6 AIR QUALITY

Air Quality is considered a Valued Ecosystem Component (VEC) as its constituents are essential to sustain life and maintain the health and well-being of humans, wildlife, vegetation and other biota. The atmosphere is also a pathway for the transport of air emissions species to marine, freshwater, terrestrial and human environments.

The health and safety of the workers is of prime importance as well, and is ensured through programs of safety training, emergency response planning, and the engineering of the offshore facilities. The air quality situation with respect to workers comprises no issues that are more complex than those of other projects. The absence of hydrogen sulphide in the produced gas reduces the potential risks that are routinely handled on many other facilities. Existing legislation for worker health and safety and the Hebron Project (the Project)-specific planning that will occur as detailed engineering proceeds will provide the requisite degree of protection for workers on the facilities.

6.1 Environmental Assessment Boundaries

6.1.1 Spatial

The Nearshore and Offshore Study and Project Areas are defined in the Environmental Assessment Methods Chapter (Chapter 4).

The Nearshore Affected Area is the area which could potentially be affected by Project activities within and surrounding the Nearshore Project Area, including associated physical works and activities at the Nalcor Energy-Bull Arm Fabrication Site. The Nearshore Affected Area for air quality is set to encompass the residences on the land adjacent to Bull Arm, recognizing that it is important to consider the potential environmental effects of the air quality that the residents experience, although professional experience indicates that the environmental effects of emissions in construction would disperse to within the range of normal background levels at this distance. The Nearshore Affected Area is presented in Figure 6-1. The Offshore Affected Area is the area within and beyond the Offshore Project Area that could potentially be affected by Project works and activities. The Offshore Affected Area for the assessment of Air Quality is defined by the air dispersion modelling extents as an area that is 100 km by 65 km and is presented in Figure 6-2. This domain is sufficient to show the reduction of the Hebron Platform emissions to near background levels. The spatial boundary for greenhouse gas (GHG) emissions is global, as the effects on climate change are through the cumulative action of global emissions.

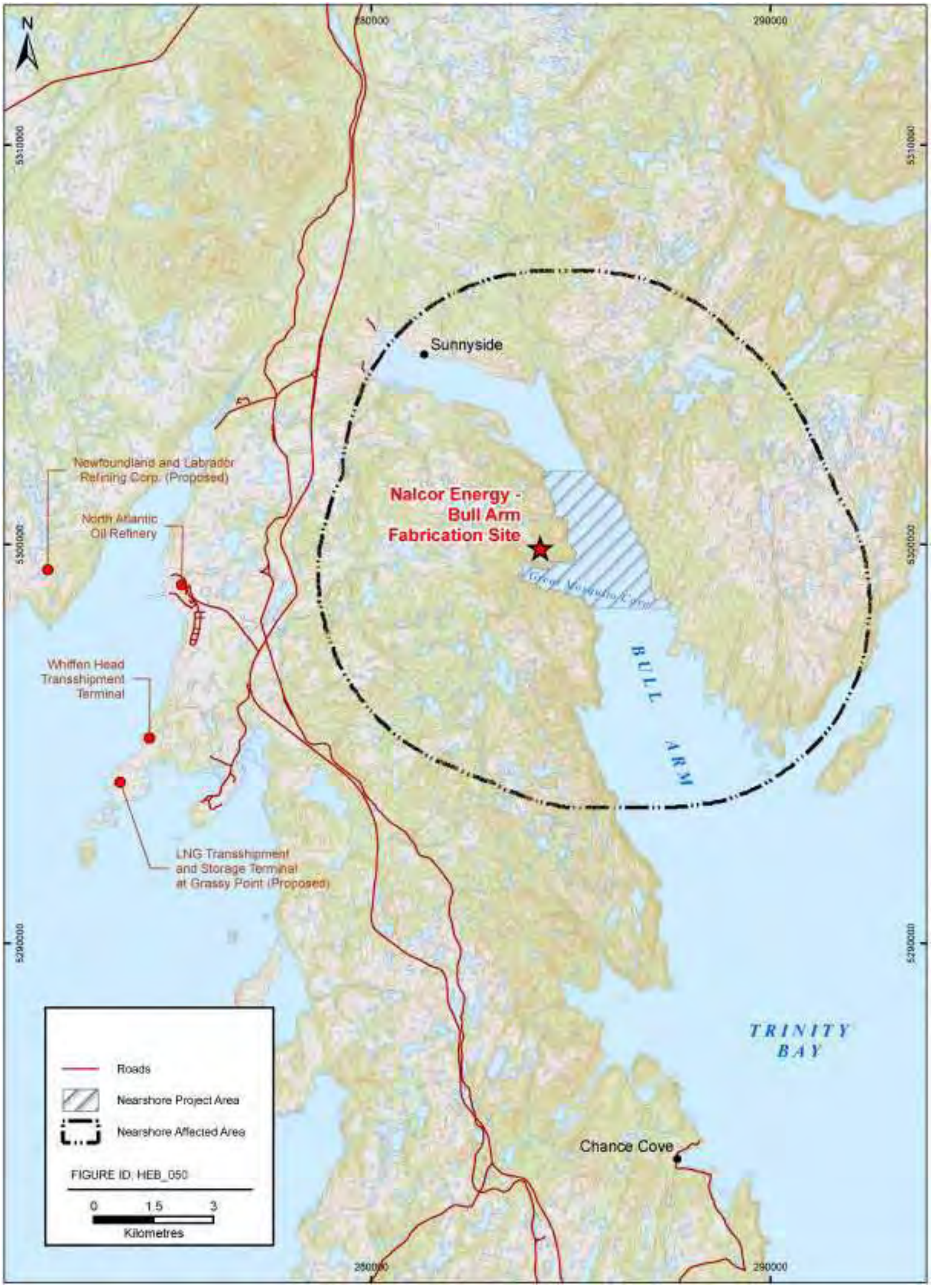


Figure 6-1 Nearshore Affected Area

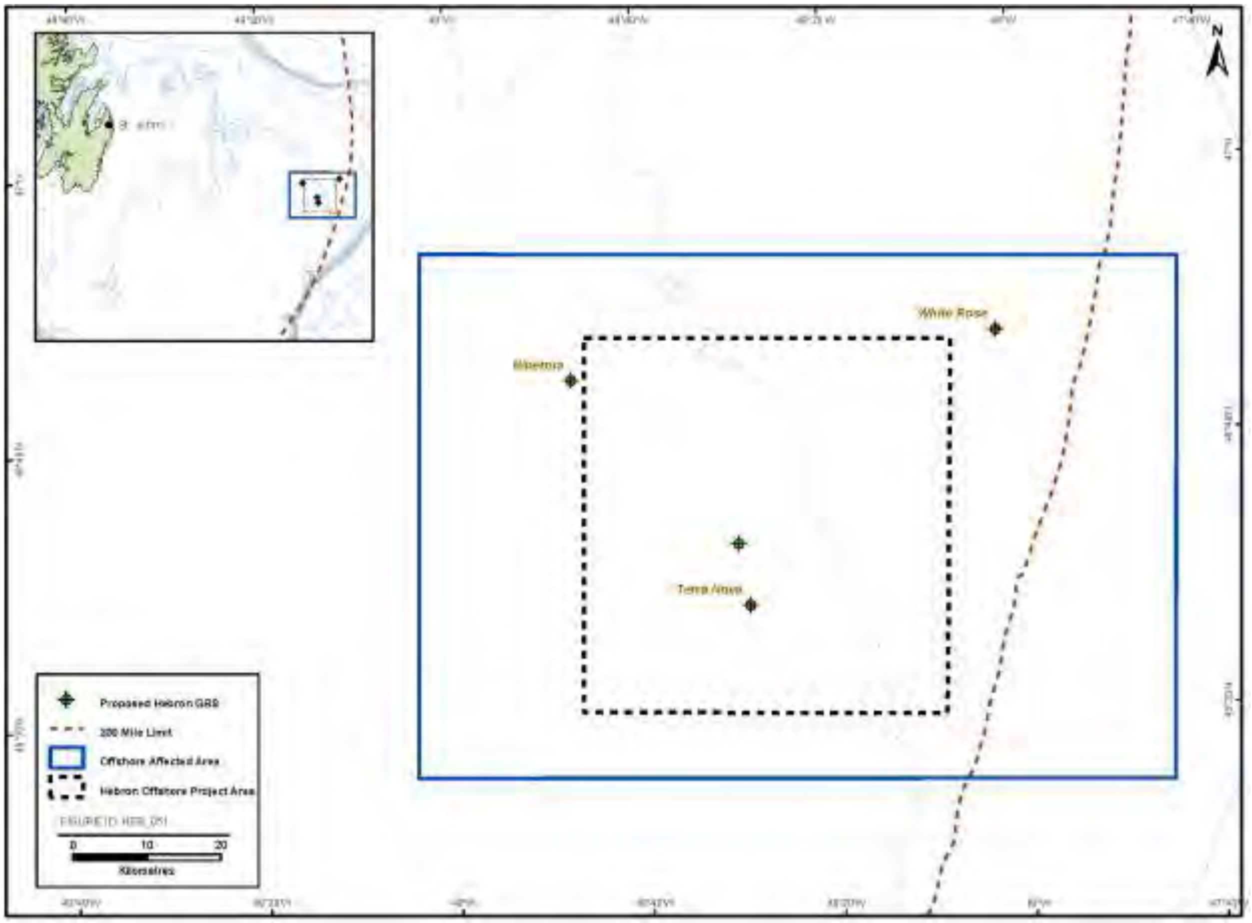


Figure 6-2 Offshore Affected Area

6.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Chapter 4). The nearshore and offshore temporal boundaries are summarized in Table 6-1.

Table 6-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation/start-up/drilling as early as 2015 • Production year-round through to 2046 or longer • Potential future activities - as required, year-round through to end of Project • Decommissioning/abandonment: after approximately 2046

6.1.3 Administrative

The administrative boundaries for Air Quality pertain mainly to regulatory limits and standards for the air emissions in the Nearshore and Offshore Project Areas, where such limits and standards exist. These limits are set by regulatory authorities to reflect environmental protection objectives, with the intent of being protective of air quality and human and environmental health.

Air quality will be assessed in the context of potential Project-related criteria air contaminants (CACs) and their ground-level concentrations (GLCs), as well as potential emissions of non-criteria air contaminants. For the purposes of this environmental assessment, the Project-related CACs include carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2), total suspended particulate matter (TSP) and volatile organic compounds (VOCs). The non-criteria air contaminants are GHGs, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

The federal government has set objectives for air quality which are taken into account by federal agencies in project environmental assessment reviews. These objectives also tend to form the basis for the air quality regulations of several provinces, including Newfoundland and Labrador. The Newfoundland and Labrador regulatory limits generally correspond to the upper limit of the Maximum Acceptable category of air quality, which are set under the *Canadian Environmental Protection Act* (CEPA). These objectives may also be used as reference by provincial or federal regulators. Additional guidelines are under development by the Canadian Council of Ministers of the Environment (CCME), and ultimately this body may develop Canada-wide Standards that harmonize the regulations in all jurisdictions.

The National Ambient Air Quality (NAAQ) Objectives and the Newfoundland and Labrador *Air Pollution Control Regulations* for specified CACs are presented in Table 6-2 for reference. In terms of the Hebron Project, the Newfoundland and Labrador Maximum Permissible Ground Level Concentrations would be applicable to the Nearshore Project Area and the NAAQ Objectives would be applicable to the Offshore Project Area.

Table 6-2 Newfoundland and Labrador *Air Pollution Control Regulations* and *Canadian Environmental Protection Act* Ambient Air Quality Objectives

Pollutant and units (alternative units in brackets)	Averaging Time Period	Newfoundland and Labrador	Canada			
		Maximum Permissible Ground Level Concentration	Canada-Wide Standards	Ambient Air Quality Objectives		
				Maximum Desirable	Maximum Acceptable	Maximum Tolerable
Nitrogen dioxide µg/m^3 (ppb)	1 hour	400 (213)	-	-	400 (213)	1000 (532)
	24 hour	200 (106)	-	-	200 (106)	300 (160)
	Annual	100 (53)	-	60 (32)	100 (53)	-
	1 hour	900 (344)	-	450 (172)	900 (344)	-
	3 hour	600 (228)				
	24 hour	300 (115)	-	150 (57)	300 (115)	800 (306)
	Annual	60 (23)	-	30 (11)	60 (23)	-
Total Suspended Particulate Matter (TSP) µg/m^3	24 hour	120	-	-	120	400
	Annual	60	-	60	70	-

Pollutant and units (alternative units in brackets)	Averaging Time Period	Newfoundland and Labrador	Canada			
		Maximum Permissible Ground Level Concentration	Canada-Wide Standards	Ambient Air Quality Objectives		
				Maximum Desirable	Maximum Acceptable	Maximum Tolerable
$PM_{2.5}$ µg/m^3	24 hour, 98th percentile over 3 consecutive years	25	30 (by 2010)	-	-	-
PM_{10} µg/m^3	24 hour	50	-	-	-	-
Carbon monoxide mg/m^3 (ppm)	1 hour	35 (31)	-	15 (13)	35 (31)	-
	8 hour	15 (13)	-	6 (5)	15 (13)	20 (17)
Oxidants – ozone µg/m^3 (ppb)	1 hour	160 (82)	-	100 (51)	160 (82)	300 (153)
	8 hour, based on 4th highest annual value, averaged over 3 consecutive years	87 (45)	65 (by 2010)	-	-	-
	24 hour	-	-	30 (15)	50 (25)	-
	Annual	-	-	-	30 (15)	-

The federal government of Canada has recently (March 2010) published *Planning for a Sustainable Future: A Federal Sustainable Development Strategy for Canada* that sets out the current targets for various environmental actions**.** Included as the target for the first goal is: *"(R)elative to 2005 emission levels, reduce Canada's total GHG emissions 17 percent by 2020"***.** The strategy is open for comments**.** The second goal of the strategy is "Air Pollutants"**.** According to the document, targets are under discussion between the federal and provincial governments, and the main implementation scheme is the Clean Air Regulatory Agenda. Within this agenda, the important activities include the National Pollutant Release Inventory (NPRI), as mandated by the CEPA (1999), and the harmonization of vehicle emission regulations within Canada and with the United States**.** Additional federal initiatives include the Base Level Industrial Emission Requirements (BLIER) that aims to quantify the minimum facility or equipment performance standards to be applied to new and existing industrial facilities and equipment in Canada**.** These standards will represent a good level of environmental performance, and apply to smog-causing pollutants such as NO_x, SO_2, VOCs, and total particulate matter (TPM). Upstream oil and gas is a target sector for determination of BLIERs, and recommendations are expected in 2010, with enforcement expected in 2015.

6.2 Existing Conditions

6.2.1 Nearshore

The air quality surrounding the Nearshore Project and Study Areas is generally good due to its remote location; however, industries surrounding the Bull Arm Site have had an effect on the local airshed over the past 100 years.

Environment Canada operates a series of ambient air monitoring stations across Canada under the National Air Pollution Surveillance Network. There are six monitoring locations in Newfoundland and Labrador, with St. John's being the closest to the Nearshore Project and Study Area. Due to the distance between this monitoring station and the Nearshore Project and Study Areas the measured data would not be representative of the local air quality. Instead, background air quality data for the Nearshore Project and Study Area were summarized using information available from nearby industrial sites and from the NPRI and from the National GHG Report.

6.2.1.1 Air Quality

The closest industrial site to the Nearshore Project and Study Areas is the Come by Chance North Atlantic Refinery, located approximately 9 km west of the Bull Arm Site and the Newfoundland Transshipment Terminal, located approximately 10 km south-west of the Bull Arm Site (Figure 6-1). Other nearby proposed facilities include the Grassy Point Liquefied Natural Gas Transshipment and Storage Terminal, the Newfoundland and Labrador Refining Corporation's (NLRC) Southern Head Marine Terminal and Associated Crude Oil Refinery and the Whiffen Head Transshipment Terminal (refer to Figure 6-1).

Background ambient air quality in and surrounding the Nearshore Affected Area was summarized in the Air Quality Impact Assessment (2007) for NLRC's proposed crude oil refinery, using data provided by the Newfoundland and Labrador Department of Environment and Conservation. These data are presented in Table 6-3.

Table 6-3 Ambient Air Quality in and Surrounding the Nearshore Affected Area

Pollutants (μg/m^3)	Time Frame	Arnolds Cove	Come by Chance	North Harbour	Southern Harbour	Sunnyside
SO_2	1-hour	348	279	200	175	235
	3-hours	220	169	125	125	149
	24-hours	79	74	20	30	70
	Annual	2	5	1	1	6
NO_2	1-hour	100	75	60	30	45
	24-hours	12	10	6	5	10
	Annual	1	1	1	1	1
$PM_{2.5}$	24-hours	10	10	9	8	11
Source: SNC Lavalin 2007						

The monitoring sites located closest to the Nearshore Project Area include Come by Chance and Sunnyside. These background concentrations indicate that the area meets the air quality regulations of the province, and attains the strictest NAAQ Objectives of Canada.

The annual emissions from the existing Come by Chance North Atlantic Refinery have also been summarized using data available from the 2008 NPRI and are presented in Table 6-4.

Table 6-4 Annual Emissions – Come By Chance North Atlantic Refinery, 2008

Facility	Criteria Air Contaminants (tonnes/yr)				
	Sulphur Dioxide (SO_2)	Carbon Monoxide (CO)	Nitrogen Oxides (as NO_2)	Total Particulate Matter (TSP)	Volatile Organic Compounds (VOCs)
North Atlantic Refinery	12,549	357	1,948	306	645
Source: Environment Canada 2009a					

The Bull Arm Site is an approved construction support facility and will, therefore, have local emissions characteristic of fabrication, such as welding, grinding, and similar activities. However, on a scale that includes the local communities, the refinery is the dominant source in the airshed.

6.2.1.2 Greenhouse Gas Emissions

According to the 2008 National GHG Emissions Report, the annual emissions of GHGs from the North Atlantic Refinery in Come by Chance were approximately 1,285,356 tonnes CO_{2eq} (Environment Canada 2009b). These emissions represent 24 percent of the provincial total. This source will be the major local contributor to concentrations of GHGs.

6.2.2 Offshore

Given its offshore location, air quality within the Offshore Project and Study Areas is likely to be very good, with only occasional exposure to exhaust products from existing offshore oil production facilities (*i.e.*, Hibernia, Terra Nova and White Rose), supply ships and other vessels in the area, as each platform would generally be downwind of another less than 15 percent of the time. This region also receives long-range contaminants from the industrial mid-west and northeastern seaboard of the United States.

To assess the existing ambient air quality in the Offshore Study Area, site specific emissions data were collected from the NPRI and National GHG reports. These reports are completed and submitted annually by each of the offshore oil and gas operators located near the proposed Hebron Project and are presented in the following sub-sections.

6.2.2.1 Air Quality

The 2008 NPRI data for CACs for each of the existing offshore oil platforms located near the proposed Hebron Project are presented in Table 6-5.

Table 6-5 2008 Annual Emissions of Criteria Air Contaminants – Existing Offshore Oil Platforms

Facility	Criteria Air Contaminants (tonnes/yr)				
	Sulphur Dioxide (SO_2)	Carbon Monoxide (CO)	Nitrogen Oxides (as NO_2)	Total Particulate Matter (TSP)	Volatile Organic Compounds (VOCs)
Hibernia	-	797	1,084	196	470
Terra Nova	-	731	2,313	208	6,717
White Rose	0.26	890	2,421	267	285
Source: Environment Canada 2009a					

6.2.2.2 Greenhouse Gas Emissions

The 2008 GHG data for each of the existing offshore oil platforms located near the Project and the provincial and national totals are presented in Table 6-6.

Table 6-6 2008 Annual Emissions of Greenhouse Gas – Existing Offshore Oil Platforms

Facility	Greenhouse Gases (GHG) (tonnes CO_2 eq per year)		
	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)
Hibernia	556,231	34,961	4,557
Terra Nova	576,456	31,274	10,597
White Rose	515,691	30,047	9,796
Provincial Total	5,140,424	97,037	35,955
National Total	247,400,881	7,983,044	4,897,951
Source: Environment Canada 2009b			

The reported GHG emissions from each of the existing oil platforms are representative and consistent with such a facility.

The national GHG emissions by sector during 2004 to 2007 are provided in Table 6-7.

As presented in Table 6-7, the major contributors of GHG emissions by sector include the utilities sector, followed by the manufacturing sector, and oil and gas extraction (including other activities such as mining and quarrying). In 2007, the GHG emissions related to the mining, quarrying and oil and gas extraction sector represented approximately 20 percent of the national annual reported GHG emissions.

Table 6-7 National Greenhouse Gas Emissions Data by Sector, 2004 to 2007

Sector	2004		2005		2006		2007	
	Emissions (kt $CO_{2\ eq}$)	% of Yearly Total	Emissions (kt $CO_{2\ eq}$)	% of Yearly Total	Emissions (kt $CO_{2\ eq}$)	% of Yearly Total	Emissions (kt $CO_{2\ eq}$)	% of Yearly Total
Mining, Quarrying and Oil and Gas Extraction	49,591	18	49,178	18	53,878	20	56,823	20
Utilities	121,459	43	123,787	44	115,868	43	121,401	44
Manufacturing	96,615	35	91,480	33	88,676	33	87,114	31
Other	11,589	4	14,148	5	13,483	5	12,755	5
Source: Environment Canada 2009b								

6.3 Project-Valued Ecosystem Components Interactions

6.3.1 Nearshore Project Activities

Project-related construction activities within the Nearshore Project Area, including the following activities, will generate air emissions from:

- Vessel traffic (supply, ferry, tow, diving support, barge, dredging, *etc.*) (CO, NO_x, TSP, VOCs, GHGs)
- Vehicle traffic (cars, trucks, buses, cranes, loaders, *etc.*) (CO, NO_x, TSP, VOCs, GHGs)
- Construction emissions from blasting, welding, concrete production and the re-establishment of the bund wall (TSP)

Therefore, potential interactions with Air Quality could result from the above-mentioned activities.

Typical air emissions from the operation of vessels during construction at the Bull Arm Site include CO, NO_x, TSP, VOCs and GHGs. Various types of vessels, including supply and ferry vessels, barges, tow vessels and diving support vessels, will be used while implementing nearshore construction activities (*i.e.*, concrete production, re-establish moorings at Bull Arm deepwater site, dredging of Bund Wall and disposal, tow-out of GBS, complete GBS construction and mate Topsides at Bull Arm deepwater site and surveys). The potential environmental effects associated with such activities will be assessed in Section 6.5 based on the operation of vessels.

Typical air emissions from the operation of vessels during construction at the Bull Arm Site include CO, NO_x, TSP, VOCs and GHGs. Various types of vessels will be used while implementing nearshore construction activities, including supply and ferry vessels, barges, tow vessels and diving support vessels.

Air emissions related to the operation of vehicles would be similar to that of vessels. Various types of vehicles will be used to carry out nearshore Project activities and include, but not limited to, cars, trucks, buses, cranes and loaders.

Emissions of CACs and GHGs will also result from typical construction activities such as blasting, welding and concrete production. The amount and type of equipment used during construction will vary depending on the construction contractor.

Electrical power for the Bull Arm Site will be acquired from the provincial utility power grid and, therefore, was not assessed in this assessment. However, There may be times during emergency situations or when power requirements are high, when additional power supply may be required. In such instances, the use of temporary generators may be required.

6.3.2 Offshore

6.3.2.1 Offshore Construction/Installation

As with the nearshore construction of the Hebron Platform, the offshore construction and installation activities (including hook-up and commissioning) also have the potential to interact with Air Quality. Air emissions associated with offshore Construction and Installation activities include:

- Vessel exhaust (*e.g.,* supply, support, tow, barge) and helicopter exhaust (CO, NO_x, TSP, VOCs, GHGs)
- Power generation exhaust (CO, NO_x, TSP, VOCs, GHGs)
- Flaring (CO, NO_x, VOCs, TSP, GHGs)
- Fugitive and venting emissions (*e.g.,* standby generators, fuel and chemical storage) (CO, NO_x, TSP, VOCs)
- Construction activities (*e.g.,* welding, solvent use) (TSP, VOCs)

Various vessels will be required to carry out a number of activities (*i.e*., OLS installation and testing, concrete mattress pads/rock dumping over OLS offloading lines, installation of temporary moorings, platform tow-out/offshore installation, underbase grouting, offshore solid ballasting, placement of rock scour protection on seafloor around final Platform location and hook-up and commissioning) during offshore construction and installation of the Hebron Platform. The typical emissions associated with the operation of the vessels will be the same as those mentioned in Section 6.3.1. The potential environmental effects associated with such activities will be assessed in Section 6.5 based on the operation of vessels. Helicopters will be used to transport personnel and supplies to and from the Offshore Project Area. The typical emissions associated with the operation of helicopters are similar to those from the operation of vessels and are outlined above.

During the construction and installation of the Hebron Platform, power generation will be supplied from two dual-fuelled turbine generators operating at full capacity. These units will use distillate fuel (diesel fuel) during offshore construction and installation of the Hebron Platform and change to produced gas once the facility is operational and gas compression is online. During the early stages of the offshore construction and installation of the Hebron Platform, however, power may be supplied by temporary generators until the dual-fuelled turbines have been commissioned. The power requirements may not require the operation of both turbines at all times. For conservative purposes throughout this assessment; however, power generation for offshore construction and installation of the Hebron Platform was based on the full capacity operation of both turbines.

The primary emissions from turbine generators include NO_x, CO, TSP and VOCs.

The emissions will generally be the same when operating on either diesel or produced gas (during the operation phase), except that the diesel fuel may have some trace SO_2 emissions and release greater quantities of CO_2, whereas natural gas will release lower quantities of CO_2 and TSP and greater quantities of NO_x.

Sulphur dioxide emissions could be of concern when the units are operating on distillate fuels (whereas the produced gas will be sweet), in which case, the sulphur emissions would be directly related to the sulphur content of the fuel. As this will be low (US EPA 2000), the emissions of SO_2 were not further assessed.

Greenhouse gases, including CO_2, N_2O and CH_4, will also be emitted during the operation of dual-fuelled turbine generators. In terms of diesel fuel, CO_2 will be produced during the combustion process but the emissions of N_2O and CH_4 will be negligible. In terms of natural gas combustion, traces of CH_4 are present in the exhaust gas as unburned fuel and CO_2 will also be emitted via the combustion process, however at slightly lower quantities than from the burning of diesel fuel (US EPA 2000).

Flaring is an essential component of the safety system of an oil and gas production facility and it is vital to ensure safe working conditions on the platform. There will be occasions during the offshore construction and installation phase of the Hebron Platform when flaring of excess gas, test flaring and/or emergency flaring will be required. Typical emissions from a flaring event include CO, NO_x, VOCs, TSP and GHGs. The quantity of GHG emitted from flaring will be measurably higher during the construction and installation phase of the Hebron Platform, until the Hebron Platform is operational and gas compression is on-line.

Fugitive emissions of VOCs will also occur during the offshore construction and installation phase of the Hebron Platform via venting from chemical and fuel storage. However, these emissions are considered to be limited in quantity and largely controlled by, for example, using closed rather than open containers, and reventing where practicable. Limited quantities of TSP and VOC emissions will be emitted during various construction activities during the construction and installation phase of the Hebron Platform. There will be also be minor quantities of VOCs and CACs from fugitive emissions from the loading and unloading of fuels and chemicals and back up-generators. However, these emissions are considered to be small in quantity and largely controlled and therefore were not assessed further.

6.3.2.2 Operations/Maintenance

Project offshore operations and maintenance activities have the potential to interact with Air Quality. Air emissions associated with offshore Operations and Maintenance activities include:

- Vessel (*e.g.,* supply, support, tow, standby) and helicopter traffic (CO, NO_x, TSP, VOCs, GHGs)
- Power generation (CO, NO_x, TSP, VOCs, GHGs)
- Gas compression (CO, NO_x, TSP, VOCs, GHGs)
- Flaring (CO, NO_x, VOCs, TSP, GHGs)
- Fugitive and venting emissions (*e.g.,* standby generators, product loading, unloading and storage, chemical and fuel storage, valve packing and seals) (CO, NO_x, TSP, VOCs)
- Maintenance activities (*e.g.,* welding) (TSP, VOCs)

Emissions produced from the operation of vessels and helicopters during the operation and maintenance phase of the Hebron Platform will be similar to those during the construction and installation phase of the platform, as discussed in Section 6.3.2.1. Vessel operation supports a number of project activities including geophysical and seismic surveys. The potential environmental effects associated with such activities will be assessed in Section 6.5 based on the operation of vessels.

During the operation of the platform and various well activities, it is planned that power generation will be supplied from four turbine generators (two dual-fuelled, one gas, and one spare). During the first year of operation (approximately eight months), only the two dual-fuelled turbine generators will be in operation and they will use diesel fuel. Once gas compression is online the two dual-fuelled units and the gas turbine generator will be in operation and will operate on produced gas. The air emissions associated with the use of these units were discussed above in Section 6.3.2.1.

Based on current design, gas compression will be accomplished via the use of two dual-fuelled turbine-driven compressors. The turbines will normally operate on natural gas with each compressor handling up to 60 percent of the design gas capacity. The air emissions will be similar to those released during power generation, as discussed in Section 6.3.2.1.

The produced water and water injection system will be operated by electrically-driven pumps and hence, there will be no direct related emissions of CACs or GHGs, as the emissions would have been accounted for through the generation of power by the turbine generators.

During operation of the Platform there will be times when excess gas will be flared, for example, during well testing and during upset conditions, and background flaring. Background flaring represents flaring associated with normal operations and encompasses pilot and sweep gas, blowdown valve leakage, pressure safety valve (PSV) leakage, and compressor seals. The emissions released during these events will be similar to those released during the construction and installation of the platform, as discussed in

Section 6.3.2.1, but smaller in quantity for background flaring, is much lower in volume, than during upset conditions.

Minor amounts of TSP and VOC emissions will be emitted during various routine maintenance activities, including welding, machine oils and cleaning solvents. There will also be some fugitive emissions of VOCs and CACs from the loading and unloading of fuels and products, from storage tanks and back up-generators. These emissions will be limited in quantity and therefore were not further assessed in this assessment.

6.3.2.3 Decommissioning/Abandonment

Project decommissioning and abandonment activities will be similar to those associated with the construction and installation of the Hebron Platform. Air emissions associated with decommissioning and abandonment include:

- Vessel (*e.g.,* supply, support, tow, standby) and helicopter traffic (CO, NO_x, TSP, VOCs, GHGs)
- Power generation (CO, NO_x, TSP, VOCs, GHGs)
- Emissions related to refloating and towing of the platform (CO, NO_x, TSP, VOCs, GHGs)

The air emissions emitted from vessel and helicopter operation related to various activities including removal of the Hebron Platform and OLS loading points, plugging and abandoning wells and the OLS pipeline, and power generation will be similar to those emitted during the construction and installation of the Hebron Platform and have been discussed in Section 6.3.2.1.

Some air emissions will result from work activities associated with the refloating and towing of the Hebron Platform. These emissions will be limited in quantity and temporary.

6.3.3 Summary

The interactions from nearshore and offshore construction and installation, and operation and maintenance activities with Air Quality that have the potential to result in an environmental effect include: vehicle traffic, power generation, gas compression, flaring, and vessel and helicopter operations. In summary, the Project can have potential effects on air quality that can be categorized as:

- A change in ambient air quality (CACs)
- A change in GHG emissions

A summary of the potential environmental effects resulting from Project-VEC interactions, including accidental and cumulative environmental effects is provided in Table 6-8. Most of the activities listed in Table 6-8 do contribute to air and GHG emissions because of the generation of power required to carry out the activity.

Table 6-8 Potential Project-Valued Ecosystem Component Interactions: Air Quality

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects	
	Ambient Air Quality	Greenhouse Gas Emissions
Construction		
Nearshore Project Activities		
Presence of Safety Zone (Great Mosquito Cove Zone followed by a deepwater site Zone)		
Bund Wall Construction (*e.g.,* sheet/pile driving, infilling, *etc.*)	x	x
Inwater Blasting		
Dewater Drydock/Prep Drydock Area	x	x
Concrete Production (floating batch plant)	x	x
Vessel Traffic (*e.g.,* supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site, *etc.*)	x	x
Lighting		
Air Emissions	x	x
Re-establish Moorings at Bull Arm deepwater site	x	x
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	x	x
Removal of Bund Wall and Disposal (dredging/ocean disposal)	x	x
Tow-out of GBS to Bull Arm deepwater site	x	x
GBS Ballasting and De-ballasting (seawater only)		
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	x	x
Hook-up and Commissioning of Topsides		
Surveys (*e.g.,* geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	x	x
Platform Tow-out from deepwater site	x	x
Offshore Construction/Installation		
Presence of Safety Zone		
OLS Installation and Testing	x	x
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines	x	x
Installation of Temporary Moorings	x	x
Platform Tow-out/Offshore Installation	x	x
Underbase Grouting	x	x
Possible Offshore Solid Ballasting	x	x
Placement of Rock Scour Protection on Seafloor around Final Platform Location	x	x
Hookup and Commissioning of Platform	x	x
Operation of Helicopters	x	x
Operation of Vessels (supply, support, standby and tow vessels/barges/Diving/ROVs)	x	x
Air Emissions	x	x
Lighting		
Potential Future Activities		
Presence of Safety Zone		
Excavated Drill Centre Dredging and Spoils Disposal	x	x
Installation of Pipeline(s)/Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insultation	x	x
Hook-up, Production Testing and Commissioning of Excavated Drill Centres	x	x
Surveys (*e.g.,* geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	x	x
Offshore Operations and Maintenance		
Presence of Safety Zone		

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects	
	Ambient Air Quality	Greenhouse Gas Emissions
Presence of Structures		
Lighting		
Maintenance Activities (*e.g.,* diving, ROV, *etc.*)	x	x
Flaring	x	x
Wastewater (produced water, cooling water, storage displacement water, *etc.*)		
Chemical Use/Management/Storage (*e.g.,* corrosion inhibitors, well treatment fluids, *etc.*)	x	
Well Activities (*e.g.,* well completions, workovers, *etc.*)		
WBM Cuttings		
Operation of Helicopters	x	x
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)	x	x
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)	x	x
Potential Future Operational Activities		
Presence of Safety Zone		
Drilling Operations from MODU at Future Excavated Drill Centres	x	x
Presence of Structures		
WBM and SBM Cuttings		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors, *etc.*)	x	
Geophysical/Seismic Surveys	x	x
Offshore Decommissioning/Abandonment		
Presence of Safety Zone		
Removal of the Platform and OLS Loading Points	x	x
Lighting		
Plugging and Abandoning Wells	x	x
Abandoning the OLS Pipeline	x	x
Operation of Helicopters	x	x
Operation of Vessels (supply, support, standby and tow vessels, ROVs)	x	x
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		
Accidents, Malfunctions and Unplanned Events		
Bund Wall Rupture	x	x
Nearshore Spill (at Bull Arm Site)	x	
Failure or Spill from OLS	x	
Subsea Blowout	x	x
Crude Oil Surface Spill	x	
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS,Platform)	x	
Marine Vessel Incident (*i.e.*, fuel spills)	x	x
Collisions (involving Platform, vessel, and/or iceberg)	x	x
Cumulative Environmental Effects		
Hibernia Oil Development and Hibernia Southern Extension (drilling and production)	x	x
Terra Nova Development (drilling and production)	x	x
White Rose Oilfield Development and Expansions (drilling and production)	x	x
Offshore Exploration Drilling Activity	x	x
Offshore Exploration Seismic Activity	x	x
Marine Transportation (nearshore and offshore)	x	x
Commercial Fisheries (nearshore and offshore)	x	x

6.4 Definition of Significance

6.4.1 Change in Ambient Air Quality

For a change in ambient air quality a significant adverse residual environmental effect is one that degrades the quality of the air such that the maximum Project-related GLC of the CAC being assessed frequently exceeds stipulated air quality guidelines in the Nearshore or Offshore Study Area. Frequently is defined as once per week for 1-hour standards and once per month for 24-hour standards.

The air quality guidelines chosen for use in the evaluation of significance for the Hebron Project are NAAQ Objectives for the “tolerable”, “acceptable”, and “desirable” levels (presented in Table 6-2). The maximum “tolerable” level denotes a concentration beyond which appropriate action is required to protect the health of the general population. The maximum “acceptable” level is intended to provide protection against effects on soil, water, vegetation, visibility, and human wellbeing. The maximum “desirable” level is the long-term goal for air quality.

6.4.2 Greenhouse Gas Emissions

In determining the significance criteria for a change in GHG emissions, guidance published by the *Federal-Provincial Territorial Committee on Climate Change and Environmental Assessment* as available on the CEAA Registry (2003) was consulted. This guideline states the following: “*the environmental assessment process cannot consider the bulk of GHG emitted from already existing developments. Furthermore, unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured*” It is, therefore, recognized that it is not possible to assess significance related to a measured environmental effect on climate change on a project-specific basis. Project emissions of GHGs will contribute to these cumulative environmental effects, but the contribution, although potentially important in comparison to local and provincial levels, will be small in a global context. Policies and regulations are being developed by the governments of Canada and Newfoundland and Labrador for regulating GHG emissions for specific sources or industry sectors.

Thus, instead of setting a specific significance criterion for environmental effects on greenhouse gas emissions and determining whether and how it can be met, a change in GHG emissions for this Project will be considered by conducting a preliminary scoping of GHG emissions, determining the industry profile (where possible), and by considering the magnitude, intensity and duration of Project emissions as directed by the Canadian Environmental Assessment Agency (the Agency) guidance (the Agency 2003). Project-related GHG emissions will also be compared to similar projects, and to provincial and national greenhouse gas emissions.

6.5 Environmental Effects Analysis and Mitigation

The assessment of the effects due to the construction/installation and decommissioning phases of the Hebron Platform at the Bull Arm Site on Air Quality have been assessed qualitatively in this assessment as there is limited information available on the quantities of equipment in use at this stage of the Project design.

The assessment of the effects due to the offshore construction/installation and operations/maintenance of the Hebron Platform has been conducted using an emissions inventory and modelling approach, in which the emissions inventory is used to predict the annual emissions released and the dispersion modelling is used to estimate the maximum GLCs.

6.5.1 Construction

6.5.1.1 Change in Ambient Air Quality

Nearshore

Emissions during the nearshore construction phase will result from typical construction activities, including blasting, grinding, welding, concrete production, vessel traffic, and the use of construction equipment, including for example, forklifts, cranes and trucks.

The primary air emissions associated with blasting, grinding, welding and concrete production are TSP and from construction equipment combustion gases. Such emissions however, will be temporary in nature and are considered to be localized, such as welding, or relatively minor in quantity and environmental effect.

Vessels will emit CO, NO_x, TSP and VOCs. These emissions however, are small in quantity, temporary and localized, and will be mitigated using vessels suitable for each work activity (*i.e.,* using appropriately sized vessels for each associated work activity) and by conducting inspections of the vessels to ensure they are being properly maintained.

Offshore

During the offshore construction and installation of the Hebron Platform, activities such as vessel and helicopter traffic and power generation have the potential to interact with Air Quality and potentially result in environment effects.

Supply and tow vessels and helicopters, will be required during the offshore construction phase of the Hebron Platform. The emissions from these sources will result from the combustion of diesel fuels (distillate fuel) in engines. Typical emissions will include CO, NO_x, TSP and small amounts of VOCs. These emissions however will be localized, small in relative quantity, temporary and mitigated by using vessels suitable for each activity and by conducting inspections of the vessels to ensure they are being properly maintained.

As described in Section 6.3.2.1, power generation during the construction and installation of the Hebron Platform will result in air emissions from the combustion of distillate fuel (diesel). The air emissions include CO_2, NO_x, TSP, VOCs and SO_2. The SO_2 would be directly related to the amount of sulphur in the fuel (anticipated to be very low and therefore was not further assessed in this assessment).

The air emissions of the above CACs (with the exception of SO_2), based on power generation during offshore construction and installation (distillate fuel versus natural gas, for comparison) are presented in Table 6-9.

Table 6-9 Criteria Air Contaminant Emissions for Power Generation (Distillate Fuel versus Natural Gas)

Function	Criteria Air Contaminants (tonnes/year)			
	Carbon Monoxide (CO)	Nitrogen Oxide (NO_x)	Total Suspended Particulate (TSP)	Volatile Organic Compounds (VOC)
Power Generation[A] (Distillate fuel)	95	448	25.8	0.88
Power Generation[B] (Natural Gas)	20	1,325	14.2	4.5

Notes:
[A] Assumed two turbines operating at full capacity(conversative case)
[B] Assumed peak operation
Source: US EPA 2000; EMCP

The air emissions related to power generation on distillate fuel will be temporary in nature, and are small in magnitude (except for NO_x) and extent. ExxonMobil Canada Properties (EMCP) will investigate the use of efficient/reduced emission technology where appropriate and incorporate into the design if emission reduction provisions can be economically obtained.

The GLCs predicted for the offshore construction and installation phase of the Hebron Platform would be similar to those predicted for the first year of operation, prior to gas compression, and are presented in Section 6.5.2.1.

6.5.1.2 Greenhouse Gas Emissions

Nearshore

During the construction of the Project at the Bull Arm Site, GHG emissions will be associated with vessel traffic through the combustion of diesel fuel in engines. These temporary emissions will be limited in quantity and mitigated through similar measures as described above in Section 6.5.1.1.

Offshore

Emissions of GHGs during the construction and installation phases of the Hebron Platform at its offshore location will result from the operation of supply and tow vessels, helicopter traffic and power generation. The emissions from the operation of vessels and helicopters include CO_2 from the combustion of diesel fuel, and will be short term, relatively limited in quantity and mitigated using similar measures as discussed above in Section 6.5.1.1.

The estimated annual emissions of GHGs from power generation during the offshore construction and installation phases of the Hebron Platform are presented in Table 6-10. Emissions estimates based on using natural gas to fuel the turbines have also been included for comparison.

Table 6-10 Greenhouse Gas Emissions from Gas Turbines – Distillate Fuel versus Natural Gas

Function	Greenhouse Gas Emissions (tonnes CO_{2eq} per year)		
	Carbon Dioxide (CO_2)	Nitrous Oxide (N_2O)	Methane (CH_4)
Power Generation[A] (Distillate fuel)	71,674	1	6.7
Power Generation[B] (Natural Gas)	269,024	19.9	5

Notes:
[A] Assumed two turbine generators operating at full capacity (conservative case)
[B] Assumed peak operation
Source: US EPA 2000; EMCP

A summary of the potential environmental effects on Air Quality during the construction and installation phases of the Hebron Platform is provided in Table 6-11 (only those activities that result in Project-VEC interactions are included). As indicated in Sections 6.3.1 and 6.3.2.1, several activities that indirectly affect Air Quality as a result of vessel traffic are assessed within the Vessel Traffic and Operation of Vessels activities of Table 6-11. Power Generation is included as an activity unique to the analysis of environmental effects to Air Quality

6.5.2 Operations and Maintenance

6.5.2.1 Change in Ambient Air Quality

During the first year of operation and normal operations of the Hebron Platform air emissions will result from power generation, gas compression, flaring, and vessel and helicopter traffic. Other emissions related to well drilling and drilling production operations will be small in quantity and extent.

Table 6-11 Environmental Effects Assessment Matrix (Construction and Installation)

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (*e.g.,* sheet/pile driving, infilling, *etc.*)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	3/3	R	2
Concrete Production (floating batch)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	4/6	R	1
Vessel Traffic (*e.g.,* supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site, *etc.*)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	3/6	R	1
Dredging of Bund Wall and Possibly Sections of Tow-out (Route to deepwater site)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	2/1	R	1
Tow-out of GBS to Bull Arm deepwater site	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	2	1/1	R	1
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	1	2/2	R	1
Offshore Construction/Installation							
Platform Tow-out/ Offshore Installation	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections • Ensure the use of properly maintained and functioning equipment	1	4	2/6	R	2
Power Generation	• Change in Ambient Air Quality • Greenhouse Gas Emissions		2	2	3	R	2
Operation of Helicopters	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Ensure properly maintained and efficient operation	1	4	3/6	R	2

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels/barges/ diving / ROVs)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	4	3/6	R	2

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Power Generation and Gas Compression

During the operation of the Hebron Platform power generation will be accomplished via the use of four turbine generator units, with three units running and one spare, at peak production. Two of these units will have dual-fuelled capacity. During the first year of operation (for approximately the first eight months); however, only the two dual-fuelled units will be in operation and these units will operate on diesel fuel, similar to the offshore construction and installation of the Hebron Platform. Once gas compression is online all units will operate on produced gas, with diesel available as a back-up fuel source. Typical air emissions from the combustion of natural gas in stationary gas turbines include NO_x, CO, and to a lesser degree TSP and VOCs. The formation of NO_x is dependent upon the temperature and residence time in the flame, whereas emissions of CO and VOCs are a result of incomplete combustion. Emissions of TSP from stationary gas turbines are considered negligible for natural gas combustion. A number of models of turbine have been identified as candidates; however, the final selection will be made in detailed engineering.

Nitrogen oxides formation from the burning of either natural gas or diesel fuel in turbine generators can occur three ways: thermal NO_x, prompt NO_x, and fuel NO_x. For the most part, all of the NO_x produced from the combustion of natural gas is through thermal NO_x, which results from the thermal dissociation and subsequent reaction of nitrogen and oxygen molecules (US EPA 2000). Changes in ambient humidity and temperature can also cause variations of up to approximately 30 percent in NO_x emissions (US EPA 2000).

EMCP will investigate the use of efficient/reduced emission technology where appropriate and incorporate into the design if emission reduction provisions can be economically obtained.

Gas compression will be accomplished via two dual-fuelled turbine-driven compressors.

Flaring

The flare system is an essential component of the process safety control equipment on an offshore production facility. The flare system will be designed for pressure relief to prevent over-pressurization of equipment during process upset conditions and to dispose of associated gas produced during emergency situations. The air emissions during flaring include CO, NO_x and VOCs. Excess gas will be flared until gas compression is online, at which time it will be injected to the sub-surface. A small amount of fuel gas will be continuously flared during normal operations (background flaring). This background flaring represents flaring associated with normal operations and encompasses pilot and sweep gas, blowdown valve leakage, PSV leakage and compressor seals.

Vessel and Helicopter Traffic

Throughout the life of the Project, standby vessels, supply vessels, product vessels and helicopters will routinely navigate between the Project's offshore location and the east coast of Newfoundland. Air emissions associated with vessel and helicopter traffic include CO, NO_x, TSP and VOCs. Air emissions from the operation of these units are considered to be minor and will be mitigated by implementing, where possible, mitigation measures described in Section 6.5.1.1.

Overall Operations

Air dispersion modelling was performed to predict the maximum ambient ground level concentrations of CACs during the first year of operation and during a peak year of operation of the Hebron Platform. Dispersion modelling is used to simulate the transport of pollutants in the atmosphere based on representative weather information, and on the emission information provided by the process engineering and design team. The model algorithms are contained in a computer program that has been accepted by regulators for such use. The US Environmental Protection Agency (EPA) approved model AERMOD was used for dispersion calculations in this project. AERMOD is the current recommended model by the US EPA, and is suitable for distances up to about 35 km, beyond which the accuracy deteriorates. In this project, preliminary calculations showed that this range was more than sufficient to reveal the maximum ground-level concentrations.

Meteorological data for the surface were obtained for the five most recent calendar years from the Hibernia platform (a similar production facility, operating in the northeast Grand Banks), and they were coupled with upper air data from St. John's. Receptor grids were incorporated into the models and consisted of a 500 m grid spacing around the Project and existing oil platforms, and a 1 km spaced grid extending from the existing platforms to the extent of the Offshore Affected Area. Discrete receptors, including the actual Hebron Platform and each of the existing platforms, were also included in the modelling study. As noted above emissions from the operation of vessels and helicopters were not included in these models. Two scenarios were modelled for the operational phase of the platform and included the following:

- First Year of Operation – Two dual-fuelled turbines operating on distillate fuel and flaring of excess gas
- Peak Hebron Platform Operation – three turbine generators operating on natural gas, two dual-fueled turbine-driven compressors operating on natural gas, and background flaring

The sources used in the modelling study, their physical stack characteristics and emission factors are presented in Tables 6-12 and 6-13, respectively. The following is a list of assumptions used in both modelling scenarios:

- Two dual-fueled turbines operating on distillate fuel for power generation during the first year of operation (conservative case)
- Three turbines operating on natural gas for power generation and two additional dual-fueled turbine-driven compressors for gas compression during peak operation of the Project
- The emission rates for NO_x and CO for the turbines were provided by EMCP
- The emission factors for TSP and VOCs for the turbines were acquired from the US EPA's AP-42 documentation for Stationary Turbines for uncontrolled units
- The emission rates for the other Grand Bank facilities were acquired from 2008 NPRI information and the stack characteristics were assumed to be similar to the Hebron Platform
- The emission rates for NO_x, CO, TSP and VOCs for flaring were provided by EMCP
- The stack physical information and the topside configuration were provided by EMCP
- Minor amounts of sulphur in the distillate fuel
- Methane gas will be sweet, therefore limited quantities of sulphur
- Water injection via electrically driven pumps
- Emissions of NO_x, CO, TSP and VOCs from vessel and helicopter traffic were not included in the model runs (but were assessed in terms of GHG emissions)
- Receptors within the 500 m safety radius surrounding the platform were excluded from the model

Cumulative emissions from the operation of the existing platforms are presented in Section 6.5.5.2.

Table 6-12 Sources and Stack Physical Parameters

Sources	Source Location UTM		Stack Physical Parameters			
	Easting (m)	Northing (m)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (°C)
Power Generation - Turbine 1	691,742	5,157,735	47	3	31.5	427
Power Generation - Turbine 2	691,742	5,157,745	47	3	31.5	427
Power Generation - Turbine 3	691,742	5,157,755	47	3	31.5	427
Gas Compression - Turbine 4	691,742	5,157,765	45.5	2	14.4	427
Gas Compression - Turbine 5	691,742	5,157,775	45.5	2	14.4	427
Flare	691,742	5,157,785	136.5	1.42	20	1,000
Hibernia	669,954	5,180,272	47	3	31.5	427
Terra Nova	693,372	5,149,964	47	3	31.5	427
White Rose	727,708	5,186,021	47	3	31.5	427

Table 6-13 Air Dispersion Modelling Emission Rates

Sources	Emission Factors (g/s)							
	1st Year of Operation				Peak Operation			
	NO_x	CO	VOCs	TSP	NO_x	CO	VOCs	TSP
Power Generation – Turbine 1	7.10	1.50	0.014	0.408	14.0	0.211	0.071	0.225
Power Generation – Turbine 2	7.10	1.50	0.014	0.408	14.0	0.211	0.071	0.225
Power Generation – Turbine 3	-	-	-	-	14.0	0.211	0.071	0.225
Gas Compression – Turbine 4	-	-	-	-	7.04	0.365	0.055	0.174
Gas Compression – Turbine 5	-	-	-	-	7.04	0.365	0.055	0.174
Flare	1.46	11.7	0.058	-	Background Flaring			
Hibernia	-	-	-	-	-	-	-	-
Terra Nova	-	-	-	-	-	-	-	-
White Rose	-	-	-	-	-	-	-	-

The air dispersion modelling results for the first year of operation of the Hebron Platform are shown in Table 6-14.

Table 6-14 Summary of Model Predictions – Maximum Predicted GLCs – First Year of Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_x (assumed to be NO_2)	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	101	400
		Hibernia	669,954	5,180,272	1.66	
		Terra Nova	693,372	5,149,964	4.39	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	1.28	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	17.0	200
		Hibernia	669,954	5,180,272	0.11	
		Terra Nova	693,372	5,149,964	0.28	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.22	
	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	1.40	100
		Hibernia	669,954	5,180,272	0.00	
		Terra Nova	693,372	5,149,964	0.03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.01	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	21.4	35,000
		Hibernia	669,954	5,180,272	1.75	
		Terra Nova	693,372	5,149,964	4.85	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	1.29	
	8-hour maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	5.55	15,000
		Hibernia	669,954	5,180,272	0.34	
		Terra Nova	693,372	5,149,964	0.61	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.34	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (μg/m^3)	NAAQ Objectives (Max Acceptable) (μg/m^3)
			UTM X	UTM Y		
CO	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	0.30	NA
		Hibernia	669,954	5,180,272	1.26E-03	
		Terra Nova	693,372	5,149,964	1.95E-02	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	1.04E-02	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	5.79	NA
		Hibernia	669,954	5,180,272	0.09	
		Terra Nova	693,372	5,149,964	0.22	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.07	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	0.98	120
		Hibernia	669,954	5,180,272	5.74E-03	
		Terra Nova	693,372	5,149,964	0.01	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.01	
	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	0.08	70
		Hibernia	669,954	5,180,272	7.00E-05	
		Terra Nova	693,372	5,149,964	1.36E-03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	5.80E-04	
VOCs	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	0.20	NA
		Hibernia	669,954	5,180,272	0.01	
		Terra Nova	693,372	5,149,964	0.03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.01	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	0.03	NA
		Hibernia	669,954	5,180,272	6.60E-04	
		Terra Nova	693,372	5,149,964	1.87E-03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	1.20E-03	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m³)	NAAQ Objectives (Max Acceptable) (µg/m³)
			UTM X	UTM Y		
VOCs	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	0.00	NA
		Hibernia	669,954	5,180,272	1.00E-05	
		Terra Nova	693,372	5,149,964	1.20E-04	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	6.00E-05	

The air dispersion modelling results for the peak operations of the Hebron Platform are shown in Table 6-15.

Table 6-15 Summary of Model Predictions – Maximum Predicted GLCs – Peak Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m³)	NAAQ Objectives (Max Acceptable) (µg/m³)
			UTM X	UTM Y		
NO_x (assumed to be NO_2)	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	338	400
		Hibernia	669,954	5,180,272	6.25	
		Terra Nova	693,372	5,149,964	17.5	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	4.94	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,500	5,158,000	64.2	200
		Hibernia	669,954	5,180,272	0.44	
		Terra Nova	693,372	5,149,964	1.28	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.87	
	Annual Average	Maximum Prediction - Gridded Receptors	693,500	5,159,500	5.86	100
		Hibernia	669,954	5,180,272	5.70E-03	
		Terra Nova	693,372	5,149,964	0.11	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.04	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m^3)	NAAQ Objectives (Max Acceptable) (µg/m^3)
			UTM X	UTM Y		
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	694,500	5,157,500	6.91	35,000
		Hibernia	669,954	5,180,272	0.16	
		Terra Nova	693,372	5,149,964	0.48	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.13	
	8-hour maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	2.38	15,000
		Hibernia	669,954	5,180,272	0.04	
		Terra Nova	693,372	5,149,964	0.06	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.05	
	Annual Average	Maximum Prediction - Gridded Receptors	693,500	5,159,500	0.18	NA
		Hibernia	669,954	5,180,272	1.60E-04	
		Terra Nova	693,372	5,149,964	2.95E-03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	1.16E-03	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	5.72	NA
		Hibernia	669,954	5,180,272	0.12	
		Terra Nova	693,372	5,149,964	0.33	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.09	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,500	5,158,000	1.18	120
		Hibernia	669,954	5,180,272	8.21E-03	
		Terra Nova	693,372	5,149,964	0.03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	1.61E-02	
	Annual Average	Maximum Prediction - Gridded Receptors	693,500	5,159,500	1.15E-01	70
		Hibernia	669,954	5,180,272	1.10E-04	
		Terra Nova	693,372	5,149,964	2.03E-03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	8.20E-04	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m³)	NAAQ Objectives (Max Acceptable) (µg/m³)
			UTM X	UTM Y		
VOCs	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	1.81	NA
		Hibernia	669,954	5,180,272	0.04	
		Terra Nova	693,372	5,149,964	0.11	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	0.03	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,500	5,158,000	0.37	NA
		Hibernia	669,954	5,180,272	2.60E-03	
		Terra Nova	693,372	5,149,964	8.11E-03	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	5.12E-03	
VOCs	Annual Average	Maximum Prediction - Gridded Receptors	693,500	5,159,500	0.04	NA
		Hibernia	669,954	5,180,272	3.00E-05	
		Terra Nova	693,372	5,149,964	6.40E-04	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	2.60E-04	

Further details on the air dispersion modelling study, as well as the concentration contour plots, can be found in Stantec 2010.

Results from the air dispersion modelling show that the results of emissions produced during the first year of operation and during peak operation of the Hebron Platform would meet the stipulated air quality criteria in the short-term and long-term, and in near-field and far-field locations. There were no exceedances of the NAAQ Objectives.

Greenhouse Gas Emissions

During peak operation of the Project, emissions of GHGs will be associated with power generation, gas compression, flaring and the operation of vessels and helicopters.

Power Generation and Gas Compression

Greenhouse gases, including CO_2, N_2O and CH_4, are emitted during the operation of turbine generators when operating on either distillate fuel or natural gas. Carbon dioxide and N_2O are produced during the combustion process, as is CH_4 in the case of distillate fuel oil. Greater amounts of CO_2 are released during the combustion of distillate fuel versus natural gas due to the higher carbon content. In terms of natural gas combustion, low levels of

CH_4 are present in the exhaust gas as unburned fuel (US EPA 2000). It is anticipated that once the platform is fully operational the dual-fuelled turbines will operate on natural gas, therefore reducing the quantity of GHGs emitted.

Flaring

It is a common practice for existing offshore facilities to inject produced gas into the sub-surface. The injection of produced gas reduces GHG emissions to the atmosphere. Prior to the operation of the gas compression and injection system, it will be necessary to flare that portion of the gas not used to fuel the generators.

While the use of injection wells will greatly reduce the platform's GHG emissions, some flaring will still be required during upset conditions and during normal operations (background flaring), but as mentioned above, such quantities are expected to be minor. The estimated GHG emissions from flaring during the first year of operation and during peak operation are presented in Table 6-16.

Table 6-16 Greenhouse Gas Emissions from Flaring during Hebron Platform Operation

Greenhouse Gas	1st Year of Operation	Peak Operation
CO_2 (tonnes/yr)	152,884	92,849
CH_4 (tonnes/yr)	791	484
N_2O (tonnes/yr)	0.283	0.173
Total $CO_{2\ eq}$ (tonnes/yr)	261,053	103,060

Vessel and Helicopter Traffic

Greenhouse gas emissions, including CO_2, will be emitted during the routine operation of standby vessels, supply vessels and helicopters through the combustion of diesel fuel.

Overall Operations

An emissions inventory for the GHG emissions related to the overall operation phase of the Hebron Platform was prepared and the results are presented in Table 6-17.

As presented in Table 6-17, the estimated GHG emissions for the operation of the Hebron Platform are similar to those reported for other existing oil platforms located near the Offshore Project Area.

Table 6-17 Greenhouse Gas Emissions during the Operation of the Hebron Platform

Function	Greenhouse Gas Emissions (tonnes/year)			
	Carbon Dioxide (CO_2)	Nitrous Oxide (N_20)	Methane (CH_4)	Total CO_2 eq
Power Generation	269,024	19.9	5	275,298
Gas Compression	174,612	6.7	3.3	176,758
Flaring	92,849	0.173	484	103,067
Vessel Traffic	12,589	ND	ND	12,589
Helicopter Traffic	491	ND	ND	491
Hebron Total				568,203
Hibernia				595,749
Terra Nova				618,327
White Rose				555,534
Source: Rolls-Royoce Marine 1991; US EPA 2000; Sikorsky 2007; Environment Canada 2009a; EMCP unpublished data				

A summary of the potential environmental effects on Air Quality during the operations and maintenance phase of the Hebron Platform is provided in Table 6-18 (only those activities that result in Project-VEC interactions are included). As indicated in Section 6.3.2.2, several activities that indirectly affect Air Quality as a result of vessel traffic are assessed within the Operations of Vessels activity in Table 6-18. Power Generation is indicated as an activity unique to the analysis of environmental effects to Air Quality.

6.5.3 Offshore Decommissioning and Abandonment

Project activities associated with decommissioning and abandonment will be similar to those associated with construction and installation, with regard to air emissions. Particularly, emissions may result from the removal of the topside facilities, Hebron Platform and offshore loading system (OLS) loading points and from vessel and helicopter traffic. The effect of each of these activities will be temporary in nature, medium in magnitude, geographic extent and duration and the same mitigative measures will be implemented during decommissioning as were used during construction.

The summary of potential environmental effects on Air Quality from decommissioning and abandonment-related activities is provided in Table 6-19 (only those activities that result in Project-VEC interactions are included). As indicated in Section 6.3.2.3, several activities that indirectly affect Air Quality as a result of vessel and helicopter traffic are assessed within the Operation of Vessels and Operation of Helicopters in Table 6-19.

Table 6-18 Environmental Effects Assessment: Operations and Maintenance

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Power Generation[B]	• Change in Ambient Air Quality • Greenhouse Gas emissions	• Investigate the use of efficient/reduced emission technology, where appropriate, and where technologically sound and economically justifiable incorporate into the design.	2	2	5/6	R	2
Maintenance Activities (*e.g.,* diving, ROV, welding, *etc.*)	• Change in Ambient Air Quality		1	1	5/3	R	2
Flaring (upset conditions)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Monitor the number of flaring events • Investigate the use of efficient/reduced emission technology, where appropriate, and where technologically sound and economically justifiable incorporate into the design.	2	3	1/1	R	2
Chemical/Fuel Management/Storage (*e.g.,* corrosion inhibitors, BOP fluids, methane leaks from valves *etc.*)	• Change in Ambient Air Quality • Greenhouse Gas	• Develop and implement Standard OPeraing Procedures (SOPs) for all chemical handling operations	1	1	5/6	R	2
Operation of Helicopters	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Ensure properly maintained and efficient operation	1	4	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ ROVs)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Maintenance and inspections	1	4	5/6	R	2

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
[B] Includes Gas Compression

Table 6-19 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Change in Ambient Air Quality	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	2	2	2/1	R	2
Operation of Helicopters	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Maintenance and inspections	1	4	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels/barges/ ROVs)	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Vessel traffic mitigation strategies, including the use of vessels suitable for each work activity and vessel inspections	1	4	3/6	R	2

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

6.5.4 Accidents Malfunctions and Unplanned Events

6.5.4.1 Change in Air Quality

Nearshore

As nearshore activities consist of routine fabrication of large marine structures, accidental releases of air emissions could result from collisions of vessels with the GBS and/or with other vessels or from a hydrocarbon spill. Either of these events could result in a release of fugitive gases to the atmosphere; however, the release would be very small in magnitude, geographic extent, and duration, and will be prevented or mitigated by implementing the following measures:

- Risk awareness, emergency response and preventative measures training
- Routine audits on the general contractors oil spill response preparedness program

- Training staff on spill response and awareness during “Tool Box Safety” meetings
- Routine inspections of equipment
- Use of oil containment booms when necessary

The most extensive incident, however, would be if either of the above events resulted in a fire. An uncontrolled fire involving distillate fuel may result in incomplete combustion and therefore the release of air emissions. Such emissions would possibly be greater in magnitude, extent and duration than the fugitive release.

Offshore

Accidental releases of air emissions in the Offshore Project Area could result from the failure of OLS pipelines, manifolds or risers, subsea blowout, hydrocarbon spill, chemical spill and/or marine vessel incident. Each of these events would result in the release of hydrocarbons and therefore the release of fugitive air emissions to the atmosphere. These air emissions will be small in magnitude, extent and duration because of a number of preventative or mitigative measures will be implemented to either aid in minimizing the likelihood of the event taking place or to minimize the effect on Air Quality if the event took place and include:

- Develop and implement Standard Operating Procedures (SOPs) for all oil handling operations
- Good communications and sound marine practices for all vessels
- Conducting periodic inspection and maintenance checks on product storage and handling and fuel transfer systems
- The general awareness of offshore workers will be increased through training, seminars and safety meetings
- Conducting periodic maintenance and inspections on helicopters and vessels

There is also a risk of an explosion and/or fire in the case of fuel and chemical leaks or spills. Appropriate systems, resources and training will be in place to reduce the frequency and magnitude of explosions and fires on the platform and to respond to any such incidents that occur. The air emissions related to a potential explosion or fire would be greater in magnitude, extent and duration than those released from a fuel or chemical spill, but still marginally small.

Accidental releases of air emissions could also result during emergency flaring events. Emergency flaring allows for the prevention of over-pressurization of equipment and safely disposes of associated gas during process upset conditions. Air dispersion modelling was performed to predict the maximum ambient GLCs during an emergency flaring event. One event was assumed to last for fifteen minutes. The flare system physical characteristics and the emission data (Table 6-20) was used in the model.

Table 6-20 Air Dispersion Modelling Emission Rates

Sources	Flaring			
	NO_x	CO	VOCs	TSP
Flare	1.46	11.67	0.058	-

As the gas is sweet, the amount of particulate matter released from the flare will be much lower than if the flare was a sour gas flare. The use of modern efficient flare technology will further reduce the particulate that would be form as unburned hydrocarbons (soot). Particulate emissions from flaring are assumed to be minimal for this analysis.

The air dispersion modelling results for an emergency flaring event of the Hebron Platform are shown in Table 6-21.

Table 6-21 Summary of Model Predictions – Maximum Predicted GLCs - Flaring

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_x (assumed to be NO_2)	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691,000	5,158,500	1.91	400
		Hibernia	669,954	5,180,272	0.180	
		Terra Nova	693,372	5,149,964	0.504	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.131	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	697,000	5,158,000	0.173	200
		Hibernia	669,954	5,180,272	0.012	
		Terra Nova	693,372	5,149,964	0.035	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.020	
	Annual Average	Maximum Prediction - Gridded Receptors	696,000	5,159,500	0.009	100
		Hibernia	669,954	5,180,272	0.000	
		Terra Nova	693,372	5,149,964	0.002	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.001	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	691,000	5,158,500	15.3	35,000
		Hibernia	669,954	5,180,272	1.44	
		Terra Nova	693,372	5,149,964	4.03	
		Hebron Platform	691,742	5,157,735	0.0001	
		White Rose	727,708	5,186,021	1.05	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (μg/m³)	NAAQ Objectives (Max Acceptable) (μg/m³)
			UTM X	UTM Y		
CO	8-hour maximum	Maximum Prediction - Gridded Receptors	697,000	5,158,000	4.54	15,000
		Hibernia	669,954	5,180,272	0.280	
		Terra Nova	693,372	5,149,964	0.508	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.277	
	Annual Average	Maximum Prediction - Gridded Receptors	696,000	5,159,500	0.069	NA
		Hibernia	669,954	5,180,272	0.001	
		Terra Nova	693,372	5,149,964	0.016	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.008	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	N/A	NA
		Hibernia	669,954	5,180,272	N/A	
		Terra Nova	693,372	5,149,964	N/A	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	N/A	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	N/A	120
		Hibernia	669,954	5,180,272	N/A	
		Terra Nova	693,372	5,149,964	N/A	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	N/A	
	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	N/A	70
		Hibernia	669,954	5,180,272	N/A	
		Terra Nova	693,372	5,149,964	N/A	
		Hebron Platform	691,742	5,157,735	N/A	
		White Rose	727,708	5,186,021	N/A	
VOCs	1 -hour Maximum	Maximum Prediction - Gridded Receptors	691,000	5,158,500	0.076	NA
		Hibernia	669,954	5,180,272	0.007	
		Terra Nova	693,372	5,149,964	0.020	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.005	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
VOCs	24-hour Maximum	Maximum Prediction - Gridded Receptors	697,000	5,158,000	0.007	NA
		Hibernia	669,954	5,180,272	0.000	
		Terra Nova	693,372	5,149,964	0.001	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.001	
	Annual Average	Maximum Prediction - Gridded Receptors	695,500	5,159,500	0.000	NA
		Hibernia	669,954	5,180,272	0.000	
		Terra Nova	693,372	5,149,964	0.000	
		Hebron Platform	691,742	5,157,735	0.000	
		White Rose	727,708	5,186,021	0.000	

Results from the air dispersion modelling for flaring show that the emissions produced from the Platform would meet the stipulated NAAQ Objectives in the short-term and long-term, and in near-field and far-field locations. The maximum grid values present the highest concentrations at any receptor.

6.5.4.2 Greenhouse Gas Emissions

Nearshore

The release of GHGs to the atmosphere from an unplanned or accidental event, including a collision or hydrocarbon spill would represent a short-term emergency situation. In the nearshore, such a release would most likely be related to a fuel spill and possibly related to a fire, and would certainly be small in magnitude, extent and duration, adding a very small amount of GHGs to the total inventory of GHG emissions for the Project.

Offshore

Accidental events that would lead to an unplanned release of GHGs in the Offshore Project Area would include an emergency depressurization to the flare, the rupture of OLS pipelines, subsea blowout or due to a fire resulting from a fuel or hydrocarbon spill. The volume of such emissions would be small relative to the Project’s total GHG inventory, and such emissions would be limited by the specific measures as outlined above in Section 6.5.4.1.

A summary of the potential environmental effects on Air Quality due to accidents, malfunctions and unplanned events attributable to the Project is provided in Table 6-22 (only those activities that result in Project-VEC interactions are included). Emergency Flaring is included as an activity unique to the environmental effects analysis to Air Quality.

Table 6-22 Environmental Effects Assessment: Accidental Events

Project Activity[A]	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Spill (at Bull Arm Site)	• Change in Ambient Air Quality	• Conduct periodic maintenance and repair on vessels • Train personnel in spill prevention and awareness • Oil containment booms	1	3	2/1	R	1
Failure or Spill from OLS	• Change in Ambient Air Quality	• Conduct periodic inspections, maintenance and repair of facilities and equipment • Train personnel in spill prevention and awareness	1	5	2/1	R	2
Subsea Blowout	• Change in Ambient Air Quality • Greenhouse Gas Emissions	• Drilling design and geotechnicla surveys • Alert/Emergency Response Continqency Plan	1	5	3/1	R	2
Crude Oil Surface Spill	• Change in Ambient Air Quality	• Conduct periodic maintenance and repair on Platform and vessels • Train personnel in spill prevention • SOPs for oil handling operations	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Ambient Air Quality	• Conduct periodic inspection, maintenance and repair of facilities and equipment • Train personnel in spills management and awareness • SOPs for chemical handling and storage	1	1	2/1	R	2
Collisions (involving Platform, vessel and/or iceberg)	• Change in Ambient Air Quality	• Risk awareness, emergency response and preventative measures, training on fuel handling and storage	1	3	2/1	R	1
Emergency Flaring	• Change in Ambient Air Quality		2	2	1/2	R	2

KEY

Magnitude:
1 = Low: Within normal variability of baseline conditions, but is well below regulatory limits and objectives
2 = Medium: increase or decrease with regard to baseline but near regulatory limits and objectives
3 = High: Increase such that the quality of the air is degraded to values that substantively exceed the regulatory limits and objectives

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effect

[A] Where there is more than one potential enviromental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

6.5.5 Cumulative Environmental Effects

The ambient air quality in the Study Area reflects the influence of emissions from other projects and activities occurring within or outside the Project Area. Other projects for consideration of cumulative environmental effects include the following:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activities
- Offshore exploration seismic activities
- Marine transportation
- Commercial fisheries

In addition, the North Atlantic Refinery, Newfoundland Transshipment Terminal, construction of the Long Harbour Processing Plant, and proposed Liquefied Natural Gas Transshipment and Storage Terminal and Southern Head Marine Terminal and Associated Crude Oil Refinery projects were considered in the cumulative effects assessment for Air Quality.

Long-range transport of airborne emissions also contributes additional loading to the local airshed from sources located on the eastern seaboard of the United States and Canada, outside of the Study Area; however, these contributions are likely to be on the margin of detection due to the distance from the eastern seaboard to the Offshore Project Area.

6.5.5.1 Nearshore

The cumulative influences of the construction of nearshore components of the GBS with other existing or proposed projects, listed above, have the potential to result in an effect on Air Quality. However, the effects of the air emissions related to the nearshore construction of the GBS are small in relative quantity, small in geographic extent and short in duration.

6.5.5.2 Offshore

Change in Ambient Air Quality

Air dispersion modelling was also conducted to assess the potential environment effects on Air Quality due to the cumulative environmental effects of the existing offshore oil platforms in the area with the operational phase of the Hebron Platform. The cumulative emissions predicted for the first year of operation would be similar to those produced during the offshore construction and installation of the platform. The same modelling program, meteorological data, receptor grids, source physical characteristics and assumptions were used to model the Project commissioning and operation cumulative scenarios as were outlined in Section 6.5.2.1. The emission rates for each source are presented in Table 6-23.

Table 6-23 Air Dispersion Modelling Emission Rates

Sources	Project - 1st Year of Operation Cumulative				Project - Peak Operation Cumulative			
	NO_x	CO	VOCs	TPM	NO_x	CO	VOCs	TPM
Power Generation - Turbine 1	7.10	1.50	0.014	0.408	14.0	0.211	0.071	0.225
Power Generation - Turbine 2	7.10	1.50	0.014	0.408	14.0	0.211	0.071	0.225
Power Generation - Turbine 3	-				14.0	0.211	0.071	0.225
Gas Compression - Turbine 4	-	-	-	-	7.04	0.365	0.055	0.174
Gas Compression - Turbine 5	-	-	-	-	7.04	0.365	0.055	0.174
Flare	1.46	11.67	0.058	-	Background Flaring			
Hibernia	34.4	25.3	14.9	6.2	34.4	25.3	14.9	6.2
Terra Nova	73.3	23.2	213	6.6	73.3	23.2	213	6.6
White Rose	76.8	28.2	9.04	8.47	76.8	28.2	9.04	8.47

The air dispersion modelling results for the cumulative environmental effect of the first year of operation for the Hebron Platform with the other existing oil platforms is presented in Table 6-24.

