder consultation early in project planning is crucial to mitigating effects of exploration activities on fisheries and other ocean users.

Table 5.3 Mitigation and Planning Considerations for Fisheries

Seismic and Seabed Surveys	• Fisheries Liaison Officer familiar with NS offshore fisheries to be present on seismic survey vessel(s) to communicate with fishing vessels in the area to avoid potential conflict with fishing activities/gear. • Adherence (at minimum) to the Statement of Canadian Practice with Respect to Mitigation of Seismic Noise in the Marine Environment and other regulatory guidelines. Enhanced mitigation may be required. • Adherence to the CNSOPB Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity. • Issuance of "Notice to Shipping" on location and scheduling of survey activities. • Commencement of seismic data acquisition in daylight hours and only if survey area confirmed to be clear of fixed fishing gear (*e.g.*, snow crab traps) or floating longline gear (*e.g.*, for large pelagics such as porbeagle shark, swordfish). • Consultation with key organizations representing fishing interests (including commercial and Aboriginal) in the area during the EA planning stage and just prior to activity start. • Consultation with DFO Science Branch to ensure survey area and timing does not overlap with research vessel programs. • Coordination of seismic program activities with fishing industry to reduce potential conflict with commercial fishing activity and DFO survey vessels. • Coordination of program activities with fishing industry to reduce potential conflict during peak fishing times. • Use of non-fluid filled streamers during seismic surveys where possible.
Exploratory Drilling	• Adherence to the CNSOPB Offshore Waste Treatment Guidelines and Offshore Chemical Selection Guidelines to minimize effects of drill waste discharges. • Issuance of Notice to Shipping on location and scheduling of drilling activities. • Consultation with key organizations representing fishing interests (including commercial and Aboriginal) in the area during the EA planning stage. • An Environmental Protection Plan must be submitted prior to drilling activity.
Vessel Traffic	• Use of common routes by supply vessels and alternate routes around key fishing grounds particularly when fishing is at its peak.

Table 5.3 Mitigation and Planning Considerations for Fisheries

Well Abandonment	• Design of wells and casings to facilitate effective mechanical cutting and removal of the wellhead; avoiding explosive means of separation where possible.
Accidental Spills	• Preparation and implementation of an Emergency Response Plan to address spill prevention and response including interactions with fishers and other ocean users. • Engineering design and process safety management protocols to prevent spills from occurring and/or reaching the marine environment including but not limited to secondary containment, inspection and maintenance, spill response kits, and blowout safeguards. • Operator to establish ongoing communication with key fisheries stakeholders and other ocean users in the event of a spill and during spill response activities, including but not limited to issuance of a Notice to Shipping/Mariners. • Outline an EEM Plan to address post-spill monitoring effects, with the scope of the EEM program directly related to the severity of the spill. • Adherence to CNSOPB Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity.

5.3.3 Data Gaps and Uncertainties

There are large data gaps associated with the understanding of areas and timing of critical life-cycle stages of various species. The understanding of these areas could potentially change during the lifetime of the SEA therefore project-specific EAs should reference updated information as applicable. . As noted above, ongoing consultation with the fisheries stakeholders is important to confirm specific fishing locations and seasons.

6.0 Potential Effects of the Environment on Exploration Activities

Offshore exploration activities require careful consideration of environmental conditions in the operating area. Aspects of the environment potentially affecting offshore exploration activities include:

- Fog and ice;
- Seismic events and tsunamis;
- Hurricanes, winds and extreme weather events;
- Marine life (biofouling and presence of species of special status);
- Climate change; and
- Sediment and seafloor stability.

The interactions between these physical forces and exploration activities need to be considered in both normal and extreme circumstances. Extreme conditions may affect program schedule and operations including the timing of seismic and drilling programs and provisions of supplies and service support.

Detailed analyses of meteorology and oceanographic conditions are included in operators' engineering feasibility and design to ensure safety of personnel, and protection of equipment, vessels and the natural environment. The Offshore Physical Environment Guidelines (NEB *et al*. 2008) provide detailed requirements for operators regarding the observation, forecasting and reporting of physical environment data to ensure safe and prudent conduct of operations, emergency response, and spill countermeasures. It is important to note that a more comprehensive analysis would be required to adequately address the risks presented by these physical factors on a project specific basis.

An overview of potential environmental conditions which could potentially affect exploration activities is provided below.

Ice

Sea ice typically forms in the western and northern coastal zones of the Gulf of St. Lawrence during December; by the end of January the sea ice starts to flow through the Cabot Strait under the influence of surface currents and wind. Some year's ice, as a mixture of drift ice and locally formed ice may extend as far as Halifax and to the southwest towards Sable Island, although this is rare. The spring breakup of ice normally commences in March and recedes to patches within the Gulf of St. Lawrence by mid-April. In severe years, ice may stay longer on the Scotian Shelf until May or June. In the event that ice does migrate to the Scotian Shelf, it is not anticipated to result in significant adverse effects since structures are now designed with ice protection systems able to withstand impacts of up to a 6 million tonne iceberg (CAPP 2012).

Icebergs generally degrade by the time they reach the Scotian Shelf but ships will track and maneuver to avoid any icebergs that may be present and drilling platforms would likely be evacuated. The extent of ice coverage and ice movements can be tracked through the Canadian Ice Service (Environment Canada 2012c). Ice accumulation on equipment and vessels from sea spray can also affect exploration activities. Sea spray can form for a large portion of the year (Nov-Apr) as it only requires air temperatures below -2°C, wind speeds of 10 km/h and water temperatures below 6°C (JWEL 2003).If working under these conditions, Operators would need to have proper de-icing equipment available for use as necessary.

Fog

Fog is often present on the Scotian Shelf, with approximately 35% of days reporting fog with a visibility less than 1 km. This jumps to 65% of days in July as warm tropical air masses move north and cause large fog banks and stratiform clouds (Hurley 2011). Impacts of fog on exploration activities pertain primarily to delay due to poor visibility and inability to detect species of concern for avoidance. Table 6.1 presents historical data for visibility acquired from the Sable Island weather station.

Table 6.1 Hours of Visibility per Month Recorded at the Sable Island Weather Station, 1971-2000

	Visibility (hours with)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
<1 km	45.8	52.1	77	107.7	166.6	205.2	215.6	127.3	35.3	28.5	32.5	28.6
1-9 km	179.9	147.8	140.3	158.1	1158.8	153.2	183.7	175.7	122.1	106.9	132.5	144.1
>9 km	518.3	477.8	526.7	454.2	418.6	361.6	344.8	441.1	562.6	608.6	555	571.4
Note: Visibility in kilometers (km) is the distance at which objects of suitable size can be seen and identified.												

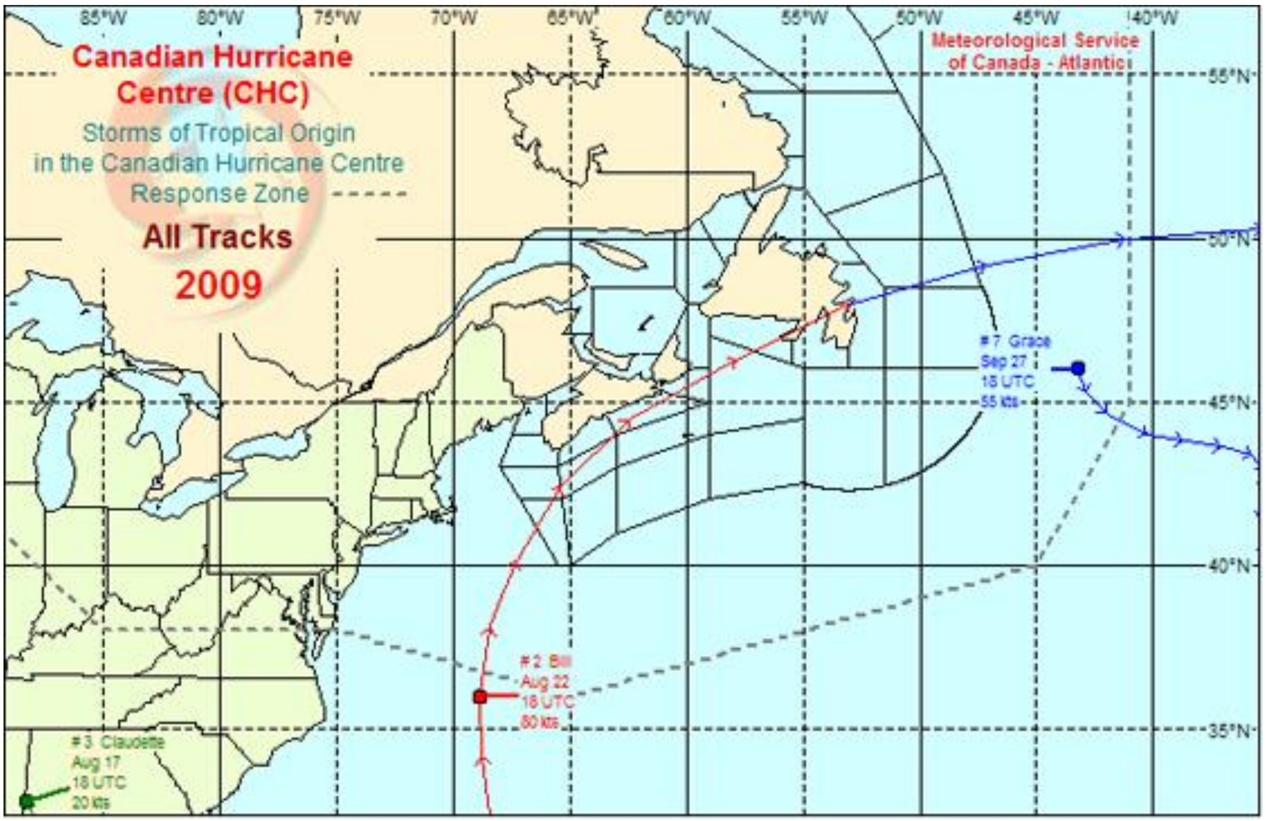
Source: Environment Canada 2012a

Seismic Events and Tsunamis

The Scotian Shelf is an area of known seismic activity with recorded earthquakes, and fault zones occurring on the Shelf. While the area is seismically active (refer to Figure 3.4), events tend to be of a low magnitude and given the short duration of exploration activities the probability of a significant seismic event or tsunami occurring during an exploration program is low. Guidance on planning and designing for seismic activity and other geological instabilities can be found in the American Petroleum Institute's design document "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design" (API 2005).

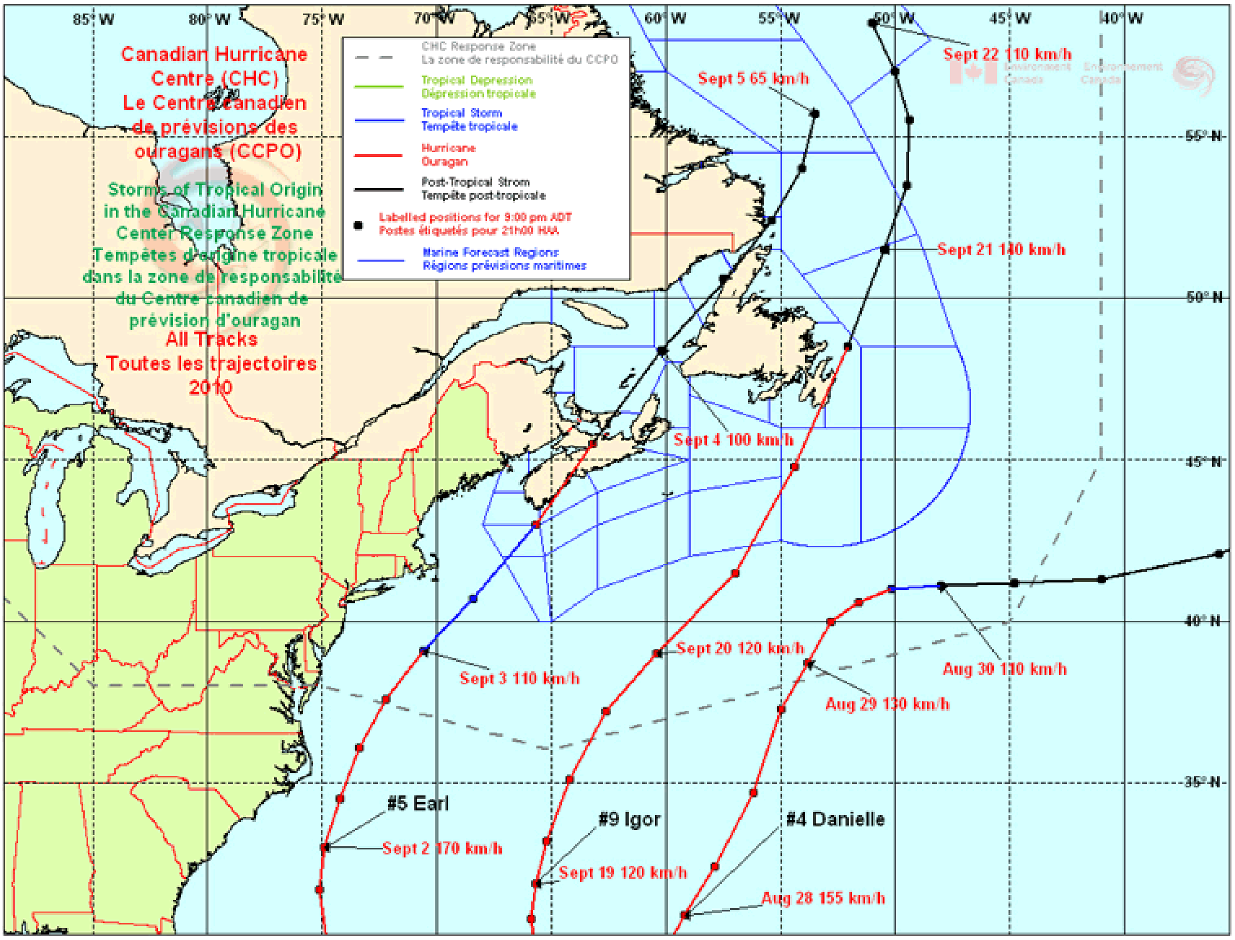
Hurricanes, Wind and Extreme Weather Events

The Scotian Shelf lies in the path of occasional hurricanes and tropical storms that travel up the eastern coast of North America in the late summer and fall. Figures 6.1 to 6.3 illustrate the tracks for storms originating in the tropics which have tracked through Atlantic Canada between 2009 and 2011.



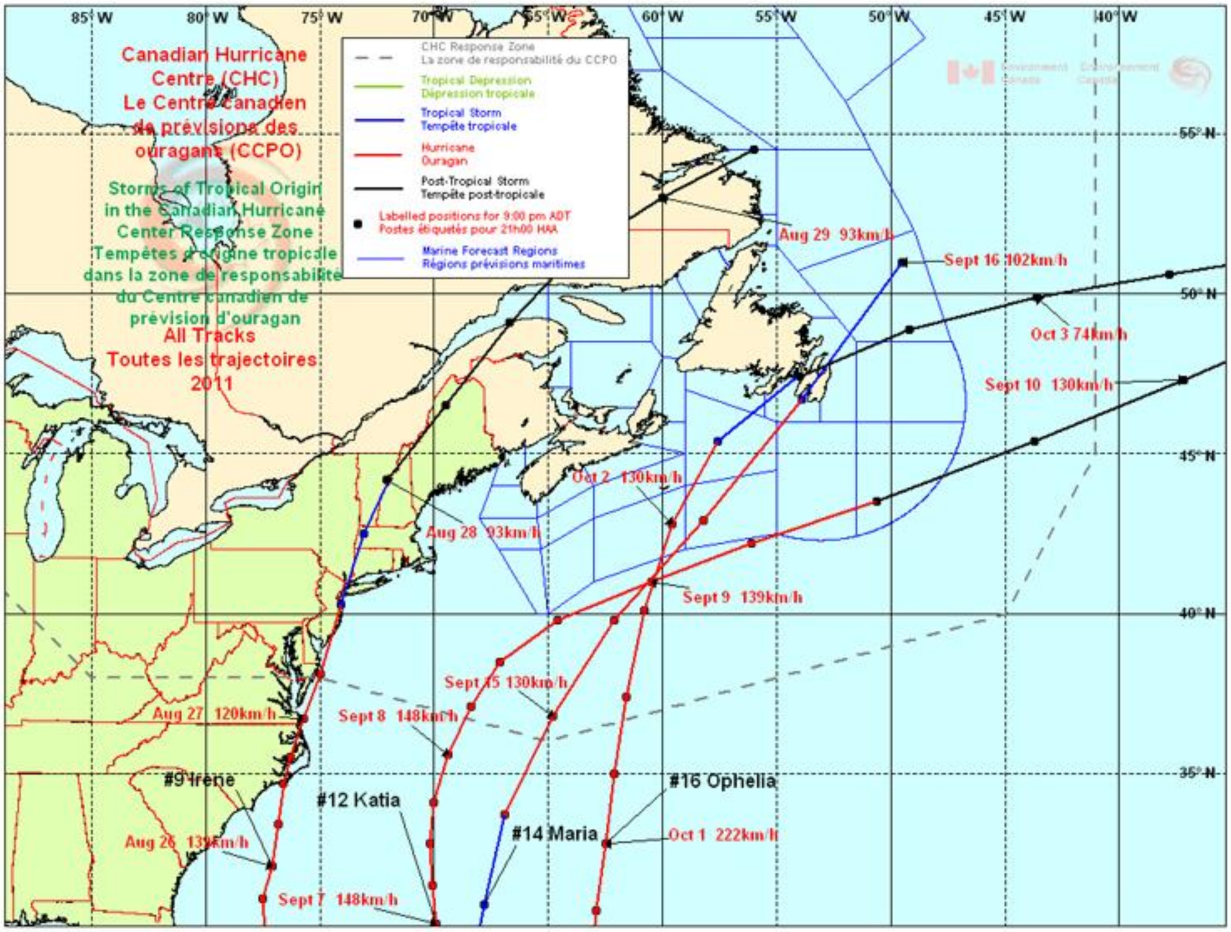
Source: Environment Canada 2012b

Figure 6.1 2009 Atlantic Canada Extratropical Storm Tracks



Source: Environment Canada 2012b

Figure 6.2 2010 Atlantic Canada Extratropical Storm Tracks



Source: Environment Canada 2012b

Figure 6.3 2011 Atlantic Canada Extratropical Storm Tracks

These large storm events pose many risks to exploration activities including reduced visibility, increased wave height, increased wind speeds and heavy precipitation. Winter storm events are also an important consideration as they have the potential to add significant weight to any equipment or vessels very quickly in the form of ice or snow.

Average wind speeds range from 17.5 km/h in September to 31.5 km/h in January while wind speeds can be sustained at 130 km/h during severe storm events. A detailed analysis of meteorological and oceanographic conditions should always be maintained to ensure storm events and high wind and wave events are anticipated and avoided.

Marine Life

The biological environment could impact exploration activities in several ways, including;

- Biofouling of instrumentation or equipment;
- Structure colonization by barnacles, urchins or sea grasses; and
- Presence or migration of species of special status could halt or delay work.

Given the timeframe anticipated for exploratory work (*e.g.*, 30 – 90 days for drilling), it is unlikely that biofouling or colonization of structures or equipment would occur. Presence of species of special status could delay seismic or drilling activities, particularly if they are present within the 500 m safety zone. Planning of programs should take into consideration known distribution of species of special status including known migration routes and timing.

Climate Change

While many of the effects of climate change are expected to be realized over extended time scales (increased temperatures, rising sea levels), others such as large storm events could occur over shorter time scales. Climate models predict an increase in large storm events both in terms of storm intensity and frequency. The Scotian Shelf lies in the path of occasional tropical storms and hurricanes and is thus directly exposed to any increases in storm intensity attributed to climate change. A detailed analysis of meteorological and oceanographic conditions should always be maintained to ensure storm events and high wind and wave events are anticipated and avoided to the extent practical.

Sediment and Seafloor Stability

A variety of sediment types exist on the Scotian Shelf with silty sediments having settled in deep basins while sand and gravel cover the shallow banks and tend to slump over the shelf edge. The Northeast Channel in the West Scotian Shelf is considered a route of active sediment transport and feeding a shelf-break sediment fan onto the Slope and into deeper water (see Figure 3.1; WWF 2009). The Shelf contains few canyons (Dawson and Verrill Canyons) which create steep banks, possible areas of slope instability and provide avenues for sediment transport between the Shelf and the deep ocean. Sediment scour, liquefaction of sediments from seismic events and slope failure could all adversely affect exploration drilling activities. In particular, scour and/or deposition could occur around footings of jack-up drilling rigs. Periodic monitoring of footings (where applicable) should be carried out, particularly during the winter storm season, to avoid adverse effects associated with sediment transport and seabed stability.

Summary

In summary, it is expected that vessels and equipment would be designed and installed (where applicable) based on appropriate environmental design criteria to ensure integrity of facilities and safety and protection of workers and the natural environment. Although effects of the environment require consideration in project-specific design and environmental assessment and monitoring plans, these effects are not expected to be significant assuming appropriate planning and design criteria are followed.

7.0 Potential Cumulative Effects

"Cumulative environmental effects" is generally used to describe environmental change resulting from several anthropogenic alterations with environmental effects overlapping in both time and space. These effects could result from the activities of several large-scale developments or the combined effects of multiple developments. SEA allows for cumulative effects assessment (CEA) at a broad scale before individual project development to assist with planning and environmental management on a regional basis and to inform project specific assessments

7.1 CUMULATIVE EFFECTS ASSESSMENT SCOPING

An important component of assessing cumulative environmental effects involves the identification of past, present and likely future projects and activities that could interact in combination with proposed activities. As indicated in Section 2, seismic exploration and drilling activities have occurred in the Nova Scotia offshore since the 1960s. Section 3.3.4 describes petroleum industry and other ocean uses in the Study Area. These ongoing activities can potentially result in effects that can overlap spatially and temporally with effects associated with petroleum exploration and thus have been considered in terms of potential cumulative environmental effects (*i.e.*, military training, shipping, oil and gas developments). The cumulative effects of commercial fishing activity have also been considered.

7.2 CUMULATIVE EFFECTS ANALYSIS

Table 7.1 presents a summarized analysis of cumulative effects for Species of Special Status, Special Areas, and Fisheries in consideration of residual effects discussed in Section 5 of this SEA and potential cumulative effects from other ocean uses and/or other contributing factors which could affect the resilience of a VEC. Data gaps and uncertainties at the SEA level of analysis limit the confidence of cumulative effects predictions. It is not possible with current approaches and methodologies to accurately predict the scope and impact of cumulative effects at the SEA level; however this constraint should not prevent identification of potential mitigation and planning considerations to reduce potential cumulative effects.

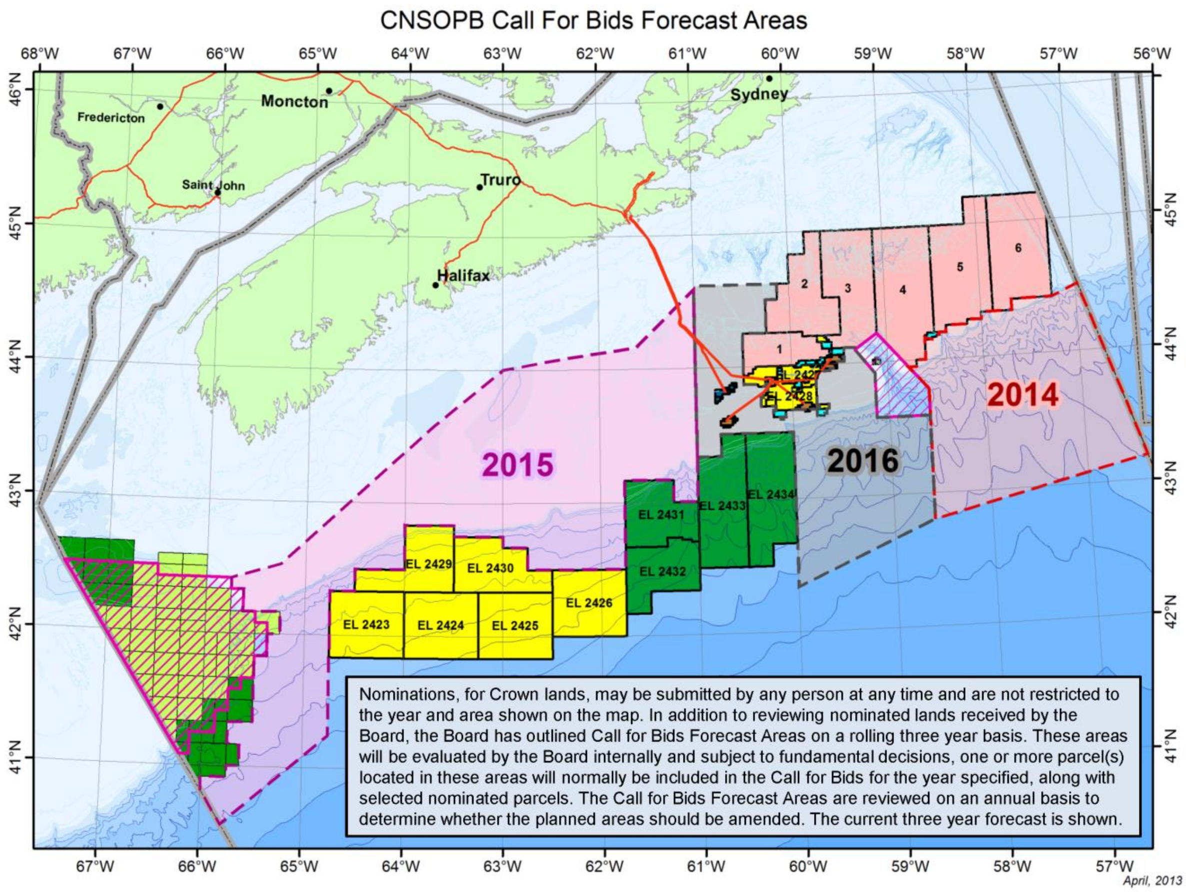
Species at risk are, by their definition, more vulnerable and less resilient than non-listed species and major threats to their survival usually are attributed to anthropogenic activities. Fishing, vessel traffic and marine pollution are the main threats to fish, marine mammal, and sea turtle Species of Special Status. Underwater noise generated by petroleum exploration activities, collisions with vessels, entanglement in fishing gear, and accidental spills would contribute to existing threats on these species.

Major threats to migratory birds, including but not limited to bird species at risk, are generally associated with loss of habitat (which could occur as a result of anthropogenic activities and/or climate change), human disturbance around nests, and predation/harvesting, While exploration activities would not normally contribute to these specific threats, mortality risks could occur as a result of flaring, stranding on platforms, and accidental spills, thereby acting cumulatively with existing stressors on these species.

Special Areas, not unlike Species of Special Status, may be more vulnerable to cumulative adverse effects than other areas in the marine ecosystem as many have been designated to protect vulnerable species and/or unique habitat. Special Areas that are designated in recognition of species at risk (*e.g.*, Roseway Basin) are vulnerable to threats that affect those particular species (*e.g.*, vessel collisions with North Atlantic right whales). In many cases, activities which could threaten the integrity of a Special Area are restricted as is the case with seasonal fishery closures/gear restrictions in fisheries conservation areas for example. Another example is the voluntary vessel traffic restriction in the Roseway Basin Area to be Avoided as the reduction of risk of vessel collision has been demonstrated to have a positive effect on survival rates of North Atlantic right whales. Conservation measures associated with Special Areas, along with standard mitigation and codes of practice for the oil and gas industry serve to reduce cumulative environmental effects on Special Areas.

With respect to fisheries, any effect which contributes to a potential loss of income can contribute to a cumulative adverse effect. Reduced fish stocks (which may be attributed to overfishing), restrictions on harvesting conditions (*e.g.*, seasonal/gear restrictions), and loss of access (*e.g.*, inshore infilling), are examples of effects on fisheries that could interact cumulatively with effects from petroleum exploration activities.

In consideration of the other ocean uses in the Study Area, the greatest potential for cumulative effects comes from other petroleum exploration and development on the nearby Sable Island Bank (*e.g.*, SOEP, Deep Panuke developments and ongoing exploration) and recent and planned exploration activities (seismic, exploration drilling) on the Scotian Slope associated with Exploration Licenses held by Shell Canada Limited and British Petroleum (BP) Exploration Operating Company Limited (refer to Figure 3.26). In addition, the CNSOPB has released a map showing forecasted Call for Bids (2014-2016) which may provide an indication of location of potential future exploration work offshore Nova Scotia (Figure 7.1).



Source: http://cnsopb.ns.ca/sites/default/files/pdfs/call_for_bids_forecast_2014-2016.pdf

Figure 7.1 CNSOPB Call for Bids Forecast Areas

The CNSOPB is responsible for authorizing all petroleum related activities in the Nova Scotia Offshore and therefore has the authority to reduce spatial and temporal overlap of activities and associated environmental effects. For example, all applications for seismic programs are reviewed by the CNSOPB to determine potential overlap with historic seismic surveys, reducing unnecessary overlap in data acquisition. Project-specific EAs should consider temporal overlaps, program timing, survey logistics and cumulative sound fields to the extent possible.

As noted by fishery stakeholders during the preparation of this SEA, the effects of climate changes should not be ignored as a contributor in the assessment of cumulative effects. Effects of climate change, some of which are already being realized, will most likely exacerbate the effects of other stressors, reducing resilience to cumulative effects of marine species (DFO 2013f).

In accordance with the Federal Adaptation Policy Framework, DFO initiated an Aquatic Climate Change Adaptation Service Program (ACCASP; 2011-2016) which undertakes risk assessments and fosters research programs to improve understanding of the risks of climate change effects on biological systems and infrastructure within their mandate. While there remains much uncertainty in climate change projections, the following generalizations have been made for the Scotian Shelf/Slope and Gulf of Maine region: increase in air and ocean water temperature (all seasons); complete disappearance of sea ice except in coastal areas; decrease in salinity; increase in stratification; and possible changes in large-scale ocean circulation with potentially substantial effects on regional ocean climate. The consequences of these changes include potential changes to food-webs which ultimately could lead to a decrease in fishery catch potential, with the Western Scotian Shelf identified as being particularly vulnerable to this effect (DFO 2013f). Furthermore, the distribution and dominance of marine mammal species as a result of changes in ice dynamics could affect their prey and thus the ecosystem structure (DFO 2013f). As the ACCASP and other climate change research initiatives continue, consequences of climate change will become better understood, and appropriate policies can be adapted to manage ecosystem changes.

Taking a collaborative approach and exploring cumulative environmental effects at an ecosystem level is key to managing cumulative effects effectively.. DFO has an ongoing mandate for Integrated Oceans Management on the Scotian Shelf. The overall purpose of integrated oceans management is for decision makers responsible for ocean-based activities to manage these activities in a manner that will sustain a healthy marine environment and provide due consideration for other ocean users. It includes the promotion of ecosystem approaches to management, conflict avoidance and mitigation, and effective intergovernmental coordination for ocean management. By implementing an integrated management approach, the health of marine ecosystems will be maintained, user conflicts will be addressed, the cumulative effects of human activities will be limited, and sustainable use of the ocean will be maximized and diversified. Key interests in ocean use and activities included 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 2002).

Intergovernmental cooperation and collaboration around management of ocean resources has allowed ocean users and regulators to better understand the nature of cumulative effects on the marine ecosystem and identify applicable adaptive management strategies. For example, EEM programs conducted by the offshore petroleum industry are designed in cooperation with various regulators, scientific experts and interested stakeholders so that data on ecosystem effects can be shared with other interested parties to inform future mitigation and environmental management decisions. Continued cooperation and information sharing among ocean users and applicable regulators will help to manage potential cumulative effects on the marine environment.

Table 7.1 Cumulative Effects Assessment

Environmental Component and Associated Residual Effects of Exploration Activities	Residual Effects of Other Past, Existing or Future Projects/Activities	Potential Cumulative Effects	Mitigation Measures for Exploration Activities
Species of Special Status	Existing marine activities in the Study Area (including military training, shipping, oil and gas developments) result in a noisy underwater environment which can potentially affect marine mammal and sea turtle behavior. Entrapment and entanglement in fishing gear (including bycatch) and collision with ships contribute to adverse effects on Species of Special Status. Changes to the marine environment, including changes which may be brought on by climate change can affect species behavior and distribution, thereby potentially affecting interactions with other marine activities and resilience to adverse cumulative effects.	Potential increase in underwater noise. Potential increase in mortality risk.	Adherence to SOCP, including soft ramp-up and use of Marine Mammal Observers with experience in identifying beaked whales when near critical habitat for beaked whales listed on Schedule 1 of *SARA*. In the event that beaked whales detected, enhanced mitigation may be required (*e.g.*, 30 minute observation period outlined in the SOCP may be extended). Use of established vessel routes for supply vessels and avoidance of known sensitive areas.