Table 6-24 Summary of Model Predictions – Maximum Predicted GLCs – Cumulative 1st Year of Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_x (assumed to be NO_2)	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	101	400
		Hibernia	669,954	5,180,272	7.80	
		Terra Nova	693,372	5,149,964	14.5	
		Hebron Platform	691,742	5,157,735	26.2	
		White Rose	727,708	5,186,021	5.17	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	693,500	5,159,000	17.1	200
		Hibernia	669,954	5,180,272	0.53	
		Terra Nova	693,372	5,149,964	3.04	
		Hebron Platform	691,742	5,157,735	1.46	
		White Rose	727,708	5,186,021	0.95	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_x (assumed to be NO_2)	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	1.72	100
		Hibernia	669,954	5,180,272	0.02	
		Terra Nova	693,372	5,149,964	0.06	
		Hebron Platform	691,742	5,157,735	0.25	
		White Rose	727,708	5,186,021	0.05	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	21.4	35,000
		Hibernia	669,954	5,180,272	3.44	
		Terra Nova	693,372	5,149,964	9.79	
		Hebron Platform	691,742	5,157,735	8.34	
		White Rose	727,708	5,186,021	4.96	
	8-hour maximum	Maximum Prediction - Gridded Receptors	729,000	5,186,000	10.6	15,000
		Hibernia	669,954	5,180,272	0.68	
		Terra Nova	693,372	5,149,964	2.35	
		Hebron Platform	691,742	5,157,735	1.30	
		White Rose	727,708	5,186,021	1.05	
	Annual Average	Maximum Prediction - Gridded Receptors	694,000	5,158,000	0.40	NA
		Hibernia	669,954	5,180,272	0.009	
		Terra Nova	693,372	5,149,964	0.12	
		Hebron Platform	691,742	5,157,735	0.08	
		White Rose	727,708	5,186,021	0.02	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	725,000	5,186,000	6.27	NA
		Hibernia	669,954	5,180,272	0.84	
		Terra Nova	693,372	5,149,964	0.71	
		Hebron Platform	691,742	5,157,735	2.37	
		White Rose	727,708	5,186,021	0.52	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	729,000	5,187,000	1.13	120
		Hibernia	669,954	5,180,272	0.05	
		Terra Nova	693,372	5,149,964	0.09	
		Hebron Platform	691,742	5,157,735	0.16	
		White Rose	727,708	5,186,021	0.09	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m³)	NAAQ Objectives (Max Acceptable) (µg/m³)
			UTM X	UTM Y		
TSP	Annual Average	Maximum Prediction - Gridded Receptors	729,500	5,189,000	0.12	70
		Hibernia	669,954	5,180,272	2.14E-03	
		Terra Nova	693,372	5,149,964	7.57E-03	
		Hebron Platform	691,742	5,157,735	0.02	
		White Rose	727,708	5,186,021	4.37E-03	
VOCs	1 -hour Maximum	Maximum Prediction - Gridded Receptors	690,500	5,150,000	154.9	NA
		Hibernia	669,954	5,180,272	22.0	
		Terra Nova	693,372	5,149,964	6.59	
		Hebron Platform	691,742	5,157,735	75.6	
		White Rose	727,708	5,186,021	14.5	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	695,000	5,151,000	27.5	NA
		Hibernia	669,954	5,180,272	1.03	
		Terra Nova	693,372	5,149,964	0.71	
		Hebron Platform	691,742	5,157,735	4.06	
		White Rose	727,708	5,186,021	2.76	
	Annual Average	Maximum Prediction - Gridded Receptors	695,500	5,153,500	2.70	NA
		Hibernia	669,954	5,180,272	0.04	
		Terra Nova	693,372	5,149,964	0.02	
		Hebron Platform	691,742	5,157,735	0.64	
		White Rose	727,708	5,186,021	0.09	

Results from the air dispersion modelling for the cumulative environmental effect of the first year of operation of the Platform with the existing oil platforms, show that the emissions would meet the stipulated NAAQ Objectives for the short-term and long-term, and in near-field and far-field locations. The air dispersion modelling results for the cumulative environmental effect of peak operation of the Hebron Platform with the other existing oil platforms is presented in Table 6-25.

Table 6-25 Summary of Model Predictions – Maximum Predicted GLCs – Cumulative Peak Operation

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
NO_x (assumed to be NO_2)	1 -hour Maximum	Maximum Prediction - Gridded Receptors	694,000	5,158,000	338	400
		Hibernia	669,954	5,180,272	9.11	
		Terra Nova	693,372	5,149,964	22.0	
		Hebron Platform	691,742	5,157,735	26.2	
		White Rose	727,708	5,186,021	13.5	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	692,500	5,158,000	64.3	200
		Hibernia	669,954	5,180,272	0.65	
		Terra Nova	693,372	5,149,964	1.32	
		Hebron Platform	691,742	5,157,735	1.46	
		White Rose	727,708	5,186,021	1.15	
NO_x (assumed to be NO_2)	Annual Average	Maximum Prediction - Gridded Receptors	693,500	5,159,500	6.11	100
		Hibernia	669,954	5,180,272	0.03	
		Terra Nova	693,372	5,149,964	0.14	
		Hebron Platform	691,742	5,157,735	0.25	
		White Rose	727,708	5,186,021	0.08	
CO	1 -hour maximum	Maximum Prediction - Gridded Receptors	725,000	5,186,000	20.9	35,000
		Hibernia	669,954	5,180,272	4.76	
		Terra Nova	693,372	5,149,964	2.90	
		Hebron Platform	691,742	5,157,735	8.34	
		White Rose	727,708	5,186,021	2.10	
	8-hour maximum	Maximum Prediction - Gridded Receptors	729,000	5,186,000	10.6	15,000
		Hibernia	669,954	5,180,272	0.57	
		Terra Nova	693,372	5,149,964	0.51	
		Hebron Platform	691,742	5,157,735	1.30	
		White Rose	727,708	5,186,021	0.56	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC (µg/m³)	NAAQ Objectives (Max Acceptable) (µg/m³)
			UTM X	UTM Y		
CO	Annual Average	Maximum Prediction - Gridded Receptors	729,500	5,189,000	0.39	NA
		Hibernia	669,954	5,180,272	0.01	
		Terra Nova	693,372	5,149,964	0.03	
		Hebron Platform	691,742	5,157,735	0.08	
		White Rose	727,708	5,186,021	0.02	
TSP	1 -hour Maximum	Maximum Prediction - Gridded Receptors	725,000	5,186,000	6.27	NA
		Hibernia	669,954	5,180,272	0.84	
		Terra Nova	693,372	5,149,964	0.71	
		Hebron Platform	691,742	5,157,735	2.37	
		White Rose	727,708	5,186,021	0.52	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	629,500	5,158,000	1.19	120
		Hibernia	669,954	5,180,272	0.05	
		Terra Nova	693,372	5,149,964	0.09	
		Hebron Platform	691,742	5,157,735	0.16	
		White Rose	727,708	5,186,021	0.09	
	Annual Average	Maximum Prediction - Gridded Receptors	693,500	5,159,500	0.14	70
		Hibernia	669,954	5,180,272	2.18E-03	
		Terra Nova	693,372	5,149,964	1.02E-02	
		Hebron Platform	691,742	5,157,735	0.02	
		White Rose	727,708	5,186,021	4.61E-03	
VOCs	1 -hour Maximum	Maximum Prediction - Gridded Receptors	690,500	5,150,000	154.9	NA
		Hibernia	669,954	5,180,272	21.9	
		Terra Nova	693,372	5,149,964	6.59	
		Hebron Platform	691,742	5,157,735	75.6	
		White Rose	727,708	5,186,021	14.0	
	24-hour Maximum	Maximum Prediction - Gridded Receptors	695,000	5,151,000	27.5	NA
		Hibernia	669,954	5,180,272	1.03	
		Terra Nova	693,372	5,149,964	0.71	
		Hebron Platform	691,742	5,157,735	4.06	
		White Rose	727,708	5,186,021	2.76	

Contaminant	Averaging Period	Receptor	Location (m)		Maximum Predicted GLC ($\mu g/m^3$)	NAAQ Objectives (Max Acceptable) ($\mu g/m^3$)
			UTM X	UTM Y		
VOCs	Annual Average	Maximum Prediction - Gridded Receptors	695,500	5,153,500	2.71	NA
		Hibernia	669,954	5,180,272	0.04	
		Terra Nova	693,372	5,149,964	0.02	
		Hebron Platform	691,742	5,157,735	0.64	
		White Rose	727,708	5,186,021	0.09	

Results from the air dispersion modelling for the cumulative environmental effect of peak operation of the Platform with the existing oil platforms, show that the emissions would meet the stipulated NAAQ Objectives for the short-term and long-term, and in near-field and far-field locations.

Greenhouse Gases

The cumulative environmental effect of the release of GHGs during the operational phase of the platform with the operation of the existing production platforms was assessed in terms of preparing an emissions inventory of GHGs and comparing that to the national total.

The Project will emit GHGs (including CO_2, N_2O, and CH_4) from power generation, gas combustion, non-routine flaring and vessel and helicopter traffic. The individual contributions of GHGs from each of the existing platforms in the area and the Hebron Platform, as well as their combined contribution, and the national total are presented in Table 6-26.

Table 6-26 Cumulative Greenhouse Gas Emissions

Facility	Greenhouse Gas Emissions (tonnes CO_2 eq per year)		
	Carbon Dioxide (CO_2)	Nitrous Oxide (N_2O)	Methane (CH_4)
Hibernia	556,231	4,557	34,960
Terra Nova	576,456	10,597	31,274
White Rose	515,691	9,796	30,047
Hebron	549565	8300	10,338
Provincial Total	5,140,424	35,955	97,037
National Total	247,400,881	4,897,951	7,983,044
Percent Contribution of the Hebron Project to National Total	0.22%	0.17%	0.13%
Source: Rolls-Royce Marine 1991; US EPA 2000; Sikorsky 2007; Environment Canada 2009b; EMCP unpublished data			

As displayed in Table 6-26 the percent contribution of GHGs from the operation of the Hebron Platform to the overall national total is substantially small in magnitude.

Once in operation, the Project will report annual emissions of CACs and greenhouse gases to Environment Canada under the NPRI and the National GHG Reporting schemes as well as meet the reporting requirements pursuant to the *Offshore Waste Treatment Guidelines*.

6.6 Determination of Significance

The determination of significance is based on the definition provided in Section 6.4. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect, and their interactions, as presented in the preceding analysis.

6.6.1 Change in Air Quality

Overall, as demonstrated by the preceding analysis, the change in air quality attributable to the Project is expected to be low to medium in magnitude, local in extent, and short term in duration. Components associated with all phases of the Project, including power generation, compression equipment and non-routine flaring, as well as accidental releases and cumulative environmental effects, will result in emissions that will not frequently exceed applicable ground-level NAAQ Objectives. Adverse effects on air quality that could occur as a result of an accidental release of large amounts of raw gas through a blowout or pipe break could only occur in an event that is considered extremely unlikely.

Therefore, by implementing appropriate mitigation measures, the environmental effects on Air Quality during the construction, operations and decommissioning phases of the Project, including accidental and cumulative environmental effects, is predicted to be not significant. A summary of the environmental effects for a change in air quality is provided in Table 6-27.

Table 6-27 Residual Environmental Effects Summary: Change in Ambient Air Quality

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction/Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Effects	NS	3	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
N/A = Not Applicable

[A] As determined in consideration of established residual environmental effects rating criteria.
[B] Includes all Bull Arm activities, engineering, construction, removal of the bund well, tow-out and installation of the Hebron Platform at the offshore site
[C] Includes decommissioning and abandonment of the GBS and offshore site
[D] Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

6.6.2 Greenhouse Gas Emissions

With respect to a change in GHG emissions, the magnitude is ranked as medium for both the construction and operations phases; however, the emissions are consistent with those currently being reported for other similar facilities in the same locale. The geographic extent is provincial, national and ultimately, global. The duration is short-term during construction and continues for the full period of operations. Nevertheless, it is not yet possible to determine the effect of these emissions on climate change. In the unlikely event of a large-scale accident or malfunction, the Project's GHG emissions will be temporarily increased.

Therefore, the Project-related change in GHG emissions, including accidental events, and the potential cumulative change in GHG emissions is rated as not significant. There is moderate level of confidence in this significance prediction due to the evolving nature of climate change science and the contributions of anthropogenic greenhouse gases to climate change. A summary of the environmental effects for a change in GHG is provided in Table 6-28.

Table 6-28 Residual Environmental Effects Summary Matrix – Greenhouse Gas Emissions

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction/Installation[B]	NS	2	N/A[1]
Operation and Maintenance	NS	2	N/A
Decommissioning and Abandonment[C]	NS	2	N/A
Accidents, Malfunctions and Unplanned Events	NS	2	N/A
Cumulative Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
N/A = Not Applicable

[A] As determined in consideration of established residual environmental effects rating criteria
[B] Includes all Bull Arm activities, engineering, construction, removal of the bund well, tow-out and installation of the Hebron Platform at the offshore site
[C] Includes decommissioning and abandonment of the GBS and offshore site
[1] Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

6.7 Follow-up and Monitoring

In the Operations and Maintenance Phase, there is no suggested follow-up or monitoring required for Air Quality. The Project will adhere to proactive maintenance scheduling and procedures to monitor and reduce factors such as corrosion, vibration, mechanical wear and fatigue. During the operation of the facility, compliance with environmental regulatory requirements and standards and emissions of CACs and GHGs will be documented annually and submitted as required by federal government reporting programs.

7 FISH AND FISH HABITAT

The Fish and Fish Habitat Valued Ecosystem Component (VEC) includes fish, shellfish, benthos, plankton, water and sediment. These components are intrinsically related to one another and together they allow a holistic approach to the assessment of potential environmental effects of the Project on the marine environment. As well as its ecological significance, the Fish and Fish Habitat VEC is directly linked to the commercial fishery and, therefore, is of social, economic and cultural significance.

7.1 Environmental Assessment Boundaries

7.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Chapter 4). The Study areas and Project areas are illustrated in Figures 7-1 and 7-2, for the nearshore and offshore, respectively. The Affected Areas for relevant Project activities have been determined by modelling (see AMEC 2010a, 2010b, JASCO 2010; Stantec 2010).

7.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are summarized in Table 7-1.

Table 7-1 Temporal Boundaries of Nearshore and Hebron Offshore Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation/start-up/drilling as early as 2015 • Production year-round through to 2046 or longer • Potential future activities - as required, year-round through to end of Project • Decommissioning/abandonment: after approximately 2046

7.1.3 Administrative

Marine fish and fish habitat are protected in Canada primarily through the *Fisheries Act.* Fisheries and Oceans Canada (DFO) has overall responsibility for the administration of the *Fisheries Act*. Fish habitat is protected under the *Fisheries Act* and by the Policy for the Management of Fish Habitat (DFO 1986). This policy applies to all projects and activities in or near water that could "*alter, disrupt or destroy fish habitat by chemical, physical, or biological means*." The guiding principal of this policy is to achieve no net loss of the productive capacity of fish habitats. Environment Canada administers Section

36 of the *Fisheries Act*, which prohibits the deposit of a deleterious substance in waters frequented by fish.

Figure 7-1 Hebron Nearshore Study and Project Areas

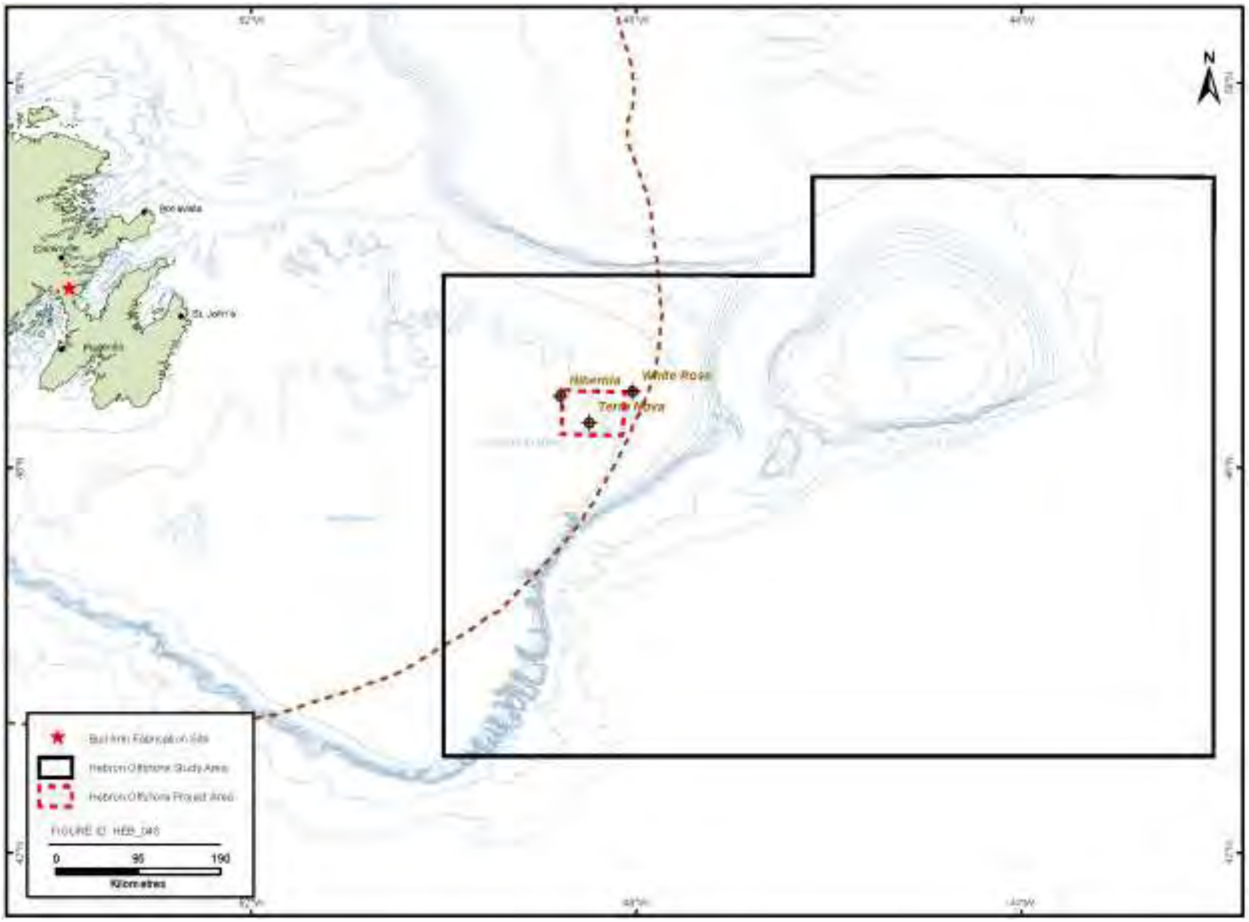


Figure 7-2 Hebron Offshore Study and Project Areas

7.2 Definition of Significance

A significant adverse residual environmental effect is one that affects fish and/or fish habitat resulting in a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

For potential environmental effects on marine fish habitat, a significant adverse residual environmental effect would be one that results in an unmitigated or non-compensated net loss of fish habitat as required in a *Fisheries Act* harmful alteration, disruption or destruction (HADD) authorization.

An adverse effect that does not meet the above criteria is evaluated as not significant.

7.3 Existing Conditions

Site-specific fish and fish habitat data were collected from the Hebron Offshore Study Area during surveys in 2001 (Chevron 2002, 2003). These data are complemented by Environmental Effects Monitoring (EEM) survey data collected by operators of adjacent offshore oil and gas projects since 1994, and by several descriptions of existing conditions for marine fish and fish habitat for other environmental assessments overlapping with the Hebron Offshore Study Area. DFO Research Vessel (RV) data from 3Lt have also been reviewed along with relevant fish and fish habitat primary literature for the Hebron Offshore Study Area.

Within the Nearshore Study Area, several fish and fish habitat baseline and EEM surveys from 1991 were conducted as part of the Hibernia Gravity Base Structure (GBS) construction project. Since then, an ocean disposal monitoring survey was conducted in Great Mosquito Cove (Lee 2005) and an extensive fish and fish habitat survey of Great Mosquito Cove was conducted for the Hebron Project in August 2009. Several researchers from Memorial University and DFO have conducted studies on fish and fish habitat within the Nearshore Study Area and those primary scientific papers were also used to compile existing information.

7.3.1 Nearshore

The primary components of the marine ecosystem in nearshore coastal environment are phytoplankton, zooplankton (including ichthyoplankton), benthos, macroinvertebrates (*e.g.*, scallop, crab), fish, marine birds and waterfowl and marine mammals. A description of the physical environment within the Nearshore Study Areas is provided in Section 3.1.

The following description of the fish and fish habitat within the Nearshore Study Area makes preferential use of site-specific information when the information is available; otherwise, a summary of information available for fish and fish habitat in the Newfoundland coastal environment as a whole is provided.

7.3.1.1 Nearshore Physical Environment Overview

Trinity Bay, on the northern Avalon Peninsula of Newfoundland, is a deep embayment with water depths greater than 200 m (Figure 7-1). Relatively stable thermal stratification of the water is expected during the summer. Lear and Pitt (1971) determined that the influence of the Labrador Current was indicated in the Bay by the presence of bottom waters with low temperatures (below 0°C) equivalent to those found along the Continental Slope. Bull Arm is an inlet approximately 6 km long and 0.3 km wide running north-south from the body of Trinity Bay. The town of Sunnyside lies at the head of Bull Arm. Bull Arm is relatively deep with water depths of up to 100 m in the middle and 150 to 180 m near the mouth. The nearshore of Bull Arm slopes fairly gradually along the shoreline to depths ranging from 9 to 27 m. The coastline approaching Great Mosquito Cove drops sharply to depths of 30 to 88 m. The coastline of the Bull Arm area is predominantly steep bedrock, with many jagged outcrops, and shore line energies range from low to moderate wave energy environment. The seabed in Bull Arm tends to be rocky in the outer portions, with mud and sand predominating in the inner harbour (Department of Development 1981). There are no major rivers draining into Bull Arm and no scheduled salmon rivers running into Bull Arm.

There is considerable annual variation in sea ice cover in Trinity Bay. Ice conditions are dependent on the supply of ice and icebergs from the north, winter and spring air temperatures in the northwestern Atlantic region and the direction of prevailing winds during the ice season. Easterly winds frequently cause Trinity Bay to be filled with offshore pack-ice, with subsequent intrusions into Bull Arm (Davidson 1985). A season of heavy ice in Trinity Bay can delay the warming of the surface waters and scour intertidal habitat and clear an area of perennial kelp and invertebrate species.

The maximum tidal variation is approximately 1 m at the entrance to Bull Arm and a probable variation of 1.5 m at the head of the Arm. MacDonald and Thompson (1985a, 1985b) documented yearly temperature cycles in Bull Arm, near Sunnyside, and noted thermal stratification may occur at shallow depths (10 to 30 m) during spring and summer. In winter, the water column is fairly homogenous at -1.5°C to -1.0°C. In the summer months, surface water temperatures may rise to 15°C. The outer portion of Bull Arm is subject to 1.5 m waves generated by southeasterly to easterly winds. Exposure is reduced proceeding inward up the arm towards Sunnyside, resulting in a low to moderate exposure.

7.3.1.2 Habitat

In Great Mosquito Cove, the bottom characteristics of the Hibernia bund wall disposal zone between pre-disposal (1995) and post disposal (2005) has been compared and documented (AMEC 2005). The survey showed that in the area of the bund wall disposal, there are mounds of sediment at depths between 20 to 40 m[8] and that fish habitat had changed relatively little since the 1995 data. Surficial substrates were covered with fines, primarily clay, and very occasional cobble and boulders were visible with coralline algae (AMEC 2005). Slightly more epifauna were observed in 2005, compared to 1995. Kelp (*Agarum* sp. and *Laminaria* sp.) was abundant in some areas and scarce to absent in other areas (AMEC 2005).

The reference area adjacent to the disposal area in Great Mosquito Cove showed substrates in this area were more variable, with pockets of boulder, till, rock or cobble covered with coralline algae or kelp and large areas of fine substrates. Seastars, urchins and rock crab were also recorded. Mounds of sediment were also reported in the reference area (AMEC 2005).

7.3.1.3 Plankton

Profiles of chlorophyll pigments in the water column are good indicators of phytoplankton biomass. Coastal bay areas of Newfoundland typically undergo phytoplankton blooms in the spring and during September and October, resulting in high levels of pigments in surface waters. In September and October of 1981, MacDonald (1984) noted an increase in surface water

8 ExxonMobil will be undertaking further bathymetric studies of Great Mosquito Cove to further delineate the depth of water and ocean bottom conditions in this area.

chlorophyll levels to a value 2.5 µg/L, characteristic of similar values for spring bloom conditions for the Sunnyside area.

Chlorophyll values for October at 20 m water depth ranged from 0.75 to 1.3 µg/L. The lower chlorophyll *a* values in November may reflect a downward transport of phytoplankton over time by current or wind mixing, hence the lower levels of phytoplankton in surface waters. Surface chlorophyll *a* values (0 to 5 m) for the deepwater stations are relatively high, with markedly lower values of 0.012 to 0.037 µg/L at depths of 118 to 172 m. These lower values at increased depth suggest that phytoplankton productivity in the surface layers has not been transported to the deeper water layers in Bull Arm.

During a fall survey in Great Mosquito Cove, chlorophyll values ranged from 0.105 to 0.809 µg/L at surface, mid-water and near-bottom depths (Newfoundland Geosciences Limited 1990). These chlorophyll values correspond well to samples from water 7 to 10 m deep near Sunnyside in November (MacDonald 1984). Total photosynthetic pigment did not increase markedly with depth, suggesting a lack of stratification in the water column and vertical mixing of nutrients in the fall months. As summer progress, it is likely that the water column does become stratified and chlorophyll concentrations increase with depth.

A distinct spring bloom has been observed near Sunnyside during April and May, with chlorophyll *a* values as high as 5.5 µg/L at 10 m. Chlorophyll *a* concentrations were generally higher in shallow water sites (MacDonald and Thompson 1985).

7.3.1.4 Benthos

Nearshore rocky habitats in Trinity Bay are typically covered with kelp and coralline algae. Mussels, periwinkles (*Littorina* spp.), whelks (*Colus* spp.), urchins, brittle stars (*Ophiopholis aculeate*), hermit crabs (*Pagurus* spp.), rock crabs and sea stars are the most common macro-invertebrate species. Vegetation decreases with increasing depth, but patches of kelp and filamentous algae occur. The most common macro-invertebrates nearshore are sea urchins, sand dollars (*Echinarachnius parma*) and rock crabs.

Coralline algae play an important role in nearshore ecology as habitat for invertebrates, as a food source for a variety of gastropods (Mandeveldt *et al.* 2006) and by limiting the re-colonization of kelp species that have been harvested by urchins (Bulleri *et al.* 2002; Bulleri and Benedetti-Cecchi 2006). The attraction of invertebrates to coralline algae beds results in the attraction of fish to feed in these areas. There has been little study of the role of coralline algae as fish habitat in the western North Atlantic.

Benthic samples were collected along transects and at selected deepwater sites in Great Mosquito Cove for Mobil in October 1989 (Newfoundland Geosciences Limited unpublished data). There is a diverse infaunal community including polychaetes, amphipods and molluscs.

Sea scallop (*Placopecten magellanicus*) and blue mussel (*Mytilus edulis*) beds have been recorded for the inner portions of Bull Arm (Osborne and

Roberts 1983). An October 1989 survey of shellfish habitat in Great Mosquito Cove revealed no large beds of blue mussels (Newfoundland Geosciences Limited 1990). Adult sea scallops occurred sporadically in Great Mosquito Cove, but were more common along the southern shoreline.

Three fish habitat types were identified in Great Mosquito Cove during marine baseline surveys (Mobil Oil 1990a). The communities were:

- A shallow water (≤10 m depth), rocky bottom community dominated by polychaetes (fringed worms (*Dodecaceria concharum*) and paddle worms (*Eulalia viridis*)), chiton (*Tonicella rubra*), gastropods (limpets (*Acmaea testudinalis*) and *Puncturella noachina*), aeolidoid nudibranchs, and echinoderms (green sea urchin (*Strongylocentrotus droebachiensis*), daisy brittle star (*Ophiopholus aculeata*) and boreal sea star (*Asterias vulgaris*))
- A nearshore midwater (10 to 12 m depth) community characteristic of mixed substrates and dominated by nematodes, polychaetes (scale worms (*Pholoe minuta*), *Microphthalmus sczelkowii* and *Harmothoe imbricate*) and thread worms (*Mediomastus ambizeta* and *Lumbrineris* sp.)), cockles (*Cerastoderma pinnulatum*), harpacticoid copepods (*Laophonte horrid*, *Ectinosoma* sp., and *Arthropsyllus serratus*), unidentified cytherid ostracods, cumacean (*Diastylis rathkei*), and gammarid amphipods (*Orchomenella minuta* and *Corophiium bonelli*)
- A deepwater (>40 m depth) community characterized by a silty substrate and dominated by polychaetes (*Gyptis vittata*, *Prionospio steenstrupi*, *Aglaopphamus neotenus*, *Cossura longocirrata*, syllid species and unattached serpulids), pelecypods (*Crenella glandula* and *Thyasira gouldi*), cytherid ostracods, and cumacean (*Leucon* sp.)

As part of the bund wall disposal site survey in 2005, benthic invertebrate samples were collected and compared to the reference area samples. The survey concluded a more robust and rich invertebrate and benthic community at the reference site than at the disposal site (AMEC 2005). Because there were insufficient baseline data for comparison, the difference between the reference and disposal sites could not be attributed to anthropogenic effects.

7.3.1.5 Fish and Shellfish

In nearshore rocky habitats, the common finfish species are gunnels (*Pholis nebulosa*), shannies (*Ulavaria subbifurcata*) and cunners (*Tautogolabrus adspersus*). American lobsters (*Homarus americanus*) are commercially fished from these habitats. At water depths beyond 10 m on soft substrates, winter flounder (*Pseudopleuronectes americanus*) and various sculpin species are common; sea scallops occur in patches. Commercial fisheries in these habitats may include capelin (*Mallotus villosus*), herring (*Clupea harengus*), mackerel (*Scomber scombrus*), winter flounder, lumpfish (*Cyclopterus lumpus*) and lobster. In deeper waters, snow crab (*Chionoecetes opilio*) and halibut are fished commercially.

In Bull Arm, the following species of finfish are commonly found and commercially fished (DFO Coastal Resource Inventory website, accessed

October 2009): cod (*Gadus morhua*), capelin, herring and mackerel. Greenland halibut (*Reinhardardtius hippoglossoides*) may be present in deeper water (200 to 300 m) outside Bull Arm. Other species include wolffish, eelpout (*Lycodes* sp.), lumpfish, skate (*Raja* sp.) and cunners. Great Mosquito Cove and "The Brood" in Bellevue are locally known as a spawning ground for herring and is commonly used for commercial harvest of herring and mackerel (see Chapter 8).

The following species profiles have been provided for those fish and shellfish expected to occur within the Nearshore Study Area and are considered ecologically and/or commercially important. These species are widely distributed and are not unique to the Study Area. Fish species considered at risk are described in Section 11.3.1.

Cunner

Cunners (*a.k.a.*, conner) range from Newfoundland to New Jersey and can occur from intertidal to 100 m water depths (Scott and Scott 1988). Multiple age classes of cunners congregate in shallow nearshore outcrop and boulder habitats, in areas of up to 20 m deep.

Cunners tend to become docile at night and move into nearby crevices. During the winter they are dormant for five or six months and retreat to deep crevices or under rocks until the spring (Green and Farwell 1971). Curran (1992) found that cunner stop feeding for up to six months when water temperature reaches levels that induce torpor and hibernation (approximately 5°C).

Spawning occurs in late July and August in Nova Scotia and eggs are pelagic for approximately three weeks (Tupper and Boutilier 1997). Spawning in Bull Arm likely occurs several weeks later than Nova Scotia. Newly settled cunners are more abundant on shallow, rocky or shell fragment substrates, with or without eelgrass (Tupper 1994). There is no evidence of active habitat selection by newly settled cunner (Auster 1989). Differences in population density between habitats are attributed to post-settlement mortality, rather than emigration. Recruitment success was found to be highest from juveniles settling on rocky reefs, followed by cobble habitats and eelgrass. Recruitment from sand substrates was reportedly zero (Auster 1989). Juvenile cunners feed on amphipods, isopods, zooplankton and small benthic epifauna (Levin 1994). After settlement, cunners have limited home ranges for the first one or two years (Tupper 1994). Juveniles even remain near their nursery area over winter, as opposed to the adults who migrate to deeper offshore waters.

As with the juveniles, adult cunner (age one year and older) are most abundant on reefs, cobble and within eelgrass, respectively, but absent from sand substrates (Auster 1989). The adult cunner's home range is limited to several hundred metres (Green 1975). Adult cunner feed on benthic invertebrates like mussels, barnacles, clams, amphipods and juvenile lobsters. They likely compete directly with lobster, crabs and starfish for mussels as prey (see Auster 1989). Various sculpin species are the primary predators of cunner (Auster 1989).

Capelin

Offshore Newfoundland, capelin generally occur in water depths between 30 and 100 m during the winter until they undergo their spawning migration. In spring or summer, capelin migrate in surface water into bays to spawn on beaches or in deeper waters of up to 125 m offshore. Beach spawning of capelin occurs when water temperatures are in the range of 6°C to 10°C, on gravel substrates ranging from 5 to 25 mm in diameter. Beach spawning is more prevalent at night. Capelin are able to spawn at the age of two; males usually die following spawning.

Spawning may occur in particular areas each year or appear sporadic. The exact time of spawning may be a function of annual water temperature. Spawning lasts four to six weeks, and usually occurs between May and July. Females produce as many as 50,000 eggs at one time. Males tend to spawn more than once during their reproductive season. Eggs attach to the substrate and remain in the sediment between 14 and 52 days, depending on temperature, but last approximately 15 days at 10°C (Scott and Scott 1988).

Upon hatching, capelin larvae remain in the sediment until the right conditions occur (*i.e.*, onshore wind). If these conditions do not occur within five days, the yolk sac is depleted and the chance of survival is poor. If there is an onshore wind during this period, emergence of the larvae occurs and capelin leave the beach. It is a very critical period for the capelin larvae because they can fall prey to any organism that feeds on plankton. Capelin larvae are passive drifters nearshore during the summer months, but become more active swimmers and make their way to deeper water offshore by autumn (see Scott and Scott 1988).

Capelin feed on zooplankton, especially copepods and euphausiids, in the pre- and post-spawning season and eat very little near spawning time (Scott and Scott 1988). Adult capelin are an integral link in the marine food web between plankton and many vertebrates. They are prey for a wide variety of species of fish, marine birds, and baleen whales. Capelin spawning habitat is delineated in Section 12.3.1.2.

Winter Flounder

Winter flounder or “blackback” occurs from central Labrador to Georgia (Scott and Scott 1988). They are an inshore shallow-water species preferring soft to moderately hard substrates (Scott and Scott 1988). Juveniles and young adults inhabit shallower water. Most winter flounder undergo a season migration to deeper waters in the fall and return to nearshore shallow waters in May and June to spawn (Scott and Scott 1988), although the seasonal migration may not be triggered by temperature alone (see Pereira *et al*.1999). Feeding migrations have also been reported from Newfoundland (Keats 1990). Mass movements of winter flounder have been reported due to habitat disturbance. Van Guelpen and Davis (1979) found that winter flounder move from the shallow nearshore waters to deeper water during storm events, possibly to avoid the interference of suspended sediments with feeding (Pereira *et al*.1999).

Flounder eggs are demersal and adhesive, so inshore, the eggs settle in clumps on sand substrates in less than 5 m of water (Pereira *et al*. 1999). Their eggs appear to have a wide salinity and temperature tolerance, with optimal hatching success in waters ranging in salinity from 10 to 30 ppt and in temperature from 3°C to 15°C (see Pereira *et al*. 1999). Hatching can occur within two to three weeks, depending on temperature, and the pelagic larvae settle out approximately eight weeks after hatching (Fahey 1983). Spawning tends to occur in areas where egg and larval dispersal by currents is limited. It has been concluded by several researchers that spawning adults choose to spawn in habitat suitable for larval settlement (see Pereira *et al.* 1999). In other words, spawning and nursery habitats overlap or are adjacent. Several studies have reported that highest densities of newly settled winter flounder occurred on muddy substrates (see Pereira *et al.* 1999).

Winter flounder are considered opportunistic feeders, cued visually by moving benthic invertebrates. Winter flounder are attracted by the most abundant and active epibenthic species (Carlson *et al.* 1997). Flounder feed primarily on benthic invertebrates (Keats 1990), especially polychaetes and amphipods (Carlson *et al.* 1997), but they also eat molluscs, capelin eggs and fish (Scott and Scott 1988).

Greenland Halibut

Greenland halibut (*a.k.a.*, turbot) thrive in the cold, northern waters. In the northwestern Atlantic, they are especially abundant in the deep coastal bays or fjords of West Greenland, off the Continental Shelf of Baffin Island and in the Ungava Bay area of Hudson Strait. They are also found at greater depths along the Continental Slope of Labrador, and in the deepwater bays of northeastern Newfoundland. Upon approaching maturity, there appears to be a general migration to Davis Strait. They are fished commercially within the Nearshore Study Area (DFO Coastal Resource Inventory website, accessed October 2009).

Small fish (less than 20 cm in length) feed on plankton and shrimp-like crustaceans, while larger fish (up to 80 cm) in the southern Labrador and Newfoundland areas eat mainly capelin. Those that swim in the deep channels of northern Labrador and West Greenland live mainly on shrimp. Very large halibut feed heavily on larger fish such as squid, cod, redfish (*Sebastes* spp.) and even other Greenland halibut.

Although Greenland halibut can be found in small numbers at depths of less than 100 m, most of them are caught near the sea bottom at depths of between 200 to 600 m. In the southern part of the range; however, they go as deep as 1,500 m.

See Section 7.3.3.5 for more details on the life history of Greenland Halibut.

Herring

In the northwest Atlantic, herring occur from southern Labrador to Cape Hatteras (Scott and Scott 1988). Herring are commercially fished in Trinity Bay in the spring and the fall (see Section 8.1.5). Herring move into the bays in the spring to spawn and feed and move to deep water to over-winter, possibly within Trinity Bay (see Chapter 5).

Great Mosquito Cove and an area known as The Brood near Bellevue, are locally known as spawning areas for herring. Herring are demersal spawners, depositing their eggs on stable substrates in high energy environments with strong tidal currents (Iles and Sinclair 1982, in Stevenson and Scott 2005). Spawning can occur on offshore banks at depths of 40 to 80 m; however, most herring stocks spawn in shallow coastal waters at depths of less than 20 m. Masses of herring eggs attach to the hard bottom substrate nearshore or to kelp leaves. Larvae hatch after approximately 30 days at 5°C and after 10 days at 15°C (Scott and Scott 1988). Duration of the pelagic larval stage is temperature-dependent and therefore depends on the time of spawning. Spring recruits will remain in the water column during spring and summer, but the fall recruits may be pelagic until the following spring. Eggs and larvae can be contained near the spawning grounds by tidally induced retention areas, or may passively drift with the dominant currents (DFO 1984).

Herring primarily feed on euphausiids (DFO 2005a) and they are an important prey item for other fish, marine birds and marine mammals.

Atlantic Mackerel

This pelagic fish undertakes long annual migrations, often travelling in dense schools in spring and fall. Most mackerel spawning occurs in the southern Gulf of St. Lawrence in June and July. These fish migrate from the Gulf in July and August through the Strait of Belle Isle, to the east coast of Newfoundland, where they are fished until November or December.

It is estimated that approximately 20 percent of adult mackerel die each year due to causes other than fishing. Sudden drops in temperature may kill even adult mackerel. Mass mortalities have been observed along the northeast coast of Newfoundland in the late fall.

Mackerel are preyed upon by large sea animals such as whales, seals, tunas, and sharks, and also by sea birds such as gannets. Cod and squid also feed upon small mackerel. Mackerel feed on plankton and on small fish, notably capelin, juvenile herring and mackerel. They engage in both "selective" feeding (the active pursuit of larger plankton and fish) and "filter" feeding, where the gill rakers filter small food items from the water.

Lumpfish

Mature lumpfish migrate inshore in the spring or early summer to spawn and return to deeper waters in the fall (Scott and Scott 1988). Males arrive on the spawning grounds several weeks in advance of the females to establish their territories. The females lay two to three egg masses on rocks in shallow water at intervals ranging from 8 to 14 days. The eggs are guarded and fanned by the male until hatching occurs after six to eight weeks, while the female returns to deeper water. Egg masses may contain more than 100,000 to 130,000 eggs measuring 2 mm in diameter and light green to yellowish in colour.

Larvae are approximately 5 mm at release and are considered semi-pelagic, remaining in the upper metres of the water column for their first year, during which time they are often associated with floating algae. After settlement, juveniles are often found in shallow water among eelgrass and kelp leaves, especially *Laminaria* sp. (Moring 1989). During their early life stages, lumpfish attach to rocks, lobster traps and other solid objects with their pelvic adhesive disc.

Juveniles eat mostly copepods and amphipods during the summer (Moring 1998). The adult lumpfish tends to feed during the winter and their diet primarily consists of coelenterates, ctenophores, chaetognaths, amphipods, euphausiids, copepods, some molluscs polychaetes and small fish, such as herring and sand lance (Scott and Scott 1988; Moring 1989).

Thorny Skate

Thorny skate (*Amblyraja radiata*) are a temperate to Arctic species, widely distributed in the North Atlantic, ranging from Greenland to South Carolina (Kulka *et al.* 2006). Thorny skate have been observed over a wide range of depths, from nearshore to 1,700 m, with most of their biomass noted to occur between 50 to 150 m (Kulka and Miri 2003). Thorny skate are observed on both hard and soft substrates (Kulka *et al.* 1996), but are primarily associated with muddy, sandy and pebble substrates (Kulka and Miri 2003). The most common temperature where skate are found is in the 3°C to 4°C range (Colbourne and Kulka 2004). Thorny skate deposit between 6 and 40 egg cases per year (DFO 2003).

Thorny skate feed on a variety of invertebrates and fish including polychaetes, crabs and whelks (Kulka and Miri 2003). The diets of larger skates include fish prey such as sculpins, redfish, sand lance and small haddock (*Melanogrammus aeglefinus*). Considerable amounts of fish offal have been found in skate stomach and this, coupled with the ventral mouth location, suggests that thorny skate are opportunistic bottom feeders. There is limited information on the predators of thorny skate, but they are likely prey for large predators such as seals, sharks and Atlantic halibut (*Hippoglossus hippoglossus*).

Thorny skate abundance has increased from the early 1970s through the mid-1980s, followed by a decline to its lowest levels in the mid-1990s, where it has remained stable (DFO 2003). Thorny skate have become concentrated in approximately 20 percent of their former range, primarily the edge of southwest Grand Banks.

Shellfish

Shellfish species in the area include American lobster, sea scallop, horse (*Modiolus modiolus*) and blue mussels, rock crab (*Cancer irroratus*) and toad crab (*Hyas coarctatus*). The northern shortfin squid (*Illex illecebrosus*) is an important but infrequent commercial species that can occur in abundance within Trinity Bay. The focus of the following descriptions is the biology of these commercial species.

Lobster

Lobsters range throughout the western North Atlantic from Cape Hatteras north to the Strait of Belle Isle and are commercially fished in the Nearshore Study Area. Populations tend to be localized in less than 50 m of water. Adult lobsters inhabit coastal waters during the summer, but migrate to warmer, deeper waters in the winter. Young lobsters generally stay close to the coast in depths of 10 m or less, and do not migrate during the winter.

Mating can occur between July and September, depending on water temperature. If water temperature remains below 5°C, spawning will be later than usual, or may not occur at all (Aiken and Waddy 1986). Embryo development is also regulated by temperature and proceeds slowly when temperatures are below 6°C. On the east coast of Newfoundland, lobster larvae begin hatching (emergence of stage 1 larvae) during the first half of July, when bottom temperatures are between 10.0°C and 13.8°C (Ennis 1995), but may be delayed if the water temperature is lower. Upon hatching, larvae are planktonic and the larvae moult through three stages to the fourth stage, the bottom-dwelling stage, between 42 days (15°C) to 94 days (10°C) (Harding 1992). Larval development cannot be completed at low temperatures, thus it is important that hatching occurs before water temperatures decline; this is particularly important in the northern part of the lobster's range. The post-larvae move down through the water column and settle on the bottom, where they grow through juvenile stages and into adult form. Post-larvae may delay settlement if faced with unsuitable habitat and may undergo a succession of "touchdowns and liftoffs" until suitable substratum is encountered (Aiken and Waddy 1986). During the pelagic stage, larvae are primarily drifters (*i.e.*, wind and currents in the upper water column largely determine their distribution) (Katz *et al.* 1994), but they can exhibit some control over distance travelled by vertical migration (Ennis 1995).

Juveniles for the first couple of years occupy self-dug tunnels or natural crevices under cobble to avoid predation by coastal predators, such as cunner (Harding 1992). Where predators are present, time is crucial during settlement and many lobsters are likely to succumb if pre-existing shelters are not found (Wahle and Steneck 1992). According to Harding (1992), juveniles stay in their burrows, feeding on passing plankton and detritus until they reach a size corresponding to a carapace length of greater than 30 mm, when they leave the tunnels at night to feed. Wahle and Steneck (1992) report that juveniles are generally found occupying crevices and holes near small boulders or burrowing under rocks and eelgrass. Juvenile lobsters usually remain within a few kilometres of where they settle and migrate over several kilometres only after becoming mature.

In Newfoundland, it takes 8 to 10 years for a lobster to reach commercial size (DFO 2006). Adult American lobsters are known to be solitary and appear to conform to the general pattern of diminishing predator avoidance with greater body size; however, lobsters do continue to shelter as adults but are more transient than smaller lobsters. Shelter availability is a critical feature of adult lobster habitat, leading adults to select habitats where burrows can be dug or where they pre-exist under rocks or boulders.

Lobster diet consists mainly of benthic invertebrates including rock crab, polychaetes, molluscs, echinoderms and fish (DFO 2006). Adult lobsters have few natural predators, with the commercial fishery accounting for most adult mortality.

Snow Crab

In the nearshore environment, snow crab are common in the estuary and the Gulf of St. Lawrence, around Cape Breton Island and in the bays of Newfoundland, from Fortune Bay to White Bay. Snow crabs feed on a variety of shellfish, worms, sea urchins, brittlestars and detritus.

Snow crabs live most commonly on muddy or sand-mud bottoms at temperatures ranging from -0.5°C to 4.5°C, at depths between 170 to 380 m off Newfoundland (DFO 2005b). The distribution of small crabs is not well documented but they are occasionally found with the adults, or on gravelly bottoms at shallower depths. In some areas, there are indications that snow crabs move from gravel bottom to mud bottom, usually in deeper waters, as they reach maturity.

Mating is thought to occur at the end of the winter or in the spring. The eggs are carried until the following year. Newly hatched larvae are approximately 3 mm long. They immediately rise to the surface, where they are carried by the currents before they settle back on the bottom, most probably at a different place than where they hatched. During this period, they go through three different larval stages before adopting the regular shape of crabs and settle to the sea floor at 3 mm wide across the shell.

See Section 7.3.3.5 for more details on the life history of snow crab.

Sea Scallops

Sea scallops are benthic bivalve molluscs found in the Northwest Atlantic, from the Strait of Belle Isle to Cape Hatteras. They occur on sand or gravel substrates at depths of 35 to 120 m in large aggregations (beds), but also occur within shallow water nearshore. Sea scallops occur in the Bull Arm area in low densities. Sea scallops do not migrate, but are capable of limited ‘swimming’ by clapping their shells together.

The primary spawning event for sea scallops in Newfoundland waters generally occurs in late September/early October and lasts between two to four weeks. The first two larval stages of the scallop are pelagic, remaining planktonic for over a month after hatching and usually settling to the seabed by December (Hart and Chute 2004). Settlement is dependent on the larvae detecting a suitable substrate (Pearce *et al.* 2004). Larvae preferentially settle on hard surfaces, preferring substrates with shell fragments and small pebbles including existing scallop beds (Hart and Chute 2004). Scallops are filter feeders, extracting plankton and nutrients from sea water.

Blue Mussel

Blue mussels are found throughout the Nearshore Study Area, moored to any firm support available. This common smooth-shelled mussel with pointed terminal beaks has a circumpolar range, south in western Atlantic Ocean to South Carolina, from slightly brackish estuaries to depths of 100 m offshore (Gosner 1978).

Mussels moor themselves with tough threads and compete with barnacles and seaweeds to cover intertidal rocks and pilings. Given a foothold of scattered stones or shells, they form shoals, even on muddy tidal flats (Gosner 1978).

Horse Mussel

Horse mussels are also found throughout the Nearshore Study Area. Horse mussels have a circumpolar range, south in western Atlantic Ocean to Long Island or Staten Island, NY. They extend up into the lower intertidal zone in eastern Maine, but are chiefly subtidal in deeper water to 80 m. This species is mainly seen as a beach shell, often cast ashore in the grip of laminarian seaweed holdfasts.

Northern Shortfin Squid

The northern shortfin squid is a highly migratory ommastrephid that inhabits the Continental Shelf and Slope waters of the Northwest Atlantic Ocean, between Iceland and the east coast of Florida, and is considered to constitute a single stock throughout its range (Dawe and Hendrickson 1998).

The onset and duration of the squid fisheries reflect the timing of squid availability on the fishing grounds. Bottom-trawl fisheries occur on the US Continental Shelf, primarily in the Mid-Atlantic Bight, and have historically occurred on the Scotian Shelf off Canada during June through late autumn (Hendrickson *et al.* 2002). In Newfoundland waters, an inshore jig fishery exists later in the year, generally during August through late autumn.

Migration patterns between US and Canadian fishing grounds are unknown. Recruitment occurs throughout the fishing season and monthly cohorts are replaced every two to three months by younger squid. Squid caught during July to November were predominantly hatched during spring (March to May) rather than winter.

Squid eat voraciously, consuming a variety of crustacean and fish, but juvenile cod and capelin are a common food for squid in Newfoundland waters (Dawe *et al.* 1997). Squid are preyed upon by several species of fish, marine birds and whales.

Short-finned squid are believed to live no more than 12 to 18 months, migrating southwestward from the adult feeding areas to an imprecisely known spawning area where, after spawning, they die.

7.3.2 Offshore

The primary components of the marine ecosystem on the Grand Banks, where the Offshore Study Area is located, are phytoplankton, zooplankton (including ichthyoplankton), benthos, macroinvertebrates (scallop, crab, shrimp), fish, marine birds and waterfowl and marine mammals. These components of the Grand Bank ecosystem have been described extensively in various documents (Mobil Oil 1985; Petro-Canada 1995; Husky Oil 2000).

Site-specific fish and fish habitat data were collected from the Hebron Offshore Study Area during surveys in 2001 (Chevron 2002, 2003). These data are complemented by EEM survey data collected by operators of adjacent offshore oil and gas projects since 1994, and by several descriptions of existing conditions for marine fish and fish habitat for other environmental assessments overlapping with the Hebron Offshore Study Area. DFO RV data from 3Lt have also been reviewed along with relevant fish and fish habitat primary literature for the Hebron Offshore Study Area.

The following description of the fish and fish habitat within the Hebron Offshore Study Area makes preferential use of site-specific information when this information is available; otherwise, a summary of information available for fish and fish habitat as a whole is provided.

7.3.2.1 Offshore Physical Environment Overview

The Offshore Project Area is located on the northeastern margin of the Grand Bank with water depths ranging from 93 to 100 m. Tidal range in the area is from 0.8 to 0.9 m. The chief water mass for the area originates with the nutrient-rich Labrador Current, but the Gulf Stream also has an important influence on the biology of this area of the Grand Bank. The mixing of the Labrador Current and the warm Gulf Stream creates a productive ecosystem. The offshore branch of the Labrador Current is 50 to 60 km to the east of the Offshore Project Area. Seasonal water temperatures can vary considerably from the surface to the substrate. Maximum surface water temperature recorded is 15.4°C and only 3.0°C near the sea bottom. The minimum surface water temperature has been recorded at -1.7°C and the minimum bottom temperature is also -1.7°C (Chevron 2001a). Current speed in the area varies from surface waters to the substrate. Annual averages of near-surface waters (at 20 m depth) are 0.77 m/s; near bottom (at 70 m), currents average 0.63 m/s annually. The maximum difference between the two depths occurs from July to September, when the average surface currents are 0.80 m/s, compared to 0.41 m/s near the bottom (Chevron 2001a). A detailed summary of oceanographic conditions in the area is provided in Section 3.2.2.

7.3.2.2 Habitat

Substrate within the Offshore Project Area is predominately fine/medium sand, with a mix of coarse cobble gravels in some areas and less than 4 percent fines (Chevron 2001b). Gravel content is lower in the southern half of the Hebron site (1.4 percent gravel) than in the northern portion (6.2 percent gravel). See Section 3.2 for more detail.

There are sedimentary bedforms throughout the Offshore Project Area that are up to 1 m thick (Chevron 2001b). The western portion of the Offshore Project Area is dominated by large sand ridges that are orientated north to south, sand ripples and sand waves (Chevron 2001b). The eastern half of the Offshore Project Area is predominantly gravel, with sand and cobbles (Chevron 2001b). Sand ridges and ripples are also present in this area. Trawls during the reconnaissance survey recovered boulders ranging from 15 to 60 cm in diameter over the western portion of the Offshore Project Area (Chevron 2003). Boulders of 1 to 2 m diameter are reported to be occasionally present over the site (Chevron 2001b).

Site-specific information on sediment particle size and benthic communities is available for the Offshore Project Area. A total of 20 stations were sampled for sediment particle size, benthic community structure analysis, sediment chemistry (metals and hydrocarbon) analyses and sediment toxicity testing in 2001. The sediment chemistry in the area appears to have been influenced by exploration drilling. Sediments near the location of an abandoned well show elevated levels of barium (3,300 ppm), lead (15 ppm), manganese (87 ppm), strontium (250 ppm), ammonia (22.7 ppm) and sulphur (0.21 percent) (Chevron 2003); the highest levels of vanadium (8 ppm) and zinc (8 ppm) were reported adjacent to another abandoned well location. Median concentrations for each of these elements were well within baseline and year one of the Terra Nova EEM program results (Chevron 2003). Eight of the twenty sediment samples taken throughout the Hebron Project Area were declared toxic using the Microtox™ test. None were declared toxic by the amphipod survival test. The Microtox™ test is known to be hyper-sensitive in substrates with less than 20 percent fines, which is the case in the Hebron Project Area (Chevron 2003).

7.3.2.3 Plankton

Phytoplankton are the most important primary producers on the Grand Banks, converting water and carbon dioxide into organic matter through photosynthesis. The resulting biomass supports the entire marine food web. Peak abundance of phytoplankton on the Grand Bank usually occurs in late April to early May, within the top 30 to 50 m of the water column (Pepin and Paranjape 1996). The spring bloom is dominated by diatoms. An autumn phytoplankton peak is also characteristic of the northern Grand Bank but an obvious peak may not occur on the southern Grand Bank (Myers *et al.* 1994). Dinoflagellates and other microflagellates dominate the fall bloom.

Zooplankton are a crucial link between primary production and higher trophic levels (*e.g.*, fish, crustaceans); many harvested species, including crab, shrimp and a number of fish species, have planktonic eggs and larvae. Herbivorous zooplankton such as copepods feed on phytoplankton, and are then in turn consumed by invertebrates, fish, birds and marine mammals. Zooplankton are also a major source of detritus for the benthic community, which serves as a critical pathway for nutrient generation.

Despite the general trend in ocean warming observed over the whole of the North Atlantic since the late 1990s, the seasonal cycles of most phyto- and zooplankton species on the Grand Bank have remained relatively stable. (Malliet and Pepin 2006).

Zooplankton in the Northwest Atlantic are dominated by copepods (Myers *et al.* 1994), whose abundance rises sharply in spring and, to a lesser degree, in fall in response to phytoplankton abundance. Ichthyoplankton, or fish eggs and larvae, constitute a portion of the zooplankton community. In the 1990s, fish larvae have been found to be most abundant to the north of the Grand Banks on the northeast Newfoundland Shelf, while the lowest densities were reported on the eastern part of the Grand Banks (Dalley *et al.* 2000). More recent ichthyoplankton surveys on the northeast Grand Banks, during late summer and early fall, indicate the ichthyoplankton may include Atlantic cod, American plaice (*Hippoglossoides platessoides*), sand lance, redfish, jellyfish, squid, lanternfish (*Myctophum* spp.), alligator fish (*Aspidophoroides monopterygius*), sculpins (unidentified), blennies, seasnails, white hake (*Urophycis tenuis*), haddock, wolffish (unidentified), witch flounder (*Glyptocephalus cynoglossus*), yellowtail flounder (*Limanda ferruginea*) and Greenland halibut (Dalley *et al.* 2000). Capelin, sand lance and redfish are the most abundant ichthyoplankton species in the area during August and September (Anderson *et al.* 1999). The temporal distribution of species potentially contributing to the ichthyoplankton within the Offshore Project Area are summarized in Table 7-2.

7.3.2.4 Benthos

Benthos refers to the community of plants and animals living in or on the seafloor. These organisms range in size from microscopic to tens of centimetres in length. The benthic fauna on the Grand Bank is mostly suspension and surface-deposit feeding (Mobil Oil 1985). A typical epibenthic community on the Grand Banks would be dominated by sand dollars, starfish and amphipods.

A primary food source for some benthos, like the sand dollar and sea urchin, is detritus. Other benthic organisms such as scallops will filter-feed on live plankton as it passes by in the current, while American plaice, for example, are predators, and actively hunt for benthic and epibenthic fauna.

The community living several centimetres within the sediment is called infauna and dominated by a variety of marine worms (polychaetes). Other common infaunal organisms include clams, amphipods and cumaceans.

Table 7-2 Spawning Time and Location of Fish Potentially near the Offshore Project Area

Fish Species	Spawning Period	Spawning Location	Timing of Pelagic Eggs/Larvae	Reference
Yellowtail Flounder	April to June	Central and southern Grand Banks	Not known	Ollerhead *et al.* 2004
Witch Flounder	March to June	Southern Grand Banks (3O) during peak spawning; northern 3L and in 3N later in summer	Not known	Ollerhead *et al.* 2004
Thorny Skate	Fall to Winter	Edge of Grand Banks, especially in 3Ps	Not known	Kulka *et al.* 2004b
Redfish	June	Northeastern edge of Grand Banks in >200 m of water	Larval extrusion typically occurs in late spring/summer months	Ollerhead *et al.* 2004
Capelin	June and July	Coastal beaches of Newfoundland	Not known	Carscadden *et al.* 2001
Snow Crab		Developing fertilized eggs are carried by the female	Larval hatch generally occurs in late spring/summer. Larvae remain planktonic for three to four months.	
Northern Shrimp	June and early July	Flemish Cap, eastern and northern edges of Grand Banks in 3LN, and near the south coast in 3P	Eggs remain attached to females from late summer/fall until larval hatch the following spring/summer. Larvae remain planktonic in upper water column for a few months	Ollerhead *et al.* 2004
Stimpson's Surf Clam	Summer/early fall and another smaller one in October	Eastern edge of the Grand Banks in 3N	Not known	Ollerhead *et al.* 2004
Greenland Cockle	Not known	Not known	Not known	

Spatial variability within the epifaunal and infaunal benthic community structure can be expected within metres on the Grand Banks (Schneider *et al.* 1987; Schneider and Haedrich 1991). When disturbance to the habitat occurs by a storm event or fishing gear, for example, epifaunal and infaunal benthos are exposed (*e.g.*, polychaetes) and vulnerable to heavy predation (*e.g.*, snow crab). The community in an affected area will undergo a succession of rebuilding and maturation over several generations. The dynamic physical environment of the Grand Banks seafloor coupled with the temporal variability in abundance of some macrofaunal species (Kenchington *et al.* 2001), results in highly variable benthic communities, even within a small area. On a larger scale, benthic community structure is not only influenced by grain size, but also by water depth and composition of the water mass (Bundy *et al.* 2000). Grain size and several benthic community indices (*e.g.*, species abundance, richness, diversity) are strongly correlated within the Terra Nova field (DeBlois *et al.* 2005).

In areas of less fines (*i.e.*, grain size of <500 µm) in the substrate, there are fewer short-lived polychaetes, amphipods and cumaceans, in particular, but fewer brittle star and the soft-shell coral were also noted (Kenchington *et al.* 2001). There are even fewer sessile species on sandy substrate because the environment is very dynamic and unstable. Most species are free-living or burrowing, with some tube-building species present as well.

The estimated benthic biomass for Northwest Atlantic Fisheries Organization (NAFO) Division 3LNO is 230.6 tonnes/km^2, compared to the less productive northern Divisions of 2J and 3K at 98.5 tonnes/km^2 total biomass (Bundy *et al*. 2000). These estimates do not include bivalve shell weight (Table 7-3).

Table 7-3 Estimates of Mean Benthic Biomass in Northwest Atlantic Fisheries Organization Units 2J3KLNO

Benthic Group	2J or 3K Biomass (t/km^2)	3LNO Biomass (t/km^2)	2J3KLNO Biomass (t/km^2)
Echinoderms	70.6	144.8	112.3
Molluscs	16.4	62.2	42.1
Polychaetes	8.8	11.9	10.5
Other	2.7	11.8	7.8
Total Biomass	98.5	230.7	172.7
Source: Bundy *et al.* (2000)			

An otter trawl survey of the Offshore Project Area during late June and early July of 2001 found that shrimp was the most abundant benthic invertebrate group, followed by sea urchins and sand dollars. Also present, but less common, were soft shelled clams, snow crab, toad crab, Iceland scallop (*Chlamys islandica*) and sea stars (Chevron 2002).

Relative abundance of dominant species in benthic samples collected within the Offshore Project Area is provided in Table 7-4. Mean relative abundance is expressed as a percent of the total. These data indicate minor differences in species composition between predominantly sand and gravel areas for the less abundant taxa. Amphipoda and Echinodermata diversity and abundance were higher in the sand dominated substrate, whereas Tunaidacea were absent in sand dominated substrate.

Polychaetes are the most abundant group of benthic invertebrates on the Grand Banks. Many of the most common polychaete species are selective deposit feeders, like members of the Spionidae and Cirratulidae families, who sort the organic material from the sediment prior to ingestion (Brusca and Brusca 1990). However, the most abundant polychaete species is *Exogene hebes*, an active predator.

Table 7-4 Hebron Taxa with Mean Relative Abundances ≥1%

Taxon		Abundance (number)		Percent of Total	
		Sand	Gravel	Sand	Gravel
Polychaeta	Spionidae	705	632	28	34
Polychaeta	Syllidae	374	232	15	13
Polychaeta	Cirratulidae	316	345	13	19
Polychaeta	Paraonidae	191	103	8	6
Polychaeta	Sigalionidae	136	87	5	5
Polychaeta	Orbiniidae	68	84	3	5
Polychaeta	Phyllodocidae	60	40	2	2
Polychaeta	Opheliidae	26	0	1	0
Polychaeta	Sabellidae	0	18	0	1
Echinodermata	Echinarachnidae	43	24	2	1
Echinodermata	Ophiuridae	35	0	1	0
Bivalvia	Hiatellidae	45	38	2	2
Amphipoda	Haustoriidae	31	0	1	0
Amphipoda	Phoxocephalidae	28	0	1	0
Amphipoda	Oedicerotidae	0	27	0	1
Tanaidacea	Tanaidacea (unspecified)	0	62	0	3
Source: Chevron (2003)					

The Opheliidae family occurred only in the sandy substrate of the Offshore Project Area (Chevron 2003). These are mostly direct deposit feeders, ingesting the substratum and digesting the organic matter contained on the particles (Brusca and Brusca 1990). As is the case within the Terra Nova Field, the most abundant species in this family was *Ophelia* sp. This is a burrowing species in soft substrata (Brusca and Brusca 1990).

Sabellid polychaetes were found exclusively within the more gravelly substrates of the Offshore Project Area (Chevron 2003). These tube-dwelling polychaetes use their feathery tentacles for suspension feeding (Brusca and Brusca 1990). Their tubes can extend 3 to 8 cm into the substrate and 5 to 7 cm above the seafloor. Another abundant polychaete in the more gravelly substrate is the Tanaidacea family. This family includes burrowers or tube suspension feeders, as well as active predators (Brusca and Brusca 1990).

The most common echinoderm found was the sand dollar (Chevron 2003). Sand dollars can occur in densities as high as hundreds per square metre by layering in loosely packed sediment (Cabanac and Himmelman 1996). It is usually the smaller juvenile sand dollars that are buried several centimetres into the substrate. Adult sand dollars may bury themselves to avoid heavy predation (Cabanac and Himmelman 1996). Sand dollars prefer areas of relatively high turbulence and current and sediment grain size of less than 230 µm (Ellers and Telford 1984). They feed by ingesting sediment particles, removing the organic material and excreting the inorganic particles. This physical shuffling of substrate by feeding and burrowing adds complexity to an often homogeneous sandy habitat. This complexity is crucial to maintaining species diversity in fine sediments (Kenchington *et al.* 2001). Sand dollar bioturbation is second only to storm events in reworking surface sediments (Stanley and James 1971). The primary predators of sand dollars are yellowtail flounder and American plaice. Other common detritivores in the area are the green sea urchin and the brittle star.

The most common bivalve molluscs were the propeller clam (*Cyrtodaria siliqua*) and a clam called the chalky macoma (*Macoma calcarea*) (Chevron 2003). Macoma is a deposit or detrital feeder. Gammarid amphipods, cumacea and isopods are also detritivores. The *Priscillina armata* amphipod was found exclusively in the sandy substrate within the Offshore Project Area. It is characteristic of clean offshore sandy substrates (Kenchington *et al.* 2001). These amphipods feed on suspended detritus (Brusca and Brusca 1990).

Deep-water corals are found primarily below the 200 m depth contour along the edge of the Continental Slope, in canyons or in channels between banks (Edinger *et al.* 2007; Campbell and Simms 2009). Some soft corals are known to occur in shallower areas on the Continental Shelf and some were found during the DFO RV surveys between 2003 and 2008 (Table 7-5; Figures 7-3 and 7-4). The sea strawberry (*Gersemia rubiformis*) and sea broccoli (*Capnella flordia*) corals were the most commonly encountered species, landed in eight and six trawls, respectively. Nepheid corals were collected in a single trawl sample.

Table 7-5 Mean Catch Depth, and Minimum and Maximum Catch Depth during DFO Research Vessel Surveys in the Offshore Project Area from 2003 to 2008 (Corals)

Group/ Family	Scientific Name	Common Name	Number of Trawls	Mean Depth (m)	Minimum Depth (m)	Maximum Depth (m)
Aylcocacean	*Capnella flordia*	sea broccoli	6	94.5	70.0	110.0
	Gersemia rubiformis	sea strawberry	8	94.8	70.0	105.0
	Unknown	unknown	3	94.0	81.0	104.0
Nepheid	Unknown	unknown	1	79.0	78.0	80.0

Within the Hebron Offshore Study Area, coral were more commonly collected in deeper water, along the edge and slope of the Continental Shelf. Strawberry and sea broccoli corals were collected in 40 and 47 RV sampling trawls, respectively. Additional species collected in more than two trawls included mushroom coral (*Anthomastus grandiflorus*), sea pen and bubblegum coral (*Paragorgia arborea*). The complete list of corals collected in RV trawls from 2003 to 2008 is provided in Table 7-6.

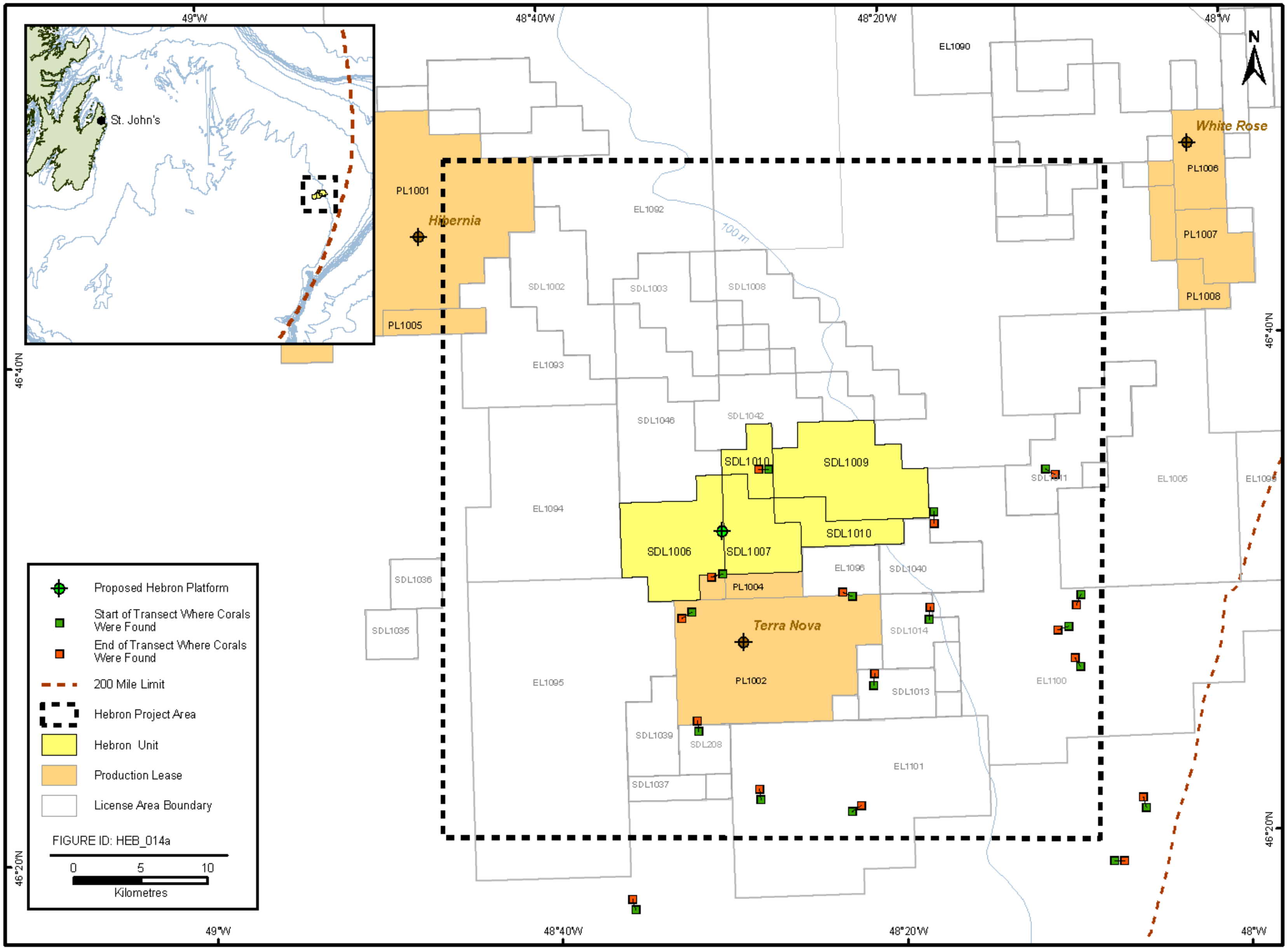


Figure 7-3 Corals Collected from the Offshore Project Area between 2003 and 2008

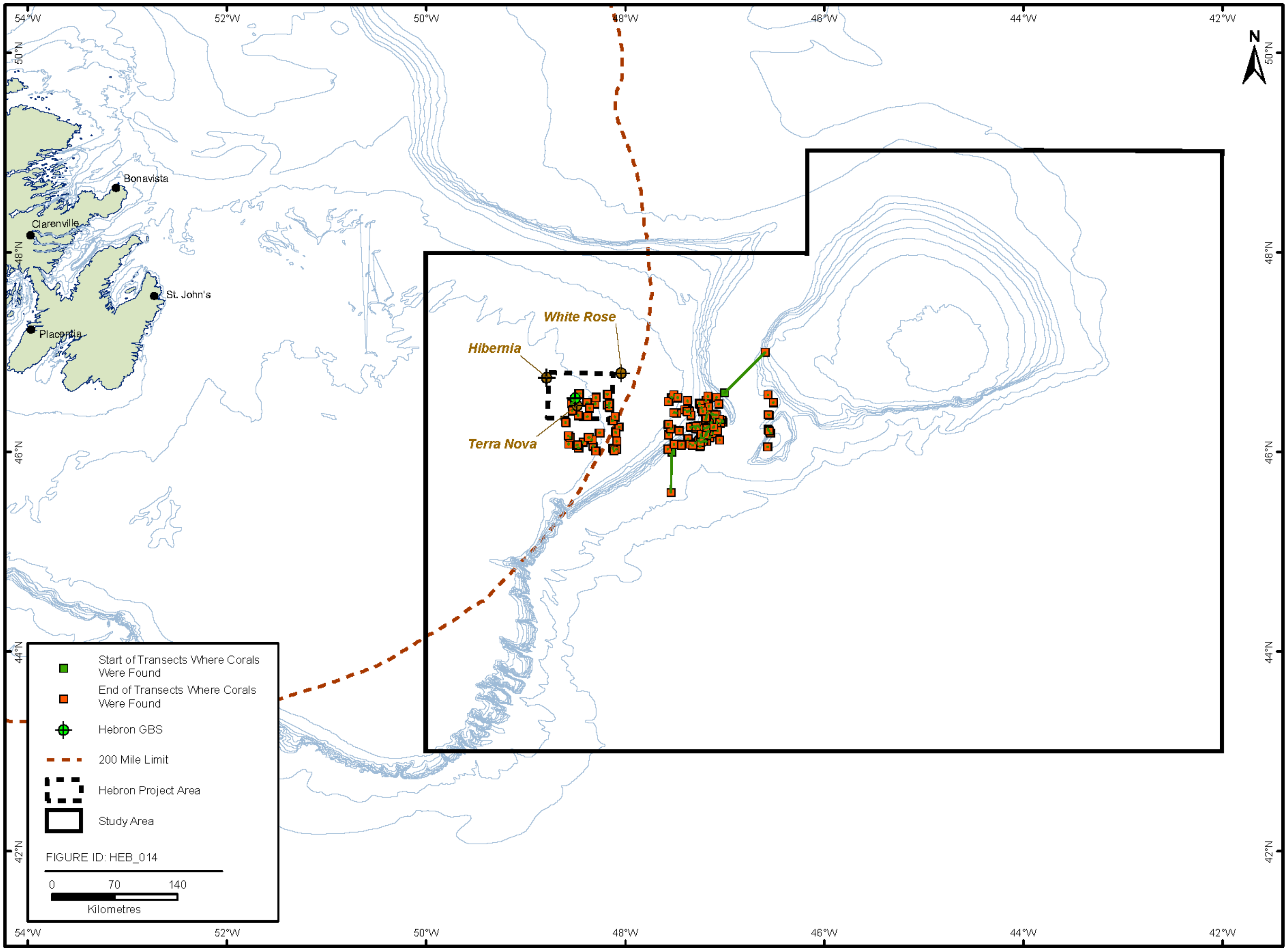


Figure 7-4 Corals Collected from the Hebron Offshore Study Area between 2003 and 2008

Table 7-6 Mean Catch Depth, and Minimum and Maximum Catch Depth during DFO Research Vessel Surveys in the Hebron Offshore Study Area from 2003 to 2008 (Corals)

Group/Family	Scientific Name	Common Name	Number of Trawls	Mean Depth (m)	Minimum Depth (m)	Maximum Depth (m)
Alyconacean	*Anthomastus grandiflorus*	mushroom coral	8	1,030.4	818.0	1247.0
	Capnella flordia	sea broccoli	47	335.8	61.0	680.0
	Gersemia rubiformis	sea strawberry	40	276.0	60.0	688.0
	Unknown	unknown	4	1,032.3	818.0	1,247.0
Neptheid	Unknown	unknown	29	604.1	64.0	1,318.0
Pennatulidacea	Pennatulidae Genus	sea pen	6	1,063.5	795.0	1,214.0
Unknown Coral	Unknown	unknown	2	427.0	173.0	684.0
Gorgonia	*Acanella arbuscula*	bonsai coral	2	1,201.5	1,189.0	1,214.0
	Acanthogorgia armata	-	3	1,094.3	818.0	1,247.0
	Paragorgia arborea	bubblegum coral	5	320.4	121.0	583.0
	Keratoisis ornata	bamboo coral	2	1,228.0	1,208.0	1,247.0
	Paramuricae Genus	black coral	1	827.0	818.0	834.0
	Radicipes gracilis	sea whip	2	932.0	840.0	1,022.0

Deep-water corals are recognized as an important component of deep-water ecosystems providing habitat for a variety of fish species, including commercially-important species (Gilkinson and Edinger 2009). Their longevity and slow growth rates may result in recovery times from a disturbance in the tens to hundreds of years. While life histories and basic biological knowledge remains largely unresolved, thereby limiting the understanding of their ecological relationships, ongoing research by the DFO-Memorial University deep-water corals research group is working to resolve some of these data gaps (Gilkinson and Edinger 2009).

Campbell and Simms (2009) would be added to some of the citations as they confirm information cited in this report.

7.3.2.5 Fish and Shellfish

Fish species most likely to occur within the Offshore Project Area are those historically widespread over the Grand Banks. These species are yellowtail flounder, American plaice, Atlantic cod and thorny skate. In more recent years, these species have been concentrated on the southern part of the Grand Banks. Monkfish (*Lophius americanus*), white hake, Atlantic halibut, haddock and pollock (*Pollachius virens*) are mostly found in the warm waters of the Southwest Slope, whereas roundnose (*Coryphaenoides rupestris*) and roughhead (*Macrourus berglax*) grenadiers, Greenland halibut and redfish are commonly found in deeper water on the slope of the Grand Banks. Common epibenthic species in deeper areas include pink shrimp (*Pandalus borealis*), queen crab (*Chinocetes opilio*), witch flounder and redfish.

Pelagic, schooling species common to the Offshore Project Area are capelin, Arctic cod (*Boreogadus saida*) and sand lance. These species are all an important food supply for larger pelagic fish species, whales, seals and marine birds.

The brittlestars, macoma bivalves, sea urchins, propeller clams and sand dollars are important components of the diet for several groundfish (Methven 1999). Smaller flatfish like yellowtail, American plaice and witch and winter flounders feed primarily on amphipods, enchinoderms and polychaetes, and may supplement their diet with sand lance. Species such as sand lance and capelin may be a larger component of the turbot and halibut diet (Methven 1999).

In general, the Offshore Project Area does not support a higher biomass of demersal fish relative to other areas of the Grand Banks (Kulka *et al.* 2003). Historically, the most abundant species in the area, and over the entire Grand Banks, were Atlantic cod and American plaice. However, in more recent years, these species have become uncommon on the northern portion of the Grand Banks. Such is the case for the Newfoundland region generally; the groundfish fisheries have been replaced by snow crab and shrimp fisheries.

Offshore Project Area Sampling

There were 17 finfish species collected by otter trawl during the Hebron biological survey in late June to early July 2001 (Chevron 2002). Sand lance were the most abundant species as indicated by catch rate, followed by capelin, mailed sculpin (*Triglops mybelini*) and American plaice. Other common species collected during this survey include alligator fish, hookear sculpin (*Artediellus uncinatus*), and spatulate sculpin (*Icelus spatula*) (Figure 7-5). Species occurring infrequently during the survey were Arctic cod, Arctic eelpout (*Lycodes reticulatus*), Atlantic cod, seasnail, snakeblenny (*Lumpenus lumpretaeformis*) and thorny skate.

The survey revealed a clear preference for the sand substrate by American plaice, mailed sculpin, hookear sculpin, sand dollar and soft-shelled clam. Species preferring the more gravelly substrate were sand lance, shrimp, capelin, sea urchin, Arctic alligator fish (*Aspidophoroides olriki*), spatulate sculpin and Iceland scallop.

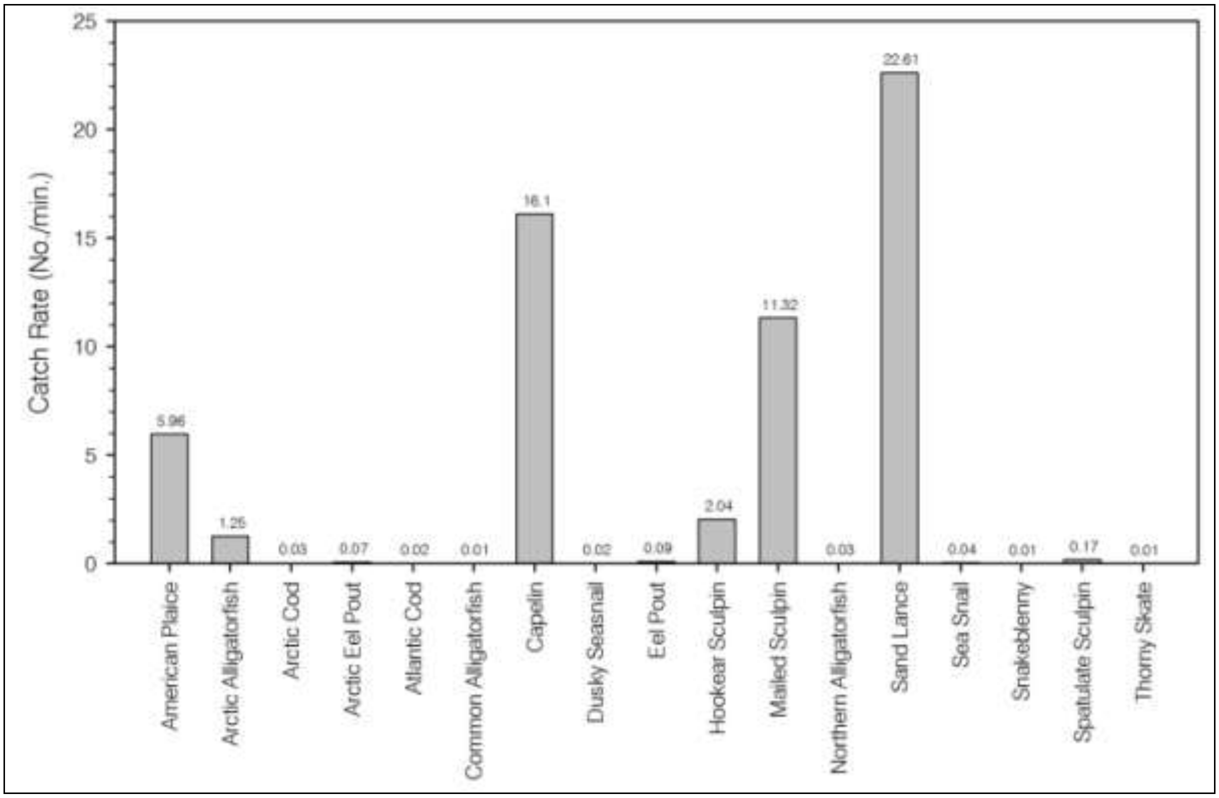


Figure 7-5 Mean Catch Rates of Fish from all Otter Trawls during the Hebron Biological Survey

Data collected during the 2007 and 2008 DFO RV surveys were analyzed to determine the potential for underused species and the most abundant species by catch weight in the Hebron Offshore Project and Study Areas. Overall, the abundance and diversity of species was much lower in the Offshore Project Area, compared to the larger Hebron Offshore Study Area. During 2007, sand lance accounted for approximately 96 percent of the total catch within the Offshore Project Area. In 2008, snow crab and American plaice were the dominant species landed, comprising 45 and 26 percent of the total landings by weight, respectively.

Within the Hebron Offshore Study Area, deepwater redfish was the most abundant species collected during 2007 and 2008, with approximately 70 and 30 percent of the catch by weight, respectively. Shrimp was also abundant, accounting for approximately 10 and 16 percent of the total landings in 2007 and 2008, respectively. Among the least abundant species in both years was roughhead grenadier, which only accounted for approximately 1 percent of the catch (Table 7-7).

Table 7-7 Species/Groups with Highest Catch Weights during DFO Research Vessel Surveys in the Hebron Offshore Project and Study Areas between 2007 and 2008 (Fish and Invertebrates)

Year	Offshore Project Area				Hebron Offshore Study Area			
	2007		2008		2007		2008	
Gear	Campelen 1800 Shrimp Trawl- Lined				Campelen 1800 Shrimp Trawl- Lined			
Total Weight Landed (kg)	113,221		20,523		3,522,382		947,810	
	Weight Landed (kg)	Percent of total (%)	Weight Landed (kg)	Percent of total (%)	Weight Landed (kg)	Percent of total (%)	Weight Landed (kg)	Percent of total (%)
Sand lance	108,951	96.23	864	4.21	226,646	6.43	97,925	10.33
Shrimp	1,277	1.13	NA	NA	363,817	10.33	153,341	16.18
American plaice	1,233	1.09	5,360	26.12	40,915	1.16	35,170	3.71
Snow crab	491	0.43	9,325	45.44	NA	NA	NA	NA
Unspecified invertebrate	368	0.33	NA	NA	NA	NA	NA	NA
Capelin	274	0.24	2,517	12.26	NA	NA	160,071	16.89
Sea urchin	269	0.24	NA	NA	NA	NA	NA	NA
Mailed sculpin	199	0.18	305	1.49	NA	NA	NA	NA
Toad crab	159	0.14	NA	NA	NA	NA	NA	NA
Comb- jelly	NA	NA	1,130	5.51	NA	NA	NA	NA
Thorny skate	NA	NA	400	1.95	81,130	2.30	146,340	15.44
Brittle star	NA	NA	332	1.62	NA	NA	NA	NA
Deepwater redfish	NA	NA	NA	NA	2,439,298	69.25	291,632	30.77
Sea sponge	NA	NA	NA	NA	193,341	5.49	NA	NA
Greenland shark	NA	NA	NA	NA	100,000	2.84	34,239	3.61
Roughhead grenadier	NA	NA	NA	NA	46,485	1.32	16,026	1.69
Greenland halibut	NA	NA	NA	NA	30,750	0.87	NA	NA
Yellowtail flounder	NA	NA	NA	NA	NA	NA	13,066	1.38

The depths at which the various species/groups were caught during the 2007 and 2008 RV surveys varied greatly. The mean depth of capture for 2007 and 2008 and the depth range (minimum and maximum) of capture for the species with the highest catch weight is presented in Table 7-8.

Table 7-8 Mean, Minimum and Maximum Catch Depth during DFO Research Vessel Surveys in the Project and Study Areas between 2007 and 2008 (Fish and Invertebrates)

Species/Group	2007		2008	
	Mean Catch Depth (m)	Range (m)	Mean Catch Depth (m)	Range (m)
Sand lance	99	45-223	129	61-301
Shrimp	363	61-1,372	204	61-656
American plaice	186	61-639	219	61-656
Snow crab	123	70-437	159	61-386
Unspecified invertebrate	488	61-1,372	NA	NA
Capelin	137	61-318	154	68-301
Sea urchin	104	65-223	233	68-196
Mailed sculpin	130	61-395	118	61-196
Toad crab	125	61-318	147	61-454
Comb- jelly	45	45-45	75	63-103
Thorny skate	338	95-1,318	296	85-656
Brittle star	152	151-154	245	105-460
Deepwater redfish	423	166-1,247	386	162-684
Sea sponge	780	166-1,372	357	101-684
Greenland shark	458	454-461	NA	NA
Roughhead grenadier	725	220-1,372	443	216-684
Greenland halibut	553	113-1,372	343	124-684
Yellowtail flounder	82	61-106	71	61-95

NA- Species was not caught this year
Source: DFO RV database accessed 2009

Species that were caught at shallow depths included yellowtail flounder, sand lance and capelin. Species caught in deeper water included roughhead grenadier, Greenland shark (*Somniosus microcephalus*), deepwater redfish (*Sebastes mentella*), shrimp, northern wolffish (*Anarhichas denticulatus*) and Greenland halibut. Species that were caught over the widest range of depths included thorny skate, shrimp and roughhead grenadier.

The environmental effects of the Hebron Project are assessed for the more common fish species within the Hebron Offshore Study Area. There are several other species that are so infrequent, there is little chance of an interaction with the Project. In most cases, these species simply prefer different habitat, but for others, their distribution or abundance has changed to the extent where they are now uncommon within this area of the Grand Banks. A brief description of the infrequently occurring species is presented for reference below. Species at risk, including American plaice, are addressed in Section 11.3.1. A more detailed description is presented for species common to the Hebron Offshore Study Area.

Uncommon Species

White hake may occur from southern Labrador to Cape Hatteras, but is most abundant in the Gulf of St. Lawrence, on the Scotian Shelf and in the Gulf of

Maine. On the Grand Banks, white hake occur infrequently except along the southwest slope (Kulka *et al.* 2004a).

Atlantic halibut occur sporadically throughout the Grand Banks, Flemish Cap and northeast Newfoundland Shelf. They are most abundant along the southwest slope of the Grand Banks and along the Laurentian Channel slope during spring. Historically, they have congregated on the centre of the Grand Banks west of the Southeast Shoal (Kulka *et al.* 2003). Halibut population estimates declined for many years, but a slight increasing trend has been observed more recently (Kulka *et al.* 2003).

For the most part, monkfish are restricted to the warmer waters of the southwest slope of the Grand Banks, but may occur in the deep trenches to the north or on the slope edge (Kulka and Miri 2003).

Winter skate (*Leucoraja ocellata*) are not expected within the Offshore Project Area. Only occasional occurrences have been reported north of the southern Grand Banks. The species is most abundant on Georges Bank and the eastern Scotian Shelf (Simon *et al.* 2003).

Common Species

Commonly occurring fish and shellfish species within the Hebron Offshore Study Area include shrimp, snow crab, Greenland halibut, yellowtail flounder, witch flounder, thorny skate, lumpfish, redfish, grenadier, sculpin, capelin, sand lance and Arctic cod.

Shrimp

Several species of penaeid and caridean shrimp can occur within the Hebron Offshore Study Area, but northern shrimp is by far the most abundant. The northern shrimp extend south from Labrador into the northern half of the Grand Banks. Northern shrimp on the northeast Newfoundland Shelf occur in areas greater than 200 m deep and prefer muddy substrates. Shrimp tend to congregate in the winter and spring, and are most widely distributed during the summer and early fall. Preferred temperatures in the spring are 2°C to 4°C and 1°C to 3°C during the fall, with very few shrimp found below 0°C or above 4°C during either survey (Colbourne and Orr 2004). Shrimp are most abundant along the slope of the Grand Banks during the spring and move to the shallower waters of the Grand Banks and northeast Newfoundland Shelf during the fall.

Shrimp spawn during late summer and fall, but the fertilized eggs are not released until the spring of the following year. Shrimp larvae remain pelagic for a few months, before becoming benthic.

Shrimp feed in both benthic and pelagic environments. During the day, shrimp are benthic and feed on detritus, phytoplankton, worms and small crustaceans. At night, shrimp move up into the water column and feed on detritus and zooplankton (Bundy *et al.* 2000). Shrimp are common prey for Greenland halibut and Atlantic cod.

Snow Crab

Snow crab are relatively sedentary and are not known to undergo seasonal or spawning migrations. The spatial distribution of snow crab appears to be a function of their age, physical habitat and time of year. Research has correlated densities of both adults and juveniles with depth, temperature and bottom substrate. Adult snow crab are present within the Hebron Offshore Study Area but are most common along the slope of the Grand Bank on muddy substrates (Dawe and Taylor 2003).

Even within the juvenile stage (*i.e.*, <70 mm carapace width), preferred habitat varies with age. Early benthic juveniles prefer different habitat types and water depths than older juveniles. Recently-settled juveniles (<30 mm carapace width) prefer a mud substrate (Robichaud 1985; Brethes *et al.* 1987), whereas older juveniles (*i.e.*, 40 to 70 mm carapace width) occur in higher densities on substrates comprised of a mix of mud and rock or gravel (Coulombe *et al.* 1985; Dawe *et al.* 1988). Given the low percentage of fines in the substrate within the Offshore Project Area, it is not considered juvenile snow crab habitat.

Snow crab mating occurs during the spring but fertilized eggs may not be released for a year or two. Once released by the female, larvae are present in the water column for three months from late spring to early fall (Dawe and Taylor 2003). Snow crab eggs and larvae may occur within the Offshore Project Area.

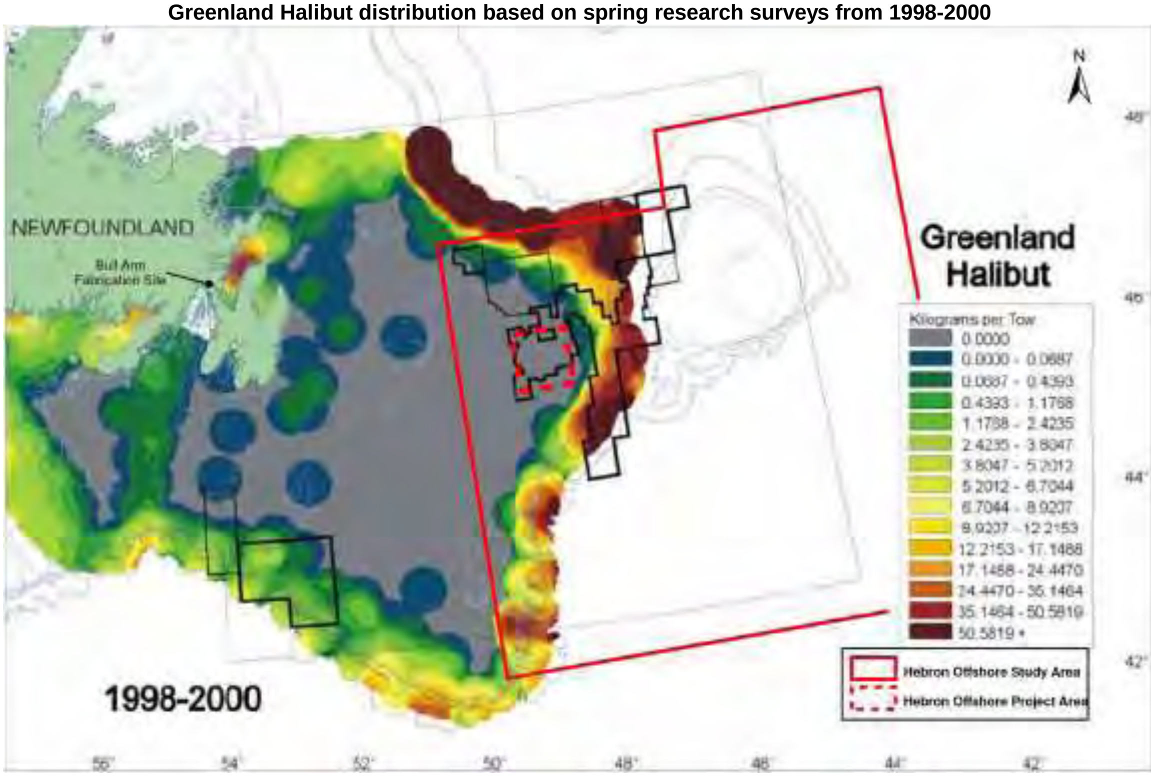
The snow crab diet includes polychaetes, brittlestars, clams, shrimp, snow crab and other crustaceans (DFO 2005b). Common predators of snow crab are thorny skate, Atlantic cod, adult snow crab and seals.

The exploitable biomass of snow crab in NAFO Division 3L (northern half of the Grand Banks) has declined since 1996. The pre-recruit index has been low since 1997 and is expected to remain low (DFO 2005b). The snow crab fishery occurs almost exclusively in water depths greater than 100 m (see Section 8.2.6.1).

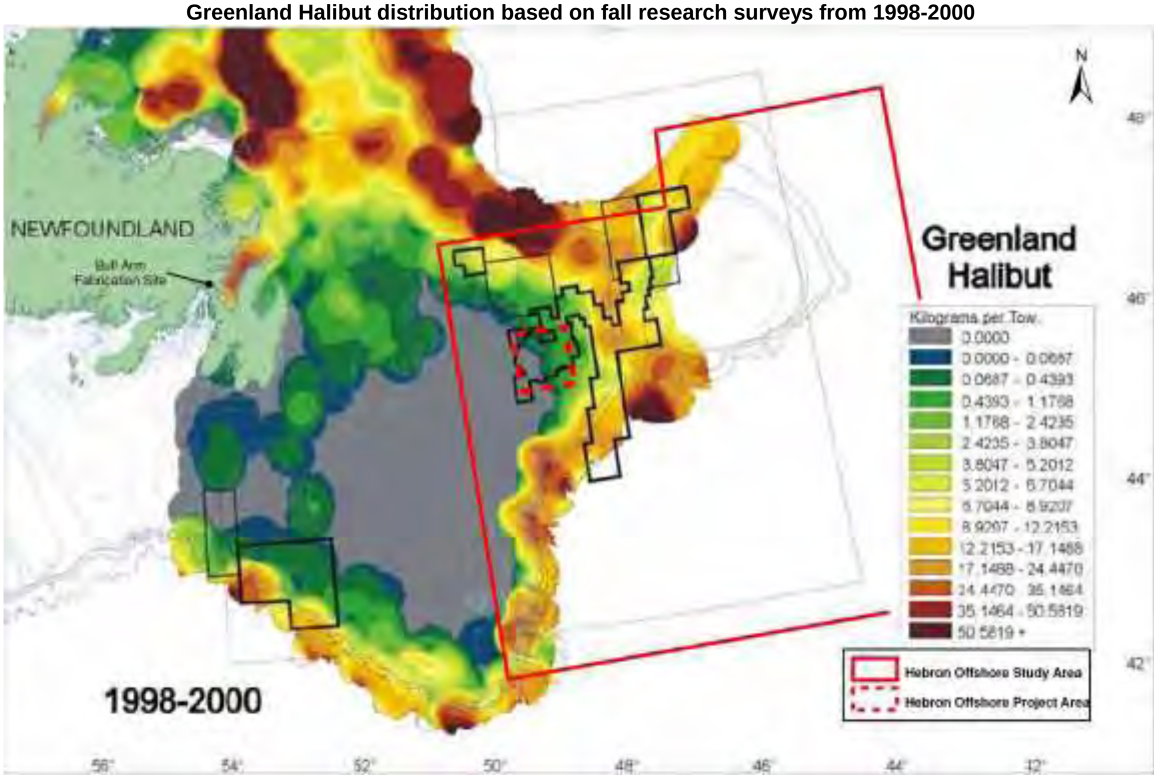
Greenland Halibut

Greenland halibut is a deep-water flatfish most common in waters from northern Labrador to the Grand Banks at temperatures between -0.5°C to 3°C. They are concentrated mainly along the northeast edge of the Grand Banks and on the northeast Newfoundland Shelf, but occur infrequently along the southeast and southwest Grand Banks slopes and into the Laurentian Channel (Bowering 2000; Kulka *et al.* 2003). Greenland halibut are relatively abundant within the Offshore Project Area during the fall, but are found more toward the edge of the Grand Banks in the spring (Figure 7-6). The most recent measure of the population of Greenland halibut on, and in the vicinity of the Grand Banks, indicates the exploitable biomass is currently at the lowest recorded level (Healey and Mahe 2005).

Greenland Halibut distribution based on spring research surveys from 1998-2000



Greenland Halibut distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003.

Figure 7-6 Greenland Halibut Distribution

May distribution of spawning yellowtail flounder, 1999-2003.

They are a semi-pelagic flatfish, spending much of their time in the water column (Scott and Scott 1988). There is indication Greenland halibut undergo a spawning migration beginning in September (Scott and Scott 1988). Spawning occurs during the winter in the Davis Strait and the Gulf of St. Lawrence. Eggs and larvae are pelagic over deep water, off the edge of the Continental Shelf (Scott and Scott 1988).

On the northeast Newfoundland Shelf, Greenland halibut feed on small crustaceans and squid when they are less than 20 cm in length. From 20 to 69 cm, their diet is primarily capelin, and at lengths over 69 cm, their diet is a variety of demersal fish (Bowering and Lilly 1992).

Yellowtail Flounder

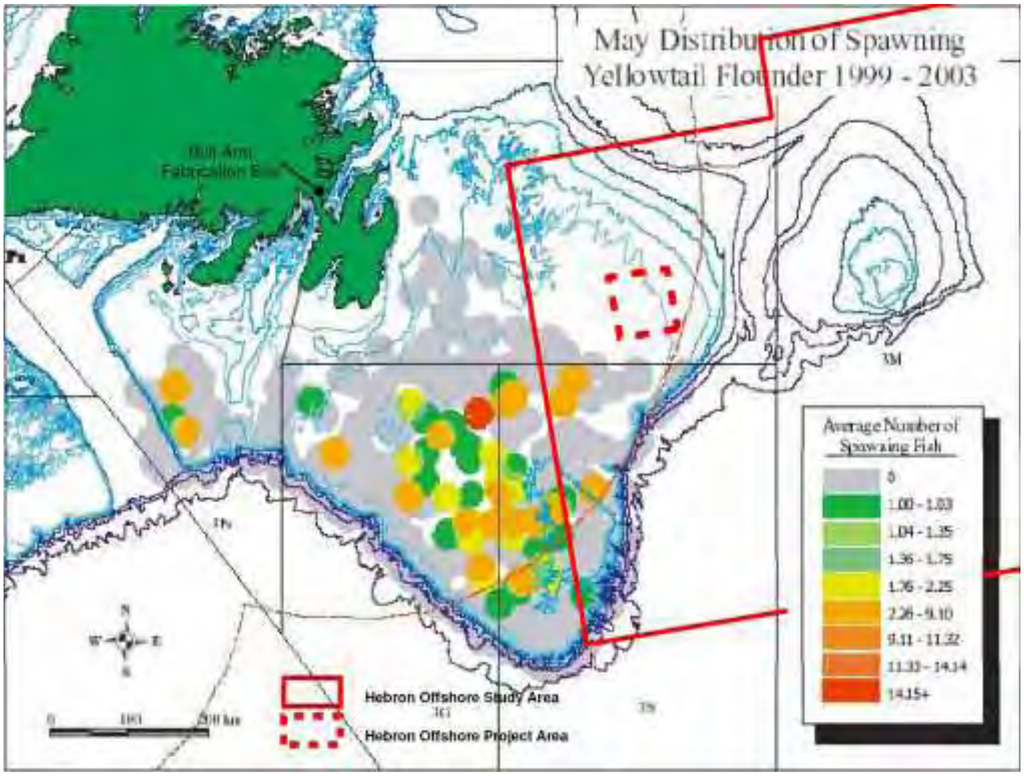
Yellowtail flounder range from Labrador to Chesapeake Bay, preferring sandy substrates and water depths less than 100 m (Walsh 1992). After a decreasing trend in population in the late 1980s to early 1990s, yellowtail populations appear to be increasing more recently (Walsh *et al.* 2000; Kulka *et al.* 2003). Historically, their distribution has included the northern portion of the Grand Banks (Walsh *et al.* 2000) and, therefore, may occur within the Offshore Project Area. The species is considered sedentary and does not undergo seasonal or spawning migrations.

Yellowtail flounder are most concentrated in the warmer waters of the Tail of the Grand Banks and along the slope of the Laurentian Channel (Kulka *et al.* 2003). The Southeast Shoal of the Grand Banks is considered a nursery area for yellowtail flounder (Walsh 1992). The newly settled juveniles prefer sand or mud-sand substrate. The Offshore Project Area is not considered a nursery area for yellowtail flounder.

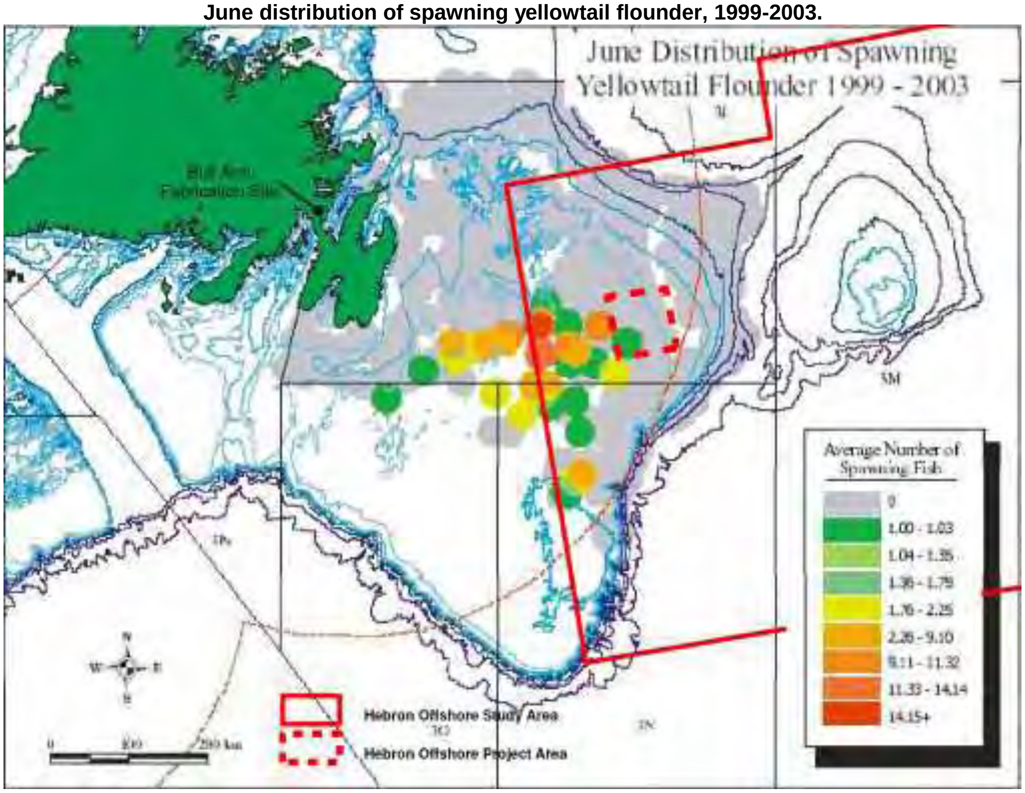
Yellowtail flounder spawn primarily on the central and southern portion of the Grand Banks, likely between April and June (Ollerhead *et al.* 2004). Spawning yellowtail have been captured near the Offshore Project Area in May and June (Figure 7-7). Yellowtail eggs are deposited on the bottom, and float to near the surface once fertilized (Scott and Scott 1988). The yellowtail diet on the Grand Bank is composed mainly of polychaetes and amphipods (Walsh 1992; Methven 1999).

Witch Flounder

Witch flounder prefer the deeper waters off the edge of the Grand Bank, but also occur on the southwestern Grand Bank (Kulka *et al.* 2003). They occur at low densities within the Offshore Project Area during the spring and fall (Figure 7-8). They are not known to undergo extensive migrations (Scott and Scott 1988), so are likely in the area year-round. The stock has recently been assessed at 5 percent of the average size of the early 1980s (Maddock-Parsons 2005a, 2005b).



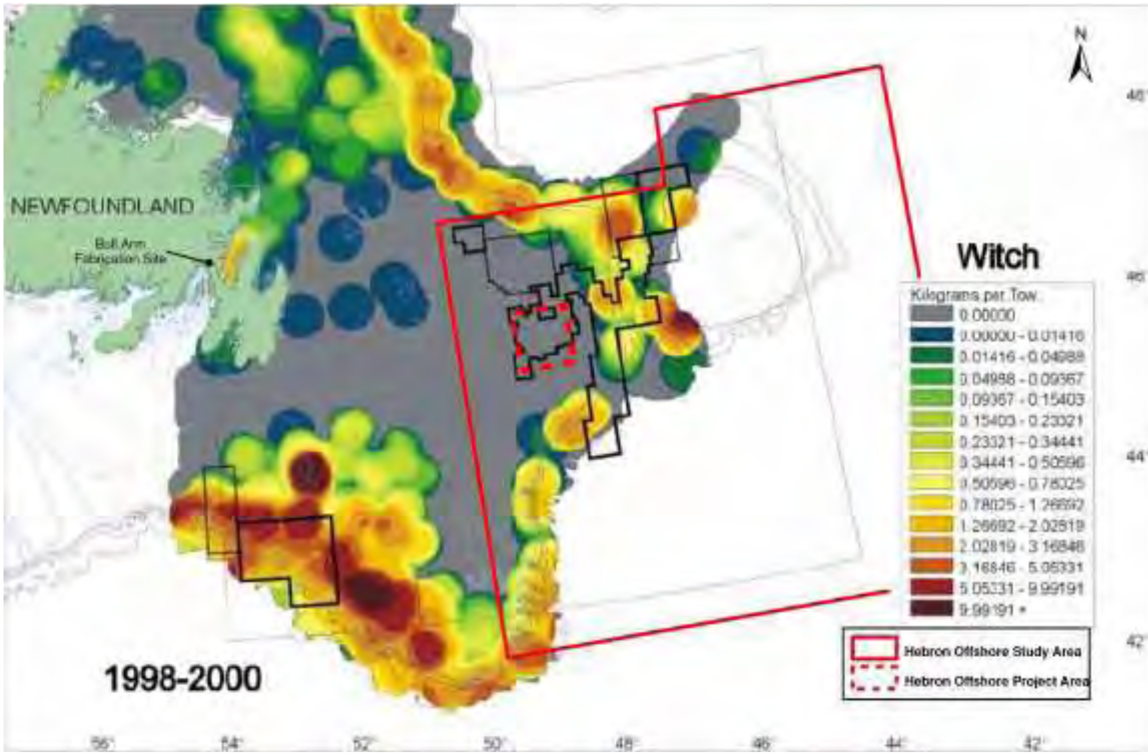
June distribution of spawning yellowtail flounder, 1999-2003.



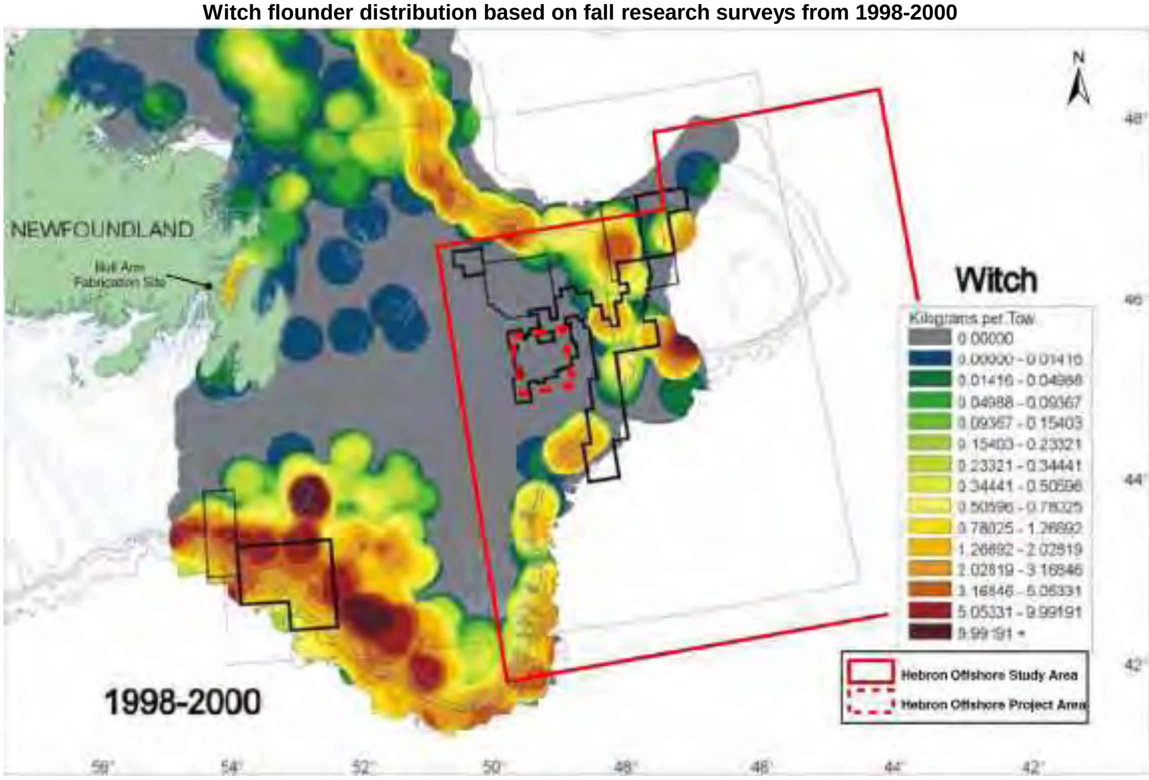
0 class represents survey sets where no fish were caught. Source: Ollerhead *et al.* 2004

Figure 7-7 Yellowtail Flounder Distribution

Witch flounder distribution based on spring research surveys from 1998-2000



Witch flounder distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003

Figure 7-8 Witch Flounder Distribution

Witch flounder spawn on the Grand Bank between March and June (Bowering 1990). Spawning has been reported near the Offshore Project Area in June (Ollerhead *et al.* 2004). Eggs are pelagic and hatch in seven to eight days at 8°C. Witch flounder larvae may be pelagic for up to a year, before settling to the seafloor (Scott and Scott 1988). The primary prey for witch flounder are decapod crustaceans and polychaetes (Methven 1999).

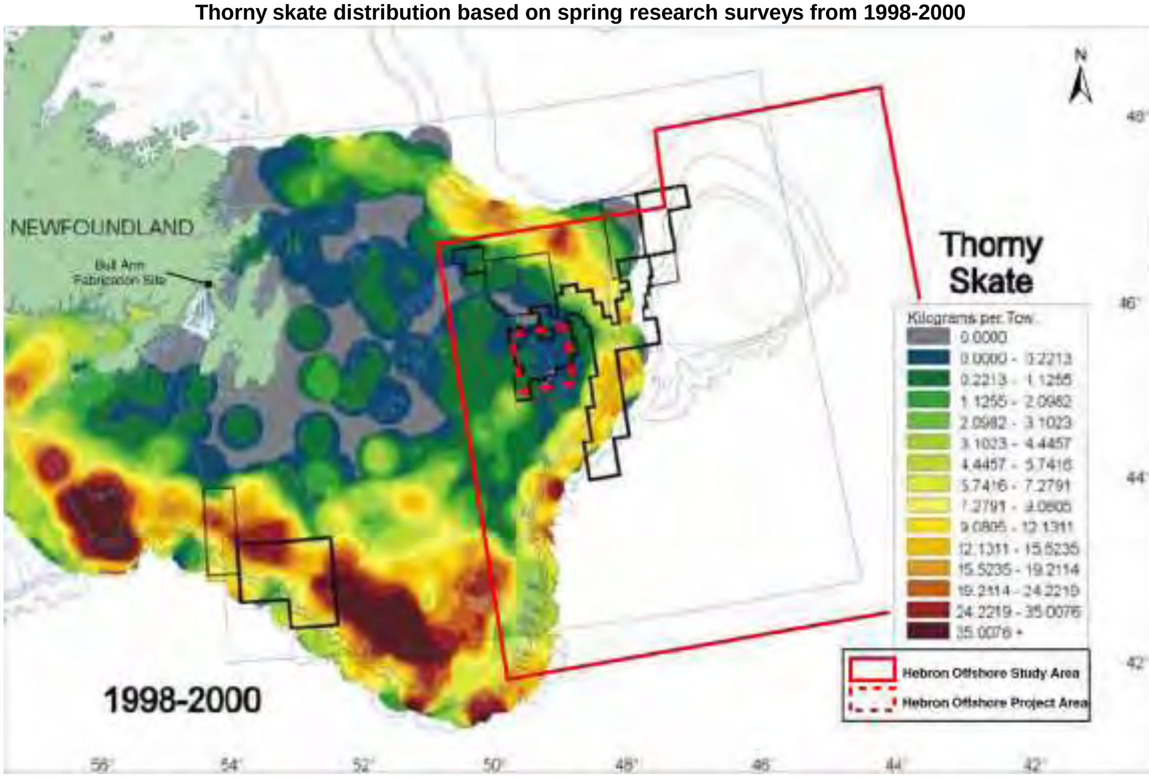
Thorny Skate

There may be up to 10 species of skates from the family Rajidae occurring in the Hebron Offshore Study Area. The most abundant, by far, is the thorny skate, followed by the smooth skate (*Raja senta*), winter skate, spinytail skate (*Raja spinicauda*) and barndoor skate (*Raja laevis*) (Kulka *et al.* 1996). Other skate species are less frequent. Thorny skate is a boreal/Arctic species occurring from Greenland to South Carolina in the western Atlantic. They are at their greatest densities on the southwestern Grand Banks and the Laurentian Channel in late fall and winter (Kulka *et al.* 2004b). In recent years, skate have been concentrating along the southwest slope and edges of the Grand Banks during the spring. During the fall, concentrations occur throughout the Tail of the Grand Banks, especially over the Southeast Shoal (Kulka *et al.* 2003). Thorny skate occur throughout the Offshore Project Area, particularly in the fall (Figure 7-9).

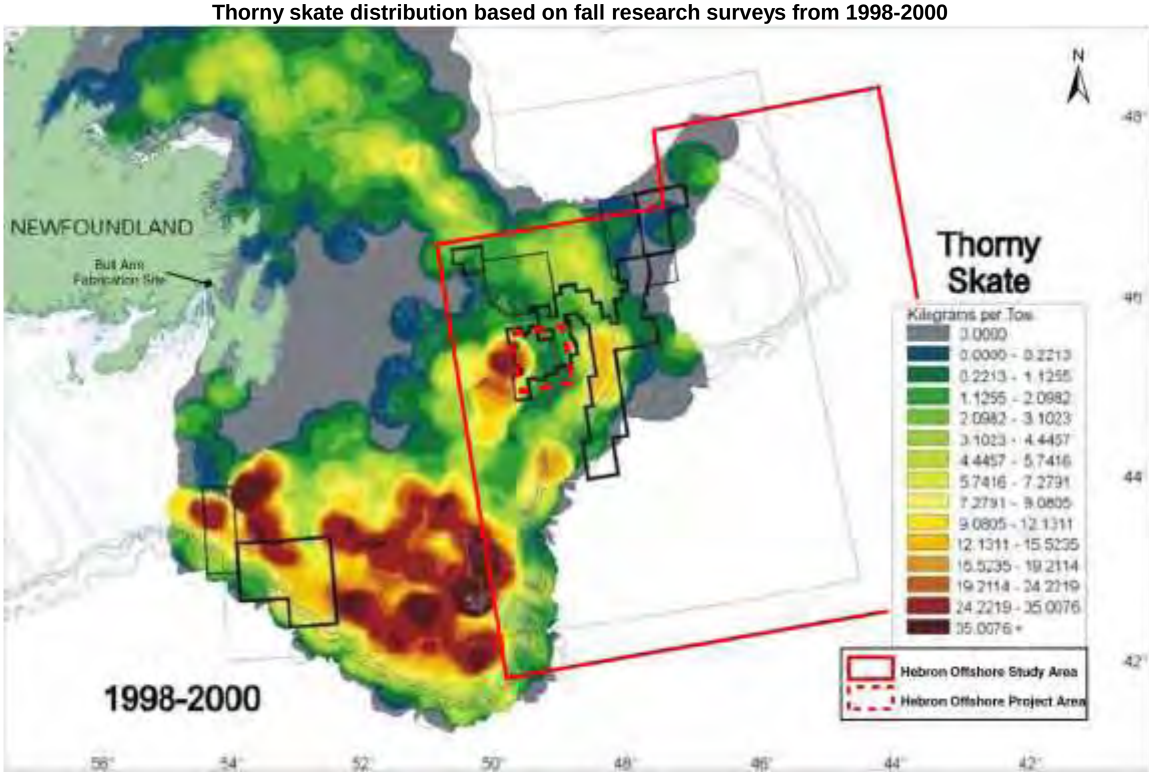
The abundance of thorny skate on the Grand Banks has been described as low but stable since the early 1900s (Kulka and Miri 2003). It is currently estimated that approximately 80 percent of the biomass is concentrated within 20 percent of the area on the southwest edge of the Grand Banks (Kulka *et al.* 2004b). There has been no genetic work conducted on skate to determine if there is a single or several populations within the Newfoundland region (includes both inshore and offshore areas), but the population dynamics of those skate sampled within, on, and in the vicinity of the Grand Banks (3LNO and 3PS) indicate the group is a single population (Kulka *et al.* 2004b). There are indications that thorny skate undergo a seasonal migration from the plateau of the Grand Banks in early winter to the edge and slope, returning in early summer (Kulka *et al.* 2004b), but are otherwise thought to be relatively sedentary (Kulka *et al.* 1996).

Thorny skate appear to spawn in the fall and winter. Young of the year skate are distributed around the edge of the Grand Banks, especially to the southwest of the Banks (Kulka *et al.* 2004b). Thorny skate consume whatever is available, preferring polychaetes and decapods (Methven 1999). Thorny skate can live up to 20 years and may lay from six to 40 egg cases per year.

Thorny skate distribution based on spring research surveys from 1998-2000



Thorny skate distribution based on fall research surveys from 1998-2000



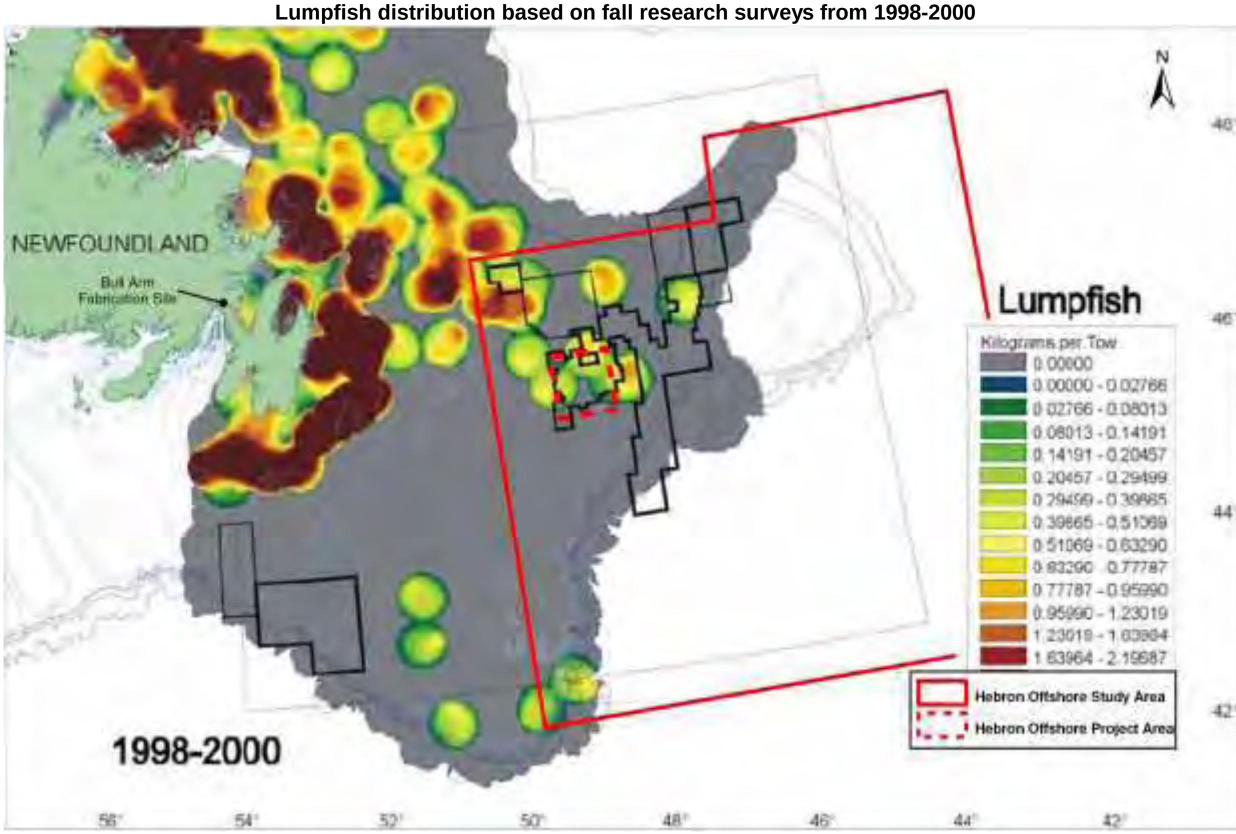
Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003

Figure 7-9 Thorny Skate Distribution

Lumpfish

Lumpfish are congregated on the St. Pierre Bank in the spring, and on the northwest Grand Banks in the fall, suggesting a north-south migration (Kulka *et al.* 2003). They generally occur in low abundance throughout the northern and southern portions of the Grand Banks (Kulka *et al.* 2003). Lumpfish have not been observed near the Offshore Project Area during DFO spring surveys, but are present in the fall (Figure 7-10). Recently, lumpfish populations are showing an increasing trend (Kulka *et al.* 2003). A summary of the life history of the lumpfish is provided in Section 7.3.3.5.

Lumpfish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003

Figure 7-10 Lumpfish Distribution

Redfish

There are primarily two species of redfish in the Hebron Offshore Study Area, *Sebastes mentella* and *S. fasciatus*. They are most abundant at depths between 100 to 700 m, along the edge and upper slope of the Continental Shelf, primarily on the outer edge of the northeast Newfoundland Shelf, the Flemish Cap, and along the Laurentian Channel slope. Redfish occurrence within the Hebron Offshore Study Area is patchy and variable (Kulka *et al.* 2003), but more likely to occur in the spring than fall (Figure 7-11).

Redfish are slow-growing and long-lived. They are pelagic, nocturnal feeders, preying primarily on copepods, shrimp, amphipods and euphausiids; lancetfish (*Alepisaurus* spp.) and lanternfish also make up a small component of the diet of larger redfish (Methven 1999). Spawning on the northeastern edge of Grand Banks occurs in June at depths greater than 200 m (Ollerhead *et al.* 2004). Live larvae, as opposed to gametes, are released from April to July over the Grand Banks. Redfish larvae have been abundant during pelagic surveys on the northern Grand Banks in August and September (Anderson *et al.* 1999).

Sculpin

There are several sculpin species common within the Offshore Project Area. The most abundant species collected during a reconnaissance survey was the mailed sculpin, but hookear and spatulate sculpins were also quite common (Chevron 2002). Spatulate sculpin were common only in gravel substrate during the survey, whereas the mailed and hookear showed no clear preference for either substrate type. These three species are small sculpins, with maximum lengths of approximately 10 cm. They prefer cold Arctic and sub-Arctic waters (Scott and Scott 1988). Their diet is believed to be primarily benthic and pelagic crustaceans and possibly polychaetes and small molluscs (Scott and Scott 1988). These species are not known to be a primary food source, but given their abundance and size, they may be preyed upon by benthic feeding fish. Spawning times are not known for the Grand Banks.

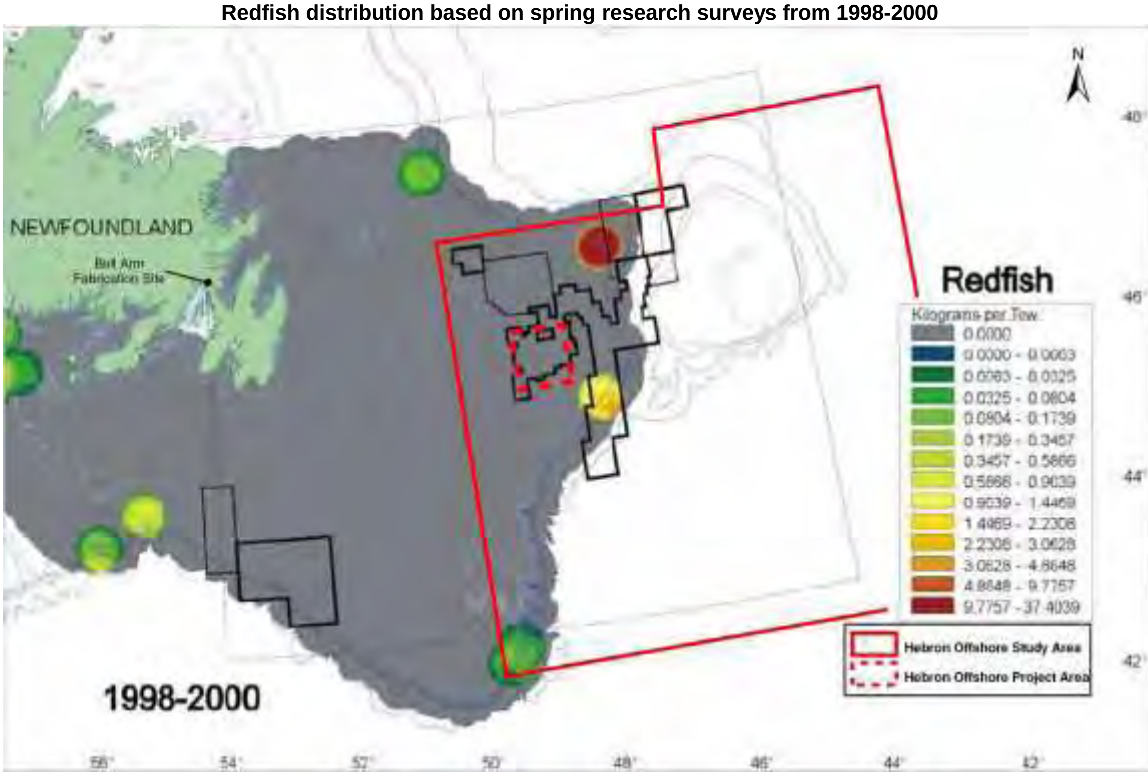
Capelin

There are four stocks of capelin in the Newfoundland region that are managed and referred to by NAFO Divisions 2SA+3KL, 3NO, 3PS and 4RST (Nakashima 1992, in Carscadden *et al.* 2001). Capelin may occur within the Offshore Project Area during spring or fall (Lilly and Simpson 2000).

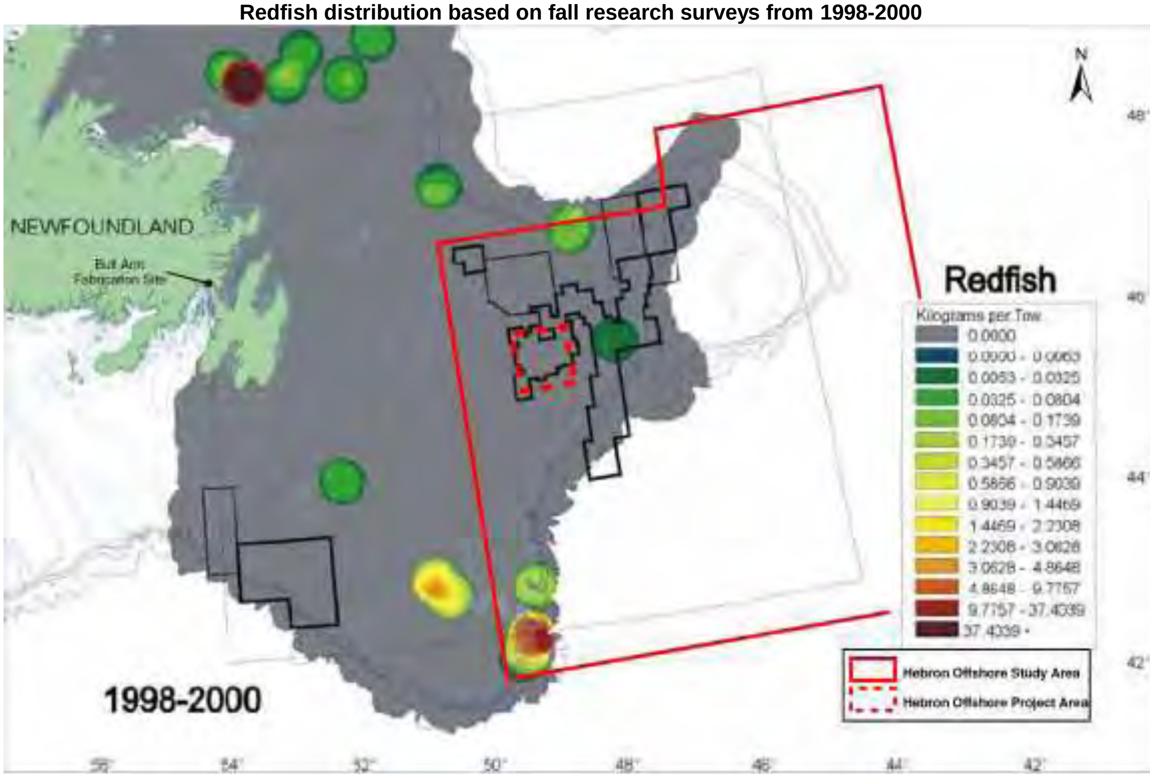
Capelin spend most of their time offshore, but the 3KL stock of capelin migrates to the coastal beaches of Newfoundland to spawn in June and July. This stock is centred on the northern Grand Banks, straddling the boundary between Division 3L and 3K (Carscadden *et al.* 2001) and in the centre of 3K in the fall (Lilly and Simpson 2000). The 3NO stock usually spawns in June and July as well, but they tend to spawn offshore (Carscadden *et al.* 1989, in Carscadden *et al.* 2001). Juveniles live offshore and spawn at three or four years of age. Capelin are preyed upon by harp seals, cod, halibut, American plaice, Atlantic salmon (*Salmo salar*), marine birds and whales.

Capelin feed on plankton, especially copepods, when they are smaller and euphausiids once they are mature. Amphipods can also be a large part of their diet (Methven 1999). A summary of the life history of the capelin is provided in Section 7.3.3.5.

Redfish distribution based on spring research surveys from 1998-2000



Redfish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003

Figure 7-11 Redfish Distribution

Sand Lance

Despite the importance of sand lance within the diets of several species on the Grand Banks, very little is known about the biology of the species. The range of the northern sand lance extends from West Greenland to Cape Hatteras, but they are most abundant on the plateau of the Grand Banks. Sand lance was one of the most abundant species found within the Offshore Project Area during the Chevron reconnaissance survey, notably in gravel substrates (Chevron 2002).

Sand lance spawn during the winter on the Scotian Shelf. Eggs are demersal and adhesive to the substrate. Sand lance larvae were abundant during pelagic surveys on the northern Grand Banks in August and September (Anderson *et al.* 1999).

Sand lance are semi-demersal, in that they feed pelagically at night on copepods, but prefer substrates of sand and fine gravel during the day (Scott and Scott 1988). Their most important predators are capelin, cod and sand lance themselves (Bundy *et al.* 2000). They also can form a significant portion of the American plaice diet in autumn and winter (Pitt 1973). Whales and harp seals also feed on sand lance (Bundy *et al.* 2000).

Arctic Cod

Arctic cod occur in the northwest Atlantic from the Arctic to the Gulf of St. Lawrence. They are semi-demersal from the age of one year and feed on zooplankton, primarily. Arctic cod feed on calanoid copepods as juveniles and hyperiid amphipods and juvenile capelin when they are older (Bundy *et al.* 2000). They are an important forage species for several species of fish, mammals and marine birds. Atlantic cod have been reported feeding on large numbers of Arctic cod off northeastern Newfoundland during the early spring. Arctic char (*Salvelinus alpinus*), Greenland halibut and Atlantic salmon also feed on Arctic cod at various times.

The distribution of Arctic cod has retreated north of the Grand Banks since the warming trend of the 1990s (Dalley *et al.* 2000). In northern Canadian waters, spawning is thought to occur in late autumn and winter.

7.4 Project-Valued Ecosystem Component Interactions

The environmental effects analysis focuses on those Project activities that potentially will result in environmental effects on Fish and Fish Habitat, as summarized in Sections 7.4.1 and 7.4.2.

Project activities with similar interactions on Fish and Fish Habitat have been grouped into four categories to provide a complete and comprehensive environmental effect analysis. Instead of assessing each Project activity separately, the grouping of activities with similar potential effects on Fish and Fish Habitat, allows for a cumulative assessment of within-Project activities.

The interactions summary categories are:

- Change in Habitat Quantity: Project activities that may result in physical alteration of fish habitat, and may be declared a HADD of fish habitat by DFO and require a Section 35(2) *Fisheries Act* Authorization

- Change in Habitat Quality: Project activities that may result in a change in the biological or physical properties of fish habitat. For example, Project activities creating suspended sediment in the water column, creating contamination, affecting a potential food source, or otherwise potentially causing sub lethal physiological effects on fish or shellfish are assessed as potential changes in fish habitat quality
- Change in Habitat Use: Project activities that may result in fish or shellfish changing their behaviour. Some activities may cause avoidance behaviour in fish or shellfish, whereas other activates may attract some species
- Potential Fish Mortality: Project activities that may result in fish or shellfish mortality

7.4.1 Nearshore

The primary nearshore Project activities during routine construction that could potentially interact directly or indirectly with marine fish and fish habitat include:

- Construction of the bund wall for the drydock at Great Mosquito Cove
- Subsequent removal of the bund wall and possible at-sea disposal of bund wall material
- Possible dredging and blasting along sections of the tow-out route to allow the GBS to transit to the Bull Arm deepwater site
- Dredge spoils disposal
- Underwater noise from sheet pile installation during bund wall construction, blasting and vessel traffic
- Watering and dewatering of the drydock
- Concrete production discharges at Great Mosquito Cove and the deepwater site in Bull Arm
- Construction of the GBS at the deepwater site
- Hook-up and commissioning activities

7.4.2 Offshore

7.4.2.1 Offshore Construction/Installation

The primary offshore Project activities during construction and installation that could potentially interact directly or indirectly with marine fish and fish habitat include:

- Site preparation activities for OLS/Platform installation
- Installation of Hebron Platform, OLS and flowlines, and rock cover and/or concrete mattresses
- For potential future activities - construction of excavated drill centre(s) and dredged spoil disposal, installation of subsea equipment and flowlines, including placement of flowline protection measures (rock cover, concrete mattresses, *etc.*), hook-up to the Hebron Platform and commissioning
- Geophysical, geological, environmental and geotechnical surveys, as required

7.4.2.2 Operations/Maintenance

The primary offshore Project activities/components during operations and maintenance that could potentially interact directly or indirectly with marine fish and fish habitat include (but are not limited to):

- Operational discharges (*e.g*., cooling water, storage displacement water, firewater, produced water, grey/black water (refer to Chapter 2 for all operational discharges))
- Drill cuttings and muds discharges (WBM from the Hebron Platform, WBM and SBM from MODU drilling associated with future activities)
- Geophysical (2D/3D/4D seismic, VSPs), geological, environmental and geotechnical surveys, as required
- Presence of Structures (*e.g*., subsea equipment in drill centres, Hebron Platform, OLS, flowlines)

7.4.2.3 Decommissioning/Abandonment

The primary decommissioning and abandonment activities that could potentially affect fish and fish habitat are removal of structures above the seafloor (*e.g.*, Hebron Platform, OLS, flowlines, subsea infrastructure in drill centres, *etc.*). All exposed hard surfaces are expected to be colonized during the life of the Project. Removal of such structures will in effect remove the artificial reef effect created during the life of the Project, reducing localized productivity. The act of removal of the structures is expected to create temporary localized turbidity as well.

7.4.3 Accidents, Malfunctions, and Unplanned Events

During the construction and operation phases of the Hebron project, there are several hydrocarbon products carried and used onboard vessels, barges, drill rigs and platforms. These include crude oil, diesel oil, synthetic drilling mud, synthetic drill (base) fluid, lubricating oils and hydraulic oils. Hydrocarbon spills may occur as a result of human error, equipment failure or loss of well control (blowout). An oil spill, although highly unlikely, could affect fish and fish habitat and potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. A description of the probability of an oil spill as well as results of the nearshore and offshore oil spill trajectory modelling are provided in Sections 14.2 and 14.3, respectively. Other accidental events such as a rupture in the bund wall, chemical spills and collisions, are also assessed.

7.4.4 Summary

A comprehensive summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present and likely future projects and accidents, malfunctions, and unplanned events, is provided in Table 7-9.

Table 7-9 Potential Project-Valued Ecosystem Component Interactions: Fish and Fish Habitat

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Fish Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosquito Cove followed by a deepwater site Zone)				+
Bund Wall Construction (*e.g.*, sheet/pile driving, infilling, *etc.*)	x	x	x	x
Inwater Blasting	x	x	x	x
Dewater Drydock/Prep Drydock Area		x	x	
Concrete Production (floating batch plant)		x	x	
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passender ferry to/from deepwater site, *etc.*)		x	x	
Lighting			x	
Air Emissions				
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	x	x	x	x
Removal of Bund Wall and Disposal (dredging/ocean disposal)	x	x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)		x		x
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site		x	x	
Hook-up and Commissioning of Topsides		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	
Platform Tow-out from deepwater site		x	x	
Offshore Construction/Installation				
Presence of Safety Zone				+
OLS Installation and testing	x	x	x	
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines	x	x	x	x
Installation of Temporary Moorings		x	x	
Platform Tow-out/Offshore Installation	x		x	
Underbase Grouting		x		
Possible Offshore Solid Ballasting		x		
Placement of Rock Scour Protection on Seafloor around Final Hebron Platform Location	x	x	x	
Hook-up and Commissioning of Hebron Platform		x		
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels/barges/diving/ROVs)		x	x	
Air Emissions				

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Fish Mortality
Lighting			x	
Potential Future Activities				
Presence of Safety Zone				+
Excavated Drill Centre Dredging and Spoils Disposal	x	x	x	x
Installation of Pipeline(s)/Flowline(s) and testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	x	x	x	x
Hook-up, Production Testing and Commissioning of Excavated Drill Centres		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	
Offshore Operations and Maintenance				
Presence of Safety Zone				+
Presence of Structures	x	x	x	
Lighting			x	
Maintenance Activities (*e.g.*, diving, ROV, *etc.*)			x	
Air Emissions				
Flaring				
Wastewater (produced water, cooling water, storage displacement water, *etc.*)		x	x	
Chemical Use/Management/Storage (*e.g.*, corrosion inhibitors, well treatment fluids, *etc.*)		x	x	
Well Activities (*e.g.*, well completions, workovers, *etc.*)		x	x	
WBM Cuttings	x	x	x	x
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)			x	
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	x
Potential Future Operational Activities				
Presence of Safety Zone				+
Drilling Operations from MODU at Future Excavated Drill Centres	x	x	x	
Presence of Structures	x	x	x	
WBM and SBM Cuttings	x	x	x	x
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors, *etc.*)		x	x	
Geophysical/Seismic Surveys		x	x	
Offshore Decommissioning/Abandonment				
Presence of Safety Zone				x
Removal of the Hebron Platform and OLS Loading Points	x	x	x	x
Lighting			x	
Plugging and Abandoning Wells		x	x	
Abandoning the OLS Pipeline	x	x	x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Fish Mortality
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels/ROVs)		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	
Accidents, Malfunctions, and Unplanned Events				
Bund Wall Rupture		x	x	x
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blowout		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)		x	x	x
Marine Vessel Incident (*i.e.*, fuel spills)		x	x	x
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)	x	x	x	
Terra Nova Development (production)	x	x	x	
White Rose Oilfield Development and Expansions (drilling and production)	x	x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (Nearshore and Offshore)		x	x	
Commercial Fisheries (Nearshore and Offshore)	x	x	x	x
+ indicates a positive interaction and possible decrease in mortality				

7.5 Environmental Effects Analysis and Mitigation

Potential environmental effects on marine fish and fish habitat during all phases of the Project are discussed by Project phase and summarized at the end of this chapter.

7.5.1 Construction and Installation

7.5.1.1 Change in Habitat Quantity

Nearshore

Construction of the bund wall, drydock, dredged areas and any in-water dredge spoil disposal areas may be declared a HADD of fish habitat by DFO and likely require a Section 35(2) *Fisheries Act* Authorization, requiring any loss of fish habitat to be compensated with the objective to achieve no net loss of productive capacity of fish habitat. The footprint of the bund wall, the area of drydock, the area to be dredged and the footprint of any at-sea disposal will be quantified and detailed within the Habitat Compensation Strategy report for the Hebron Project. The development and implementation of the Strategy and subsequent Habitat Compensation Plan will prevent significant adverse residual environmental effects to habitat quantity.

The bund wall footprint and the area to be drained for the drydock in Great Mosquito Cove may temporarily affect to a small degree, the quantity of available habitat for fish and shellfish for an estimated 24 months. During this time, the submerged surface area of the bund wall will provide new habitat for some species. Species associated with boulder habitats like periwinkles, barnacles and blue mussels may increase in abundance where boulders replace fine grained substrates. The addition of boulders to a relatively flat sand/gravel habitat may attract fish and shellfish. Adult lobster will be attracted from marginal habitats in the immediate area by newly created habitat that the armour stone crevices may provide. Areas vacated by these individuals may become available for new recruit lobsters. Other fish species that may colonize the bund wall area are rock gunnel (*Pholis gunnellus*), eelpout, radiated shanny (*Ulvaria subbifurcata*) and longhorn sculpin (*Myoxocephalus octodecemspinosus*). The bund wall may not only provide shelter for these species, but also create a feeding ground for several additional fish and shellfish species. Invertebrate species may inhabit the rocky subtidal portions of the bund wall, include rock crab, mussels, polychaetes, starfish, brittlestars, periwinkles, barnacles, urchins and fan worms.

The drydock area will be drained and unavailable for use by fish or shellfish for an estimated 24 months, until the bund wall is removed for the tow-out of the GBS to the deepwater site in Bull Arm.

If dredging is required prior to GBS tow-out, there will be an alteration of habitat within the dredged area(s). Macrobenthic species diversity may decrease briefly, but overall abundance and biomass of the benthic community in most habitats will likely not decrease as opportunistic invertebrate and fish species move into and thrive in the dredged area. Depending on the depth of the overburden in the area to be dredged, a very similar habitat to the existing substrate may be exposed and the dredged area will be re-colonized from neighbouring communities within one (*e.g.*, polychaetes and amphipods) to several (*e.g.*, scallop) years. This habitat disturbance within the dredged area is therefore temporary and highly reversible. Existing benthic habitat within the disposal area will be altered by the placement of dredged material. The magnitude of the alteration will depend on the similarity of the dredged material to the existing substrate within the disposal area. For example, if the dredged material is a mix of cobble and boulder and the material is placed over existing rocky substrate, less alteration of the habitat is expected compared to disposal of fine grained sediments in an area of rocky substrate.

Offshore

Activities affecting habitat quantity during offshore construction include Hebron Platform and OLS installation/protection and flowline installation.

There is currently no plan to trench the OLS, but to protect the line with rock cover and or concrete mattresses. The footprint of the OLS on the seafloor will restrict access by fish and shellfish to some habitat. However, the presence of unburied material over the OLS (*i.e.*, concrete mattresses and rock cover) is expected to create habitat by increasing the amount of available hard substrate habitat that could be colonized by local flora and fauna, creating a reef effect for fish populations in otherwise barren sandy or soft bottom areas. Where flowlines and equipment are buried, the overlying sediments will provide habitat upon which benthic communities will recover.

Installation of the GBS will have a similar effect in that access to habitat under the GBS will be lost to fish and shellfish, but colonization by invertebrates on the concrete GBS is expected.

Future Activities: Construction

If excavated drill centres and flowlines are installed as part of the Hebron Project in the future, associated dredging may be completed by a suction hopper dredge or alternate technology (*e.g.*, clam shell). The potential environmental effects of each technology are similar, but they may differ in extent. The clam shell dredge will side cast the material during drill centre excavation, which will confine sediment dispersion and the disposal pile footprint to near the excavation site. The suction hopper dredge vessel would cut the substrate and vacuum the material up to the vessel for disposal at a pre-approved disposal site.

The areas to be dredged will result in a temporary loss of productivity within the footprint of the excavated drill centre or flowline. Several studies indicate that dredging causes an initial reduction in the abundance, species diversity and biomass of the benthic community and that substantial progress towards full restoration of the fauna and sediments can be expected within a period of approximately two to four years following cessation (Kenny *et al.* 1998; Sardá *et al.* 2000; Van Dalfsen *et al.* 2000). It has been suggested that recolonization of a dredged area by polychaetes occurred within 5 to 10 months after the cessation of dredging in a site located within the North Sea, with restoration of biomass to pre-dredge levels anticipated within two to four years (Van Dalfsen *et al.* 2000).

Productivity within the footprint of the dredge spoils disposal area is decreased due to smothering under several centimetres of sand and gravel dredged from the excavated drill centre. However, on the surface of the disposal pile, the emergence of infauna from the excavation will create a newly available food source for snow crab, skate and any flatfish or benthic feeder in the area.

On the periphery of the disposal pile, sessile epifauna such as bryozoans, barnacles, brittlestars and urchins will be smothered, whereas infauna such as most polychaetes, amphipods and clams are burrowing species and can be expected to resurface from a covering of several centimetres.

As with the nearshore, any offshore activities declared to cause a HADD by DFO will require a Section 35(2) *Fisheries Act* Authorization and any loss of fish habitat will be fully compensated with the objective to achieve no net loss of productive capacity of fish habitat. Offshore Project design has not progressed to the stage of being able to accurately quantify the footprint of possible excavated drill centre(s), the OLS or flowline installations, nor the area of the dredge spoil disposal footprint. However, potentially affected areas can be estimated from previous similar projects on the Grand Banks. The nominal areal extent of the activities with the potential to affect habitat quantity is provided in Table 7-10.

Table 7-10 Nominal Seafloor Disturbance Area for Offshore Project Components

Project Component	Quantity	Typical Dimensions on the Seafloor	Typical Seafloor Area
Hebron Platform	1	133 m	13,892 m^2
OLS	2	0.6 x 2,400 m	1,440 m^2
Future Activities			
Excavated Drill Centre (70 m x 70 m)	Up to 4	130 x 130 m	16,900 m^2
Excavated Drill Centre dredge spoils disposal	Up to 4	1 km x 1 km	1 km^2
Flowline bundle	Up to 4	0.5 x 4,000 m	2,000 m^2

In accordance with the DFO policy of no net loss of fish habitat, a habitat compensation program will be developed in conjunction with DFO as a mitigation measure for the net loss of fish habitat resulting from nearshore and offshore Hebron Project activities.

7.5.1.2 Change in Habitat Quality

Project activities may affect water and sediment quality and the sound environment, as described in this section. To mitigate these environmental effects, measures have been included within the Project design so that adverse residual significant effects will likely not occur.

Nearshore

Bund wall construction and removal, drydock dewatering, concrete washwater discharge, dredging, blasting and sheet pile driving are the primary nearshore construction activities that could affect the quality of fish habitat in the Nearshore Project Area. The potential environmental effects of these activities are discussed separately below, but considered together in the effects analysis and significance determination of the Hebron Project on fish and fish habitat.