Table 7.1 Cumulative Effects Assessment

Environmental Component and Associated Residual Effects of Exploration Activities	Residual Effects of Other Past, Existing or Future Projects/Activities	Potential Cumulative Effects	Mitigation Measures for Exploration Activities
Special Areas	Other ocean uses generate noise and traffic in and around special areas although residual effects are expected to be limited given implementation of codes of practice for operating in proximity to some special areas (*e.g.*, Roseway Basin). Chronic hydrocarbon discharges from vessels result in oiling of species (particularly diving birds) and Special Areas (*e.g.*, shoreline of Sable Island). Fishing activities, particularly bottom trawling, can adversely affect areas of benthic ecological significance.	Potential increase in underwater noise. Potential increase in hydrocarbon contamination as a result of chronic discharges or accidental spills.	Development and implementation of Codes of Practice to minimize interaction with Special Areas.
Fisheries	Past and existing petroleum exploration and development projects have resulted in loss of fishing access due to establishment of safety zones (typically 500 m) around operational survey vessels and/or platforms. Historic overfishing has resulted in reduction of fish stocks and in some cases prompted the establishment of fisheries conservation areas which restrict fishing activity. Climate change-related effects on the marine environment have influenced species distribution and abundance, thereby affecting catchability.	Potential cumulative effect of loss of access and gear conflict with addition of new drilling and/or seismic programs. Potential reduced catchability and increased fishing effort, reducing net income.	Use of Fisheries Liaison Officer (seismic programs) and ongoing communication with stakeholders and coordination of program activities with fishing industry to reduce potential conflict during peak fishing times. Financial compensation for damage to fishing gear.

8.0 Data Gaps and Recommendations

The CNSOPB recognizes information gaps in SEA and project-based EAs and continues to identify priority areas of research in cooperation with federal departments and agencies and other stakeholders. Initiatives such as the Environmental Studies Research Funds (ESRF) and the Program of Energy Research and Development (PERD), of which the CNSOPB is a member, target information gaps pertaining to energy research and environmental and social issues associated oil and gas exploration and development on Canada's frontier lands.

In 2011, ESRF, the Offshore Energy Environmental Research Association (OEER) and the E&P Sound and Marine Life Joint Industry Program (JIP) of the International Oil and Gas Producers Association (OGP) hosted a workshop in Halifax, NS to discuss the design of studies to assess the effect of seismic sound sources. This workshop built on previous ESRF and OGP workshop and meetings focusing on effects of seismic sound on fish. The main outcome of this workshop was a set of recommendations associated with future studies to advance understanding of effects of seismic sound on fish behavior (CEF 2011). ESRF has identified hydrocarbon spills and seismic as priority research areas for the offshore in 2013.

Table 8.1 below summarizes data gaps and recommendations specifically relevant to potential exploration activities in the SEA Study Area and reflects gaps and recommendations previously identified by others (*e.g.*, CEF 2011; Hurley 2009). Ongoing research being conducted by OGP, OEER and ESRF programs, as well as Project specific EEM is also expected to provide a continuing source of valuable environmental information to help address these data gaps (ESRF 2013).

In light of these data gaps and uncertainties, a precautionary approach to oil and gas exploration should be taken in the vicinity of sensitive areas and presence of species at risk. This precautionary approach may mean enhanced mitigation and monitoring until understanding of potential interactions and effects can be improved and appropriate mitigation developed accordingly.

Table 8.1 Summary of Data Gaps and Recommendations

Data Gap/Uncertainty	Implications/Recommendations
General lack of site-specific information on the distribution of species of special status including migratory birds in the Study Area.	Monitoring and observation programs of species of special status during operator-specific exploration programs can increase knowledge, particularly if the data can be collected and analyzed using standardized methods.

Table 8.1 Summary of Data Gaps and Recommendations

Data Gap/Uncertainty	Implications/Recommendations
Uncertainty regarding MPA Network planning process – additional AOIs/MPAs could be identified; the boundaries of existing AOIs/MPAs could be changed; some EBSAs require further investigation of their ecological importance and sensitivity to petroleum exploration activities; management approaches have not been finalized (*e.g.*, allowable and prohibited activities).	Additional MPAs may be identified in the Study Area thereby requiring additional planning and mitigation considerations. The CNSOPB is committed to reviewing and updating SEAs on a regular basis to ensure validity; therefore it is likely that any change to EBSA and/or MPA designations would be addressed in these updates accordingly.
Uncertainty around sublethal effects of seismic sound on marine animals and in particular, behavioral effects.	Research programs have studies underway to address sound source characterization and propagation; physical and physiological effects and hearing; behavioral reactions and biologically significant effects; and mitigation and monitoring. The most relevant studies are those that are conducted while the species are exposed to actual seismic surveys. Future seismic surveys on the Western Scotian Shelf would present an important research opportunity to fill knowledge gaps regarding seismic noise and North Atlantic right whales and blue whales. DFO held a National Canadian Scientific Advisory process to review mitigation and monitoring measures for addressing seismic impacts on SARA-listed whale species in March 2014.
Uncertainty around effects of underwater noise (including seismic and drilling sound) and drilling discharges on coral and sponge communities.	Exploration activities near sensitive benthic areas will avoid known concentrations of coral and sponges. However, exploration activities in the vicinity of these concentrations could involve EEM activities to document potential effects of exploration activities on coral and sponge communities.
There is a lack of information regarding the deeper areas of the marine benthic environment on the Scotian Slope.	The ongoing erosion of Dawson and Verill Canyons and areas in between may enhance the biological productivity in the area, which would attract species, including those of special status.
There are large data gaps associated with the understanding of areas and timing of critical life-cycle stages of various species.	As knowledge increases about areas and timing of critical life stages over the life of the SEA, project-specific EAs should reference updated information as applicable.
Consequences of seismic exploration (sound levels) and accidental spills on special areas in the Study Area.	Site-specific acoustic and spill fate modeling should be conducted for project-specific EAs for exploration projects proposed in Phase 3A Project Area with mitigation and monitoring plans implemented as appropriate.
Environmental assessments for exploration drilling and development projects on the Scotian Shelf and/or Slope to date have modeled blowout scenarios involving condensate from gas fields that	Oil spill trajectory modeling should be conducted for a location within the Phase 3A Project Area, with product properties and flow estimates based on a spill scenario involving a well blowout in the event

Table 8.1 Summary of Data Gaps and Recommendations

Data Gap/Uncertainty	Implications/Recommendations
are known to be present. There are currently no modeling results available for a blowout scenario involving crude oil fields offshore Nova Scotia which have yet to be discovered.	an oil reservoir is likely to be discovered. This may be project-specific and/or site-specific and will provide information on expected behavior of a crude oil spill on the Scotian Shelf/Slope.
Consequences and lessons learned from past oil and gas accidents and malfunction incidents.	Project-specific EAs for exploratory drilling should include discussions on lessons learned from the Gulf of Mexico oil spill (Macondo incident) that may be relevant to the specific project.
Detection of presence and behavioral effects of marine mammals (particularly beaked whales) and sea turtles associated with seismic exploration and drilling.	Continuous use of PAM (and trained marine mammal observers as well as adherence to (and in some cases enhancement of) the Statement of Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment. The use of a marine mammal observer with experience in identifying beaked whales is an important factor for increasing probability of sighting these whales. Trained observers and improved data will enhance understanding of distribution and behavior of species of special status.

In recognition of mitigation and monitoring measures and ongoing research to address these data gaps, it is expected that adverse environmental effects from oil and gas exploration activities can be managed to acceptable levels within the Phase 3A Project Area.

9.0 Summary and Conclusions

This report is an SEA of potential impacts of petroleum exploration activities on the Western Scotian Shelf and is intended to assist the CNSOPB and potential developers with respect to future applications and environmental management planning within the Phase 3A Project Area. This SEA has focused on VECs and interactions of concern as identified in the Scoping Document (Appendix A). Mitigation measures to reduce environmental effects and address data gaps and uncertainties are summarized in Table 9.1.

Table 9.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
Seismic and Seabed Surveys	• Avoidance of Roseway Basin Area Critical Habitat, Northeast Channel Coral Conservation Area (intrusive seabed surveys), and Sambro Bank and Emerald Basin Vazella Closure Areas (intrusive seabed surveys). • Schedule surveying to minimize interaction with peak haddock spawning in the Haddock Box (April to May). • If beaked whales are detected, enhanced mitigation may be required for seismic surveys (*e.g.*, the 30 minute observation period outlined in the Statement of Canadian Practice with Respect to Mitigation of Seismic Noise in the Marine Environment may be extended to 60 minutes to account for longer diving times. • Use of trained wildlife observers, with experience in identifying beaked whales listed on Schedule 1 of *SARA*, to visually monitor and record marine mammal, sea turtle and marine bird interactions and to help enforce safe operating distances. • Seabird monitoring to be completed following the CWS pelagic seabird monitoring protocol provided in Appendix C. • Detailed acoustic modeling as input to any project-specific EAs for seismic projects in the Phase 3A Project Area that may occur in the June-December period when North Atlantic right whales may be congregating in the Study Area. These modeling results may be used to define appropriate safety zones for shutdown (*e.g.*, 180 dB rms safety zone) and the buffer zone around the Roseway Basin Critical Habitat/Area to be Avoided. • Fisheries Liaison Officer (FLO) familiar with NS offshore fisheries to be present on the seismic survey vessel(s) to communicate with fishing vessels in the area and to avoid potential conflict with fishing activities/gear. For conventional (single vessel) seismic programs FLOs may be trained as marine wildlife observers and perform both tasks. • Use of Passive Acoustic Monitoring (PAM) as per the "Statement of Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment". • Adherence to the CNSOPB "Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity". • Issuance of "Notice to Mariners" on location and scheduling of survey activities. • Commencement of seismic data acquisition only if survey area confirmed to be clear of fixed fishing gear (*e.g.*, lobster traps) or floating longline gear (*e.g.*,

Table 9.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
	for large pelagics such as tuna and swordfish). • Consultation with key organizations representing fishing interests (including commercial and Aboriginal) in the area during the EA planning stage and just prior to commencement of any work to coordinate seismic program activities with fishing industry and to reduce potential conflict with fishing activity during peak fishing times. • Consultation with DFO Science Branch to ensure survey area and timing minimizes potential for conflict with research vessel program plans. • Consultation with the DND to ensure survey areas and timing minimizes the potential for conflict with exercises and/or training.
Exploratory Drilling	• Avoid exploration drilling in Roseway Basin, Northeast Channel Coral Conservation Area, and the Sambro Bank and Emerald Basin Vazella Closure areas. • Conduct pre-drilling ROV investigation to determine presence of corals, sponges, or other sensitive features as required by the CNSOPB. • Areas with known aggregations of cold water coral and other sensitive features shall be avoided during oil and gas drilling activities. If aggregations of cold water coral are found to occur as the result of an environmental assessment that is conducted following an application for drilling or production, the CNSOPB requires mitigation to avoid harming these aggregations (DFO 2006). • Follow Canadian Wildlife Service mitigation measures when finding a dead or injured bird (*i.e.*, Williams and Chardine handling protocol). • Adherence to the CNSOPB "Offshore Waste Treatment Guidelines" and "Offshore Chemical Selection Guidelines" to minimize effects of drill waste discharges during drilling programs. • Adherence to Nova Scotia Offshore Drilling and Production Regulations. • Bulk transfer and hose handling procedures as per best available practice. • Minimize flaring and ensure the use of high-efficiency igniters as per best management practice. • Focus all area lighting on the work areas of offshore platforms and down shade lights to minimize marine bird attraction. • Conduct a post-drilling ROV survey to verify that the muds and cuttings are within the predicted zone of influence. • Emergency contingency measures and response plans will be developed to address significant weather scenarios. • Monitor seabird interactions with the drilling rig/platform. • Enhanced mitigation and EEM programs may be required for activities within or adjacent to special areas, such as spawning areas (*e.g.*, the Haddock Box), the Roseway Basin Area to be Avoided/Critical Habitat, Northeast Channel Coral Conservation Area and/or Sambro Bank and Emerald Basin Vazella Closure areas. • Develop codes of conduct to guide new exploratory activities in the vicinity of the Roseway Basin Area to be Avoided/Critical Habitat. • Issuance of "Notice to Shipping" on location and scheduling of drilling

Table 9.1 Summary of Key Mitigation for Exploration Activities in Phase 3A Study Area

Exploration Activity	Proposed Mitigation
	activities. • Consultation with key organizations representing fishing interests (including commercial, Aboriginal and recreational) in the area during the EA planning stage.
Vessel Traffic	• Adherence to Transport Canada Guidelines for the Control of Ballast Water Discharge from Ships in Waters under Canadian Jurisdiction. • Use of existing vessel routes to the extent practical. • Seasonal avoidance of the Roseway Basin Area to be Avoided (June 1 to December 31). • Use of common routes by supply vessels and alternate routes around key fishing grounds particularly when fishing is at its peak.
Well Abandonment	• Design of wells and casings to facilitate effective mechanical cutting and removal of the wellhead; avoiding explosive means of separation where possible. • If use of explosives is necessary, the recommendations set out in the *Guidelines for the use of Explosives in or near Canadian Fisheries Waters* (Wright and Hopky, 1998) will be followed.
Accidental Spills	• Detailed spill probability and behavior modeling as input to any project-specific EAs for a drilling project in the Phase 3A Project Area. • Engineering design and protocols to prevent spills from occurring and/or reaching the marine environment including but not limited to secondary containment, inspection and maintenance, spill response kits, and blowout safeguards. • Implement Emergency and Oil Spill Response Plan accepted by the CNSOPB to address spill prevention and response including interactions with fishers and other ocean users, and includes spill response exercises. • Outline an EEM Plan to address post-spill monitoring effects, with the scope of the EEM Plan directly related to the severity of the spill. • Operator to establish ongoing communication with key fisheries stakeholders and other ocean users in the event of a spill and during spill response activities, including but not limited to issuance of a Notice to Shipping/Mariners. • Adherence to CNSOPB "Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity".

Stakeholder consultation will play an important role in mitigating effects on fisheries and other ocean users. Assuming adherence to applicable standards and regulations and implementation of mitigation and monitoring as recommended, the issuance of exploration rights in the Phase 3A Project Area is not expected to result in unacceptable adverse environmental effects such that populations of species of special status or integrity of special areas would be compromised beyond sustainable levels. It should be noted that there is the potential requirement for additional or alternative mitigation measures on a case by case basis at the Project level. Effects of exploration on fisheries are also not expected to result in unacceptable effects provided the implementation of recommended mitigation and ongoing communication with fishery stakeholders.

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APPENDIX A

Scoping Document

Scoping Document for the Strategic Environmental Assessment for the Western Scotian Shelf and Slope

Canada-Nova Scotia Offshore Petroleum Board

August 2013

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1.0 Introduction

This document describes the scope of two strategic environmental assessments (SEAs) for offshore petroleum exploration activities in the marine area on the Western Scotian Shelf and Slope. The Phase 3A SEA will address seismic and exploratory drilling on the Western Scotian Shelf (west of Sable Island Bank to Browns Bank) out to water depths of 2000 m, and the Phase 3B SEA will address seismic and exploratory drilling on the adjacent Western Scotian Slope in water depths in excess of 4,500 m (refer to Figure 1 for the SEA Proposed Project Areas). This Scoping Document outlines the factors to be considered in the SEAs, the scope of those factors, and guidelines for the preparation of the SEA reports.

The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) has the responsibility pursuant to the *Canada-Nova Scotia Offshore Resources Accord Implementation Act* and the *Canada-Nova Scotia Offshore Resources Accord Implementation Act (Nova Scotia)* (the Accord Acts) to ensure that offshore oil and gas activities proceed in an environmentally responsible manner. The CNSOPB conducts SEAs in those areas offshore Nova Scotia that may have the potential for offshore petroleum exploration activity but that were not subject to a recent SEA nor to recent and substantial project-specific environmental assessments. In addition, the CNSOPB endeavours to review SEAs within five years of completion to determine validity.

This scoping document has been prepared by the CNSOPB, and will be subject to regulatory and stakeholder review before finalization.

2.0 Background

SEA incorporates a broad-based approach to environmental assessment (EA) that proactively examines the environmental effects that may be associated with a plan, program or policy proposal and that allows for the incorporation of environmental considerations at the earliest stages of program planning. SEA typically involves a broader-scale (*i.e.*, regional, sectoral) assessment that considers the larger ecological setting, rather than a project-specific EA that focuses on site-specific issues with defined boundaries.

In this particular case, information from these SEAs will assist the CNSOPB in its determination in respect to the potential issuance of future exploration rights within the Western Scotian Shelf and Slope SEA areas and may identify general restrictive or mitigative measures that should be considered for application to consequent exploration activities.

An exploration license confers:

- The exclusive right to explore, drill and test for petroleum;
- The exclusive right to develop those portions of the offshore area in order to produce petroleum; and
- The exclusive right, subject to compliance with the other provisions of the Accord Acts, to apply for a production license.

Activities associated with exploration licenses may include: conduct of seismic surveys, other geophysical surveys and geotechnical surveys; drilling of wells (either exploration or delineation); and well abandonment.

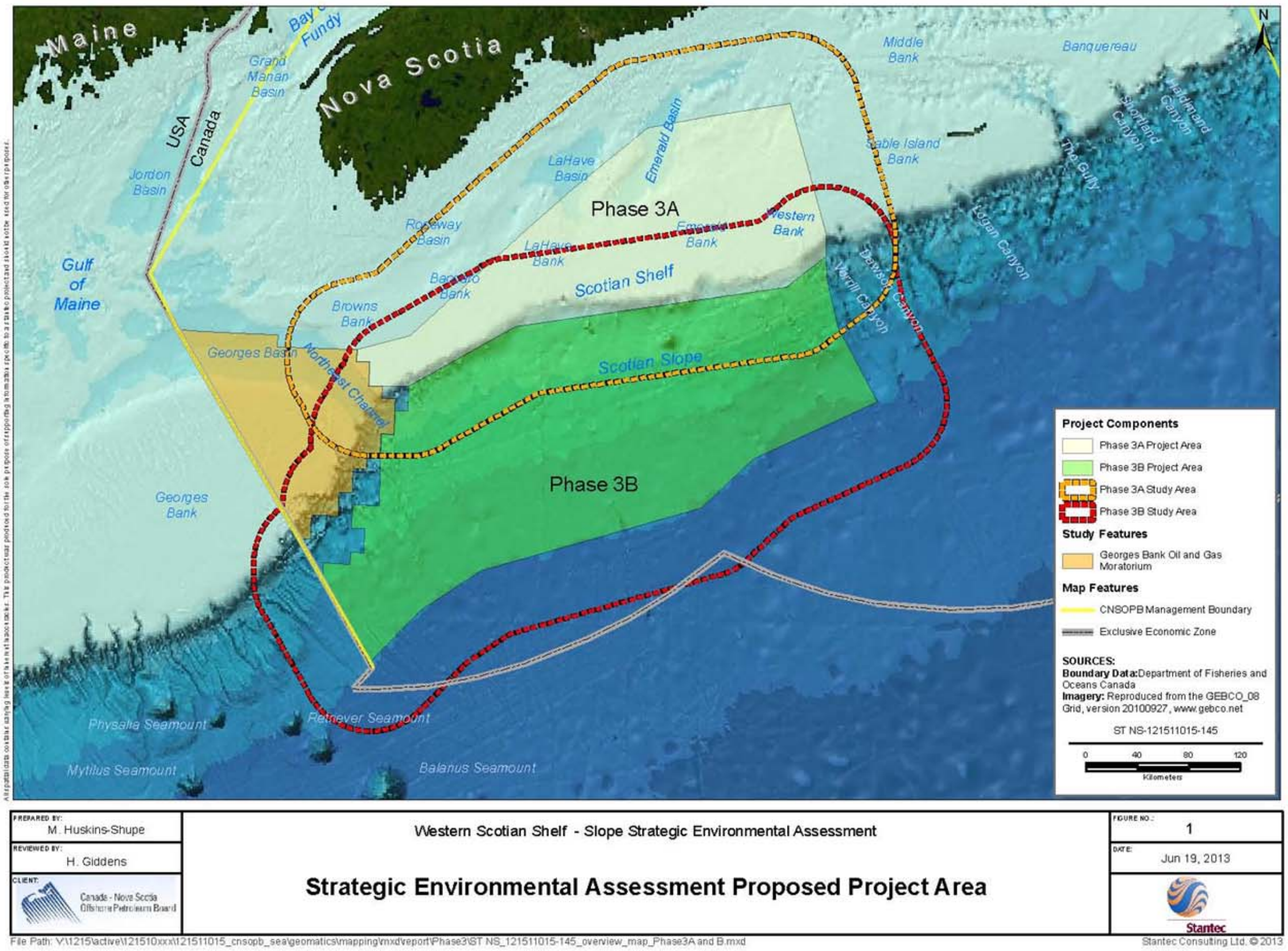
Each of these activities requires the specific approval of the CNSOPB, including a project-specific assessment of its associated environmental effects, and may also be subject to review by Federal Government Departments, such as Fisheries and Oceans Canada and Environmental for compliance with applicable legislation and/or regulations. The SEA does not replace this requirement for a project-specific EA. However, the SEA assists in focusing these EAs by providing an overview of the existing environment, discussing in broader terms the potential environmental effects associated with offshore oil and gas exploration activities in a large area or region, identifying knowledge and data gaps, highlighting issues of concern, and making recommendations for mitigation and planning.

3.0 Geographic Scope

The SEA proposed project areas encompass the areas shown on Figure 1. Projects areas shown could be included in any potential Call for Bids lands or resulting Exploration Licence lands. As per guidance from the Canadian Environmental Assessment Agency[1], the spatial domain of the SEA study areas may extend beyond the boundaries of the project areas where relevant, to include potential project interactions with the Valued Environmental Components (*i.e.*, within zones of influence of certain project discharges/emissions). Within the entire Phase 3 SEA study areas, water depths range from 50 m to over 4500 m. The Phase 3A SEA encompasses portions of the Western, Emerald, LaHave, Baccaro, and Browns Banks on the Western Scotian Shelf. The Phase 3B SEA focuses on the Western Scotian Slope, encompassing Dawson and Verrill Canyons and extending approximately to the western and southern boundaries of Canada's Exclusive Economic Zone (EEZ). The Phase 3B study area extends beyond the boundary of the EEZ into US waters.

[1] Operational Policy Statement entitled "The Process for Defining the Spatial Boundary of a Study Area During an Environmental Assessment of Offshore Exploratory Drilling Projects" (CEA Agency 2003).

Figure 1 SEA Proposed Study Areas for Phase 3A and Phase 3B



4.0 Objectives

Each SEA will:

- Provide an overview of the existing environment;
- Generally describe typical offshore oil and gas exploration activities (production activities are excluded);
- Describe and evaluate potential adverse environmental effects associated with offshore oil and gas exploration, including cumulative effects from existing production projects near the study areas, if any;
- Identify knowledge and data gaps;
- Identify species of special status and special areas that may interact with exploration activities;
- Identify fisheries and other ocean users that may interact with future exploration programs;
- Make recommendations for general mitigation measures that should be employed during offshore petroleum exploration activities;
- Identify, where appropriate, activities/areas requiring enhanced levels of mitigation; identify, if feasible, the level of enhanced mitigation required;
- Identify follow-up measures (*i.e.*, environmental effects monitoring), as appropriate, that may be required to verify environmental assessment predictions related to future offshore petroleum exploration activities; and
- Assist the CNSOPB in its determination in respect to the potential issuance of future exploration rights within the SEA areas of the Western Scotian Shelf and Slope.

5.0 Past and Current Petroleum Activity

In 2012, Shell Canada Limited (Shell) and BP Exploration Operating Company Limited (BP) acquired Exploration Licenses (ELs) on the western Scotian Slope, committing to exploratory work programs on these licenses. Shell is currently conducting a three-dimensional (3D) Wide Azimuth (WAZ) seismic survey in and near ELs 2423, 2424, 2425, 2426, 2429 and 2430. A map is available on the CNSOPB Offshore Project webpage: http://www.cnsopb.ns.ca/offshore-activity/offshore-projects/shell-shelburne-seismic-program.

This survey utilizes a four-vessel fleet of two streamer vessels and two additional source vessels. It is anticipated that the 3D WAZ seismic survey will be at least 65 days in duration and occur during the period from mid-May to mid-September 2013. Data acquisition is not expected to take longer than 120 days[2]. BP has indicated that it will likely propose a seismic exploration program in and near ELs 2431, 2432, 2433, and 2434 in 2014, although an application has not been filed as of the time of preparation of this document. There are no parcels associated with the NS13-1 Call for Bids within the Phase 3 SEA study areas.

Several exploration wells have been drilled on the Western Scotian Bank and Slope, all of which have been plugged and abandoned. At the western extent of the Phase 3A and Phase 3B study areas is the Georges Bank Prohibited Zone, within which a moratorium currently exists for petroleum exploration..

6.0 Scope of SEA

6.1 SCOPE OF THE PROJECT

The SEAs (for Phases 3A and 3B) will describe all foreseeable offshore oil and gas exploration activities in the study area. It will examine potential environmental interactions associated with these petroleum exploration activities. Exploration activities to be considered in the SEA include exploratory and delineation drilling, seismic survey activities (2D, 3D, wide angle azimuth (WAZ), vertical seismic profiling, geohazard surveys), geotechnical surveys, and wellsite abandonment. The focus of the SEA will be on offshore exploration activities (and interactions with the environment of those activities) which are under the jurisdiction of the CNSOPB. The SEA will describe where data and information are lacking, or limited. Suggestions for strategies to address data gaps will be identified.

6.2 SPATIAL AND TEMPORAL BOUNDARIES

The spatial boundary for exploration activities to be considered in the Phase 3A and Phase 3B SEAs is shown in Figure 1. The boundaries for the study areas will take into consideration the Operational Policy Statement entitled “The Process for Defining the Spatial Boundary of a Study Area During an Environmental Assessment of Offshore Exploratory Drilling Projects” (CEA Agency 2003).

The SEAs will include the offshore petroleum exploration activities, as described in the preceding section, which may occur within the SEA Project Area as a result of future Call for Bids. The SEAs will be reviewed in at least five years to determine validity.

[2] CNSOPB Offshore Activity Report. Shell Shelburne Seismic Program. http://cnsopb.ns.ca/offshore-activity/offshore-projects/shell-shelburne-seismic-program

6.3 FACTORS TO BE CONSIDERED

This section outlines the Valued Environmental Components (VECs) to be assessed in the SEAs and includes rationale for the inclusion of each of these components. Appendix A describes those components that will not be considered in the SEA because experience and research has shown that they are unlikely to be significantly adversely affected by petroleum exploration activities. Rationale for the exclusion of these components, and specific mitigation that must be implemented to allow for their exclusion in the SEAs, are also included in Appendix A. These exclusions are considered outside the scope of the SEAs and do not require assessment.

6.3.1 Valued Environmental Components

Each VEC (including components or subsets thereof) will be identified and the rationale for its selection provided. VECs could include “Species of Special Status”, “Special Areas”, “Fisheries”, and “Other Ocean Uses” in the vicinity of the study areas since these categories appear to cover environmental components to be potentially adversely affected by offshore hydrocarbon exploration activities.

Species of Special Status

Species of Special Status includes consideration of the following species and their critical habitat which may be present in the SEA study areas and determined to be potentially affected during exploration activities: species designated as at-risk under the *Species at Risk Act* (SARA); species assessed as endangered, threatened, or of special concern by the Committee on the Status of Endangered Wildlife of Canada (COSEWIC) and/or migratory birds protected by the *Migratory Birds Convention Act, 1994*. These are expected to include, but may not be limited to, leatherback and loggerhead turtle, North Atlantic right whale, fin whale, northern bottlenose whale, blue whale, Sowerby’s beaked whale, coral/sponges, and migratory birds.

Special Areas

Designated areas of special interest due to their ecological and/or conservation sensitivities (*i.e.*, marine protected areas, existing or future coral conservation zones, critical habitat, fish conservation areas, *etc.*) could be potentially affected by exploration activities in the SEA study areas. At a minimum, this discussion will include consideration of coral and sponge conservation areas, fisheries conservation areas, the Roseway Basin Area to be Avoided, and ecologically and biologically significant areas (EBSAs)). The Georges Bank Moratorium Area will also be discussed. The scope of the VEC also includes the inhabitants of the special area which may not be covered under the Species of Special Status VEC.

Fisheries

Commercial, recreational and aboriginal fisheries (including relevant fish species) that could be affected by exploration activities in the SEA study areas will be considered. The focus of the assessment of this VEC is on potential interactions with commercial fishing activities, including aboriginal fisheries interests as applicable, through environmental effects on fisheries resources, displacement from current or traditional fishing areas, or gear loss or damage resulting in a demonstrated financial loss to commercial fishing interests. Key fisheries on the Shelf within the study areas to consider are primarily, but not limited to, groundfish including cusk, cod, haddock, pollock, halibut, hake (white, red, silver), monkfish, and redfish. Inshore and offshore lobster will also be considered as relevant within the study areas. Key fisheries on the Slope consist primarily of large pelagics including tunas, swordfish, and sharks.

Other Ocean Uses

Other ocean uses that could be affected by exploration activities in the SEA study areas (*i.e.*, marine shipping, military use, research surveys, and other petroleum development activities, *etc.*) will also be considered.

6.3.2 Scope of the Factors to be Considered

Each SEA will include the following:

- Historical overview of offshore petroleum exploration activities in the study areas and a discussion of regional offshore oil and gas activities in the Nova Scotia offshore area;
- Overview of typical offshore petroleum exploration activities (well site surveys, vertical seismic profiling, 2D/3D/3D WAZ seismic, geotechnical programs, exploration drilling and well abandonment) and methods to carry out these activities (including a brief description of various types of rigs and vessels);
- Overview of the physical and biological environments in the SEA study areas based on existing information and data, with data gaps highlighted. This section will include a broad overview that clearly describes the biological communities that may be encountered in the study area;
- Overview of other marine activities in the SEA study areas (*e.g.*, commercial, recreational and Aboriginal fisheries, marine transportation);
- Identification and qualitative assessment of potential environmental interactions of the VECs with petroleum exploration activities;
- Identification of mitigation measures and monitoring that might be considered in project-specific EAs for offshore activities to minimize adverse residual environmental effects, highlighting specific or enhanced mitigation that may be required to address specific

concerns especially those proposed for any Species of Special Status or Special Areas identified within or adjacent to the SEA study areas;

- Discussion of potential planning implications/considerations (*i.e.*, need for additional data, special mitigation) which may have to be considered in project-specific EAs within the SEA study areas;
- General discussion of effects and mitigation of potential accidental events and malfunctions associated with offshore oil and gas exploration activity; and
- General discussion of potential cumulative environmental effects associated with multiple offshore human use activities in the study areas based on past, present and an estimate of potential future human use activity.

The SEAs will consider the environmental factors and issues outlined in Sections 6.3.3-6.3.5, as a minimum, with emphasis upon factors unique to the SEA study areas. Sufficient supporting information will be provided, or referenced and summarized if it already exists in publicly available publications. Substantive uncertainties or information gaps will be identified.

6.3.3 Potential Exploration Activities - Environment Interactions

For each of the identified VECs, a description of the interactions of petroleum exploration activity with the environment will be presented. Proposed activities include:

- Seismic surveying;
- Seabed surveying (*i.e.*, geophysical, geotechnical data collection);
- Vertical seismic profiles (VSPs);
- Exploratory/delineation drilling (*e.g.*, mobile offshore drilling unit (semi- submersible or drill ship)) and ancillary activities;
- Vessel traffic (*e.g.*, supply vessels, seismic vessels, helicopters); and
- Well abandonment operations.

Potential project interactions include, but are not limited to the following:

- Underwater noise (*e.g.*, during seismic surveying, seabed surveying, drilling) issues (*e.g.*, hearing loss, behavioural effects, *etc.*) on Species of Special Status and harvestable fish species;
- Effects (*e.g.*, smothering, toxicity) of operational discharges (*i.e.*, drill wastes) on Species of Special Status and harvestable fish species, particularly bottom-dwelling fish and shellfish species, and special areas;

- Interference with fisheries and other ocean uses during routine operations (*i.e.*, seismic surveying, seabed surveying, drilling) and/or accidental events (*e.g.*, large oil spill, blow-out);
- Attraction (due to lights and/or flares) of migratory birds to platform structures or support vessels; and
- Effects of accidental events (*e.g.*, large condensate spill) on all VECs.