Suspended Sediment

Fine-grained sediment can be suspended in the water column during the following nearshore Project activities:

- Bund wall construction
- Disposal of dredged material at sea
- Drydock dewatering
- Mooring replacement/upgrades
- Blasting in areas of fine-grained sediment

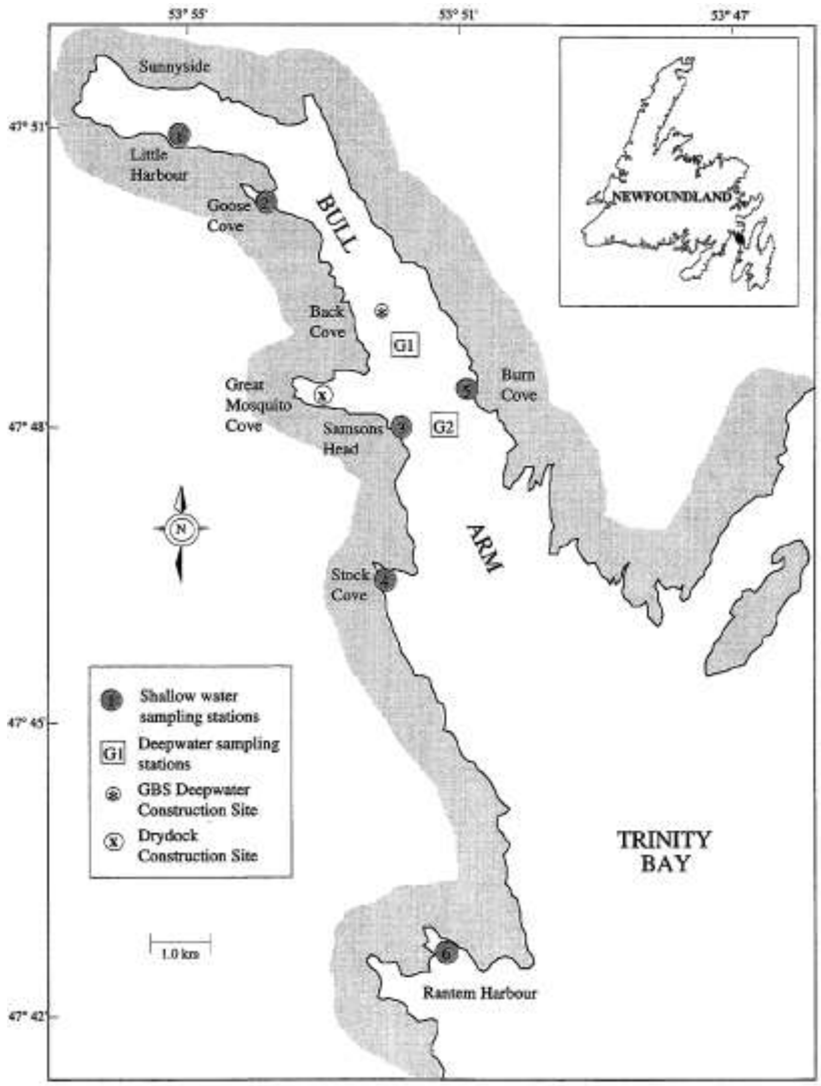
One effect of increased levels of suspended sediment is a reduction in the amount of light that is able to transmit through the water column. If elevated levels of suspended solids are sustained before or during a plankton bloom, a decrease in primary productivity may result. In turn, the food supply for young fish and shellfish may be diminished during that period. Zooplankton may be affected as well. Copepods show negative effects and reduced numbers when there is moderate loading of suspended solids (Robinson and Cuthbert 1996, and references therein). This may have localized effect on prey selection for some fish species.

Eggs and larvae of finfish and shellfish are generally more prone to physical damage from increased levels of suspended sediment because they are passive drifters and cannot avoid the affected area like the post-settlement life stages. Total suspended solid (TSS) levels of 1,000 mg/L have caused mechanical damage to herring larvae (Boehlert and Yoklavich 1984). Suspended sediment may cause respiratory and feeding problems for finfish species in the area or they may simply avoid the area of construction activity (Robinson and Cuthbert 1996, and references therein). The severity of effects of suspended sediments increases as a function of sediment concentration and duration of exposure (Newcombe and Jensen 1996). Sublethal effects in several fish species have been reported after several days of exposure to suspended sediment concentrations of approximately 650 mg/L or greater (Appleby and Scarratt 1989). Concentrations of this magnitude would likely be localized to the immediate site of seabed disturbance and within the area fish are expected to avoid due to construction activity (see Section 7.5.1.3).

Shellfish are generally more susceptible to the effects of increased sediment load than finfish because they are filter feeders (Peddicord 1980). If the levels of suspended solids are sufficient, non-organic sediment loading can cause macroinvertebrates to ingest sediment particles that may inhibit digestion. Under extreme sediment loading, shellfish tend to stop feeding for as long as required.

Suspended sediments will resettle on the seabed after disturbance. The rate and location of this process is dependent upon the sediment grain size and the water currents in the area. Fines (silt/mud) will drift longer distances in the water column. Observed sediments within the Great Mosquito Cove area are comprised predominantly of sands, often with gravels. The frequent outcrops of consolidated sediments suggest a very thin layer of unconsolidated sediments on top of the bedrock (Lee 2005). Given this substrate composition, any re-suspended sediments would be expected to settle through the water column relatively quickly. Hitchcock *et al.* (1999) monitored the settlement of sediment from a number of dredging operations. The results indicated that in general, the majority of sediments settled within 10 to 15 minutes of release, and coarse sands (>2 mm) and gravels settled out virtually instantaneously.

An EEM program was conducted within Bull Arm from 1991 to 1997 (Christian and Buchanan 1998) during the Hibernia GBS construction phase. In an effort to monitor the potential environmental effects on the quality of fish and fish habitat, six shallow water (<20 m) sampling stations were established throughout Bull Arm from the innermost site at Little Harbour near Sunnyside to the outermost one at Rantem Harbour. In addition, deepwater (>120 m) grab samples for surficial sediments were collected at two stations; one just north of, and one immediately south of the entrance to Great Mosquito Cove (Figure 7-12). A total of 43 field trips were conducted at Bull Arm during the Hibernia EEM Program.



Source : Christian and Buchanan (1998)

Figure 7-12 Environmental Effects Monitoring Study Area, Hibernia Project, Bull Arm

Nearshore sedimentation was measured as total deposited solids (TDS) and volatile deposited solids (VDS) during the Hibernia EEM program (Christian and Buchanan 1998). Generally, the highest values of TDS and VDS occurred in the fall, followed by a decrease in the winter and a slight increase in the spring. Those areas with the most freshwater influence (*i.e.*, Stock Cove and Goose Cove) displayed the highest absolute levels compared to the other stations. The most marked inter-annual difference occurred at Station 3, the station nearest the construction site, during the time of breaching the drydock bund wall (Figure 7-12). At this time, the TDS increased and the VDS/TDS decreased markedly. TDS amounts also increased at adjacent stations but to a lesser degree.

The following is a list of mitigation measures designed to reduce sediment loading during construction. These will be implemented, where applicable, to reduce potential effects. Additional mitigation measures will be investigated during Front-end Engineering Design (FEED) and detail design and engineering:

- Investigate the use of washed rock or in-water sediment control measures for fill material in the construction of the bund wall
- Investigate technologies to reduce sedimentation during dredging operations
- Minimal movement of barge anchors to reduce resuspension of sediments
- Releasing water for hydrostatic testing only when it meets criteria set out in the *Fisheries Act* or *Canadian Environmental Protection Act* (CEPA) (or the Newfoundland and Labrador *Environmental Control Water and Sewer Regulations*, 2003, of discharged from a land-based settling pond), prior to discharge
- Where applicable, adherence to Canadian Council of Ministers of the Environment (CCME) *Environmental Quality Guidelines* for the protection of aquatic life when considered in conjunction with existing ambient water quality and site-specific factors
- Use of settlement basins and/or containment areas for concrete washwater
- Use of best practices, continuous improvement programs and best available technology

Contamination

If the dredge spoils or material used for bund wall construction have levels of metals, hydrocarbons or other compounds above background level, there is increased risk of introducing or spreading contaminated soils. Concrete washwater or uncured concrete can be very alkaline and affect the quality of fish habitat if exposed to the marine environment.

The EEM results within Bull Arm during the Hibernia GBS construction phase (Christian and Buchanan 1998) tested for the effects of contamination and indicated no detectable effect on fish heath as measured by Mixed Function Oxygenase (MFO) activity, histopathology, bile metabolites or gill parasitism. During the EEM program, iron and manganese were the only elements recorded above the Maximum Allowable Effects Levels, the concentration level in sediments above which the frequency of associated biological effects are unacceptable. At Station 3, 10 of the 21 trace metal analytes were distinctly more concentrated in the "breach" composite sample (Figure 7-12). Most PAHs and total petrogenic hydrocarbons in sediments collected throughout the EEM were below their respective Maximum Allowable Effects Levels.

Blue mussels were also monitored during the Hibernia EEM program to test for indications of contamination. There were no obvious differences in condition index of blue mussels sampled outside of the bund wall breach time and those sampled during and immediately following breach time. Concentrations of 13 trace metal analytes in mussels were essentially unchanged throughout the EEM program regardless of location, exposure time duration, sampling season and period of exposure relative to bund wall breaching. Concentrations of the remaining eight trace metal analytes appeared most affected by sampling season. Arsenic, copper, nickel, selenium and tin consistently appeared most concentrated in mussel soft tissue sampled in May. Barium, chromium and vanadium appeared most concentrated in mussels sampled in the fall. Almost all polycyclic aromatic hydrocarbon (PAH) concentrations in muscle tissue were below the analytical detection limit. Those that did exceed limits of quantitation were considered to be minimal (Christian and Buchanan 1998).

The potential impact from concrete production is the effects of washwater released to the environment. Liquid wastes may contain hazardous materials such as cement, concrete additives and oil.

Cement is very alkaline and washwater from spoiled concrete or from the cleaning of the batch plant mixers and mixer trucks, conveyors and pipe delivery systems can be expected to have very high pH, which may exceed regulatory limits. Similarly, spoiled concrete or washwater would contain concrete additives and agents, some of which are toxic to aquatic species. Aggregates, particularly the finer sand fractions can be expected to be washed from spoiled concrete or discharged in washwater. Uncontrolled release of such washwater will be prevented.

Mitigation measures to reduce the risk of contamination during nearshore construction may include:

- Concrete washwater containment and testing to meet applicable regulations *(e.g.,* CEPA, *Fisheries Act* and provincial *Water Resources Act*) prior to discharge
- Investigate use of washed-rock for bund wall construction
- EPP to address discharge of all chemicals to the marine environment
- Treatment of washwater from batch plants prior to discharge/disposal

Noise and Blasting

Nearshore fish habitat quality may also be affected by noise. Underwater noise created by blasting, sheet piling and vessel traffic can affect the physiology of fish and invertebrates. Background noise in the ocean can originate from a range of natural and anthropogenic sources, including oceanic turbulence, thermal noise, surface wave action, animal communications and vessel traffic. Large tankers, at full steam, may have a source noise level of 170 dB re 1 μPa at 1 m and average fishing vessels emit noise between 127 and 146 dB at 100 m. Typical peak levels of ambient noise range from 110 to 120 dB re 1 μPa in shallow water (Richardson *et al.* 1995), depending on oceanographic conditions, shipping and other human activity. Therefore, typical peak background values of 110 dB re 1 μPa are a reasonable assumption for shallow nearshore waters. However, noise level is very much dependent upon frequency, in that levels at higher frequencies are typically lower.

Fish with swim bladders and specialized auditory couplings to the inner ear (*e.g.*, herring) are considered to be most sensitive to sound pressure. Fish with a swim bladder but without a specialized auditory coupling (*e.g.*, cod and redfish) are moderately sensitive, while fish with a reduced or absent swim bladder (*e.g.*, mackerel and flounder) have low sensitivity (Fay 1988). The swimbladder is the most likely site of damage in finfish, but the kidney, liver and spleen may also be ruptured. In comparison to finfish, benthic invertebrates and shellfish are likely less affected by sudden pressure changes underwater because they do not have contained airspaces.

Acoustic modelling of pile driving activity into bedrock at Great Mosquito Cove was conducted. The model estimated a source level of 216 dB re 1 μPa @ 1 m and that a sound pressure of >190 dB re 1 μPa (rms) will extend to approximately 300 to 400 m from the bottom of Great Mosquito Cove, depending on distance of the bund wall from the shoreline (JASCO 2009). If pile driving is required at the deepwater site in Bull Arm, the model estimates that a sound pressure of >190 dB re 1 μPa (rms) will occur less than 100 m from the source. At sound pressures of 192 dB re 1 μPa, fish may be stunned temporarily and internal injuries may result at levels of 200 dB re 1 μPa (Turnpenny and Nedwell 1994). There is limited risk of these interactions occurring given that fish are expected to avoid the area near in-water construction activity. The mitigation measures outlined below will further reduce the risk of damage to fish.

Underwater noise levels from a tug vessel were estimated at 185 dB re μPa at 1 m during transit and as 193 dB re μPa @ 1 m when the vessel is doing an anchor pull. These are conservative assumptions used for modelling (JASCO 2009). The sound pressure level emitted by the tug is not expected to cause any physical injury to fish since the 193 dB is the maximum sound pressure expected within 1 m of the tug's propeller (see JASCO 2009).

Blasting may be required at Great Mosquito Cove to provide adequate draft or channel width for the GBS tow-out to the deepwater site. Because the details of the potential blasting have not yet been determined, a sample scenario was developed using the simple case of a single explosive charge with size and burial depth as prescribed by current DFO guidelines (Wright and Hopky 1998). If blasting were required in Great Mosquito Cove, results of acoustic modelling for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998) indicate that greater than 200 dB re 1 uPa (rms) sound exposure levels would occur for approximately 50 m from the blast source and that sound pressures of between 190 and 199 dB re 1 uPa (rms) sound levels would occur from the mouth of Great Mosquito Cove to the eastern side of Bull Arm (JASCO 2009). Sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario and therefore injury to egg and larval stages is not expected (Turnpenny and Nedwell 1994).

In-water blasting will be limited in duration and frequency and will be governed by a series of mitigation measures designed to reduce potential effects on fish. Any blasting that may be required near the shoreline will adhere to DFO's *Guidelines for Use of Explosives in Canadian Fisheries Waters* (Wright and Hopky 1998). The mitigations listed in these guidelines include:

- Backfilling a loaded charge hole
- No detonation of explosive in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (*i.e.*, overpressure) greater than 100 kPa (14.5psi) in the swimbladder of a fish
- No detonation of explosive that produces, or is likely to produce, a peak particle velocity greater that 13 mm/s in a spawning bed during the period of egg production
- Mitigation to help further reduce the potential for physiological effects of noise on fish and fish habitat during construction may include:
- Use of acoustic harassment devices or a ramp-up of detonation pressures to encourage fish to move away from the blasting area
- Use of bubble curtains and other acoustic absorbents, where feasible; to contain shock waves

Offshore

There are several construction and installation activities in the Offshore Project Area that could affect the quality of fish habitat. Installation of the OLS, flowlines and Hebron Platform and geophysical, seismic, geohazard and/or geotechnical surveys) and potential future excavated drill centre construction, are the primary offshore construction activities which could affect the quality of fish habitat.

Suspended Sediment

The above discussion regarding sedimentation and potential effects on fish and shellfish in the nearshore also applies to the assessment of potential offshore effects. The primary difference between the nearshore and offshore sites is the role that the contrasting physical environment will have on the dispersion of suspended sediments.

Dispersion of sediment during dredging and dredge spoils disposal is dependent upon the excavated sediment grain size, water depth and currents in the area in which they are disposed. Surficial sediments in the offshore are much coarser than those in Great Mosquito Cove and are therefore expected to settle more quickly. Observed sediments within the Hebron Project Area are comprised predominantly of sands and gravels with limited fine material (see Section 3.1.6).

Contamination

As summarized in Section 7.3.3.2, there are indications of previous drilling activities in the surficial sediments of the Offshore Project Area. Several metals were found to have concentrations above the median for the Offshore Project Area (Chevron 2003). The highest levels of barium, lead, manganese and strontium within the Offshore Project Area were found less than 750 m southeast of an abandoned oil well. These metals in other samples from the Offshore Project Area were well within the range from baseline and Year One of EEM programs at Terra Nova (Chevron 2003).

Given that the metals concentrations reported are total concentrations, there is little risk that the metals will become highly bioavailable to filter feeding organisms should the sediments become suspended during offshore construction activities.

Low-level fuel and lube range hydrocarbons were detected in 16 and 11 of 20 samples, respectively, during the sediment quality survey at Hebron (Chevron 2003). The median concentration of fuel range hydrocarbons was 0.81 mg/kg, while the median for lube range hydrocarbons was 0.75 mg/kg. Hydrocarbon concentrations were below 2 mg/kg in all samples. PAHs were not detected above an estimated quantification limits (EQL) of 0.05 mg/kg in any sediment samples from Hebron.

These are not concentrations that are expected to cause hydrocarbon contamination should they become suspended in the water column during offshore construction activities.

All discharges during the construction and installation phase of the Project will adhere to the *Offshore Chemical Selection Guidelines* (NEB *et al.* 2009).

Noise

There are several potential sources of noise during offshore construction activities. Surveys geophysical, seismic and/or geohazard surveys), and possible pile driving for OLS installation are the primary potential sources. Other sources of noise from construction include geotechnical surveys vessels, and in water construction activities such as dredging of excavated drill centres and installation of the OLS, flowlines and Hebron Platform structures. It is not certain whether these activities will be required during the construction phase of the Project or whether they may be spread out over the entire life of the Project.

The focus of this analysis is on the effects of seismic sound sources on fish habitat quality, given that seismic surveys potentially produce the highest levels of sound pressure of all the geophysical surveys proposed for this Project. Seismic airguns release most of the acoustic energy focused in a vertically downward direction. The noise associated with airguns can range between approximately 215 and 235 dB re 1 µPa-m for a single airgun and approximately 235 to 260 dB re 1 µPa-m for arrays (Richardson *et al.* 1995). Source levels off to the sides of the array in the horizontal are generally lower. In general, the frequency output of an airgun depends on its volume: larger airguns generate lower-frequency impulses. However, due to the pulsive nature of the source, airguns inevitably generate sound energy at higher frequencies, above 200 Hz, although the energy output at these frequencies is substantially less than at low frequencies.

Sub-lethal injury has only been observed as a result of repeated exposure to very high received levels of sound, at a higher cumulative level than would be expected in the field under normal seismic operating conditions (LGL 2008a). Depending on source noise level, water depth and distance of the fish relative to the source, injuries (such as eyes and internal organs) would only occur within a few tens of metres with lesser symptoms such as hearing damage possible out to several hundred metres (Turnpenny and Nedwell 1994).

Snow crab eggs have shown delayed embryonic development after exposure to seismic energy (Payne 2004). Christian *et al.* (2004) exposed snow crab eggs to 221 dB at 2 m and demonstrated possible signs of retarded development. However, eggs in nature are unlikely to be exposed to noise levels of range or intensity as they are carried by the female on the seafloor (the same is true for shrimp). Results from a DFO (2004a) study on the effects of seismic activity on adult snow crab indicated no changes to embryo mobility of hatched larvae affected.

Sub-lethal physiological effects on lobsters exposed to seismic energy were observed by Payne *et al.* (2007) during preliminary exploratory studies. The observed serum biochemical effects included reduced levels of serum protein, specific serum enzymes, and serum calcium. In some cases, the reduced levels persisted for a period of weeks.

In conclusion, invertebrates without gas-filled organs appear less vulnerable to the effects of airguns than fish with gas-filled organs. Benthic invertebrates in water deeper than about 20 m (*i.e.*, at the Hebron Offshore Project Area) are likely far enough away from the seismic source near the surface so that particle velocity effects become negligible.

Seismic activities associated with the Project will adhere to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2008).

7.5.1.3 Change in Habitat Use

There are Project activities that have the potential to affect the behaviour of fish and shellfish. In-water activities in the Nearshore and Offshore Project Areas may affect habitat use by fish and shellfish by causing avoidance or attraction behaviours. To mitigate these environmental effects, measures have been included within the Project design so that adverse residual significant effects will likely not occur. These measures include noise control measures, and application of standard seismic mitigation measures. These are described in more detail in this section.

Nearshore

Increased noise and activity levels due to dredging, bund wall construction, vessel traffic, blasting, lights and surveys (*e.g.*, geophysical, geohazard, geotechnical, environmental) during nearshore construction and installation activities may affect habitat use by causing avoidance or attraction of fish and invertebrates.

A comparison of moderately-sensitive species, such as cod, haddock, pollock and redfish, determined a measurable behavioural response in the range of 160 to 188 dB re 1 μPa (Turnpenny and Nedwell 1994; Richardson *et al.* 1995). If blasting were required in Great Mosquito Cove, results of acoustic modelling for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998), indicate that 180 and 190 dB re 1 uPa (rms) sound levels occur at 2.7 km and 0.99 km, respectively, from the blast site (JASCO 2010). The noise from nearshore blasting is therefore expected to cause a startle response and temporary avoidance of the area by some species. Behavioural effects of noise on benthic invertebrates, such as lobster and crab, are not well documented. Few invertebrates have gas-filled spaces, and therefore, are less likely to be behaviourally affected by underwater noise, as are fish.

Most available literature indicates that the environmental effects of noise on fish are transitory, and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible effects on individuals and populations.

The mitigation measures presented above for noise and blasting (Section 7.5.1.1) may also reduce the potential effects from noise on habitat use. Operational lights used in or near the marine environment may affect pelagic migratory fish species. Studies from the Pacific coast report changes in juvenile herring and sand lance distribution at night, in artificially lighted areas (Nightingale and Simenstad 2002). Predators may also have been attracted by the increase in juvenile herring and sandlance under the lights (Nightingale and Simenstad 2002). Lights are also known to attract squid, if they are present in the area. Many planktonic species and life stages are phototaxic; floating to near surface during the day and settling to deeper water at night. Any lights on the water at night may attract nekton that have active swimming ability.

Offshore

Installation of the OLS, flowlines and Hebron Platform, geophysical, seismic, and/or geohazard and/or geotechnical surveys and potential future excavated drill centre construction are the primary offshore construction activities that could affect the behaviour of fish and invertebrates, and therefore, habitat use. The focus is on the environmental effects of seismic sound sources on fish habitat use, given that seismic surveys potentially produce the highest levels of sound pressure of all the geophysical surveys proposed for this Project.

Source levels during seismic surveys are usually in excess of the noise levels that elicit a response in fish, so the area in which fish react to the noise may extend several kilometres in the open ocean. There are several well documented observations of fish and invertebrates exhibiting behaviours that appeared to be in response to exposure to seismic activity like a startle response, a change in swimming direction and speed, or a change in vertical distribution (Blaxter *et al.* 1981; Schwarz and Greer 1984; Pearson *et al.* 1992; McCauley *et al.* 2000; Wardle *et al.* 2001; Hassel *et al.* 2003), although the importance of these behaviours is unclear. Some studies indicate that such behavioural changes are temporary (*i.e.*, within minutes (Pearson *et al.* 1992, in Skalski *et al.* 1992)), while others imply that marine animals might not resume pre-seismic behaviours and/or distributions for a number of days (Løkkeborg 1991; Engås *et al.* 1996). Conversely, pollock on a shallow coastal reef were observed during a signal of 230 dB re1 μPa (Wardle *et al*. 2001). Direct visual observations determined that only minor changes in fish behaviour patterns were detectable around the reef. When smaller pollock passed within a few metres of the array and were exposed to approximately 229 dB, they showed a typical "C-start" response and moved away only a few metres.

The expected distance for fish to react to a typical peak source level of 250 to 255 dB re 1 μPa is from 3 to 10 km (Engås *et al.* 1996). A reaction may simply mean a change in swimming speed or direction (Løkkeborg *et al.* 2010). The spatial range of response in fish will vary greatly with changes in the physical environment in which the sounds are emitted. In one environment, fish distribution has been shown to change in an area of 74 km x 74 km (40 x 40 nautical miles (nm)) and 250 to 280 m deep for more than five days after shooting ended, with fish larger than 60 cm being affected to a greater extent than smaller fish (Engås *et al.* 1996). The potential effect of a spatial response in fish during sensitive times is unknown, in part due to data constraints associated with life histories of many species and overall lack of knowledge of seismic effects during sensitive periods for most, if not all species. Behavioural effects on lobsters exposed to seismic energy were observed by Payne *et al.* (2007) during preliminary exploratory studies. Four of the five exposure trials resulted in observed increases in food consumption, and these feeding differences were often apparent several weeks post-exposure. Behavioural effects of exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20-inch airgun have been reported (McCauley *et al.* 2000). The behavioural responses included squid firing their ink sacs and moving away from the airgun, startle responses and increased swimming speeds.

Christian *et al.* (2004) conducted a behavioural investigation during which caged snow crabs were positioned 50 m below a seven-gun array. No obvious startle behaviours were observed. Results from a DFO (2004a) study on the effects of seismic activity on adult snow crab, indicated no changes in feeding activity.

Seismic activities associated with the Project will adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment

(C-NLOPB 2008). Potential effects of lighting on fish are addressed in the nearshore discussion above.

7.5.1.4 Potential Mortality

Project activities may result in lethal effects to fish and shellfish, as described in this section. To mitigate these environmental effects, measures have been included within the Project design so that significant adverse residual environmental effects likely will not occur. These measures include standard blasting control measures, and the application of standard seismic mitigation measures. These are described in more detail in this section.

Nearshore

Mortality of fish and shellfish during nearshore construction could result from dredging, spoils disposal, bund wall construction and blasting.

Dredging and dredge spoils disposal increase the levels of suspended sediment. In conditions of extreme sediment load, mortality of finfish and shellfish results from extreme oxygen deficient water or respiratory obstruction. Levels of 100,000 mg/L kaolin resulted in an average mussel mortality of 10 percent after 5 and 11 days (Peddicord 1980). However, the highest suspended sediment levels reported during concurrent activities of till placement, dredging, drilling and underwater blasting for the Hibernia project at the mouth of Great Mosquito Cove were less than 40 mg/L (LeDrew, Fudge & Associates 1991). Dredging may cause mortality of some sessile invertebrates, like mussels and scallops, by crushing if a clam dredge is used. Sessile epifaunal species may be smothered during dredge spoils disposal.

The blasting program in the nearshore will be designed to minimize the risk of mortality to fish. Nearshore and in-water blasting will adhere to DFO's *Guidelines for Use of Explosives in Canadian Fisheries Waters* (Wright and Hopky 1998), which is designed to mitigate fish mortality. In-water sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario and therefore, fish mortality is not expected (Turnpenny and Nedwell 1994). Nevertheless, mortality of sessile invertebrates in the immediate area of blasting is likely due to compression waves and flying debris.

Mitigation measures to reduce the risk of mortality to fish during nearshore construction activities are provided in Section 7.5.1.2.

Offshore

Potential for future dredging of excavated drill centre, spoils disposal and flowlines installation have the potential to cause mortality of shellfish and potentially to eggs and larvae of fish.

Installation of the OLS and GBS has the potential to cause mortality of benthic invertebrate species. However, the relative number of individuals potentially within the footprints of these sub-sea structures is negligible when compared to the population numbers in adjacent habitat.

Dredging and spoils disposal will be required for excavated drill centre construction, but also may be required for OLS and flowline installation. Regardless of the dredging method chosen, some mortality of sessile invertebrates (*e.g.*, clams and scallops) may be expected from crushing and smothering. Smothering of sessile invertebrates is also expected from installation of the Hebron Platform, and concrete and/or rock mattress placement over the flowlines and OLS. Anchoring of construction and support vessels or drill rigs will have similar, highly localized effects. These effects are considered highly reversible on a population level, as disturbed areas will soon recolonize, including colonization of the subsea structures themselves.

Studies considering the effects of marine aggregate extraction have concentrated on establishing the rates and processes of macrobenthic recolonization upon cessation of dredging (Kenny *et al.* 1998; Desprez 2000; Sardá *et al.* 2000; Van Dalfsen *et al.* 2000). These studies indicate that dredging causes an initial reduction in the abundance, species diversity, and biomass of the benthic community and that substantial progress towards full restoration of the fauna and sediments can be expected within a period of approximately two to four years following cessation (Kenny *et al.* 1998; Sardá *et al.* 2000; Van Dalfsen *et al.* 2000).

The risk of direct mortality to fish and shellfish from seismic surveys is limited to pelagic eggs and larvae. Acute mortality of eggs and larvae has been demonstrated in experimental exposures, but only when the eggs and larvae were exposed very close to the seismic sound sources and the received pressure levels were very high (see Dalen *et al.* 2007 for a review).

Recent collaborative research was conducted by the Fish Food and AIlied Workers (FFAW) Union and Fisheries and Oceans Canada (DFO) on the potential effects of sound on developing monkfish eggs (Payne *et al.* 2009). This study found that there were no significant differences observed between control and exposed larvae examined 48 to 72 hours post-esposure. Thhis study recognizes the potential difficulty in collection of monkfish veils, so it was decided that research should also be conducted on capelin eggs. Although artificial fertilization was poor, no significant differences in mortality were observed between control and capelin eggs exposed to seismic energy and examined three days post-exposure to 20 airgun discharges (Payne *et al.* 2009). Payne *et al.* (2009) concluded it is unlikely that seismic surveys pose any real risk to either monkfish eggs or near-hatch larvae that may float in veils on the sea surface during monkfish spawning.

There have been no reports of mass fish kills from seismic surveys (Payne 2004). Since fish are likely to be driven away by approaching seismic shots, fish mortality is not expected (Turnpenny and Nedwell 1994).

Mortality in shrimp was not observed after exposure to an airgun array with a peak pressure of 196 dB (re 1µPa at 1 m) (Andriguetto-Filho *et al.* 2005). Caged shrimp were also exposed to the airguns at very close range; there were no reported mortalities (Andriguetto-Filho *et al.* 2005). Webb and Kempf

(1998) subjected shrimp to a 15-gun array (volume 480 cubic inches with source levels of 190 dB re 1µPa at 1 m depth) and reported no evidence of mortality or reduced catch rates for the shrimp.

Data on the effects of seismic surveys on macroinvertebrates (*e.g.*, crab and scallops) are limited, but the available data suggest that mortality through physical harm is unlikely below sound levels of 220 dB re 1 µPa @ 1 m (Royal Society of Canada 2004). There are no indications of acute or mid-term mortality in adult snow crab due to seismic activity, nor does there appear to be any effect on the survival of embryos carried on the female or on the locomotion of the larvae after hatch (DFO 2004a). The Royal Society of Canada (2004) suggests that seismic surveys will have no effect on the marine benthos, provided the water depth is greater than 20 m, as will be the case for this Project.

Seismic activities associated with the Project will adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2008). The risk of mortality to sessile invertebrates from dredging will be reduced by having dredging contained to the smallest area possible and restricting dredge spoils disposal to a designated disposal area.

The environmental effects of the Project during the construction and installation phase and the mitigations to be implemented are summarized in Table 7-11.

Table 7-11 Environmental Effects Assessment: Construction and Installation

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Presence of Safety Zone	• Potential Decrease in Fish Mortality	• None required	1	2	2/6	R	2
Bund Wall Construction (*e.g.*, sheet/pile driving, infilling, *etc.*)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains, if feasible • HADD authorization and compensation • Chemistry of rock and till material will be tested prior to placement • Investigate use of washed-rock or in-water sediment control measures in bund wall construction.	1	1	3/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
In-water Blasting	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* • Bubble curtains, if required • Compliance with terms of Section 32 *Fisheries Act* Authorization	1	2	2/1	R	2
Dewater Drydock/Prep of Drydock Area	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch plant)	• Change in Habitat Quality • Change in Habitat Use	• Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be treated prior to discharge or directed to a settling basin	1	1	3/3	R	2
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Procedures will be in place specifying speed for vessels within the traffic lane and in Bull Arm	1	1	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use	• Restrict disturbance to mooring sites	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route (may require at-sea disposal)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Investigate use in-water sediment control measures • Fish habitat compensation	1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging/ocean disposal)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains, if required • Compliance with terms of Section 32 *Fisheries Act* Authorization (if required)	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	1/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Quality • Potential Mortality	• Intake of water at depth (10 m, below most productive zone) and adhering to the *Freshwater Intake End-of-Pipe Fish Screen Guidelines*	1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs and best available technology	1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Quality • Change in Habitat Use	• Comply with appropriate regulatory limits with respect to discharges into marine waters	1	1	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Survey equipment and vessels will only use the power required to attain the data , therby minimizing noise.	1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Offshore Construction/Installation							
Presence of Safety Zone	• Potential decrease in Mortality	• None required	1	2	3/6	R	2
OLS Installation and Testing	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Efficient installation with minimal seabed disturbance • Fish habitat compensation • Chemical selection management system • Adherence to regulations	1	2	2/1	R	2
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines	• Change in Habitat Quantity • Change in Habitat Use • Change in Habitat Use	• Efficient installation with minimal seabed disturbance • Fish habitat compensation	1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs and best available technology	1	1	2/1	R	2
Platform Tow-out/Offshore Installation	• Change in Habitat Quantity • Change in Habitat Use	• Fish habitat compensation	1	4	2/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Underbase Grouting	• Change in Habitat Quality	• Use of best practices, continuous improvement programs and best available technology	1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Quality	• None required	1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Final Hebron Platform Location	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs and best available technology	1	1	2/1	R	2
Hook-up and Commissioning of Hebron Platform	• Change in Habitat Quality	• Implement chemical selection management system; adherence to regulatory limits with respect to discharges in to marine waters	1	1	2/1	R	2
Operation of Vessels (supply, support, standby and tow vessels/barges/diving/ ROVs)	• Change in Habitat Quality • Change in Habitat Use		1	2	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Potential Future Construction Activities							
Presence of Safety Zone	• Potential Decrease in Mortality	• None required	1	2	3/6	R	2
Excavated Drill Centre Dredging and Spoils Disposal	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Fish habitat compensation	1	2	2/1	R	2
Installation of Pipeline(s)/Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Efficient installation with minimal seabed disturbance • Fish habitat compensation	1	2	2/1	R	2
Hook-up, Production Testing and Commissioning of Excavated Drill Centres	• Change in Habitat Quality • Change in Habitat Use	• Implement chemical selection management system; adherence to regulatory limits with respect to discharges in to marine waters	1	2	2/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Survey equipment and vessels will only use the power required to attain the data, thereby minimizing noise	1	3	2/1	R	2

KEY

Magnitude:
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Significant adverse environmental effects on fish and fish habitat from construction and installation activities nearshore and offshore are not likely to occur. Environmental effects are generally low in magnitude, of limited geographic extent and reversible.

7.5.2 Operations and Maintenance

7.5.2.1 Change in Habitat Quantity

All Project environmental effects on habitat quantity occur in the construction phase. As presented in Section 7.5.1.1, a Project-specific Habitat Compensation Strategy and Plan will be developed and implemented to mitigate adverse environmental effects and prevent significant adverse residual environmental effects on marine fish habitat.

During the operations and maintenance phase, the potential environmental effects of the Project on fish habitat quantity will result from the presence of new subsea structures. Primarily, the Hebron Platform and the rock mattress and/or concrete mattress cover over the flowline and OLS will provide new hard substrate habitat to be colonized and perform as an artificial reef. The presence of these structures over an unstable sand and gravel substrate enhances the habitat complexity of the surrounding area and increases localized productivity. The new surfaces will become colonized by sponges, anemones, brittlestars and seastars, which themselves provide habitat for smaller epifaunal and epifloral species. Studies in the North Sea indicate most of the fouling biomass in the upper 50 m is composed of seaweeds, hydroids, soft corals, anemones and mussels. Hydroids, soft corals, anemones and tubeworms are the most common animals below 50 m (Welaptega 1993, in Husky Oil 2000). An artificial reef effect is created shortly after the installation and the structures become a source of food and shelter for several species of fish and shellfish, especially juveniles.

7.5.2.2 Change in Habitat Quality

Operational discharges (WBM and cuttings, seawater discharges, storage displacement water, produced water, grey and black water, drains, *etc.*) could affect fish habitat quality. Potential future developments could include drilling from a MODU at excavated drill centres. The effects of excavated drill centre construction have been discussed in Section 7.5.1.2, but the effects of MODU drilling on fish habitat quality are addressed here.

To mitigate potential environmental effects on water and sediment quality, measures have been included within the Project design so that significant adverse residual environmental effects will likely not occur. Use of best practices, continuous improvement programs and best available technology will be applied if technically and economically feasible and reliable. Results from the EEM programs at Hibernia, White Rose and Terra Nova have confirmed their respective assessment predictions of no significant environmental effect on the marine environment as a result of discharges. These are described in more detail in this section.

Drilling Discharges

Discharge of WBMs and associated cuttings is regulated by the C-NLOPB. WBMs and cuttings do not require treatment prior to discharge (in accordance with the *Offshore Waste Treatment Guidelines* (OWTG) (NEB *et al.* 2002)). The discharge of WBMs may increase metals such as barium, arsenic, cadmium, copper, lead and zinc in sediments, but these metals are not bioavailable, and thus unlikely to accumulate in benthic species. Elevated levels of metals have been found to occur within 250 to 500 m of the drill site, but sometimes occur further, depending on environmental conditions and the number of wells drilled (see Hurley and Ellis 2004). Signals of drill muds (*i.e.*, barite) have been detected 5,000 m from Terra Nova (18 production wells) and 8,000 m from Hibernia (32 production wells) (Hurley and Ellis 2004), but not at levels likely to have any biological effect.

From modelling of WBM cutting discharge from 52 wells at the Hebron Platform, thicknesses of 1 to 2 m is estimated within 10 m distance and 10 to 20 cm within 25 m distance. These estimates are based on preliminary analyses which will be updated during FEED and detailed engineering phases. Thicknesses of at least 1 cm are generally confined to within about 50 to 60 m of the GBS. These cuttings near the GBS are almost exclusively the fast-settling pebbles and sand (a very small percentage of the fines will drift for a time and ultimately settle near the GBS) whereas at distances greater than about 50 to 200 m, the deposits will be exclusively fines (see AMEC 2010a).

WBMs are expected to remain in suspension in a thin layer area above the seafloor. Since drill mud will remain in suspension, the most likely species to be affected by drill mud release are filter feeders. Contamination associated with the use of WBMs is of minimal concern to the environment, since it is virtually free of hydrocarbons and the metals present are in a form that is not readily bioavailable (CAPP 2001). Although changes in benthic density and diversity from drilling muds have been detected within 1,000 m of drill sites, most of these effects are found within the 50 to 500 m range and are of short duration (Hurley and Ellis 2004). Additives to WBMs are selected for use in accordance with the *Offshore Chemical Selection Guidelines* (National Energy Board *et al.* 2009), which ensures that the additives selected have an acceptable risk to the environment. Metals from WBMs and cuttings have not been demonstrated to cause biological effects (Canadian Association of Petroleum Producers 2001; Hurley and Ellis 2004). There will be no discharge of SBMs from the Hebron Platform during normal operations.

There is potential for SBM and WBM discharge from MODU operations at excavated drill centres during the life of the Project. The effects of SBM drill mud and cuttings release on the Grand Banks has been assessed in the Hibernia environmental assessment (Mobil Oil 1985), White Rose Comprehensive Study and addendum (Husky Oil 2000; 2001), the Terra Nova environmental assessment (Petro Canada 1997), Significant Discovery License (SDL) 1040 Delineation Drilling Screening (Husky and Norsk Hydro 2006) and the Husky exploratory drilling environmental assessments and updates (LGL 2003, 2005a, 2006a, 2007a). Primary literature and industry reports on the effects of drill mud and cuttings have been reviewed in US Minerals Management Service (MMS) (2000), CAPP (2001a, 2001b), NEB *et al*. (2002), Buchanan *et al.* (2003), Hurley and Ellis (2004) and Neff (2005). Results from the EEM programs at Hibernia, White Rose and Terra Nova have confirmed their respective assessment predictions of no significant environmental effect on the marine environment for those production projects. Mathieu *et al.* (2005) and DeBlois *et al.* (2005) also concluded that the Terra Nova project demonstrated no significant environmental effects on fish health and fish habitat after a three-year period where six wells were drilled using a combination of water-based and synthetic-based muds.

Liquid Discharges

Produced water will be discharged with cooling water, below the summer thermocline depth. Produced water discharges may induce flocculation that could concentrate and transport metal and organic compounds contained in formation water to the benthos. The temperature of the produced water discharge will be approximately 70°C and below the summer thermocline, which occurs between 20 and 30 m from the surface (see Chapter 3). Storage displacement water will also be discharged below the thermocline, at a temperature of approximately 30°C. Temperature of the liquid discharge will reach ambient within meters of the discharge point.

Based on preliminary analyses to be updated during FEED and detailed engineering phases, at a modelled produced water discharge elevation of 35 m, the plume reaches the bottom. A dilution factor of 300 is achieved within a horizontal distance of 139 m (in August) to 171 m (in February) (AMEC 2010a). For storage displacement water, the modelling shows that under all ambient conditions that can typically be expected in the Project Area, an oil concentration criteria of 0.1 ppm can be achieved within a distance of 200 m, but will be unlikely to rise near the ocean surface (AMEC 2010a).

Sensitivity analyses indicate that increasing the discharge elevation has little effect on dilution, and reducing the discharge temperature has only limited effect on dilution.

Effects resulting from the discharge of produced water are expected to be undetectable further than 500 m from the Hebron Platform. Within 500 m, Querbach *et al.* (2005) quantified these potential effects of chronic and acute exposure to produced water from an offshore oil production facility on some commonly found marine organisms. They concluded that survival, growth and fertilization success of the species in question (haddock, lobster and sea scallop) were all reduced. The assessed levels of exposure were also shown to have negative effects on the physical condition of a species of diatom, *Thalassiosira pseudonana*. The early planktonic life stages of fish, as well as phytoplankton and zooplankton, are particularly sensitive to contaminants due to the inability of these organisms to move from areas of contamination. However, the proportion of the total population that is exposed to these routine discharges is very small and indistinguishable from the high rate of natural mortality.

Operational discharges will be dispersed rapidly and planktonic organisms will be exposed to continuously diminishing concentrations of produced water as they drift away from the source. Experiments on the toxicity of produced water on snow crab larvae indicate that produced water has a very low toxicity potential (J. Payne, pers. comm., in Jacques Whitford 2005). Somerville *et al.* (1987) found that cod and herring larvae and phytoplankton appear to be unaffected by produced water. Both PAHs and phenols have been detected at very low concentrations in marine bivalves attached to legs of offshore Gulf of Mexico platforms; all concentrations were well below the marine acute criteria and there appears to be little net bioaccumulation in fish species that may prey on biofouling organisms (Neff 2002).

The two primary components of produced water that are of environmental concern are the aromatic hydrocarbons (or the benzene, toluene, ethylbenzene and xylene (BTEX) fraction of total petroleum hydrocarbons (TPH) analyses) and PAHs. BTEX is soluble in seawater and highly toxic to marine organisms. However, there is minimal exposure risk to marine organisms given the rapid loss due to evaporation, adsorption and sedimentation, biodegradation and photolysis (Johnsen *et al.* 2004). PAHs are less soluble but more persistent in the environment (Holdway and Heggie 2000) and the associated toxicity to marine organisms are primarily related to benzene and naphthalene fractions (Brand *et al.* 1989, in Holdway and Heggie 2000).

Naphthalene fractions are rapidly degraded in the water column (Johnsen *et al.* 2004). Low-molecular weight PAHs are the dominant fraction of produced water; these fractions degrade more readily than the high-molecular PAH fractions, which generally have a more specific toxicological nature, potentially interacting with cellular protein and DNA (Neff 2002; Johnsen *et al.* 2004). However, their concentrations in a produced water plume are very low due to the rapid dilution following discharge, and are rarely at levels high enough to cause toxic effects in marine plants and animals (Neff 2002; Johnsen *et al.* 2004).

Concentrations of phenols (and alkylated phenols) in produced water declines rapidly due to dilution, evaporation and bio- and photo-degradation with distance from a discharge point (Neff 2002). The solubility of phenols is very low in sea water, with concentrations often below detection limits; however, concern remains about their potential to disrupt reproduction when the degree of alkylation is increased (Johnsen *et al.* 2004). Laboratory-based studies on uptake of alkylated phenols in fish species have indicated that there is uptake in fish within 100 to 1,000 m of a discharge point, located primarily in the gastro-intestinal tract; and that the fish excreted the alkylated phenols (and all other associated compounds) via bile to background levels within 24 to 48 hours (Sundt and Baussant 2003).

The expected amount of toxic and/or carcinogenic forms of PAHs and alkylated phenols in a produced water plume are generally below detection limits or at very low concentrations (Neff 2002). Produced water discharge will be treated to meet the oil in water limits stipulated in the OWTG (National Energy Board *et al.* 2002). The feasibility of produced water re-injection is being investigated during FEED studies.

Grey and black water produced on the Hebron Platform will be treated as per the OWTG. Black water or sewage will be macerated to 6 mm particle size or less prior to discharge. Organic matter associated with discharges will disperse quickly in an open ocean environment and degraded by bacteria.

All liquid discharges will adhere to the OWTG discharge limits and are subject to an Offshore Chemical Management System screening. Discharges limits are based on best available technologies and are the focus of continuous improvement programs. Where practicable, use of technology to reduce discharge limits below those in the OWTG will be implemented.

7.5.2.3 Change in Habitat Use

During the Hebron Project operations and maintenance phase, there is potential for noise generated by geophysical surveys, dredging, vessel traffic and drilling, all of which could affect fish habitat use. The environmental effect of noise from geophysical surveys and vessel traffic was discussed in Section 7.5.1.2 as a construction phase activity. To mitigate these environmental effects, measures have been included within the Project design so that adverse residual significant effects will likely not occur. These measures include noise control and application of standard seismic mitigation measures.

A semi-submersible drill rig produces a broad band noise level at approximately 154 dB re 1 μPa (Richardson *et al.* 1995), which would be reflective of the MODU drilling for potential development of excavated drill centres in the future. Drilling noise from the Hebron Platform is expected to be less, given that the drill rig is inside the Hebron Platform. For comparison, noise from a drillship is emitted at a range between 174 and 185 dB re 1 μPa, a dredge vessel at 187 dB re 1 μPa and a large tanker can emit noise at approximately 186 dB re 1 μPa (Richardson *et al.* 1995).

Most available literature indicates that the effects of noise on fish are transitory, and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on fish as a result of noise should result in negligible environmental effects on individuals and populations. Behavioural effects of noise on benthic invertebrates, such as crab, are not well documented. Few invertebrates have gas-filled spaces, and therefore, are less likely to be affected by underwater noise, as are fish.

There is some evidence that lights on the water may attract some fish species. Operational lights used in or near the marine environment may affect pelagic migratory fish species. Studies from the Pacific Coast report changes in juvenile herring and sand lance distribution at night, in artificially lighted areas (Nightingale and Simenstad 2002). Predators of these species may also have been attracted by the increase in juveniles under the lights (Nightingale and Simenstad 2002). Lights are also known to attract squid, if they are present in the area. Many planktonic species and life stages are phototaxic; floating to near surface during the day and settling to deeper water at night. Any lights on the water at night may attract nekton that have active swimming ability.

The artificial reef effect created by subsea structures may attract nearby fish and shellfish to feed or for shelter. The rock mattress used to cover the OLS is not expected to pose an obstacle to the movement of snow crab.

7.5.2.4 Potential Mortality

Operational discharges of WBMs may result in mortality of shellfish, whereas the presence of a Safety Zone may actually decrease the mortality rate. To mitigate adverse environmental effects, measures have been included within the Project design so that adverse residual significant effects will likely not occur. These measures include standard blasting control measures and the application of standard seismic mitigation measures. These are described in more detail in Section 7.5.1.2 and in this section.

Shellfish such as scallops will be smothered within a 50 m radius of the WBM discharge, whereas infauna such as clams are burrowing species and can be expected to resurface from a covering of several centimetres (Husky and Norsk Hydro 2006; Fredette and French 2004; Maurer *et al.* 1980). Based upon the published literature (reviewed in Husky 2000, 2001; LGL 2005a, 2006b; US MMS 2000; CAPP 2001b; Hurley and Ellis 2004; Neff 2005), the benthos can be expected to recover over a period of several months to several years, but most likely within one year after cessation of drilling. Sessile organisms are likely to be smothered in areas where cuttings are greater than 1 cm thick (Bakke *et al.* 1989).

In the case of potential MODU drilling, WBMs and treated SBMs will be released. Due to a larger average size and discharge rate, SBM cuttings stay closer to the well site and do not disperse as widely as WBMs and cuttings. No additional smothering of sessile benthic invertebrates is expected to occur as a result of SBM discharge as the area will have been subjected to smothering from previous WBM deposition.

Implementation of a Safety Zone around the Hebron Platform, OLS and flowlines could have a minor positive effect by creating an artificial reef and provide food and shelter to benthic species. The Safety Zone may act as refuge for some species and decrease mortality rates.

The effects of geophysical, seismic, geohazard and geotechnical have been assessed as a construction activity.

The environmental effect of the Project during the operations and maintenance phase and the mitigation to be implemented are summarized in Table 7-12.

Table 7-12 Environmental Effects Assessment: Operations and Maintenance

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Safety Zone	• Potential Decrease in Mortality	• None required	1	2	5/6	R	2
Presence of Structures	• Change in Habitat Quanity • Change in Habitat Quality • Change in Habitat Use	• Minor positive reef effect, no mitigation required	1	1	5/6	R	2
Lighting	• Change in Habitat Use		1	1	5/6	R	2
Maintenance Activities (*e.g.*, diving, ROV, *etc.*)	• Change in Habitat Use	• Use of best practices, continous improvement programs	1	1	5/3	R	2
Wastewater (produced water, cooling water, storage displacement water, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs • Adherence to discharge limits as per OWTG	1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Chemical Use/Management/Storage (*e.g.*, corrosion inhibitors, well treatment fluids, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs • chemical management system for screening of chemicals	1	2	5/6	R	2
Well Activities (well completions, work overs, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs and best available technology	1	1	5/2	R	2
WBM Cuttings	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Re-use of drill mud	1	2	5/2	R	2
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)	• Change in Habitat Use		1	1	5/6	R	2
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2008)	1	3	3/2	R	2
Potential Future Operational Activities							
Presence of Safety Zone	• Potential decrease in Mortality	• None required	1	2	5/6	R	2
Presence of Structures	• Change in Habitat Quanity • Change in Habitat Quality • Change in Habitat Use	• Minor positive reef effect, no mitigation required	1	1	5/6	R	2
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quanity • Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quanity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Use of best practices, continuous improvement programs • Adherence to OWTG	1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continuous improvement programs • Chemical management system for screening of chemicals	1	1	5/6	R	2
Geophysical/Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2008)	1	3	3/2	R	2

KEY

Magnitude:

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2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected

3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:

1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:

1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Operations and maintenance activities are not likely to result in any significant adverse environmental effects on Fish and Fish Habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible. The presence of structures and Safety Zones will create reef and refuge effects, respectively. Results from the EEM programs at Hibernia, White Rose and Terra Nova have confirmed the respective assessment predictions of no significant environmental effect on the marine environment for those production projects.

7.5.3 Offshore Decommissioning and Abandonment

The Operator will decommission and abandon the Hebron production facility according to regulatory requirements in place at the time of end of Project life. The GBS infrastructure will be decommissioned and the wells will be plugged and abandoned. The GBS structure will be designed for removal at the end of its useful life, although the decision as to whether this will be required will be made at that time. The decision to remove or abandon in place the pipeline and other subsea equipment will be made after a thorough analysis and in compliance with all applicable regulations

7.5.3.1 Change in Habitat Quantity

The possible removal of offshore subsea infrastructure during Project decommissioning and abandonment may affect the quantity of fish habitat in the Offshore Project Area; however, the effects of habitat quantity will be of less magnitude and geographic extent than during Project construction (see Section 7.5.1.1). The possible removal of the Hebron Platform, rock and/or concrete mattress cover over the OLS and or flowlines, will remove the reef and refuge effect that these structures had created.

7.5.3.2 Change in Habitat Quality

Project decommissioning and abandonment activities may affect fish habitat quality during the possible removal of subsea structures through vessel noise and suspended sediments. The environmental effects of these activities are expected to be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and suspended sediments on fish habitat quality are discussed in Section 7.5.1.2.

7.5.3.3 Change in Habitat Use

Project decommissioning and abandonment activities could affect the behaviour of fish and invertebrates and therefore habitat use. The noise and underwater activity required during possible removal of subsea structures (*e.g.*, OLS, flowlines and wellhead) will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and underwater activity on fish habitat use are discussed in Section 7.5.1.3.

7.5.3.4 Potential Mortality

Project decommissioning and abandonment activities have the potential to cause mortality of fish and shellfish during the possible removal of subsea structures. Activities will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential for underwater construction activity to cause mortality of fish and shellfish is discussed in Section 7.5.1.4.

A minor negative environmental effect could result from the removal of a Safety Zone around the Hebron Platform, OLS and flowlines. The refuge effect created by the Safety Zone for some species will be removed upon Project decommissioning and abandonment.

The environmental effect of the Project during the decommissioning and abandonment Phase and the mitigation to be implemented are summarized in Table 7-13. Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm.

Table 7-13 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Safety Zone	• Potential Mortality		1	2	3/6	R	2
Removal of the Hebron Platform and OLS Loading Points	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs	1	2	2/1	R	2
Lighting	• Change in Habitat Use		1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs	1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs	1	2	3/1	R	2
Operation of Vessels (supply, support, standby and tow vessels/barges/ROVs)	• Change in Habitat Quantity • Change in Habitat Use		1	3	3/6	R	2
Surveys (Geophysical, Geological, Geotechnical, Environmental, ROV, Diving, *etc.*	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality		1	2	3/2	R	2

KEY

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Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Decommissioning and abandonment activities are not likely to result in any significant adverse environmental effects on fish and fish habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible.

7.5.4 Accidents Malfunctions and Unplanned Events

The potential environmental effects from spill events on fish and fish habitat in the Nearshore and Offshore Study Areas are assessed together under each environmental effect category.

The type and probability of various types of spill in the offshore is discussed in Chapter 14, as well as modelling results for oil spill trajectory in the nearshore and offshore. The complete modelling reports are provided as AMEC 2010b.

Spill prevention will be incorporated into the design and operations of the Hebron Project. All offshore systems and structures, procedures and programs will be designed with consideration of preventing the loss of any hydrocarbons or chemicals. Examples of measures to reduce the likelihood of oil spills include equipment and facility design, routine maintenance and testing for all aspects of the production program, the use of good communications and sound marine practices, regular inspections and audits of the offshore structures, and employee awareness training. ExxonMobil Canada Properties (EMCP) will also undertake all of the necessary planning, training, and exercising to ensure that the appropriate spill response capability is in place for all phases of the Project, in the unlikely event of an accident release. Oil Spill Response is included as part of the contingency planning undertaken for the Project.

7.5.4.1 Change in Habitat Quantity

The quantity of fish habitat would not be expected to be affected due to an accidental release of hydrocarbons in the nearshore or the offshore. In the nearshore, an accidental release of diesel resulting from a collision or grounding of a construction vessel or barge is the most credible scenario. A diesel spill on the surface of the water would not likely affect the quantity of habitat, given its properties of evaporation and dispersion (see AMEC 2010b). In the offshore, a spill of crude oil would dissipate through evaporation as well, but would have potential to form tar balls and sink to the sea floor. In any case, the quantity of fish habitat affected by a spill would be negligible.

An accidental release of cuttings and muds (WBMs and/or SBMs) would form a small component and would be within of the cuttings footprint discussed above.

7.5.4.2 Change in Habitat Quality

The quality of fish habitat could potentially be affected by an accidental release of hydrocarbons or chemicals in the Nearshore or Offshore Study Areas.

Environmental effects of oil spills on plankton would be short-lived, although zooplankton are more sensitive than phytoplankton. Phytoplankton production may be inhibited by oil concentrations under a slick, but standing crop and species composition of the phytoplankton may be unaffected.

Johansson *et al.* (1980) found that zooplankton densities declined near a spill but rebounded within five days. Data from the *Prestige* oil spill did not reveal any significant shifts in zooplankton biomass during the spring bloom after the spill (Varela *et al.* 2006). Calanoid copepods were the dominant group of zooplankton in 2003, as they were in previous years (Varela *et al.* 2006). The capability of both phytoplankton and zooplankton to metabolize hydrocarbons would reduce the environmental effects on the pelagic ecosystem. Fish would accumulate hydrocarbons if they eat contaminated zooplankton, but they are also able to metabolize hydrocarbons, so there is no potential for biomagnification.

The environmental effects of a hydrocarbon spill on invertebrates and invertebrate habitat are determined by factors such as species and life history stage, type of habitat, weather and time of year. Hydrocarbons can be detectable in sediments for several years if they are not physically or biologically disturbed (Sanders *et al.* 1980). Low levels of hydrocarbons in the substrate can have sublethal effects on nearby invertebrates, resulting in possible histopathological damage. When small spills of diesel are stranded on shorelines, the diesel will penetrate porous sediments, but are quickly washed by wave action and tidal flushing.

The benthic community would be at most risk from a blowout. Oil from a blowout can reach the seafloor (thereby affecting the benthic invertebrate community) through weathering, losing buoyancy and eventually sinking or by associating with particulate matter suspended in the water and eventually sinking (Elmgren *et al.* 1983). Crustaceans appear to be the most sensitive organisms in benthic communities. Most oil spills have resulted in major environmental effects on crustacean fauna (Elmgren *et al.* 1980; Sanders *et al.* 1980; Dauvin and Gentil 1990; Jewett *et al.* 1999).

When compared to a crude spill, the nature of diesel fuel is such that it evaporates from the surface relatively quickly and does not persist in the environment for any length of time (National Oceanic and Atmospheric Administration 2006). Diesel has a low viscosity and is readily dispersed within the water column when winds reach approximately 9 to 13 km/h (5 to 7 knots) or with breaking waves. It is possible for diesel to be dispersed by wave action and may form droplets that are kept in suspension and move with currents. Diesel may also be restricted from dispersion and evaporation by sea ice and therefore maintain its toxic potential. A spill in Bull Arm during the ice season would have a localized effect on productivity. Microalgae grow on the undersurface of sea ice and can account for up to 30 percent of the annual productivity in the water column (Clark and Finley 1982).

Egg and larval stages would be more subject to physiological effects from a crude or diesel spill as they cannot actively avoid the spill nor have they developed any detoxification mechanisms. Environmental effects to eggs and larvae can include morphological malfunctions, genetic damage, reduced growth or localized mortality (see Section 7.5.4.4).

Given the potential spill scenarios within the Nearshore and Offshore Study Areas (see Sections 14.2 and 14.3, respectively), there is more potential for diesel to interact with the benthic community than crude oil. In the unlikely event of a diesel spill from a vessel or barge accident in the nearshore, diesel could reach the shoreline of the Nearshore Study Area (Figure 7-13). Diesel has been found to have an immediate toxic effect on many intertidal organisms, including periwinkles, limpets, gastropods, amphipods and other potential prey of fish and shellfish (Pople *et al.* 1990; Stirling 1977; Wormald 1976; Cripps and Shears 1997; Kennicutt *et al.* 1991).

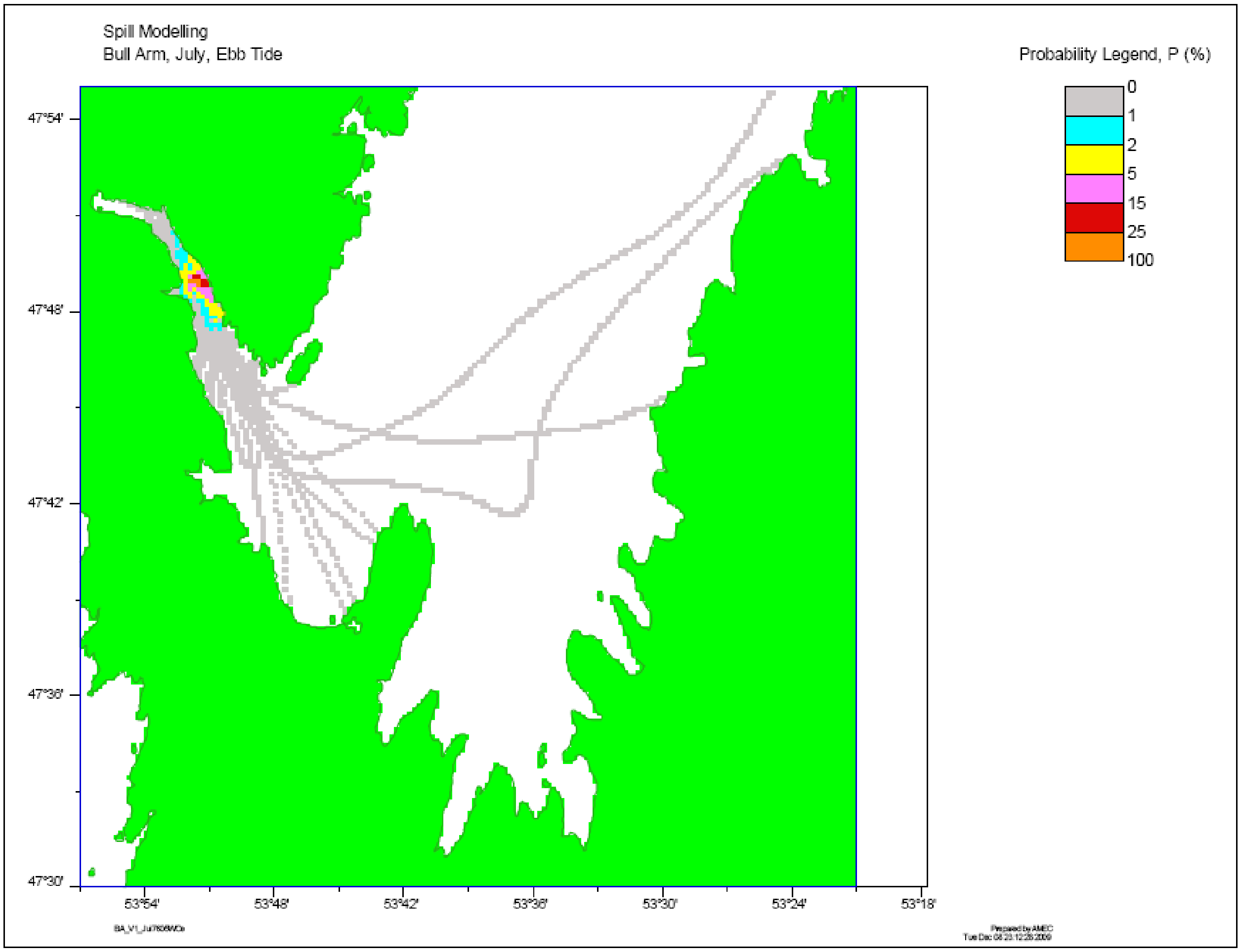

Figure 7-13 Diesel Spill Probability Plot in the Nearshore Study Area

Another potential spill scenario is the failure of the SBM handling system during potential future MODU drilling. There are few studies that focus on the fate and effects of an accidental release of drilling muds and fluids (US Minerals Management Service 2004b; Canada-Nova Scotia Offshore Petroleum Board 2005). Drilling fluids and muds are known for their degradation under certain environmental conditions. The rate of biodegradation is dictated by temperature, hydrostatic pressure and oxygen levels. Smothering of potential food sources for fish and shellfish may occur due to the weight of the barite where the SBM collects in a layer of 1 cm or more (Bakke *et al.* 1989), in particular in areas where sediment unevenness may permit pooling of the SBM. The SBM would likely be confined to the sediment-water interface and would not likely be incorporated into the sediment as would be the case with cuttings. Marine fauna that depend on this interface for food or that are non-tolerant to the SBM would be most affected. Another potential environmental effect would be reduced recruitment caused by habitat selection in settling invertebrate larvae.

Biological effects are usually not detectable outside 500 m (Hurley and Ellis 2004), but may occur to a distance of 1,000 m (Olsgård and Gray 1995). At concentrations of 1.5 mg/L, ParaDrill IA appears to have caused weight loss in sea scallop somatic and reproductive tissues; however, the effects were reversed after exposure ceased (Armsworthy *et al.* 2005). Bioaccumulation of PAHs from ParaDrill IA particulate can occur in scallop, depending on the concentration, suspended particulate matter and feeding rate of the scallop. The sea scallop is one of the most sensitive species to drilling waste in that low PAH levels of 0.05 to 2.0 mg/L have been shown to affect growth and reproduction (Cranford *et al.* 2005). These effects likely result from physical effects, since SBMs are non-toxic. These effects are caused by the physical properties of the SBMs and WBMs, as fine particles of bentonite and barite interfere with digestion and feeding of scallops (Armsworthy *et al.* 2005) and possibly other bivalve species (Barlow and Kingston 2001).

7.5.4.3 Change in Habitat Use

An accidental event in the Nearshore or Offshore Study areas could cause a change in fish behaviour and thus affect use of a particular habitat. Juvenile and adult finfish have been known to avoid areas of oiled sediment (Irwin *et al.* 1998). Less mobile invertebrates could not so easily avoid the oil. The ability of fish to avoid an oiled area must be considered within the context of their habitat requirements. Presumably, if fish were avoiding an area, they would seek the next clean area of similar habitat. The habitat seeking behaviour may have consequences on the mortality rates of juvenile fish and shellfish through predation and on the success of foraging of all life stages, if alternate habitats are not readily available. However, alternate habitats are available for both the Nearshore and Offshore Study areas and changes in behaviour not likely to have further consequences.

7.5.4.4 Potential Mortality

In the unlikely event of a rupture in the bund wall, mortality of fish and shellfish in the immediate area could result. Depending on the rate of collapse of the bund wall, some fish and shellfish near the rupture point could be entrained in the surge of water into the drydock area. Fish and mobile shellfish outside the immediate entrainment area would likely avoid the risk.

In the unlikely event of a hydrocarbon spill, lethal effects on eggs and larvae are more likely during an oil spill than adult fish mortality. Eggs and larvae tend to congregate in the upper water column where they could be directly exposed if they occur at the same time and in the same space as an oil spill. Also, fish eggs and larvae are more vulnerable to hydrocarbons since they have not yet developed any detoxification mechanisms, and cannot actively avoid the spill. Fish eggs generally appear to be highly sensitive to oil contamination at certain stages and then become less sensitive just prior to larval hatching (Kühnhold 1978; Rice 1985). Rice *et al.* (1986) reported that larval sensitivity varies with yolk sac stage and feeding conditions, with eggs and larvae exposed to high concentrations of oil exhibiting morphological malformations, genetic damage and reduced growth. Embryo damage may not be apparent until the larvae hatch (Kühnhold 1974).

Given the high rate of natural mortality of eggs and larvae, the environmental effects of a localized spill would be undetectable, and recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of a spawning area were lost (Rice 1985). No effect was detected at the population level when herring larvae survival was reduced by 58 percent due to the *Exxon Valdez* spill (Hose *et al.* 1996).

The spatial extent of hydrocarbon spills offshore is highly variable depending on the nature of the spill and the weather conditions immediately after the spill. A summary of those scenarios is presented in Sections 14.2 and 14.3, and a complete spill modelling report is provided in AMEC 2010b.

The environmental effect of the potential accidental events and the mitigation to further reduce the likelihood of occurrence and potential effects is summarized in Table 7-14.

Table 7-14 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Change in Habitat Use • Potential Fish Mortality	• Prevention through design standards and maintenance	1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan	1	3	2/1	R	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	1	5	2/1	R	2
Subsea Blowout	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	2	5	3/1	R	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Prevention through design standards and maintenance	1	5	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan	1	1	2/1	R	2
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Ship operations will adhere to Annex I of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78)	1	5	2/1	R	2
Collisions (involving Hebron Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Ice Management Plan • Adherence with all standard navigation procedures,Coast Guard requirements and navigation systems	1	3	2/1	R	2

KEY

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3 = High: >25 percent of the population or habitat in the Study Area will be affected

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Ecological/Socio-economic Context:
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[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Due to the reversibility and limited duration of an accidental event, potential environmental effects of a spill (hydrocarbon or chemical), blowout or bund wall rupture on marine fish and fish habitat is considered adverse but not significant and not likely to occur. Natural recruitment is expected to re-establish the population to its original level and avoidance of the area is expected to be temporary should an accidental event occur.

7.5.5 Cumulative Environmental Effects

7.5.5.1 Nearshore

Cumulative environmental effects on marine Fish and Fish Habitat in the Nearshore Study Area could occur as a result of the proposed Project in combination with commercial fisheries, which can contribute to physical disturbance during trawling and noise effects, and marine transportation, which can contribute to contamination and noise effects.

It is unlikely that nearshore routine activities associated with marine transportation would have much adverse direct environmental effects on marine Fish and Fish Habitat within the Nearshore Study Area. There is some recreational marine transportation, but other than commercial fisheries-related transportation, there is little commercial vessel traffic within the Nearshore Study Area. While commercial fisheries have an environmental effect on marine invertebrates and fish through resource exploitation, the current level of commercial fishing activity within the Project Area is limited. The commercial fishery is managed by DFO to maintain fish populations at sustainable levels.

7.5.5.2 Offshore

In the Hebron Offshore Study Area, cumulative environmental effects on marine fish and fish habitat could occur as a result of the proposed Project in combination with the following activities:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activity
- Offshore seismic activity
- Marine Transportation and
- Commercial fisheries

Cumulative environmental effects on marine Fish and Fish Habitat in the Hebron Offshore Study Area could occur as a result of the proposed Project in combination with past, present and future oil and gas activities, which can contribute to physical disturbance, contamination, smothering of benthic organisms and noise effects. Commercial fisheries contribute to physical disturbance during trawling and noise effects, while chronic oil spills by marine transportation contributes to contamination as well as noise effects within the Hebron Offshore Study Area. These industries can interact cumulatively with the Hebron Project to have adverse environmental effects on Fish and Fish Habitat.

As of February 2010, there have been a total of 308 exploration, delineation and development/production wells drilled on the Grand Banks, including 104 exploration wells, 45 delineation wells and 159 development/production wells (C-NLOPB 2010a). As of April 2010, there were 46 SDLs, 24 Exploration

Licenses (ELs) and eight Production Licenses active on the Grand Banks (C-NLOPB 2010b). According to the C-NLOPB website, there are two proposed exploratory drilling programs on the Grand Banks. The currently proposed drilling activities are summarized in Table 7-15.

Table 7-15 Proposed Drilling Activity on the Grand Banks

Proponent	Exploration Activity (*e.g.*, wells, seismic surveys)	Location	Timing	Comments
Statoil Canada	Maximum of 27 wells	Jeanne d'Arc Basin Flemish Pass	2008 to 2016	Single and/or dual side-track exploration and appraisal/ delineation wells
Suncor	Maximum of 18 wells	Jeanne d'Arc Basin	2009 to 2017	Single and/or dual side-track exploration wells
Husky	Wells	Jeanne d'Arc Basin	2008 to 2017	Eighteen oil and gas targets; combination of vertical and deviated (twin) wells

EEM programs for production facilities in the Newfoundland offshore have demonstrated that the mitigation measures being implemented with respect to marine fish and fish habitat have been effective. It is generally accepted that the biological zone of influence from cuttings deposition is confined to within 500 m of the well (Hurley and Ellis 2004; Neff 2005). The changes to marine fish habitat as measured by benthic community changes have been primarily attributed to physical alterations in sediment texture, including smothering as opposed to toxic effects (Hurley and Ellis 2004). The data from current Canadian EEM programs suggest that benthic community change can be detected within 1,000 m of the drill site, with some habitat types and more sensitive species affected over greater distances, particularly along the axis of predominant current (Hurley and Ellis 2004).

The effects of drill mud and cuttings deposition in the area immediately adjacent to a well lessen considerably one to two years after drilling cessation (Kingston 1987; Gray *et al.* 1990). Fish habitat, as measured by changes in benthic community structure around single exploration wells, returned to baseline conditions within one year after cessation of drilling (Hurley and Ellis 2004). At Hibernia, partial re-injection of SBM drill cuttings commenced in March 2000; full re-injection capacity began in September 2002. In the 2002 EEM field study, a substantial reduction in hydrocarbon concentrations in sediment was already observed. The concentration of hydrocarbons was comparable to levels found in 1998 after one year of drilling and concentrations of barium were comparable to 1999 levels, after two years of drilling. The biological effects of drilling are considered reversible.

For the assessment of StatoilHydro Canada Ltd.'s proposed drilling program, LGL (2008b) calculated that for the drilling of up to 45 wells between 2008 and 2017, the total area of seabed potentially covered by at least 1 cm of drill cuttings would be approximately 45 x 0.8 km^2 or 36 km^2 (approximately 0.034 percent of the StatoilHydro Canada project area). The Husky White Rose New Excavated Drill Centre Construction and Operations Program, is proposing up to 54 wells; the total area potentially affected by drill cuttings deposition (without consideration of the potential for overlap) would be 54 x 0.8 km^2 or 43.2 km^2. These two areas combined represent approximately 0.07 percent of their cumulative project areas (LGL 2008b). The Hibernia South Project proposed a maximum of six excavated drill centres each supporting up to 11 wells, resulting in the worst case scenario (*i.e.*, no overlap of cuttings) of 8.8 km^2 of seabed covered by a minimum of 1 cm of drill mud and cuttings (Jacques Whitford 2009). Such is most likely not to be the case and as the cumulative affected area of 8.8 km^2 is an over-estimation. This cumulative area represents less than 1 percent of the Hibernia South project area.

The proposed Hebron Project could have up to 52 wells drilled from the Hebron Platform, with an additional 15 wells that may be drilled from MODUs within the Project Area. As a worst case, if it is assumed that all wells outside the Hebron Platform are separated such that drill cuttings are not re-injected and deposits around each well do not overlap, the result would be 12 km^2 of cuttings deposition around the MODU wells (0.8 km^2 x 15), plus 0.8 km^2 around the Hebron Platform. A total of 12.8 km^2 equals less than 0.5 percent of the Offshore Project Area of approximately 2,560 km^2.

There is a potential cumulative environmental effect from the WBM discharge when considered together with other drilling projects. While it is acknowledged that each production or exploration well is contributing to a cumulative environmental effect on marine fish habitat, each of these projects is affecting a localized area and the environmental effects are reversible. Each of these projects is also required to adhere to the OWTG (National Energy Board *et al.* 2002) and related monitoring requirements.

It is unlikely that routine activities associated with marine transportation have much adverse direct environmental effect on marine Fish and Fish Habitat. However, although commercial fisheries can have an environmental effect on marine Fish and Fish Habitat, the current level of commercial exploitation within the Project Area is very limited and DFO manages the fishery to keep populations at sustainable levels.

All discharges from the Hebron Project will be in accordance with the OWTG (National Energy Board *et al.* 2002). As general marine vessel discharges are also regulated, it is not predicted that any significant cumulative environmental effects on marine fish habitat would result. Produced water potentially affects the chemistry of the receiving environment within 50 to 500 m from each operating facility (HMDC 2005; Querbach *et al.* 2005), so there will be no additive environmental effect between projects. Pelagic organisms are not likely to be exposed to more than one plume. If fish do move between operation platforms, the ability of fish to metabolize low level hydrocarbons will reduce the potential for chronic effects.

The timing of seismic surveys within and between projects within the Hebron Offshore Study Area are unlikely to overlap. The only known project to coincide with the timing of the Hebron surveys is the Statoil Canada seismic survey of the Jeanne d’Arc Basin (in and near EL 1100 and EL 1101), and within the Terra Nova Field), which may continue up to 2016. Both the Suncor seismic survey in the Jeanne d'Arc Basin and the EMCP geohazard survey are scheduled for 2010.

The Hibernia South Project anticipated up to six drill centres may be required, and possibly two, 1-km^2 dredge spoil disposal areas, although more may be required. The Hebron Project may require up to four excavated drill centres as part of future development plans. As a conservative assumption, the excavation of each excavated drill centre may require its own dredge spoil area, each approximately 1 km^2. However, it is possible that a dredge spoils disposal area may be used more than once. The total area of the potential HADD has yet to be determined, but EMCP will adhere to the DFO policy of no net loss of the productive capacity of fish habitat from this Project. The spatial and temporal scales of potential environmental effects from dredging, compared to the amount of existing similar habitat on the Grand Banks, the high potential for reversibility and the commitment for habitat compensation, will reduce the cumulative environmental effects from dredging and disposal.

Given that the predicted environmental effect of the proposed Project is not significant, and that other oil and gas activities in the Offshore Project Area are likely to have similar environmental effects on Fish and Fish Habitat, and given the limited nature of commercial fishing in the area, and the temporal and spatial overlap with other projects is limited, the cumulative environmental effects of the Project on Fish and Fish Habitat are predicted to be not significant.