6.3.4 Cumulative Exploration Activities - Environment Interactions

Cumulative environmental effects will be examined in consideration of the past, present and potential future petroleum activities in the SEA study areas and mitigation measures identified. Planned and reasonably foreseeable exploration activities will be included in the cumulative environmental effects assessment and it will also consider other non-petroleum activities ongoing in the SEA study areas (and adjacent Shelf and Slope areas) such as commercial fishing, marine traffic, and fisheries research surveys.

6.3.5 Effects of the Environment on the Project

For exploration activities identified, the SEA will include a discussion of the physical environmental conditions which could potentially affect exploration activities, including earthquakes, tsunamis, turbidity currents, and significant storm (severe winds and waves) events within the SEA study areas.

7.0 Conclusions and Recommendations

Based on the information presented in the physical and biological environment overview, the description of potential exploration activities-environment interactions and the application of mitigation measures, conclusions will be presented and planning approaches recommended for the CNSOPB to consider in the issuance of exploration licenses in the SEA study areas. Data gaps with the potential to affect the validity of these conclusions will be highlighted. Should project-specific EAs be conducted in areas where data gaps are identified in this, or other, studies, these data gaps will need to be addressed at the project-specific EA level. Sensitive issues, particularly those of public concern identified during the SEA process, will also be highlighted.

8.0 Consultations

Throughout the development of the SEAs, the CNSOPB and its contractor will consult with federal government departments, fisheries and other ocean users, and local non-governmental organizations. Information on the SEA process will be provided and stakeholders will be encouraged to discuss issues and concerns that are relevant to the SEA study areas and SEA objectives. SEA documents will be posted on the CNSOPB Public Registry.

It is anticipated that the final SEAs will be published for public/stakeholder review and comment for a 6-week period commencing mid-November 2013. Comments received will be considered by the CNSOPB, and the SEAs revised as appropriate, with final SEA documents published no later than April 2014.

APPENDIX A

Components and Activities Outside of the Scope

Appendix A

These SEAs will include an overview of the biological communities in the SEA study areas in order to provide a detailed description of which species may be anticipated, and when they are likely to occur. This includes all marine birds, marine mammals, sea turtles, marine benthos and fish populations that potential future operators may encounter during their programs. The assessment of potential environmental effects within the SEAs for identification of recommended mitigation measures will be focused on the VECs identified above, however, as mitigation measures beyond standard mitigation are unlikely to be required for species considered to be not at-risk or for conventional areas within the study area. The following components are therefore excluded from the scope of the SEA process that is focused on the assessment of potential effects.

I) Air Quality

Emission sources from the proposed project are seismic and other survey/support vessels and drilling rigs. It is anticipated that emissions from routine exploration-related operational activities will not cause an exceedence(s) of applicable air quality standards or guidelines. Since there are limited emissions sources and few receptors (if any) in the SEA study areas, and given the short duration of exploration projects, assessment of potential effects on air quality can be excluded from the SEA and EAs provided that future licenses holders/operators adhere to:

- MARPOL Annex VI, Regulations for the Prevention of Air Pollution from Ships; and
- Air Emissions provisions of the Offshore Waste Treatment Guidelines, including submissions of greenhouse gas emissions.

However, malfunctions and accidental events (*i.e.*, blow-out) may have an environmental effect on air quality. An environmental assessment of the potential effects of air quality as a result of a blow-out on VECs proposed in Section 6.3 (*i.e.*, Species of Special Status, Special Areas, Fisheries) is the appropriate focus for this assessment rather than “Air Quality” per se. Assessment of the environmental effects of malfunctions and/or accidental events is required as is stated in Section 6.3.

II) Water Quality

Assessment of the potential environmental effects of discharges from platforms/vessels on water quality during routine exploration activities can be excluded from the SEA and EAs provided that future leaseholders/operators adhere to:

- Nova Scotia Offshore Area Petroleum Geophysical Regulations;
- Offshore Waste Treatment Guidelines; and
- *Fisheries Act* (Section 36).

Compliance with the above requirements involves implementation of standard mitigation and will prevent adverse environmental effects on water quality for routine operations. However, malfunctions and accidental events (*i.e.*, oil spills) may have an environmental effect on water quality. An environmental assessment of the potential effects on water quality as a result of oil spills on VECs proposed in Section 6.3 (*i.e.*, Species of Special Status, Special Areas, Fisheries) is the appropriate focus for this assessment rather than Water Quality per se. Assessment of the environmental effects of malfunctions and/or accidental events is required as is stated in Section 6.3.

III) Fish

Fish species of special status, important feeding, nursery, and/or spawning grounds for fish, and commercial, recreational and Aboriginal fisheries resources are addressed under relevant VECs (Species of Special Status, Special Areas, and Fisheries VECs) and assessed as stated in Section 6.3. Fish species which are not species of special status, don't support fishery resources or other fish species of special status, and are not present in such abundance for a special area to be designated for that species, are excluded from the effects assessment section of the SEA provided that future licenses holders/operators adhere to:

- Statement of Canadian Practice with Respect to the Mitigation of Seismic Noise in the Marine Environment (SOCP).

The SOCP was developed as a result of an extensive review by federal and provincial government advisors and scientific experts of the most effective and appropriate mitigation measures used world-wide to minimize adverse environmental effects on marine life. Compliance with the SOCP will result in minimization and/or avoidance of adverse residual environmental effects on marine fish and other marine life.

IV) Marine Benthos

Discharges of drilling mud and rock cuttings during exploration drilling can result in burial or toxic effects on the marine benthos. Based on past environmental effects monitoring results and other research studies, these effects are understood to be limited spatially and temporally. However, in recognition of sensitive and/or commercially important benthic species that may occur within the SEA study areas (*e.g.*, sponges, corals, scallops, clams, quahogs, crabs, shrimps, and sea cucumbers), these effects will be assessed in the Special Areas and Fisheries VECs, respectively, as stated in Section 6.3. No further assessment of marine benthos is required at this time.

V) Marine Mammals and Sea Turtles

As stated in Section 6.3, the potential for environmental effects on marine mammal and/or sea turtle Species of Special Status that may occur within the SEA study area, as well as those species that may occur in nearby designated environmentally sensitive areas will be assessed under the Species of Special Status VEC and Special Areas VEC respectively. Provided that appropriate mitigation is applied for species of special status, it is not anticipated that exploration activities will have an adverse environmental effect at the population level for secure populations of marine mammals or sea turtles.

No further assessment beyond that stated in Section 6.3 will be required provided that:

- The proponent adheres to mitigation measures outlined in the Statement of Canadian Practice with Respect to the Mitigation of Seismic Noise in the Marine Environment for marine mammals and sea turtles.

As stated in Section 6.3, the proponent should note that additional mitigation may be required following the conduct of a project-specific EA.

VI) Seabirds

It is recognized that the attraction of any avian species to lights on platforms/vessels or to flares during drilling operations/well testing, may cause injury or death from collisions or may disrupt migrations. An environmental assessment of the potential adverse environmental effects on avian species of special status (including migratory birds) will be carried out under the Species of Special Status VEC, as outlined in Section 6.3. Population level effects on seabirds, however, are not anticipated.

As stated in Section 6.3, the proponent should note that additional mitigation may be required following the conduct of a project-specific EA.

No further assessment of environmental effects on seabirds not assessed in Section 6.3 shall be required, provided that:

- The SEA and EAs consider the potential impacts of vessel lights/flares on avian species of special status (including migratory birds) and identify any necessary mitigation measures (*i.e.*, should birds land on vessels involved with the project, then implementation of the Williams and Chardine handling protocol brochure entitled “The Leach’s Storm Petrel: General Information and Handling Instructions” should be carried out. A permit is required from the Canadian Wildlife Service of Environment Canada to implement this protocol).

APPENDIX B

Composite Fishery Landings Maps and Landings Values

Fisheries and Oceans Canada (2013)
2006-2011 Landed Weight and Value of Commerfical Fish Species in NAFO areas 4W, 4X, 5ZE, by unit area
Weight in kilograms; value in CDN$

	2006		2007		2008	
	Landed Weight	Landed Value	Landed Weight	Landed Value	Landed Weight	Landed Value
Groundfish						
4Wd	20,446	189,258	4,783	41,100	7,506	57,097
4We	12,492	112,835	17,269	67,518	32,743	240,315
4Wf	5,702	26,460	15,162	54,629	2,531	20,153
4Wg	232,768	864,619	116,084	951,625	98,733	827,915
4Wh	3,591,201	2,806,079	2,306,288	2,053,971	4,524,291	3,915,384
4Wj	581,134	1,221,602	186,049	964,375	114,608	768,774
4Wk	3,437,579	2,910,948	3,163,283	2,865,113	3,616,319	3,359,915
4Wl	6,078,178	4,639,899	6,878,712	5,637,993	5,219,594	4,364,800
4Wm	27,437	49,779	40,162	67,204	13,899	31,041
4Wu	19,999	37,136	64,200	85,225	37,144	63,243
4Xl	7,096	23,494	6,663	35,199	8,657	14,164
4Xm	965,260	1,131,716	1,894,552	1,758,756	1,354,890	1,423,902
4Xn	2,766,125	4,177,634	3,387,355	5,610,497	3,474,903	5,600,017
4Xo	2,459,644	5,076,002	2,304,896	4,540,651	2,094,243	4,720,936
4Xp	6,083,159	8,416,682	8,658,394	10,684,643	7,837,787	9,214,336
4Xq	3,255,934	4,233,643	4,934,027	6,269,986	4,856,319	5,380,597
4Xr	2,638,019	4,076,505	3,091,294	3,472,597	1,912,653	1,771,645
4Xs	1,908,980	3,166,798	1,249,157	2,111,214	1,580,966	2,760,432
4Xu	916,110	1,674,053	904,937	1,208,896	844,714	1,306,003
4Xx	216	1,323				
5ZEh	1,161	1,686	3,285	4,187		
5ZEj	14,195,850	22,061,304	13,437,089	19,843,184	16,018,783	21,659,434
5ZEm	327,730	499,463	342,157	489,843	667,864	930,552
5ZEu	138,605	223,148	101,063	179,953	116,042	158,870
Total Groundfish	49,670,825	67,622,066	53,106,861	68,998,358	54,435,189	68,589,523

Fisheries and Oceans Canada (2013)

2006-2011 Landed Weight and Value of Commerfical Fish Species in NAFO areas 4W, 4X, 5ZE, by unit area

Weight in kilograms; value in CDN$

	2006		2007		2008	
	Landed Weight	Landed Value	Landed Weight	Landed Value	Landed Weight	Landed Value
Pelagics						
4Wd	46,482	669,566	34,219	448,614	70,221	1,385,785
4We	1,245	18,576	3,190	33,435		
4Wg	244,221	500,927	103,671	743,782	110,358	683,102
4Wh	4,451,616	1,380,065	3,380,808	744,182	196,618	39,342
4Wj	1,232,178	1,268,080	815,958	584,255	102,296	654,571
4Wk	5,072,209	3,405,234	3,773,226	2,938,045	2,867,310	1,549,745
4Wl	375,621	1,251,952	919,679	1,530,075	155,025	507,693
4Wm	121,698	973,076	114,605	936,467	101,326	714,734
4Wu	79,981	148,090	322,619	229,508	262,786	146,205
4Ww	137,932	1,030,819	173,771	1,276,457	78,253	603,515
4Xl	138,929	1,177,036	93,973	747,030	78,807	521,701
4Xm	639,021	1,364,925	1,198,023	937,902	175,910	622,833
4Xn	289,792	2,348,212	222,878	891,995	263,089	1,554,254
4Xo	4,020,283	1,508,849	1,927,830	869,227	1,319,731	816,671
4Xp	281,951	2,397,991	101,574	1,196,064	962,709	1,948,357
4Xq	30,737,073	6,780,825	29,968,781	5,573,172	33,563,152	5,839,771
4Xr	5,891,307	1,257,876	8,401,818	1,505,751	6,260,239	1,468,535
4Xs	16,477,243	3,311,222	35,891,221	7,774,530	12,832,630	2,907,414
4Xu	2,560,940	1,424,215	2,403,761	929,871	3,283,742	1,694,911
4Xx	184,036	1,419,842	214,572	1,530,113	148,964	1,064,453
5ZEj	124,244	1,064,952	176,101	1,611,858	214,658	1,834,746
5ZEm	189,152	1,552,668	106,605	839,620	234,545	1,525,693
5ZEu	41,769	363,695	19,309	174,970	22,599	211,755
Total Pelagics	73,338,923	36,618,691	90,368,192	34,046,925	63,304,968	28,295,785
Shellfish						
4Wd	3,249,216	26,449,277	4,064,181	36,641,193	5,377,392	41,020,878
4We	1,618,621	3,591,909	2,180,970	5,971,878	2,880,549	9,269,924
4Wf	1,461,246	1,561,639	1,165,594	1,880,984	727,271	874,478
4Wg	292,260	558,720				
4Wh	187,536	255,325	168,116	226,669	281,429	384,593
4Wj	364,929	480,487	702,075	921,718	455,571	645,018
4Wk	1,226,578	14,186,322	1,343,470	19,353,446	1,392,898	14,718,897
4Wl	24,784	9,822	4,309	2,668	8,046	4,951
4Wm	4,938	8,234				
4Wu	8,775	28,866	13,636	65,046	100,618	345,972

Fisheries and Oceans Canada (2013)
2006-2011 Landed Weight and Value of Commerfical Fish Species in NAFO areas 4W, 4X, 5ZE, by unit area
Weight in kilograms; value in CDN$

	2006		2007		2008	
	Landed Weight	Landed Value	Landed Weight	Landed Value	Landed Weight	Landed Value
4Xm	1,392,028	12,549,164	988,803	11,200,770	1,390,880	11,901,011
4Xn	239,381	1,547,040	171,503	1,261,446	197,258	1,439,852
4Xo	11,598,760	107,084,485	10,957,647	87,473,708	10,319,353	91,029,466
4Xp	7,297,222	11,936,210	7,171,957	11,166,283	3,452,973	6,431,139
4Xq	17,286,219	119,552,552	13,513,683	106,845,783	13,453,719	110,727,999
4Xr	6,888,848	55,390,605	5,926,828	45,304,186	7,160,906	50,702,397
4Xs	9,587,911	46,721,832	9,264,556	41,644,721	10,433,913	48,065,761
4Xu	127,638	189,801	321,128	472,082	653,151	850,675
5ZEj	30,051,198	40,385,630	36,592,827	49,006,220	48,471,364	64,330,886
5ZEm	4,186,633	6,193,469	186,141	971,252	335,246	1,122,191
Total Shellfish	97,094,721	448,681,388	94,737,424	420,410,050	107,092,537	453,866,087
Other Species						
4W	2,308	27,993	537	8,267	1,254	19,264
4X	37,947,892	3,401,776	15,899,904	1,702,893	16,571,842	2,227,731
5ZE	36,567	398,938	42,802	467,072	14,944	163,051
Total Other Species	37,986,767	3,828,707	15,943,243	2,178,232	16,588,040	2,410,045
Grand Total	**258,091,236**	**556,750,852**	**254,155,720**	**525,633,563**	**241,420,734**	**553,161,441**

Fisheries and Oceans Canada (2013)
2006-2011 Landed Weight and Value of Commerfical Fish Species in NAFO areas 4W, 4X, 5ZE, by unit area
Weight in kilograms; value in CDN$

	2009		2010		2011	
	Landed Weight	Landed Value	Landed Weight	Landed Value	Landed Weight	Landed Value
Groundfish						
4Wd	2,443	20,689	7,845	72,669	24,499	122,134
4We	84,554	277,893	28,113	120,739	24,207	275,992
4Wf	4,392	25,436	2,026	15,938	35,609	49,115
4Wg	106,635	1,151,151	138,309	1,041,031	529,692	1,783,231
4Wh	3,041,492	1,992,446	2,236,130	1,690,623	2,446,573	2,124,796
4Wj	159,631	655,311	134,232	785,926	998,198	1,817,618
4Wk	3,365,110	2,803,938	4,159,517	3,547,808	3,623,771	3,468,371
4Wl	4,196,655	3,665,127	3,810,787	3,324,817	3,329,407	3,065,544
4Wm	22,105	14,965	18,924	32,024	52,168	77,515
4Wu	75,683	70,574	61,375	115,722	140,272	239,808
4Xl	15,252	27,249	9,861	23,196	4,920	9,468
4Xm	2,186,086	1,938,545	654,409	655,415	1,309,933	1,305,759
4Xn	4,648,408	6,219,231	4,264,703	6,223,447	5,192,722	6,996,312
4Xo	1,975,659	4,977,049	3,051,700	6,015,681	2,174,066	6,038,674
4Xp	8,479,304	10,556,858	7,543,014	8,914,626	6,052,507	8,163,963
4Xq	4,622,528	6,142,870	4,851,609	6,391,473	4,300,059	5,585,213
4Xr	891,615	1,421,146	698,197	1,125,628	1,113,765	2,091,236
4Xs	821,017	1,407,469	753,411	1,421,500	502,559	1,139,449
4Xu	598,684	1,174,913	452,283	921,267	371,559	836,595
4Xx			1,988	2,897	1,345	10,831
5ZEh	871	594	3,841	5,225		
5ZEj	18,836,584	29,764,676	18,054,785	23,489,437	12,794,762	20,021,357
5ZEm	363,779	640,635	891,189	1,152,411	1,395,136	2,387,077
5ZEu	120,676	199,305	210,529	255,270	86,294	135,521
Total Groundfish	54,619,163	75,148,068	52,038,777	67,344,768	46,504,023	67,745,579

Fisheries and Oceans Canada (2013)

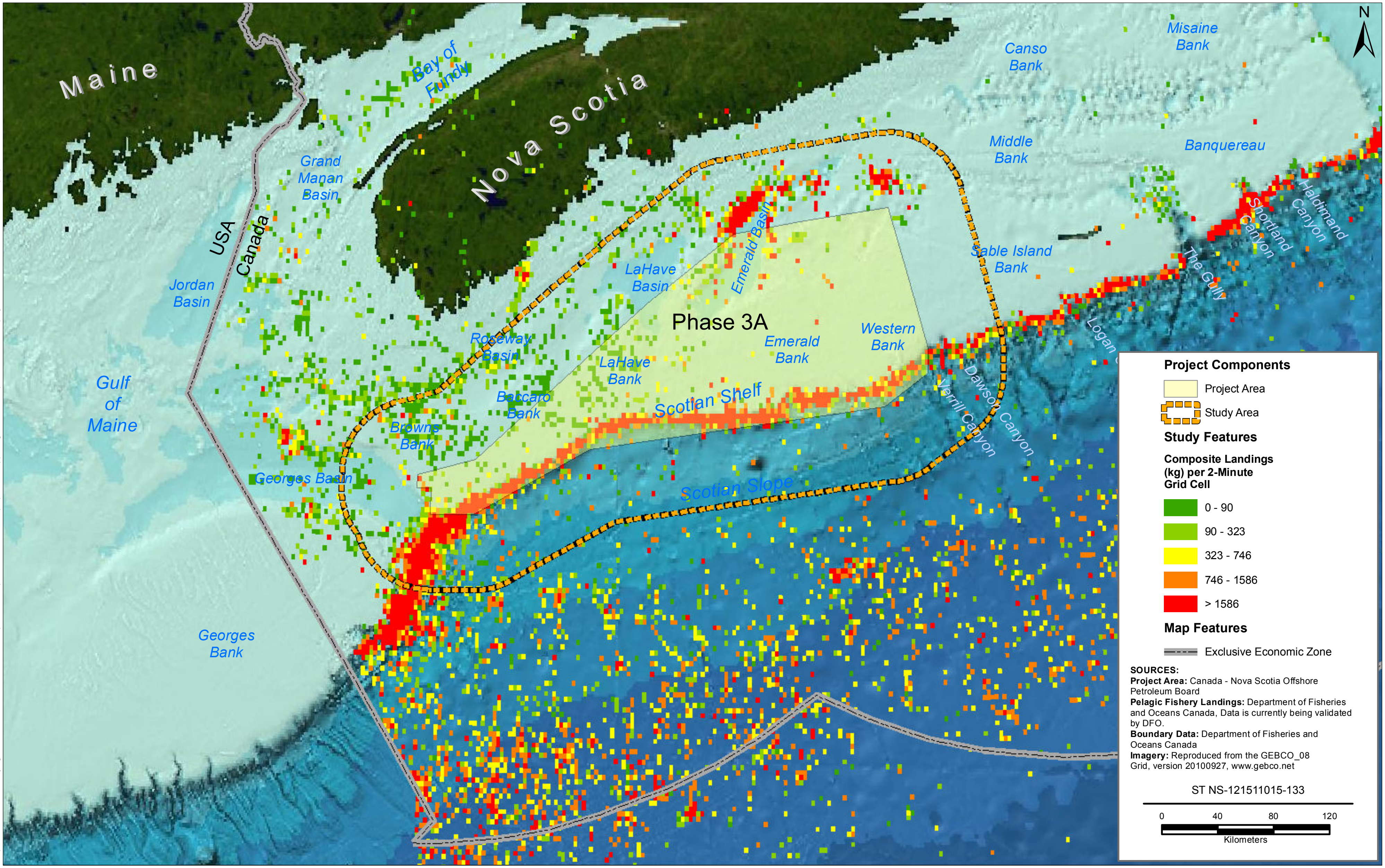
2006-2011 Landed Weight and Value of Commerfical Fish Species in NAFO areas 4W, 4X, 5ZE, by unit area

Weight in kilograms; value in CDN$

	2009		2010		2011	
	Landed Weight	Landed Value	Landed Weight	Landed Value	Landed Weight	Landed Value
Pelagics						
4Wd	57,631	246,593	27,414	425,129	19,920	511,658
4We						
4Wg	33,910	203,104	86,402	658,040	91,043	610,197
4Wh	668,246	214,816	125,113	295,371	105,152	90,173
4Wj	13,128	69,301	33,012	248,618	82,868	634,245
4Wk	13,187,492	5,601,511	9,757,428	4,168,967	11,284,212	4,729,269
4Wl	473,130	304,950	379,995	2,809,187	494,328	2,465,609
4Wm	69,831	715,950	28,684	212,587	40,926	280,992
4Wu	884,069	406,014	416,194	440,274	130,606	142,676
4Ww	24,993	206,165	10,283	87,438	43,742	274,290
4Xl	68,019	494,578	59,063	428,197	124,737	552,596
4Xm	264,571	480,146	161,373	541,618	622,989	1,612,168
4Xn	387,185	1,845,350	308,962	1,265,267	340,675	2,094,490
4Xo	4,164,644	1,689,151	7,420,422	3,148,731	2,295,265	2,249,189
4Xp	188,387	896,317	71,615	750,792	126,878	1,149,811
4Xq	31,672,497	9,719,069	19,779,741	4,808,939	27,940,146	7,386,984
4Xr	4,127,336	1,140,678	6,251,696	2,322,279	6,534,125	2,797,996
4Xs	12,694,073	3,251,308	22,174,826	6,955,318	13,591,524	3,449,297
4Xu	1,423,259	1,082,036	1,811,613	1,422,941	1,159,564	1,222,449
4Xx	145,822	1,329,830	141,297	1,141,881	66,755	423,218
5ZEj	196,036	1,603,910	112,351	1,133,145	138,858	1,224,756
5ZEm	243,362	1,590,142	410,539	3,197,320	138,418	999,025
5ZEu	15,776	105,994	6,553	50,137	29,663	203,509
Total Pelagics	71,003,397	33,196,914	69,574,576	36,512,177	65,402,394	35,104,595
Shellfish						
4Wd	5,696,488	33,631,331	5,387,892	30,583,880	4,897,553	36,211,650
4We	4,117,344	9,343,480	5,977,396	17,595,852	5,520,937	23,989,004
4Wf	1,257,473	1,111,265	996,734	1,840,541	1,013,184	1,249,748
4Wg	99,555	291,377	140,447	527,970		
4Wh	25,154	43,123	188,771	277,431	107,685	213,201
4Wj	216,253	284,278	72,458	95,138	158,061	275,453
4Wk	1,659,981	14,055,137	1,333,728	10,923,232	1,675,398	15,048,628
4Wl	4,209	5,047	7,718	157	11,379	2,595
4Wm						
4Wu	87,534	224,117	76,867	261,612	92,199	526,484

Fisheries and Oceans Canada (2013)
2006-2011 Landed Weight and Value of Commerfical Fish Species in NAFO areas 4W, 4X, 5ZE, by unit area
Weight in kilograms; value in CDN$

	2009		2010		2011	
	Landed Weight	Landed Value	Landed Weight	Landed Value	Landed Weight	Landed Value
4Xm	1,266,562	10,333,902	1,491,125	12,264,463	1,770,189	15,306,330
4Xn	96,672	622,103	133,641	1,015,998	99,639	860,406
4Xo	8,694,501	75,293,916	11,150,028	93,281,461	12,021,429	93,929,456
4Xp	267,992	2,042,370	2,041,352	5,059,870	8,405,292	13,676,413
4Xq	11,831,021	97,462,936	13,541,881	108,692,133	13,332,651	105,185,911
4Xr	7,687,592	49,428,850	8,790,431	57,210,463	10,715,369	70,597,481
4Xs	10,225,817	45,311,605	11,909,516	51,104,141	11,580,069	61,125,020
4Xu	746,918	1,153,919	583,870	773,043	634,780	972,922
5ZEj	46,245,748	61,131,193	42,074,934	56,448,576	33,378,003	52,216,089
5ZEm	1,943,665	3,334,511	2,725,918	4,442,396	4,501,205	7,693,497
Total Shellfish	102,170,479	405,104,461	108,624,707	452,398,358	109,915,022	499,080,288
Other Species						
4W	406	5,899	64	977	13	228
4X	43,292,238	1,407,571	41,123,145	3,366,737	16,989,030	1,355,449
5ZE	16,193	176,708	6,028	65,739	22,469	-
Total Other Species	43,308,837	1,590,177	41,129,237	3,433,454	17,011,512	1,355,678
Grand Total	**271,101,876**	**515,039,620**	**271,367,297**	**559,688,757**	**238,832,951**	**603,286,140**



PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 1
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Large Pelagic Landings, 2006-2010**	Stantec

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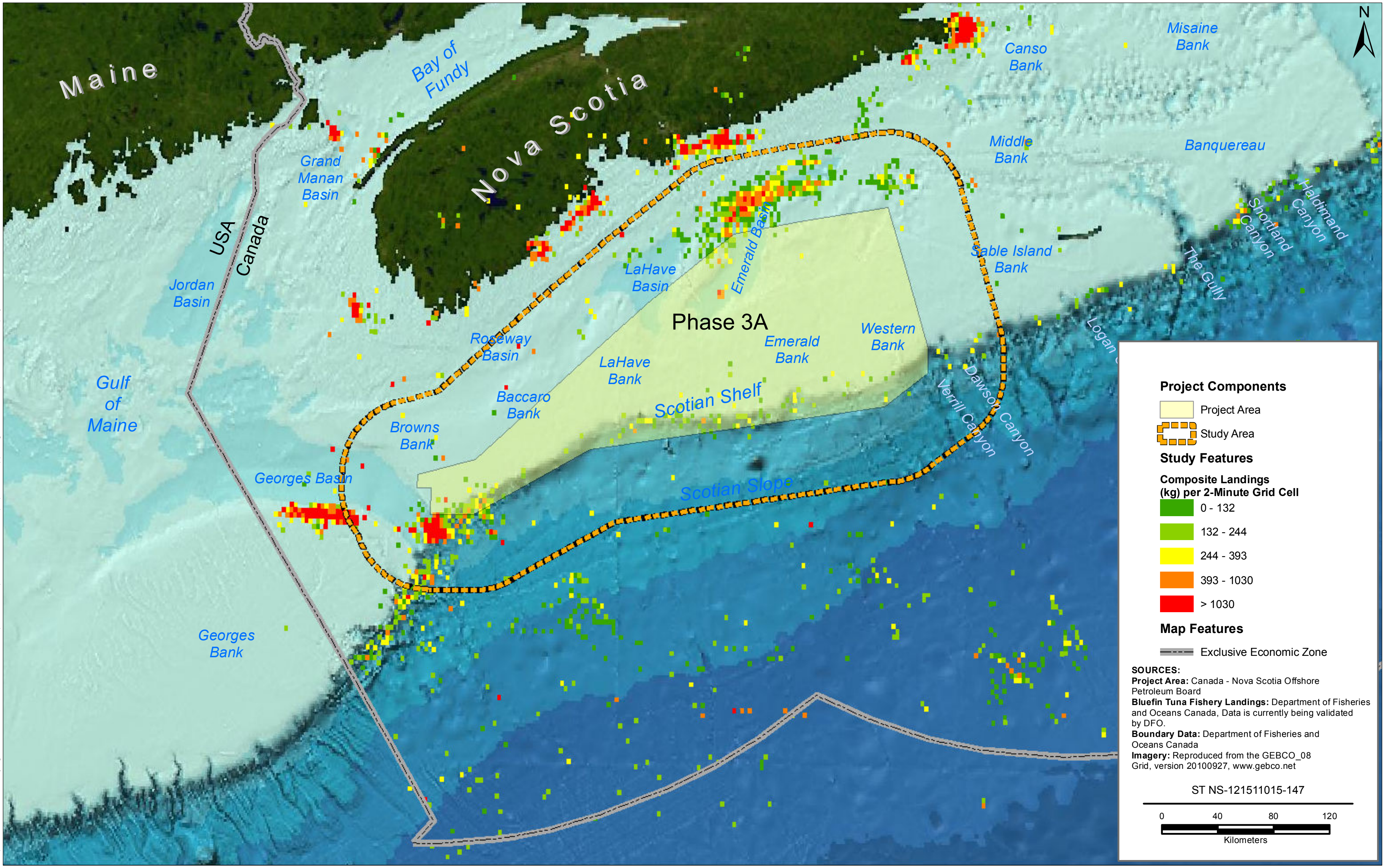

PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 2
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Bluefin Tuna Landings, 2006-2010**	Stantec

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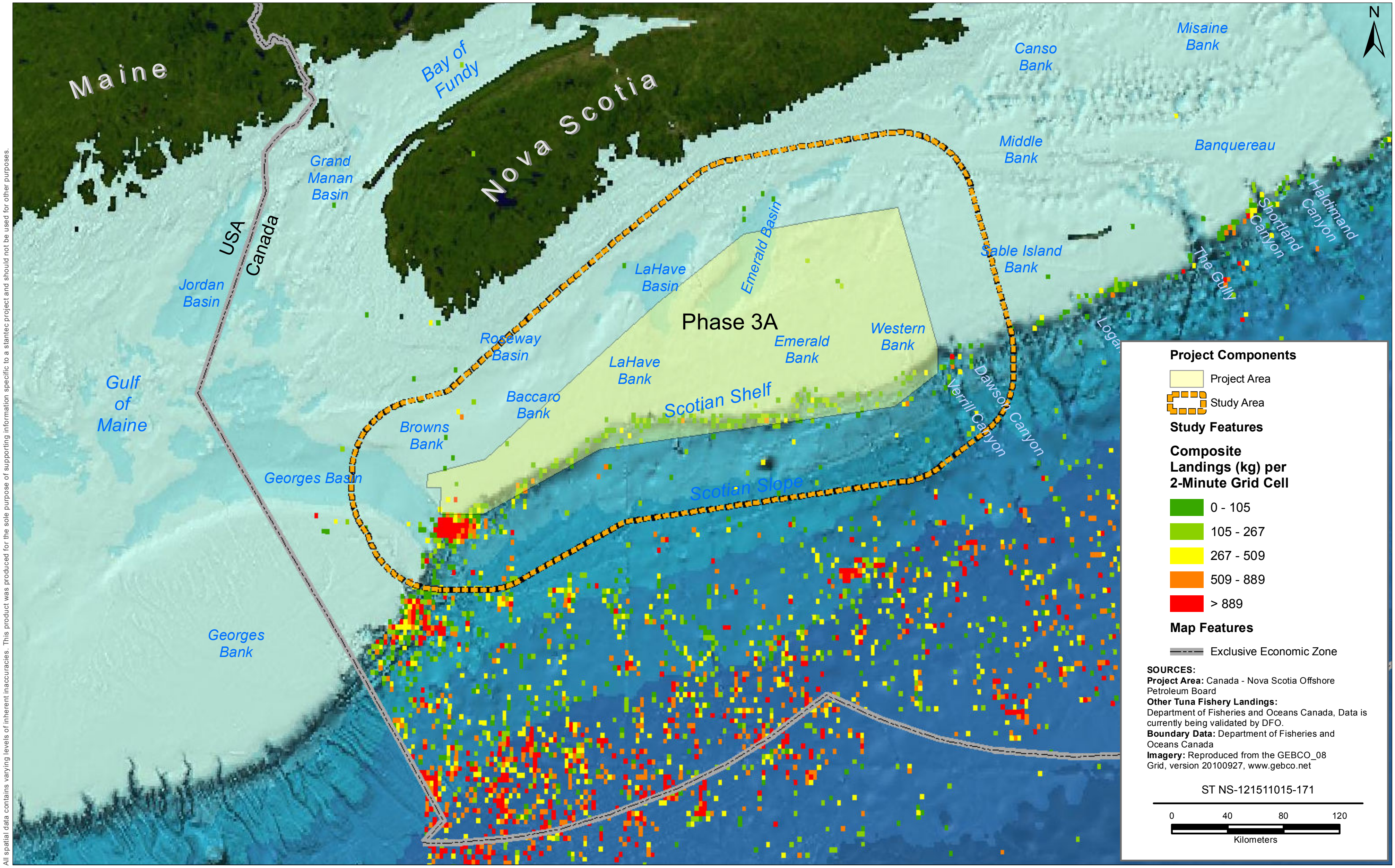


PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

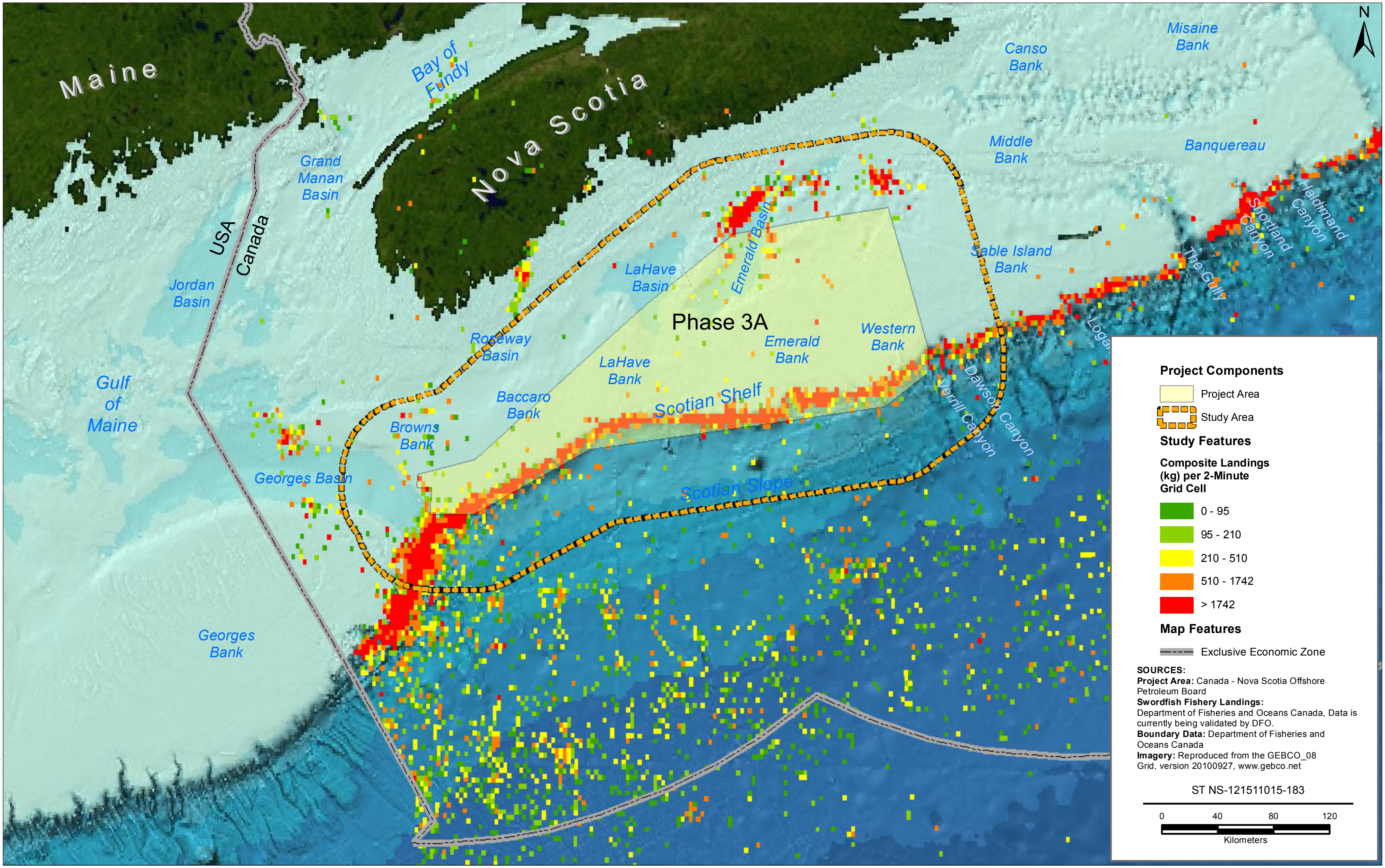
Other Tuna Landings, 2006-2010

FIGURE NO.: 3

DATE: Oct 03, 2013

Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-171_TunaOther_Phase3A.mxd



PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 4
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Swordfish Landings, 2006-2010**	Stantec

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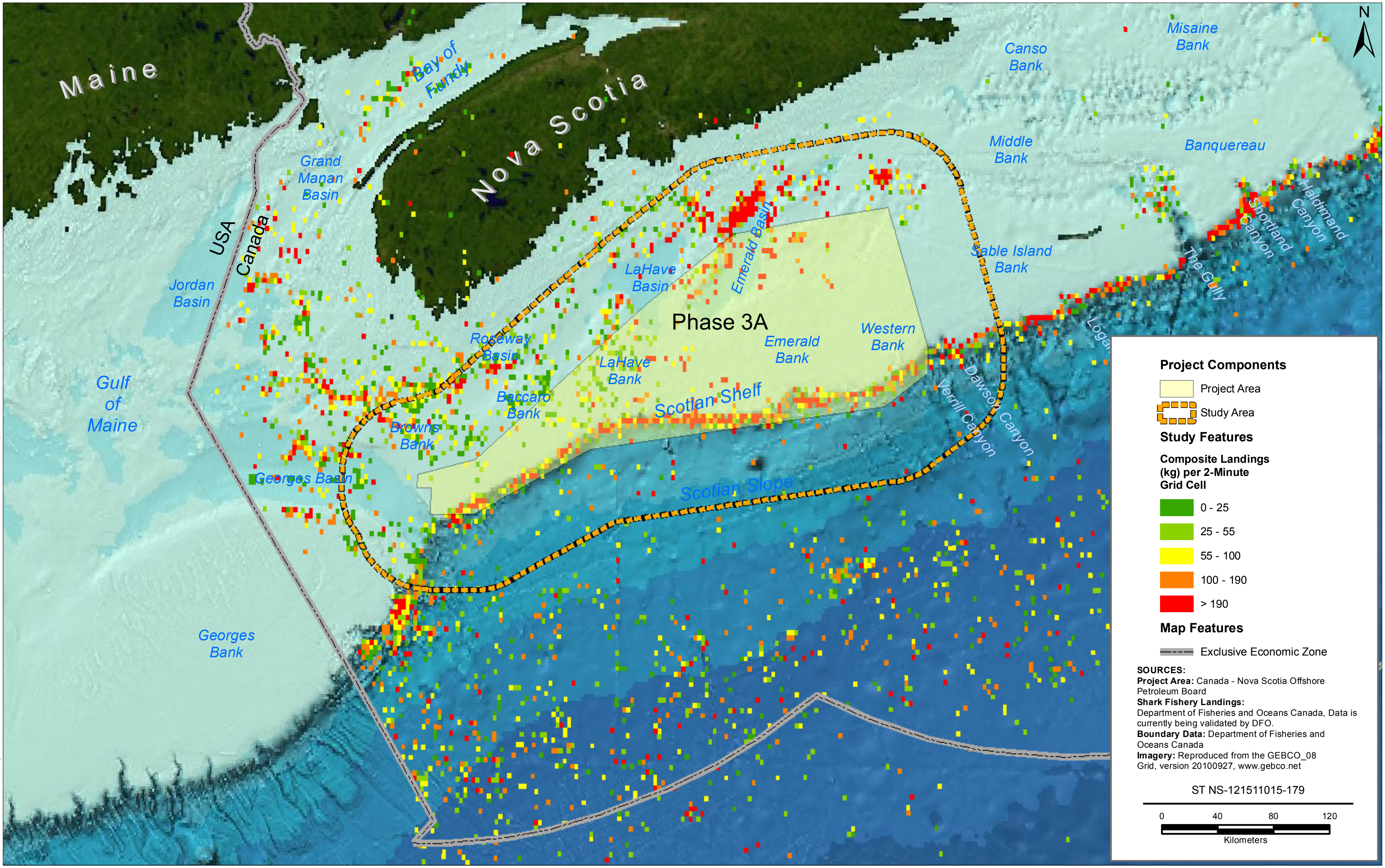
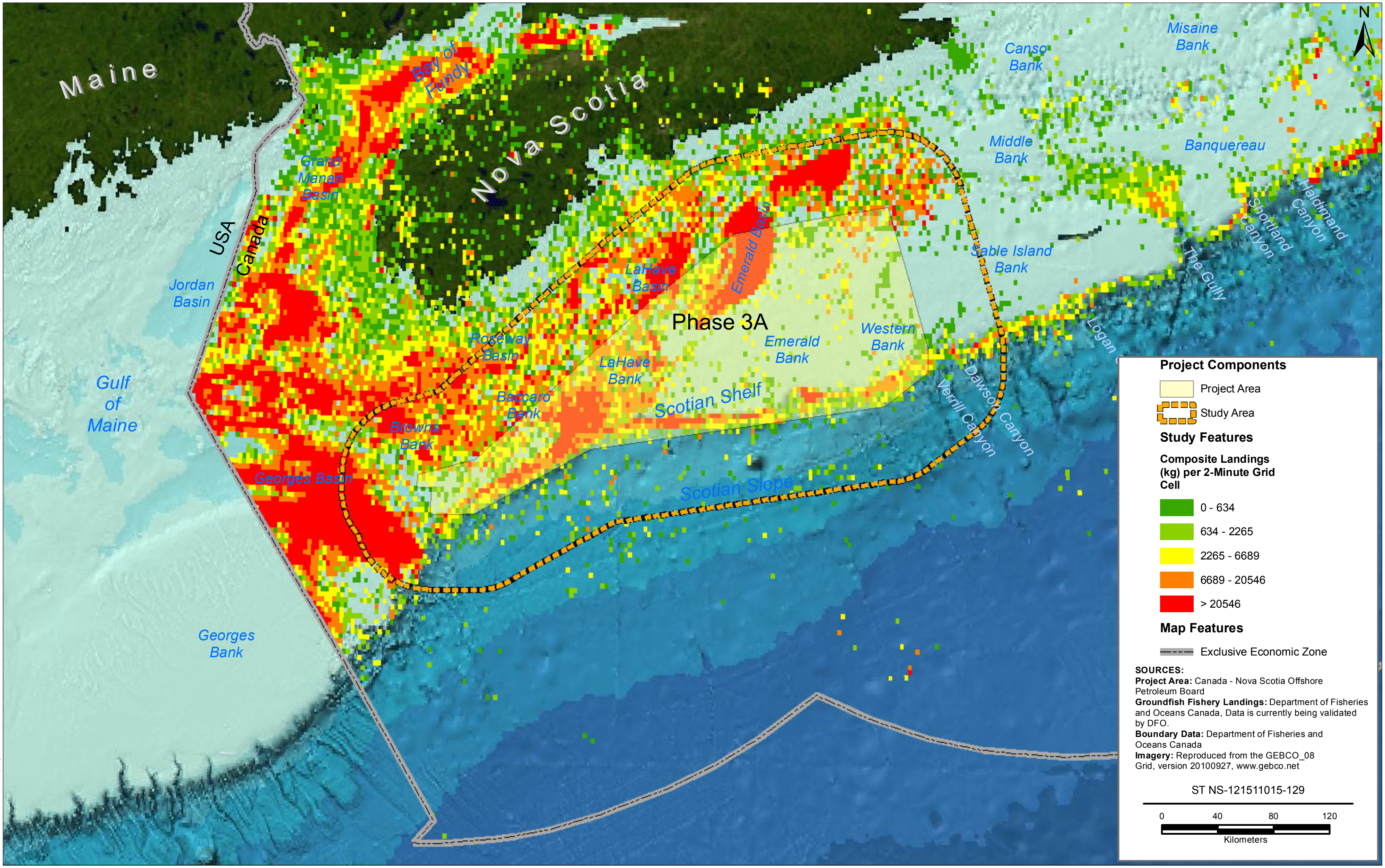


PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 5
REVIEWED BY: C Shupe	**Shark Landings, 2006-2010**	DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-179_Shark_Phase3A.mxd



PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

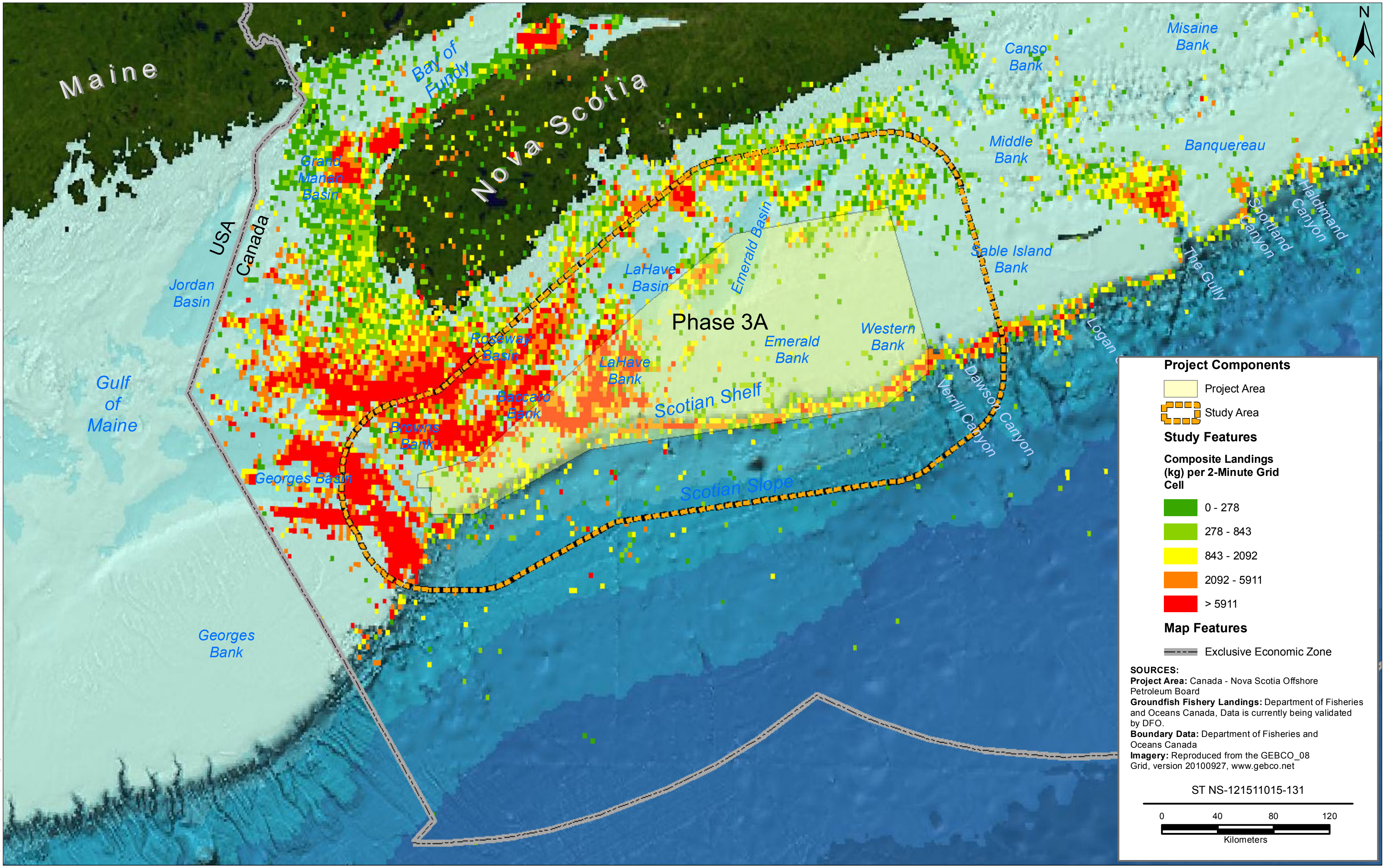
Groundfish Landings, All Gear Types, 2006-2010

FIGURE NO.: 6

DATE: Oct 03, 2013

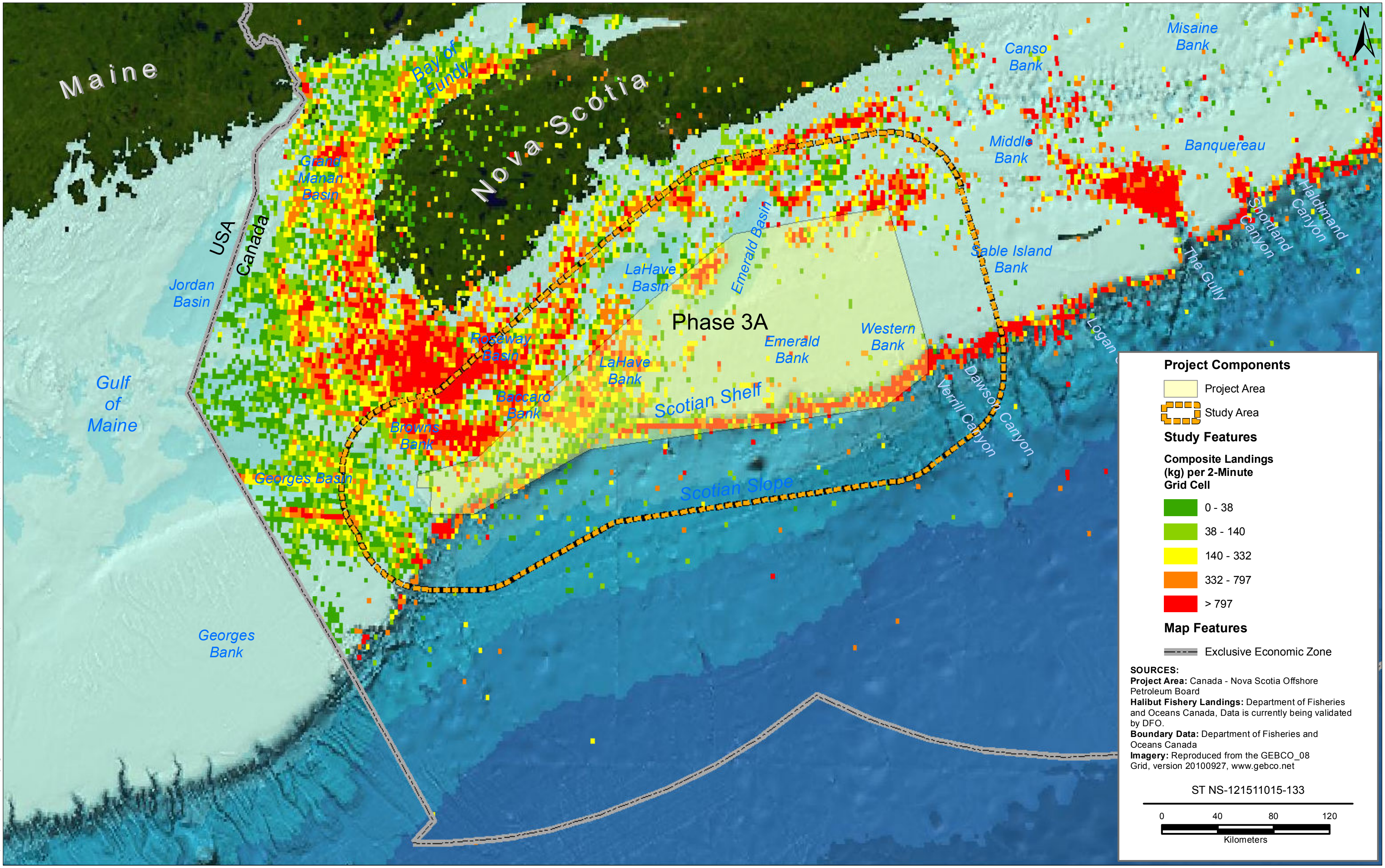
Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-129_Groundfish_AllGearTypes_Phase3A.mxd



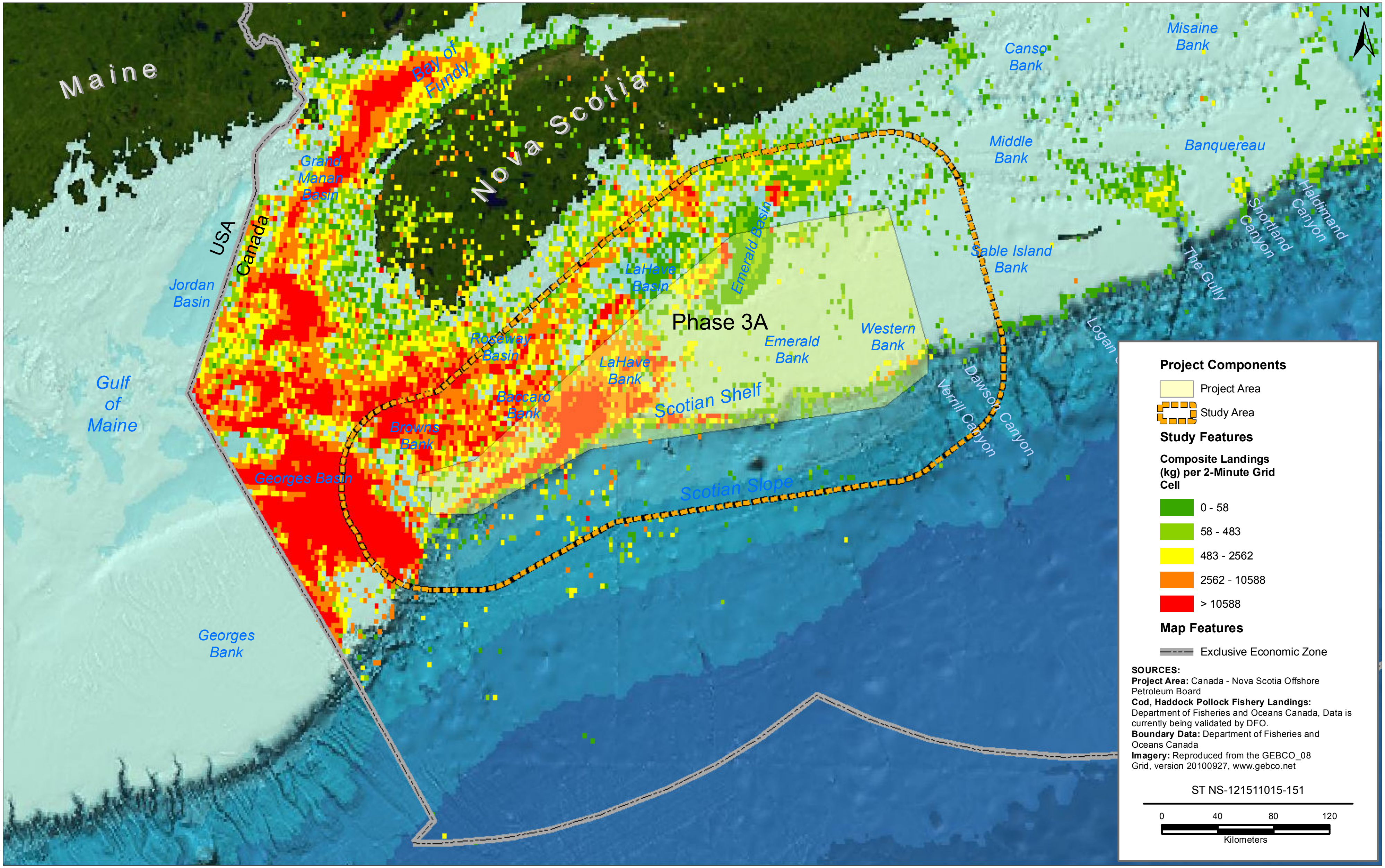
PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 7
REVIEWED BY: C Shupe	**Groundfish Landings, Longline, 2006-2010**	DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-131_Groundfish_LongLine_Phase3A.mxd



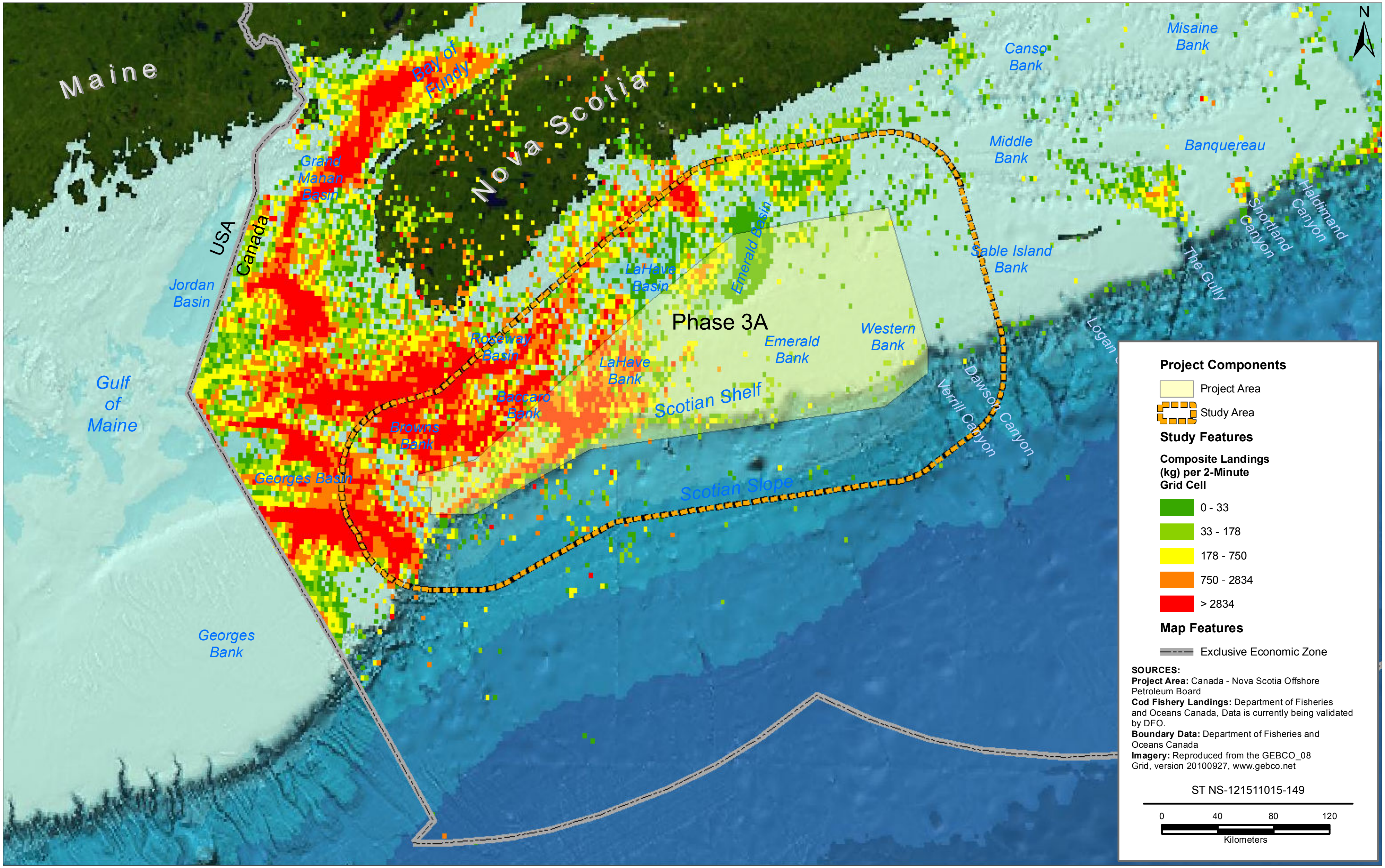
PREPARED BY: M. Huskins-Shupe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 8
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Halibut Landings, 2006-2010**	Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-133_Halibut_Phase3A.mxd



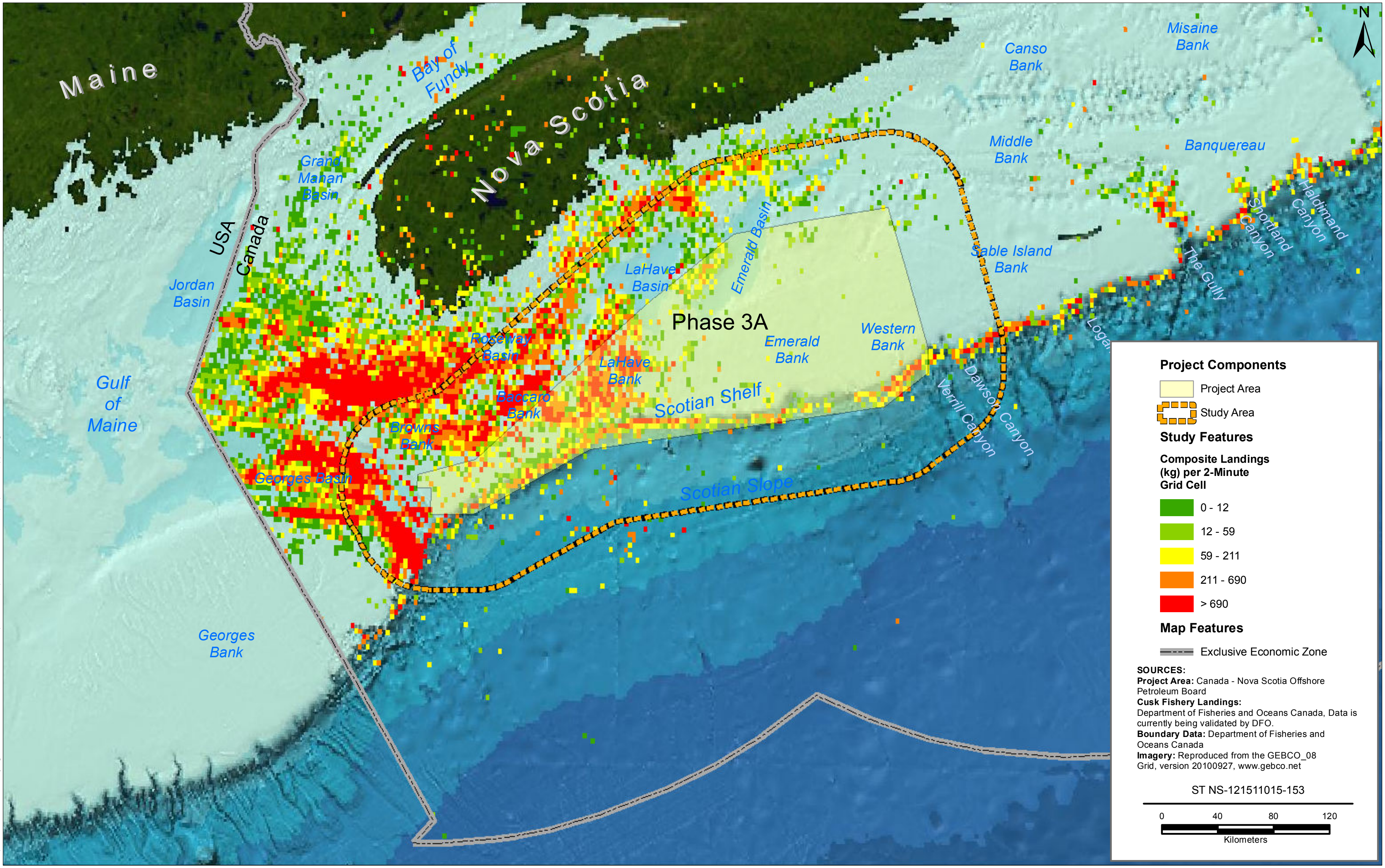
PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 9
REVIEWED BY: C Shupe	**Cod, Haddock, Pollock Landings, 2006-2010**	DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-151_Cod_Haddock_Pollock_Phase3A.mxd



PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 10
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Cod Landings, 2006-2010**	Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-149_Cod_Phase3A.mxd



PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

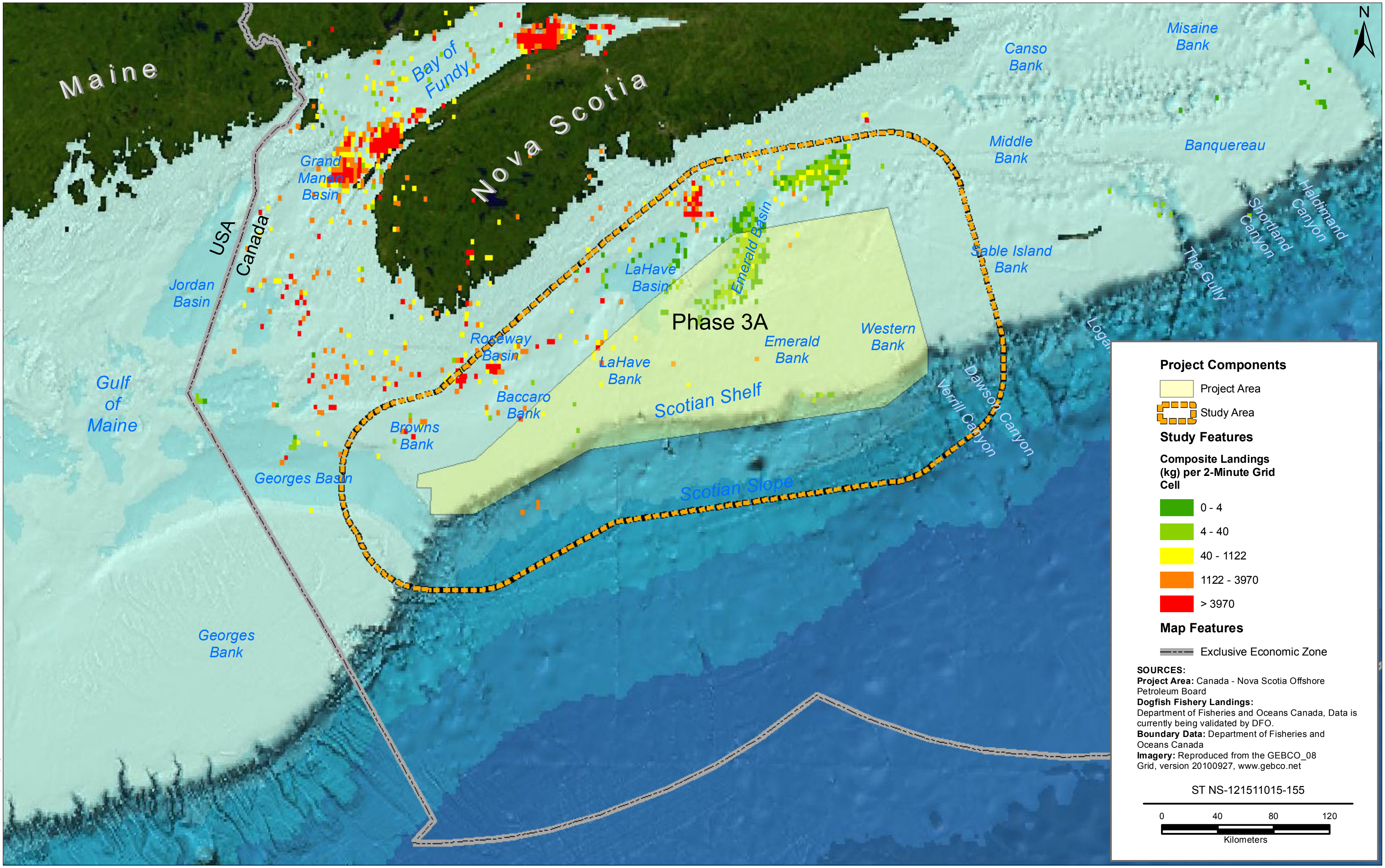
Cusk Landings, 2006-2010

FIGURE NO.: 11

DATE: Oct 03, 2013

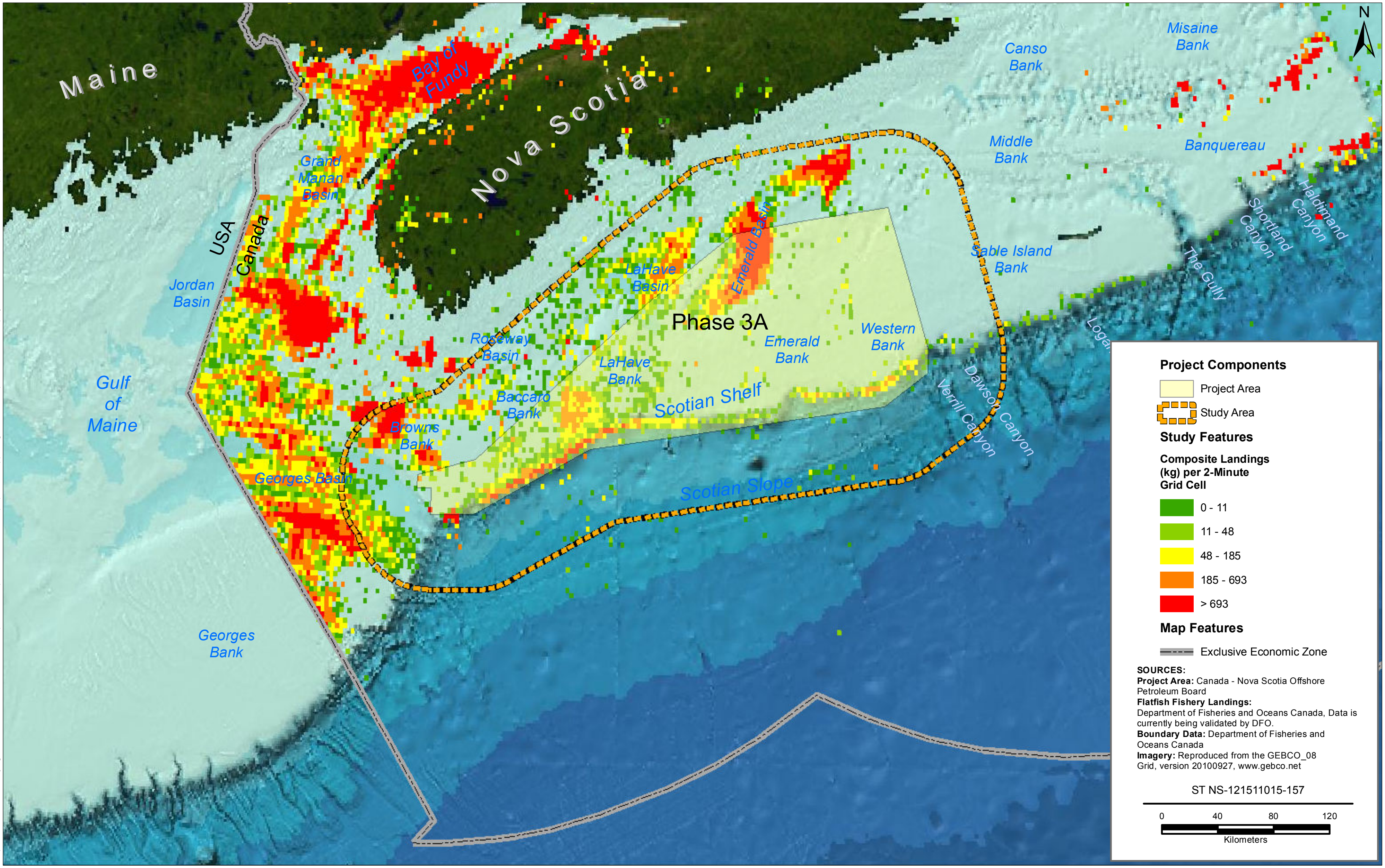
Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-153_Cusk_Phase3A.mxd



PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 12
REVIEWED BY: C Shupe	**Dogfish Landings, 2006-2010**	DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-155_Dogfish_Phase3A.mxd



PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

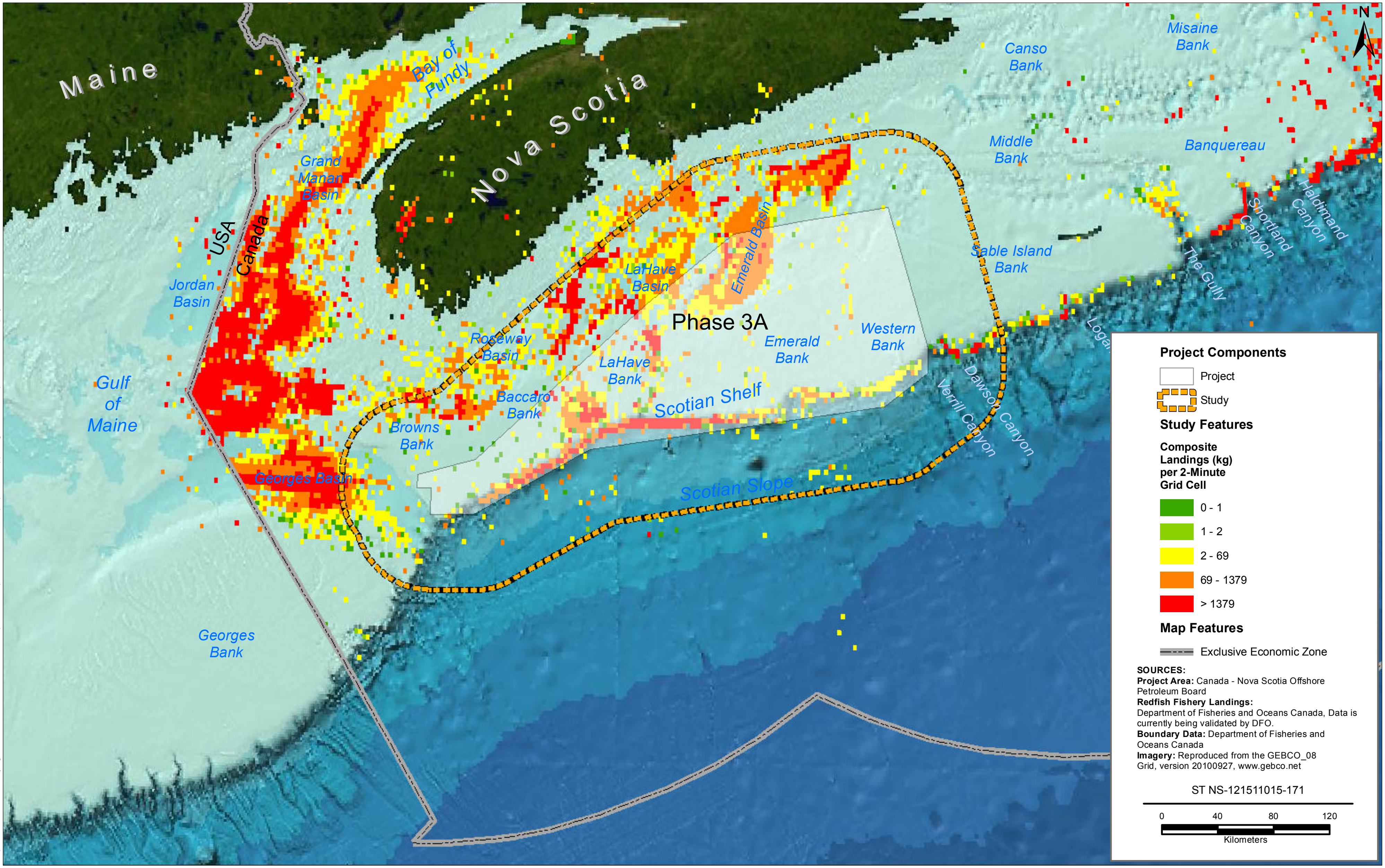
Flatfish Landings, 2006-2010

FIGURE NO.: 13

DATE: Oct 03, 2013

Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-157_Flatfish_Phase3A.mxd



PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

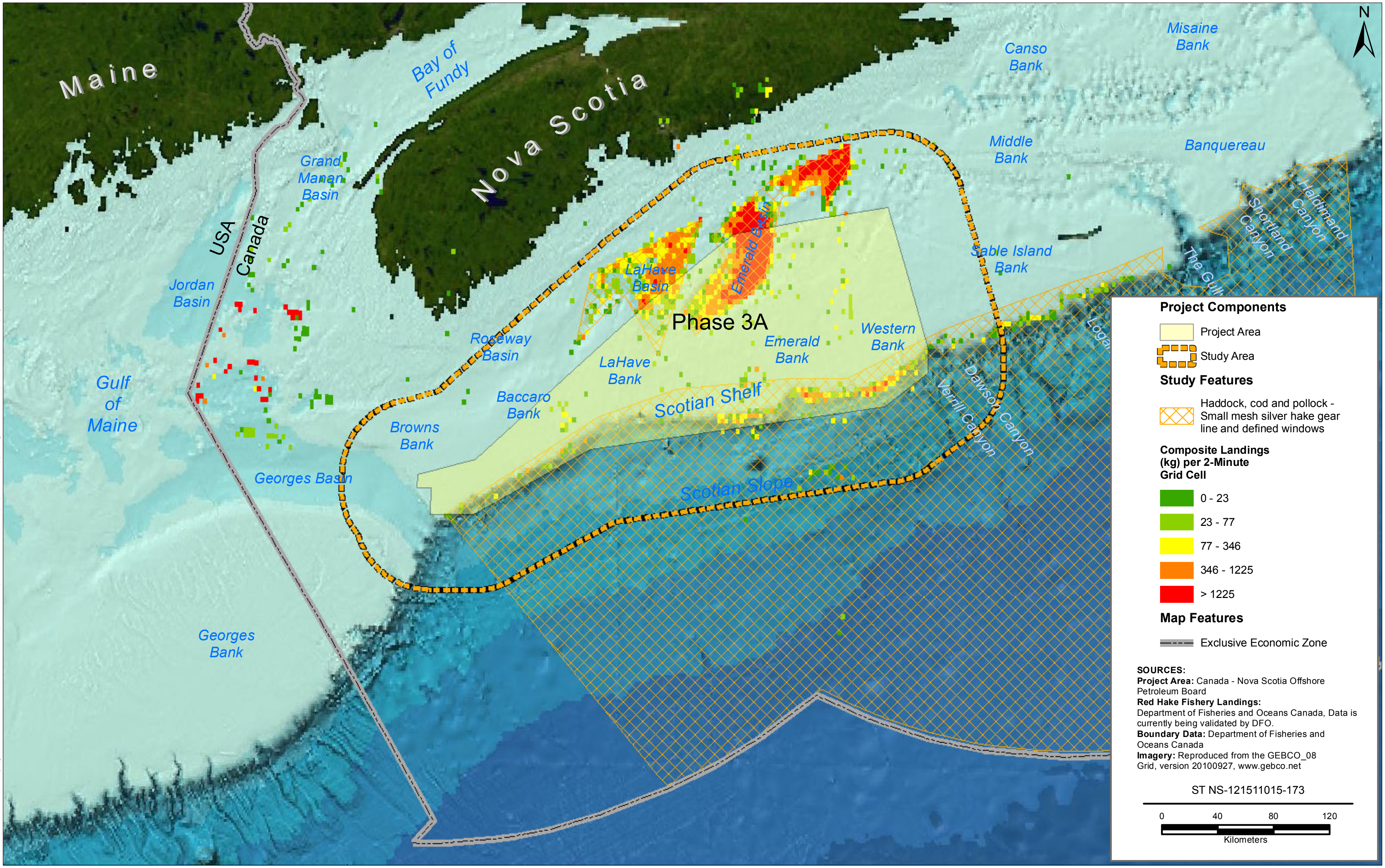
Redfish Landings, 2006-2010

FIGURE NO.: 14

DATE: Oct 03, 2013

Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-173_Redfish_Phase3A.mxd



PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

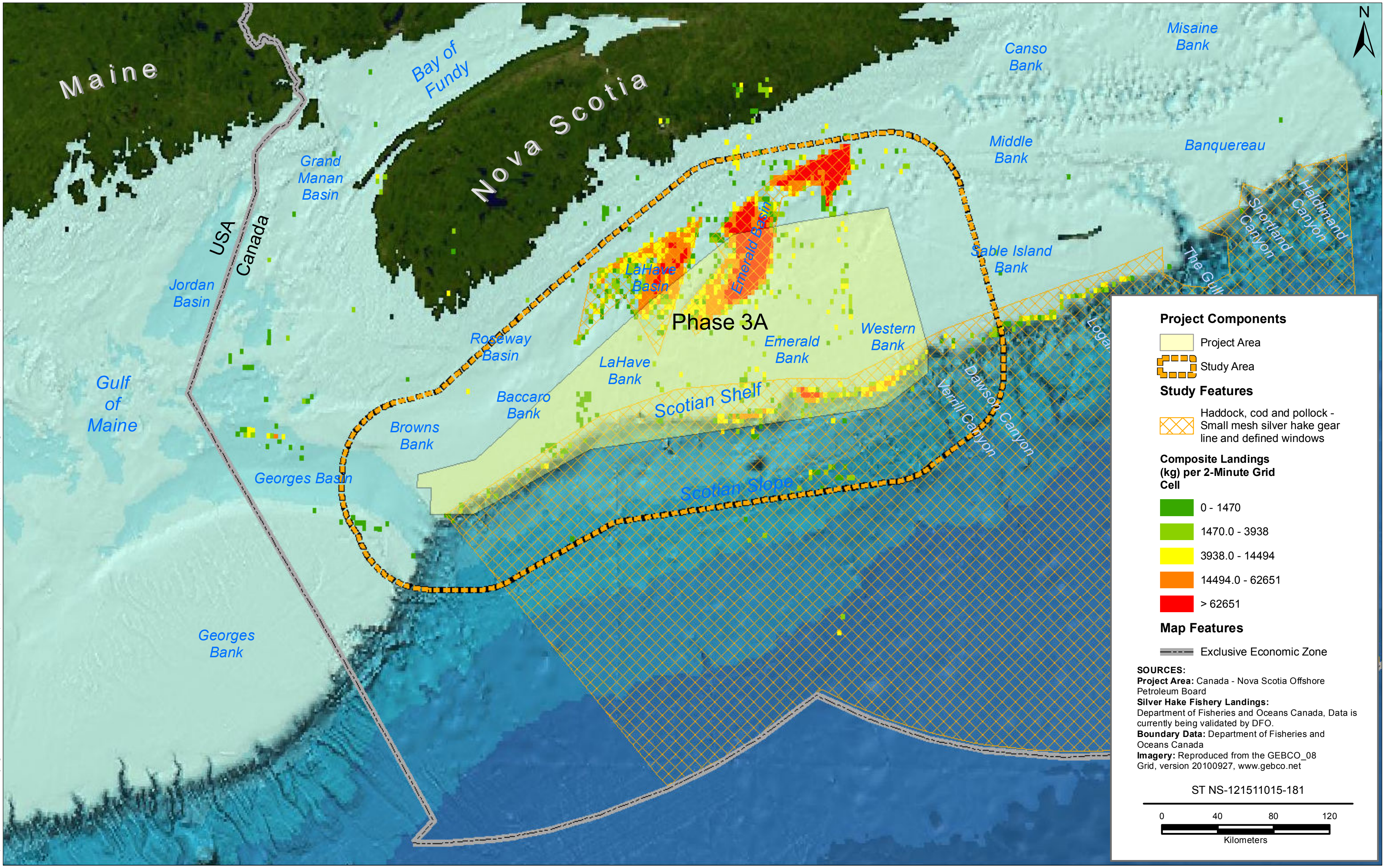
Red Hake Landings, 2006-2010

FIGURE NO.: 15

DATE: Apr 11, 2014

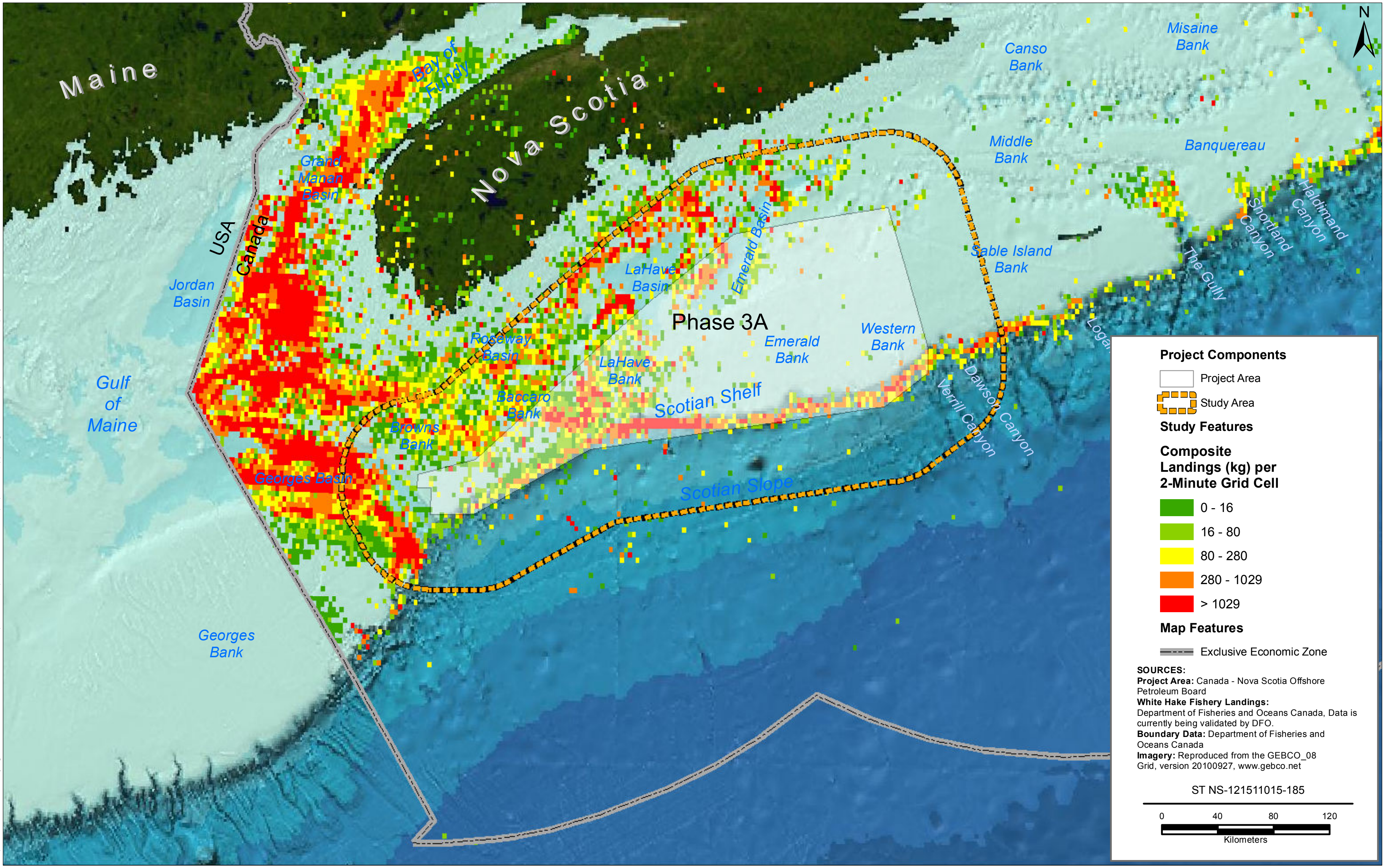
Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-175_Redhake_Phase3A.mxd



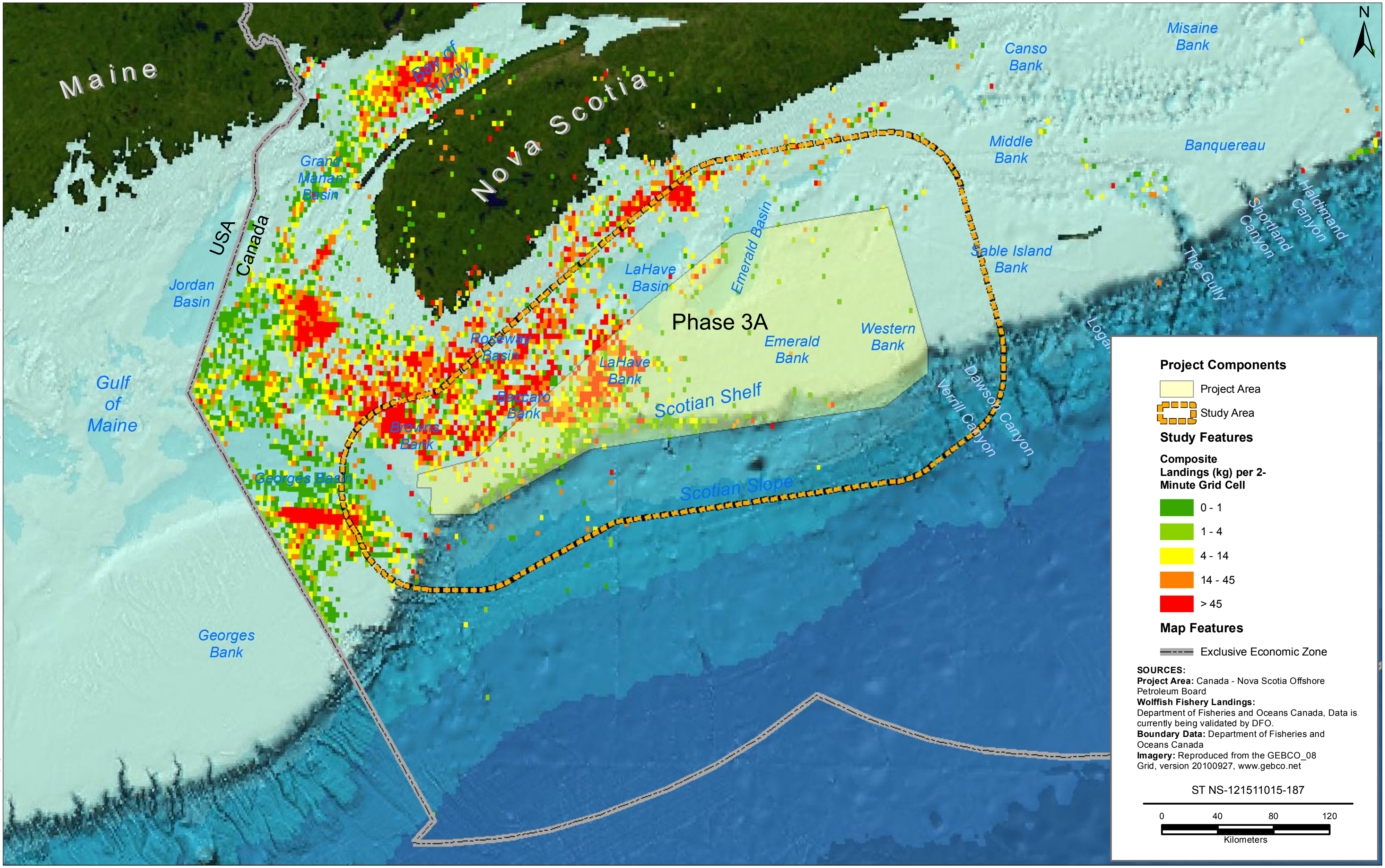
PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 16
REVIEWED BY: C Shupe	**Silver Hake Landings, 2006-2010**	DATE: Apr 11, 2014
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-181_Silverhake_Phase3A.mxd



PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 17
REVIEWED BY: C Shupe	**White Hake Landings, 2006-2010**	DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-185_Whitehake_Phase3A.mxd



PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

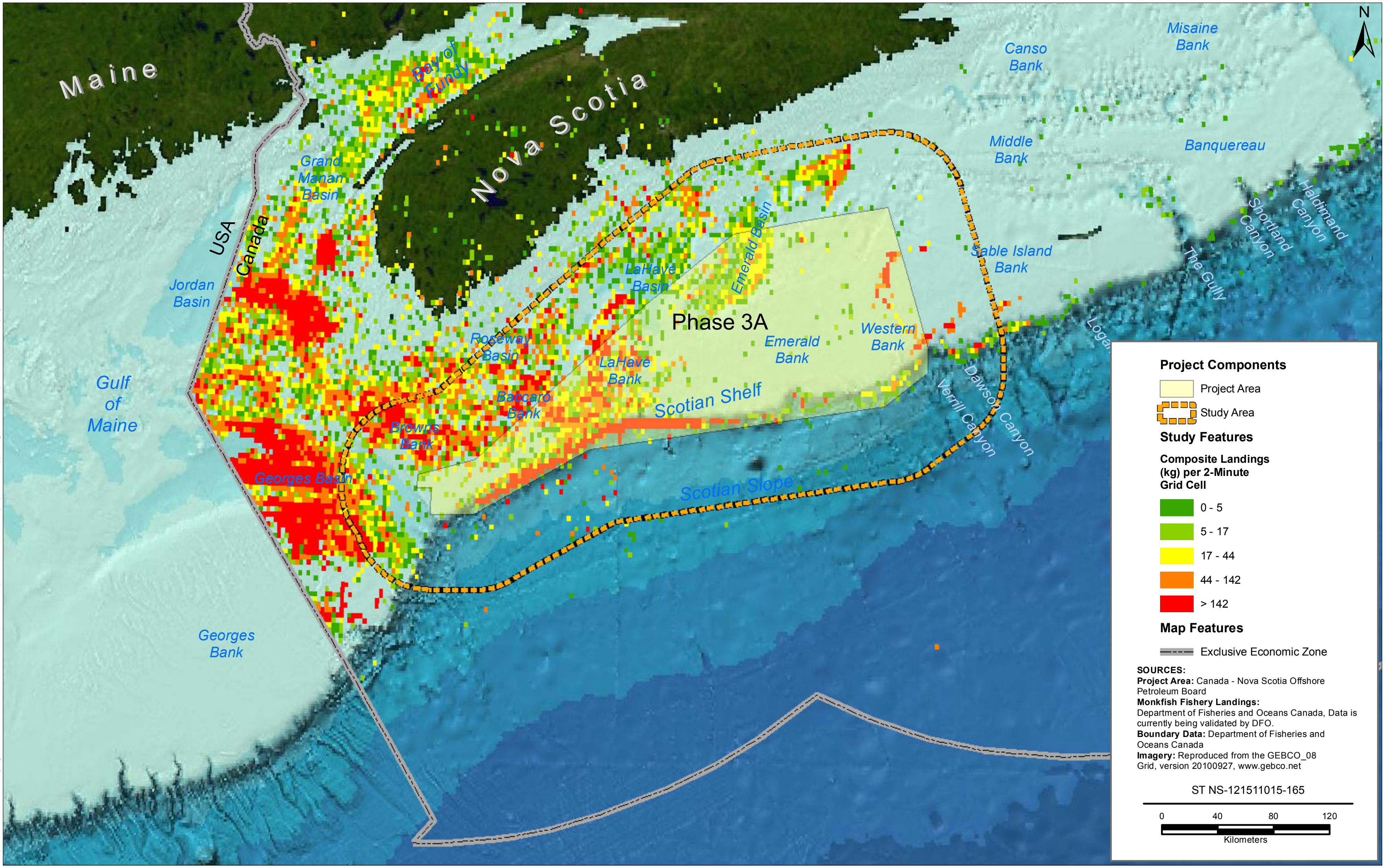
Wolffish Landings, 2006-2010

FIGURE NO.: 18

DATE: Oct 03, 2013

Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-187_Wolffish_Phase3A.mxd



PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

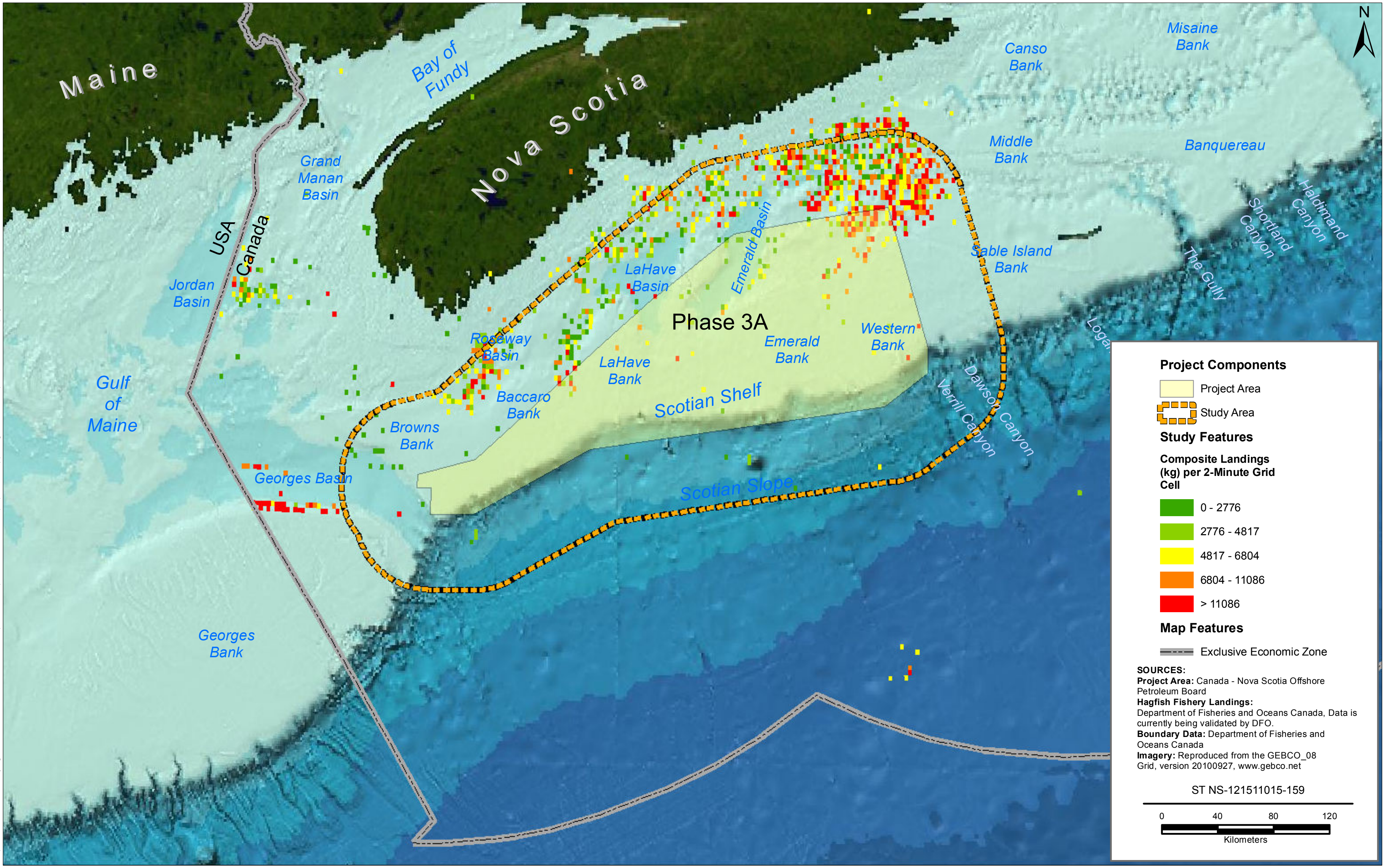
Monkfish Landings, 2006-2010

FIGURE NO.: 19

DATE: Oct 03, 2013

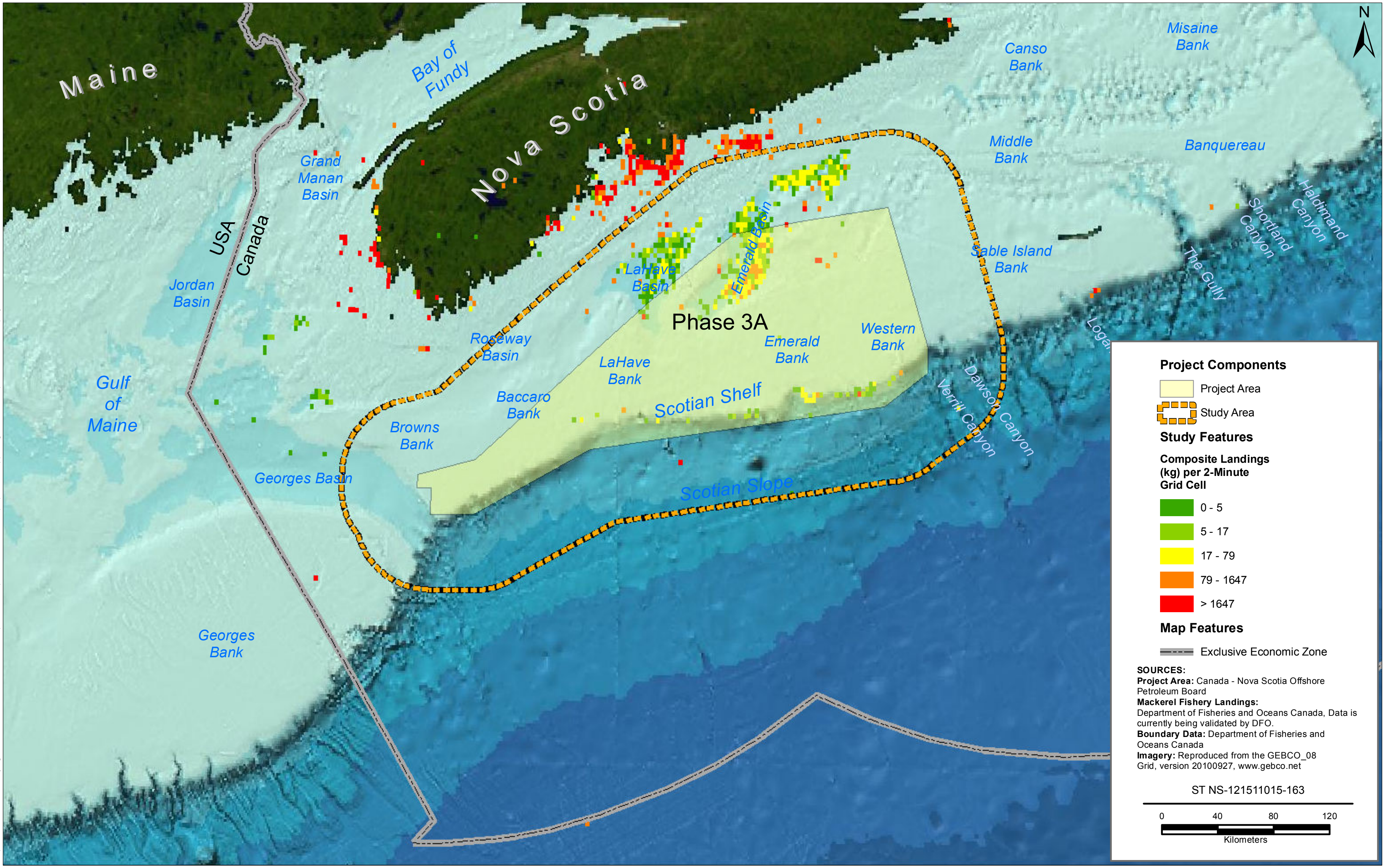
Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-165_Monkfish_Phase3A.mxd



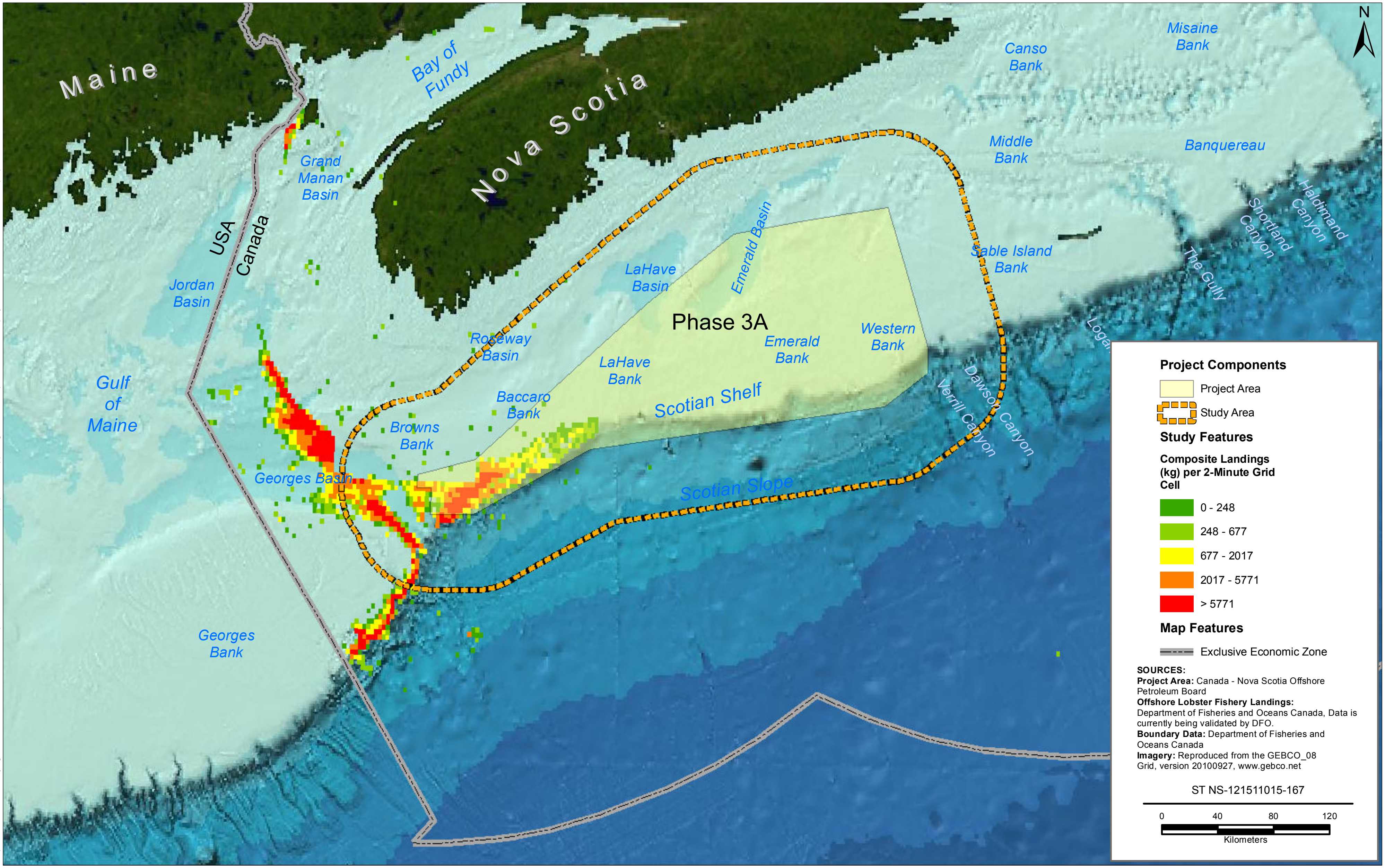
PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 20
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Hagfish Landings, 2006-2010**	Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-159_Hagfish_Phase3A.mxd



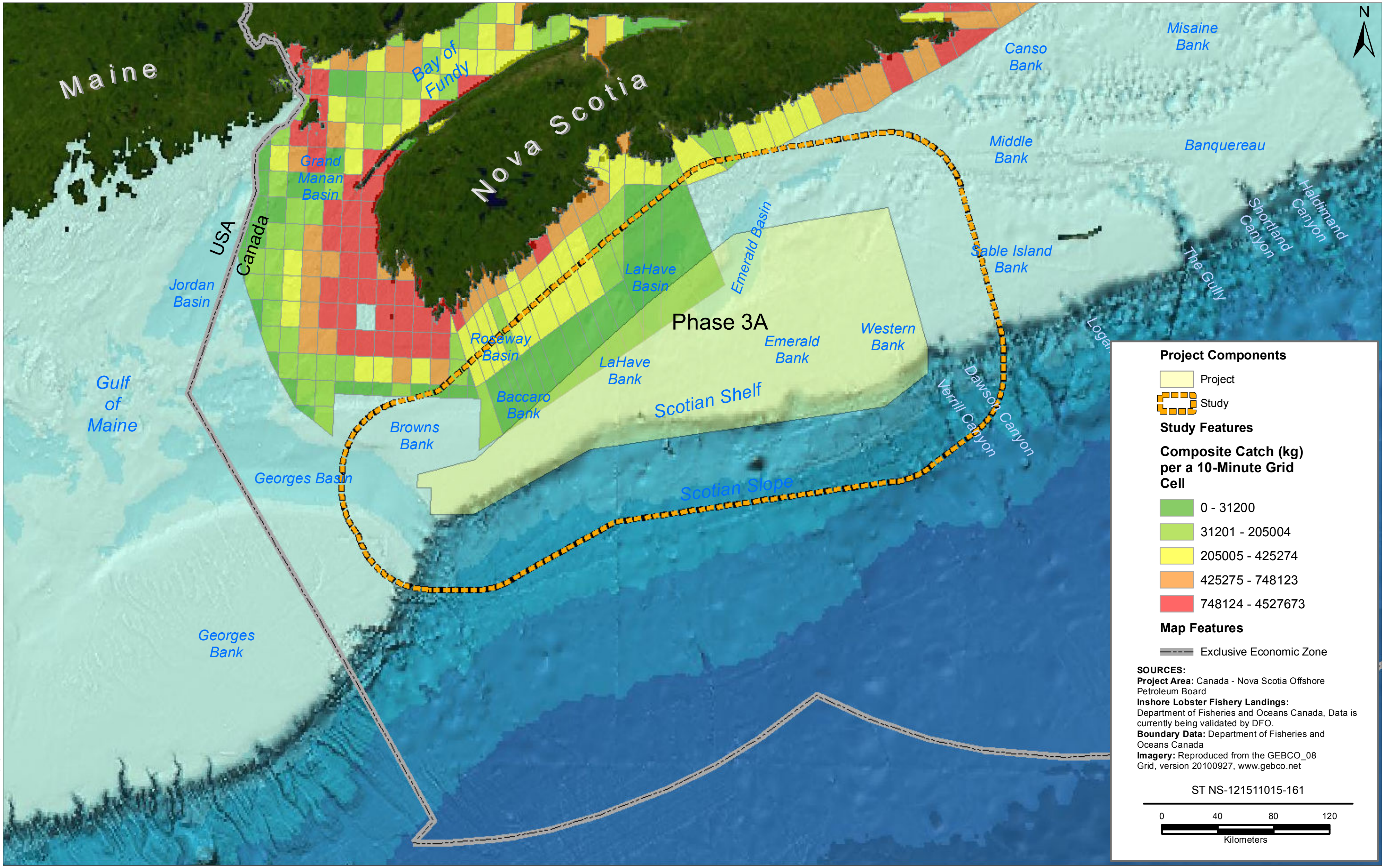
PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 21
REVIEWED BY: C Shupe	**Mackerel Landings, 2006-2010**	DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board		Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-163_Mackerel_Phase3A.mxd



PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 22
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Offshore Lobster Landings, 2006-2010**	Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-167_LobsterOffshore_Phase3A.mxd



PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

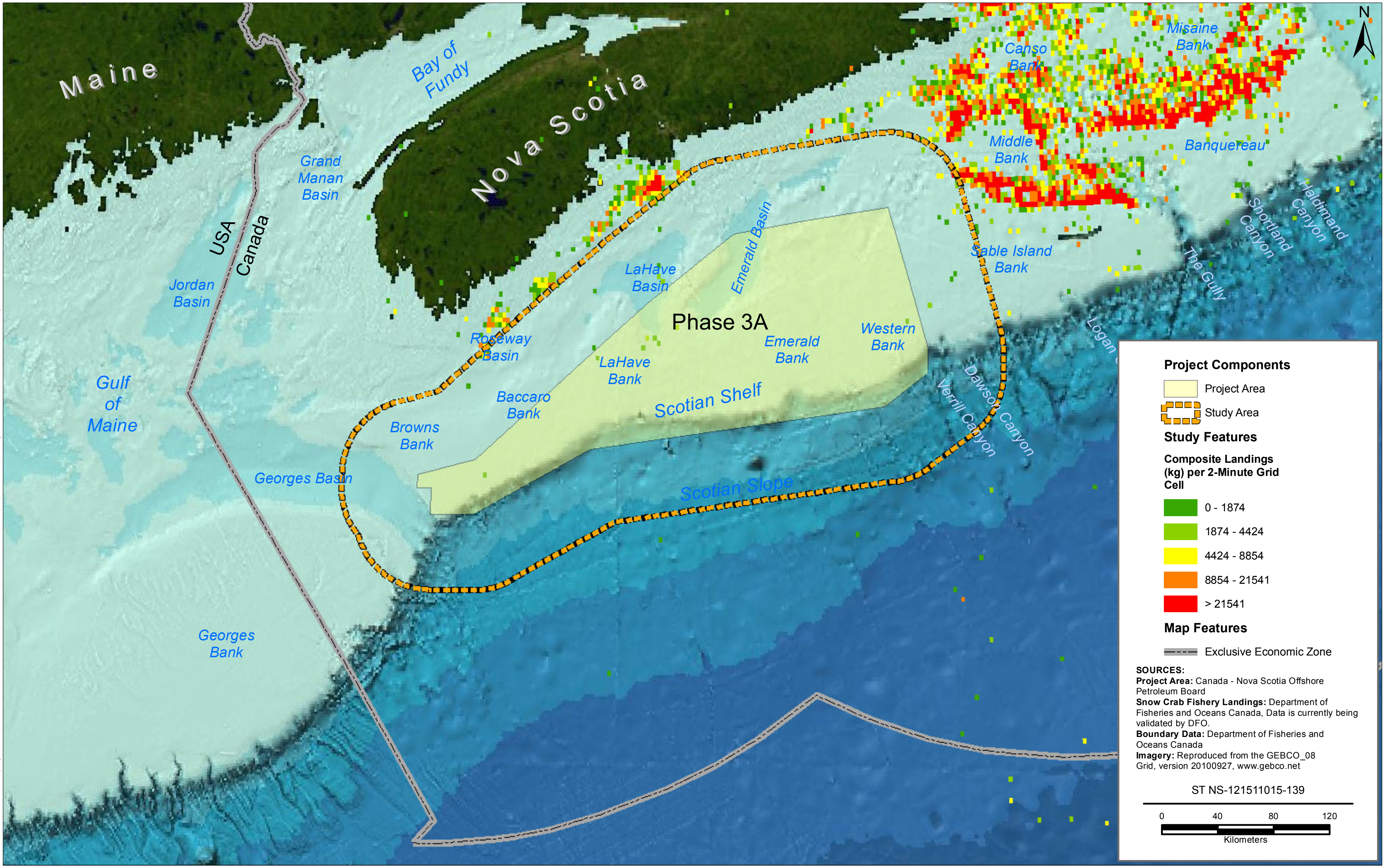
Inshore Lobster Landings, 2008-2011

FIGURE NO.: 23

DATE: Oct 03, 2013

Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-161_LobsterInshore_Phase3A.mxd



PREPARED BY: M. Huskins-Shupe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Snow Crab Landings, 2006-2010

FIGURE NO.: 24

DATE: Oct 03, 2013

Stantec

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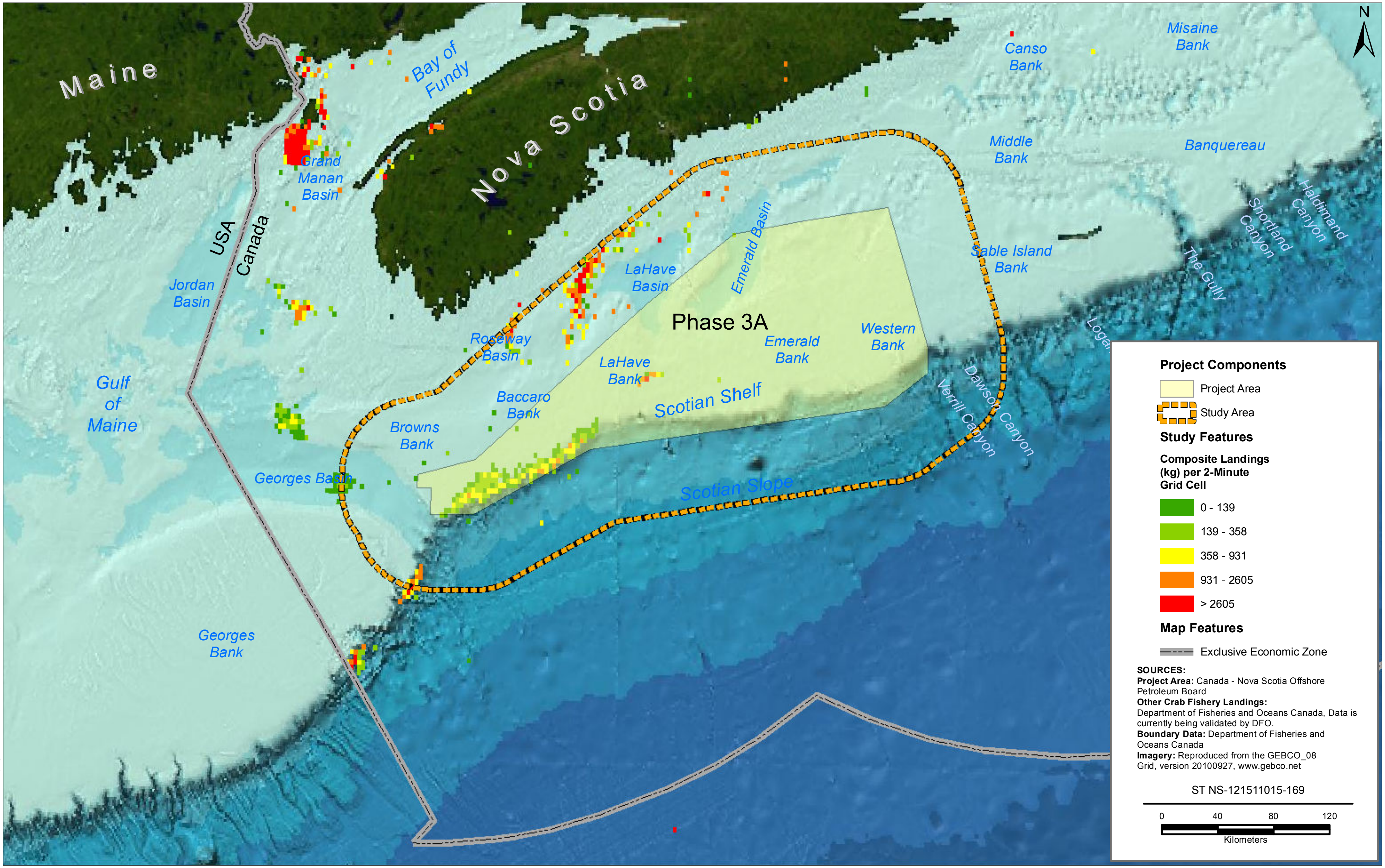

PREPARED BY: R Sutcliffe	Western Scotian Shelf and Slope Strategic Environmental Assessment	FIGURE NO.: 25
REVIEWED BY: C Shupe		DATE: Oct 03, 2013
CLIENT: Canada - Nova Scotia Offshore Petroleum Board	**Other Crab Landings, 2006-2010**	Stantec

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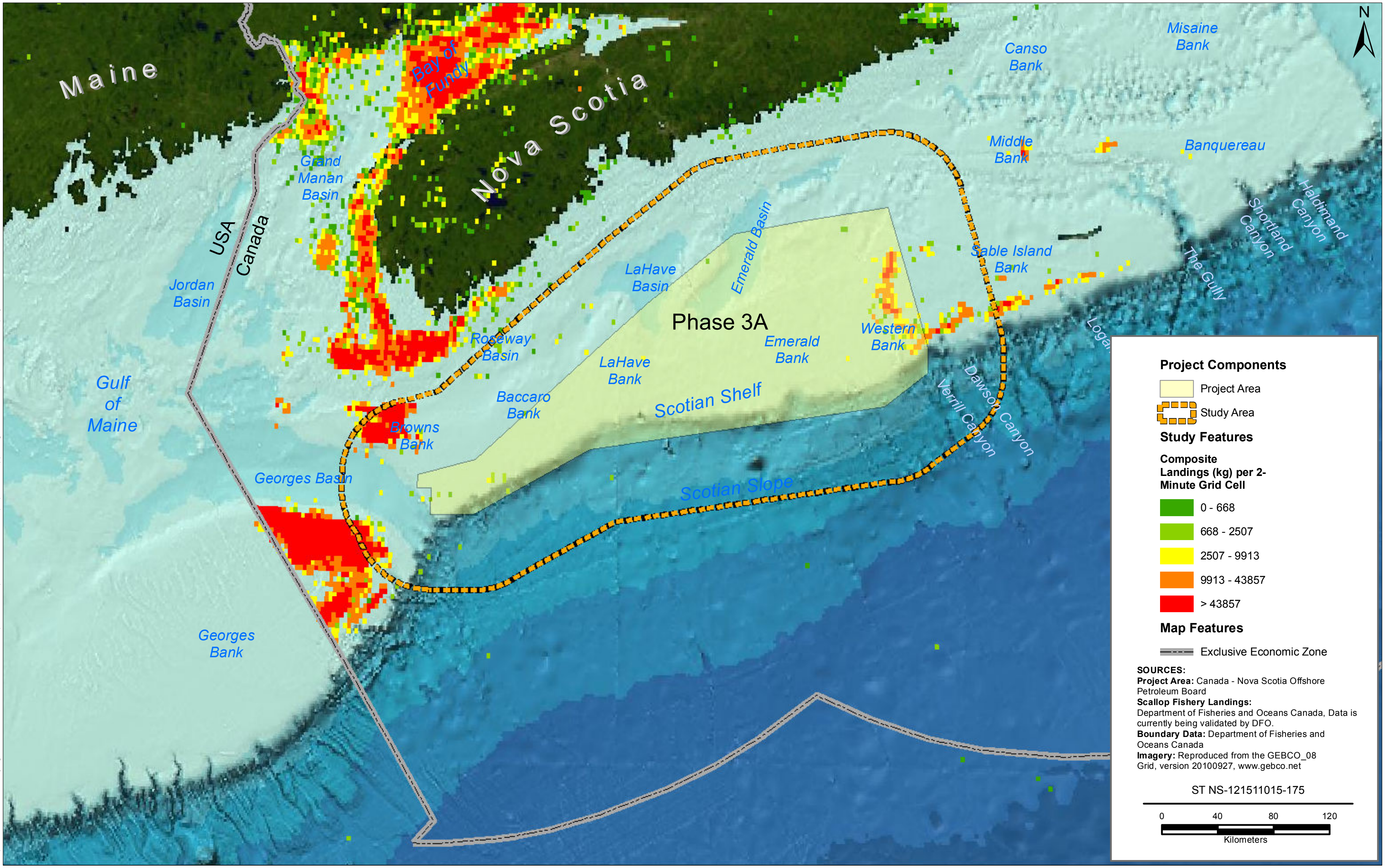

PREPARED BY: R Sutcliffe

REVIEWED BY: C Shupe

CLIENT: Canada - Nova Scotia Offshore Petroleum Board

Western Scotian Shelf and Slope Strategic Environmental Assessment

Scallop Landings, 2006-2010

FIGURE NO.: 26

DATE: Oct 03, 2013

Stantec

File Path: V:\1215\active\121510xxx\121511015_cnsopb_sea\geomatics\mapping\mxd\report\Phase3\Phase 3A\ST_NS_121511015-177_Scallop_Phase3A.mxd

APPENDIX C

Eastern Canada Seabirds at Sea (ECSAS) Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms (Gjerdrum *et al.* 2012)

Environment Canada Environnement Canada

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Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms

Carina Gjerdrum, David A. Fifield, and Sabina I. Wilhelm

Atlantic Region

Canadian Wildlife Service
Technical Report Series Number 515

Canada

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EASTERN CANADA SEABIRDS AT SEA (ECSAS) STANDARDIZED PROTOCOL FOR PELAGIC SEABIRD SURVEYS FROM MOVING AND STATIONARY PLATFORMS

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ABSTRACT

Marine birds play an important role in marine ecosystems and their responses to oceanographic variability can be used to monitor changes in the marine environment. To understand their roles and to identify and minimize human impacts on birds at sea, data on their offshore distributions and abundance are required. Numerous methods are employed throughout the world's oceans to study seabirds at sea from ships, but for studies to be comparable, methods have to be standardized. In Atlantic Canada, data were collected between 1966 and 1992 under PIROP (Programme Intégré de Recherches sur les Oiseaux Pélagiques), but there was no systematic monitoring of birds at sea after the mid-1980s. In 2005, the Canadian Wildlife Service of Environment Canada re-initiated the pelagic seabird monitoring program in eastern Canada (Eastern Canada Seabirds at Sea; ECSAS) and developed a survey protocol based on those used elsewhere in the Atlantic. We record birds observed along a line transect, scanning a 90^{o} arc to one side of the ship, and follow the recommended snapshot approach for flying birds (Tasker et al. 1984). Distance sampling methods are incorporated to address the variation in bird detectability. This method allows the estimation of seabird densities. In this report we describe the general methods we use to conduct seabird surveys at sea, and then provide detailed instructions on how to fill out each data field. We also provide worked examples for surveys from moving and stationary platforms. It is our hope that this report will serve as a guide for other such studies in the Atlantic and beyond so that comparisons of seabird communities can be made among regions and between research organizations.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 History of pelagic seabird surveys in eastern Canada

Gathering systematic information on the pelagic distribution of seabirds in eastern Canadian waters was pioneered by R.G.B. Brown (Canadian Wildlife Service; CWS) through PIROP (Programme Intégré de Recherches sur les Oiseaux Pélagiques), a joint initiative between the Canadian Wildlife Service and P. Germaine at l'Université de Moncton. Data collection under PIROP occurred from the late 1960s until the early 1990s, with the bulk of the data collected during the 1970s. In addition to doing much of the field work, R.G.B. Brown published extensively on the oceanographic factors that influence seabird distribution (e.g., Brown 1970, 1976, 1979, 1985), and produced a series of atlases summarizing the seasonal distribution and abundance of seabirds in the northwest Atlantic (Brown et al. 1975, Brown 1977, 1986). In the early 1990s, A.R. Lock (CWS) organized the PIROP data into one database and published a Gazetteer, which re-mapped the pelagic distribution of seabirds throughout the northwest Atlantic, with special emphasis on abundance and distribution of seabirds vulnerable to marine oil pollution (Lock et al. 1994). The PIROP database has since been used to examine seabird migration, seasonal moult, and the abiotic factors that influence seabird distribution (Huettmann 2000, Huettmann and Diamond 2000, 2001a,b, 2006).

The PIROP database continued to be relied on heavily well after data collection had ceased, particularly as it related to environmental assessments and impact statements associated with increasing offshore oil and gas activities and the high chronic oiling rates of seabirds reported along the east coast (Wiese and Ryan 2003, Lucas and MacGregor 2006). By the early 2000s, it became evident that current data were required to fill substantial spatial and temporal gaps in the database, and that a revival of a pelagic seabird survey program was necessary. An important step toward this implementation was to develop a standardized survey protocol.

1.2 Development of the standardized protocol

Early PIROP surveys were based on 10 min observation periods during which all birds observed were recorded, regardless of their distance from the moving vessel. These surveys were designed to gather information on the relative abundance and distribution of seabirds, and the short recording periods allowed observations to be related to the variable oceanographic conditions of the area (Brown et al. 1975). Following a review of survey methods by Tasker et al. (1984), PIROP surveys after 1984 recorded birds observed within a 300 m band transect, scanning a 90^{o} arc to one side of the ship. This change in protocol allowed the estimation of densities (i.e., birds per square kilometer) but the protocol did not adopt the recommended snapshot approach for flying birds, which often move faster than the ship and thus inflate estimates of local density (Tasker et al. 1984, Gaston et al. 1987). During the re-vitalization of the pelagic seabird survey program for the Canadian east coast in the early 2000s, A.R. Lock recommended that CWS seek pan-Atlantic coordination and develop survey protocols based on those used by the European Seabirds At Sea (ESAS) group. This was successfully established with the help of K. Camphuysen, past chair of the ESAS group, who generously provided materials and at-sea training on current seabird survey practices in the North Sea.

Standardised data collection among institutes of various countries bordering the North Sea began in the early 1980s, with the establishment of the ESAS database. Early surveys focused on assessing the vulnerability of certain areas to surface pollutants and were therefore designed to collect data that allowed the mapping of relative abundance and distribution of seabirds at sea (see Camphuysen 1996 for review). More recently, surveys in the North Sea have evolved to include the collection of detailed behavioural data, with considerable interest in foraging behaviour of individuals (Camphuysen and Garthe 2004). The methods require extensive training and practice for an observer to gain proficiency in identifying and recording the 92 codes for behaviour and association, in addition to the flight direction data, and were deemed too detailed for the proposed pelagic seabird survey program in eastern Canada. Therefore, a selection of behavioural and association codes taken from the ESAS protocol have been implemented along with the general methods used by European observers, to develop the standardized protocol presented in this report. This protocol will allow for direct comparison with data collected currently in the northeast Atlantic.

We developed a standardized protocol for surveys conducted from two types of observation platform, moving (e.g., oceanographic research or platform supply vessels) and stationary (e.g., oil production rig or supply vessel on stand-by). The protocol for surveys conducted aboard moving platforms was modelled after Tasker et al. (1984), and the protocol for stationary platforms was adapted from methods described in Tasker et al. (1986) and Baillie et al. (2005). Distance sampling methods were included to address variation in bird detectability and to allow for calculation of correction factors to account for missed birds (Buckland et al. 2001). We also reduced the observation period length from 10 min to 5 min in order to obtain more precise spatial information for each bird sighting. This change does not, however, affect our ability to compare seabird densities to those surveys that use longer observation periods. The Eastern Canada Seabirds at Sea (ECSAS) program has used this survey protocol, with minor modifications, in eastern Canada since 2006 (Gjerdrum et al. 2008, Fifield et al. 2009), during which time almost 80,000 km of transect have been surveyed and 144,000 birds counted. In this report, we describe the general methods we use to conduct surveys, and then describe each data field in detail. A series of appendices provide distance estimation equations, data field coding details, example surveys and blank datasheets.