7.5.6 Determination of Significance

The determination of significance is based on the definition provided in Section 7.2. It considers the magnitude, geographic extent, duration, frequency, reversibility, and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Fish and Fish Habitat, after taking into account any proposed mitigation, is summarized in Table 7-16.

The potential environmental effects of the Project on Fish and Fish Habitat are not considered of sufficient geographic extent, magnitude, duration, frequency and/or reversibility to result in a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Any potential environmental effects of the Project on marine fish habitat will be mitigated. The potential environmental effects of the Hebron Project on Fish and Fish Habitat are therefore predicted to be not significant.

Table 7-16 Residual Environmental Effects Summary: Fish and Fish Habitat

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction/Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	2	N/A
Cumulative Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.
[B] Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site.
[C] Includes decommissioning and abandonment of the GBS and offshore site.
[D] Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

As required by the *Canadian Environmental Assessment Act* (CEAA), an analysis of potential environmental effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on Fish and Fish Habitat are predicted that could affect renewable resource use.

7.5.7 Follow-up and Monitoring

The CEAA definition of "follow-up program" is "*a program for (a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project*". Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. Compliance monitoring on its own, does not satisfy the requirements for a follow-up program. Compliance monitoring is conducted to ensure that a project and its activities are meeting the relevant environmental standards, guidelines and regulations. Compliance monitoring will be conducted for the Project in accordance with regulatory requirements.

An environmental protection program may require effects monitoring at Bull Arm during construction. Similarly, if ocean disposal permits are required, EMCP will implement a monitoring program in accordance with the provisions of the Ocean Disposal Permit.

The offshore and nearshore EEM programs that will be designed and implemented for this Project are both considered as follow-up monitoring as defined by CEAA.

EMCP will implement an offshore EEM program that will be designed to determine if activities associated with the Hebron Project, as predicted in this environmental assessment, are affecting the receiving environment. The parameters of the EEM program may include those being monitored by other offshore oil and gas operations (*i.e.*, sediment chemistry, sediment toxicity, water chemistry, fish taint, fish health and body burden). However, the details of the EEM design program will be determined in consultation with regulatory, scientific authorities and other interested stakeholders. An overview of the process that will be followed in the design of the EEM program is provided in Section 15.2.

A fish habitat compensation monitoring program will also be implemented as a follow-up monitoring program once the habitat compensation measures implemented. Details of the compensation monitoring program will be outlined in the Hebron Habitat Compensation Strategy report.

8 COMMERCIAL FISHERIES

8.1 Environmental Assessment Boundaries

8.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Chapter 4). The Study Areas and Project Areas are illustrated in Figures 8.1 and 8.5, for the nearshore and offshore, respectively.

8.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are provided in Table 8-1.

Table 8-1 Temporal Boundaries of Nearshore and Hebron Offshore Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation/start-up/drilling as early as 2015 • Production year-round through to 2046 or longer • Potential future activities - as required, year-round through to end of Project • Decommissioning/abandonment: after approximately 2046

8.1.3 Administrative

Administrative boundaries for commercial fisheries are the Northwest Atlantic Fisheries Organization (NAFO) Division and Unit Areas as determined by DFO which manages the fisheries resources in the area and is primarily responsible for scientific surveys within the area. The Nearshore Study Area falls entirely within NAFO sub-division 3Lb, which includes all of Trinity Bay. The Offshore Study Area encompasses several sub-divisions within NAFO Division 3LMN. The Offshore Project Area is located entirely within sub-division 3Lt. DFO manages the fisheries in both the Nearshore and Offshore Study Areas. The Provincial Department of Fisheries and Aquaculture manages aquaculture, emerging fisheries and developing fishery projects within the territorial seas (12 nm).

8.2 Definition of Significance

The following definition of significance is used for the Commercial Fisheries assessment:

- Not Significant: does not have a measurable effect on commercial fishing incomes.
- Significant: has a measurable and sustained adverse effect on commercial fishing incomes.

8.3 Existing Conditions

This section describes the existing and recent commercial fisheries in the Nearshore and Offshore Study and Project Areas.

8.3.1 Nearshore Project Area

8.3.1.1 Study Area Homeports

The boundaries of the Nearshore Study Area (Figure 8-1) include all of Bull Arm and Tickle Bay, bounded on the east by a line from Tickle Harbour Point to the southern headland of Deer Harbour, as described in Chapter 4.

While other Trinity Bay-based fishing enterprises may occasionally operate on established fishing grounds in this part of the bay, most of the harvesting activities are conducted by fishers from seven fishing homeports in the southernmost part of the bay: Sunnyside; Chance Cove; Bellevue; Thornlea; Norman's Cove; Long Cove; and Chapel Arm. Discussion and analysis of harvesting activities in this section focus on the fishing activities of enterprises from these seven homeports.

8.3.1.2 Data Sources and Use

Analysis of fish harvesting activities examined in this section relies on data from the Statistics Division of the Fisheries and Oceans Canada (DFO) and from the department's Regional Licensing Office. In addition to using relevant information from the DFO catch and effort database (*e.g.*, for the overview of fisheries activities in Unit Area 3Lb discussed above), a special data run was requested from the Statistics Division that focused specifically on the activities of enterprises in the seven homeports. This was the smallest geographic area for which DFO was able to provide information without infringing on its data confidentiality guidelines.

Additional information on fishing enterprises and harvesting was obtained during consultations with Study Area fishers based in the seven relevant communities. These consultations are described in Section 5.3.

Figure 8-1 Nearshore Project and Study Areas

8.3.1.3 Enterprises, Vessels and Species Licenses

There are a total of 35 Core[9] and non-Core fishing enterprises in the Nearshore Study Area (Table 8-2), 23 of them operating vessels in the less than 40-foot class size, and 12 using vessels in the greater than 40-foot class size. The two non-Core enterprises in the Study Area are in Bellevue and in Chapel Arm. These 35 enterprises employ 70 to 80 individuals.

Table 8-2 Total Number of Core and Non-Core Enterprises by Fleet, Nearshore Study Area Homeports, 2009

Homeport	<40'	40' and greater	Total
Sunnyside	3	1	4
Chance Cove	6		6
Bellevue	4	2	6
Thornlea	1	2	3
Long Cove	4	2	6
Norman's Cove	3	3	6
Chapel Arm	2	2	4
Total	23	12	35
Source: DFO 2009d (Licensing Branch)			

The distribution of species licenses by vessel size is shown in Tables 8-3 and 8-4. Core fishing enterprises collectively hold a total of 288 species licences. Additionally, the two non-Core enterprises hold nine licences in total.

Table 8-3 Licenses held by Core Enterprises by Fleet, Nearshore Study Area Homeports, 2009

Species/Gear Type	Vessels <40'	Vessels >40'	Total
Bait	19	4	23
Capelin FG[A]	21	5	26
Capelin PS[B]	-	6	6
Groundfish FG[A]	21	12	33
Herring FG[A]	20	3	23
Herring PS[B]	-	7	7
Mackerel FG[A]	21	7	28
Mackerel PS[B]	-	8	8
Lobster	18	3	21
Scallop	-	2	2
Shrimp	-	3	3
Squid	21	10	31
Snow Crab	21	12	33
Sea Urchin	4	-	4

[9] "Core" enterprises are those which are headed by a Core fisher. A Core fisher must be the head of an enterprise, hold key species licences (*i.e.*, for Newfoundland, groundfish, capelin, lobster, snow crab, scallop, shrimp, and all species using purse seine), have a demonstrated attachment to the fishery, and be dependent on the fishery. See http://www.dfo-mpo.gc.ca/communic/lic_pol/ch3_e.htm

Species/Gear Type	Vessels <40’	Vessels >40’	Total
Whelk	11	4	15
Seal	17	7	24
Eel	1	-	1
Totals	195	93	288
Source: DFO 2009d (Licensing Branch) [A] FG = Fixed gear [B] PS = Purse seine			

Table 8-4 Licenses held by Non-Core Enterprises by Fleet, Nearshore Study Area Homeports, 2009

Species/Gear Type	Vessels <40’	Vessels >40’	Total
Bait	1		1
Capelin FG[A]	1		1
Capelin PS[B]	-		-
Groundfish FG[A]	2		2
Herring FG[A]	1		1
Herring PS[B]	-		-
Mackerel FG[A]	-		-
Mackerel PS[B]	-		-
Lobster	1		1
Scallop	-		-
Shrimp	-		-
Squid	2		2
Snow Crab	-		-
Sea Urchin	-		-
Whelk	-		-
Seal	1		1
Eel	-		-
Totals	9		9
Source: DFO 2009d (Licensing Branch) [A] FG = Fixed gear [B] PS = Purse seine			

Only the larger vessels (greater than 40-foot) are licensed to fish certain species such as shrimp and scallop, or to participate in fisheries where quotas are allocated to mobile gear sectors. All of the 33 Core enterprises are licensed to fish crab. The 21 smaller boats harvest their crab entirely within Trinity Bay (within UA 3Lb; see Figure 8-2), while the 12 larger vessels take this species in quota zones well beyond Trinity Bay (the two non-Core enterprises are not permitted to harvest snow crab).

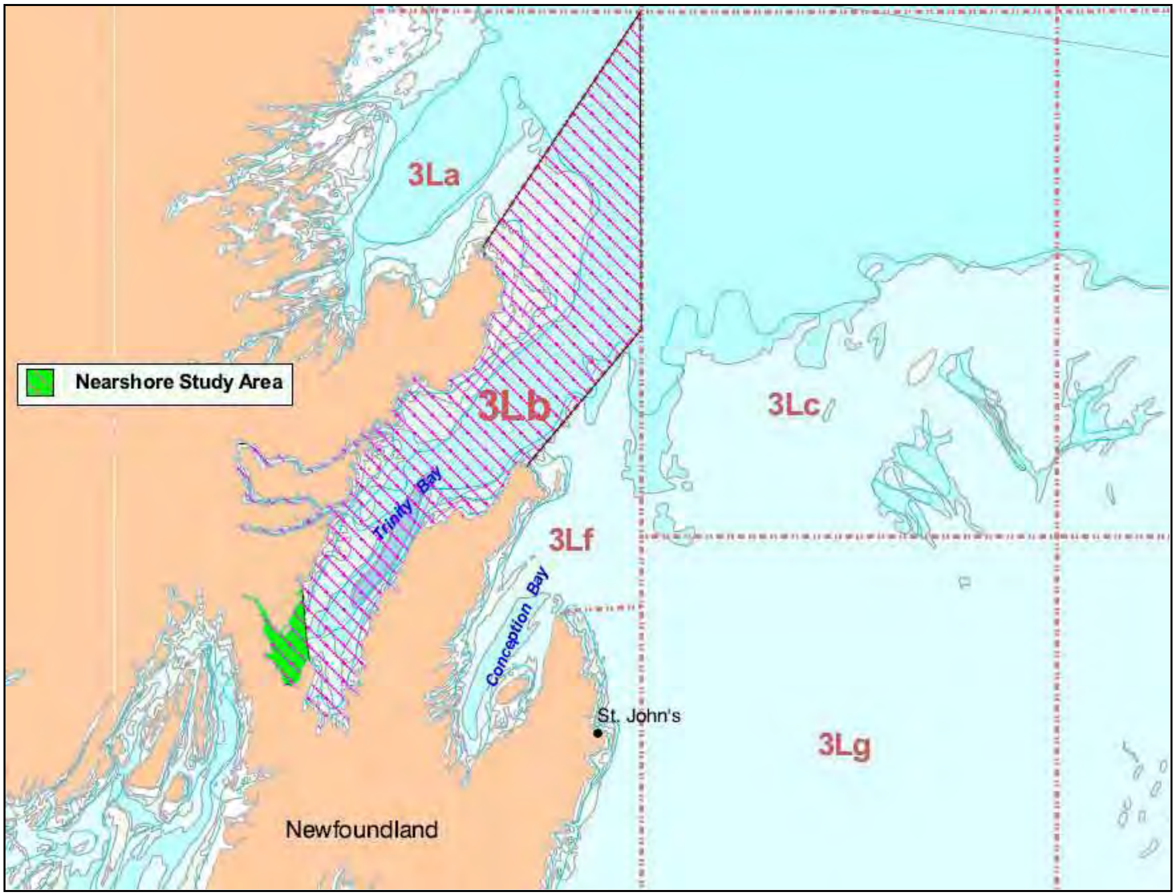

Figure 8-2 Trinity Bay, Unit Area 3Lb

8.3.1.4 Key Species Catches – Trinity Bay Fishing Grounds (Nearshore Study Area Homeports)

Overall landings have fluctuated from year to year during the past 10 years, ranging from a peak of about 3,200 tonnes in 2000 to a low of 1,500 tonnes in 2002. Despite these ups and downs, the general trend has been relatively stable.[10]

As indicated in Tables 8-5 and 8-6, the annual average catch 2004 to 2008 was just over 2,100 tonnes, and the average annual fishing income just over $1 million.

[10] Unless otherwise indicated, all landings in this section refer to species catches harvested from UA 3Lb by vessels based in the seven Nearshore Study Area homeports.

Table 8-5 Average Harvest by Quantity, 2004 to 2008

Species	Tonnes	% of Total
Cod, Atlantic	27.00	1.3
Redfish	0.08	0.0
American plaice	0.00	0.0
Yellowtail flounder	0.01	0.0
Winter flounder	7.23	0.3
Turbot/Greenland halibut	0.01	0.0
Skate	1.34	0.1
Herring, Atlantic	247.08	11.5
Mackerel	346.87	16.2
Eels	0.12	0.0
Capelin	1,315.86	61.4
Shark, blue	0.02	0.0
Squid, Illex	56.47	2.6
Whelks	0.06	0.0
Sea Urchins	8.55	0.4
Lobster	2.16	0.1
Crab, Queen/Snow	124.21	5.8
Seal fat	1.05	0.0
Roe, lumpfish	4.00	0.2
Total	2,142.12	100.0

Table 8-6 Average Harvest by Value, 2004 to 2008

Species	Value	% of Total
Cod, Atlantic	$36,579	3.5
Redfish	$44	0.0
American plaice	$1	0.0
Yellowtail flounder	$4	0.0
Winter flounder	$3,393	0.3
Turbot/Greenland halibut	$9	0.0
Skate	$316	0.0
Herring, Atlantic	$47,493	4.5
Mackerel	$106,193	10.0
Eels	$649	0.1
Capelin	$339,115	32.1
Shark, blue	$27	0.0
Squid, Illex	$20,253	1.9
Whelks	$59	0.0
Sea Urchins	$18,467	1.7
Lobster	$25,122	2.4
Crab, Queen/Snow	$442,393	41.9
Roe, lumpfish	$16,640	1.6
Total	$1,056,755	100.0

As indicated in Tables 8-5 and 8-6, capelin, mackerel and herring accounted for almost 90 percent by weight of the total catch with crab and squid making up a further 8.5 percent. Capelin, mackerel and herring also made up almost 50 percent of the average annual value of landings. Crab and lobster contributed a further 44 percent of the area's annual fishing income. Together, these five species have generated over 90 percent of all fishing income from species caught in Trinity Bay. Cod, sea urchin, squid and lumpfish make up most of the remaining portion of their annual earnings.

These catch and value figures pertain only to the species caught by Nearshore Study Area enterprises within Trinity Bay. The total average income for nine all enterprises is actually higher than the $1.056 million shown in Table 8-6. The 12 vessels in the "greater than 40-foot fleet" harvest considerable quantities of other species, such as crab and shrimp, and occasionally some pelagics, on grounds well beyond Trinity Bay/3Lb. In 2008, for example, the total value of crab caught by all Nearshore Study Area enterprises on all fishing grounds was just under $2.5 million, but $425,000 (17 percent) was taken from crab grounds in Trinity Bay. In the same year, the "greater than 40-foot fleet" harvested $455,000 worth of shrimp from grounds beyond Trinity Bay.

Based on historical catch data and consultations with nearshore fishers, most of the annual catch by Study Area enterprises operating "less than 40-foot vessels" is harvested from grounds within Trinity Bay. It is also reasonable to conclude that, with the exception of a portion of the crab, most of the all-species catch by "vessels less than 40-foot" comes from grounds within the Study Area. Enterprises in the "greater than 40-foot fleet" harvest a large portion of their annual catch of several key species within the Study Area.

8.3.1.5 Key Species Seasons

The seasons for various key Study Area species are shown in Table 8-7.

Table 8-7 Fishing Season by Species

Species	Fishing Season
Lobster	April 27 to July 8
Crab	Usually late April to the end of June; the opening date depends on winter ice conditions. In the past five or six years, crab has generally been harvested in May and June.
Cod	Usually opens in the first week of September and continues for about four weeks.
Herring	The mobile gear fishery usually takes place in October-November but can last into December depending on available quota. A fixed-gear fishery (usually with nets) in spring supplies bait for the lobster and crab fisheries.
Capelin	Mobile and fixed-gear fisheries usually take place within a 10 to 12 day window in late July-early August. (The opening date depends on capelin arrival and on DFO regulations.) In the period 2006 to 2008, the capelin fishery within the study area took place entirely in July.
Mackerel.	Usually opens August 15 and continues into December (Harvesting period is unpredictable, depending on mackerel arrival). During the period 2006 to 2008, the only mackerel fishery was in 2007, when all of the catch was made in October.
Sea Urchin	Generally harvested in late fall and in winter months when the roe content and quality is most suited to market demand.

8.3.1.6 Key Species Fisheries

This section provides a brief overview of trends in several key Nearshore Study Area species over the past decade. The discussion focuses on species which might be affected by Project activities, as identified by Nearshore Study Area fishers.

Harvesting locations identified in this section are based on the following information: fishers' previous experience with, and knowledge of, fish harvesting activities in the Bull Arm-Tickle Bay area; information obtained from fishers during recent consultations; and, analysis of a limited amount of geo-referenced catch data (for 35-foot to 65-foot vessels only)[11]. Fishing areas for key pelagic species (capelin, mackerel and herring) are shown in Figure 8-3.

Figure 8-3 Nearshore Study Area Harvesting Locations for Key Pelagic Species, 2006 to 2008

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[11] DFO's catch and effort database for less than 35-foot enterprises usually has a very low portion of geo-referenced information, because these fishers are not required to record the longitude/latitude location of their catches, except for snow crab. A higher portion of the catch taken by larger vessels is geo-referenced. The discussion in this section is based on available geo-referenced catch data indicating the harvesting locations for capelin, mackerel and herring that fall within the geographic boundaries of the Nearshore Study Area. All of these data are for vessels between 35-foot and 65-foot for the past three years only (2006 to 2008).

Capelin

Annual capelin catches over the past 10 years have ranged from 1,260 to 3,500 tonnes. In nearly all years, the majority of the capelin caught by Study Area enterprises has been taken within Trinity Bay (3Lb). Fixed-gear fisheries account for most of the capelin harvested in the area; in 2007 and 2008, fixed-gear vessels took 77 percent and 82 percent, respectively. In addition, the majority of the catch, approximately 64 percent, is typically harvested by the smaller vessels. All of the 2008 catch came from 3Lb, with a landed value of $336,000.

In 2006, capelin were harvested during July in several locations along the western shore of Tickle Bay between Green Head and Ram Head and in other Tickle Bay locations (*e.g.*, on grounds just to the west of Tickle Harbour Point). In the same year, one enterprise in the 35-foot to 44-foot fleet harvested 17.5 tonnes of capelin just below Green Head using fixed gear (see Figure 8-3).

In 2008, larger (35-foot to 44-foot and 45-foot to 54-foot) vessels, using fixed and mobile gear, harvested 273 tonnes of capelin in nearshore grounds between Chance Cove and the entrance to Bull Arm. In that year, Study Area vessels less than 35-foot caught 824 tonnes of capelin valued at $210,000. Though no data are available to indicate the locations where these capelin were harvested, it is likely that a substantial portion of the 824-tonne catch was taken within the Study Area (*i.e.*, on some of the same capelin grounds fished by the larger vessels discussed above).

Herring

Herring catches were generally poor in the first six years of this decade. There were no landings in 2000, 2001 or 2003, and only 3.6 tonnes were landed in 2005. However, the fishery has been improving since 2006, with 333 tonnes harvested in that year and 534 tonnes harvested in 2007. Herring is not a high-value species; the annual average value of the Nearshore Study Area catch over the three years (2006 to 2008) was only $78,000. However, it provides a good income boost. Like most pelagic species, herring can be harvested very efficiently and relatively cheaply, close to the fisher's homeport. Over the past 10 years, 90 percent to 100 percent of the catch has come from 3Lb, and in the past three years, approximately 72 percent of the catch has been taken by the larger vessels using mobile gear.

In 2006, according to DFO geo-referenced catch data, purse seiners caught 35 tonnes of herring in October. There were no landings in 2007. The largest harvest of herring was in November 2008, with over 125 tonnes of herring harvested, all by larger vessels. Herring were taken by tuck seine and by purse seine on grounds just off Western Head. This species was also harvested in the outer part of Bull Arm and in the middle portion of Tickle Bay (see Figure 8-3).

Mackerel

Mackerel is a relatively new species for Study Area fishers. There were no landings in the period 1999 to 2003, and only 36 tonnes were taken in 2004. However, almost 500 tonnes were landed in 2005, and catches in 2006 and 2007 were 884 and 974 tonnes, respectively. In 2007, almost 97 percent of the catch came from 3Lb, up from 70 percent in the previous year. However, mackerel landings dropped to 180 tonnes in 2008, with all of the fish caught outside Trinity Bay. In general, most of this species is harvested by the "greater than 40-foot vessels" using mobile gear. Smaller vessels, however, landed almost 40 percent (385 tonnes) of the total catch in 2007. In that year, this fishery was worth $265,000 to Study Area enterprises.

Study Area enterprises have been harvesting large quantities of mackerel within 3Lb since 2004. However, according to DFO geo-referenced catch data, 2007 was the only year that mackerel was harvested on grounds within the Study Area. In October of that year, the "greater than 40-foot vessels" using fixed and mobile gear harvested 253 tonnes in the Study Area. Harvesting locations included: within Great Mosquito Cove, grounds close to shore near the entrance to Rantem, off Ram Head, at various locations along the west side of Bull Arm between Ram Head and Great Mosquito Cove, and on grounds off the south shore of Bull Island (see Figure 8-3).

Snow Crab

All of the 33 Core enterprises hold crab licenses, but only vessels less than 35-foot who hold "Inshore" crab licences may fish crab in Trinity Bay, designated as Crab Fishing Area (CFA) 6A. The remaining 12 enterprises operating vessels greater than 40-foot hold either "Large Supplementary" or "Small Supplementary" crab licenses and harvest their quota on grounds well beyond Trinity Bay.

The crab fishery is the most economically important fishery in the Nearshore Study Area. During the past 10 years, it has generated an annual average income of $2.88 million for all Study Area enterprises combined (including catches made by larger Nearshore Study Area vessels on grounds beyond 3Lb, *e.g.*, on quota areas outside 200 miles).

The average annual landed value of crab of these enterprises from Trinity Bay (Crab Fishing Area (CFA) 6A) is just under $465,000, based on annual average landings of 130 tonnes from this area. Over the past decade, snow crab harvesting in Trinity Bay have generated approximately 16 percent of the average annual value of the total crab ($2.88 million) catch by all Nearshore Study Area enterprises.

Nearshore Study Area enterprises operating vessels less than 35-foot harvest crab on grounds within Trinity Bay, including those located in the deeper water within Tickle Bay and Bull Arm. Crab gear is set in water depths between 200 and 300 m. Crab harvesting locations within the Study Area are indicated in Figure 8-4. There are approximately 15 well established harvesting locations, most of which are located in the deeper water within Tickle Bay. The relative importance of each site as a harvesting location is also indicated on Figure 8-4. For example, crab fishing area with number 26 indicates that this area has 26 “data hits” stacked on top of one another. In other words, it is likely a very abundant crab harvesting location, a potential “hot spot” where a particular fisher (or several fishers) will fish throughout the season or from year to year. Detailed analysis of the DFO geo-referenced data shows that this location yielded 10.3 tonnes of crab catch between 2005 and 2007. Another “hot spot” with 13 data points yielded 2.5 tonnes during one season.

Figure 8-4 Nearshore Study Area Snow Crab Harvesting Locations, 2003 to 2008

Lobster

Lobster catches have been in decline since the late 1990s, when the annual catch was about five tonnes. In the past five years, landings have ranged between 1.3 and 2.9 tonnes. In 2003, the catch was worth just under $50,000. Most of the lobster is harvested by vessels less than 35-foot; three of the 22 license holders are enterprises operating vessels greater than 40-foot.

Lobster are fished on grounds close to a homeport. Pots are set close to shore, generally in water depths of less than 20 m. Chance Cove lobster fishers set some of their gear on the west side of Bull Arm between Ram Head and Great Mosquito Cove. Sunnyside fishers set their lobster gear in various shoreline locations within Bull Arm, including grounds directly within Great Mosquito Cove.

Sea Urchin

Sea urchins have been harvested in the Study Area since 1998; however, there have not been any landings since 2006, primarily because of poor market conditions. Landings peaked at 43 tonnes in 2003, when the catch was worth just over $100,000. Urchins are fished by vessels less than 35-foot and, with the exception of 1999 and 2003, when small quantities were taken in 3La, all of the landings have been from Trinity Bay.

This species is taken by divers on kelp beds in water depths between 3 and 12 m. Within the Study Area, urchins have been harvested in several nearshore locations within Bull Arm, including in Great Mosquito Cove, on grounds close to Chance Cove, and in Bellevue Bight. This species has not been harvested since 2006. Fishers note that urchin harvesting could resume if market conditions improve.

8.3.2 Offshore Fisheries

This section describes commercial fisheries in the Offshore Study Area and, in particular, the Offshore Project Area. It focuses primarily on domestic Canadian fisheries from 2004 to 2008, but also provides a historical overview of the general region. This general overview includes data analysis that characterizes international fisheries in the Offshore Study Area beyond Canada’s 200 nautical mile (nm) Exclusive Economic Zone (EEZ).

The Offshore Study Area, the Offshore Project Area and proposed Hebron Platform site are shown in relation to the 200 nm EEZ and NAFO fisheries management Unit Areas in Figure 8-5. The Offshore Project Area is located within NAFO unit area 3LT. The Offshore Study Area includes portions or all of NAFO unit areas 3LMN.

8.3.2.1 Data Sources and Use

The commercial fisheries descriptions of the domestic harvest for the Offshore Study Area are based in part on data derived from the DFO Newfoundland and Labrador Region and Maritimes Region catch and effort datasets for the period 1986 to 2008[12]. Maritimes Region data are included because a portion of the harvest (7 to 8 percent by quantity, mainly shrimp) is typically landed in Nova Scotia. Foreign catches landed outside these areas are not included in the DFO data.

[12] The data represent all catch landed within the Scotia-Fundy section of DFO Maritimes Region and for all Newfoundland and Labrador landed catch. Foreign catches landed outside these areas are not captured by the data. The data are still classified by DFO as preliminary, though the species data shown in this report are not likely to change to any significant extent when the data are finalized. Initial data for 2009 were also received (April 2010) and these indicate that fishing activities in 2009 (in terms of quantities and harvesting locations) were quite consistent with those in recent years (*i.e.*, 2004-2008)

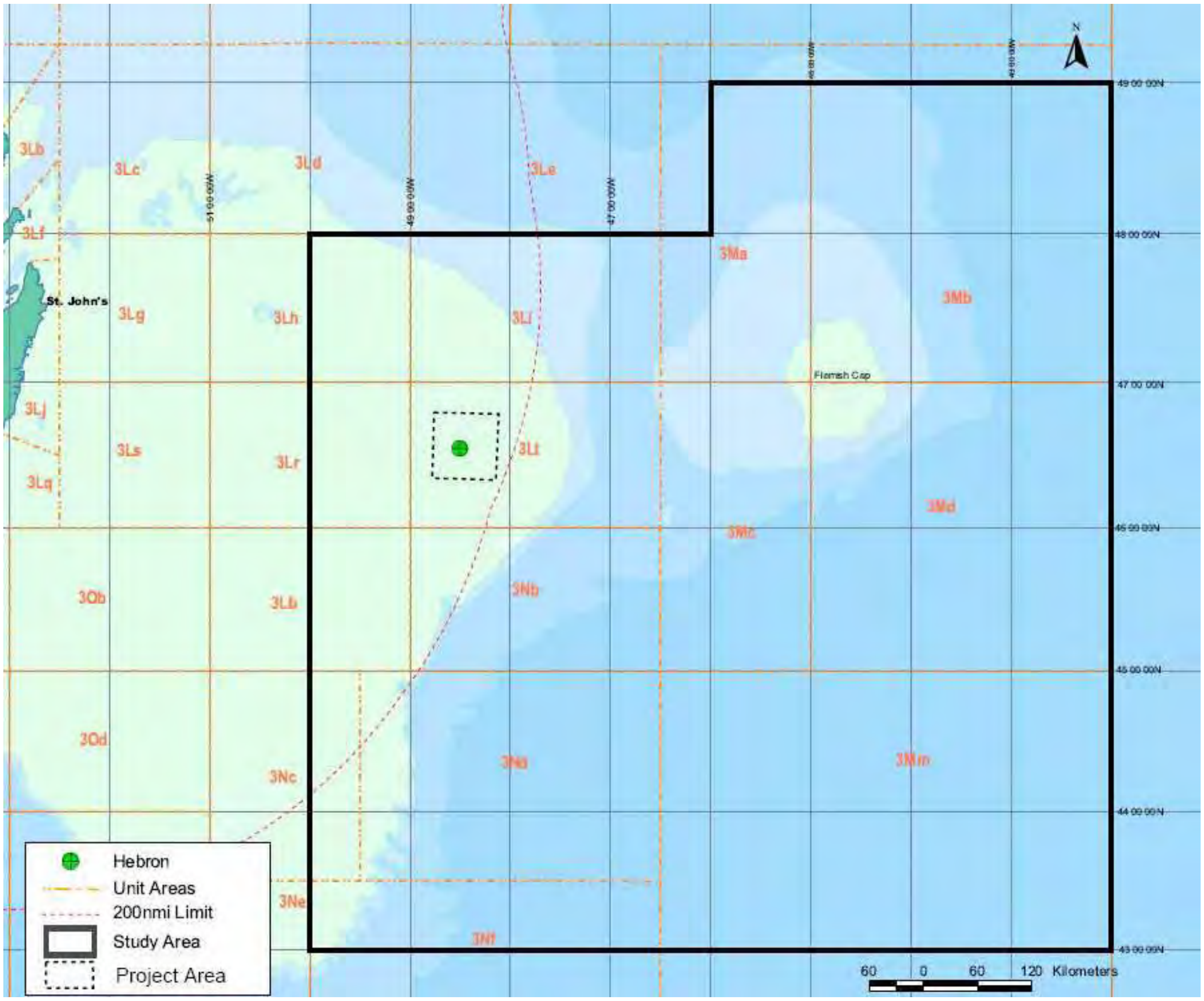


Figure 8-5 Offshore Study Area, Project Area and Other Zones

Most of the catch data for the Offshore Study Area are geo-referenced (*e.g.*, an average of 98 percent by quantity of the harvest from Unit Area 3Lt over the past five years), which allows plotting of past harvesting locations[13]. The fish harvesting maps in the following sections show harvesting locations as dark points. The points are not "weighted" by quantity of harvest, but show where fishing effort was recorded.

For foreign fisheries, primarily outside the EEZ, NAFO datasets (STATLANT 21A data) for 2004 to 2008 are used (NAFO 2009). These datasets capture NAFO-managed harvests by Canadian fishers and non-Canadian NAFO states at the fisheries management Division level within the NAFO

[13] The location given is that recorded in the vessel's fishing log, and is reported in the database by degree and minute of latitude and longitude; thus the position is accurate within approximately 0.5 nm of the reported coordinates. It should be noted that for some gear, such as mobile gear towed over an extensive area, or for extended gear, such as longlines, the reference point does not represent the full distribution of the gear or activity on the water. However, over many data entries, the reported locations create a fairly accurate indication of where such fishing activities occur.

Convention Area[14]. The location of these divisions and the relevant Convention Area boundary are shown in Figure 8-6.

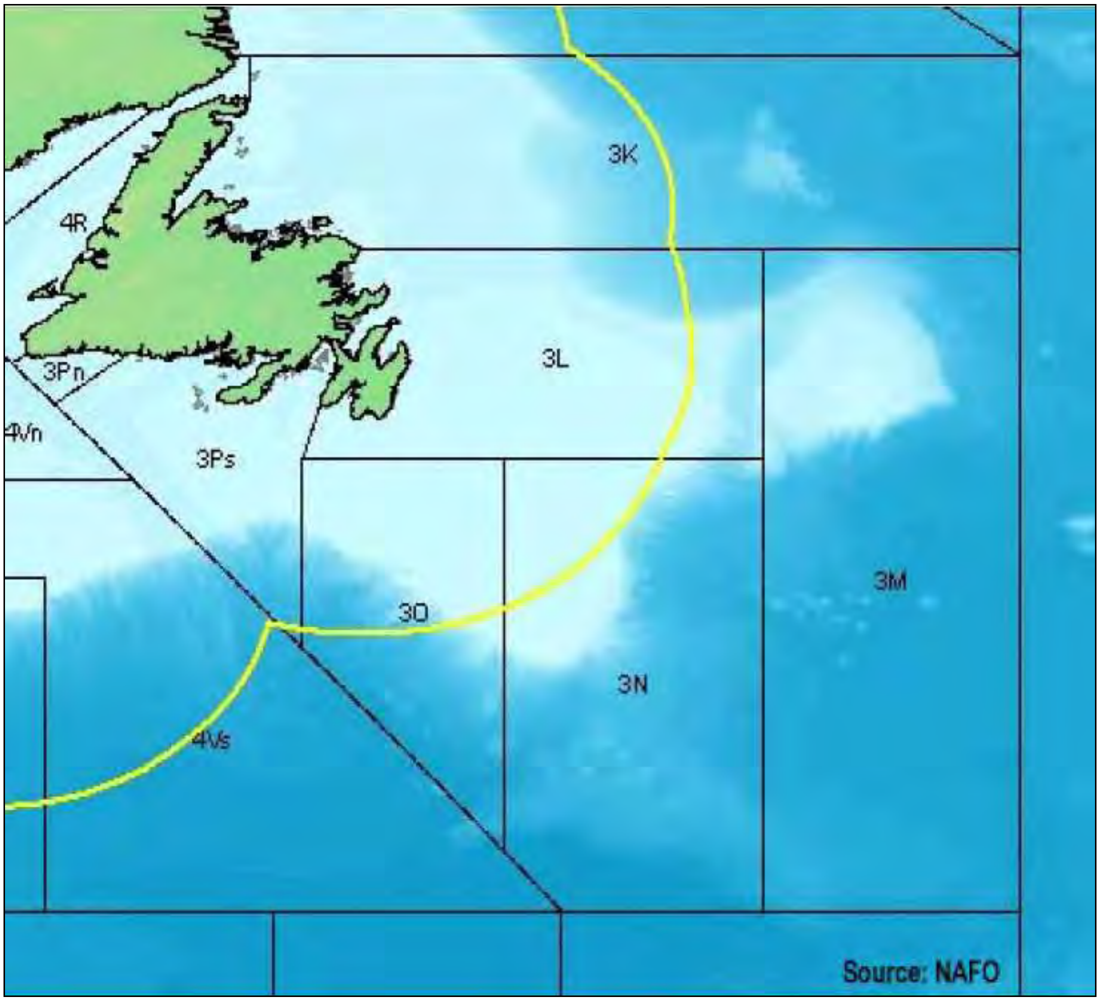


Figure 8-6 Northwest Atlantic Fisheries Organization Divisions

In most of the following data tables, the weight of the harvest (in tonnes) is given rather than value, since these quantities are directly comparable from year to year. Values (for the same quantity of harvest) may vary annually with species, negotiated prices, changes in exchange rates and fluctuating market conditions.

Where values are used in this section, they are taken directly from the DFO datasets and are not corrected to current dollars. Other sources consulted include DFO species management plans, quota reports, other research reports and studies, and consultations with scientists, managers and fishing interests. Additional information was obtained during consultations with offshore fishers, described in Chapter 5.

[14] The Hebron Offshore Study Area includes parts of NAFO Divisions 3N, 3L and 3M; the Hebron Platform is within 3L.

8.3.2.2 Historical Overview of Regional Fisheries

Until the early 1990s, most of the harvesting in the offshore areas of the eastern Grand Bank was groundfish (*i.e.*, demersal species) taken by large stern otter trawlers. Groundfish harvested included Atlantic cod, redfish, American plaice and several other species. In 1992, with the acknowledgement of the collapse of several of these stocks, a harvesting moratorium was declared and directed fisheries for cod virtually ended in the area. In 2003, the Committee on the Status of Wildlife in Canada (COSEWIC) listed the Atlantic cod (Newfoundland and Labrador population) as an endangered species.

Shrimp and crab, formerly underused species, have come to replace most of the groundfish harvested since the collapse in 1992. These two species are now the principal catches by most harvesters in the Study Area, as they are in many other areas offshore Newfoundland and Labrador. Other economically important fisheries in the offshore Study Area are the deep sea clams (propeller and Stimpson’s surf) and Greenland cockles. In Newfoundland and Labrador waters, this fishery is localized primarily near eastern and southeastern edges of the Bank. It has grown to become a key part of the region’s harvest since its start in 1989. Fish landings from 1986 to 2008 from NAFO Unit Areas 3LMN are illustrated in Figures 8-7 and 8-8.

The historical landings in Unit Area 3Lt are similar, except that the impact of the closures on groundfish harvesting has been even more pronounced, as indicated in Figure 8-9. It should be noted; however, that even before the moratorium (*e.g.*, 1984 to 1990), Unit Area 3Lt usually accounted for just over 2 percent of the NAFO 3L groundfish harvest.

8.3.2.3 Domestic Fisheries

In general, the Offshore Study Area fisheries have changed little over the past decade or so, as the preceding graphs show. Although fishers express hopes that the groundfish fisheries (especially cod) will return to previous levels in these areas, there is not yet sufficient reliable indication of when and if this might occur. Since 1992 through 2009 there has been virtually no change in the groundfish fisheries in Unit Area 3Lt, which has consistently recorded harvests of less than 2 percent of its pre-1992 levels.

The following table (Table 8-8) shows the average domestic harvest in more recent years (2004 to 2008) by quantity and value recorded specifically within the Study Area. The principal fisheries (by quantity of harvest) within the Study Area are snow crab (approximately 40 percent by quantity of the overall harvest/64 percent by value), northern shrimp (36 percent quantity/25 percent value) and a variety of deep sea clams and cockles (21 percent quantity/10 percent value). The remaining fisheries are for groundfish (mainly yellowtail flounder, with lesser quantities of halibut and American plaice); together these species make up less than 3 percent by quantity or value.

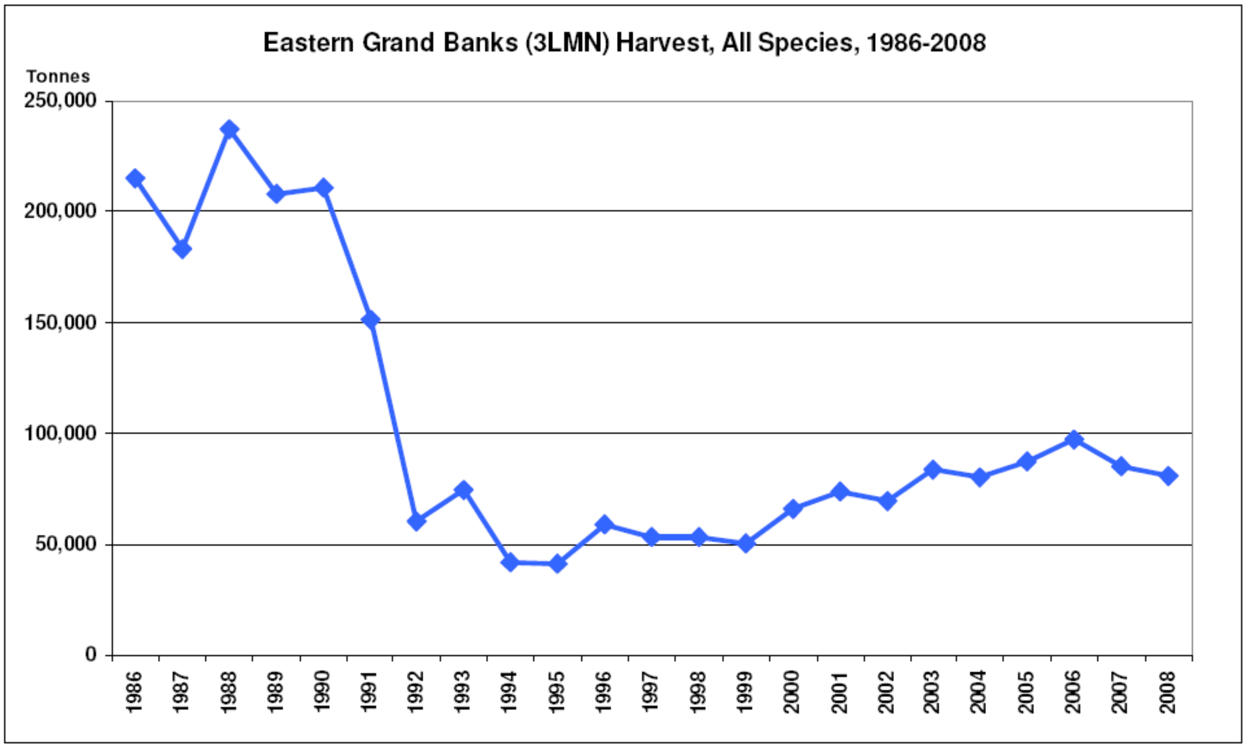


Figure 8-7 **Eastern Grand Bank Harvest, All Species, 1986 to 2008**

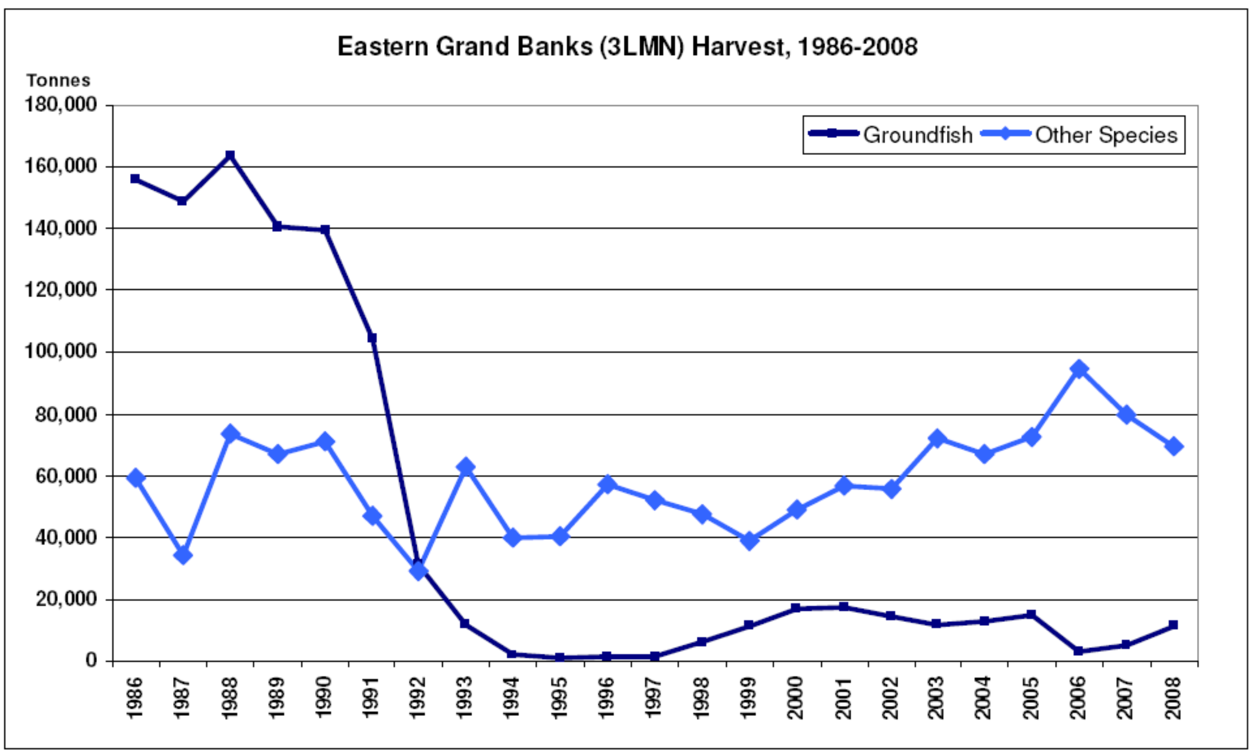


Figure 8-8 **Eastern Grand Bank Harvest, Groundfish versus Other Species, 1986 to 2008**

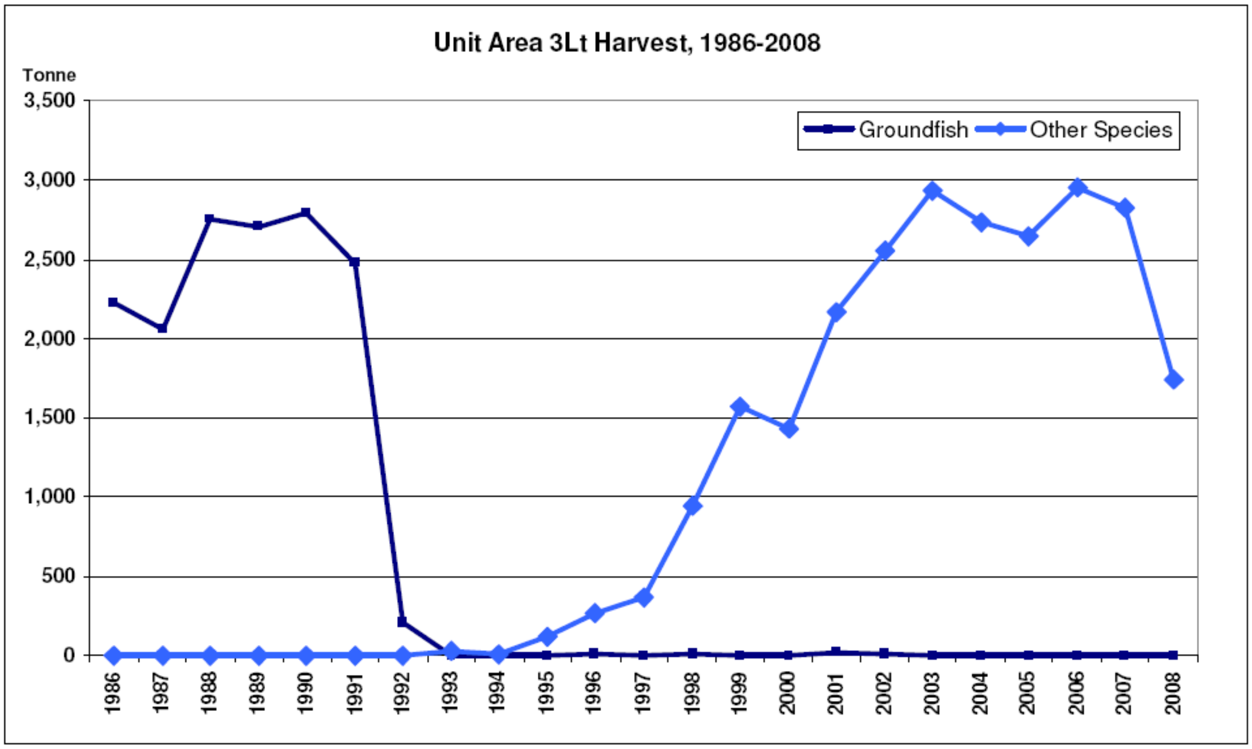


Figure 8-9 Unit Area 3Lt Harvest, Groundfish versus Other Species, 1986 to 2008

Table 8-8 Offshore Study Area Quantity and Value of Harvest by Species, all Months, 2004 to 2008

Species	Quantity (t)	% of Total	Value ($)	% of Total
Cod	4.2	0.0	4,999	0.0
Halibut	19.7	0.1	226,008	0.5
American plaice	31.5	0.1	15,592	0.0
Yellowtail flounder	592.6	2.4	327,744	0.8
Turbot	2.2	0.0	4,032	0.0
White hake	1.0	0.0	733	0.0
Roundnose grenadier	1.6	0.0	1,454	0.0
Total groundfish	652.8	2.7	580,562	1.4
Swordfish	15.2	0.1	37,199	0.1
Tunas	4.4	0.0	27,171	0.1
Sharks	1.9	0.0	768	0.0
Deepsea bivalves (clams/cockles)	4,993.8	20.5	4,078,278	9.7
Scallops	30.3	0.1	40,288	0.1
Shrimp	8,828.3	36.3	10,372,915	24.7
Snow crab	9,796.9	40.3	26,817,261	63.9
All other	3.1	0.0	784	0.0
Total, all species	24,326.6	100.0	41,955,224	100.0

Source: DFO 2009e (Maritimes and Newfoundland and Labrador and Maritimes Regions 2005-2009) All data tables and graphs include both Newfoundland and Labrador and Maritimes Region DFO catch and effort data

8.3.2.4 Offshore Project Area

Since the early 1990s there has been very little fish harvesting activity within the vicinity (*i.e.*, 30 to 50 km) of the proposed Hebron production site and the associated leases. What little harvesting there has been has been almost exclusively for snow crab over the last five years (2004 to 2008).

The harvesting data from within the Offshore Project Area by year for 2004 to 2008 are shown in Table 8-9.

Table 8-9 Species Harvest by Year from Offshore Project Area, 2004 to 2008

Year	Species	Quantity (t)	Value ($)
2004	Snow crab	6.5	35,369
2005	Snow crab	9.2	29,289
2006	Snow crab	6.0	13,009
2007	Snow crab	0.7	2,076
2008	Snow crab	2.5	8,396
Average		5.0	17,628

Harvesting Locations

Geo-referenced harvesting locations (DFO 2009f) in relation to the Offshore Study Area and the Project Area (aggregated for all species during all months) for 2004 to 2008 are shown in Figures 8-10 to 8-14.

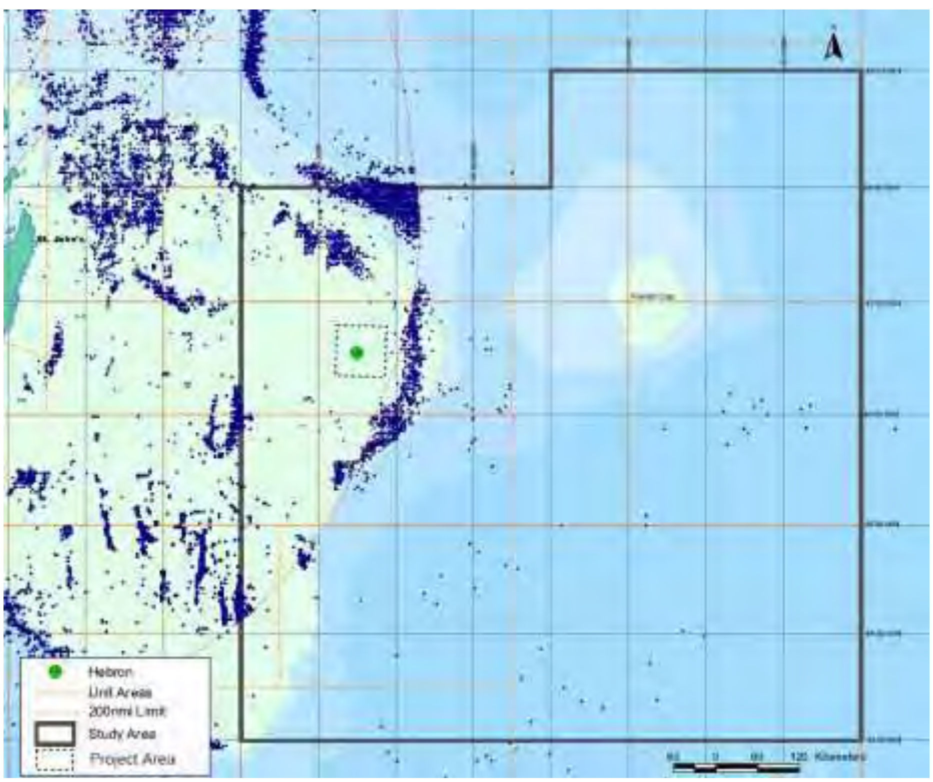


Figure 8-10 Domestic Harvesting Locations, 2004

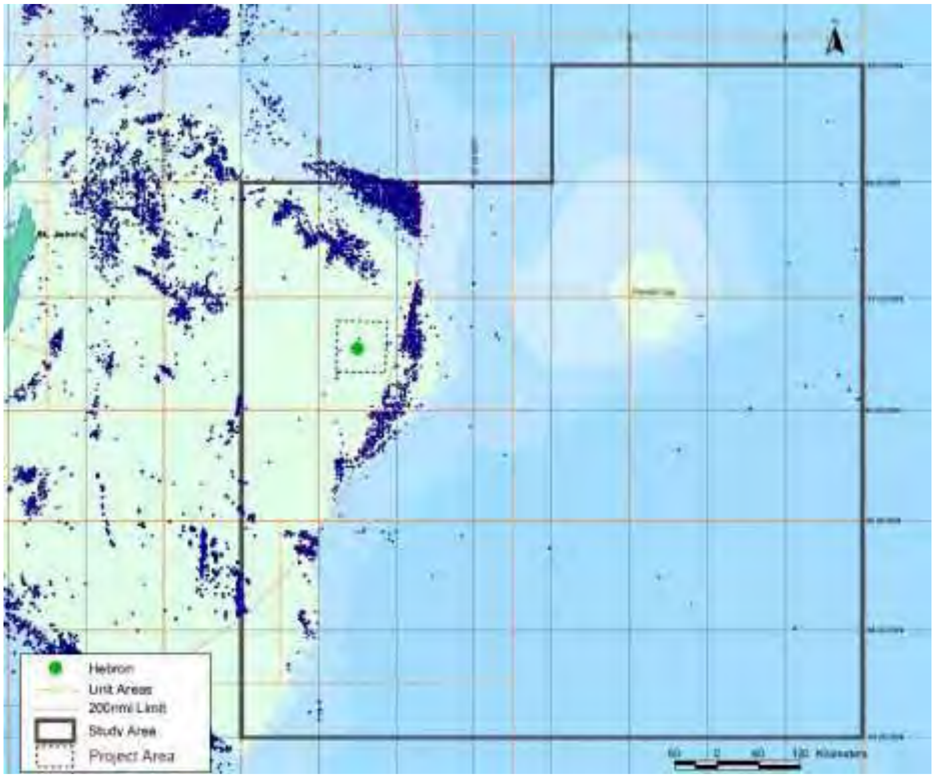


Figure 8-11 Domestic Harvesting Locations, 2005

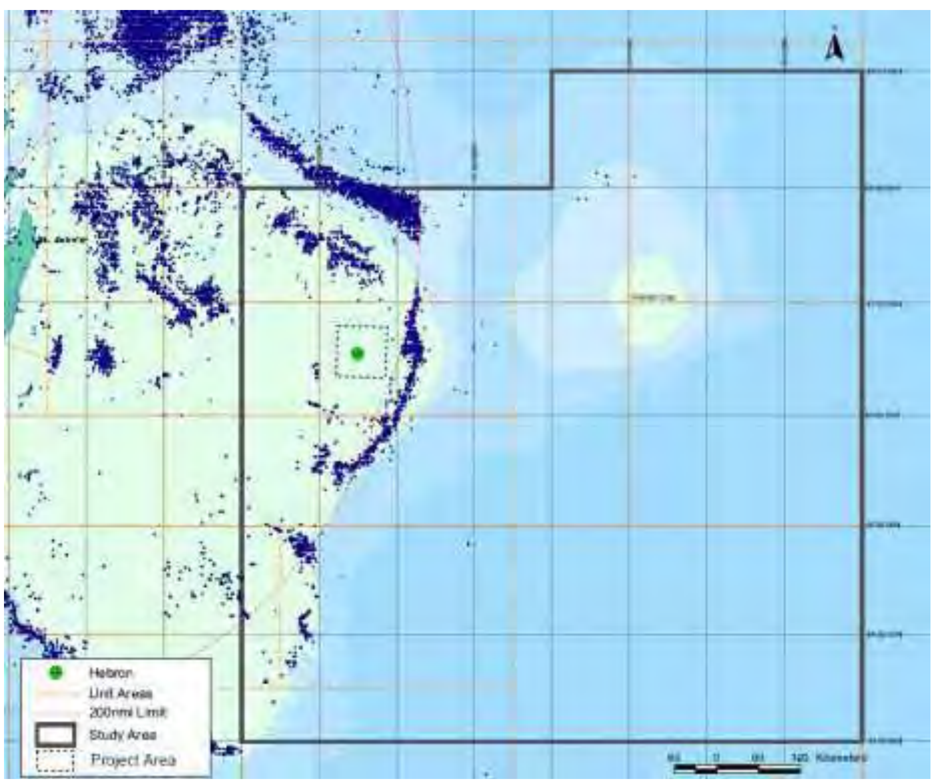


Figure 8-12 Domestic Harvesting Locations, 2006

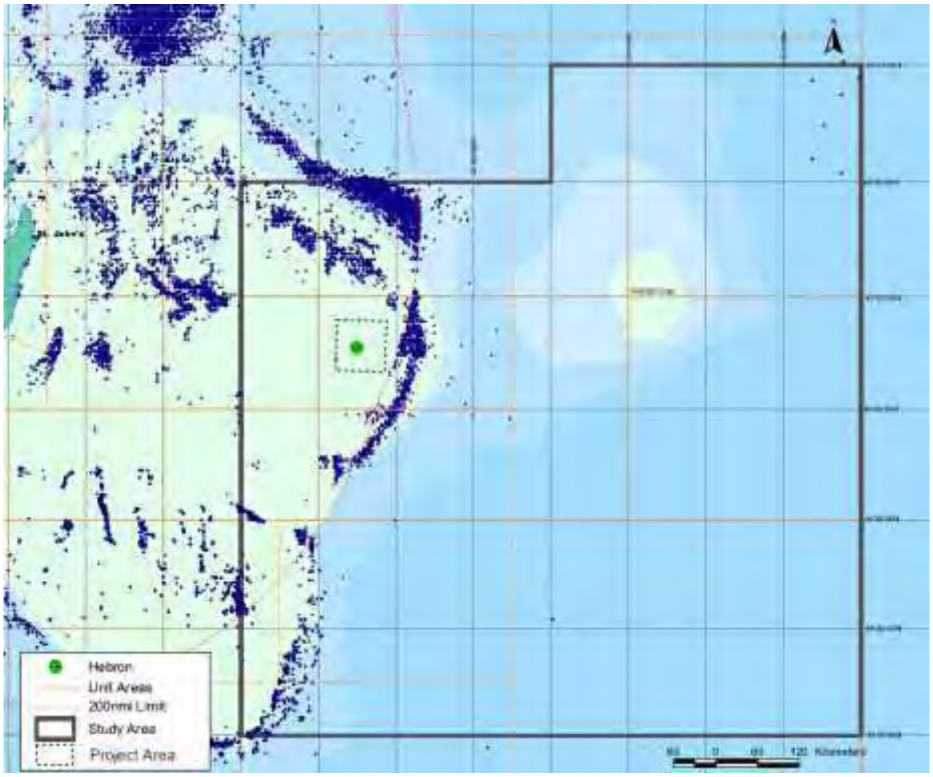


Figure 8-13 Domestic Harvesting Locations, 2007

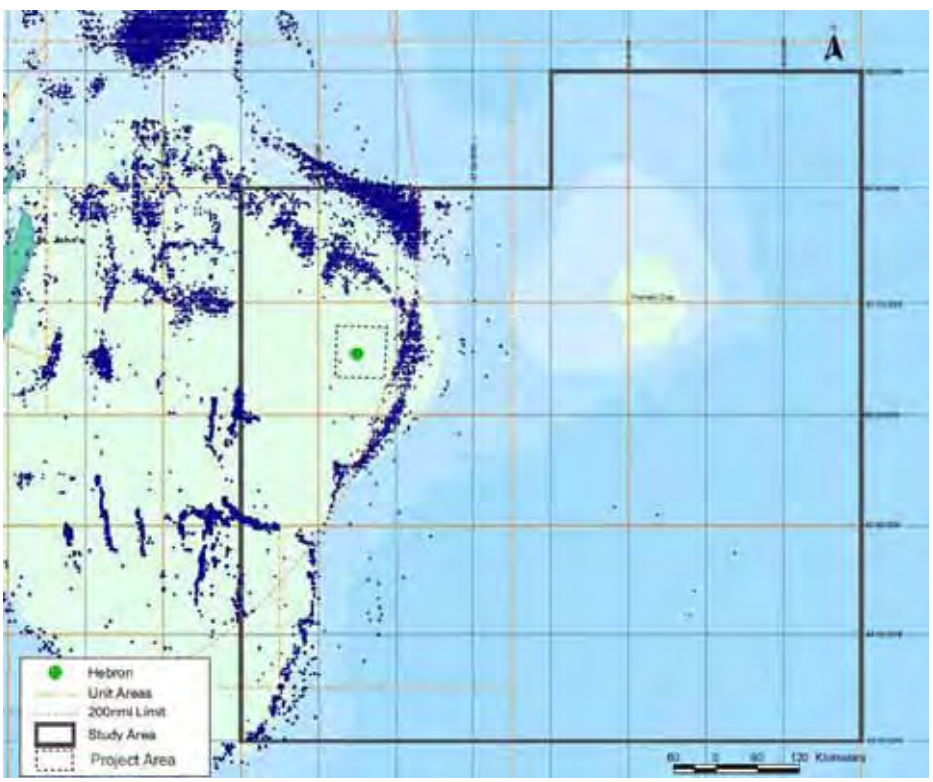


Figure 8-14 Domestic Harvesting Locations, 2008

As indicated in these figures, the harvesting locations are quite consistent from year to year. Most of the fish harvesting within and near the Offshore Study Area is concentrated on or near the shelf edge and slope. Much of this is at depths between 200 m and 500 m.

8.3.2.5 Timing of the Harvest

The quantity and value of fish harvested by month, averaged over the past five years, for the Offshore Study Area and the Offshore Project Area are shown in Figures 8-15 to 8-17. In both areas, overall harvesting effort and income have been highest May to July and lowest during the fall. However, the timing of the harvests can vary to some degree from year to year with resource availability, fisheries management plans and enterprise harvesting strategies. There was no recorded harvest before May and none after July in the Offshore Project Area.

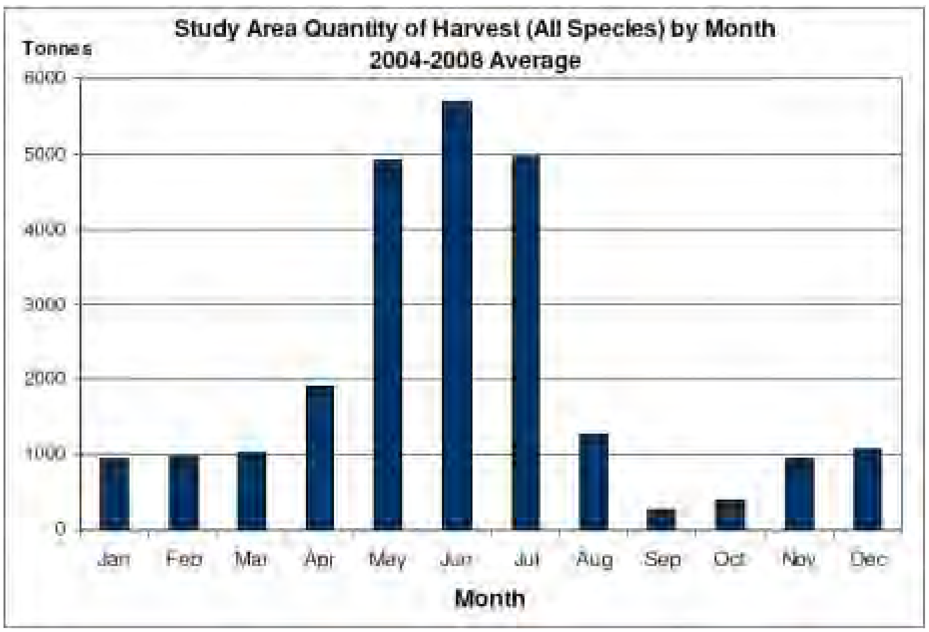


Figure 8-15 Offshore Study Area Quantity of Harvest by Month, 2004 to 2008, Averaged

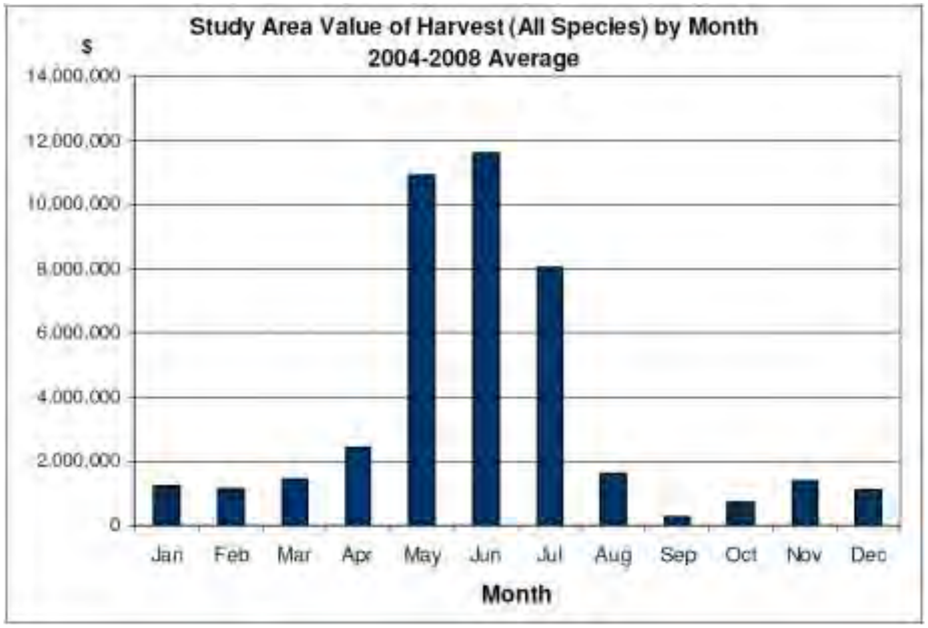


Figure 8-16 Offshore Study Area Value by Month, 2004 to 2008, Averaged

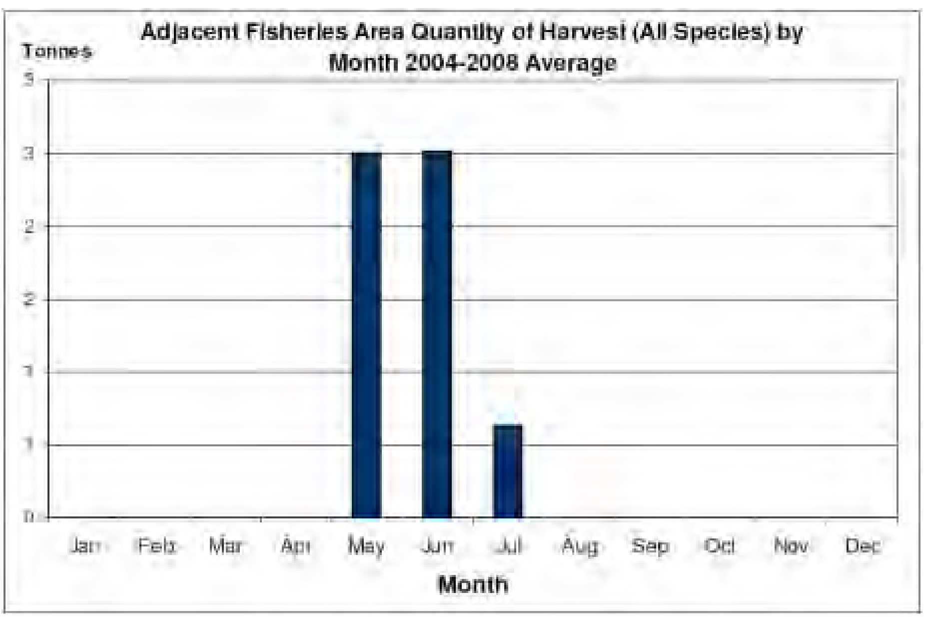


Figure 8-17 Offshore Project Area Quantity of Harvest by Month, 2004 to 2008, Averaged

The locations of domestic harvesting for all species by month (data aggregated) for 2004 to 2008 from Offshore Project Area fishing grounds are shown in Figures 8-18 to 8-29.

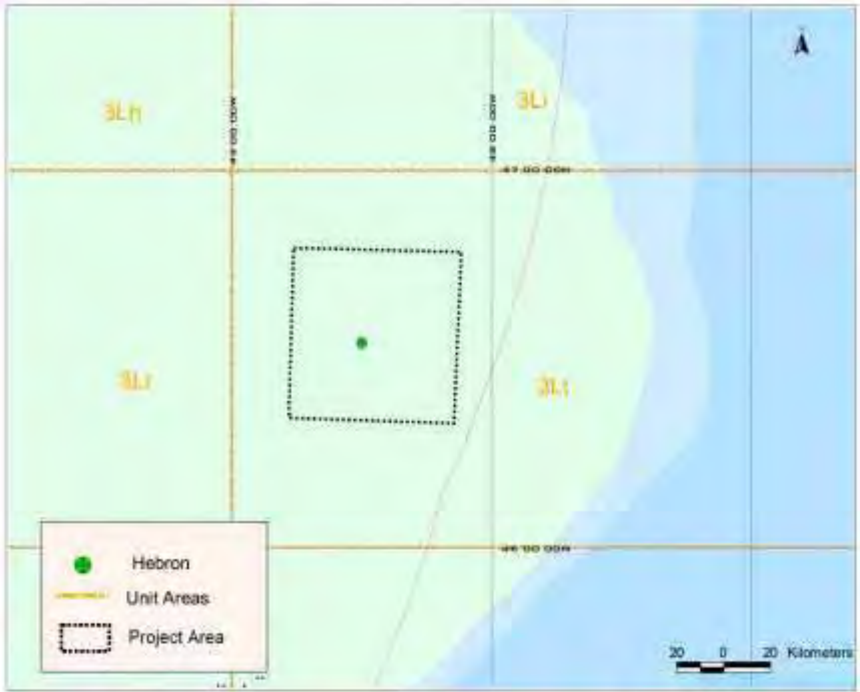


Figure 8-18 Location of Domestic Harvest, All Species, January 2004 to 2008, Aggregated

Figure 8-19 Location of Domestic Harvest, All Species, February 2004 to 2008, Aggregated

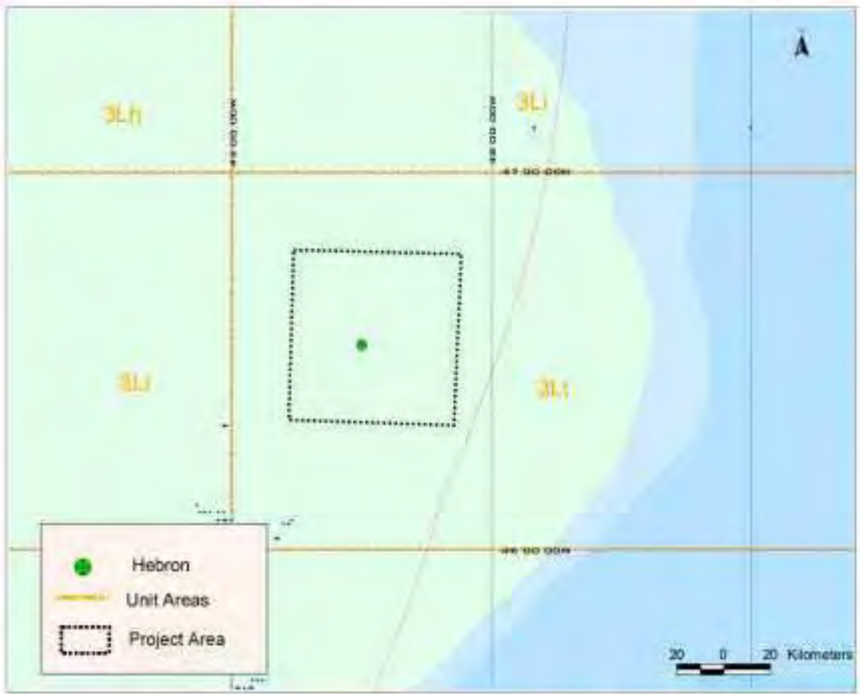


Figure 8-20 Location of Domestic Harvest, All Species, March 2004 to 2008, Aggregated

Figure 8-21 Location of Domestic Harvest, All Species, April 2004 to 2008, Aggregated

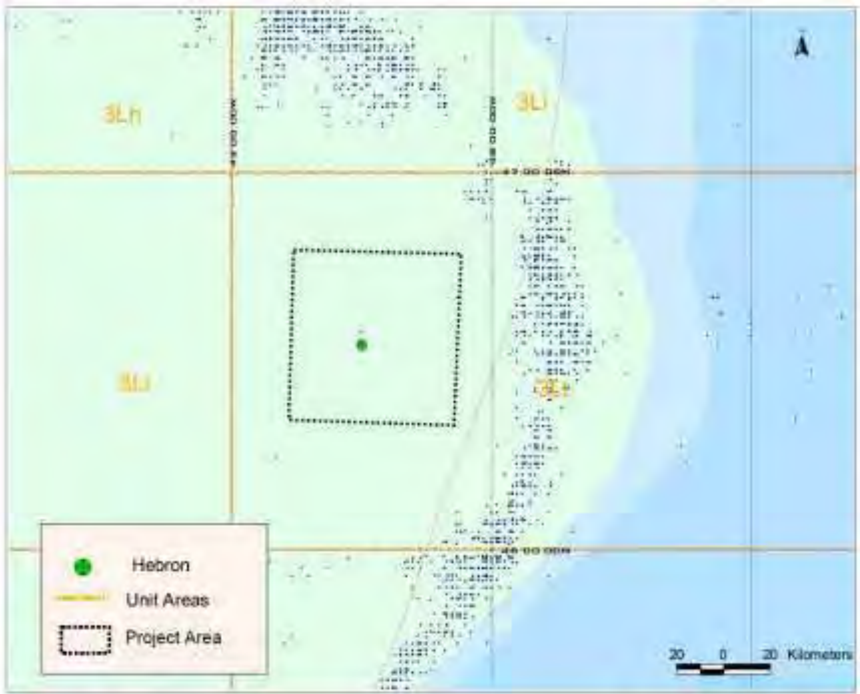


Figure 8-22 Location of Domestic Harvest, All Species, May 2004 to 2008, Aggregated

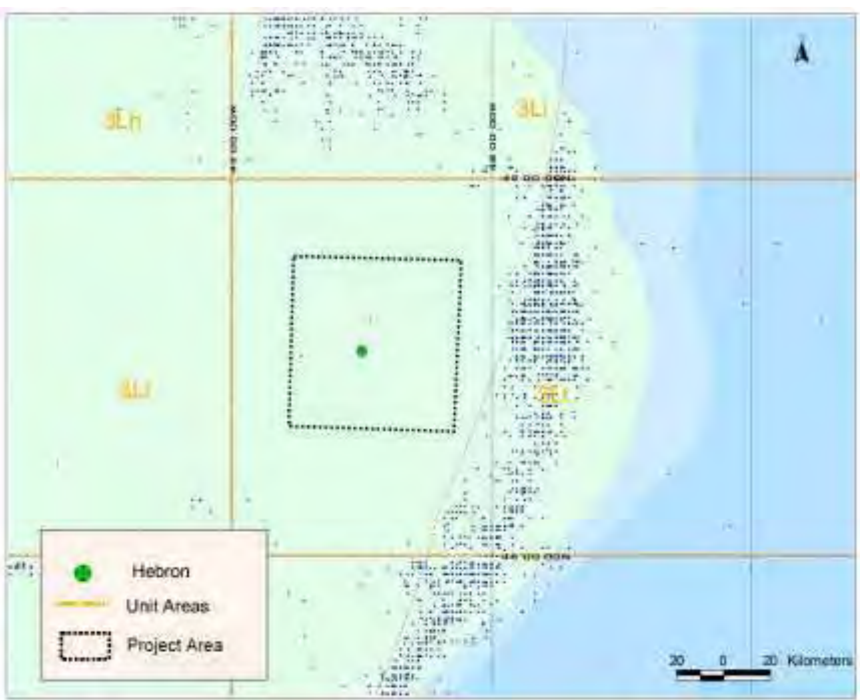


Figure 8-23 Location of Domestic Harvest, All Species, June 2004 to 2008, Aggregated

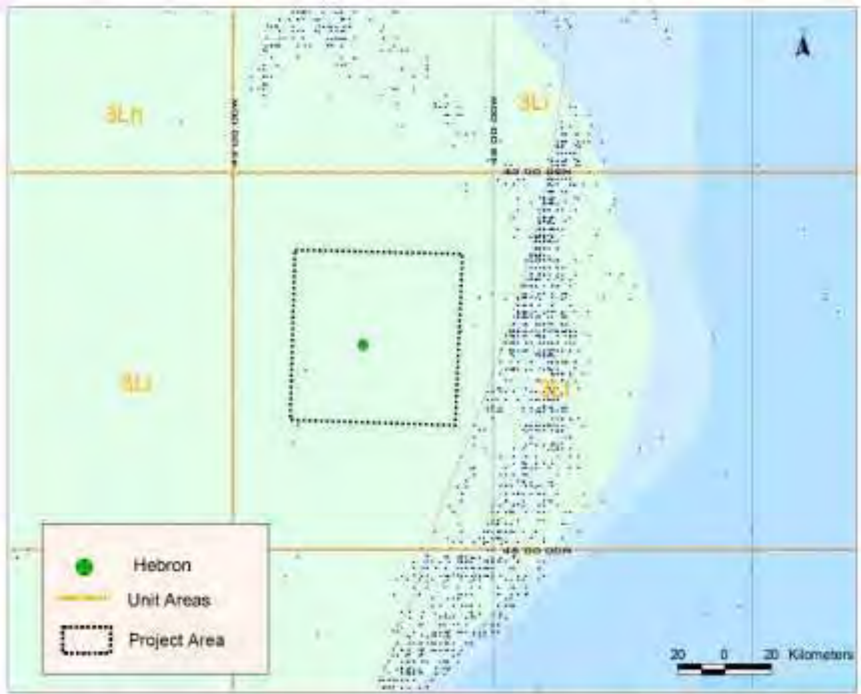


Figure 8-24 Location of Domestic Harvest, All Species, July 2004 to 2008, Aggregated

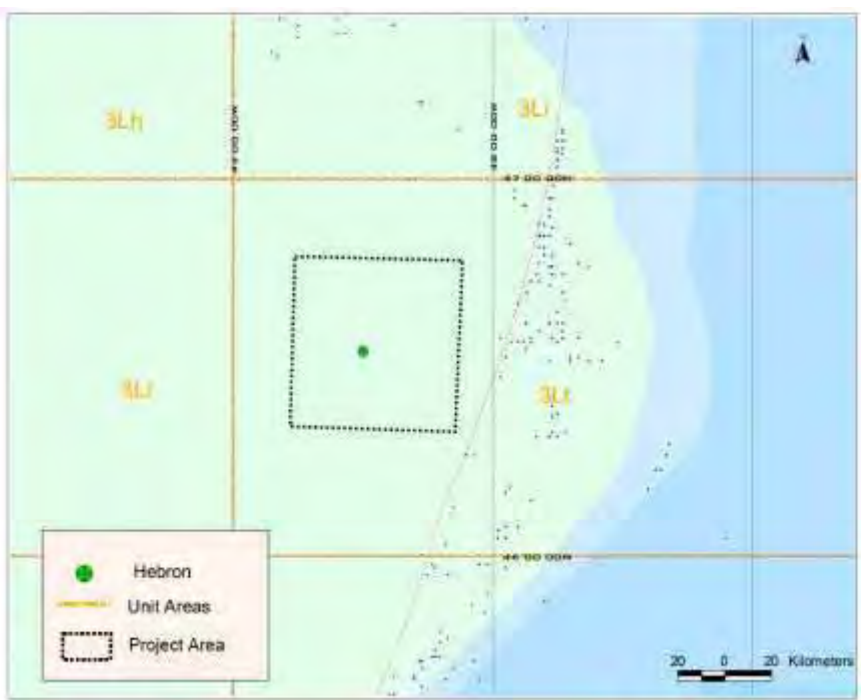


Figure 8-25 Location of Domestic Harvest, All Species, August 2004 to 2008, Aggregated

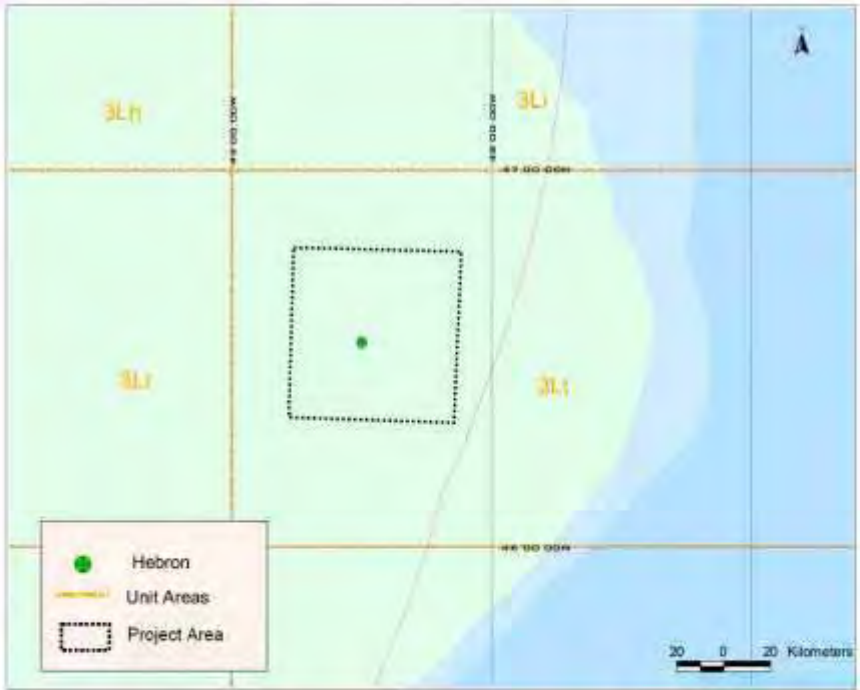


Figure 8-26 Location of Domestic Harvest, All Species, September 2004 to 2008, Aggregated

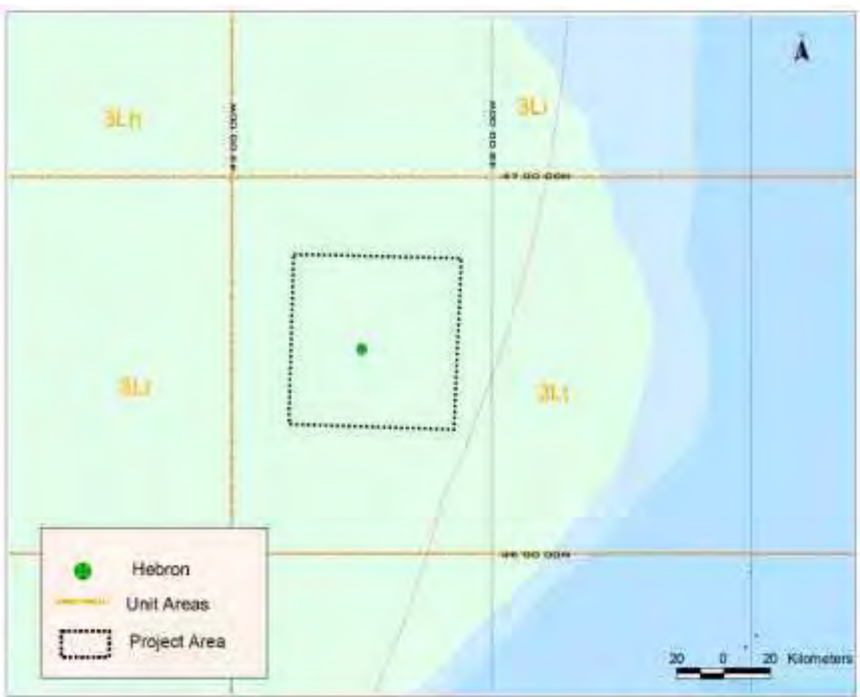


Figure 8-27 Location of Domestic Harvest, All Species, October 2004 to 2008, Aggregated

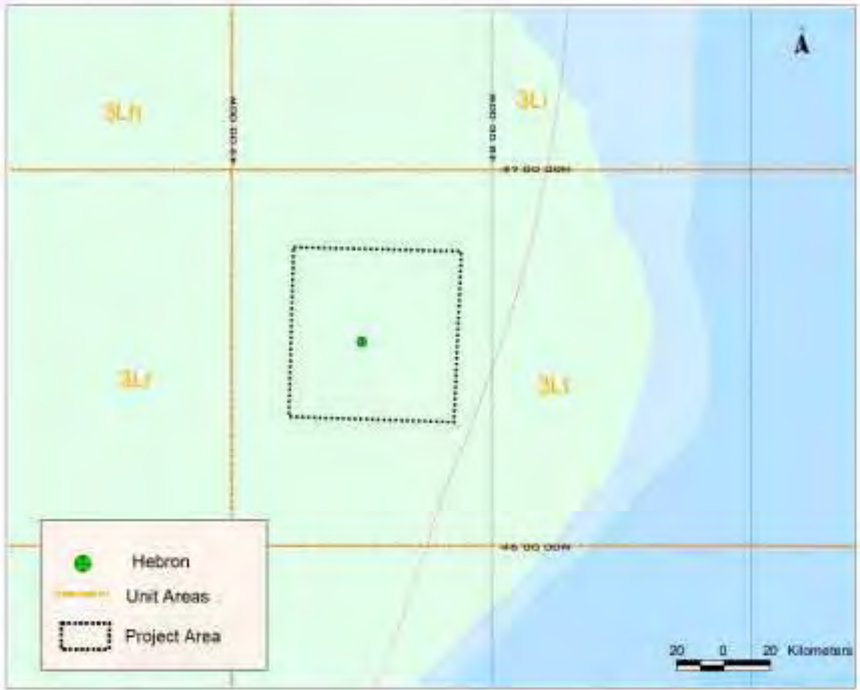


Figure 8-28 Location of Domestic Harvest, All Species, November 2004 to 2008, Aggregated

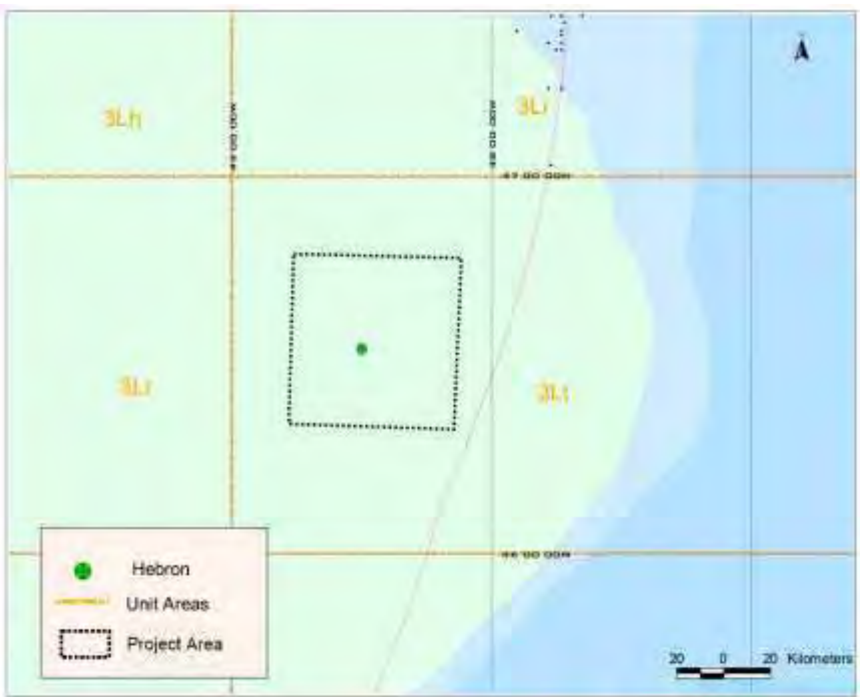


Figure 8-29 Location of Domestic Harvest, All Species, December 2004 to 2008, Aggregated

8.3.2.6 Fishing Gear

Except for groundfish, the gear types used in the Offshore Study Area and the Offshore Project Area are almost exclusively specific to the species harvested – crab pots for snow crab, shrimp trawls for northern shrimp and hydraulic dredges for deep sea clams (Table 8-10). Groundfish is harvested primarily with stern otter trawls (approximately 96 percent) and the remainder with longlines. Longlines are also used for the small quantity of large pelagics (tunas, swordfish) caught in the eastern reaches of the Study Area.

Table 8-10 Offshore Study Area Landings by Gear Type, 2004 to 2008, Averaged

Gear	Quantity (t)	% of Total	Value ($)	% of Total
Otter trawl, bottom	624.1	2.6	342,694	0.8
Shrimp trawl	8,829.6	36.3	10,373,933	24.7
Longlines[A]	50.3	0.2	314,147	0.7
Trap/Pot*	9,798.4	40.3	26,817,356	63.9
Hydraulic Dredge	5,024.2	20.7	4,118,565	9.8
Total	24,326.5	100.0	41,966,696	100.0

[A] Fixed gear

The locations of fixed and mobile gear harvesting locations during 2004 to 2008, aggregated, are shown on Figures 8-30 and 8-31.

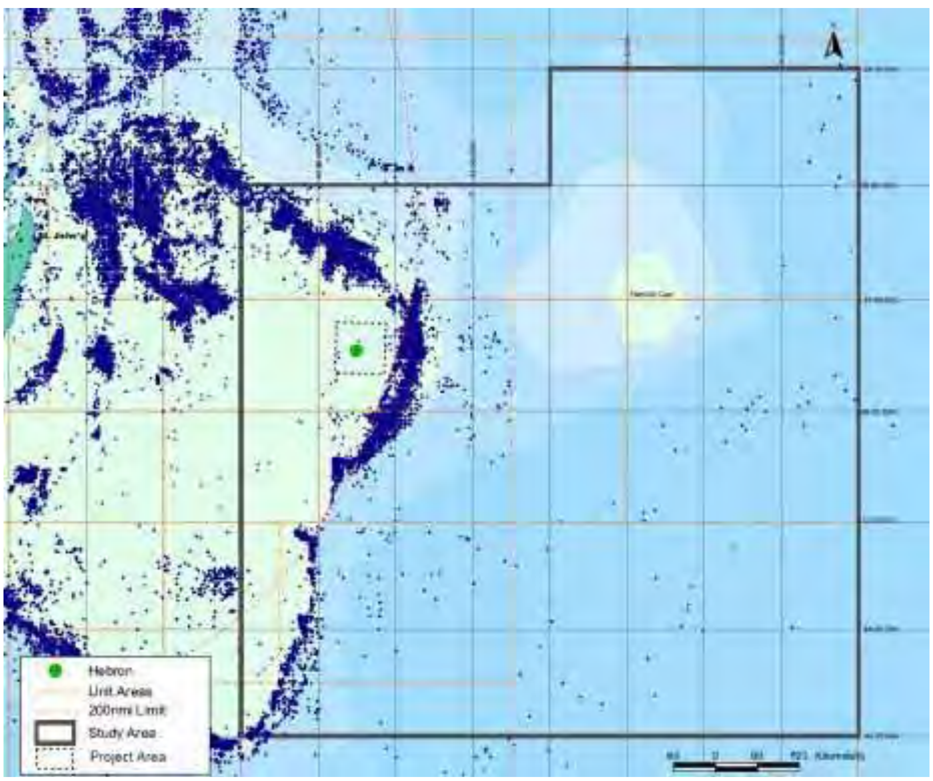


Figure 8-30 Fixed Gear Harvesting Locations, 2004 to 2008, Aggregated

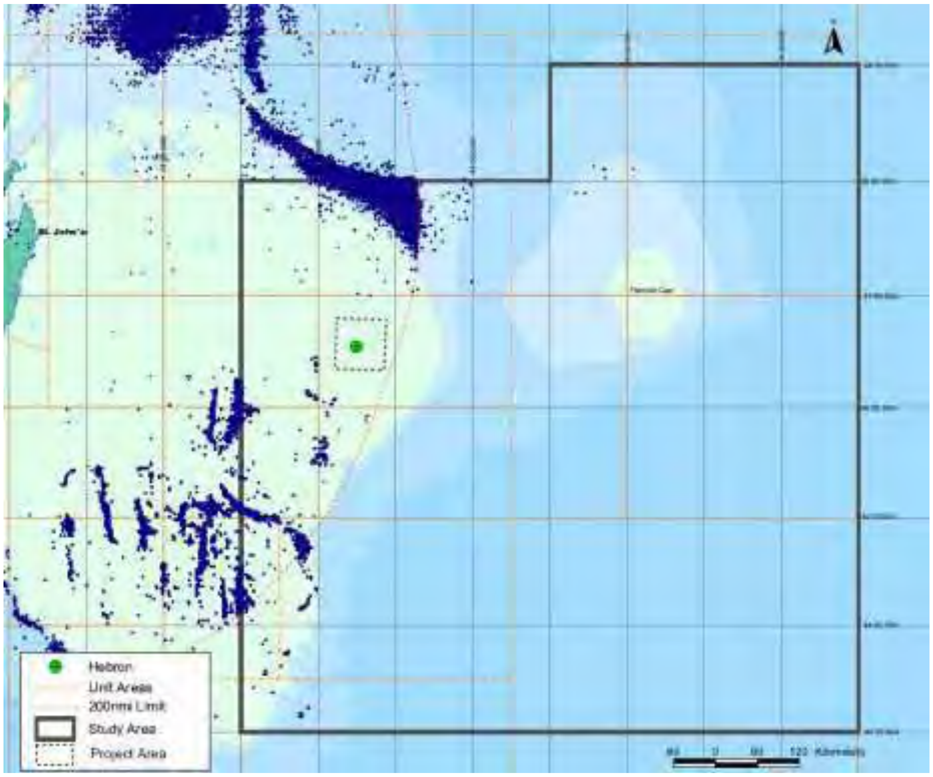


Figure 8-31 Mobile Gear Harvesting Locations, 2004 to 2008, Aggregated

Crab Pots

The amount of gear fishers are permitted to use varies by license category, and also by the area in which a license holder may be fishing. Crab pots are set on the seabed in strings buoyed at the surface. Crab gear generally has a highflyer (radar reflector) at one end and a large buoy at the other. Some fishers use highflyers at both ends. Depending on weather, they may be left unattended several days at a time. Fishers typically try to leave approximately 20 fathoms (36.5 m) on the seabed between each pot. Thus, allowing slack for the anchor ropes on either end of the string to extend upwards at an angle, the distance between the typical highflyer and end-buoy of, for example, a 50 to 60 pot string of crab gear would be approximately 1.8 to 2.3 km.

Shrimp Trawls

Shrimp harvesting uses mobile shrimp trawls. These are modified stern otter trawls, for both inshore and offshore vessels, though some use beam trawls.

Hydraulic Dredges

Used for deep sea clams, these boat-based dredges are dragged along the sea bottom by the ship. Sea water is pumped through a large hose in front of the dredge as it is pulled along the sea floor. The jets of water temporarily fluidize the sand and allow the dredge to go through, picking up the clams.

Stern Otter Trawls

These are large bottom-tending nets towed behind vessels, most of which are 150 to 200 feet in length. After filling with fish, the net is winched aboard, emptied and re-deployed.

8.3.2.7 Principal Fisheries

The following sections provide information on the principal fisheries in the offshore Study Area.

Snow Crab

In terms of both quantity of catch and value, the crab fishery has been the most significant fishery in the Study Area (40 percent by quantity and 64 percent by value) and the only one recorded in the Project Area in the last several years. The crab quota areas are shown on Figure 8-32 and the quotas for the snow crab fishery in relevant portions of 3LMN are listed in Table 8-11.

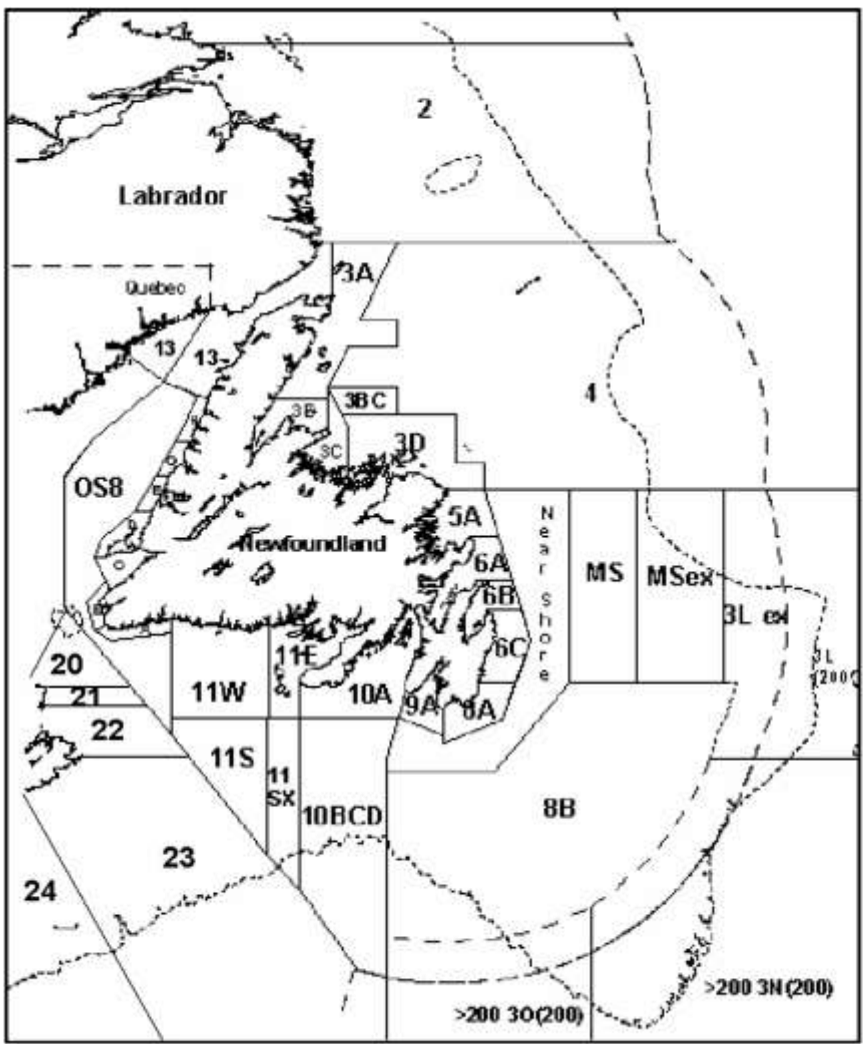


Figure 8-32 Newfoundland and Labrador Snow Crab Fishing Areas

Table 8-11 Relevant 2009 Snow Crab Quotas

Licenced Category/Quota Definition	Quota (t)
3L Full Time Midshore	668
3L Full Time Midshore Extended (MSX)	1,386
3L Full Time Outside 170 and Inside 200NM (3LX)	999
3L Full Time Outside 200NM (3L200)	533
3L Supplementary Large Midshore	602
3L Supplementary Large Midshore Extended (MSX)	1,427
3L Supplementary Large Outside 170 Inside 200NM (3LX)	1,426
3L Supplementary Large Outside 200 NM (3L200)	1,112
3L Supplementary Small Midshore (MS)	2,580
3L Supplementary Small Outside 50NM (8B)	680
3L Supplementary Small 8B Exploratory (8BX)	2,720
3N Full Time Outside 200NM (3N200)	512
3N Supplementary Large Outside 200NM (3N200)	1,048
3N Offshore (3NEX/3NO)	401

Snow crab harvesting locations recorded for 2004 to 2008, aggregated for all years, during all months, are shown in Figure 8-33. As illustrated in this figure, snow crab effort (placement of fixed gear crab pots) is consistently focused on key grounds, based on both license restrictions and resource availability. Within the Study Area, the main focus is along and near the shelf break, either just inside or outside the 200 nm EEZ boundary, which also matches license conditions.

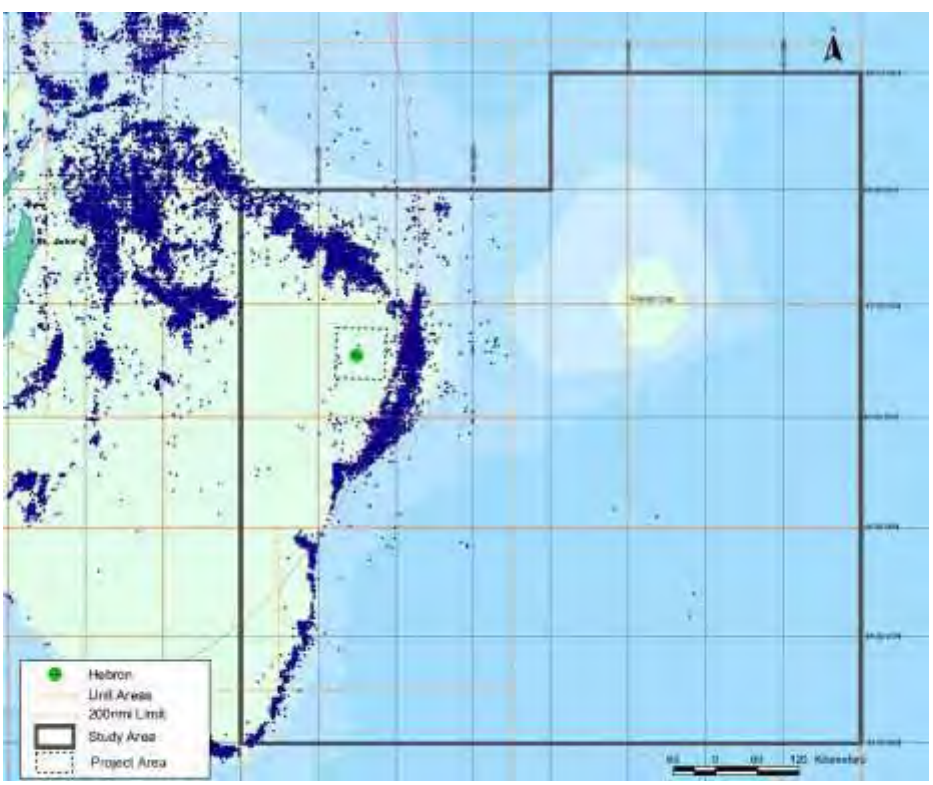


Figure 8-33 Snow Crab Harvesting Locations, 2004 to 2008, Aggregated

Snow crab seasons may vary somewhat each year by quota/license category, depending on when quotas are taken, or if other factors intervene, such as the presence of too much soft shell crab. However, it usually occurs within the April to July period. The average harvest by month for the 2004 to 2008 for the Offshore Study Area is shown in Figure 8-34.

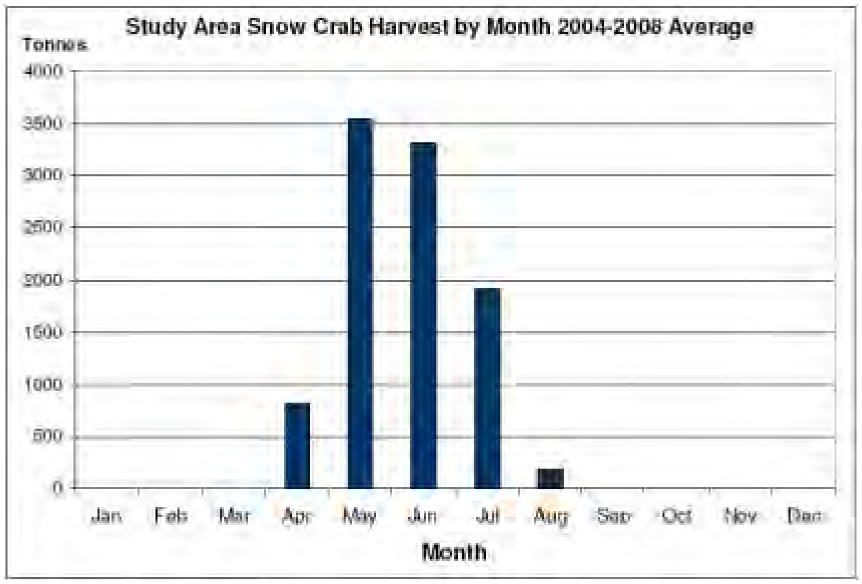


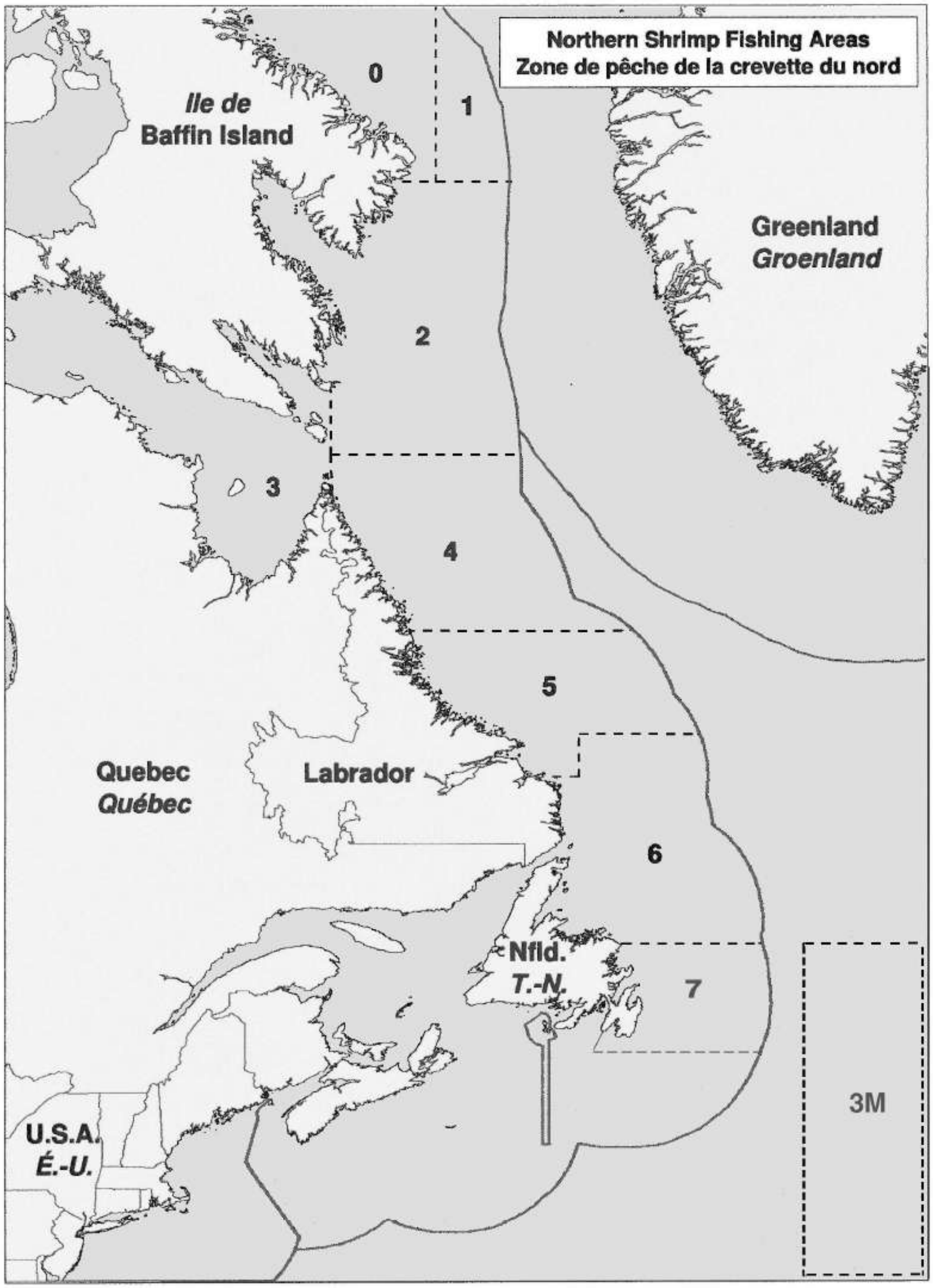
Figure 8-34 Offshore Study Area Quantity of Snow Crab Harvest by Month, 2004 to 2008, Averaged

Northern Shrimp

Shrimp has also been a major fishery in the Offshore Study Area (36 percent by quantity and 25 percent by value). The Offshore Study Area overlaps shrimp fishing areas (SFA) 7, which has domestic quotas. The relevant quotas for 2009 are listed in Table 8-12. The shrimp fishing areas (SFA) are shown in Figure 8-35.

Table 8-12 Area 7 2009 Northern Shrimp Quotas

Licence Category/Quota Definition	Quota (t)
Area 7 - Offshore > 100-foot and Special Allocations	5,344
Area 7 - 2J Fishers	739
Area 7 - 3K Fishers North of 50'30	739
Area 7 - 3K Fishers South of 50'30	4,562
Area 7 - 3L Fishers	11,353
Area 3M (International waters)	Not designated



Source: NAFO

Figure 8-35 Shrimp Fishing Areas

The harvesting locations recorded for 2004, 2005 and 2006, all months, are shown in Figure 8-36.

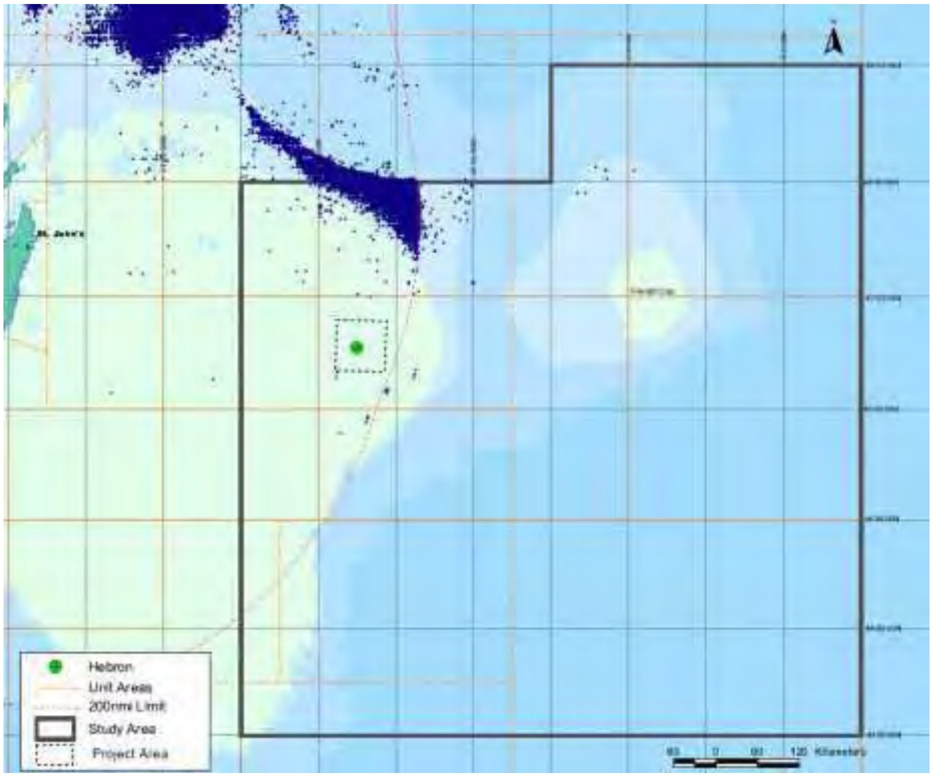


Figure 8-36 Northern Shrimp Domestic Harvesting Locations, 2004 to 2008, Aggregated

The shrimp harvest, pursued in the Offshore Study Area by larger trawlers from Newfoundland and Nova Scotia, can occur year-round, though the summer months (June and July) have been the most important time. The average northern shrimp harvest by month for 2004 to 2008 for the Offshore Study Area is shown in Figure 8-37.

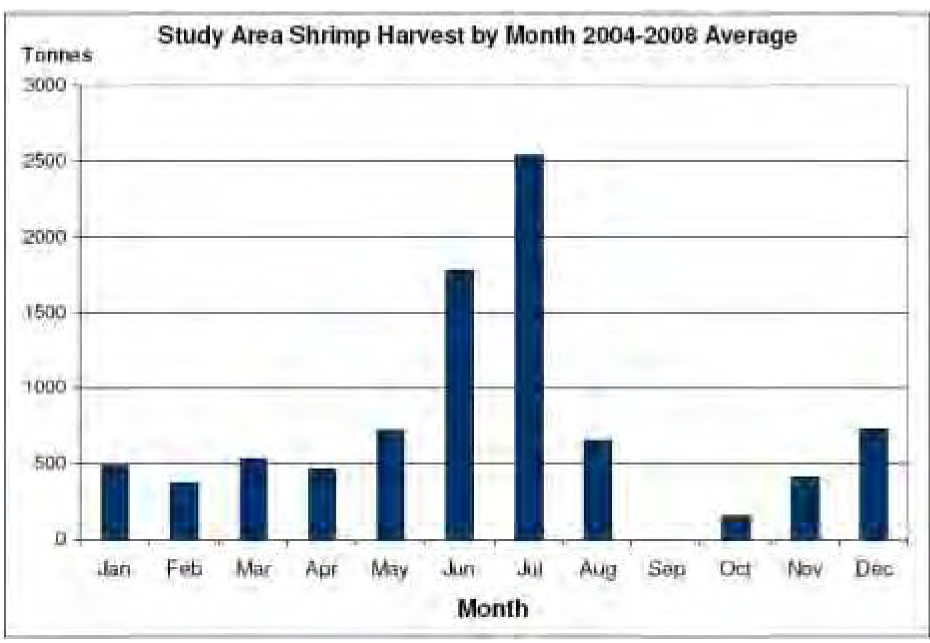


Figure 8-37 Offshore Study Area Quantity of Northern Shrimp Harvested by Month, 2004 to 2008, Averaged

Offshore Bivalves

This fishery in the Study Area is primarily Greenland cockles, Stimpson's (Arctic) surf clams and a small quantity of propeller clams.

Offshore deepwater clams and cockles were the third most significant fishery in the Study Area (21 percent by quantity and 10 percent by value) for 2004 to 2008. It would have had a higher average value except that in 2008, owing to ship logistics and mechanical issues, the harvesting company involved focused on the western deep sea clam grounds on the eastern Scotian Shelf, rather than the Newfoundland grounds. Consequently, in 2008 only 10 tonnes were harvested, compared to the previous four-year average of 2,360 tonnes (C. Boyd, pers. comm.).

According to the latest management plan (DFO 1998), the three vessels in the fishery are specialized large factory freezer vessels, equipped to operate year round. Each vessel has equal allocations for each commercial fishing area (Banquereau and Grand Banks), and each vessel lands product for further processing at separate plants. Recorded locations for 2004 to 2008 are shown in Figure 8-38. Because these bivalves are slow-growing species, the harvesting usually occurs on different beds from one year to the next to allow time for the grounds to recover.

Figure 8-38 Deep Sea Clams/Cockles Harvesting Locations, 2004 to 2008, Aggregated

Over the past several years, the Grand Banks portion of this fishery has been largely confined to localized areas within NAFO Division 3N, mainly within Unit Area 3Nd, but in 2006 the harvest expanded northward into 3Lr and 3Lt (see Figure 8-38). Another recent change in this fishery is an increase in the Greenland cockle harvest, which accounted for 65 percent of the Grand

Banks deep sea clams harvested in 2006. In contrast, before 2004, no cockles were reported, and during 2004 and 2005 the species made up approximately 20 percent of the harvest. As a result of the increase in cockle harvesting, the overall deep sea clam fishery increased by more than 50 percent in 2006, compared to the average recorded harvest from 2000 to 2005.

In recent years, the majority of this fishery in the area has been harvested by a Newfoundland-based vessel (from Grand Bank) operated by Clearwater Ltd. Partnership, which holds all three of the Atlantic Canadian licences for this species. The quota is divided between grounds on Banquereau Bank and the eastern Newfoundland Grand Banks. The fishery may be conducted year-round, commencing January 1 of each year. Clearwater Ltd. Partnership usually fishes Banquereau first and then the Grand Banks, as indicated in Figure 8-39. The average timing of the harvest over the 2004 to 2008 period for the Study Area is also shown in Figure 8-39; harvesting effort is distributed throughout the year.

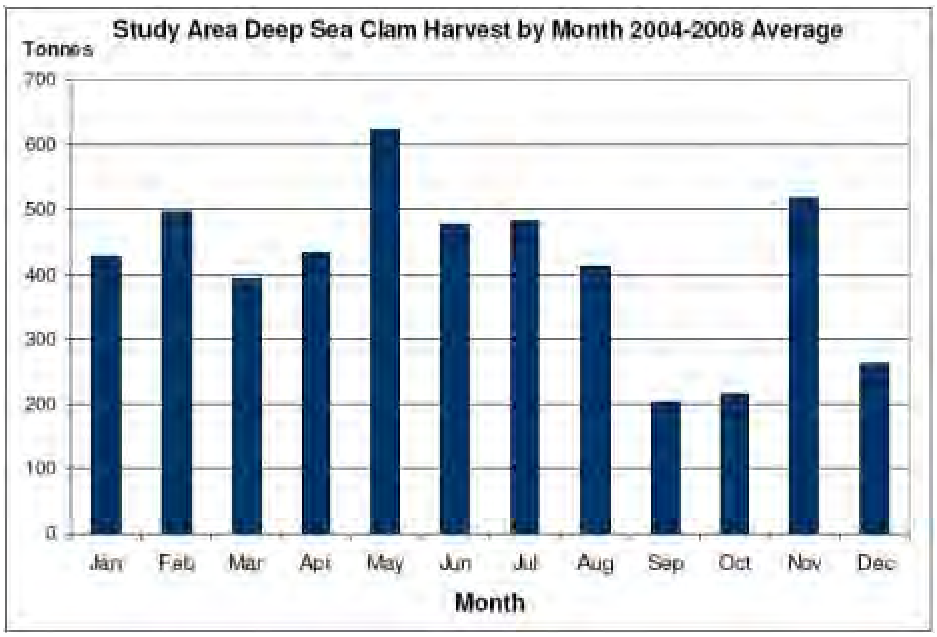


Figure 8-39 Offshore Study Area Quantity of Deep Sea Clam Harvest by Month, 2004 to 2008, Averaged

Groundfish

Overall, groundfish harvests made up just 2.7 percent of the Offshore Study Area harvest by quantity and 1.4 percent by value in 2004 to 2008. Many groundfish species are harvested together, either as directed or by-catch fisheries. The main fisheries in recent years in the Offshore Study Area has been for yellowtail flounder, although halibut has also been important because of its high relative value. The domestic harvesting locations for all groundfish species for 2004 to 2008 are shown in Figure 8-40. As indicated in this figure, most fishing occurs in the northern and west parts of the Offshore Study Area, and very little in the Offshore Project Area.

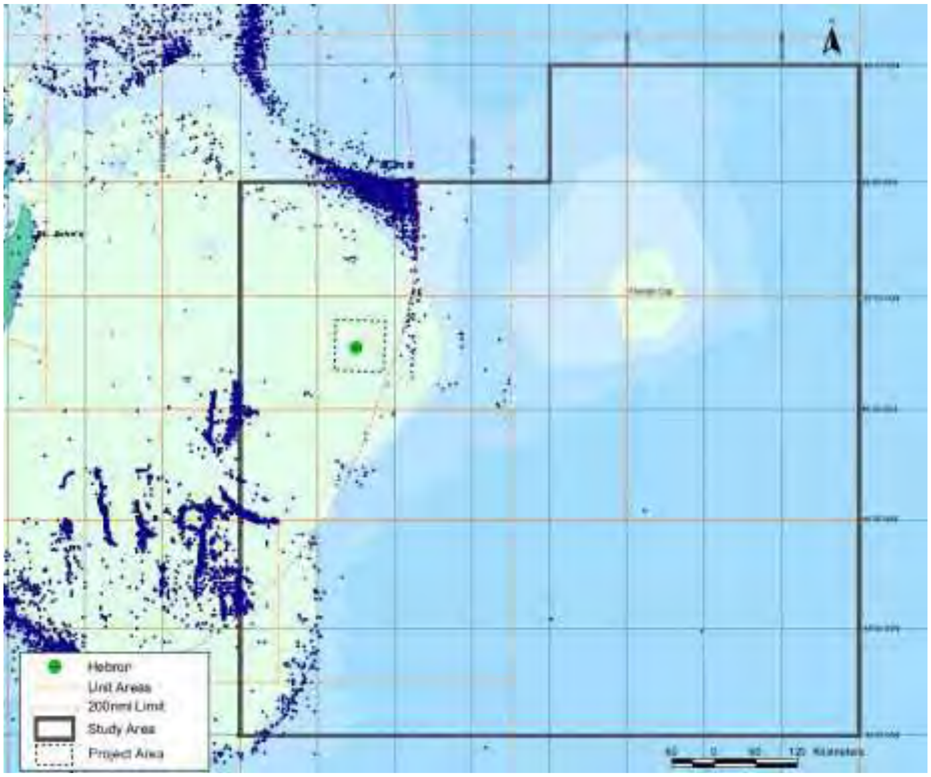


Figure 8-40 Groundfish Harvesting Locations, 2004 to 2008, Aggregated

The average timing of groundfish harvesting for 2004 to 2008 in the Offshore Study Area is shown in Figure 8-41.

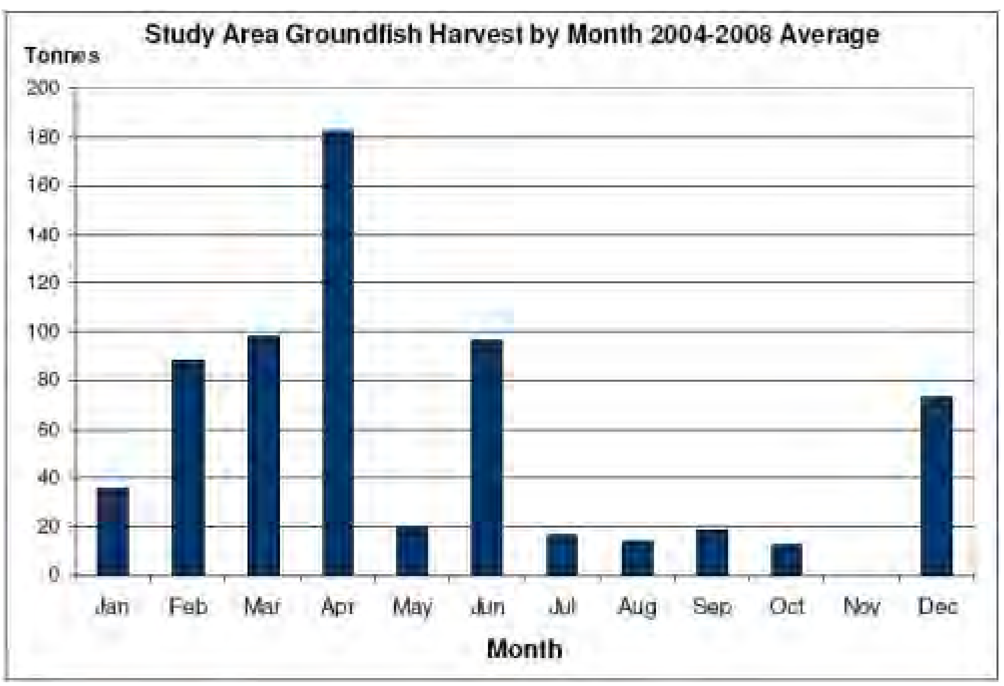


Figure 8-41 Offshore Study Area Quantity of Groundfish Harvest by Month, 2004 to 2008, Averaged

8.3.2.1 International Fisheries

Several Convention nations have harvested a variety of fish stocks in the NAFO areas to the north and west of the Study Area. This is primarily in the area of the NAFO Divisions 3LMN from the waters outside Canada's EEZ.

The landings by foreign fisheries from 1985 to 2004 are illustrated in Figure 8-42. They show harvests by foreign and (for comparison) domestic harvesters from these Divisions, most of which are within the Study Area.

The principal species harvested during this period were northern shrimp, capelin, cod and turbot (snow crab is not managed by NAFO). Other than Canadian ships, those fishing in these areas during this time included fishing vessels from Denmark, Iceland, Cuba, Japan, South Korea, Russia, the US and various European Union nations.

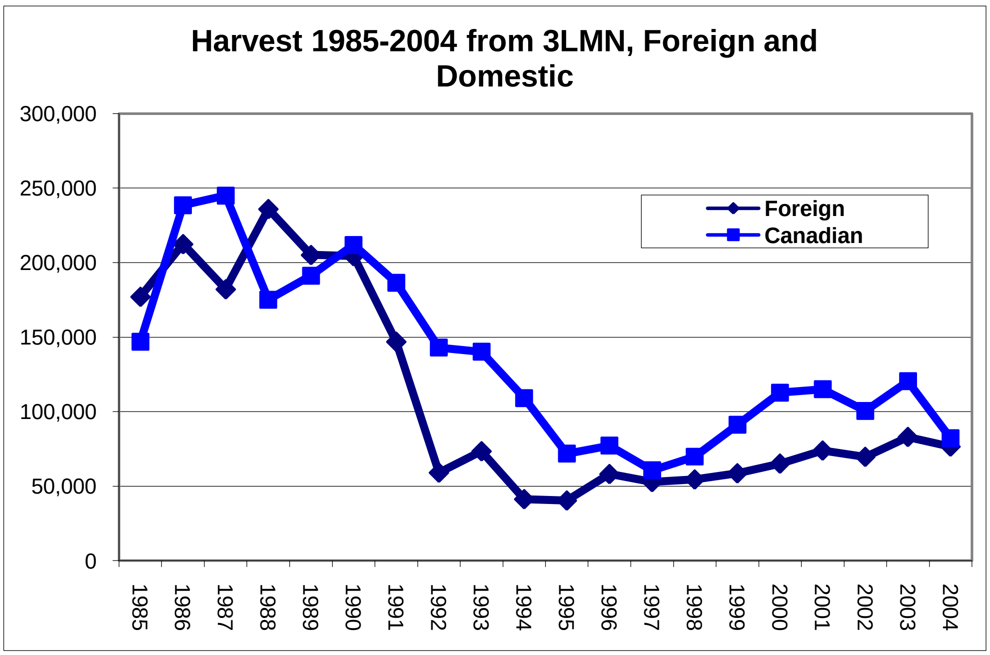


Figure 8-42 Harvest (1985-2004) from Divisions 3LMN, Foreign and Domestic, NAFO-managed Stocks

8.3.3 Fisheries Research Surveys

DFO research surveys in 3L and/or 3N overlap with parts of the Offshore Study Area. The preliminary schedule for any year is usually available in the early spring, and the spring survey is typically conducted within NAFO Division 3LNO in May to June. The fall survey usually operates in these areas from early October to about mid-December. Often, the *R/V Templeman* will be used during the spring surveys (and the *Teleost*), and either the *R/V Templeman* or the *R/V Needler,* in the fall. More specific plans are typically available as the season moves forward in the year, and may be modified as circumstances change (W. Brodie, pers. comm.).

A typical schedule from recent years is provided in Table 8-13. In any year of activity, contact will need to be maintained to understand the current season's schedule.

Table 8-13 Typical Fisheries Research Schedules

Scientist/Ship	Survey	Start Date	End Date
R/V Templeman or R/V Needler			
Brodie	Multi-species 3LNO	06-May	20-May
Brodie	Multi-species 3LNO	21-May	03-Jun
Brodie	Multi-species 3LNO	04-Jun	17-Jun
Brodie	Multi-species 3LNO	18-Jun	28-Jun
Brodie	Multi-species - 3KLNO	01-Oct	07-Oct
Brodie	Multi-species - 3KLNO	08-Oct	21-Oct
Brodie	Multi-species - 3KLNO	22-Oct	04-Nov
Brodie	Multi-species - 3KLNO	05-Nov	18-Nov
Brodie	Multi-species - 3KLNO	19-Nov	02-Dec
Brodie	Multi-species - 3KLNO	03-Dec	16-Dec
R/V Teleost			
Brodie	Multi-species 3KLMNO	03-Dec	16-Dec

Industry-DFO collaborative post-season research surveys of snow crab also have been undertaken in 3L and other NAFO Divisions since 2003. These research activities are conducted by snow crab harvesters in the fall between September and November. Surveys take place on established crab fishing grounds at fixed "stations" that generally follow a grid pattern (R. Saunders, pers comm.).

8.4 Project-Valued Ecosystem Component Interactions

This section considers potential interactions through all Project phases between the Project and commercial fish harvesting activities conducted in order to generate fishing income. These activities include accessing and setting gear on established fishing grounds, retrieving/hauling the gear to harvest the fish and getting the catch back to port. Interactions resulting in impacts which might interrupt or prevent any part of that process (such as having grounds closed to fishing, impediments en route to or from fishing grounds, lost fishing gear, or lost or reduced catch) are the focus of the assessment in Section 8.5.

Economic impacts could also result from physical effects on commercial fish species and their habitats. Potential Project effects on Fish and Fish Habitat are considered to be not significant with the appropriate mitigations in place (see Chapter 7).

8.4.1 Issues

The potential effects considered in this section reflect the issues raised by both inshore and offshore fishers during the consultations for this CSR, which are summarized in Sections 5.3.1 and 5.3.2, respectively. These issues are also typical of those raised and assessed for similar offshore development projects in these areas in the past. Potential interactions with, and effects on, fisheries science/research surveys (industry-led and DFO) are also considered in this section. These issues are addressed in the mitigation subsections of Section 8.5.

8.4.1.1 Nearshore

Exclusion from fishing grounds. Fishers expressed concern that marine construction operations would result in their being excluded from pelagic species fishing areas within Bull Arm such as grounds close to the deepwater site. They wanted to know what the “rules of the road” would be with respect to where and when they would be allowed to fish. Sunnyside fishers who fish lobster and other species in Great Mosquito Cove wanted to know if they would be allowed to continue fishing these grounds, at least in the initial stages of the Project.

Disruption of harvesting operations. Fishers expressed concern about general Project activities on the water (vessel traffic) and the effects these might have on their fish harvesting operations. This included high levels of activity that would make fishing more difficult or dangerous, and might result in de facto exclusion from busy areas. Fishers were concerned that Project-related vessel traffic could interfere with crab fishing activities or other species harvesting operations within the Tickle Bay portion of the Traffic Lane.

Effects of noise and lights on catchability. Fishers stated concern about effects of construction-related noise and light on fish behaviour and/or movement within Bull Arm, especially during the time when the Gravity Base Structure (GBS) is moored at the deepwater site. Fishers stated, for example, that a purse seiner might miss a catch of mackerel if lights associated with platform construction activities in the middle of Bull Arm deflected a school of fish away from the grounds, resulting in an economic loss for the vessel operator.

Gear and vessel damage. Fishers were concerned about potential damage to fishing gear or fishing vessels resulting from Project-related vessels or debris escaping from the site.

8.4.1.2 Offshore

Lost or damaged gear. Fishing gear damage, and the concomitant or subsequent loss of catch, may result from regular support vessel operations, as well as from other activities such as iceberg towing or geophysical surveys. Most gear damage incidents involve fixed gear (*e.g.*, crab pots); mobile gear (*e.g.*, shrimp trawls) is rarely affected. In most cases, the owner of gear damaged by an oil-related vessel activity is identified and compensated, after submitting a claim to the responsible operator through gear compensation programs currently in place. However, fishers say that an increase in the number of "un-attributable" damage incidents, for which no claim is provable because it cannot be linked to petroleum industry operations, even though fishers are convinced that project vessels are responsible. Many of these cases involve the loss of small items (*e.g.*, a 90-inch balloon buoy). Fishers say that while each such incident can be viewed as a nuisance - a regular component of the "cost of doing business" offshore - the rising number of these incidents contributes to the overall sense of unease and distrust among fishers.

Fishers stressed that gear replacement is often not the biggest part of their resulting economic loss. It may not be possible for the enterprise to make up the lost fishing time associated with a gear damage incident. The entire trip may be lost, or the enterprise may fail to make its quota for the season. Fishers indicated in such cases there should be some mechanism in place to compensate for the lost catch, as well as for the damaged gear.

Fishers noted that, as fishing seasons become more confined, the potential economic consequences of lost fishing time will increase. Fishers believe that certain routine oil industry activities already compound this situation. For example, the busiest months for the offshore crab fishery are generally April to July; iceberg deflection operations are undertaken during the same months and in many of the same areas fishers set their crab gear.

Lost fishing grounds. In addition to the Safety Zones that are established around production platforms, fishers expressed concern regarding the lack of protocols and standards for establishment of Closest Point of Approach (CPA) zones around oil and gas activities. Although fishers reported that the three existing oil production installations occupy a relatively small total area, they feel that the operational "zone of influence" extends well beyond the boundaries of the official Safety Zone of each installation. Fishers repeatedly stated that the combined restraints of existing DFO quota areas and existing oil operations already force them to operate within a relatively narrow band of fishing grounds. Fishers are of the view that the Hebron development and operations will exacerbate this situation.

As discussed above, fishers feel that there is an inadequate level of understanding and communication between the two industries at sea. For their part, fishers admit they are not always informed about the "rules of the road", why particular rules or protocols were developed, or what their rights and responsibilities are when operating in the general vicinity of an offshore production facility. For example, fishers are not sure what their CPA should be when they are transiting waters adjacent to an operator's Safety Zone. Some operators apparently require fishing vessel to maintain a CPA of 9.2 km (5 nm), while others ask them to maintain a CPA of 18.5 lm (10 nm). Without a common understanding, agreement on compliance and enforcement is difficult.

Reduced fishing opportunity. Fishers stated a growing concern that the ongoing development of the Jeanne d'Arc Basin oil field area is beginning to have a negative effect on their ability to harvest fisheries resources in adjacent areas of the Grand Banks. It appears to fishers that the size of the area in which they can safely and efficiently fish is shrinking, resulting in reduced fishing opportunity.

The lack of well-understood protocols are perceived as having a measurable negative economic impact on their operations, according to fishers. Fishers stated that this is occurring because fishing vessels are forced to steam around an oil field area to get from one quota area to the next, rather than being able to transit through that area while maintaining a reasonably safe distance (*i.e.*, CPA) from the installation, resulting in lost fishing time and increased fuel costs. Fishers frequently cited the need to maximize fishing time as the most critical issue they face. They noted that preventing any such loss of opportunity in the first case is preferable to financial compensation for that loss after the fact.

Effects on future fisheries. Fishers noted that if further development occurs in the Jeanne d'Arc Basin, effects on future fishing activities could increase substantially. The situation is not yet overly problematic, for several reasons, according to fishers. To begin with, the three existing production facilities are not situated on important fishing grounds. At present, two species dominate the Grand Banks fishery: shrimp and snow crab. Neither of these species is fished extensively in the immediate vicinity of Hibernia or Terra Nova; however, there are well-established crab grounds near the White Rose installation (*e.g.,* to the east of this oilfield area, both inside and outside and the 200 nm limit line).

Fishers point out that if DFO changes current quota area allocation boundaries (as fishers have been requesting), there would be more crab fishing within the Jeanne d'Arc Basin. Likewise, there would be much more fishing vessel activity in and around the Hibernia/Terra Nova/White Rose zone if offshore groundfish quotas were reinstated. Changes in the current quota zone boundaries, or the resumption of offshore groundfish fisheries, would alter the existing distribution of harvesting locations and fishing vessel activity patterns. Fishers expressed concern that with these potential changes, the presence of the existing three oil field installations, combined with the effects of Hebron development activities during the next several years, could result in future lost fishing opportunities.

Oil Spills. Fishers stated concern about the commitment of oil companies to compensate the fishing industry in the event of an oil spill. They stated that the oil industry does not "have a good reputation about cleaning up its messes". They would like to see more information made available about how a compensation program for an oil spill would actually work. They wanted to know more about what concrete steps would be taken following an oil spill, how claims would be submitted and assessed, *etc*.

8.4.2 Potential Interactions (and Impact Pathways)

Each of the commercial fisheries issues identified by fishers and potential impacts relate to possible reductions in fishing income, and specifically to net fishing income losses. Losses might occur because of decreased revenues (reduced catches, prices or marketability) or because of increased expenses (higher fuel costs, replacing damaged gear), or both. As the previous discussion indicates, these losses might arise from a variety of different impact pathways. For the purpose of the assessment these pathways are considered under four specific categories:

- Access to Fishing. Those activities that prevent access to former or potential fishing grounds (loss of access to areas such as the Safety Zones)
- Fishing Vessel Operations. Those activities that might result in temporary or ongoing interference with fishing activities (vessel traffic or other Project marine activities beyond the Safety Zones that impede or otherwise interfere with fishing)
- Fishing Gear. Those activities which could damage, foul or cause the loss of fishing gear, including consequent catch losses (vessel traffic beyond Safety Zones, or escaped debris)
- Catchability. Those activities which might affect the catchability of commercial fish species (issues related to scaring fish from the harvesting area or away from fishing gear)

The Project activities that have the potential to interact with each of the preceding categories (Effects), organized by location (nearshore and offshore) and phase (construction, operations, *etc.*) are provided in Table 8-14. It should be noted that most of the construction related activities and operations will be wholly contained within the Safety Zones and therefore most of the specific construction activities, such as bund wall construction and drydock preparation, will not interact with commercial fisheries.

Table 8-14 Potential Project-related Interactions with Commercial Fisheries

Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Access to Fishing Grounds	Fishing Vessel Operations	Fishing Gear	Catchability
Construction				
Nearshore Project Activities				
Presence of Safety Zones (Great Mosquito Cove Zone followed by a deepwater site Zone)	x			
Bund Wall Construction (*e.g.*, sheet/pile driving, infilling, *etc.*)				
Inwater Blasting				x
Dewater Drydock/Prep Drydock Area				
Concrete Production (floating batch plant)				
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site, *etc.*)		x	x	
Lighting				
Air Emissions				

Project Activities, Physical Works, Discharges and Emissions	Potential Effects: Access to Fishing Grounds	Potential Effects: Fishing Vessel Operations	Potential Effects: Fishing Gear	Potential Effects: Catchability
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)		x	x	
Removal of Bund Wall and Disposal (dredging/ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)				
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site				
Hook-up and Commissioning of Topsides				
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	x
Platform Tow-out from deepwater site	x	x	x	
Offshore Construction/Installation				
Presence of Safety Zone	x			
OLS Installation and Testing				
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines				
Installation of Temporary Moorings		x		
Platform Tow-out/Offshore Installation	x	x	x	x
Underbase Grouting				
Possible Offshore Solid Ballasting				
Placement of Rock Scour Protection on Seafloor around Final Platform Location				
Hook-up and Commissioning of Platform				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels/barges/diving/ROVs, ice management)		x	x	
Air Emissions				
Lighting				
Potential Future Activities				
Presence of Safety Zone	x			
Excavated Drill Centre Dredging and Spoils Disposal		x	x	
Installation of Pipeline(s)/Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation				
Hook-up, Production Testing and Commissioning of Excavated Drill Centres				
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, Diving *etc.*)		x	x	x
Offshore Operations and Maintenance				
Presence of Safety Zone	x			
Presence of Structures				

Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Access to Fishing Grounds	Fishing Vessel Operations	Fishing Gear	Catchability
Lighting				
Maintenance Activities (*e.g.*, diving, ROV, *etc.*)				
Air Emissions				
Flaring				
Wastewater (produced water, cooling water, storage displacement water, *etc.*)				
Chemical Use/Management/Storage (*e.g.*, corrosion inhibitors, well treatment fluids, *etc.*)				
Well Activities (*e.g.*, well completions, workovers, *etc.*)				
WBM Cuttings				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)		x	x	
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	x
Potential Future Operational Activities				
Presence of Safety Zone	x			
Drilling Operations from MODU at Future Excavated Drill Centres				
Presence of Structures				
WBM and SBM Cuttings				
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors, *etc.*)				
Geophysical/Seismic Surveys		x	x	x
Offshore Decommissioning/Abandonment				
Presence of Safety Zone	x			
Removal of the Hebron Platform and OLS Loading Points				
Lighting				
Plugging and Abandoning Wells				
Abandoning the OLS Pipeline				
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels/ROVs,)		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	x
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture				
Nearshore Spill (at Bull Arm Site)	x	x	x	
Failure or Spill from OLS	x	x	x	
Subsea Blowout	x	x	x	
Crude Oil Surface Spill	x	x	x	

Project Activities, Physical Works, Discharges and Emissions	Potential Effects			
	Access to Fishing Grounds	Fishing Vessel Operations	Fishing Gear	Catchability
Other Spills (fuel, chemicals, drilling muds or waste materials/debris from the drilling unit, GBS, Hebron Platform)		x	x	
Marine Vessel Incident (*i.e.*, fuel spills)	x	x	x	
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x		
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)		X		
Terra Nova Development (production)		X		
White Rose Oilfield Development and Expansions (drilling and production)		X		
Offshore Exploration Drilling Activity				
Offshore Exploration Seismic Activity				
Marine Transportation (Nearshore and Offshore)		x		
Commercial Fisheries (Nearshore and Offshore)	--	--	--	--

Accidental events (such as spills) and associated potential effects on the fisheries are discussed and assessed in Section 8.5.3. Cumulative environmental effects are discussed in Section 8.5.4.

8.5 Environmental Effects Analysis and Mitigation

This section presents the assessment of impacts on the commercial fisheries, based on the potential interactions identified, including a determination of the significance of the impacts after the identified mitigations are applied. In terms of mitigations, it should be noted that many elements and procedures to avoid, reduce or eliminate impacts on the commercial fisheries have already been designed into the Project plans. These include the use of environmentally sound construction and operational methods and materials, best practices, and location and timing considerations.

8.5.1 Construction/Installation and Operations/Maintenance

The categories of potential impacts (those affecting access to fishing grounds, fishing vessel operations, fishing gear and catchability) are the same during both the construction and operations phases of the Project, as are many of the effects pathways (*e.g.*, exclusion from Safety Zones). Consequently, many of the mitigations are also the same. Thus the effects and mitigations for both these phases are discussed together. For the Nearshore Project Area, there will be no operations and maintenance phase activities.

8.5.1.1 Nearshore

Access to Fishing Grounds

Before the start of marine activities in Great Mosquito Cove, a Safety Zone will be established. The size of the zone will be dependent upon the mooring arrangement within Bull Arm at the deepwater site. ExxonMobil Canada Properties (EMCP) will consult with fishers regarding the establishment of the Safety Zone. All fisheries activities will be excluded from this Safety Zone area, between 2011 and 2016, for safety reasons and to allow platform construction activities to take place in an efficient and timely manner.

When the partially-completed GBS is ready to be towed to the deepwater site within Bull Arm, another Safety Zone will be established around that marine construction site. This Safety Zone will extend out 500 m from the centre of the deepwater site. During construction activities at the deepwater site, estimated to be 2+ years, fishers will be temporarily prohibited from fishing within the Safety Zone, and will have to access alternate fishing grounds. EMCP will actively engage fishers throughout all phases of project activities to keep them informed as to the timing of and locations of these Safety Zones. In addition, EMCP, in consultation with local fishers, will implement mitigations to reduce disruption to their traditional fish harvesting activities.

During the tow-out of the completed platform from the Nearshore Area, there will also be a temporary exclusion/Safety Zone around the Hebron Platform and the ships tending it. However, this will be of short duration and will be continually moving.

While the establishment of the construction Safety Zones will create a temporary loss of access to fishing grounds first at the Great Mosquito Cove site and later at the deepwater site, they will, in fact, serve as key mitigations to avoid or prevent impacts from many other activities and to help ensure the safety of workers, fishers and other marine users.

Fishing Vessel Operations

Some Project activities will take place outside the designated Safety Zones, *e.g.*, vessel transits. This would include service and supply ships, tugs, towing operations, barge, and a shift change ferry to/from the deepwater site. Other activities that might occur outside the Safety Zone in Bull Arm would be re-establishing moorings near the deepwater site, possible dredging of sections of the tow-out route within Trinity Bay, ocean disposal operations, activities related to the GBS tow-out to the deepwater site and the final platform tow-out from the bay. There may also be a need for localized surveys outside the Safety Zones.

Each of these activities has the potential to affect the efficiency of fishing vessel operations (more time reaching alternative grounds, delays for traffic) within the Nearshore Study Area, and/or to contribute to increased expenses (additional fuel costs).

As noted, the confinement of most activities within the Safety Zones will reduce the potential for interference with day-to-day fishing operations. For those activities that do occur outside these areas, several further mitigations will be established to minimize impacts on fishing vessel operations (see below). For instance, fisheries representatives have frequently noted that good communications at sea are effective ways to minimize interference between offshore oil and gas exploration projects and fishing activities.

Fishing Gear

Project construction-related ships operating outside the Safety Zones (*e.g.*, tow out, routine vessel traffic, dredging) could make contact with and damage fishing gear or cause its loss. Such conflicts are more likely to involve fixed fishing gear (*e.g.*, crab pots) than mobile gear since those vessels can actively avoid conflicts.

As noted, the establishment of the construction Safety Zones will reduce the likelihood of conflicts with gear because, with the exception of vessels delivering materials by sea via the Traffic Lane, and a limited number of other operations, most construction-related activities will be confined to these two areas.

Catchability

As addressed in Chapter 7, Project activities might result in the scaring of fish causing them to avoid an area, thereby affecting the "catchability" of commercial species. Noise will be created by sheet/pile driving, dredging and underwater blasting activities associated with re-establishing the bund wall for the drydock and widening of the tow-out channel for the partially completed platform.

Depending on the placement of fishing gear in relation to the noise source, the effects on a particular harvesting opportunity might be either positive or negative. Finfish species, such as groundfish or pelagics might be either driven away from or towards waiting fishing gear.

Similar effects are not usually documented for benthic invertebrates such as lobster and crab (see Christian *et al.* (2004); Parry and Gason (2006)). Biophysical and behavioural effects of sound on biota, including commercial and prey species, are considered in Chapter 7 where effects are assessed as *not significant* with mitigations in place.

As described, construction Safety Zones will be established in consultation with Project Area fishers. This will reduce the impacts of pile/sheet driving or dredging activities on fish harvesting operations since there will be none in the immediate area of these operations. As such, there will likely be a sound attenuation buffer between construction activities and fisheries operations beyond the boundary of the Safety Zone. Prior to the start of marine construction activities, EMCP will undertake a detailed analysis and assessment of shock waves from blasting in order to identify and assess their geographic extent beyond the Safety Zones and the potential effect on fish.

EMCP will consult with fishers in the area regarding the timing of blasting activities and the implementation of monitoring programs. To the extent possible, blasting will be planned to avoid interference with finfish harvesting activities.

Mitigations

The following are proposed mitigations to address the issues discussed above and in Section 8.4.1.1.

- **Fisheries Liaison Committee**. A fisheries liaison committee can facilitate communications between Project construction at Bull Arm and local fisheries activities. Such a committee could include representation of local fishers, Project personnel and the FFAW, and may be similar to the liaison committee established during construction of the Hibernia GBS. EMDC, in consultation with local fishers, will establish a liaison committee before the start of construction activities
- **Fisheries Compensation Plan**. EMCP will establish a fisheries compensation plan associated with construction activities at Bull Arm. The compensation plan will be developed based on existing practice and industry-based guidance
- **Nearshore Project Fisheries Liaison Officer.** EMCP will employ the services of a dedicated local area Project Fisheries Liaison Officer (FLO). The role of this position is to maintain continuous communication between fishers and Project personnel and contractors at Bull Arm regarding the daily construction and fisheries activities in the Project Area
- **Designated Vessel Traffic Lane.** EMCP will re-establish the vessel traffic lane for the approach to Bull Arm, Trinity Bay. All vessels will be required to travel within this lane, and therefore should minimize interference with fish harvesting activities and minimize the opportunity for gear conflicts in other areas
- **Vessel Traffic Management Plan**. EMCP in consultation with local fishers will implement a traffic management plan for Bull Arm. This plan should facilitate marine communications between fishers, Project vessels and other users in the area. It may include such provisions as communications protocols, speed of vessel in designated areas, *etc.*
- **Communications and Notification**. Communications will be maintained via marine radio to facilitate information exchange between Project personnel and fishers. EMCP will establish a marine communication protocol that will include provisions for notification of activities outside the established Safety Zone and other Project information that may be warranted. Such information will be exchanged via established mechanisms such as Notice to Mariners and the FLO
- **On-Board Fisheries Liaison Officer**. The requirement for a Fisheries Liaison Officer will be determined based on Project activity and in consideration of C-NLOPB guidance (*i.e.*, *Geophysical, Geological, Environmental and Geotechnical Guidelines*, (C-NLOPB 2008)) and in consultation with the FFAW and fishers in the area in accordance with a protocol being developed by One Ocean

- **Single Point of Contact.** As required, a single point of contact may be engaged to facilitate communications regarding gear loss/damage or other compensation claims pursuant to a fisheries compensation program

8.5.1.2 Offshore

Access to Fishing Grounds

During construction, EMCP will establish a Safety Zone around the offshore site. The Safety Zone will extend 500 m from the perimeter of construction vessels in the area and will be of short duration. All fisheries activities will be excluded from this area during construction and installation. However, analysis of past fishing activities indicates no harvesting has occurred within the zone in the past two decades indicating that the area is not currently used by the industry as fishing grounds (see Section 8.3).

During the tow-out of the Hebron Platform there will also be a temporary exclusion/Safety Zone around the platform and the ships tending it. However, this will be of short duration and will be continually moving.

For the operations phase, EMCP will establish a permanent Hebron Platform Safety Zone that extends 500 m from the perimeter of the platform, OLS and pipeline system. A recent initiative by One Ocean involved the creation of a factsheet highlighting the Safety Zones for each offshore production facility. EMCP will work with One Ocean to update these factsheets to include the Safety Zone for the Hebron Project.

As discussed above (under Nearshore mitigations) the offshore construction and operations phase Safety Zones function as key mitigations to avoid or prevent impacts from many other activities and to help ensure the safety of workers, fishers and other marine users since they will contain most of the specific construction and operations activities.