2. GENERAL REQUIREMENTS FOR SEABIRD OBSERVERS

Seabird observers collecting data on pelagic seabird occurrence and behaviour for the ECSAS program are required to use this standardized protocol. It is also strongly recommended (and may be required) that each observer participate in a training workshop. The workshop includes instruction on boat safety, survey methods, distance sampling, and seabird identification. Instruction takes place in a classroom, although students will also be expected to train with an experienced observer at sea. Students will be evaluated in their understanding of the recording methods and seabird identification. As trips can last anywhere between three days and six weeks and travel in a variety of environmental conditions, observers can expect to stand for long periods of time, often under arduous conditions. Limited space on board the vessels may also require observers to share living areas. To ensure the highest quality of data is collected, observers should have the following:

- Experience working with seabirds and a strong knowledge of their behaviour and ecology
- Ability to rapidly identify Atlantic seabirds in all plumages, in various lighting conditions, reduced visibilities, and in rough ocean conditions

- Ability to follow the ECSAS protocol for surveying seabirds at sea
- Ability to accurately record data on data sheets (or electronically) according to protocol, including information on vessel, weather conditions, and birds
- Ability to work independently
- Experience travelling in boats and an ability to work in rough sea conditions without getting seasick
- Good communication skills and the ability to live and work closely with ship's crew and staff for extended periods of time

3. DISTANCE SAMPLING: THE IMPORTANCE OF RECORDING DISTANCES TO BIRDS

3.1 Introduction to Distance Sampling

A crucial question to address in any survey program is that of detection probability. It is well known that some birds will be missed by even the best observer due to sea and weather conditions, vessel characteristics, observer fatigue, etc. (Buckland et al. 2001). The question is, how many? If we do not account for detectability we are forced to assume that all animals within the survey transect are detected, which will underestimate abundance, perhaps drastically. In that case, all we can produce are (likely biased) indices of relative abundance. Relative abundance indices are difficult to compare between surveys, years, observers, etc. when variation in detectability is not assessed (i.e., failure of the assumption of constant proportionality) (Norvell et al. 2003).

Distance sampling is a powerful technique that allows us to estimate the proportion of birds present that are actually detected (i.e., detection probability) and to automatically factor this into abundance calculations (Buckland et al. 2001). Distance sampling is based on the premise that the likelihood of detecting a bird decreases the further away it is from the observer. Likewise, detectability varies by species and environmental conditions.

The subsequent data analysis involves the use of specialized software called Distance (Thomas et al. 2010). The software works by comparing the number of birds actually observed within each distance class with the number that would have been counted if every bird had been detected. If all birds present were detected, then on average there should be equal numbers of birds in each equal-size distance class[†]. This is the same as saying that birds in all distance classes have equal detection probability (Figure 2a). In reality, this never happens. Bird detectability and thus the number in each distance class decreases with distance from the observer. This can readily be seen by simply plotting the number of birds actually observed in each distance class as a histogram. The histogram in Figure 2b shows a typical data set where detection probability decreases with distance. The smooth dark line is a curve that has been fit to the histogram. A correction factor, called the detection probability, is computed by dividing the area under the curve by the area of the entire dashed rectangle. The distance sampling software does this and thus computes abundance, taking birds that were missed into account. Note that detectability will also be affected by other factors including the identity and behaviour of the species, weather conditions, sea state, and observer, all of which the software factors into the analysis (Thomas et al. 2010).

[†] Distance automatically adjusts for distance classes of unequal width.

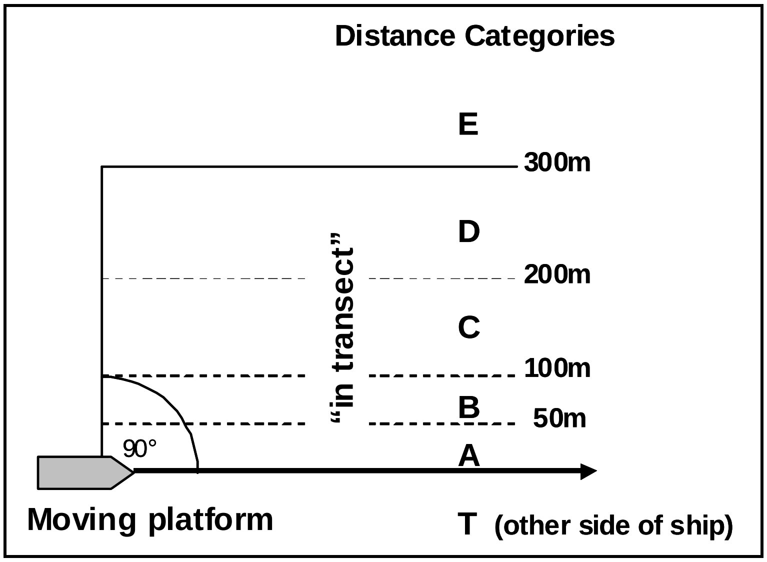

Figure 1. Illustration of a survey using a 90^o scan, covering a 300 m transect from a moving platform. All birds observed within this transect, whether flying or on the water, are recorded. The perpendicular distance from the line to birds detected on the water or in flight is estimated. Birds observed outside the transect are normally also recorded if this does not affect observations within the transect. Distance categories "E" and "T" are both considered not in transect. See Section 4 for details of distance measurements.

For distance sampling to work, all the observer has to do is estimate the distance to each flock of birds, which we do in distance classes or "bins" (Figure 1). Note that the mathematical framework requires that the observer records the *perpendicular* distance from the ship's track line to each flock (Figure 1). Imagine extending a 300 m long "yardstick" perpendicular to the ship, counting each flock and estimating its distance as it passes under the stick. In this way, a 300 m wide rectangular swath of ocean is surveyed as the ship proceeds. In reality, it is often necessary to estimate the perpendicular distance before the ship reaches a flock of birds because they are in flight or to ensure that birds on the water are not displaced by the ship (see section 4.1).

3.2 Analysis assumptions

Distance sampling produces unbiased density estimates while depending on only a small set of assumptions (Thomas et al. 2010). These include: 1) all birds on the line (i.e., within the first distance class) are detected, 2) birds are neither attracted to nor displaced by the survey platform before being detected (requires looking well ahead of the vessel for some species) and 3) distances are measured accurately. The first assumption is due to the internal mathematics used by the software to compare the relative numbers of birds in each distance class. If many birds in distance class "A" are missed, then the computed probability of detection will be artificially high, resulting in an underestimate of abundance. It is therefore extremely important to ensure that all birds in the first bin are detected. However, a balance of effort is required so that observers are not concentrating so much on birds that are close to the vessel that they will miss other more distant birds. In order to avoid violating the third assumption, observers are also required to look well ahead of a moving platform to detect birds before they dive or fly away.

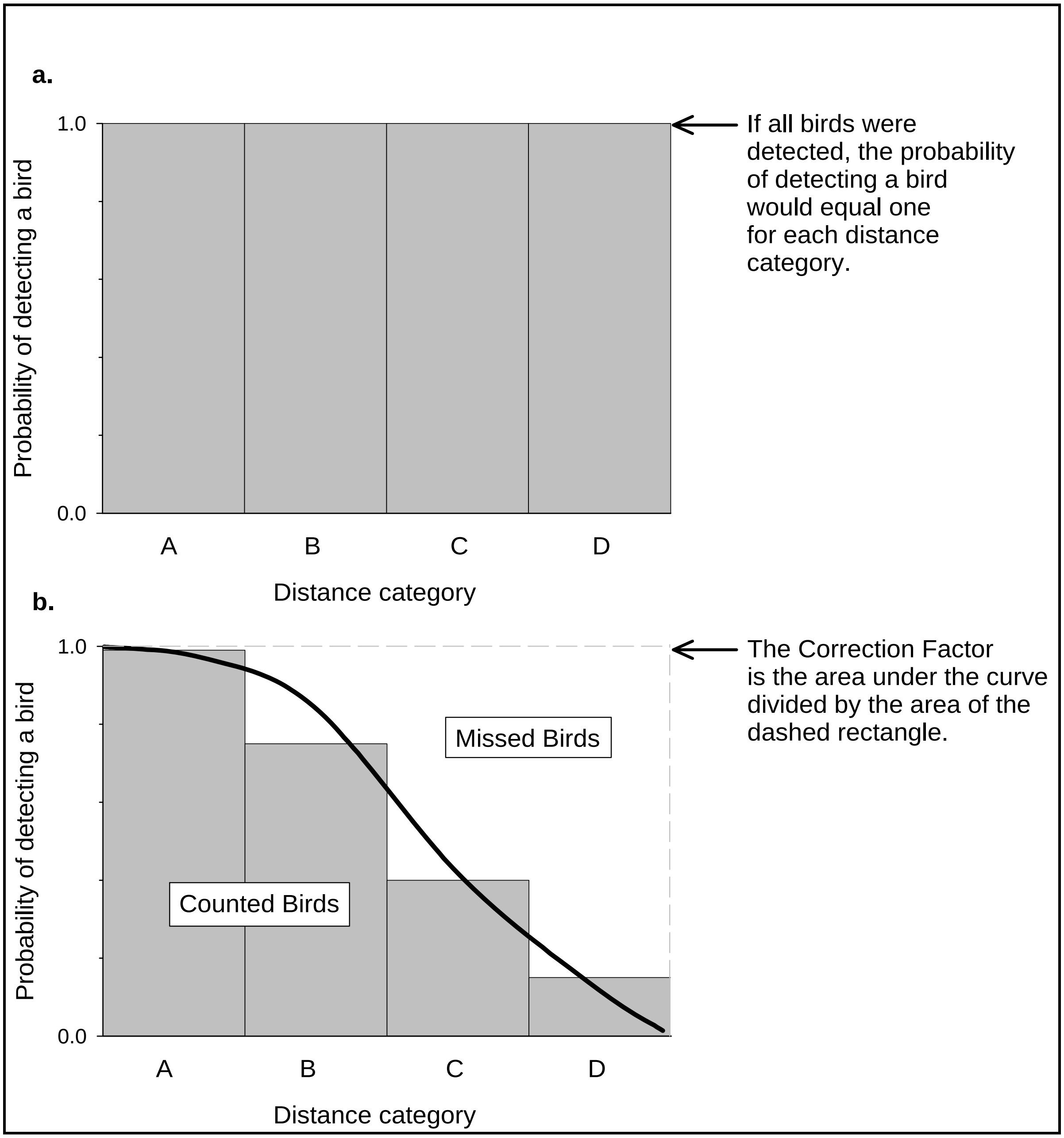

Figure 2. Typical example showing how the histogram would look if (a) all birds were detected, and (b) detectability of birds decreasing with increasing distance. The correction factor is computed as the area under the curve divided by the area of the entire dashed rectangle.

4. GENERAL METHODS FOR SEABIRD SURVEYS

4.1 Surveys from moving platforms

Surveys are conducted while looking forward from the moving survey platform, scanning at a 90^{o} angle from either the port or starboard side (Figure 1). The transect is continuously surveyed by eye to count and identify birds present in air or on water. Binoculars are used to confirm species identification, and other details, such as age, moult, and behaviour. Observers scan ahead regularly (e.g., every minute) to detect birds that may dive as the ship approaches. If large concentrations of birds in the transect fly off as the ship approaches, binoculars can be used to help count individuals, and these birds are recorded as being on water. Priority is given to birds observed in transect (Figure 1). Birds not in transect are also important and are recorded if these observations do not interfere with observations of birds in transect.

A survey consists of a series of 5 min observation periods, which are exclusively dedicated to detecting birds. As many consecutive 5 min observation periods are conducted as possible, regardless if birds are present or not, and consistent coverage throughout the day is encouraged. The transition between observation periods may take one or two minutes, in order to record the vessel's position and any conditions that may have changed since the last 5 min observation period (see Section 5.1 on recording observation period information). Transits longer than two hours may need to be broken up to avoid observer fatigue.

Surveys are best conducted when the platform is travelling at a minimum speed of 4 knots (7.4 km/h) and a maximum of 19 knots (35.2 km/h). Surveys can be done when the ship is travelling less than 4 knots, but birds are often attracted to slow moving or stationary vessels. If birds are clearly gathering around the vessel and settling on the water when the ship is moving at decreased speeds (i.e., less than 2 knots), cease your observations. If the ship is no longer moving at all, switch to the protocol used for stationary surveys (section 4.2). When visibility is poor due to rain or fog and the entire width of the 300 m transect is not visible, surveys from moving platforms can still be conducted, however, observers must record the width of the transect that is visible during the survey (e.g., 200 m) in the "Notes" section of the record sheet (see Appendix X for blank record sheets). When no birds are detected during a 5 min period, it is important to record "No birds observed" on the datasheet. If vessel speed or direction changes significantly during an observation period, record the time and location of termination and begin a new observation period.

Observers should practice estimating the locations of the various distance bands. This is best accomplished with a distance gauge made from a transparent plastic ruler (see Appendix I). This gauge should be kept close at hand to quickly verify bird distances.

4.1.1. Detecting and recording bird sightings

One of the primary goals of pelagic surveys is to quantify bird distribution and abundance. To do this, we need estimates of density, which is the number of birds occupying a prescribed area of ocean surface at any given instant in time. During a 5 min observation period, a 300 m wide rectangular area of ocean will be covered (see Figure 1, Appendix VII), the length of which is determined by ship speed. For example, for a ship traveling at 10 knots, the rectangle will be 300 m wide and approximately 1500 m long. To compute bird density, it would be ideal to be able to count all birds that occur within this rectangle *at a single instant in time,* before they swim or fly away, giving a measure of birds/km^2. Since we do not have the ability to see the entire area simultaneously, birds must be counted as the ship approaches them.

4.1.2. Recording birds on the water

All birds observed on the sea surface are continuously recorded throughout the 5 min period and their perpendicular distance from the observer is estimated (Figure 1). If a bird appears to have been flushed off the water, it is counted as a bird on water and not subsequently counted as a flying bird during a snapshot – see below. Observers scan ahead regularly (e.g., every minute) to detect birds that may dive as the ship approaches.

4.1.3. Recording birds in flight

During the observation period, more birds will fly through the survey area than were present in that area at a single instant in time (Tasker et al. 1984). The faster the birds fly relative to the ship's speed, the greater the number of birds will pass through the transect area during a 5 min period. If these flying birds are counted continuously as they are encountered, their density will be overestimated by an amount that is proportional to the relative speeds of the bird and observer (Tasker et al. 1984, Spear et al. 1992). Therefore, flying birds are recorded using a series of instantaneous counts, or snapshots, at regular intervals along the transect (see Appendix VII for an example). The time interval between snapshots depends on the speed of the ship and is chosen so that the ship moves roughly 300 m between snapshots (Table 1). For example, if the platform is moving at a speed of 10 knots, snapshots will occur every minute for the duration of the 5 min observation period. At the time of the snapshot, all flying birds within the transect and up to 300 m ahead of the observer are counted (Figure 1, Appendix VII). In this way, the entire survey transect is covered by a series of instantaneous snapshots. During each snapshot, flying birds are recorded as in transect only if they are within 300 m to the side or 300 m ahead of the vessel (Figure 1). All other flying birds that are seen beyond 300 m OR between snapshot intervals are recorded as not in transect. Birds recorded not in transect (or not in semi-circle for stationary surveys) provide important information on distribution, timing of occurrence, and behaviour, and effort should be made to record them if at all possible. Nothing is recorded if no birds are observed during the snapshot. *It is important to remember that all 5 min observation periods begin with a snapshot of flying birds.*

Table 1. Intervals at which instantaneous snapshot counts of flying birds are conducted from a moving platform.

Platform Speed (knots)	Interval between counts (min)
< 4.5	2.5
4.5 - 5.5	2
5.5 - 8.5	1.5
8.5 - 12.5	1
12.5 - 19	0.5

4.1.4. Lines of flying birds

Some species (e.g., murres (*Uria* spp.), Northern Gannets (*Morus bassanus*)) may fly in long lines across the survey area. At the time of the snapshot, the number of birds in the flock is counted and the distance class is assigned according to the location of the centre of the flock. All the birds are recorded as in transect if the centre of the flock is within the 300 m transect. If the centre of the group is beyond 300 m, they are recorded as not in transect, despite some individuals being within 300 m (see Appendix VII).

4.1.5. Large numbers of birds

When very large numbers of birds are encountered that overwhelm the observer's ability to count and measure the distance to individual flocks (this does not include typical ship-followers circling the ship), snapshots (of all birds whether in flight or on water) are conducted rather than continuous counts. Snapshot intervals are the same as those used to count flying birds (Table 1). At the time of the snapshot, all the birds that occur within 300 m of the observer (perpendicular to, as well as ahead of the observer) are counted, but the flying birds are not separated from those on the water. Another count does not occur until the next snapshot interval when the ship has travelled another 300 m. Although it is not practical to estimate distance to each bird, you should indicate whether the birds were observed within 300 m (see Section 5.2). If the majority of the birds are in the air, they can be recorded as flying. However, if they appear to be flushing off the surface of the water as the ship approaches, or continuously moving between the water and air, they are recorded as on the water. When such large flocks are recorded in this way, it is important to indicate the change in protocol in the notes. This scenario is a relatively rare occurrence. Most of the time, distance estimates can be made and flying birds can be separated from those observed on the water.

4.1.6. Birds that follow the ship

After recording a flying bird, it is not subsequently recorded again if it is following the ship. The same bird is not recorded on subsequent snapshots, even if it leaves and then re-enters the survey area. When dozens or more birds are following the vessel, it will be impossible to determine which individuals have already been recorded and which have recently joined the ship. For example, Northern Fulmars (*Fulmarus glacialis*) at times circle the ship in large numbers and as far out as the edge of the transect and beyond. In this case, the number of birds following the ship is estimated at regular intervals (i.e., once an hour) and their association as ship followers (code 18; Appendix VI) is recorded. The ship followers are ignored at intervals between counts. If it can be determined that new individuals are joining the flock, these are recorded and their distance from the observer is estimated.

4.2. Surveys from stationary platforms

Observations from stationary platforms (including ships stopped on station or on standby) are conducted using instantaneous counts, or snapshots, of birds within an area that is scanned at regular intervals throughout the day. These surveys will usually last only a few seconds. The survey is conducted from a position outdoors whenever possible, as close to the edge of the platform as permitted. A position near the edge will increase the detection rates of birds, especially for birds that use the waters at the base of the platform. If surveys are being conducted from a stationary platform such as an oil drilling rig, observers should scan from the same location each time in order to increase the comparability among scans.

Surveys are conducted by scanning a 180^{o} arc, giving priority to birds within a 300 m semi-circle (Figure 3). Observers should practice estimating the locations of the various distance bands prior to beginning observations. This is best accomplished with a distance gauge made from a transparent plastic ruler (see Appendix I). This gauge should be kept close at hand to quickly verify bird distances. The area is visually swept only once per scan, from one side to the other, and all birds on the water and in flight are systematically recorded at that time. The distance to birds from the observer is estimated and recorded for all birds (Figure 3). Binoculars and spotting scopes can be used to confirm species identification and other details as necessary.

The same area is surveyed once every hour during the day, regardless if birds are present or not. When the entire width of the 300 m semi-circle is not visible, the observer indicates the limit of visibility on the data sheet. When no birds are detected during a scan, it is important to record "No birds observed" on the record sheet.

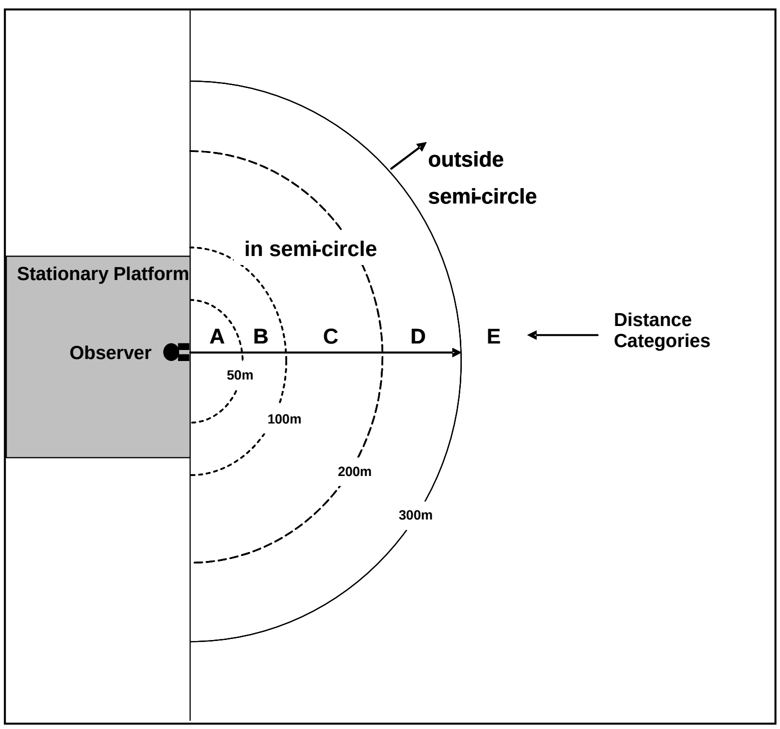

Figure 3. Illustration of survey using a 180^{o} scan, surveying an area 300 m from a stationary observer. All birds observed within this area, whether flying or on the water, are recorded. Birds visible beyond 300 m are also important and are recorded, if at all possible. The distances to all birds are estimated. Birds observed outside the 300 m semi-circle are recorded as not in semi-circle.

5. DATA RECORDING

This section provides detailed information on recording information during each observation period. See Appendix X for example data sheets. Section 5.1 describes the data fields that must be filled in for each 5-minute observation period. Section 5.2 describes the fields recorded for each bird sighting.

5.1 Observation Period Information

It is important to fill in all the fields under the heading “Observation period information” for moving platform surveys, or “Scan information” for stationary surveys at the beginning of each survey. The information collected here may affect which birds are observed and therefore will be important to incorporate into any subsequent analyses.

Company/agency: Seabird observers may be volunteers or contracted through private industry or government agency. Indicate the company, agency or organisation that has requested the surveys (e.g., Canadian Wildlife Service, ExxonMobil, Memorial University).

Platform name and type: Platform type may include seismic ship, offshore supply vessel, fishing boat, research ship, ferry, etc.

Observer(s): Indicate the first and last name of the primary observer. Also record the name of any additional observers assisting with the survey.

Date: Record the date that the survey took place. Use format DD-MMM-YYYY (e.g. 12-Apr-2008) to avoid ambiguity.

Time at start / Time at end: Record the time (using 24 h notation) at the start and end of the observation period. Use Universal Time (UTC) to standardize across regions. Note that the conversion from local time to UTC will be influenced by daylight savings time.

Latitude and longitude at the start and end of the observation period: Indicate position of platform in either decimal degrees (e.g. 47.5185) or degrees and decimal minutes (e.g. 47˚ 31.11´) depending on which format is available to you.

Platform activity: Platform activity may influence observations and should therefore be noted. Activities could include steaming, seismic array active, drilling, off-loading at drilling rig, etc.

Scan type (for stationary platforms only): Conduct a 180˚ scan for all stationary surveys. If part of the survey area is obstructed, indicate the scan angle used.

Scan direction (for stationary platforms only): Indicate the true (not magnetic) bearing when looking straight ahead, at centre of semi-circle.

Visibility: Measure visibility by determining the greatest distance at which you can distinguish objects, ideally black, against the horizon sky with the unaided eye. Under normal atmospheric conditions, visibility depends only on the height above the sea surface from which it is observed (visibility in kilometres = 3.84 * sqrt(height in meters)). For example, on a clear day on a vessel 12 m above the surface, maximum visibility will be 13 km. Visibility will be considerably less during foggy conditions.

Weather conditions: Record the general weather conditions at the time of the survey according to codes in Appendix II. Record the most prominent conditions within the survey area. For example, if there are distant fog patches that do not directly affect the survey conditions, the weather code will be 0 or 1. Alternatively, if there is < 50% cloud cover but you are travelling through fog patches, the weather code will be 2.

Glare conditions: Light reflecting off the surface of the water can often influence bird detection. Record the glare conditions at the time of the survey according to codes in Appendix II.

Sea state code: Sea state codes give an approximate description of current conditions on the surface of the water. Use codes from Appendix III.

Wave height: Estimate wave height (m) from the highest point of a wave (peak) to the lowest point (trough).

Wind speed or force: Indicate wind speed in knots. If observations are from a moving platform, be sure to record the TRUE wind speed, as this takes into account the 'apparent' wind generated from the forward momentum of the vessel. If relative wind speed is the only measurement available, indicate that you are recording relative wind speed so that appropriate adjustments can be made later. If no measurements are available, estimate wind speed using Beaufort codes from Appendix III.

Wind direction: Wind direction is the direction from which a wind originates. If observations are from a moving platform, be sure to record the TRUE wind direction, as this takes into account the 'apparent' wind generated from the forward momentum of the vessel. If relative wind direction is the only measurement available, indicate that you are recording relative wind direction so that appropriate adjustments can be made later. Use ***ND*** (No Direction) if the wind direction is variable or too light to indicate a particular direction.

Ice Type and Concentration: If ice is present during the survey, indicate the type and concentration using codes from Appendix IV. Indicate in the notes if the ice is present only beyond the transect limits.

Platform speed and direction (for moving platforms only): Record the platform speed in knots and the true (NOT magnetic) platform direction. If the platform speed or direction changes significantly during an observation period, terminate the observation period and record the time and position of termination. Start a new observation period, recording the new speed and/or direction.

Observation side (for moving platforms only): Circle whether you are surveying from ***Starboard*** or ***Port***.

Height of eye (meters): Indicate height of observer's eye above the water in meters. This measurement is important to calibrate distance categories (Appendix I) and may need to be measured with a measuring tape or rope.

Outdoors or Indoors: Circle ***Out*** when conducting observations from a position outdoors and ***In*** for indoor observations.

With snapshot? (for moving platforms only): Indicate if snapshot method is being used for birds in flight by circling ***Y*** or ***N***. Under normal circumstances, snapshots should always be used for birds in flight.

Notes: Make note of disturbances or relevant activities in the area, especially if there are large vessels or fishing activities nearby, or if your vessel is sounding the fog horn.

5.2 Bird Information

At a minimum, the species (which can be unknown), count, fly or water, and in transect (or in semi-circle, if doing stationary surveys) fields MUST be filled in for each sighting. Note that some fields are only appropriate for certain species. For example, age and sex will only be recorded for species where this can be determined (e.g., ageing gulls or sexing waterfowl). Priority is given to birds that are in transect, since these are the only birds that are used in density estimates. Birds recorded not in transect or not in semi-circle give us important information on distribution, timing of occurrence, and behaviour, and effort should be made to record them if time permits.

Species: Identify each individual bird seen to species. If this is not possible, identify to genus or family. Record all unknowns, even if they are identified only as "unknown gull" or "unknown bird". See Appendix V for a list of commonly used species codes. See Section 5.2.1 for information on recording mixed species/age flocks. When garbage is encountered within the survey area, it should be recorded as GARB. Marine mammals, fish and sharks should also be recorded if possible.

Count: Record the number of birds in each sighting in the count field. Record homogenous flocks on a single line. For example, a group of 10 Common Murres (*Uria aalge*) close together on the water is recorded in a single row as a flock of 10 and not as 10 individual rows. If large numbers are present, estimate the number as accurately as possible.

Fly or Water?: Indicate whether the bird(s) observed is in flight (***F***) or on the water (***W***). Occasionally you will have a songbird that may land on the ship. We record these as on the ship (***S***). When surveying close to land, birds sitting on land may be recorded as ***L***.

In transect or semi-circle?: Indicate if bird observed is in (***Y***) or out (***N***) of the transect (moving) or semi-circle (stationary). See Section 5.2.2 for more details. Give priority to birds that are in the transect or semi-circle. Record birds seen outside the transect if activity levels permit.

Association and Behaviour: Record one or more association and/or behaviour codes with each bird when appropriate (see Appendix VI for association and behaviour codes, and refer to Camphuysen and Garthe (2004) for further information).

Distance: Record the distance to each bird or flock. This information is used to assess detectability and account for missed birds (see Section 3). For all birds, estimate the perpendicular distance between the bird(s) and the observer (Figure 1). Distance categories are as follows: ***A*** = 0-50 m, ***B*** = 51-100 m, ***C*** = 101-200 m, ***D*** = 201-300 m, and ***E*** = > 300 m. Record flocks of birds as a single unit by recording the distance to the ***centre*** of the flock. For example, if a group is straddling the 300 m boundary with the flock centre located in ***D*** (with some individuals inside and some individuals outside the transect) record **the entire flock** as being in ***D*.** If the flock centre is outside the transect, record the entire flock as distance class ***E***. It is very important to record distance to birds within the 300 m strip, but if this is not possible (i.e., too busy), you may use ***3*** = within 300 m but no distance recorded. Distance ***T*** is used to indicate that the bird or flock was observed on the opposite side of the vessel.

Flight direction: Indicate true heading direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, ***or NW)*** for birds in flight if they are not associated with the platform. If birds are flying erratically such that no one direction is appropriate, record them as ***ND* (no direction)**. Note that *ND* is not the same as not recording flight direction. For example, if the data field is left blank, flight direction information was not collected for that sighting. However, if *ND* was recorded for the sighting, that particular bird(s) was flying erratically, in circles, etc.

Age: Record age based on plumage, where ***J***(uvenile) = first coat of true feathers acquired before leaving the nest; ***I***(mmature) = the first fall or winter plumage that replaces the juvenile plumage and may be worn for several years (across multiple moults) until reaching adulthood; and ***A***(dult) = all subsequent plumages.

Plumage: Adult plumage can be further categorized as ***B***(reeding) = spring and summer plumage, or ***NB*** (non-breeding) = fall and winter plumage. ***M*** is used to indicate a bird with flight feathers moulting.

Notes: Record other pertinent information such as color phase, unusual behaviours, etc.

5.2.1 Recording mixed groups of birds

Sometimes flocks of birds will contain multiple species or age classes and will require multiple rows on the datasheet (e.g., a flock containing both Great and Sooty Shearwaters (*Puffinus gravis* and *P. griseus*), or a flock of Black-legged Kittiwakes (*Rissa tridactyla*) containing both adult and immature birds). Subsets of the group that share the same morphological and behavioural characteristics are recorded in the same row (e.g., all adult kittiwakes in breeding plumage flying in the same direction). Other individuals from the group that have different characteristics (e.g., juveniles) are recorded in subsequent rows. Draw an arc linking all rows from the group to indicate that they were together (see example in Appendix VII).

5.2.2 For moving platforms, when are birds recorded as in transect?

Whether birds are in transect or not depends on whether they are on the water or in flight. Birds on the surface of the water within 300 m perpendicular distance from the observer are always considered in transect (Figure 1). When visibility is good, birds on the water may be seen up ahead of the platform, perhaps as far as 400 m or 500 m ahead, but still within the 300 m transect. Because these individuals may dive or fly away as a result of the approaching vessel, they should be counted as in transect and their perpendicular distance recorded when they are first detected (unless the observation period will end before the ship reaches them, in which case they are recorded in the next period). Flying birds are only considered in transect if they are observed during a snapshot AND they are physically within the snapshot block (within 300 m to the side and 300 m ahead of the vessel) (Figure 1, Appendix VII).

6. CONCLUSION

The Eastern Canada Seabirds at Sea (ECSAS) monitoring program uses this protocol to collect distribution and abundance information for birds at sea in Atlantic Canada. The protocol follows recommendations for standardized recording techniques (Tasker et al. 1984) that are used in the North Sea and northeastern Atlantic with modifications to allow for the estimation of bird detectability (Buckland et al. 2001). Although we are far from achieving a global standardization of methods, it is our hope that this report will serve as a guide for others conducting pelagic bird surveys in our region and elsewhere so that comparisons among seabird communities can be made. It is our recommendation that before any surveys are conducted, observers have the skills necessary to identify the seabirds in their survey area, and participate in a training program that includes specific instruction on implementing the protocol. Future modifications of the protocol will be necessary as methods are tested and techniques developed, and we encourage any feedback that will improve upon our current survey approach.