The requirement for a FLO during tow-out of the Hebron Platform to the offshore location will be determined in consultation with the FFAW.

Fishing Vessel Operations

Most construction- and operations-related activities that could affect fishing vessel operations will occur within the Safety Zone. Therefore there will be no interaction with fishing operations. Activities that have a potential to interfere with fishing activities include supply ships, as well as the initial Hebron Platform tow-out to the offshore site. There may also be a need for localized surveys some of which might extend outside the Safety Zone in both phases.

Fishing Gear

Ships and other vessels traversing marine areas outside the Safety Zone (including some geophysical, geological and geotechnical operations) and the Hebron Platform during tow-out have the potential to make contact with and damage fishing gear or cause its loss. As discussed, typically such conflicts involve fixed fishing gear such as crab pots. Considering the relatively low level of fish harvesting in the Offshore Project Area in recent decades (see Section 8.3), gear conflicts are more likely to occur enroute between seaports and the offshore work area than near the Offshore Project Area.

Catchability

As discussed in more detail in the Nearshore section, above, fish may move from an area because of loud noises underwater. During offshore construction, this could be the result of noise associated with certain platform installation activities or with geophysical, geological and geotechnical surveys. Noise does not appear to affect invertebrate harvests (such as snow crab; see Section 7.5.2), which is the only recorded harvest in the Project Area for many years.

Because most activities producing sound will be limited to the Safety Zone during construction and operations, effects of sound will be minimal.

Mitigations

The restriction of most activities within the Safety Zone will avoid most of the potential for interference with fishing vessel operations. For those activities that do occur outside the Safety Zone, mitigation measures will be established to minimize impacts on fishing vessel operations. For geophysical, geological and geotechnical activities specifically, the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2008) provide guidance aimed at minimizing, specifically, any impacts of well-site seismic surveys on commercial fish harvesting.

The relevant Guidelines state (Section II, Interaction with Other Ocean Users of Appendix 2, Environmental Mitigative Measures):

- Well Site Surveys
    1. The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and the local fishing interests are informed of each other’s planned activities. Communication throughout survey operations with fishing interests in the area should be maintained
    2. The operator should publish a Canadian Coast Guard “Notice to Mariners” and a “Notice to Fishers” via the CBC Radio program Fisheries Broadcast
    3. Operators should implement a gear and/or vessel damage compensation program, to promptly settle claims for loss and/or damage that may be caused by survey operations. The scope of the compensation program should include replacement costs for lost or damaged gear and any additional financial loss that is demonstrated to be associated with the incident. The operator should report on the details of any compensation awarded under such a program

4. Procedures must be in place on the survey vessel(s) to ensure that any incidents of contact with fishing gear are clearly detected and documented (*e.g.*, time, location of contact, loss of contact, and description of any identifying markings observed on affected gear). As per Section 4.2 of these Guidelines, any incident should be reported immediately to the 24-hour answering service at (709) 778-1400 or to the C-NLOPB Duty Officer

- Seismic Programs

  In addition to the measures indicated in Section 1 above, the following mitigation measures should also be implemented

  a) Surveys should be scheduled, to the extent possible, to reduce potential for impact or interference with DFO science surveys. Spatial and temporal logistics should be determined with DFO to reduce overlap of seismic operations with research survey areas, and to allow an adequate temporal buffer between seismic survey operations and DFO research activities

  b) Seismic activities should be scheduled to avoid heavy fished areas, to the extent possible. The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained. The use of a FLO onboard the seismic vessel is considered best practice in this respect

  c) Where more than one survey operation is active in a region, the operator(s) should arrange for a 'Single Point of Contact' for marine users that may be used to facilitate communication

The following describe how the Project will implement these guidelines, as appropriate, as well as other measures designed to mitigate potential effects:

- **Vessel Traffic Route**. In the offshore areas, traffic associated with Project construction and operations will transit within traffic routes used by existing operators. This will also greatly reduce the potential for gear conflicts
- **Operational Protocols**. One Ocean is exploring concerns raised by fishers regarding such operational issues as restrictions on fishing vessel transits in the vicinity of offshore installations. EMCP will work cooperatively with One Ocean and the fishing industry in this initiative
- **Communications and Notification.** Communications will be maintained directly at sea by Project Vessels via Marine Radio to facilitate information exchange with fishers. Relevant information regarding Project activities occurring outside the establish Safety Zone will be publicized, when appropriate, using established communication mechanisms such as the Notice to Mariners
- **On-Board Fisheries Liaison Officer**. The requirement for a FLO during certain offshore Project activities will be determined based on Project activity, and in consideration of C-NLOPB guidance (*i.e.*, Geophysical, Geological, Environmental, and Geotechnical Guidelines (C-NLOPB

2008)) in consultation with the FFAW and fishers in the area, in accordance with a protocol being developed by One Ocean

- **Single Point of Contact**. As required, a single point of contact may be engaged to facilitate communications regarding gear loss/damage or other compensation claims pursuant to an offshore fisheries compensation program
- **Fishing Gear Compensation Program**. EMCP will establish a Fishing Gear Compensation Program (FGCP) to cover loss of or damage to fishing gear resulting from Project activities. The compensation program will be developed based on C-NLOPB and Canadian Association of Petroleum Producers guidance

8.5.2 Decommissioning/Abandonment

During decommissioning operations the effects and the mitigations will be similar to those during construction, with whatever additional measures the situation (considering the then-current fisheries) requires.

8.5.3 Accidents, Malfunctions, and Unplanned Events

Accidental events that might affect commercial fisheries in both the Nearshore and Offshore areas are almost exclusively related to the unplanned release of hydrocarbons, whether refined or crude product. One exception is the accidental release of construction debris, which might damage fishing gear beyond the Safety Zones.

8.5.3.1 Spills

Chapter 7 concludes that biophysical effects on fish from a spill will be *not significant.* However, economic impacts might still occur if a spill prevented or impeded a harvester’s ability to access fishing grounds (because of areas temporarily excluded during the spill or spill clean-up), caused damage to fishing gear (through oiling) or resulted in a negative effect on the marketability of fish products (because of market perception resulting in lower prices).

While there is little fish harvesting in the Offshore Project Area, in the case of an uncontrolled release from the Hebron Platform, a slick could reach an active fishing area (*e.g.* to the east of the Platform in summer). In that case, it is likely that fishing would be halted, owing to the possibility of fouling gear. If the release site is some distance from snow crab fishing grounds, there would be time to notify fishers of the occurrence and prevent the setting or hauling of gear and thus prevent or minimize gear damage.

Exclusion from the spill area would be expected to be short-term, as typical sea and wind conditions in the Project Area would promote fairly rapid evaporation and weathering of the slick, and fishing vessels would likely be able to return within several days. Nevertheless, if fishers were required to cease fishing, harvesting might be disrupted (though, depending on the extent of the slick, alternative fishing grounds might be available in a nearby area). An interruption could result in reduced catches, or extra costs associated with having to relocate crab harvesting effort.

Effects due to market perceptions of poor product quality (no buyers or reduced prices, *etc.*) are more difficult to predict, since the actual (physical) impacts of the spill might have little to do with these perceptions. It would only be possible to quantify these effects by monitoring the situation if a spill were to occur and if it were to reach snow crab harvesting areas.

EMCP will establish a fisheries compensation plan for the Project.

8.5.3.2 Control and Containment of Debris

The accidental release or escape of construction debris from the Safety Zones could damage fishing gear if it became caught or entangled.

Appropriate precautions will be taken during construction to prevent the escape of debris from onshore and marine construction sites. If debris did escape and damage gear, fishers will be entitled to make a claim under the FGCP, described above.

The environmental effects of the Project on Commercial Fisheries and the mitigations to be implemented are summarized in Table 8-15.

8.5.4 Cumulative Effects

During consultations (reported in Section 5.3), offshore fish harvesters indicated concerns about the Hebron Development Project related to the combined effects of Hebron with other petroleum industry activities in the Jeanne d'Arc Basin oil field area. They cited concerns about reduced fishing opportunity resulting from general activities, such as extensive vessel hailing zones around each installation, ice deflection activities, and surveys. Fishers report that the current situation is forcing fishing vessels to steam farther in order to get around activities and installations to reach grounds, costing fishing time and increasing expenses, and that additional activities will exacerbate conditions. In particular, fishers cited growing levels of frustration, misunderstanding and miscommunication between fishing industry and petroleum industry operations, as described in Chapter 5.

EMCP is committed to work with the OOWG, relevant offshore fishers, FFAW representatives and other agencies to ensure good relations, cooperation and partnering between all offshore marine user groups.

With the described mitigations in place, the effects of Project-related construction/installation and operations/maintenance activities on access to fishing grounds, fishing vessel operations (movements and harvesting), fishing gear, and catachability of commercial species within the Nearshore Project Area will be *not significant.*

Table 8-15 Environmental Effects Assessment: Commercial Fisheries

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Construction							
Nearshore Project Activities							
Presence of Safety Zones (Great Mosquito Cove Zone follwed by a deepwater site)	• Access to Fishing Ground	• Fisheries Compensation Plan	1	2	2/6	R	2
Inwater Blasting	• Catchability	• Safety Zone, FLC, Timing	1	2	2/1	R	2
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site, *etc.*)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, VTMP, Fisheries Compensation Plan, N&C	1	1	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, N&C, VTMP	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, Fisheries Compensation Plan, VTMP	1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging/ocean disposal)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, Fisheries Compensation Plan, N&C, Timing	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, FLO, SPOC, N&C	1	1	1/1	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FLO, Fisheries Compensation Plan, SPOC, N&C, Timing	1	1	2/1	R	2
Platform Tow-out from Deepwater SIte	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, FLO, SPOC, N&C	1	1	3/6	R	2

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Offshore Construction/Installation							
Presence of Safety Zone	• Access to Fishing Ground	• OOWG	1	2	3/6	R	2
Installation of Temporary Moorings	• Fishing Vessel Operations	• Safety Zone, FGCP, N&C	1	1	2/1	R	2
Platform Tow-out/Offshore Installation	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear • Catchability	• FGCP, FLO, SPOC, Safety Zone, N&C	1	4	2/6	R	2
Operation of Vessels (supply, support, standby and tow vessels/barges/diving/ ROVs)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, OOWG, FGCP, Traffic Route	1	2	3/6	R	2
Potential Future Activities							
Presence of Safety Zone	• Access to Fishing Ground (A)		1	2	3/6	R	2
Excavated Drill Centre Dredging and Spoils Disposal	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, FGCP, N&C	1	2	2/1	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FGCP, SPOC, N&C	1	3	2/1	R	2
Offshore Operations and Maintenance							
Presence of Safety Zone	• Access to Fishing Ground		1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, OOWG, FGCP, Traffic Route	1	1	5/6	R	2
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FLO, FGCP, SPOC, N&C	1	3	3/2	R	2

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Potential Future Operational Activities							
Presence of Safety Zone	• Access to Fishing Ground		1	2	5/6	R	2
Geophysical/ Seismic Surveys	• Fishing Vessel Operations • Fishing Gear • Catchability	• FGCP, FLO, SPOC, N&C	1	3	3/2	R	2
Offshore Decommissioning/Abandonment							
Presence of Safety Zone	• Access to Fishing Ground (+)		1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels/ROVs)	• Fishing Vessel Operations • Fishing Gear	• Safety Zone, FGCP, Traffic Route	1	3	3/6	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Fishing Vessel Operations • Fishing Gear • Catchability	• Safety Zone, FLO, FGCP, SPOC, N&C	1	2	2/2	R	2
Accidents, Malfunctions and Unplanned Events							
Nearshore Spill (at Bull Arm Site)	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	3	2/1	R	2
Failure or Spill from OLS	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	2/1	R	2
Subsea Blowout	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	3/1	R	2
Crude Oil Surface Spill	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials/debris from the drilling unit, GBS, Hebron Platform)	• Fishing Vessel Operations • Fishing Gear	• Fisheries Compensation Plan, control and containment of debris	1	1	2/1	R	2

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Marine Vessel Incident (*i.e.*, fuel spills)	• Access to Fishing Grounds • Fishing Vessel Operations • Fishing Gear	• Oil Spill Compensation	1	5	2/1	R	2
Collisions (involving Hebron Platform, vessel, and/or iceberg)	• Fishing Vessel Operations	• Fisheries Compensation Plan, N&C	1	3	2/1	R	2

KEY

Magnitude:
1 = Low: does not have a measurable effect on commercial fishery net incomes
2 = Medium: has a measurable effect on commercial fishery net incomes, but is temporary and/or is highly localized
3 = High: has a measurable and sustained effect on commercial fishery net incomes

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 =< 1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

Acronyms:
FLC = Fisheries Liaison Committee (Nearshore)
FGCP = Fishing Gear Compensation Program (Offshore)
FLO = Fisheries Liaison Officer (in consultation with FFAW)
VTMP = Vessel Traffic Management Plan
SPOC = Single Point of Contact
N&C = Notification and Communications
OOWG = One Ocean Working Group

The offshore construction Safety Zone is not an area typically used as harvesting grounds in recent years, and thus there should be no impact on fish harvesting operations. Considering the relatively low level of fish harvesting in the Project Area, and the type of fisheries in recent decades, few gear conflicts or catchability effects are likely to occur. The most likely occurrence of interactions and impacts is along the route from ports servicing the Project and the Project Area. With the mitigations identified above in place, the effects of Project-related construction/installation and operations/maintenance activities on access to fishing grounds, fishing vessel operations (movements and harvesting), fishing gear, and catachability of commercial species within the Offshore Project Area during construction and installation will be *not significant.* This also applies to potential future construction activities which would be accorded the similar mitigations.

Like the construction Safety Zone, the permanent platform Safety Zone will not occupy an area typically used as harvesting grounds so there should be no reduction in fishing income as a result of its presence. For issues related to traffic along the route from ports servicing the platform, and for any surveys, the mitigations identified above will be in place. Consequently the effects of Project-related activities on access to fishing grounds, fishing vessel operations, fishing gear and catachability of commercial species within the Offshore Project Area during operations and maintenance (including possible future activities) will be *not significant.*

Economic effects from accidental events, including hydrocarbon spills (caused by loss of access, gear damage or changes in market value) could be considered *significant* to the commercial fisheries. However, the application of appropriate mitigative measures (*e.g.*, compensation plan) would reduce the potential impact to *not significant*. The same is true for gear damage sustained because of debris release, with the FGCP in place.

The cooperative development of appropriate and mutually agreed protocols and procedures through the OOWG will minimize future economic impacts, and cumulative effects would be *not significant*.

8.5.5 Determination of Significance

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Commercial Fisheries, after taking into account any proposed mitigation, is summarized in Table 8-16.

Table 8-16 Residual Environmental Effects Summary: Commercial Fisheries

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction/Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Effects	NS	3	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria
[B] Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
[C] Includes decommissioning and abandonment of the GBS and offshore site
[D] Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

The potential environmental effects of the Project on Fish and Fish Habitat are not considered of sufficient geographic extent, magnitude, duration, frequency and/or reversibility to have a measurable effect on commercial fishing incomes. Therefore the potential environmental effects of the Hebron Project on Commercial Fisheries are predicted to be not significant.

9 MARINE BIRDS

The Marine Birds Valued Ecosystem Component (VEC) includes species of birds that typically use the nearshore/coastal marine and offshore environments. The groups considered under the Marine Birds VEC are waterfowl (geese and ducks), cormorants, fulmars and other shearwaters, storm-petrels, gannets, phalaropes and other shorebirds, larids (jaegers, skuas, gulls, and terns), stercorariids (jaegers, skuas), and alcids (*e.g.*, Dovekie (*Alle alle*), murres, and Atlantic puffin (*Fratercula arctica*)).

9.1 Environmental Assessment Boundaries

9.1.1 Spatial and Temporal

9.1.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Section 4.3.2). The Study Areas and Project Areas are illustrated in Figures 9-1 and 9-2, for the nearshore and offshore, respectively. The Affected Areas for several Project activities have been determined by modelling (see AMEC 2010a, 2010b; JASCO 2010; Stantec 2010.)

9.1.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Chapter 4). The nearshore and offshore temporal boundaries are summarized in Table 9-1

Table 9-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation/start-up/drilling as early as 2015 • Production year-round through to 2046 or longer • Potential future activities - as required, year-round through to end of Project • Decommissioning/abandonment: after approximately 2046

Figure 9-1 Hebron Nearshore Study and Project Areas

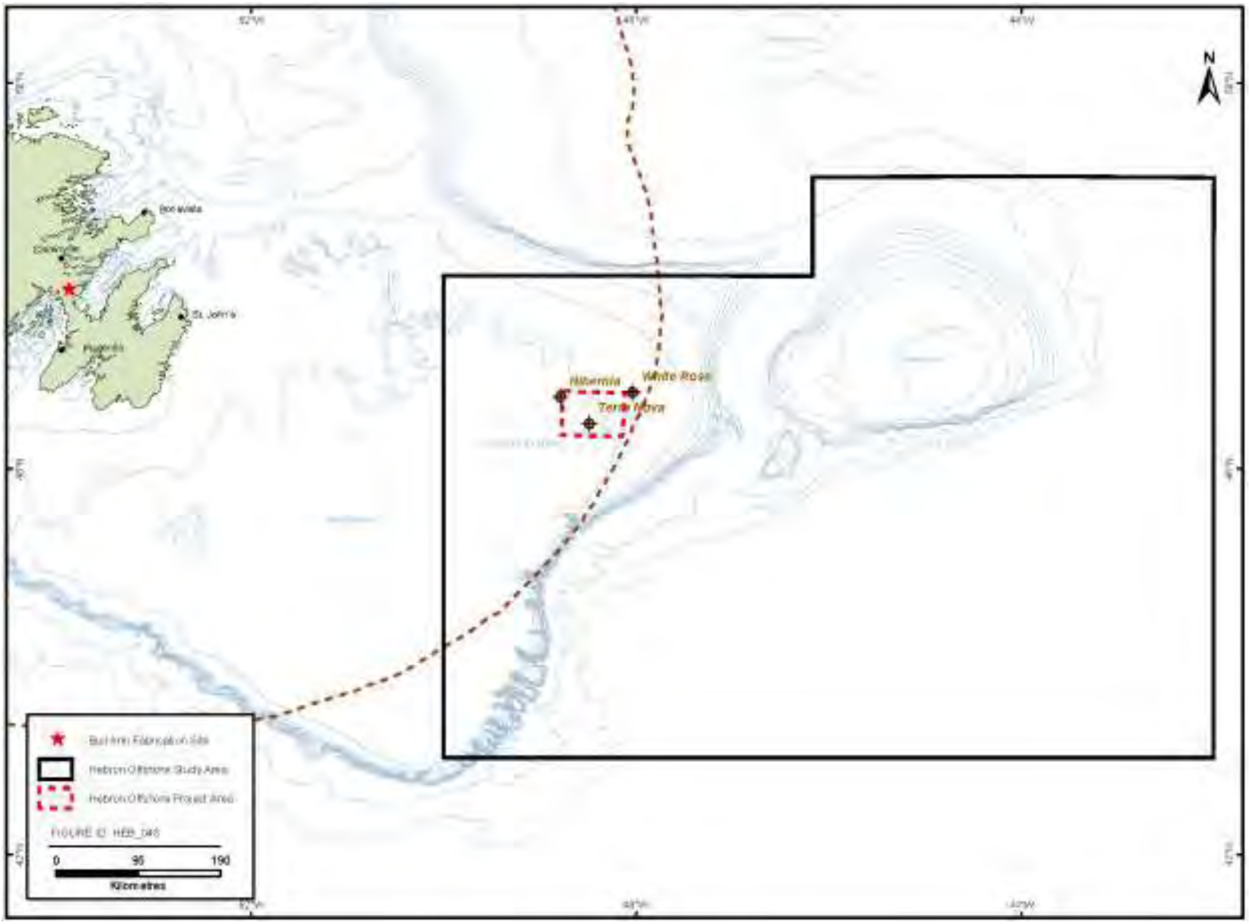


Figure 9-2 Offshore Study and Project Areas

9.1.2 Administrative

Most migratory and many non-migratory bird species are protected under the federal *Migratory Birds Convention Act, 1994*. The *Act* states, in part, that "No person or vessel shall deposit a substance that is harmful to migratory birds, or permit such a substance to be deposited, in waters or an area frequented by migratory birds or in a place from which the substance may enter such waters or such an area." Bird species at risk are protected under the *Species at Risk Act* (SARA) (refer to Section 11.6).

9.2 Definition of Significance

A significant adverse residual environmental effect is one that affects marine birds by causing a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Areas. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

An adverse effect that does not meet one of the above criteria is evaluated as not significant.

9.3 Existing Conditions

9.3.1 Nearshore

Bull Arm is a steep-sided narrow arm near the bottom of Trinity Bay. Most of the shoreline is rocky and treed to the high tide mark before dropping off into relatively deep water. The tidal zone is mostly narrow and rocky. Habitat for shorebirds (Charadriiformes), such as shoreline deposits of fine sediments and tidal flats, is limited in the Nearshore Study Area. The rocky cliffs could provide nesting habitat for Black Guillemot (*Cepphus grylle*). Bald Eagles (*Haliaeetus leucocephalus*) nest in Trinity Bay and may nest in trees near the shoreline of Bull Arm. Gull and tern species (*i.e.*, Common Tern (*Sterna hirundo*), Arctic Tern (*Sterna paradisaea*), Herring Gull (*Larus argentatus*) and Great Black-backed Gull (*Larus marinus*)) are common throughout coastal Newfoundland, probably include Bull Arm as part of a feeding area and may also nest in small numbers. There are no known concentrations of seaducks (Anatidae) in the winter, summer or during migration in the Nearshore Study Area. Bull Arm is sheltered from the open waters of Trinity Bay, where Dovekie and Thick-billed Murre (*Uria lomvia*) are known to occur in considerable numbers during the winter months (Lock *et al.* 1994).

Bellevue Beach, located at the southern boundary of the Nearshore Study Area, is an important habitat for marine birds. A strong tidal current flowing over a mud flat at the south end of Bellevue Beach creates a rich marine habitat. Gulls, terns, shorebirds and Ospreys (*Pandion haliaetus*) are common here in season. Great Black-backed, Herring and Ring-billed Gulls (*Larus delawarensis*) feed in the tidal currents and on the tidal flats at low tide. There is a nesting colony of gulls and terns on Bellevue Island, 0.5 km from the tidal flats. In 1989, 1100 nests of Ring-billed Gull were recorded on Bellevue Island (Cairns *et al.* 1989). Smaller numbers of Great Black-backed and Herring Gulls, and Common and Arctic Terns also nest on this island (Cairns *et al.* 1989). Significant numbers of Osprey hunt for fish in the tidal currents; up to 20 Osprey have been observed hovering in the air above the rip tide at one time (B. Mactavish, LGL Ltd., unpublished observations, August 26, 2009). Approximately 15 species of migrating shorebirds, including the Red Knot (*Calidris canutus*), occur regularly on the Bellevue Beach tidal flats during south bound migration (July to October; Table 9-2). The *rufa* subspecies of Red Knot is currently listed as Endangered by the Committee on the Status of Endagered Wildlife in Canada (COSEWIC). This species is described in more detail in Section 11.3.3.1.

Table 9-2 Shorebirds Regularly using Bellevue Beach in the Nearshore Study Area

Species	Scientific Name	Season of Occurrence	Status in Nearshore Study Area
Black-bellied Plover	(*Pluvialis squatarola*)	Aug-Nov	migrant
American Golden-Plover	(*Pluvialis dominica*)	Aug-Oct	migrant
Semipalmated Plover	(*Charadrius semipalmatus*)	Jun-Oct	migrant and summer visitor
Spotted Sandpiper	(*Actitis macularius*)	May-Sep	migrant and local breeder
Greater Yellowlegs	(*Tringa melanoleuca*)	May-Oct	migrant and may breed locally
Lesser Yellowlegs	(*Tringa flavipes*)	Aug-Oct	migrant
Hudsonian Godwit	(*Limosa haemastica*)	Aug-Oct	migrant
Ruddy Turnstone	(*Arenaria interpres*)	Jul-Oct	migrant
Red Knot	(*Calidris canutus rufa*)	Aug-Oct	migrant
Sanderling	(*Caldris alba*)	Jul-Oct	migrant
Semipalmated Sandpiper	(*Caldris pusilla*)	Jul-Oct	migrant
Least Sandpiper	(*Caldris minutilla*)	Jun-Sep	migrant
White-rumped Sandpiper	(*Caldris fuscicollis*)	Jul-Nov	migrant
Pectoral Sandpiper	(*Caldris melanotos*)	Aug-Oct	migrant
Short-billed Dowitcher	(*Limnodromus griseus*)	Jul-Sep	migrant

9.3.2 Offshore

The Hebron Offshore Study Area includes portions of the Grand Banks, Flemish Pass and Flemish Cap; however, much of the Study Area is off the Grand Banks. Those features include shelf, slope and deep-water habitats, as well as cold Labrador Current and warm Gulf Stream waters, all of which influence the distribution and abundance of marine birds. Marine birds are not spread evenly over the ocean but tend to be concentrated over anomalies such as shelf edges and areas where currents mix. Mixing in the water column at these edges creates a productive environment for plankton, which is the base of marine food webs.

The Grand Banks Shelf and Slope are rich in abundance and diversity of marine birds (Brown 1986; Lock *et al.* 1994) throughout the year. The food resources of the Grand Banks support many locally breeding birds. Several million marine birds nest along the coasts of the Avalon Peninsula and elsewhere along southeastern Newfoundland, and forage on the Grand Banks during and following the nesting season. In addition to local breeding birds, there are many non-breeding marine birds on the Grand Banks during the summer months. Most of the world's population of Greater Shearwater (*Puffinus gravis*) is thought to migrate to the Grand Banks and eastern Newfoundland to moult and feed during summer months after completion of nesting in the Southern Hemisphere. During the winter months, marine birds from the Arctic and subarctic of eastern Canada, and from Greenland, gather on the Grand Banks. All species of marine birds require more than a single year to become sexually mature. Many of those non-breeding sub-adult marine birds, especially Northern Fulmars (*Fulmarus glacialis*) and Black-legged Kittiwakes (*Rissa tridactyla*), are present on the Grand Banks year-round.

Little is known about the occurrence of birds in the deeper waters of the southeastern portions of the Offshore Study Area, away from the shelf and slope. However, such habitats typically are less productive and thus support far fewer numbers and variety of marine birds than the shelf and slope.

9.3.2.1 Data Sources and Survey Effort for Marine Birds in the Study Area

Most data on the occurrence of marine birds in the Offshore Study Area from the Grand Banks Shelf and Slope and Orphan Basin include the June through September period. Marine bird surveys conducted by environmental observers on offshore installations in the Terra Nova field during 1999 to 2009 fill in some of the data gaps for the October to May period. There are data gaps for all seasons for the Flemish Cap, the deep waters east of the Flemish Cap and southeast of the Grand Banks (see below). The principal sources of data in the Offshore Study Area are surveys conducted by the Canadian Wildlife Service (CWS), and by biologists onboard seismic vessels as part of a marine mammal and marine bird monitoring program required by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB).

Most of the information available up to 2000 was collected by the CWS through PIROP (Programme intégré de recherches sur les oiseaux pélagiques). Those data have been published for 1969 to 1983 (Brown 1986), and up to the early 1990s (Lock *et al.* 1994). In 2006, the CWS resumed surveying marine bird abundance and distribution and those recent data have become available (CWS 2009). The PIROP survey coverage within and around the Offshore Study Area is presented in Figure 9-3. PIROP marine bird data are of birds per linear kilometre. New survey protocols have been developed by CWS which permit the derivation of density estimates (Wilhelm *et al. in prep*.).

Systematic marine bird observations (Tasker surveys; Tasker *et al.* 1984) were conducted on the northern Grand Banks and the adjacent Orphan Basin from 2004 to 2008. The results of those surveys have greatly increased the knowledge base regarding marine bird distribution and diversity in those areas, at least during the warmer months of June through September (Moulton *et al.* 2005b, 2006b; Lang and Moulton 2008; Abgrall *et al.* 2008a, 2008b, in prep.). Marine bird data from other sources have been summarized for the period 1999 to 2002 by Baillie *et al.* (2005) and Burke *et al.* (2005). Tasker surveys provide marine bird data as densities (numbers per km^2). The offshore research and seismic-related cruises on which Tasker surveys and other marine bird observations were conducted are listed in Table 9-3. The geographic distribution of Tasker surveys in and around the Offshore Study Area is illustrated in Figure 9-4.

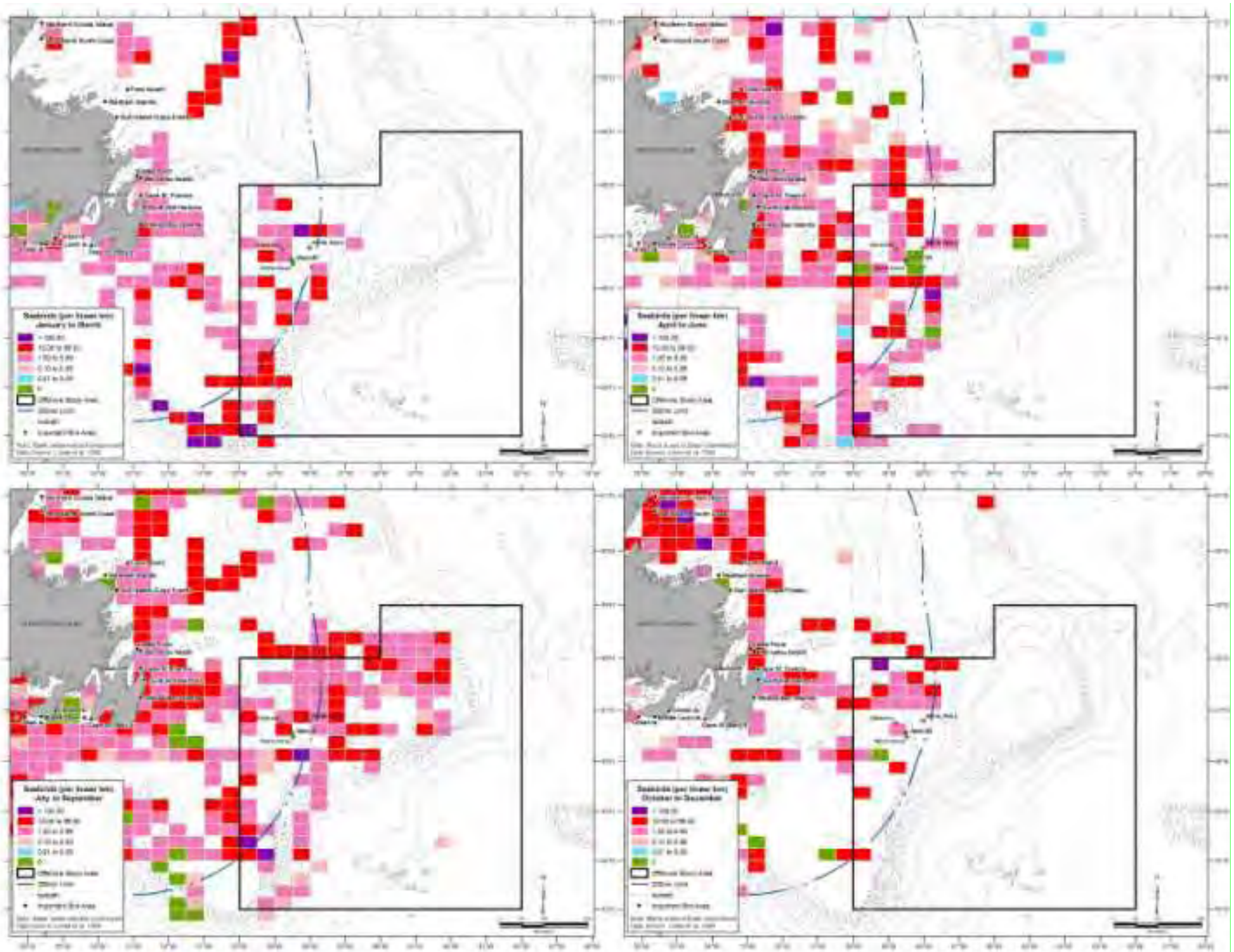


Figure 9-3 Geographic and Seasonal Distribution of Canadian Wildlife Service PIROP Survey Effort and Results in and around the Offshore Study Area

Table 9-3 Recent Seismic, CSEM and Research Cruises in and around the Offshore Study Area during which Marine Bird Observations were Conducted by Biologists (2004 to 2008)

Project	Time Period	Location (Relative to Project Area and/or Study Area)	Approximate Water Depth (m)	Species with Highest Relative Abundances during Observations
CCGS *Hudson* Research Expedition	June 2004	South Grand Banks (southwestern Study Area)	< 100	Greater Shearwater
CCGS *Hudson* Research Expedition	June 2004	Salar Basin (southwestern Study Area)	> 1,000	Greater Shearwater Northern Fulmar
CCGS *Hudson* Research Expedition	June 2004	Western Slope of Southern Flemish Pass (north-central Study Area)	~ 500	Northern Fulmar Greater Shearwater Sooty Shearwater
CCGS *Hudson* Research Expedition	June 2004	Sackville Spur (northeast of Study Area)	~ 1,000	Northern Fulmar Greater Shearwater Great Black-backed Gull
CCGS *Hudson* Research Expedition	June-July 2004	Orphan Basin (north of Study Area)	> 2,000	Northern Fulmar Greater Shearwater Great Black-backed Gull Leach's Storm-Petrel
CCGS *Hudson* Research Expedition	July 2004	North Grand Banks (northwestern Study Area)	200-1,000	Greater Shearwater Manx Shearwater
Seismic Program for Chevron Canada Resources and ExxonMobil Canada Limited	June-September 2004	Orphan Basin (north of Study Area)	1,850-2,500	Northern Fulmar Greater Shearwater Leach's Storm-Petrel Sooty Shearwater Black-legged Kittiwake (Aug-Sept)
Seismic Program for Chevron Canada Resources and ExxonMobil Canada Limited	May-September 2005	Orphan Basin (north of Study Area)	1,108-2,747	Northern Fulmar Leach's Storm-Petrel Greater Shearwater Black-legged Kittiwake, Dovekie, & Thick-billed Murre (May-June) Great Black-backed Gull (Aug-Sept)
Seismic Program for Husky Energy Inc.	October-November 2005	Approximately 75 km northwest of *Terra Nova* FPSO (northwestern Study Area)	68-376	Northern Fulmar Dovekie Black-legged Kittiwake Thick-billed Murre
Petro-Canada`s *Terra Nova* Hull Cleaning	May-June 2006	46 km radius around *Terra Nova* FPSO	65-190	Leach's Storm-Petrel
Seismic Program for Husky Energy Inc.	July-August 2006	1) 95 km north & 2) 15 km east of *Terra Nova* FPSO	86-387	Greater Shearwater Leach's Storm-Petrel
CSEM Program for ExxonMobil Canada Limited	August-September 2006	Orphan Basin (north of Study Area)	2,076-2,603	Greater Shearwater Leach's Storm-Petrel Black-legged Kittiwake Northern Fulmar
Seismic Program for Petro-Canada	June-July 2007	Approximately 17 km northwest of *Terra Nova* FPSO (northwestern Study Area)	61-171	Greater Shearwater Northern Fulmar Leach's Storm-Petrel
CSEM Program for ExxonMobil Canada Limited	July-September 2007	Orphan Basin (north of Study Area)	1,122-2,789	Leach's Storm-Petrel Greater Shearwater Northern Fulmar
Seismic Program for Petro-Canada, StatOil Hydro, and Husky Energy Inc.	May-September 2008	Jeanne d'Arc Basin	66-119	Greater Shearwater Northern Fulmar Leach's Storm-Petrel

Sources: Lang and Moulton (2004, 2008); Moulton *et al.* (2005b, 2006b); Lang *et al.* (2006); Lang (2007); Abgrall *et al.* (2008a, 2008b, in prep.)

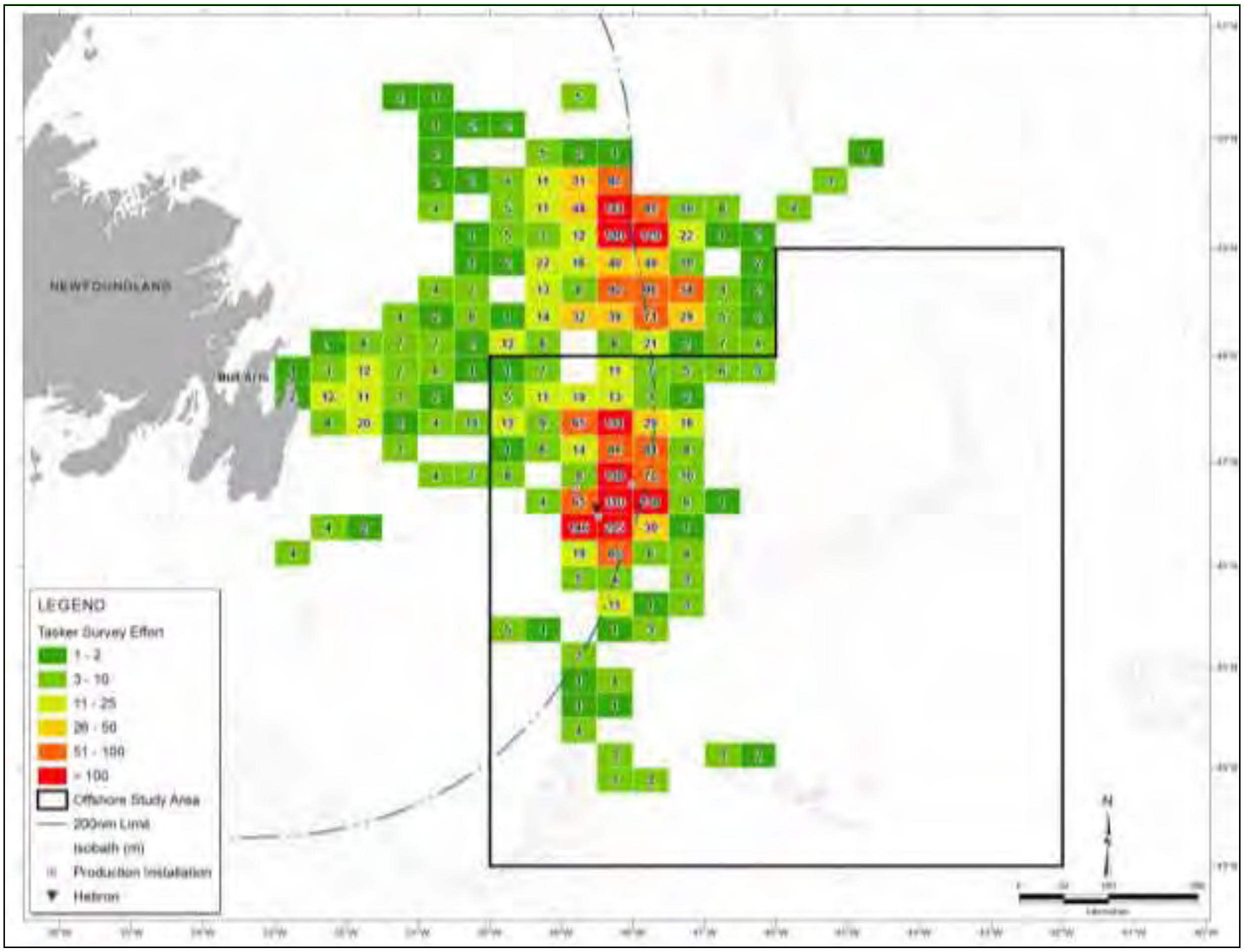


Figure 9-4 Geographic Distribution of Tasker Surveys (number of 10-minute counts) Conducted during 2004 through 2008 in and around the Offshore Study Area

Marine bird surveys conducted from the drill platform in the Terra Nova field from 1999 to 2009 used variable survey methods from 2-minute to 10-minute-counts of all birds within a 300 m radius of the drill platform. Relative abundances, as well as spatial and temporal distribution of marine birds were derived from these data (Suncor unpublished data 2009).

9.3.2.2 General Patterns of Marine Bird Occurrence in the Offshore Study Area

The following description of marine bird occurrence in the Offshore Study Area pertains primarily to the Grand Banks (shelf and slope) and the Orphan Basin. Those are the areas where sufficient survey effort has been conducted to describe patterns of marine bird occurrence with reasonable confidence. Little is known about the distribution and abundance of marine birds in other parts of the Offshore Study Area. However, a similar mix of species is expected to occur there, but generally in lower densities than on the shelf and slope; the deeper waters away from the shelf and slope are typically less productive.

The Grand Banks (shelf and slope) are known to support large numbers and diversity of marine birds at all seasons (Brown 1986; Lock *et al.* 1994). This is likely true of the Flemish Cap and its slopes as well, given that the same factors promoting increased productivity (upwelling and mixing) are present. In all seasons, densities of birds generally are higher along the shelf break. Approximately 27 species of marine birds occur annually on the Grand Banks in at least small numbers. The species and general monthly abundance expected on the Continental Shelf and slope waters of the Offshore Study Area are listed in Table 9-4.

The highest densities and diversity occur during the July to September period (Brown 1986; Lock *et al.* 1994). That is the period when there is the combination of non-breeding summering species (*e.g.*, Greater Shearwater), plus post-breeding local nesters that have moved to the offshore from coastal colonies (*e.g.*, Leach's Storm-petrel (*Oceanodroma leucorhoa*), Black-legged Kittiwake). The lowest densities occur during the winter months, December through March. Nevertheless, the Grand Banks support hundreds of thousands of birds even during winter. Large numbers of Arctic breeding Thick-billed Murre, Dovekie, Northern Fulmar and Black-legged Kittiwake migrate to eastern Newfoundland, including the Grand Banks, for the winter. During migration periods (April-May; September-November), other marine birds (*e.g.*, jaegers, terns, phalaropes) migrate north in spring and south in autumn over the Grand Banks between breeding sites in the Arctic (Canada and Greenland) and wintering areas in more southern latitudes.

The only species of eastern offshore marine bird that is listed under SARA is the Ivory Gull (*Pagophila eburnea*). This species is currently listed as "Endangered" on Schedule 1. It is likely rare and of less than annual occurrence in the Offshore Study Area (see Section 11.3.3.2 for more details).

9.3.2.3 Marine Bird Nesting Colonies Along Southeastern Newfoundland

Enormous numbers of marine birds nest on the Avalon Peninsula. The marine bird breeding colonies on Baccalieu Island, the Witless Bay Islands and Cape St. Mary's are among the largest in Atlantic Canada. More than 4.6 million pairs nest at these three locations (Table 9-5 and Figure 9-5). That includes the largest Atlantic Canada colonies of Leach's Storm-Petrel (3,336,000 pairs on Baccalieu Island), Black-legged Kittiwake (43,927 pairs on Witless Bay Islands), Thick-billed Murre (1,000 pairs at Cape St. Mary's) and Atlantic Puffin (216,000 pairs Witless Bay Islands). No marine bird nesting colonies are located within either the Nearshore or Offshore Study Areas, so these sites are not discussed within the Sensitive or Special Areas VEC. They are included here as part of the life histories of the species and populations that may occur with the Study Areas.

Table 9-4 Monthly Abundance of Bird Species Occurring on Continental Shelf Waters within and around the Offshore Study Area

Common Name	Scientific Name	Monthly Abundance											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Procellariidae													
Northern Fulmar	*Fulmarus glacialis*	C	C	C	C	C	C	U-C	U-C	C	C	C	C
Greater Shearwater	*Puffinus gravis*					U	C	C	C	C	C	S	
Sooty Shearwater	*Puffinus griseus*					S	S-U	S-U	S-U	S-U	S-U	S	
Manx Shearwater	*Puffinus puffinus*				S	S	S	S	S	S	S		
Hydrobatidae													
Leach's Storm-Petrel	*Oceanodroma leucorhoa*				U-C	U-C	U-C	U-C	U-C	U-C	U-C	S	
Wilson's Storm-Petrel	*Oceanites oceanicus*						S	S	S	S			
Sulidae													
Northern Gannet	*Morus bassanus*				S	S	S	S	S	S	S		
Phalaropodinae (Scolopacidae)													
Red Phalarope	*Phalaropus fulicarius*					S	S	S	S	S	S		
Red-necked Phalarope	*Phalaropus lobatus*					S	S	S	S	S			
Laridae													
Herring Gull	*Larus argentatus*	S	S	VS	VS	VS	VS	VS	VS	S	S	S	S
Iceland Gull	*Larus glaucoides*	S	S	S	S							S	S
Lesser Black-backed Gull	*Larus fuscus*					VS	VS	VS	VS	VS	VS	VS	VS
Glaucous Gull	*Larus hyperboreus*	S	S	S	S						S	S	S
Great Black-backed Gull	*Larus marinus*	U	U	VS	VS	VS	VS	VS	U	U	U	U	U
Ivory Gull	*Pagophila eburnea*	VS VS?	VS	VS	VS								
Black-legged Kittiwake	*Rissa tridactyla*	C	C	C	C	S	S	S	S	S	C	C	C
Arctic Tern	*Sterna paradisaea*					S	S	S	S	S			
Stercorariidae													
Great Skua	*Stercorarius skua*					S	S	S	S	S	S		
South Polar Skua	*Stercorarius*					S	S	S	S	S	S		

Common Name	Scientific Name	Monthly Abundance											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	maccormicki												
Pomarine Jaeger	*Stercorarius pomarinus*					S	S	S	S	S	S		
Parasitic Jaeger	*Stercorarius parasiticus*					S	S	S	S	S	S		
Long-tailed Jaeger	*Stercorarius longicaudus*					S	S	S	S	S			
Alcidae													
Dovekie	*Alle alle*	U-C	U-C	U-C	U-C	S	VS	VS	VS	S	C	C	U-C
Common Murre	*Uria aalge*	S-U	S-U	S-U	S-U	S	S	S	S	S	S-U	S-U	S-U
Thick-billed Murre	*Uria lomvia*	U-C	U-C	U-C	U-C	VS-S	S	VS-S	VS-S	VS-S	U-C	U-C	U-C
Razorbill	*Alca torda*				S	S	S	S	S	S	S	S	
Atlantic Puffin	*Fratercula arctica*				S-U	S	S	S	S	S-U	S-U	S-U	

Notes: C = Common, present daily in moderate to high numbers; U = Uncommon, present daily in small numbers; S = Scarce, present, regular in very small numbers; VS = Very Scarce, very few individuals or absent. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from 2004, 2005, 2006 and 2007 monitoring studies in the Orphan Basin and Jeanne d'Arc Basin and extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986) and Lock *et al.* (1994)

Sources: Brown (1986); Lock *et al.* (1994); Baillie *et al.* (2005); Moulton *et al.* (2005b, 2006b); Lang *et al.* (2006); Lang (2007); Lang and Moulton (2008); Abgrall *et al.* (2008a, 2008b, in prep.)

Table 9-5 Numbers of Pairs of Marine Birds Nesting at Marine Bird Colonies in Eastern Newfoundland

Species	Wadham Islands	Funk Island	Cape Freels and Cabot Island	Baccalieu Island	Witless Bay Islands	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island
Procellariidae									
Northern Fulmar	-	46[A]	-	12[A]	22[A,F]	Present[A]	-	-	-
Manx Shearwater	-	-	-	-	-	-	13[K]	-	-
Hydrobatidae									
Leach's Storm-Petrel	1,038[D]	-	250[J]	3,336,000[J]	667,086[H,I,J]	-	13,879[H]	100,000[J]	103,833[M]
Sulidae									
Northern Gannet		9,837[b]		1,712[B]	-	14,789[L]	-	-	-
Laridae									
Herring Gull	-	500[J]	-	Present[A]	4,638[e,j]	Present[J]	20[J]	5,000[J]	Present[mM]
Great Black-backed Gull	Present[D]	100[J]	-	Present[A]	166[E,J]	Present[J]	6[J]	25[J]	-
Black-legged Kittiwake	-	810[J]	-	12,975[J]	23,606[F,J]	10,000[J]	-	50[J]	-
Arctic and Common Terns	376[J]	-	250[J]	-	-	-	-	-	-
Alcidae									
Common Murre	-	412,524[C]	2,600[J]	4,000[J]	83,001[F,J]	15,484[J]	-	-	-
Thick-billed Murre		250[J]	-	181[J]	600[J]	1,000[J]	-	-	-
Razorbill	273[D]	200[J]	25[J]	100[J]	676[F,J]	100[J]	-	-	-
Black Guillemot	25[J]	1[J]	-	100[J]	20+[J]	Present[J]	-	-	-
Atlantic Puffin	6,190[D]	2,000[J]	20[J]	30,000[J]	272,729[F,G,J]	-	-	-	-
TOTALS	7,902	426,268	3,145	3,385,080	1,052,546	32,256	13,918	105,075	65,280

Sources: [A] Stenhouse and Montevecchi (1999a); [B] Chardine (2000); [C] Chardine *et al.* (2003); [D] Robertson and Elliot (2002); [E] Robertson *et al.* (2001); [F] Robertson *et al.* (2004); [G] Rodway *et al.* (2003); [H] Robertson *et al.* (2002); [I] Stenhouse *et al.* (2000); [J] Cairns *et al.* (1989); [K] Robertson (2002); [L] CWS (unpubl. Data); [M] Russell (2008)

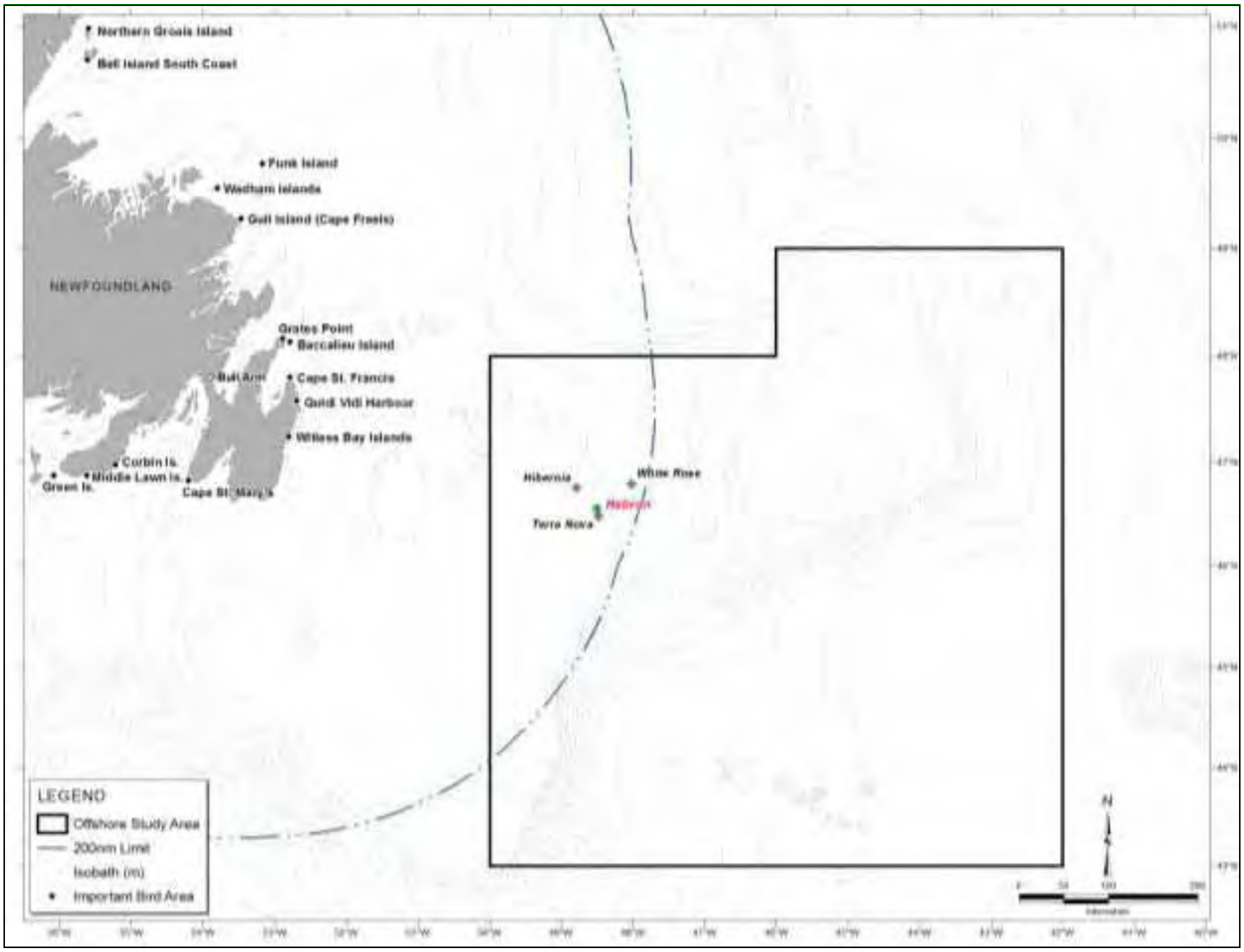


Figure 9-5 Map of Important Bird Areas including Marine Bird Colonies along Southeastern Newfoundland

All these birds feed on the Grand Banks during the nesting and/or post-nesting seasons (May to September). In addition, Funk Island, located 150 km northwest of the Grand Banks, supports the largest colony of Common Murre in Atlantic Canada. Many of these birds would reach the northern Grand Banks during the breeding season.

There are nine marine bird nesting sites on the southeast coast of Newfoundland from Cape Freels to the Burin Peninsula meeting the criteria for an Important Bird Area (IBA) (an IBA is a site that provides essential habitat for one or more species of breeding or non-breeding birds) (Figure 9-5). In addition, Grates Point, Mistaken Point and Placentia Bay qualify as IBAs because of important wintering populations of Common Eider (*Somateria mollissima*). A total of 5.2 million pairs of birds breed at these sites. The Study Area is well beyond the foraging range of breeding birds during the breeding season, approximately May to August. At Witless Bay, Common Murres forage up to 200 km from the breeding site but usually only 50 to 100 km (Cairns *et al.* 1990, in Gaston and Jones 1998). However, during post-breeding dispersal, the Study Area is within range of all marine birds breeding in eastern Newfoundland and Labrador.

9.3.2.4 Species Profiles

The world range, and seasonal occurrence and abundance of marine birds in the Study Area are described in this section. The monthly abundance status for each species is summarized in Table 9-4. Information was derived primarily from Brown (1986), Lock *et al.* (1994), Baillie *et al.* (2005), and Abgrall *et al.* (2008a, 2008b, in prep.).

Procellariidae (Fulmars and Shearwaters)

Northern Fulmar and the four species of shearwaters that are expected to occur in the area feed on a variety of invertebrates, fish and zooplankton at or very near the surface. Capelin is an important food source for shearwaters. Shearwaters secure their prey by swimming on the surface and picking at items on the surface, or dipping their heads under the water. They are also capable of diving a short distance under the surface, probably no more than 1 m or so. They may do this by flying low over the water and then plunging into the water with enough force to get them below the surface for a few seconds, or dive from a sitting position.

Northern Fulmar

Northern Fulmar is common in the Offshore Study Area all year. The Northern Fulmar breeds in the North Atlantic, North Pacific, and Arctic oceans. In the Atlantic Ocean, it winters south to North Carolina and southern Europe. (Brown 1986; Lock *et al.* 1994). Through band recoveries, it is known that most individuals in Newfoundland waters are from Arctic breeding colonies. Adults and sub-adult birds are present in the winter with sub-adults remaining through the summer. Fewer than 100 pairs breed in eastern Newfoundland (Cairns *et al.* 1989). Fulmars were found to be most numerous during spring and autumn 1999 to 2002 on the northeast Grand Banks, based on observations from drill rigs (Baillie *et al.* 2005).

Results from seismic monitoring programs indicate that Northern Fulmar is much less common on the Jeanne d'Arc Basin during spring and summer than during fall and winter, or in deep water areas such as Orphan Basin at all times of the year (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.; Suncor unpubl. data).

Table 9-6 Average Densities of Marine Birds by Week Recorded during 10-minute Marine Bird Counts

Species	Average Density (number of individuals per km²) per 10-minute Observation Period						
	1-7 October	**8-14 October**	**15-21 October**	**22-28 October**	**29 Oct. - 4 Nov.**	**5-8 November**	**All weeks combined**
Northern Fulmar	3.07	25.57	4.35	34.17	10.00	10.77	14.72
Dovekie	1.53	5.07	10.14	13.58	7.07	4.16	7.09
Black-legged Kittiwake	1.16	8.38	11.76	8.97	4.29	5.78	6.57
Thick-billed Murre	0	1.86	5.01	4.16	7.41	9.58	4.11
Greater Shearwater	11.82	1.71	0.45	0	0	0	2.87
Atlantic Puffin	0.86	1.73	2.37	1.34	1.65	0.51	1.46
Common Murre	1.05	0.88	1.52	0.83	0.05	0.20	0.81
Great Black-backed Gull	0.25	1.59	0.65	0.67	0.51	0.46	0.68
Leach's Storm-Petrel	1.02	0.39	0.46	0.54	0.04	0	0.47
Sooty Shearwater	0.19	1.03	0.50	0.61	0	0	0.40
Glaucous Gull	0	0	0.06	0.50	0.04	0.48	0.16
Herring Gull	0.04	0.05	0.00	0.06	0.20	0.76	0.13
Pomarine Jaeger	0.21	0	0	0	0	0	0.04
Jaeger sp.	0.08	0	0	0.07	0	0	0.03
Murre sp.	0	0.05	0.04	0.08	0	0	0.03
Northern Gannet	0.07	0	0	0	0.09	0	0.03
Razorbill	0.14	0	0	0	0	0	0.03
Iceland Gull	0	0	0	0	0.05	0.09	0.02
Lesser Black-backed Gull	0	0.12	0	0	0	0	0.02
Parasitic Jaeger	0	0.05	0	0.04	0	0	0.02
Red Phalarope	0.07	0	0	0.04	0	0	0.02
Skua sp.	0	0.05	0.05	0	0	0	0.02
Great Skua	0	0	0.05	0	0	0	0.01
Manx Shearwater	0	0	0	0.04	0	0	0.01
South Polar Skua	0.03	0	0	0	0	0	0.01
All species	**21.7**	**48.6**	**37.4**	**65.7**	**31.4**	**458.7**	**39.8**

Source: Abgrall *et al.* (2008a)
Note: Recorded in the Seismic Analysis Area and adjacent areas where the *Western Neptune* sailed, October 1 to November 8, 2005, arranged in order of decreasing density

Table 9-7 Average Densities of Marine Birds by Week Recorded during 10-minute Marine Bird Counts

Species	Average Density (number of individuals per km²) per 10-minute Observation Period						
	9-16 July	17-23 July	24-30 July	31 July - 6 August	7-13 August	14-16 August	All Weeks Combined
Greater Shearwater	2.54	7.04	4.33	8.90	1.57	0.62	5.06
Leach's Storm-Petrel	1.15	0.17	0.24	0.41	0.42	0.10	0.60
Northern Fulmar	0.15	0.05	0.05	0	0	0.05	0.07
Sooty Shearwater	0.07	0	0.05	0.02	0.03	0	0.04
Atlantic Puffin	0.12	0	0	0	0	0	0.03
South Polar Skua	0	0	0.05	0.05	0	0	0.02
Common Murre	0.08	0	0	0	0	0	0.02
Skua sp.	0	0	0.05	0	0	0	0.01
Red Phalarope	0	0	0.10	0	0	0	0.01
Pomarine Jaeger	0	0	0.05	0	0.03	0	0.01
Northern Gannet	0	0	0	0.02	0	0	0.01
Murre sp.	0	0.05	0	0.03	0	0	0.01
Manx Shearwater	0.02	0	0	0.03	0	0	0.01
Great Black-backed Gull	0	0	0	0	0	0.03	0.01
Dovekie	0	0	0	0.03	0	0	0.01
Black-legged Kittiwake	0	0	0	0	0	0.05	0.01
All Species	**4.14**	**7.32**	**4.91**	**9.49**	**2.03**	**0.85**	**5.93**

Source: Abgrall *et al.* (2008a)
Note: Recorded in the Seismic Analysis Area and adjacent areas where the *Western Regent* sailed, July 9 to August 16, 2006, arranged in order of decreasing density

Table 9-8 Average Densities of Marine Birds Bi-monthly Recorded during 10-minute Marine Bird Counts

Species	Average Density (number of individuals per km²) per 10-minute Observation Period									
	21-31 May	1-15 June	16-20 June	1-15 July	16-31 July	1-15 August	16-31 August	1-15 September	16-29 September	Grand Total
Greater Shearwater	0.05	2.11	15.07	26.65	19.93	24.27	9.81	9.04	3.18	11.92
Sooty Shearwater	0	0.33	1.04	0.25	0.1	0.07	0.53	6.06	3.98	1.65
Northern Fulmar	0.08	0.18	3.54	0.15	0.26	0.57	1.02	1.41	3.03	1.24
All murres	1.1	0.25	0.46	0.31	0.29	0.02	0.88	1.61	3.57	1.02
Leach's Storm-Petrel	0.22	0.13	0.21	0.21	0.97	0.57	0.49	1.49	2.92	0.9
Common Murre	0.72	0.09	0.28	0.31	0.24	0	0	1.51	3.42	0.84
Unidentified Murre	0.38	0.12	0.18	0	0.03	0.02	0.88	0.08	0.15	0.18
Great Black-backed Gull	0	0	0	0	0	0	0.03	0.55	0.52	0.15
Atlantic Puffin	0	0.02	0.13	0.14	0.02	0	0	0.02	0.59	0.11
Manx Shearwater	0	0	0.06	0.14	0.21	0.07	0	0	0	0.05
Pomarine Jaeger	0	0	0	0	0	0.02	0.06	0.12	0.14	0.04
South Polar Skua	0	0	0	0.14	0.03	0.03	0.06	0.04	0	0.03
Great Skua	0	0	0	0.03	0	0	0.03	0.06	0.04	0.02
Northern Gannet	0	0	0	0	0	0	0.16	0.03	0	0.02
Dovekie	0.03	0	0.02	0	0	0	0	0	0.07	0.02
Black-legged Kittiwake	0	0.02	0.07	0	0	0	0.03	0.03	0.02	0.02
Thick-billed Murre	0	0.04	0	0	0.03	0	0	0.02	0	0.01
Red Phalarope	0	0	0	0	0	0	0	0.05	0	0.01
Long-tailed Jaeger	0	0	0	0	0	0	0	0.03	0.02	0.01
Unidentified phalarope	0	0	0	0	0	0	0	0.03	0	0.005
Parasitic Jaeger	0	0	0	0	0	0	0	0.005	0.02	0.003
Wilson's Storm-Petrel	0	0	0	0	0	0	0	0.02	0	0.003
Herring Gull	0	0	0	0	0	0	0	0.02	0	0.002
Unidentified	0	0	0	0	0	0	0.03	0	0	0.002

Species	Average Density (number of individuals per km²) per 10-minute Observation Period									
	21-31 May	**1-15 June**	**16-20 June**	**1-15 July**	**16-31 July**	**1-15 August**	**16-31 August**	**1-15 September**	**16-29 September**	**Grand Total**
Skua										
Unidentified Jaeger	0.03	0	0	0	0	0	0	0	0.02	0.002
Lesser Black-backed Gull	0	0	0	0	0	0	0	0	0.02	0.002
Arctic Tern	0	0	0	0	0	0	0	0	0.02	0.002
All Birds	**1.51**	**3.03**	**20.6**	**31.03**	**21.82**	**25.63**	**13.14**	**20.59**	**18.12**	**17.23**

Note: Recorded in the Seismic Analysis Area and adjacent areas where the *Veritas Vantage* sailed, May 21 to September 29, 2008, arranged in order of decreasing density

Cory's Shearwater

Cory's Shearwater (*Calonectris diomedea*) is rare in the Offshore Study Area and is present during the July to September period. Cory's Shearwater is a subtropical species breeding in the eastern Atlantic Ocean on Azores Island and the Cape Verdes Islands, the Mediterranean and western Indian Ocean. In late summer, small numbers reach the waters off southern Nova Scotia. A few occur in southern Newfoundland waters, including the Grand Banks. Cory's Shearwater was recorded from drill platforms on the northeast Grand Banks, but because of the Cory's similarity in appearance to the abundant Greater Shearwater, the actual numbers of Cory's observed is unclear (Baillie *et al.* 2005; Suncor unpubl. data).

Cory's Shearwater was not identified during seismic or controlled-source electromagnetic (CSEM) monitoring programs in the Jeanne d'Arc Basin or Orphan Basin.

Greater Shearwater

The Greater Shearwater breeds on the Tristan de Cunha Islands in the south Atlantic Ocean from October to March. It spends its non-breeding season on the North Atlantic. Greater Shearwater has an important presence on the Grand Banks. A considerable portion of the entire population of approximately 5,000,000 migrate from the Southern Hemisphere breeding sites to feed and moult on the Grand Banks and offshore eastern Newfoundland in June and July (Lock *et al.* 1994). After moulting, birds remain in the area until early November. Greater Shearwater was the most numerous species observed from drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie *et al.* 2005). Numbers increased through the summer to a peak in September then decreased rapidly with stragglers into November. Median flock size was usually less than 50 but occasionally up to 1,200.

Results from seismic monitoring programs in the Jeanne d'Arc Basin also indicate that Greater Shearwater is quite abundant during the summer period, with numbers declining in early fall (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep). It was among the most numerous species observed by environmental observers on offshore installations on the Terra Nova oil field during June to September from 1999 to 2009 (Suncor unpubl. data).

Sooty Shearwater

Sooty Shearwater (*Puffinus griseus*) is predicted to be present in the Study Area from May to early November. It is expected to be scarce in May, uncommon from June to October and scarce in early November.

Sooty Shearwater breeds in the south Atlantic and south Pacific Oceans. It spends most of the non-breeding season in the Northern Hemisphere. Some Sooty Shearwaters follow the same migration pattern as Greater Shearwater by migrating north to Canadian waters in spring. Sooty Shearwater is usually outnumbered by Greater Shearwater in eastern Canada (Brown 1986). Numbers peaked at 2.5 birds/day at one drill platform on the northeast Grand Banks 2000 and 2001 (Baillie *et al.* 2005).

Sooty Shearwater was the second most abundant marine bird species over the course of the 2008 seismic monitoring program in the Jeanne d'Arc Basin; increased densities in September may reflect staging prior to southward migration (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep)

Manx Shearwater

Manx Shearwater (*Puffinus puffinus*) is scarce in the Offshore Study Area during the April to October period. Manx Shearwater breeds in northeast Atlantic Ocean. It is uncommon in the northwest Atlantic, and has only recently begun nesting in North America. The only known established breeding colony in North America is at Middle Lawn Island off the Burin Peninsula, Newfoundland, where less than 100 pairs breed (Cairns *et al.* 1989). Other nest sites in Newfoundland have not been confirmed. Most Manx Shearwater observed in North American waters are probably non-breeding sub-adults and post-breeding birds from European breeding colonies. Manx Shearwater winters in middle latitudes of the Atlantic Ocean. A total of 39 were observed on drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie *et al.* 2005). This represents <0.1 percent of all the birds recorded.

Manx Shearwater densities averaged <0.1 birds/km^2 per month from May to October during seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b in prep).

Hydrobatidae (Storm-Petrels)

Leach's and Wilson's (*Oceanites oceanicus*) Storm-Petrels feed on small crustaceans, various small invertebrates, and zooplankton. These storm-petrels usually feed while on the wing, picking small food items from the surface.

Leach's Storm-Petrel

Leach's Storm-Petrel is common in the Offshore Study Area between April and early November. Leach's Storm-Petrel breeds in the north Pacific and North Atlantic Oceans. It winters at the middle latitudes and south of the equator in both oceans. It is a very abundant breeder in eastern Newfoundland, with more than 4,000,000 pairs nesting on islands off the eastern Avalon Peninsula. The largest breeding colony in the world is at Baccalieu Island on the northeast Avalon Peninsula, where over 3.3 million pairs nest (Lock *et al.* 1994). They range far from breeding colonies to feed. Many non-breeding sub-adults remain at sea through the breeding season. An average of less than one Leach's Storm-Petrel per day was recorded from the drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie *et al.*

2005). That number is low compared to the numbers of Leach's Storm-Petrels seen from ships in the same area, and may have been a result of the tall height of observers off the water and the lack of persistent use of binoculars for scanning. Storm-Petrels are difficult to see because they are dark and fly very low over the water.

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 densities ranged from 0.1 to 1.1 birds/km^2 (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep).

Wilson's Storm-Petrel

Wilson's Storm-Petrel is scarce in the Offshore Study Area between June and September. The Wilson's Storm-Petrel breeds in the south Atlantic Ocean and Antarctic. In their non-breeding season (May to October), they migrate north to waters off southern Nova Scotia and Newfoundland. This species is uncommon in Newfoundland waters June to September (Brown 1986). During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 very few were detected (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep).

Sulidae (Gannets)

Northern Gannets (*Morus bassanus*) feed on cephalopods and small fish including capelin, mackerel, herring and Atlantic saury. They secure prey in spectacular fashion by plunging from a height of up to 30 m above the water and reaching depths of up to 10 m. They pop back to the surface within a few seconds of entering the water.

Northern Gannet is scarce in the Offshore Study Area between April and October, and generally absent from the Offshore Study Area outside that period. The Northern Gannet breeds in the North Atlantic from Canada to Iceland and the British Isles. The species winters at sea south of their breeding range but north of the equator. Approximately 12,000 pairs nest on three colonies in the eastern Newfoundland. Gannets are common near shore and scarce beyond 100 km from shore. The Offshore Project Area is farther off shore than the range of most Northern Gannets.

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 very few were detected (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep).

Phalaropodinae (Phalaropes)

Red-necked (*Phalaropus lobatus*) and Red (*Phalaropus fulicarius*) Phalaropes eat zooplankton at the surface of the water. They secure food by swimming and rapidly picking at the surface of the water. These phalarope species are scarce in the Offshore Study Area during the May to October period, and generally absent outside that period.

Both species breed in the Arctic and subarctic of North America and Eurasia. They winter at sea mostly in the Southern Hemisphere. They migrate and feed offshore, including Newfoundland offshore waters during spring and autumn migrations. The two phalaropes are often difficult to distinguish at sea. Red Phalarope usually outnumbers Red-necked Phalarope in Newfoundland waters (Brown 1986). Phalaropes seek out areas of upwelling and convergence where rich sources of zooplankton are found. They are locally numerous along the shelf edges off Newfoundland and Labrador.

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008 very few phalaropes were detected (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.).

Laridae (Skuas, Jaegers, Gulls and Terns)

Skuas and jaegers feed by chasing other species of birds until they either drop food or disgorge the contents of their stomachs. This method of securing food is called kleptoparasitism. The Long-tailed Jaeger (*Stercorarius longicaudus*), the smallest member of this group, also feeds on small invertebrates and fish that it catches by dipping to the surface of the water while remaining on the wing.

Great Skua and South Polar Skua

These two skua species occur in the Offshore Study Area during the May to October period; they are usually scarce during this period.

The Great Skua (*Stercorarius skua*) breeds in the North Hemisphere, in Iceland and northwestern Europe. The South Polar Skua (*Stercorarius maccormicki*) breeds in the Southern Hemisphere from November to March and migrates to the Northern Hemisphere where it is present May to October. Both species occur in Newfoundland waters from May to October. Identifying skuas to species is very difficult at sea. Skuas usually occur where other marine birds are numerous, particularly along shelf edges.

Skuas occurred in such low densities that they were infrequently recorded during systematic surveys on the Jeanne d'Arc Basin in 2005, 2006 and 2008 (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.).

Pomarine Jaeger, Parasitic Jaeger and Long-tailed Jaeger

These three jaeger species are scarce in the Offshore Study Area during the May to October period. All three species of jaeger nest in the subarctic and Arctic in North America and Eurasia. They winter at sea in the Pacific Ocean and Atlantic Ocean. Pomarine (*Stercorarius pomarinus*) and Parasitic (*Stercorarius parasiticus*) Jaegers winter mainly south of 35°N, and Long-tailed Jaegers winter mainly south of the equator. The three species of jaeger are relatively easy to identify in adult plumage but very difficult in sub-adult plumages. As a group, their habits are very similar. Adults migrate through Newfoundland waters in spring and fall, while sub-adults often migrate only part way to the breeding grounds and are often present in Newfoundland waters all summer. Like skuas, they are kleptoparasites, preying chiefly on Black-legged Kittiwakes and Arctic Terns. Densities of jaegers, like most predators, are relatively low. Peak numbers occur during migration in May and early June, and September to October.

All three jaeger species were observed in low densities during seismic monitoring programs in the Jeanne d'Arc Basin in 2005, 2006 and 2008 (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.).

Herring, Great Black-backed, Lesser Black-backed, Iceland, and Glaucous Gull

The predicted status in the Offshore Study Area for Herring Gull is scarce throughout the year; Great Black-backed Gull is uncommon from August to February and very scarce from March to July; Glaucous Gull (*Larus hyperboreus*) is scarce from late October to April; Iceland Gull (*Larus glaucoides*) is scarce from November to April; and Lesser Black-backed Gull (*Larus fuscus*) is considered very scarce from May to December.

Herring Gull breeds in northern North America, Europe and northeast Russia and winters in the southern part of its breeding range. The breeding range of the Great Black-backed Gull is restricted to areas surrounding the North Atlantic Ocean. It winters in coastal Canada and Europe. Iceland Gull breeds in northeast Canadian Arctic and Greenland and winters on open coastal waters south to the New England states. Glaucous Gull breeds in the subarctic and Arctic of North America, Greenland and Eurasia and winters within its breeding range and south of it. With the exception of the Great Black-backed Gull, these large gulls are generally rare to scarce far from shore on the Grand Banks.

On drill platforms on the northeast Grand Banks during 1999 to 2002, Great Black-backed Gull was common from September to February and nearly absent from March to August (Baillie *et al.* 2005). A similar pattern was observed by environmental observers on offshore installations on the Terra Nova oil field from 1999 to 2009 (Suncor, unpubl. data). Herring Gulls were present in consistent numbers throughout the year but in lower numbers than Great Black-backed Gulls. Results from seismic monitoring programs in Jeanne d'Arc Basin in 2005, 2006 and 2008 indicate that large gulls were most numerous from mid August to October (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.).

Black-legged Kittiwake

The predicted status of Black-legged Kittiwake in the Offshore Study Area is common from October to May and scarce from June to August and uncommon in September. The Black-legged Kittiwake has a circumpolar breeding range. In Canada, it breeds from the Arctic south to Nova Scotia, and it winters at sea in the northern Pacific Ocean and northern Atlantic Ocean. Black-legged Kittiwake is an abundant marine bird off the Newfoundland coast. Breeding colonies on the Avalon Peninsula and northeast coast of Newfoundland total approximately 77,400 pairs (Cairns *et al.* 1989). Many of the 4,000,000 pairs that breed in the North Atlantic Ocean spend some time off the east coast of Newfoundland (Brown 1986; Lock *et* *al.* 1994). Black-legged Kittiwake is present in all months of the year on the Grand Banks. Observations from the drill platforms on the northeast Grand Banks during 1999 to 2002 showed Black-legged Kittiwakes were present in October to May, but were most prevalent during November to December (Baillie *et al.* 2005). It was among the most numerous species observed by environmental observers on offshore installations on the Terra Nova oil field during the winter months (Suncor, unpubl. data).

During marine bird monitoring programs conducted between May and October, Black-legged Kittiwake was found to be most numerous in October (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.).

Arctic Tern

Arctic Tern is a scarce spring and autumn migrant in the Offshore Study Area, occurring between May and September. The Arctic Tern breeds in subarctic and Arctic regions of North America and Eurasia. In the western Atlantic, its breeding range includes Newfoundland and extends south to Nova Scotia. The Arctic Tern winters at sea in the Southern Hemisphere. Arctic Terns are migrants at sea through Newfoundland and Labrador waters in spring and autumn. Small numbers of Arctic Terns have been recorded during 2005, 2006 and 2008 seismic monitoring programs in Jeanne d'Arc Basin (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.).

Alcidae (Dovekie, Murres, Black Guillemot, Razorbill and Atlantic Puffin)

Alcids feed by diving and pursuing prey underwater. They eat fish, copepods, amphipods, cephalopods, molluscs, crustaceans and other invertebrates.

Dovekie

The predicted status in the Offshore Study Area is common from October to November and uncommon to common from December to May. Dovekies breed in the North Atlantic, primarily in Greenland and east Nova Zemlya, Jan Mayen and Franz Josef Land in northern Russia. This species winters at sea south to 35°N. The Dovekie is a very abundant bird, with a world population estimated at 30 million (Brown 1986). A large percentage of the Greenland breeding Dovekies winters in the western Atlantic, mainly off Newfoundland (Brown 1986). The low numbers of Dovekies observed from the drill platforms on the northeast Grand Banks 1999 to 2002 was attributed to the difficulty in seeing the small birds from the observation posts (Baillie *et al.* 2005).

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008, Dovekies were most numerous in May and October (Tables 9-6 to 9-8) (Lang 2007; Abgrall *et al.* 2008a, 2008b, in prep.). Dovekies were found to be fairly common during marine bird monitoring of Husky's 2005 seismic program (Abgrall *et al.* 2008a). Densities within the Study Area ranged from 1.0 to 9.9 birds per km^2 in areas where the majority of 10-minute counts were conducted. Dovekies were first observed on October 3, when 500 individuals were counted. This species was observed daily during October in numbers typically ranging from 100 to 300. Maximum daily totals from incidental sightings were 2,000 on October 13, 1,500 on October 28 and 2,500 on November 4 (Abgrall *et al.* 2008a, in prep.).

Common Murre

The predicted status for Common Murre in the Study Area is scarce to uncommon throughout the year. The Common Murre breeds in the north Pacific Ocean and North Atlantic Ocean. In the western Atlantic, it winters from southern Newfoundland to Massachusetts. It is an abundant breeder in eastern Newfoundland with nearly half a million pairs, with 80 percent of those on Funk Island (Table 9-5). During breeding season, the Offshore Study Area is probably too far from breeding sites to be used regularly for foraging. In the non-breeding season between August and March, Common Murres are likely to occur on the northern Grand Banks. Due to low density and high difficulty in detecting murres at sea, surveys generally underestimate their numbers.

Common Murre was seen in small numbers almost daily throughout the May to September 2008 seismic monitoring program in Jeanne d'Arc Basin except during the first half of August (Abgrall *et al.* in prep.). The first adult-chick pair was seen on August 29 and these pairs were common after September 13, with up to 75 individuals (adults and flightless chicks) per day. In October and November 2005, an average density of 0.81 birds/km^2 was observed for Common Murre in Jeanne d'Arc Basin (Abgrall *et al.* 2008a). Weekly densities derived from 10-minute Tasker counts peaked at 7.5 birds/km^2 in the third week of October.

Thick-billed Murre

The predicted status of Thick-billed Murre in the Offshore Study Area is uncommon to common from October to April and very scarce to scarce from May to September. Thick-billed Murres breed in subarctic and Arctic areas in North America and Eurasia. In Atlantic Canada, they breed as far south as Newfoundland, and winters in open water within the breeding range and in the western Atlantic south to New Jersey.

The Thick-billed Murre is the winter murre in eastern Newfoundland. Many of the more than 2,000,000 Arctic Canada and Greenland breeders winter in Newfoundland and Labrador waters. The Grand Banks has been identified as an important wintering area for Thick-billed Murres (Brown 1986; Lock *et al.* 1994). Relatively small numbers (approximately 2,000) breed in eastern Newfoundland (Table 9-5). It is likely that Jeanne d'Arc Basin is part of the main wintering area for Thick-billed Murres in eastern North America.

As expected, only small numbers of Thick-billed Murres were seen on Jeanne d'Arc Basin during the May to September 2008 seismic monitoring program; the birds were primarily seen during May and June (Abgrall *et al.* in prep.). An average density of 0.01 birds/km^2 was derived from quantitative counts over the course of the seismic monitoring program. The authors report that visible northward migration was apparent on May 7 and 21, 2008 (Abgrall *et al.* in prep.). Thick-billed Murre was observed almost daily during the October and

November 2005 seismic monitoring program in Jeanne d'Arc Basin (Table 9.6) (Abgrall *et al.* 2008a). The average density was 4.11 birds/km^2 with a peak density of 9.58 birds/km^2 observed during November 5 to 8 (Table 9.6).

Razorbill

The predicted status of Razorbill (*Alca torda*) in the Offshore Study Area is very scarce from April to November, and likely absent in other months. Razorbills breed in the North Atlantic Ocean in Maine, eastern Canada, Greenland, Iceland and Great Britain. They typically winter south to North Carolina and France. Razorbills are relatively scarce compared to the murres. Most of the 20,000 pairs of breeding in Atlantic Canada are in southeast Labrador (Brown 1986). Approximately 710 pairs breed in eastern Newfoundland (Table 9-5).

Razorbills, for the most part, winter south of Newfoundland from Nova Scotia to North Carolina. They are probably rare or uncommon on the northeastern Grand Banks as a migrant. Observations of Razorbills at sea are often obscured because of the difficulty in differentiating them from the murres.

Atlantic Puffin

The predicted status of Atlantic Puffins in the Offshore Study Area is scarce to uncommon from April to November. The Atlantic Puffin breeds in the North Atlantic in Maine, Nova Scotia, Newfoundland and Labrador, Greenland, Iceland and northwest Europe. Atlantic Puffins are abundant in the North Atlantic with approximately 12,000,000 pairs (Brown 1986). Approximately 320,000 pairs nest in Atlantic Canada, mostly in southeast Newfoundland (Brown 1986). In North America, Atlantic Puffins are thought to winter from southern Newfoundland to southern Nova Scotia.

The Offshore Study Area is probably east of the breeding sites used as foraging areas in the summer. Migrants and post-breeders may use the northern Grand Banks in late summer and early autumn. Only one was observed from the drill platforms on the northeast Grand Banks 1999 to 2002 (Baillie *et al.* 2005). This was at least partly due difficulty in detecting them at sea.

During the October to November 2005 seismic monitoring program in Jeanne d'Arc Basin, Atlantic Puffin was observed on 32 of the 39 days with survey effort, daily counts typically ranged from 20 to 50 individuals, and the average density was 1.46 birds/km^2 (Table 9-6) (Abgrall *et al.* 2008a). Relatively few Atlantic Puffins were reported during summer seismic monitoring programs in Jeanne d'Arc Basin (Tables 9-7 and 9-8) (Abgrall 2008a in prep.).

9.4 Project-Valued Ecosystem Component Interactions

Project activities with similar interactions on Marine Birds have been grouped into four categories to provide a complete and comprehensive environmental effect analysis. Instead of assessing each Project activity separately, the grouping of activities with similar potential effects on Marine Birds, allows for a cumulative assessment of within-Project activities.

The interactions summary categories are:

- Change in Habitat Quantity: Project activities that may result in physical alteration of habitat available to marine birds
- Change in Habitat Quality: Project activities that may result in a change in the biological or physical properties of marine bird habitat
- Change in Habitat Use: Project activities that may result in marine birds changing their behaviour. Some activities may cause avoidance behaviour in birds, whereas other activates may attract some species
- Potential Bird Mortality: Project activities that may result in marine bird mortality

9.4.1 Nearshore

9.4.1.1 Nearshore Project Activities

Nearshore Project activities have the potential to have effects on habitat quantity, habitat quality, and habitat use for marine birds. Bund wall construction can create a limited reduction in habitat quantity by obstructing use. Project emissions including noise and lights can result in reduced habitat quality. Activities with the greatest potential for disturbance (*i.e.*, change in habitat use) include pile driving (bund wall construction), blasting, vessel traffic and dredging. Lighting during periods of darkness may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or infrastructure leading to injury or strandings. Several activities (*e.g.*, blasting, dredging, pile driving and vessel traffic) may also lead to temporary disturbance of marine birds in a localized area. Mortality of marine birds is not expected to be an environmental effect of most routine activities in the Nearshore Study Area, except perhaps from collisions with vessels/infrastructure.

9.4.2 Offshore

9.4.2.1 Offshore Construction/Installation

Offshore construction/installation activities have the potential to result in effects on habitat use, and, to a lesser extent, habitat quality and habitat quantity (*e.g.*, placement of the Hebron Platform structure will obstruct use of a limited area of habitat). Activities with the greatest potential for disturbance (*e.g.*, effects on habitat use) include the operation of helicopters, the operation of vessels, seismic surveys and dredging activities. Lighting at night throughout the Project may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality. It is unknown if there is hearing impairment to marine birds spending considerable amounts of time below the surface of the water and in close proximity to airgun pulses during seismic surveys. Few of the species that occur in the Offshore Study Area spend considerable time below the surface of the water.

In addition, several activities may also lead to temporary disturbance of marine birds in a localized area. With the exception of collisions with infrastructure, mortality of marine birds is not expected to be an environmental effect of activities in the Offshore Study Area during the construction/installation phase.

9.4.2.2 Operations/Maintenance

Operations/maintenance activities have the potential to result in changes to habitat quality and habitat use. Interactions are summarized here:

- Lighting and flaring at night and periods of low visibility for the duration of the Project may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality
- The operation of helicopters, the operation of vessels, and seismic surveys have potential for disturbance
- The discharges of fluids or solids have the potential to foul the feathers of marine birds and possibly lead to ingestion of non-biological substances, which may lead to mortality
- Hearing impairment to marine birds spending considerable amounts of time below the surface of the water and in close proximity to airgun pulses during seismic surveys may be a possibility. However, as mentioned above, there is no evidence to support this

9.4.2.3 Decommissioning/Abandonment

Effects of Project decommissioning/abandonment activities have the potential to affect habitat use by marine birds, similarly to those effects experienced during the construction and operations phases. Lighting during darkness periods may attract marine birds, particularly the Leach's Storm-Petrel, which may strike vessels or platform infrastructure leading to injury, strandings, or mortality. In addition, the operation of helicopters and vessels may also lead to temporary disturbance of marine birds in a localized area.

9.4.2.4 Accidents, Malfunctions and Unplanned Events

The primary accidental event associated with the proposed Project having environmental consequences of concern is the unintentional release of hydrocarbons either during development drilling or production operations. The hydrocarbon products subject to accidental release include crude oil, diesel oil, synthetic drilling muds and/or fluids, synthetic drill (base) fluid, lubricating oils, and hydraulic oils. The main event of concern that can result in a hydrocarbon spill is a loss of well control (blowout). Hydrocarbon spills may also occur as a result of human error or equipment failure during loading/unloading, storage tank overflows, hydraulic system failures, drains system failures and others. An oil spill, although unlikely, could potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. Several accidents, malfunctions, and unplanned events could result in mortality for marine birds within the Affected Area (see Section 9.5.4).

Other effects include a change in habitat quality (*i.e.*, effects on habitat that could result in physical and/or physiological effects on marine birds).

9.4.3 Summary

A summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present, and likely future projects, and accidents, malfunctions and unplanned events is provided in Table 9-9.

Table 9-9 Potential Project-related Interactions on Marine Birds

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosquito Cove Zone followed by a Deepwater Zone)				
Bund Wall Construction (*e.g.*, sheetpile driving, infilling, *etc.*)	x		x	
Inwater Blasting		x	x	x
Dewater Drydock/Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passender ferry to/from deepwater site, *etc.*)			x	x
Lighting		x	x	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site			x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)			x	
Removal of Bund Wall and Disposal (dredging/ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site			x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)			x	
Platform Tow-out from deepwater site			x	
Offshore Construction/Installation				
Presence of Safety Zone				
OLS Installation and Testing			x	
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Installation of Temporary Moorings			x	
Platform Tow-out/Offshore Installation			x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location			x	
Hookup and commissioning of Platform			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels/barges/diving/ROVs)			x	x
Air Emissions		x		
Lighting		x	x	
Potential Future Activities				
Presence of Safety Zone				
Excavated Drill Centre Dredging and Spoils Disposal			x	
Installation of Pipeline(s)/Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation			x	
Hook-up, Production Testing and Commissioning of Excavated Drill Centres			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)			x	
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures			x	x
Lighting		x	x	
Maintenance Activities (*e.g.*, diving, ROV, *etc.*)			x	
Air Emissions		x		
Flaring		x	x	x
Wastewater (produced water, cooling water, storage displacement water, *etc.*)		x		x
Chemical Use/Management/Storage (*e.g.*, corrosion inhibitors, well treatment fluids, *etc.*)		x		
Well Activities (*e.g.*, well completions, workovers, *etc.*)			x	
WBM Cuttings		x		
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)			x	x
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	
Potential Future Operational Activities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Presence of Structures			x	x
WBM and SBM Cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors, *etc.*)		x		
Geophysical/Seismic Surveys		x	x	
Offshore Decommissioning/Abandonment				
Presence of Safety Zone				
Removal of the Hebron Platform and OLS Loading Points			x	
Lighting		x	x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels/ROVs)			x	x
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)		x	x	
Accidents, Malfunctions, and Unplanned Events				
Bund Wall Rupture		x	x	
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blowout		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials/debris on the drilling unit, GBS, Hebron Platform)		x	x	x
Marine Vessel Incident (*i.e.*, fuel spills)		x	x	x
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)	x	x	x	x
Terra Nova Development (production)	x	x	x	x
White Rose Oilfield Development and Expansions (drilling and production)	x	x	x	x
Offshore Exploration Drilling Activity	x	x	x	x
Offshore Exploration Seismic Activity			x	
Marine Transportation (nearshore and offshore)			x	x
Commercial Fisheries (nearshore and offshore)			x	x

9.5 Environmental Effects Analysis and Mitigation

There is limited information and few detailed studies regarding the effects of construction and offshore industrial activities on marine birds. However, noise and routine discharges have the greatest potential to affect the habitat quality of marine birds, while lighting, vessel traffic and helicopter overflights likely have the greatest potential to affect marine birds by changing habitat use. Blasting and flaring, as well as collisions with infrastructure, may also lead to mortality of marine birds and are discussed at the end of the review.

9.5.1 Construction and Installation

9.5.1.1 Change in Habitat Quantity

Nearshore

In the Nearshore Project Area, construction of the bund wall will result in a limited reduction of available habitat. However, it should be noted that this will represent a relatively small footprint within an area that has previously been disturbed during construction activities of other projects (*i.e.*, does not represent a loss of important marine bird habitat).

Offshore

The placement of the Hebron Platform at the offshore site location will result in minimal habitat loss for pelagic and migratory marine bird species. Given the relatively small footprint of the Hebron Platform within total available habitat and reversibility of the effect once the Platform is removed, this effect is not considered to be significant.

9.5.1.2 Change in Habitat Quality

Nearshore

Blasting

The key nearshore Project activity that could have an effect on habitat quality is inwater blasting. Underwater shock waves resulting from blasts in the Nearshore Study Area during construction activities have the potential to injure (or kill) marine birds that are nearby at the time of the blast. Most species of marine birds that occur off eastern Newfoundland spend little time below the water's surface and, thus, are unlikely to experience injury if they do not occur in very close proximity to the blast.

Stemp (1985) did not mention damage to birds on the water surface when 25 to 125 kg charges were detonated underwater. Marine birds hovering over the explosion sites, apparently attracted to floats, were often stunned by water blasted up into the air. Most recovered and flew away but a small number of these were killed. Blasts at the construction site will likely be sufficiently buried and small that there will be no upward blast of water into the air.

Yelverton *et al.* (1973) conducted controlled tests to quantify the effects of high explosives on ducks 0.6 m underwater (exposed to 0.45 kg charges at slant ranges of 7 to 33.5 m) and at the surface (exposed to 0.45 to 3.63 kg charges at ranges of 3 to 6.4 m). No deaths occurred at 11+ m for ducks exposed to detonations while underwater, but those just beyond the lethal zone (see Section 9.5.1.5) had extensive lung haemorrhage and liver and kidney damage. Those that were 25.3 to 33.5 m away had no eardrum ruptures or other detectable injuries. Ducks that survived the blasts showed no delayed mortality over a 14-day post-blast period. Ducks at the surface were less prone to blast damage. No deaths were observed at distances of 4.6 to 6.4 m from detonations. Based on the Yelverton *et al.* (1973) data, Yelverton (1981) estimated safe ranges for birds on the surface as 8 m, birds at 1 m below the surface as 119 m, and birds at 15 m depth as 262 m.

Most species of marine birds that occur off eastern Newfoundland spend little time below the water's surface and, thus, are unlikely to experience injury if they do not occur in very close proximity to the blast. However, some species of the family Alcidae are known to spend considerable time submerged during foraging. Of the alcids, most species primarily occur nearshore when attending nesting colonies; however, no known major nesting colonies of alcids occur within the Nearshore Study Area. The Black Guillemot is known to forage in nearshore areas throughout eastern Newfoundland and could potentially occur in the Nearshore Study Area. Attraction of birds to blasting operations due to the presence of fish killed during blasts is not expected since the blasting program will be designed to not kill fish (see Chapter 7). It is unlikely that fish will be killed by blasting during the construction activities.

An observer will be placed nearby the blasting site to monitor if diving marine birds occur within a Safety Zone of the blast location. Blasts may cause fish mortality which could attract diving and plunge feeding birds. Blasts should be delayed until birds move outside the designated Safety Zone. The designated Safety Zone will be determined in conjunction with the CWS.

Lighting

In Newfoundland waters, marine birds, mainly Leach's Storm-Petrels, are often attracted to lights at night and/or during darkness-like conditions (*e.g.*, foggy conditions), including coastal lighthouses and ships at sea. Birds may become injured by flying directly into the source of light or associated infrastructure. Alternatively, light-attracted Storm-Petrels may strike infrastructure (including vessels) and strand (or experience mortality). Storm-Petrels have short and weak legs that limit their ability to become airborne from solid, flat surfaces. Furthermore, Storm-Petrels will remain stranded until found and released; thus, without proper release, animals will remain stranded until they starve or die. Stranded marine birds also risk becoming oiled by landing or moving through catchment basins.

Foggy nights seem to attract more birds (Williams and Chardine 1999). Leach's Storm-Petrels breed in large numbers in eastern Newfoundland, with Baccalieu Island at the northeastern tip of Trinity Bay representing the largest breeding colony in the world. Lighting is potentially an issue during Project activities that provide continuous use of lights during darkness or periods of poor visibility.

ExxonMobil Canada Properties (EMCP) will develop protocols for regular searches of birds that may become stranded on all vessels and facilities. Recovered birds will be released in accordance with standard protocols (Williams and Chardine 1999; Husky Energy 2008). A marine bird salvage and release permit under the authority of the Federal Migratory Bird Permit must be applied for and obtained from the Canadian Wildlife Service.

Air Emissions

Although air emissions could, in theory, affect the health of some resident marine birds, the effects would likely be minimal because emissions of potentially harmful materials will be small and rapidly disperse to undetectable levels. Air emissions are expected to have a negligible effect on the habitat quality of the Marine Bird VEC.

Offshore

Seismic Surveys

The key potential future Project activity during construction in the offshore that is predicted to have an effect on habitat quality is seismic surveys. Birds have good hearing abilities in air (Fay 1988), but their hearing underwater is not well known. The hearing systems of marine birds are most likely best adapted for hearing in air, but likely have some sensitivity in water. Diving birds within a large but unknown radius of an underwater sound source could hear a sound pulse if the birds are underwater at the time the pulse arrives. Potentially, marine birds that are diving in close proximity to a loud underwater sound could be injured.

Seismic sound energy is predominantly directed downward and below the surface of the water. Received sound above the water is significantly reduced from that underwater and is likely to have little or no effect on birds that have their heads above water or are in flight. It is possible that birds on the water at close range would be startled by the sound, however, the presence of the ship and associated gear should have already warned any birds of unnatural visual and auditory stimuli. Received sound levels of airgun pulses in the upper few metres of the water column are also considerably diminished from those at depth due to pressure-release effects and interference phenomena that occur at and near the surface (Richardson *et al.* 1995).

Most species of marine birds that are expected to occur in the Offshore Study Area (see Table 9-4) feed at less than one metre from the surface of the ocean. This includes members of Procellariidae, Hydrobatidae, Phalaropodinae, and Laridae. Northern Gannet plunge dive to a depth of 10 m, but animals remain submerged for only a few seconds in total, so would have minimal chance to receive underwater seismic sound. The only group of marine birds that spends considerable time submerged underwater is the Alcidae (Dovekie, Common Murre, Thick-billed Murre, Razorbill, Black Guillemot (*Cepphus grylle*) and Atlantic Puffin). Alcids secure food by diving under the water and propelling their bodies rapidly through the water with their wings. All are capable of reaching considerable depths and spending prolonged periods of time submerged (Gaston and Jones 1998). Murres regularly dive to a maximum depth of 100 m and have been recorded underwater for up to 202 seconds (Gaston and Jones 1998).

The effects of seismic sounds on Alcidae are unknown. Sounds are probably not important to Alcidae in securing food. However, all six species are quite vocal at breeding sites indicating auditory capabilities are important in that part of the life cycle of Alcidae.

It is thought that the presence of an on-coming seismic vessel may potentially alert alcids (and other marine birds on the water), thereby flushing animals from the area (see assessment of the effect of seismic surveys on habitat use below) prior to being exposed to any airgun sounds or occurring in close proximity to operating airguns. Of the Alcidae found in the Offshore Study Area, the Dovekie is likely common in the fall, the Common Murre is uncommon from fall to spring, the Thick-billed Murre is likely uncommon from fall to spring, the Black Guillemot is scarce year-round, the Razorbill is scarce from Spring to late fall, and the Atlantic Puffin is likely uncommon from spring to late fall.

Seismic surveys should be planned, to the extent possible, to avoid periods of known concentration in the Offshore Study Area for members of the Alcidae. Thus, it is predicted that there is not likely to be a significant effect on habitat quality in the Offshore Study Area during construction/installation.

Lighting

As described previously in Nearshore, Habitat Quality, marine birds (particularly Leach's Storm-Petrels) and potentially some migrating land birds may be attracted to lights during periods of darkness or poor visibility. Attraction can cause birds to strike lights and associated infrastructure, potentially leading to injury, stranding, and mortality. Foggy nights seem to attract more birds, and Leach's Storm-Petrels are more common in the Offshore Study Area during late summer to early fall. Leach's Storm-Petrels have also been observed in densities ranging from 0.1 to 4.9 birds/km^2 during monitoring from May to September aboard seismic vessels operating in the Jeanne d'Arc Basin (Lang 2007; Abgrall *et al.* 2008a, 2008b, *in prep.*). Stranded Leach's Storm-Petrels have been recorded during monitoring aboard seismic vessels in the Jeanne d'Arc Basin each summer and/or fall period from 2005 to 2008; June and July/August have the lowest number of birds recovered (2 and 11, respectively) while a total of 130 birds have been recovered over a week-long period in late September and 107 birds have been recovered during a 10-day period in early October (Lang *et al.* 2006; Abgrall *et al.* 2008; Lang and Moulton 2008; Abgrall *et al. in prep.*). Young-of-the-year birds appear to be more susceptible to light attraction than are adults, but the extent of Storm-Petrel susceptibility is unclear.

Other marine bird species, as well as migrating land birds, are also known to be attracted to lights on offshore oil and gas platforms at night, especially during foggy or overcast conditions. Birds could potentially injure themselves by flying into structures on the platform (Avery *et al.* 1978). Some accounts also describe birds becoming disoriented and flying aimlessly about the lights for hours, consuming energy and being delayed in their foraging or migration.

EMCP will develop protocols for regular searches of birds that may become stranded on all vessels and facilities. Recovered birds will be released in accordance with standard protocols (Williams and Chardine 1999; Husky Energy 2008).

Air Emissions

Although air emissions could, in theory, affect the health of some resident marine birds, the effects would likely be minimal because emissions of potentially harmful materials will be small and rapidly disperse to undetectable levels. Air emissions are expected to have a negligible effect on the habitat quality of the Marine Bird VEC.

9.5.1.3 Change in Habitat Use

Nearshore

Temporary and localized disturbances are the most likely effects of Project construction activities on marine birds. In coastal regions, varying levels of human disturbance (from human presence to physical substrate disturbance and construction activities) are known to cause minor disturbance of several species. Such disturbance could have important environmental effects on birds if opportunities to forage or breed become limited as a result of the activities.

Burger *et al.* (2007) described the effects of human presence, cars or planes and dog presence on the average number of Herring Gulls, Laughing Gulls (*Leucophaeus atricilla*) and shorebirds that included Red Knot. The responses of gulls and shorebirds differed considerably, with gulls generally returning to pre-disturbance levels within 5 min of a disturbance. All shorebirds responded most strongly to the presence of dogs and did not return to the beach within the 10-min post-disturbance monitoring period. Red Knots also appeared to be more responsive to humans than to cars or planes, showing moderate signs of recovery to pre-disturbance within 30 sec of car or plane disturbance relative to periods greater than 10 min for human disturbance.

Burger (1988) monitored the abundance of shorebirds (species not provided) and Laughing Gulls and Herring Gulls during pre- and post-activities associated with demolition, beach clean-up and construction for development on a coastal mudflat in New Jersey. Activities included the use of chainsaws, humans picking up and/or piling debris from the mudflat and crane loading from the beach. The overall number of birds using the mudflat was higher during the period prior to coastal activities. Birds also moved away when activity began and returned when activity ceased. Gulls that moved farther out on the mudflat had measurably lower foraging efficiencies, and foraging efficiencies of gulls did not return to previous levels until 60 to 90 min after work began. Mitigation measures that restricted human activity to a 100 m stretch of beach at a time succeeded in significantly reducing adverse effects and in allowing birds to rest and feed.

It should be noted that the Nearshore Study Area does not contain important bird habitat and is already an area that has been subjected to disturbance from human activity. Nonetheless, Project activities that have the potential to result in behavioural disturbances, in turn resulting in potential changes in habitat use, are evaluated below.

Pile Driving

Pile driving involved in the construction of the bund wall, produces impulsive sound levels high enough to temporarily disturb marine birds occurring in close proximity at a localized scale. The environmental effects of pile driving on Marine Birds in the Nearshore Study Area are not well known, but these activities will occur in a small area that has been previously disturbed by construction activities associated with other projects. There are no known marine bird nesting colonies located within Bull Arm, Trinity Bay, nor are there any known concentrations of foraging marine birds that could potentially be affected by pile driving activities.

Blasting

Blasting operations may cause temporary and localized behavioural disturbance, potentially resulting in a change in habitat use. However, there are no specific sound levels for blasting activities that are linked with behavioural effects on marine birds. The environmental effects of blasting in the Nearshore Study Area are not well known, but these activities will occur in an area that has been previously disturbed by construction activities associated with other projects. There are no known marine bird nesting colonies located within Bull Arm, Trinity Bay, nor are there any known concentrations of foraging marine birds that could potentially be affected by blasting activities. Therefore any effects would most likely be on individuals that may occur in the area. Blasts that are closely spaced relative to the dive duration of birds could have greater impacts. Widely spaced blasts will likely result in no more than one pulse (if any) being received during a given dive. In general, birds may interrupt their foraging dives and return to the surface. It is possible that some might leave the area, but available evidence suggests that disturbance would be temporary. In contrast, some marine birds, such as gulls or other scavengers, may be attracted to blasting activities if fish are killed as a result of detonation (see Section 7). Blasting activities will be required to adhere to *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* (Wright and Hopky 1998). Monitoring of a Safety Zone, as described above, will also mitigate potential disturbance of Marine Birds.

Lighting

Lighting is an issue during Project activities that provide continuous use of lights during darkness periods in the Nearshore Study Area. Mitigation measures to address the impacts of lighting on marine birds were described previously in Section 9.5.1.2.

Vessel Traffic

Marine birds may be temporarily disturbed by passing vessels associated with Project activities, including construction and survey vessels. Some species are also attracted to vessels and follow them for extended periods. There is concern for vessels passing known concentrations of foraging or nesting marine birds, but no known concentrations are likely to occur within Bull Arm or Trinity Bay that potentially may be affected. Vessels of large size, which are fast-moving, or move with an erratic course, though unlikely to occur, are more likely to disturb birds. However, vessels operating within the Nearshore Study Area will typically be moving at slow speed or will remain stationary for extended periods, and will, therefore, be less likely to affect nearby marine birds. Whenever possible, vessels associated with the Project should maintain a steady course and speed. Concentrations of marine birds, if any occur, should be avoided.

Other Activities

Several other activities associated with the Construction Phase in the Nearshore Study Area may induce temporary and localized disturbance of marine birds (Table 9-9). However, no nesting or feeding concentrations of marine birds are expected to occur within the small areas associated with these activities, and bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

Offshore

Temporary and localized disturbances to marine birds in the Offshore Study Area may result in similar behavioural changes and affect bird habitat use. Project activities creating noise, such as vessel traffic, helicopter operations, and seismic surveys, and light emissions are most likely to potentially result in a change in habitat use.

Vessel Traffic

Marine birds may potentially be temporarily disturbed by passing vessels associated with Project activities. However, many bird species are known to have adapted to ship traffic throughout the world. Some species, such as Northern Fulmar and gulls, are attracted to ships and often follow them for extended periods (Wahl and Heinemann 1979; Brown 1986).

While vessels which pass in close proximity to bird colonies may create concern for disturbance, the routing of Project vessels will not take them within 2 km of any nesting marine bird colonies.

Operation of Helicopters

Most marine birds flush or dive in response to low-flying aircraft (*e.g.*, Polar Gas Project 1977; Husky Oil 2000; LGL Ltd. unpubl. data). The magnitude of these disturbances is likely low, given infrequent flights at low levels. Of greater concern are flights over large colonies of nesting marine birds. An aircraft flying low near a marine bird colony is capable of causing a panic response by the birds, which can result in eggs and flightless young being accidentally pushed off cliff ledges when the adults suddenly flush, or being unguarded and thus exposed to harsh weather and predators.

As with current regular helicopter servicing of offshore platforms in the Jeanne d'Arc Basin, helicopters used for the Project will likely be based at St. John's Airport and will generally fly "straight" to the Offshore Study Area. Helicopters will be directed to avoid the closest marine bird colonies (*e.g.*, Witless Bay Ecological Reserve) and any known concentrations. *The Wilderness and Ecological Reserves Act* states that no aircraft will fly lower than 300 m or take off or land within the reserve during the period 1 April to 1 September.

Seismic Surveys

Seismic surveys have the potential to affect the habitat quality of marine birds, particularly members of the Alcidae (described above), but seismic surveys also have the potential to disturb marine birds. The main environmental effect of seismic surveys on habitat use by marine birds is that of the operation of vessels, as described above. In general, limited information is available on the behavioural effects of seismic surveys on marine birds.

A study on the effects of underwater seismic surveys on moulting Long-tailed Ducks (*Clangula hyemalis*) in the Beaufort Sea showed no effects on movement or diving behaviour (Lacroix *et al.* 2003). The authors suggested caution in interpretation of these data, however, because they were limited in their ability to detect subtle disturbance effects and recommended studies on other species to fully understand the effects of seismic sounds.

Other Activities

Various other activities associated with the Construction Phase in the Offshore Study Area may induce temporary and localized disturbance of marine birds (refer to Table 9-9). These activities are not expected to occur near any known nesting colonies, so they should not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common during summer periods (particularly Greater Shearwater, Sooty Shearwater and Leach's Storm-Petrel), winter periods (particularly Black-legged Kittiwake and Thick-billed Murre), fall (particularly Dovekie), or year-round (particularly Northern Fulmar) in the Offshore Study Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

9.5.1.4 Potential Mortality

The only routine Project construction/installation activity that is predicted to potentially result in mortality of marine birds is blasting in the nearshore.

Marine birds occurring in close proximity to an explosion can be injured or killed. At a given distance, death is more likely for birds that are below the surface than for those at the surface. For birds at the surface, available information suggests that there is little or no risk of injury or death unless the birds are very close to the explosion. As noted above, most of the marine bird species occurring in the Nearshore Study Area spend very little time submerged; only members of the Alcidae are known to dive to considerable depth and spend substantial periods below water. However, most alcid species will occur farther offshore or near nesting colonies that do not occur within the Nearshore Study Area.

Fitch and Young (1948) described the effects of 73 kg high explosive charges on marine birds occurring nearby. Cormorants (Phalacrocoraciidae) that dove beneath the surface to feed on fish attracted to the blasts were killed consistently; distances of birds to the detonations were not reported. Pelicans were also frequently killed, but only when their heads were below water. A few gulls sustained broken wings when they were struck by a column of water rising into the air.

As evaluated above under effects on Habitat Use (Section 9.5.1.3), Yelverton *et al.* (1973) conducted controlled tests to quantify the effects of high explosives on ducks. Based on the Yelverton *et al.* (1973) data, Yelverton (1981) estimated safe ranges for birds on the surface as 8 m, birds at 1 m below the surface as 119 m, and birds at 15 m depth as 262 m.

Environment Canada cannot authorize by permit or exempt the inadvertent mortality ("incidental take") caused by construction (or other) activities of bird species protected by the *Migratory Birds Convention Act* (Environment Canada 2007). Instead, Environment Canada recommends that proponents adopt migratory bird protection measures and monitor for the presence of migratory birds based on scientifically credible methods before and during the period in which activities are carried out. An observer experienced in marine bird identification and behaviour will be placed nearby the blasting site to monitor if diving marine birds occur within a specified safety zone of the blast location. Blasts should be delayed until birds move outside the designated safety zone. The safety zone will be determined in consultation with the CWS.

The environmental effects of Project construction/installation activities on Marine Birds are summarized in Table 9-10.

Table 9-10 Environmental Effects Assessment: Construction and Installation

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (*e.g.*, sheet/pile driving, infilling, *etc.*)	• Change in Habitat Quantity • Change in Habitat Use	• Equipment design • Potential use of bubble curtains • Safety zone • monitoring	1	1	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* • Monitor appropriate safety zone for diving birds	1	2	2/1	R	2
Dewater Drydock/Prep Drydock Area	• Change in Habitat Use	• Discharge area and depth designed to reduce suspended sediment	1	1	2/1	R	2
Concrete Production (floating batch)	• Change in Habitat Use	• Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be directed to a settling basin • The settling basin will be cleaned on an as required basis to ensure that the retention capacity is maintained at all times	1	1	3/3	R	2
Vessel Traffic (*e.g.,* supply, tug support, tow, diving support, barge, *etc.*)	• Change in Habitat Use • Potential Mortality	• Maintain steady course and speed • Avoid concentrations of marine birds	1	2	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds per CWS protocol	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Use	• Restrict disturbance to mooring sites	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Use		1	1	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Removal of Bund Wall and Disposal (dredging/ocean disposal)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Monitor appropriate safety zone for diving and plunge-feeding birds	1	1	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (*e.g.*, geophysical, geological geotechnical, environmental, *etc.*)	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Use		1	1	3/6	R	2
Offshore Construction/Installation							
OLS Installation and Testing	• Change in Habitat Use		1	2	2/1	R	2
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines	• Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out/Offshore Installation	• Change in Habitat Use		1	1	2/6	R	2
Underbase Grouting	• Change in Habitat Use		1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Platform Location	• Change in Habitat Use		1	1	2/1	R	2
Hook-up and Commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes, where possible	1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels/barges/diving/ ROVs)	• Change in Habitat Use • Potential Mortality	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed • Avoid concentrations of marine birds	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	5	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Proper release of stranded birds	1	2	3/6	R	2
Potential Future Activities							
Excavated Drill Centre Dredging and Spoils Disposal	• Change in Habitat Use		1	1	2/1	R	2
Installation of Pipeline(s)/Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up, Production Testing and Commissioning of Excavated Drill Ccentres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, *etc.*)	• Change in Habitat Use		1	3	2/1	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Given that Project activities are mostly localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse effects on Marine Birds from construction or installation activities associated with the Project.

9.5.2 Operations and Maintenance

9.5.2.1 Change in Habitat Quantity

None of the Project activities in the Offshore Study Area during the Operations and Maintenance Phase are predicted to result in changes in habitat quantity for marine birds.

9.5.2.2 Change in Habitat Quality

Primary Project activities that could potentially result in changes in habitat quality for marine birds include lighting and flaring, operational discharges and seismic surveys.

Lighting

As described previously for lighting in the Offshore Study Area during the construction/installation phase (Section 9.5.1.2), lighting of infrastructure in the Offshore Study Area will likely attract marine birds (especially Leach's Storm-Petrels) during darkness and low visibility periods. Mitigation measures described in this section will also be applied during operation to limit the potential effects on marine birds.

Flaring

Night-migrating or night-active marine birds might be attracted by gas flaring in the Offshore Study Area, similar to the effect described for lighting (above). The Leach's Storm-Petrel is the species most likely to be affected, particularly on foggy nights in late summer to early fall. However, the heat and noise generated by the flare may deter marine birds from the immediate area under most night-time conditions. When attracted to the flare, marine birds may strike infrastructure and become injured or stranded.

As in the case of lighting (described above), EMCP will develop protocols for regular searches of birds that may become stranded on all vessels and facilities. Recovered birds will be released in accordance with standard protocols (Williams and Chardine 1999; Husky Energy 2008). Stranded bird reports will be provided to the CWS.

Operational Discharges

Activities that involve the storage and discharge of fluids and solids that occur during the operations and maintenance phase in the Offshore Study Area have the potential to foul marine birds. Fouling the feathers of marine birds may affect their ability to fly and possibly lead to ingestion of toxic substances. The discharge of some fluids like water-based muds and cuttings could potentially leave a sheen on the water surface, although this effect will be mitigated by discharge at depth and is unlikely to occur. The discharge of any blowout preventer fluid is likely to have minimal environmental effects on marine birds because low-toxicity glycol-water mixes will be used; these fluids are also typically released on a periodic basis near the seafloor. Produced water has the potential to affect birds if sheening occurs on the sea. This effect is considered below in Section 9.5.4.2. Sanitary waste and wastewater generated by the platform and support vessels will be macerated before subsurface discharge. Cooling water will be chlorinated and discharged overboard at an approximate temperature of 30°C, with a residual chlorine level <0.5 ppm. Thus, the volume of entrainment will be low and the area of thermal effects will be small.

Some marine birds, such as the Leach's Storm-Petrel, are known to feed on naturally-produced oily slicks on the water of biological origin and could possibly be attracted to a slick. However, Leach's Storm-Petrels do not spend much time on the water and would remain on the wing during an investigation of a slick, reducing the chances that feathers will contact the fluid. Some species such as shearwaters, Northern Fulmars and gulls may be attracted to vessels and the platform (discussed below in Presence of Structures); these birds may rest on the water, making them more likely to come in contact with discharges. Some marine birds, particularly gulls, may be attracted to sewage particles, but the small amount discharged below the surface is unlikely to increase the abundance of marine birds in the Offshore Study Area.

To minimize the possibility of fouling marine bird feathers, fluids will be discharged below the water's surface whenever possible. It is predicted that the residual environmental effect of fluid/solid storage or discharge on the habitat quality of marine birds in the Offshore Study Area will affect a limited area and be of low magnitude.

Seismic Surveys

As described above for seismic surveys in the Offshore Study Area during the construction/installation phase, most species of marine birds that are expected to occur in the Offshore Study Area have limited potential to be exposed to underwater sounds produced by airguns during seismic surveys. These species are not expected to experience any hearing impairment as a result of seismic surveys. However, members of the family Alcidae forage under the water's surface to maximum depths of 100 m for up to 202 seconds. It is possible that alcids may experience an unknown level of hearing impairment if exposed at a close proximity to underwater airgun pulses. The environmental effects of seismic sounds on alcids are completely unknown. It is thought that the presence of an on-coming seismic vessel may potentially alert alcids (and other marine birds on the water), thereby flushing animals from the area (see Section 9.5.2.3) prior to being exposed to any airgun sounds or occurring in close proximity to operating airguns. Seismic surveys should be planned, to the extent possible, to avoid periods of known concentration in the Offshore Study Area for members of the Alcidae.

9.5.2.3 Change in Habitat Use

Potential changes in habitat use during Hebron Project operations relate primarily to the presence of the structures (and associated lighting), vessel and helicopter traffic, seismic surveys, and other activities that generate noise/ light that could potentially induce temporary and localized disturbance of marine birds.

The physical structure of the platform and support vessels could affect marine birds by attracting them. Additionally, it is possible that the artificial reef affected, created by stationary structures will affect marine bird prey. Shearwaters, Northern Fulmars, and gulls are the species most likely to be attracted to the platform and may rest on the water nearby.

Effects and mitigation associated with lighting, vessel traffic, helicopter traffic, and seismic surveys have been discussed under the construction/installation phase (Section 9.5.1.3) and are applicable to the operations and maintenance phase.

Various other activities associated (*e.g.*, lighting, flaring) with the operations and maintenance phase in the Offshore Study Area may induce temporary and localized disturbance of marine birds. These activities are not expected to occur near any known nesting colonies, so will not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common during summer periods (particularly Greater Shearwater, Sooty Shearwater and Leach's Storm-Petrel), winter periods (particularly Black-legged Kittiwake and Thick-billed Murre), fall (particularly Dovekie), or year-round (particularly Northern Fulmar) in the Offshore Study Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

9.5.2.4 Potential Mortality

It is possible that marine birds attracted by gas flaring at night might become incinerated, collide with platform structures, or strand on the platform, thereby causing mortality (Russell 2005; Montevecchi 2006). However the heat and noise generated by the flare may deter marine birds from the immediate area under most night-time conditions. As described above, the Leach's Storm-Petrel is the most likely marine bird species to be affected, particularly on foggy nights in late summer to early fall (Williams and Chardine 1999). There is currently no known mitigation for this potential effect, but flaring is expected to have minimal impact on marine birds over the duration of the Project.

Although free oil is usually removed from produced water before discharge, oil sheens are sometimes associated with produced water discharges (*e.g.*, ERIN Consulting Ltd. and OCL Services Ltd. 2003). These sheens are thought to be derived from the dispersed oil or soluble medium- to high-molecular weight hydrocarbons components of produced water (Veil *et al.* 2004). Data on the relationship between sheen thickness and lethality to marine birds are lacking (Hartung 1995). The geographic extent of produced water is usually thought to be 1 km^2 or less (Fraser *et al.* 2006). Fraser *et al.* (2006) modelled the potential effect of produced water on the Grand Banks on alcids. They used published estimates of alcid density and also assumed a daily occurrence of sheens (210 days) and that any contact between birds and sheens causes mortality—these assumptions are considered a worst case scenario. Their modelling suggests a potential negative impact ranging in magnitude from low to high within 1 km^2. The Environmental Studies Research Find (ESRF) has commissioned a study on the effects of sheens on marine birds that has not yet been published. See Section 9.5.4 for a more detailed discussion of the effects of oil exposure on marine birds.

The environmental effects of Project operation/maintenance activities on Marine Birds are summarized in Table 9-11.

Table 9-11 Environmental Effects Assessment: Operations and Maintenance

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Presence of Structures	• Change in Habitat Use • Potential Mortality		1	1	5/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	2	5/6	R	2
Maintenance Activities (*e.g.,* diving, ROV, *etc.*)	• Change in Habitat Use	• Use of best practices	1	1	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Flaring	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality		1	1	5/6	R	2
Wastewater (Produced water, storage displacement water, *etc.*)	• Change in Habitat Quality • Potential Mortality	• Subsurface discharge	1	2	5/6	R	2
Chemical Use/Management /Storage (*e.g.*, corrosion inhibitors, well treatment fluids, *etc.*)	• Change in Habitat Quality		1	1	5/6	R	2
Well Activities (well completions, workovers, *etc.*)	• Change in Habitat Use		1	1	5/2	R	2
WBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes where possible	1	4	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels/shuttle tankers/barges/ROVs)	• Change in Habitat Use • Potential Mortality	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course & speed • Avoid concentrations of marine birds	1	4	5/6	R	2
Surveys (*e.g.*, geophysical, 2D/3D/4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Maintain steady course & speed • Avoid concentrations of marine birds	1	3	3/2	R	2
Potential Future Operational Activities							
Drilling operations from MODU at Future Excavated Drill Centres	• Change in Habitat Use		1	1	3/6	R	2
Presence of Structures	• Change in Habitat Use • Potential Mortality		1	1	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrosion inhibitors, *etc.*)	• Change in Habitat Quality		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	2	5/6	R	2
Geophysical/Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use	• Plan surveys to avoid concentrations of members of Alcidae	1	3	3/2	R	2

KEY

Magnitude:

N = Negligible: There may be some environmental effect but it is not considered to be measurable

1 = Low: <10 percent of the population or habitat in the Study Area will be affected

2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected

3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Given that project activities are mostly localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse effects on Marine Birds from the operation and maintenance activities associated with the Project.

9.5.3 Offshore Decommissioning and Abandonment

None of the Project activities in the Offshore Study Area during the decommissioning and abandonment phase are predicted to result in changes in habitat quantity, or mortality for marine birds. Lighting and surveys may affect habitat quality as discussed previously during the construction and operations phases. Changes in habitat use are described below.

Activities associated with the removal of the Hebron Platform and offshore loading system (OLS) loading points may induce temporary and localized disturbance of marine birds. These activities are not expected to occur near any known nesting colonies, so will not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common in the Offshore Study Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

Effects and mitigation associated with lighting, vessel traffic, helicopter traffic and surveys, have been discussed under the construction (Section 9.5.1.3) and are applicable to the decommissioning/abandonment phase.

The potential effects of decommissioning activities are expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

The environmental effects of Project decommissioning/abandonment activities on Marine Birds are summarized in Table 9-12.

9.5.4 Accidents, Malfunctions and Unplanned Events

Marine birds are the marine biota most at risk from oil spills. Shorebirds (plovers Charadriidae, and sandpipers Scolopacidae), sea ducks and other coastal water birds (*e.g.*, loons (Gaviidae), grebes (Podicipedidae) and cormorants) are also at risk, as they use the marine environment to varying degrees. Reported effects vary with species, type of oil, weather conditions, time of year, and duration of the spill (Gorsline *et al.* 1981). Natural inter-annual variation in other factors that affect populations (*e.g.*, prey availability and weather) reduces the ability of scientists to assess the full effect of oil spills on bird populations (Eppley 1992; White *et al.* 1995; Votier *et al.* 2005).

9.5.4.1 Change in Habitat Quality

Nearshore

Hydrocarbon spills or collisions resulting in hydrocarbon spills may affect habitat quality as described for the Offshore Study Area below.

Table 9-12 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Removal of the Hebron Platform and OLS Loading Points	• Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies • Avoid flying at low altitudes where possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels/ROVs)	• Change in Habitat Use • Potential Mortality	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course & speed • Avoid concentrations of marine birds	1	3	3/6	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving, *etc.*)	• Change in Habitat Quality • Change in Habitat Use	• Maintain steady course & speed • Avoid concentrations of marine birds	1	2	3/2	R	2

KEY

Magnitude:

N = Negligible: There may be some environmental effect but it is not considered to be measurable

1 = Low: <10 percent of the population or habitat in the Study Area will be affected

2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected

3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Offshore

It is possible that bird exposed to oil in the Offshore Study Area may return to nesting sites. Nesting marine birds that have survived oil contamination generally exhibit decreased reproductive success. Nesting marine birds transfer oil from their plumage and feet to their eggs (Albers and Szaro 1978). Very small quantities (1 to 20 μL) of oil on eggs have produced developmental defects and mortality in avian embryos of many species (Albers 1977; Albers and Szaro 1978; Hoffmann 1978, 1979a; Macko and King 1980; Parnell *et al.* 1984; Harfenist *et al.* 1990). The resultant hatching and fledging success of young appears to be related to the type of oil (Hoffman 1979b; Albers and Gay 1982; Stubblefield *et al.* 1995) and the timing of exposure during incubation. Embryos are most sensitive to oil during the first half of incubation (Albers 1978; Leighton *et al.* 1985). Breeding birds that ingest oil generally exhibit a decrease in fertilization (Holmes *et al.* 1978), egg laying and hatching (Hartung 1965; Ainley *et al.* 1981), chick growth (Szaro *et al.* 1978), and survival (Vangilder and Peterle 1980; Trivelpiece *et al.* 1984), as well as a reduction in mean eggshell thickness and strength (Stubblefield *et al.* 1995). Growth was retarded in Herring Gull chicks, Black Guillemot chicks, and Mallard (*Anas platyrhynchos*) ducklings after they ingested oil directly (Peakall *et al.* 1981; Szaro *et al.* 1981).

Oil spills that affect prey availability of a species with low seasonal dietary variation could have a greater effect on that species through an indirect reduction in reproduction and poorer chick condition (Velando *et al.* 2005). Eppley and Rubega (1990) suggested that exposure to an Antarctic oil spill causes changes in the normal parental behaviour of South Polar Skua, thus exposing young to increased predation and contributing to reproductive failure in that population. In another case, abandonment of nesting burrows by oiled adult Leach's Storm-Petrels may contribute to reproductive failure in that population (Butler *et al.* 1988). Therefore, a spill that occurs during the reproductive period could cause mortality of young even if the adults survived the exposure to oil.

Other sublethal effects of oil contamination include reduced feeding rates (Sanderling (*Calidris alba*); Burger and Tsipoura 1998).

9.5.4.2 Change in Habitat Use

Nearshore

Hydrocarbon spills or collisions resulting in hydrocarbon spills will affect habitat use as described for the Offshore Study Area below. A rupture in the bund wall may result in increased sedimentation in the water column. After sediment released by a bund wall rupture settles out of the water column, siltation of fish habitat and benthos may result in lower numbers of prey available to marine birds. Marine birds will learn to avoid silted areas because of low prey densities until benthic fish habitat recovers.

Offshore

There are possible changes in habitat use of oiled areas by both oiled and un-oiled birds. After a large oil spill off the coast of Washington by the *Nestucca* in December 1988, a study of oiled shorebirds suggested that within 10 days of the oil spill they could be found at beach roosting sites, but that after 10 days they tended to remain in the harbour rather than complete their usual return flight to beach roosting sites at high tide (Larsen and Richardson 1990). In June 1979, an oil spill occurred from the *Ixtoc I* off Texas, causing shorebirds there to avoid oil-affected foreshores and instead use poorer backshore feeding habitats and freshwater pools (Chapman 1981). Three months after the oil spill, storms cleaned the beaches, but shorebirds failed to return to the foreshore feeding habitats at their pre-spill levels (Chapman 1981).

The greatest decrease in use of contaminated habitats immediately following a spill occurs in species that feed on or close to shore and that either breed along the coast or are full-year residents (Wiens *et al.* 1996). Day *et al.* (1995) showed that species lacking clear evidence of recovery tended to be intertidal feeders and residents. However, they also found that other ecologically similar species did not show signs of initial impact or showed rapid recovery.

9.5.4.3 Potential Mortality

Nearshore

Hydrocarbon spills or collisions resulting in hydrocarbon spills can cause mortality as described for the Offshore Study Area below. The spill modelling suggests that there is little chance of a spill spreading beyond Bull Arm to affect marine bird concentration areas such as Bellevue Beach or nesting colonies outside the Nearshore Study Area (*e.g.*, off the Bonavista and Bay de Verde Peninsulas).

Offshore

Exposure to oil causes thermal and buoyancy deficiencies that typically lead to the deaths of affected marine birds. Although some may survive these immediate effects, long-term physiological changes may eventually result in death (Ainley *et al.* 1981; Williams 1985; Frink and White 1990; Fry 1990). Reported effects vary with bird species, type of oil (Gorsline *et al.* 1981), weather conditions, time of year, and duration of the spill or blowout. Although oil spills at sea have the potential to kill tens of thousands of marine birds (Clark 1984; Piatt *et al.* 1990), some studies suggest that even very large spills may not have long-term effects on marine bird populations (Clark 1984; Wiens 1995).

External exposure to oil occurs when flying birds land in oil slicks, diving birds surface from beneath oil slicks, and swimming birds swim into slicks. The external exposure results in matting of the feathers, which effectively destroys the thermal insulation and buoyancy provided by the air trapped by the feathers. Consequently, oiled birds may suffer from hypothermia and/or drown (Clark 1984; Hartung 1995). Birds living in coldwater environments, such as the Study Area, are most likely to succumb to hypothermia (Hartung 1995). Most mortalities occur during the initial phase of oil spills when large numbers of birds are exposed to floating oil (Hartung 1995).

Oil spills at sea have the potential to kill tens of thousands of birds (Clark 1984; Piatt *et al.* 1990). However, it is difficult to estimate how many marine birds are oiled during any particular oil-spill, because some birds may not reach shore (dead or alive), and beached carcasses may be scavenged or washed out to sea before being counted (Ford *et al.* 1987). There is also no clear correlation between the size of an oil spill and numbers of marine birds killed, because the density of birds in a spill area, wind velocity and direction, wave action, and distance to shore can have a greater bearing on mortality than the size of the spill (Burger 1993). Accordingly, even small spills can cause cumulative mass mortality of marine birds (Joensen 1972; Carter *et al.* 2003; Hampton *et al.* 2003). In contrast, relatively low mortalities have been recorded from some huge spills. For example, the *Amoco Cadiz* spilled 230,000 tonnes of crude oil along the French coast, causing the recorded deaths of 4,572 birds (Clark 1984). A major spill that persists for several days near a nesting colony could kill a high proportion of pursuit-diving birds (*e.g.*, murres) within the colony (Cairns and Elliot 1987).

Oiled birds that escape death from hypothermia and/or drowning often seek refuge ashore, where they engage in abnormally excessive preening in an attempt to remove the oil (Hunt 1957, in Hartung 1995). The preening leads to the ingestion of significant quantities of oil that, although apparently only partially absorbed (McEwan and Whitehead 1980), can cause lethal effects. Noted effects on Common Murres and Thick-billed Murres oiled off Newfoundland's south coast include emaciation, renal tubular degeneration, necrosis of the duodenum and liver, anemia, and electrolytic imbalance (Khan and Ryan 1991). Glaucous-winged Gulls (*Larus glaucescens*) experienced similar effects after they ingested bunker fuel oil during preening (Hughes *et al.* 1990).

Another commonly observed effect is adrenal hypertrophy. This condition tends to make birds more vulnerable to adrenocortical exhaustion (*e.g.*, Mallards (Hartung and Hunt 1966; Holmes *et al.* 1979), Black Guillemots (Peakall *et al.* 1980), and Herring Gulls (Peakall *et al.* 1982)). The adrenal gland maintains water and electrolyte balance that is essential for the survival of birds living in the marine environment. Hartung and Hunt (1966) found that ingested oils can cause lipid pneumonia, gastrointestinal irritation, and fatty livers in several species of ducks. Aromatic hydrocarbons have been detected in the brains of Mallards (Lawler *et al.* 1978) and are probably associated with observed symptoms (*e.g.*, lack of coordination, ataxia, tremors and constricted pupils) of nervous disorders (Hartung and Hunt 1966). Polycyclic aromatic hydrocarbons (PAH) can also be detected in plasma samples of oiled Common Murres (Troisi and Borjesson 2005). The availability of an immunoassay for the determination of PAH concentrations in plasma samples of oiled birds potentially can serve in the exposure assessment during oil spill response and rehabilitation (Troisi and Borjesson 2005).

Other toxicological effects, however, do not appear to differ between oiled and unoiled birds (Kammerer *et al.* 2004; Pérez-López *et al.* 2006). Levels of zinc, copper, arsenic, chromium, lead, and cadmium were all similar in the liver of three species (Common Murre, Atlantic Puffin, and Razorbill Murre) affected by the *Prestige* oil spill of September 2002 on the northwest Spanish Galician coast; only mercury showed increased levels in the liver of oiled birds (Pérez-López *et al.* 2006). Vanadium hepatic and renal concentrations did not prove to be appropriate biomarkers for recent exposure to oil spills following analyses of samples from Common Murres, Black Scoters (*Melanitta nigra*), and Common Eiders exposed to the *Erika* wreck off coastal France (Kammerer *et al.* 2004).

Birds exposed to oil are also at risk of starvation (Hartung 1995). For example, oiled Common Eiders generally deplete all of their fat reserves and much of their muscle protein (Gorman and Milne 1970). In addition, energy demands are higher because the metabolic rate of oiled birds increases to compensate for the heat loss caused by the reduced insulating capacity of their plumage. This can expedite starvation (Hartung 1967; McEwan and Koelink 1973). For birds living under harsh environmental conditions (*e.g.*, winters in colder climates), even a seemingly insignificant amount of oiling can have fatal consequences (Levy 1980).

Oiled birds that are cleaned and released might not have high survival rates. Pooling across the three species with the most band recovery data between 1969 and 1994 (Western Grebe (*Aechmophorus occidentalis*), White-winged Scoter (*Melanitta fusca*) and Common Murre), the median days that cleaned birds survived were 4 to 11 days, or a mean of four days (Sharp 1996). Birds that survived longer were those that typically had a low degree of oiling and spent less time in captivity; initial or release weights did not seem to matter (Sharp 1996). Birds cleaned after 1990 using more modern methods do not have a higher survival rate than those cleaned before 1990 (Sharp 1996).

Birds are particularly vulnerable to oil spills during nesting, moulting, and the period of time before young marine birds gain the ability to fly. Because newly fledged murres and Northern Gannets are unable to fly for the first two to three weeks at sea, they are less likely to be able to avoid contact with oil during that time (Lock *et al.* 1994). Before and during moult, the risks of hypothermia and drowning are increased (Erasmus and Wessels 1985), because feather wear and loss reduce the ability to repel water by about 50 percent (Stephenson 1997).

It is clear that truly aquatic and marine species of birds are most vulnerable and most often affected by exposure to marine oil spills. Diving species such as Black Guillemot, murres, Atlantic Puffin, Dovekie, eiders, Long-tailed Duck, scoters, Red-breasted Merganser (*Mergus serrator*), and loons are considered to be the most susceptible to the immediate effects of surface slicks (Leighton *et al.* 1985; Chardine 1995; Wiese and Ryan 1999; Irons *et al.* 2000). Alcids, especially Common and Thick-billed Murres, often have the highest oiling rate of marine birds recovered from beaches along the south and east coasts of the Avalon Peninsula, Newfoundland (Wiese and Ryan 2003). Those were the only group of marine birds to show an annual increase over a 13-year period (2.7 percent) in the proportion of oiled to stranded birds (Wiese and Ryan 1999). There also appears to be a strong seasonal effect, as significantly higher proportions of alcids (along with other marine bird groups) are oiled in winter versus summer (Wiese and Ryan 1999).

Other species such as Northern Fulmar, shearwaters, storm-petrels, gulls, and terns are vulnerable to contact with oil because they feed over wide areas and make frequent contact with the water's surface. They are also vulnerable to the disturbance and habitat damage associated with oil spill cleanup (Lock *et al.* 1994).

Shorebirds may be more affected by oil spills than has been suggested by carcass counts. A total of 7,800 collected bird carcasses were identified after the *Nestucca* oil spill off Washington state in 1988, but only six shorebird carcasses were present out of 3574 oiled shorebirds observed by Larsen and Richardson (1990). The authors suggested that this reveals a historic difficulty in finding shorebird carcasses, which may be explained by the higher mobility of oiled shorebirds (Larsen and Richardson 1990).

It appears that direct, long-term sublethal toxic effects on marine birds are unlikely (Hartung 1995). The extent of bioaccumulation of the chemical components of oil in birds is limited because vertebrate species are capable of metabolizing them at rates that minimize bioaccumulation (Neff 1985, in Hartung 1995). Birds generally excrete much of the hydrocarbons within a short time period (McEwan and Whitehead 1980).

Some studies have suggested that oil pollution is unlikely to have major long-term effects on bird productivity or population dynamics (Clark 1984; Butler *et al.* 1988; Boersma *et al.* 1995; Erikson 1995; Stubblefield *et al.* 1995; White *et al.* 1995; Wiens 1995, 1996; Seiser *et al.* 2000) while others suggest the opposite (Piatt *et al.* 1990; Walton *et al.* 1997; Votier *et al.* 2005). Natural inter-annual variation in other factors that affect populations (*e.g.*, prey availability and weather) reduces the ability of scientists to assess the full effect of oil spills on bird populations (Eppley 1992; White *et al.* 1995; Votier *et al.* 2005).

Studies conducted following the *Exxon Valdez* oil spill in 1989 have tried to ascertain whether marine bird populations have recovered in the Prince William Sound area in Alaska. Esler *et al.* (2002) noted that as of 1998, the Harlequin Duck (*Histrionicus histrionicus*) population that winters in Prince William Sound has not yet recovered, based on initial high mortalities, the decrease in population size only in oiled areas during 1995 to 1997, and the fact that fewer female adults survived winters in oiled areas possibly because of continued oil exposure through at least 1998 (likely still from the *Exxon Valdez* spill). For other populations, it is not as clear whether they have or have not yet recovered. Irons *et al.* (2000) conducted a study of marine bird densities and found that as of 1998, five taxa (mostly those that dive for their food) were still negatively affected by the oil spill, including cormorants, goldeneyes (*Bucephala* spp.), mergansers, Pigeon Guillemot (*Cepphus columba*), and murres. Furthermore, as of July 2000, goldeneyes, mergansers (*Mergus* spp.), Pigeon Guillemot, and Black-legged Kittiwake had decreased significantly in oiled areas, and only one species, the Black Oystercatcher (*Haematopus bachmani*), had shown signs of recovery (Irons *et al.* 2001). Wiens *et al.* (2001) disagreed with the study design and interpretation of data by Irons *et al.* (2000), maintaining that most populations are no longer affected by the oil spill. However, Esler *et al.* (2002) pointed out that the studies that have found rapid recovery of bird populations are either based on presence/absence data (Wiens *et al.* 1996), which are not informative about the status of populations, on a short time period and inappropriate geographic scale for some species (Day *et al.* 1997), or on summer data (Murphy *et al.* 1997) when some populations mainly overwinter in Prince William Sound. All authors do agree; however, that bird populations responded differently to the *Exxon Valdez* oil spill. Some populations showed little signs of being affected, other populations recovered quickly, and some populations took as much as a decade to fully recover (*e.g.*, Pigeon Guillemot; Golet *et al.* 2002, in Esler *et al.* 2002). Populations of bird species with little genetic differentiation among breeding colonies are less likely to be affected severely by an oil spill because they have a greater potential for population recovery through dispersal (Riffaut *et al.* 2005).

Several oil spills have occurred in or near the Study Area, and "small" oil releases (most likely from bilge pumping and de-ballasting by trans-Atlantic vessel traffic) occur frequently, killing thousands of marine birds (Brown *et al.* 1973, Anon. 1990, Chardine and Pelly 1994, Wiese and Ryan 2003). These illegal discharges total more metric tons of oil on a world-wide basis than the total spillage from more well-known catastrophic spills, such as the *Exxon Valdez* and others (Brander-Smith *et al.* 1990, in Wiese and Ryan 2003). Between 1984 and 1999, the southeast coast of Newfoundland had the highest recorded rates in the world of oiled dead birds per kilometre of beach (0.77 versus 0.02 to 0.33 elsewhere; Wiese and Ryan 2003).

In February 1970, the *Irving Whale* spilled between 11,356 to 26,497 L (3,000 and 7,000 gallons) of Bunker C oil near St. Pierre and Miquelon, which subsequently spread along Newfoundland's southeast coast. It was estimated that 7,000 birds, primarily Common Eiders, were killed (Brown *et al.* 1973). During the same month, the *Arrow* ran aground in Chedabucto Bay, Nova Scotia. Approximately 9,463,265 L (2,500,000 gallons) of Bunker C fuel oil were spilled, and at least 2,300 birds were killed in the bay itself (Brown *et al.* 1973). Primarily diving birds were affected, most notably Long-tailed Duck, Red-breasted Merganser, murres, Dovekie, and grebes (Brown *et al.* 1973). The spill spread offshore to Sable Island where mostly murres, Dovekie, and Northern Fulmar were killed. The lowest estimate of marine bird mortality from that part of the slick was 4,800 birds (Brown *et al.* 1973). In November 2004, a spill of crude oil occurred from the FPSO on the *Terra Nova* oil field. Based on the total area of the spill and on marine bird densities derived from marine bird surveys conducted in the spill area after the release, CWS has estimated that mortality to marine birds in the area may have been in the order of 10,000 (Wilhelm *et al.* 2007). This estimate depends on a number of assumptions including: the marine bird surveys conducted seven and eight days following the incident were representative, the proportion of those birds flying during those surveys that made contact with the oil is known, and that the oil covered the entire surface area within the slick's perimeter. In fact, the high sea state during and after the spill resulted in areas of slick-free water within the slick (Wilhelm *et al.* 2007). Using a different method, a Memorial University scientist arrived at a mortality estimate for the Terra Nova spill which was of similar order of magnitude as the CWS estimate. He did this by inserting the *Terra Nova* spill volume into Burger's (1993) regression of mortality estimates on spill volumes, which was derived from historical spills occurring in a wide range of locations (Wilhelm *et al.* 2007).

On a broader geographical scale, estimates of the number of birds that die annually from I spills range from 21,000 on the Atlantic coast of Canada, and 72,000 in all of Canada (Thomson *et al.* 1991), to 315,000 ± 65,000 Common Murres, Thick-billed Murres and Dovekies annually in southeastern Newfoundland alone due to illegal oil discharges from ships (Wiese and Robertson 2004). Clark (1984) estimated that 150,000 to 450,000 birds die annually in the North Sea and North Atlantic from oil pollution from all sources.

Mitigation for accidental hydrocarbon spills will consist of following the protocols detailed in the spill response plan. The oil spill response plan is under development. Depending on the nature and tiered response required, mitigations include the provision for spill response equipment and the rescue and rehabilitation of oiled marine birds. Marine bird rehabilitation will be facilitated through ExxonMobil's North American support network. These procedures will minimize the potential mortality from such accidental events.

The environmental effects of Project accidental events activities on Marine Birds are summarized in Table 9-13.

Table 9-13 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Change in Habitat Use	• Prevention through design standards and maintenance • Emergency Response Contingency Plan	1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	3	2/1	R/I [B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Subsea Blowout	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	3/1	R/I[B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	1	2/1	R/I[B]	2
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2
Collisions (involving Hebron Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	3	2/1	R/I [B]	2

KEY

Magnitude:

N = Negligible: There may be some environmental effect but it is not considered to be measurable

1 = Low: <10 percent of the population or habitat in the Study Area will be affected

2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected

3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
[B] Potential Mortality effects reversible at the population level and irreversible at the individual level

The potential environmental effects from some of the assessed accidental event scenarios could be high in magnitude, high in geographical extent and moderate in duration. Therefore, a significant residual adverse environmental effect is possible as a result of a project-related accidental event. However, this event is considered unlikely.

9.5.5 Cumulative Environmental Effects

Marine oil and gas exploration, commercial fishery activity, marine transportation, and existing production activity (*e.g.*, White Rose, Hibernia, and Terra Nova) all have the potential to interact with marine birds (see Table 9-9). Hunting of marine birds occurs in the Nearshore Study Area. It is unlikely that routine activities associated with other marine exploration, existing production areas, marine transportation, and commercial fisheries have substantive environmental effects on marine birds. The one exception would be an accidental hydrocarbon spill or blowout in the Offshore Study Area.

9.5.5.1 Nearshore

With the exception of marine bird hunting, cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area as fewer activities have the potential to interact with the current Project (see Section 9.5.5.2 for cumulative environmental effects assessment of the Offshore Study Area).

Most hunting of marine birds in Newfoundland and Labrador waters occurs inshore. The harvested populations are primarily sea ducks (especially Common Eider) and murres (mostly Thick-billed Murre). Sea ducks occur primarily inshore, but Thick-billed Murre occurs both inshore and offshore (autumn to spring). The last harvest survey was run in 2001 and estimated that approximately 300,000 murres were harvested in Newfoundland and Labrador (Wiese *et al.* 2004). Since then, based on permit purchases, there has been a general decline in hunter participation (CWS, unpublished data). Wiese *et al.* (2004) modelled the impacts of hunting and oil pollution on the population growth of Thick-billed Murres and found that hunting decreased the population growth at the same rate as chronic oil pollution, arising primarily from illegal discharges of oily water from ships. Hunting of sea ducks and murres may therefore have a cumulative effect with effects of accidental hydrocarbon spills and produced water (Wiese *et al.* 2004).

9.5.5.2 Offshore

The effects of illumination on structures and vessels, air emissions, discharges, underwater sound, accidental hydrocarbon spills from exploration vessels, existing production drilling platforms and vessels, other exploratory drilling structures and platforms may have cumulative effects with Project activities and Project accidental events.

Marine birds, particularly Leach's Storm-Petrels, may be attracted to the lights of offshore structures and vessels at night and during periods of poor visibility. As a result, Leach's Storm-Petrels may strand on offshore platforms, as discussed in the previous assessment. The stranding of birds at offshore platforms is largely mitigated by bird handling and release protocols so that any cumulative effects, if they occur, would be low and not significant.

The Project will create additional emissions to the atmosphere, but air emissions from one drilling operation will be relatively small in scale and within the range of other offshore marine activities such as marine shipping. Emissions will very rapidly dissipate in the windy offshore environment and will not endanger the health of marine birds since any exposures will be of very low concentrations and durations. Any cumulative effects are considered negligible.

Drill mud and other discharges are regulated by the *Offshore Waste Treatment Guidelines* (OWTG) (National Energy Board *et al.* 2002), and the quantities involved, geographic extents and magnitudes are small. There are few pathways for drill mud/cuttings discharges to affect marine birds, other than the potential exception of a sheen of synthetic-based mud (SBM) under flat calm conditions. As described for the effects of discharges on marine birds, any cumulative effect is considered not significant.

The bycatch of marine birds in commercial fisheries has historically been a known source of at-sea mortality. However, bycatch of marine birds in commercial fisheries (*e.g.*, inshore gill netting) has declined sharply since 1992 (Piatt and Nettleship 1987; Benjamins *et al.* 2008). This has probably had a positive impact on marine bird populations, both those nesting in Newfoundland and those nesting in the Arctic. Consequently, the effects of commercial fisheries probably no longer pose any significant cumulative effects on marine birds.

As described in the assessment above, underwater sound has the potential to disturb marine birds that spend prolonged periods submerged near a loud sound source. Alcids are the only family of marine birds found in Newfoundland offshore waters that are known to dive underwater for extended periods and are, thus, more likely to be affected by underwater sound than other species. Avoidance or behavioural disturbance is the most likely effect of underwater sound produced by offshore operations associated with the Project or other nearby operations, but these effects are expected to be low in magnitude and only affect a small area. Thus, it is predicted that cumulative effects of underwater sound on marine birds are not significant.

A major spill or blowout on the Grand Banks could affect marine birds, depending on the type, size, location, timing, species, and life stages involved. A major spill is statistically very unlikely to coincide among various operations on the Grand Banks. Nevertheless, cumulative effects could occur from chronic discharges of oil bilges at sea by ships transiting the area or from other activities that could affect marine birds. A major oil spill could significantly affect marine birds on the Grand Banks and thus result in a significant cumulative effect when considered in addition to other stressors on bird populations (*e.g.*, hunting, bycatch in commercial fishing, or oiling from bilge dumping). However, condensate from a deepwater blowout may be considerably reduced when it reaches the surface, and the wind and wave conditions typical of the Grand Banks will further aid in the dispersal of condensate. Spill countermeasures and marine bird rehabilitation would additionally reduce potential effects.

9.5.6 Determination of Significance

The determination of significance is based on the definition provided in Section 9.2. It considers the magnitude, geographic extent, duration, frequency, reversibility, and ecological context of each environmental effect with the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

Adverse effects of attraction to illumination on structures and vessels on Marine Birds during the construction/installation phase of the Project are predicted to be *low* in magnitude, geographic extent, duration, frequency when mitigation measures are practiced. Although significant at the individual level, these effects are predicted to be reversible at the population level. These effects are therefore predicted to be *not significant*.

Adverse effects of attraction to illumination on structures and vessels on Marine Birds during the operation and maintenance phase are predicted to be *low* in magnitude, geographic extent, duration, frequency when mitigation measures are practiced. Adverse effects of produced water on Marine Birds during the operation and maintenance phase are predicted to be *low* in magnitude, geographic extent, duration, frequency when mitigation measures are practiced. Although potentially significant at the individual level, these effects are predicted to be reversible at the population level. Therefore, these effects are predicted to be *not significant*.

Adverse effects of attraction to illumination on structures and vessels on Marine Birds during the decommissioning and abandonment phase of the project are predicted to be *low* in magnitude, geographic extent, duration, frequency when mitigation measures are practiced. Although significant at the individual level, these effects are predicted to be reversible at the population level. These effects are therefore predicted to be *not significant*.

Adverse effects of accidents, malfunctions and unplanned events (*i.e.*, hydrocarbon and other chemical spills due to collisions, failure of OLS manifolds or risers, subsea blowouts, batch spills or marine vessel incidents) are predicted to be *low* to *high* in magnitude, *low* to *high* in geographic extent, *low* to *moderate* in duration, and *low* in frequency. Although significant at the individual level, these effects are predicted to be reversible at the population level. Nevertheless, these effects are predicted to be *significant*. Smaller scale spills and blowouts in calm conditions may be mitigated via oil spill response measures and marine bird rehabilitation; however, these mitigations are recognized to be limited. There will be an emphasis on accident prevention at all phases of the Project.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Marine Birds, after taking into account any proposed mitigation, is summarized in Table 9-14.

Because the adverse effects of each Project phase are predicted to be *not significant,* the adverse effects of the Project overall is predicted to be *not significant*.

Table 9-14 Residual Environmental Effects Summary: Marine Birds

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction/Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	S	1	1
Cumulative Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.
[B] Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site.
[C] Includes decommissioning and abandonment of the GBS and offshore site.
[D] Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

9.5.7 Follow-up and Monitoring

The CEAA definition of "follow-up program" is "a program for (a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project”. Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. Compliance monitoring on its own, does not satisfy the requirements for a follow-up program. Compliance monitoring is conducted to ensure that a project and its activities are meeting the relevant environmental standards, guidelines and regulations. Compliance monitoring will be conducted for the Project in accordance with regulatory requirements.

A specific EEM program to verify the accuracy of assessment predictions and the efficacy of mitigation measures is not planned for Marine Birds.

For MODU drilling operations, EMCP will implement a marine bird observation program similar to those conducted during exploration drilling programs in the Newfoundland and Labrador Offshore Area. EMCP supports initiatives such as the recent ESRF marine bird monitoring program and will investigate the development of a marine bird observation program from Hebron Project supply vessels, where space is available. Marine bird monitoring protocols will be based on those outlined in Moulton and Mactavish (2004) as per the C-NLOPB Guidelines (C-NLOPB 2008), and will consider the new protocols recommended by CWS (Wilhelm *et al.* in prep.).