7. ACKNOWLEDGEMENTS

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APPENDIX I. Estimating distance categories

The various distance categories can be estimated using the following equation[1]:

$$d_h = 1000 \frac{(ah3838\sqrt{h}) - ahd}{h^2 + 3838d\sqrt{h}}$$

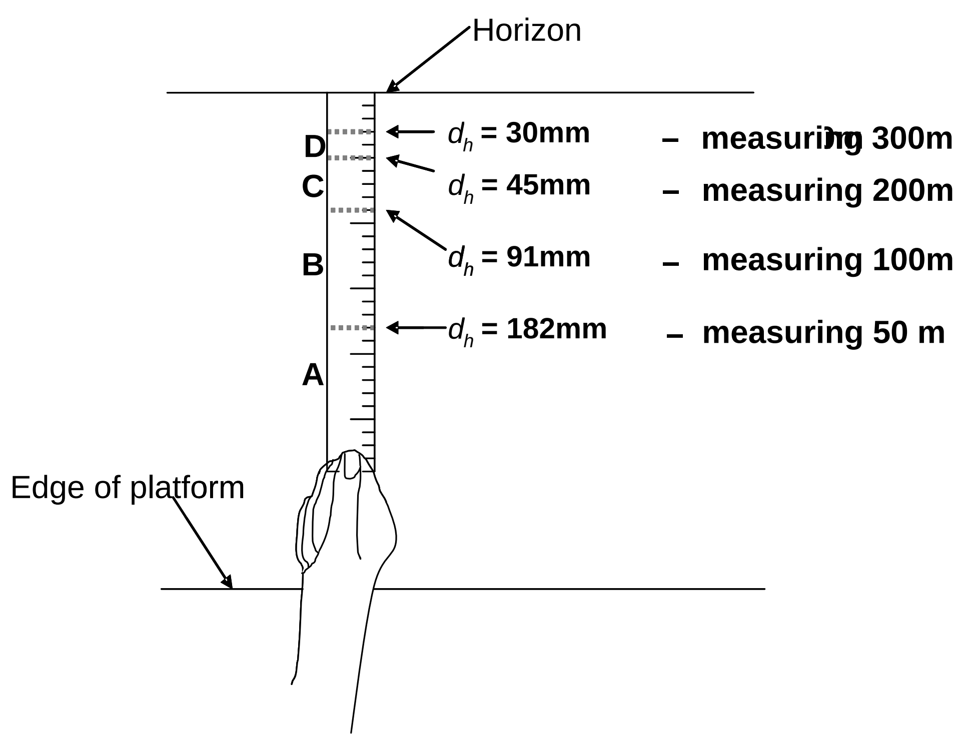
e.g. if a = 0.730 m, h = 12.5 m, and d = 300 m
then d_h = 30.0 mm

where:

d_h = distance below horizon (mm)
a = distance between the observer's eye and the ruler when observer's arm is fully out-stretched (m)
h = height of the observer's eye above the water at the observation point (m)
d = distance to be estimated (m; a separate calculation is required for each of 50, 100, 200, 300)

Distances are easily estimated using a gauge made from a transparent plastic ruler. A different ruler will be required for each combination of observer arm length (a) and platform height (h). Calculate d_h for the boundary of each distance class (A, B, C, D) and mark them on the ruler (dashed lines in figure). To use the gauge, extend the arm fully and keep the top end of the ruler aligned with the horizon. The dashed lines now demark the distance class boundaries on the ocean surface. Keep the gauge nearby during surveys to quickly verify bird distances.

Measurements for an observer with a = 73 cm and h = 12.5 m:



[1] Formula derived by J. Chardine, based on Heinemann 1981. A spreadsheet is available from the corresponding author to perform this calculation.

APPENDIX II. Codes for general weather conditions and glare

Code	Description	Explanation
Weather conditions		
0		< 50% cloud cover (with no fog, rain, or snow)
1		> 50% cloud cover (with no fog, rain, or snow)
2		patchy fog
3		solid fog
4		mist/light rain
5		medium to heavy rain
6		fog and rain
7		snow
Glare conditions		
0		none
1		slight/grey
2		bright on the observer’s side of vessel
3		bright and forward of vessel

APPENDIX III. Codes for sea state and Beaufort wind force

Wind Speed (knots)	Sea state code and description	Beaufort wind force and description
0	**0** Calm, mirror-like	**0** calm
01 – 03	**0** Ripples with appearance of scales but crests do not foam	**1** light air
04 – 06	**1** Small wavelets, short but pronounced; crests do not break	**2** light breeze
07 – 10	**2** Large wavelets, crests begin to break; foam of glassy appearance; perhaps scattered white caps	**3** gentle breeze
11 – 16	**3** Small waves, becoming longer; fairly frequent white caps	**4** moderate breeze
17 – 21	**4** Moderate waves with more pronounced form; many white caps; chance of some spray	**5** fresh breeze
22 – 27	**5** Large waves formed; white foam crests more extensive; probably some spray	**6** strong breeze
28 – 33	**6** Sea heaps up; white foam from breaking waves blows in streaks in direction of wind	**7** near gale
34 – 40	**6** Moderately high long waves; edge crests break into spindrift; foam blown in well-marked streaks in direction of wind	**8** gale
41 – 47	**6** High waves; dense streaks of foam in direction of wind; crests of waves topple and roll over; spray may affect visibility	**9** strong gale
48 – 55	**7** Very high waves with long overhanging crests; dense foam streaks blown in direction of wind; surface of sea has a white appearance; tumbling of sea is heavy; visibility affected	**10** storm
56 - 63	**8** Exceptionally high waves; sea is completely covered with white patches of foam blown in direction of wind; edges blown into froth; visibility affected	**11** violent storm
64 +	**9** Air filled with foam and spray; sea completely white with driving spray; visibility seriously affected	**12** hurricane

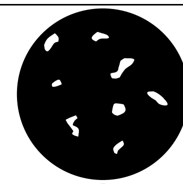
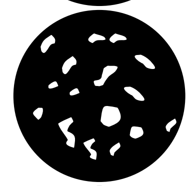
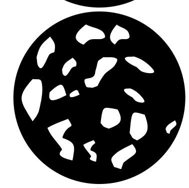
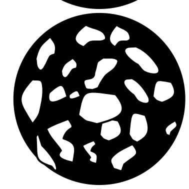
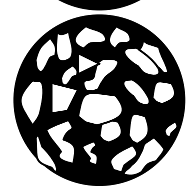
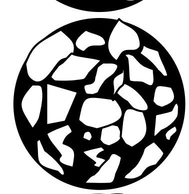
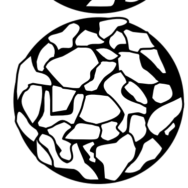
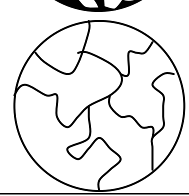
APPENDIX IV. Codes for ice conditions

Adapted from NOAA: Observers Guide to Sea Ice

Sea Ice Forms

Code	Name	Description
0	New	small, thin, newly formed, dinner plate-sized pieces
1	Pancake	rounded floes 30 cm - 3 m across with ridged rims
2	Brash	broken pieces < 2 m across
3	Ice Cake	level piece 2 - 20 m across
4	Small Floe	level piece 20 - 100 m across
5	Medium Floe	level piece 100 -500 m across
6	Big Floe	level, continuous piece 500 m - 2 km across
7	Vast Floe	level, continuous piece 2 - 10 km across
8	Giant Floe	level, continuous piece > 10 km across
9	Strip	a linear accumulation of sea ice < 1 km wide
10	Belt	a linear accumulation of sea ice from 1 km to over 100 km wide
11	Beach Ice or Stamakhas	irregular, sediment-laden blocks that are grounded on tidelands, repeatedly submerged, and floated free by spring tides
12	Fast Ice	ice formed and remaining attached to shore

Sea Ice Concentration

Code	Concentration	Description	
0	< one tenth	"open water"	
1	two-three tenths	"very open drift"	
2	four tenths	"open drift"	
3	five tenths	"open drift"	
4	six tenths	"open drift"	
5	seven to eight tenths	"close pack"	
6	nine tenths	"very close pack"	
7	ten tenths	"compact"	

APPENDIX V. Species codes for birds seen in Eastern Canada

Common name	Species code	Latin name
COMMON, REGULAR OR FREQUENTLY SEEN SPECIES		
Northern Fulmar	NOFU	*Fulmarus glacialis*
Great Shearwater	GRSH	*Puffinus gravis*
Manx Shearwater	MASH	*Puffinus puffinus*
Sooty Shearwater	SOSH	*Puffinus griseus*
Wilson’s Storm-Petrel	WISP	*Oceanites oceanicus*
Leach‘s Storm-Petrel	LESP	*Oceanodroma leucorhoa*
Northern Gannet	NOGA	*Morus bassanus*
Red Phalarope	REPH	*Phalaropus fulicaria*
Red-necked Phalarope	RNPH	*Phalaropus lobatus*
Long-tailed Jaeger	LTJA	*Stercorarius longicaudus*
Parasitic Jaeger	PAJA	*Stercorarius parasiticus*
Pomarine Jaeger	POJA	*Stercorarius pomarinus*
Great Skua	GRSK	*Stercorarius skua*
Herring Gull	HERG	*Larus argentatus*
Iceland Gull	ICGU	*Larus glaucoides*
Glaucous Gull	GLGU	*Larus hyperboreus*
Great Black-backed Gull	GBBG	*Larus marinus*
Black-legged Kittiwake	BLKI	*Rissa tridactyla*
Common Murre	COMU	*Uria aalge*
Thick-billed Murre	TBMU	*Uria lomvia*
Razorbill	RAZO	*Alca torda*
Dovekie	DOVE	*Alle alle*
Atlantic Puffin	ATPU	*Fratercula arctica*
SPECIES MORE COMMONLY SEEN INSHORE		
Common Loon	COLO	*Gavia immer*
Red-throated Loon	RTLO	*Gavia stellata*
Red-necked Grebe	RNGR	*Podiceps grisegena*
Horned Grebe	HOGR	*Podiceps auritus*
Great Cormorant	GRCO	*Phalacrocorax carbo*
Double-crested Cormorant	DCCO	*Phalacrocorax auritus*
Greater Scaup	GRSC	*Aytha marila*
Common Eider	COEI	*Somateria mollissima*
Harlequin Duck	HARD	*Histrionicus histrionicus*
Long-tailed Duck	LTDU	*Clangula hyemalis*
Surf Scoter	SUSC	*Melanitta perspicillata*
Black Scoter	BLSC	*Melanitta nigra*
White-winged Scoter	WWSC	*Melanitta fusca*
Red-breasted Merganser	RBME	*Mergus serrator*
Black Guillemot	BLGU	*Cepphus grylle*

Common name	Species code	Latin name
INFREQUENTLY OR RARELY SEEN SPECIES		
Cory’s Shearwater	COSH	*Calonectris diomedea*
Audubon’s Shearwater	AUSH	*Puffinus lherminieri*
Lesser Scaup	LESC	*Aythya affinis*
King Eider	KIEI	*Somateria spectabilis*
South Polar Skua	SPSK	*Stercorarius maccormicki*
Bonaparte's Gull	BOGU	*Larus philadelphia*
Ivory Gull	IVGU	*Pagophila eburnea*
Black-headed Gull	BHGU	*Larus ridibundus*
Laughing Gull	LAGU	*Larus articilla*
Ring-billed Gull	RBGU	*Larus delawarensis*
Lesser Black-backed Gull	LBBG	*Larus fuscus*
Sabine’s Gull	SAGU	*Xema sabini*
Common Tern	COTE	*Sterna hirundo*
Arctic Tern	ARTE	*Sterna paradisaea*
Roseate Tern	ROTE	*Sterna dougallii*
CODES FOR BIRDS IDENTIFIED TO FAMILY OR GENUS		
Unknown Bird	UNKN	
Unknown Shearwater	UNSH	*Puffinus* or *Calonectris*
Unknown Storm-Petrel	UNSP	Hydrobatidae
Unknown Duck	UNDU	Anatidae
Unknown Eider	UNEI	*Somateria*
Unknown Phalarope	UNPH	*Phalaropus*
Unknown Jaeger	UNJA	*Stercorarius*
Unknown Skua	UNSK	*Stercorarius*
Unknown Gull	UNGU	Laridae
Unknown Tern	UNTE	*Sternidae*
Unknown Alcid	ALCI	Alcidae
Unknown Murre or Razorbill	MURA	*Uria* or *Alca*
Unknown Murre	UNMU	*Uria*

APPENDIX VI. Codes for associations and behaviours

From Camphuysen and Garthe (2004). Choose one or more as applicable.

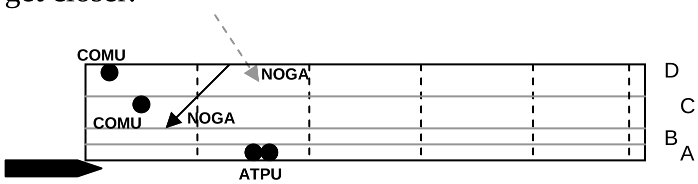
Code	Description
Association	
10	Associated with fish shoal
11	Associated with cetaceans
13	Associated with front (often indicated by distinct lines separating two water masses or concentrations of flotsam)
14	Sitting on or near floating wood
15	Associated with floating litter (includes plastic bags, balloons, or any garbage from human source)
16	Associated with oil slick
17	Associated with sea weed
18	Associated with observation platform
19	Sitting on observation platform
20	Approaching observation platform
21	Associated with other vessel (excluding fishing vessel; see code 26)
22	Associated with or on a buoy
23	Associated with offshore platform
24	Sitting on offshore platform
26	Associated with fishing vessel
27	Associated with or on sea ice
28	Associated with land (e.g., colony)
50	Associated with other species feeding in same location

Code	Description	Explanation
Foraging behaviour		
30	Holding or carrying fish	carrying fish towards colony
32	Feeding young at sea	adult presenting prey to attended chicks (e.g., auks) or juveniles (e.g., terns)
33	Feeding	method unspecified (see behaviour codes 39,40,41,45)
36	Aerial pursuit	kleptoparisitizing in the air
39	Pattering	low flight over the water, tapping the surface with feet while still airborne (e.g., storm-petrels)
40	Scavenging	swimming at the surface, handling carrion
41	Scavenging at fishing vessel	foraging at fishing vessel, deploying any method to obtain discarded fish and offal; storm-petrels in the wake of trawlers picking up small morsels should be excluded
44	Surface pecking	swimming birds pecking at small prey (e.g., fulmar, phalaropes, skuas, gulls)
45	Deep plunging	aerial seabirds diving under water (e.g., gannets, terns, shearwaters)
49	Actively searching	persistently circling aerial seairds (usually peering down), or swimming birds frequently peering (and undisturbed by observation platform) underwater for prey
General behaviour		
60	Resting or apparently sleeping	reserved for sleeping seabirds at sea
64	Carrying nest material	flying with seaweed or other material; not to be confused with entangled birds
65	Guarding chick	reserved for auks attending recently fledged chicks at sea
66	Preening or bathing	birds actively preening feathers or bathing
Distress or mortality		
71	Escape from ship (by flying)	escaping from approaching observation platform
90	Under attack by kleptoparasite	bird under attack by kleptoparasite in an aerial pursuit, or when handling prey at the surface
93	Escape from ship (by diving)	escaping from approaching observation platform
95	Injured	birds with clear injuries such as broken wings or bleeding wounds
96	Entangled in fishing gear or rope	birds entangled with rope, line, netting or other material (even if still able to fly or swim)
97	Oiled	birds contaminated with oil
98	Sick/unwell	weakened individuals not behaving as normal, healthy birds, but without obvious injuries
99	Dead	bird is dead

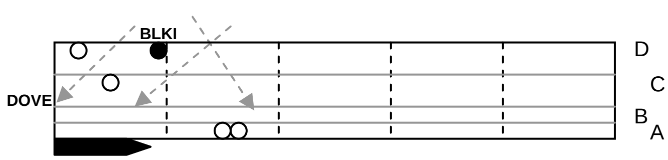
APPENDIX VII. Example 5 min survey from a moving platform†

See associated datasheet on pg. 30: We are on a ship travelling east at 10 knots, so in 5 minutes we will travel a distance of approximately 1.5 km. Based on the speed of the vessel, we will conduct a snapshot for flying birds every minute (see Table 1), or 5 times during the survey, and record flying birds detected between snapshots as NOT in transect. In the diagrams that follow, birds on water are represented by dots and flying birds by arrows (birds are at the position of the arrowhead). The vertical dashed lines in the diagrams indicate the boundaries of the 300 m snapshot blocks. Remember, we record the perpendicular distance to all birds.

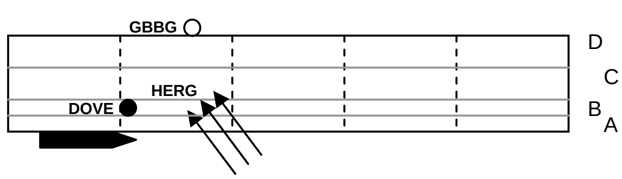
a) We begin the observation period at 11:00 with a snapshot of the flying birds and a count of the birds we see on the water. We see 2 separate adult Northern Gannets flying, although we only count one as in transect, at distance C, as the other is more than 300 m in front of the vessel (at distance D). We also see 2 Common Murres on the water to the port side of the vessel, at distances C and D. These are recorded as in transect. We can also see 2 puffins together on the water, more than 300 m in front of the vessel. We will also count these as in transect, although we will be careful not to count them again as we get closer.



b) Now we are about 30 seconds into the 5 min observation period, **in between snapshot counts**. We have already counted the 2 murres and 2 puffins on the water (shown in the figure as open circles), but an adult Black-legged Kittiwake has appeared on the water at distance D, and we add this to our list as in transect. Despite the appearance of a flying Dovekie within 300 m of the vessel at distance C, we do not count it as in transect because we are between snapshots. We add the Dovekie to our list but indicate that it is NOT in transect.

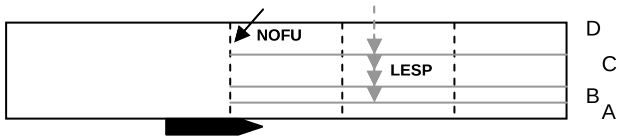


c) At minute 1, we take another snapshot count of flying birds. A flock of 3 Herring Gulls is seen traveling NW. The centre of the flock is at distance B. We also see one Dovekie on the water at distance B, and one Great Black-backed Gull outside 300 m (distance category E). These are all in transect except for the gull at distance E.

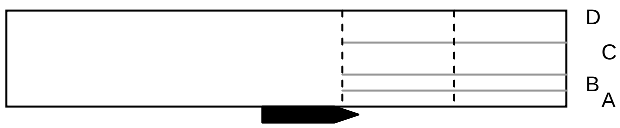


† Adapted from Tasker et al. 1984.

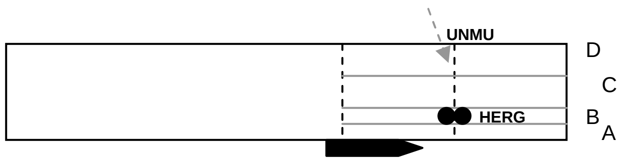
d) At minute 2, we perform another snapshot and count one flying Northern Fulmar in transect at distance D travelling SW. We record the flock of 4 Leach's Storm-Petrels flying south ahead of the vessel (at distance C) but do NOT count them as in transect as they are beyond 300 m.



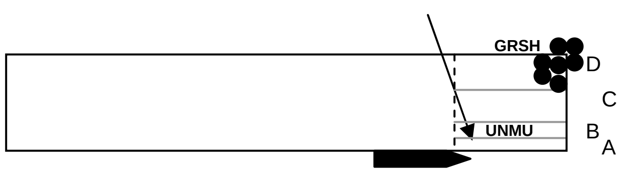
e) At minute 3 we conduct another snapshot. No new birds are observed, so nothing new is written on our data sheet.



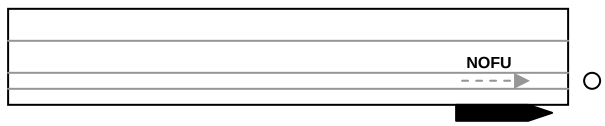
f) At 3:42, a murre of unknown species is observed flying but we DO NOT count it as in-transect because we are **between snapshots**. We will record it as NOT in transect. We record the 2 Herring Gulls feeding (behaviour code 44) up ahead on the water, both in transect at distance B. Because one is a juvenile and one is an adult, we enter them on separate datasheet rows, linking the two with an arc in the left margin.



g) At minute 4, our next snapshot takes place and we note that the unknown murre that we saw flying earlier (see frame f) can now be recorded as in transect at distance B, as it is within 300 m of the vessel AND observed during the snapshot. If we know for certain that this is the same individual we previously recorded as NOT in transect (frame f), we can cross the previous observation out. If we are not certain that this is the same individual we do not cross anything out. There is also a large flock of 200 Great Shearwaters on the water near the edge of the 300 m transect. Since the centre of the group is within the transect, at distance D, we count ALL the shearwaters as being at distance D. If the centre of the group had been beyond 300 m, we would have recorded them as outside the transect at distance E, despite some individuals being in the transect.



h) As we approach the end of the 5 min observation period, we record a Northern Fulmar that is following us (at distance B), but has not been previously recorded. We record it as NOT in transect since we are not at a snapshot point. Remember, you must record ship-followers as “associated with platform” (code 18). We do not include the kittiwake we can see ahead of the vessel, because by the time we reach it, the 5 min observation period will be over. This bird will be counted in the next period.



Example datasheet of a 5 min survey from a moving platform

Observation Period Information:

Company/agency	**CWS**		Sea state code	**3**
Platform name and type	**Hudson, DFO Research**		Wave height (m)	**1**
Observer (s)	**Carina Gjerdrum**		True wind speed (knots) **OR** Beaufort code	**12**
Date (DD/MMM/YYYY	**24 May 2007**		True wind direction (deg)	**93˚**
Time at start (UTC)	**11:00**		Ice type code	**0**
Time at end (UTC)	**11:05**		Ice concentration code	**0**
Latitude at start / end	**42˚46.307**	**42˚45.803**	True platform speed (knots)	**10.0**
Longitude at start / end	**-61˚59.156**	**-61˚58.233**	True platform direction (deg)	**191˚**
Platform activity	**Steaming**		Observation side	Starboard Port
Visibility (km)	**13.5**		Height of eye (m)	**12.3**
Weather code	**0**		Outdoors or Indoors	Out or In
Glare conditions code	**1**		Snapshot used?	Yes or No

Notes:

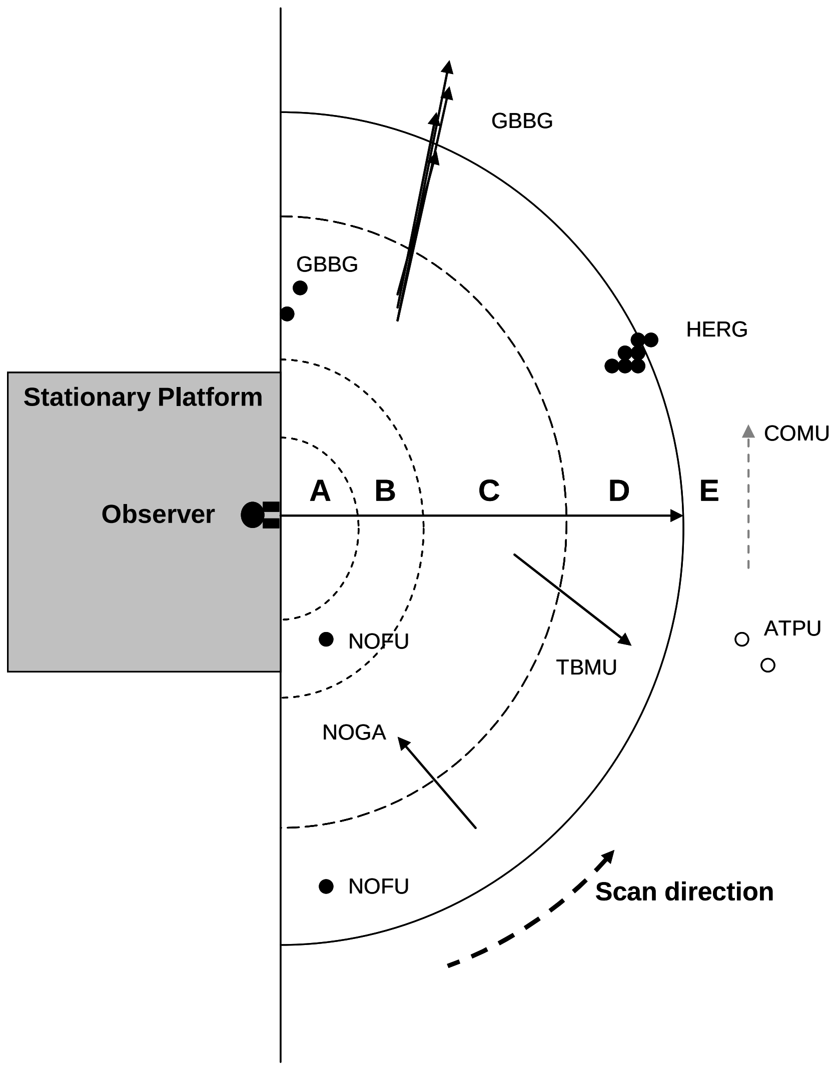
Bird Information: *this field <u>must</u> be completed for each record

	* Species	* Count	* Fly or Water?	* In transect?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments
a)	NOGA	1	F	Y	C			SW	A			
	NOGA	1	F	N	D			SE	A			
	COMU	1	W	Y	C							
	COMU	1	W	Y	D							
	ATPU	2	W	Y	A							
b)	BLKI	1	W	Y	D				A			
	DOVE	1	F	N	C			SW				
c)	HERG	3	F	Y	B			NW				
	DOVE	1	W	Y	B							
	GBBG	1	W	N	E							
d)	NOFU	1	F	Y	D			SW				
	LESP	4	F	N	C			S				
f)	UNMU	1	F	N	D			SE				
	HERG	1	W	Y	B		44		A			
	HERG	1	W	Y	B		44		J			
g)	UNMU	1	F	Y	B			SE				
	GRSH	200	W	Y	D							
h)	NOFU	1	F	N	B	18						

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.
[2]Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction
[3]***J***(uvenile), ***I***(mmature), or ***A***(dult); [4]***B***(reeding), ***NB***(non-breeding), ***M***(oult)

APPENDIX VIII. Example survey from a stationary platform

See associated datasheet on pg. 33: We are facing east and about to conduct our first survey of the day from an offshore oil platform. We have estimated the distance from where we are standing out to 50 m, 100 m, 200 m, and 300 m using our ruler gauge created with the formula outlined in Appendix I. We will now visually scan a 180^{o} arc, counting all birds observed and estimating their distance from the platform. Before we begin the scan, we record the required Observation Period Information at the top of the datasheet. The survey begins on the right hand side of the semi-circle. In the diagram that follows, birds on water are represented by dots and flying birds by arrows (birds are at the position of the arrowhead).



a) A Northern Fulmar sits on the water approximately 250 m away from us. Another sits within 100 m of us. We add both of these as separate entries on the datasheet.

b) An adult Northern Gannet is flying towards us at distance C and we record it as in semi-circle.

c) We observe a flying Thick-billed Murre travelling southeast, and we record it as in semi-circle at distance D.

d) We can see 2 Atlantic Puffins beyond 300 m sitting on the water. We record them on the datasheet in distance E but note that they are NOT in the semi-circle.

e) We also see a Common Murre flying north beyond 300 m and record it as NOT in semi-circle at distance E.

f) A flock of 7 Herring Gulls is observed at the edge of the 300 m semi-circle. Because the centre of the group is within the semi-circle, at distance D, we count ALL the gulls as being at distance D. If the centre of the group had been beyond 300 m, we would have recorded them as outside the semi-circle at distance E, despite some individuals being in the semi-circle.

g) Four Great Black-backed Gulls are flying north, away from the platform. Since the centre of the flock is outside the semi-circle, these individuals are recorded as outside the semi-circle at distance E (see Section 4.1.4, ***Lines of Flying Birds***)

h) Two additional Great Black-backed Gulls are sitting in the water feeding at distance C. The code for feeding behaviour is ‘33’ (see Appendix VI). Because one is an immature and one is an adult, we enter them in two datasheet rows, linking the two with an arc in the left margin.

Example datasheet for a survey from a stationary platform

Scan Information:

Company/agency	**CWS**	Weather code	**1**
Platform name and type	**Terra Nova FPSO**	Glare conditions code	**0**
Observer (s)	**Carina Gjerdrum**	Sea state code	**3**
Date (DD/MMM/YYYY)	**13 April 2007**	Wave height (m)	**1**
Time at start (UTC)	**0800**	True wind speed (knots) **OR** Beaufort code	**12**
Latitude	**46˚45.000**	True wind direction (deg)	**93˚**
Longitude	**-48˚46.799**	Ice type code	**0**
Platform activity	**Anchored offshore**	Ice concentration code	**0**
Scan type	**180º or other (specify:)**	Height of eye (m)	**33 m**
Scan direction	**East**	Outdoors or Indoors	Out or In
Visibility (km)	**10 km**		

Notes:

Bird Information: *this field must be completed for each record

	* Species	* Count	* Fly or Water?	* In semi-circle?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments
a)	NOFU	1	W	Y	D							
	NOFU	1	W	Y	B							
b)	NOGA	1	F	Y	C			NW	A			
c)	TBMU	1	F	Y	D			SE				
d)	ATPU	2	W	N	E							
e)	COMU	1	F	N	E			N				
f)	HERG	7	W	Y	D							
g)	GBBG	4	F	N	E			N				
h)	GBBG	1	W	Y	C		33		I			
	GBBG	1	W	Y	C		33		A			

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.
[2]Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction
[3]***J***(uvenile), ***I***(mmature), or ***A***(dult); [4]***B***(reeding), ***NB***(non-breeding), ***M***(oult)

APPENDIX IX. Check-list of materials required while conducting seabird surveys

- ☐ Multiple pens or sharp pencils **(required)**
- ☐ Multiple copies of blank recording sheets and clipboard **(required)**
- ☐ Binoculars **(required)**
- ☐ Watch or clock **(required)** - with countdown timer that can beep on snapshot intervals
- ☐ Global Positioning System (GPS) to determine vessel position, speed and direction plus extra batteries **(required)**
- ☐ Compass or GPS to determine flight direction of birds **(required)**
- ☐ Copy of protocol (**required**)
- ☐ Seabird identification guide (**required**)
- ☐ Transparent ruler to determine distances (**required**)
- ☐ Steel toed boots (**required** for most vessels)
- ☐ Security and medical certificates (**required** for most vessels)
- ☐ Notebook (recommended)
- ☐ Warm and waterproof clothing (recommended)
- ☐ Calculator or Excel spreadsheet[†] for equation in Appendix I to determine observation distances (recommended)
- ☐ Laptop for data entry (recommended). Software is available for data entry from corresponding author.

[†] An Excel spreadsheet that automatically performs these calculations is available from the corresponding author.

APPENDIX X. Blank record sheets for moving and stationary platforms

Record sheet for a moving platform survey

Observation Period Information:

Company/agency			Sea state code	
Platform name and type			Wave height (m)	
Observer (s)			True wind speed (knots) **OR** Beaufort code	
Date (DD/MMM/YYYY)			True wind direction (deg)	
Time at start (UTC)			Ice type code	
Time at end (UTC)			Ice concentration code	
Latitude at start / end			True platform speed (knots)	
Longitude at start / end			True platform direction (deg)	
Platform activity			Observation side	Starboard Port
Visibility (km)			Height of eye (m)	
Weather code			Outdoors or Indoors	Out or In
Glare conditions code			Snapshot used?	Yes or No

Notes:

Bird Information: *this field <u>must</u> be completed for each record

* Species	* Count	* Fly or Water?	* In transect?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.
[2]Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction
[3]***J***(uvenile), ***I***(mmature), or ***A***(dult); [4]***B***(reeding), ***NB***(non-breeding), ***M***(oult)

Record sheet for a stationary platform survey

Scan Information:

Company/agency		Weather code	
Platform name and type		Glare conditions code	
Observer (s)		Sea state code	
Date (DD/MMM/YYYY)		Wave height (m)	
Time at start (UTC)		True wind speed (knots) **OR** Beaufort code	
Latitude		True wind direction (deg)	
Longitude		Ice type code	
Platform activity		Ice concentration code	
Scan type	180º or other (specify:)	Height of eye (m)	
Scan direction		Outdoors or Indoors	Out or In
Visibility (km)			

Notes:

Bird Information: *this field <u>must</u> be completed for each record

* Species	* Count	* Fly or Water?	* In semi-circle?	* Distance[1]	Assoc.	Behav.	Flight Direc.[2]	Age[3]	Plum.[4]	Sex	Comments

[1] ***A*** = 0-50m, ***B*** = 51-100m, ***C*** = 101-200m, ***D*** = 201-300m, ***E*** = > 300m, ***3*** = within 300m but no distance recorded.
[2]Indicate flight direction (***N***, ***NE***, ***E***, ***SE***, ***S***, ***SW***, ***W***, or ***NW***); ***ND*** = no apparent direction
[3]***J***(uvenile), ***I***(mmature), or ***A***(dult); [4]***B***(reeding), ***NB***(non-breeding), ***M***(oult)