BHP Canada Exploration Drilling Project (2019-2028)

Chapters 1-5

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Report

February 2020

Executive Summary

BHP Petroleum (New Ventures) Corporation (BHP) is proposing to undertake an exploration drilling program within the areas of its existing offshore exploration licences (ELs) 1157 and 1158 in the Orphan Basin, approximately 350 kilometres (km) northeast of St. John's, Newfoundland and Labrador (NL). Over the term of the ELs (2019-2028), the BHP Canada Exploration Drilling Project (herein referred to as the "Project") will include drilling of up to 20 wells, with an initial well to be drilled as early as 2021, pending regulatory approval.

BHP's current offshore interests, EL 1157 and EL 1158, were issued to BHP, as the sole interest holder, by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) in January 2019. The term of these ELs extends from January 15, 2019 to January 15, 2028. BHP will serve as the operator for this exploration drilling program.

The Project will constitute the first drilling, testing, and abandonment of an offshore exploration well within each of the ELs issued to BHP by the C-NLOPB. The Canadian Environmental Assessment Agency (now the Impact Assessment Agency of Canada; CEA Agency) determined the requirement for an environmental assessment process, under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), and provided Environmental Impact Statement (EIS) guidelines to BHP on June 28, 2019 (Appendix A).

Although at the time of submission the new federal *Impact Assessment Act* (IAA) has been implemented, the Project is proceeding under CEAA 2012. Subsection 181(1) of the IAA allows the environmental assessment of a designated project by the CEA Agency commenced under CEAA 2012 to continue under that process as long as the notice of commencement was posted before the IAA was enacted (August 28, 2019). BHP received it's notice of commencement on June 28, 2019 and chose to remain under the CEAA 2012 process.

The EIS focuses on the identification of potential adverse environmental effects of the Project on valued components (VCs) and assesses their biological, social, and/or cultural significance according to the EIS Guidelines. The assessment focuses on the VCs identified in relation to section 5 of CEAA, 2012, as required by the EIS Guidelines and are comprised of environmental attributes that are of interest or concern to BHP, regulatory agencies, resource managers, Indigenous peoples, scientists, key stakeholders, and/or the general public. BHP selected the same six VCs that have been assessed in other recent CEAA 2012 exploration drilling projects:

- Marine Fish and Fish Habitat (including Species at Risk)
- Marine and Migratory Birds (including Species at Risk)
- Marine Mammals and Sea Turtles (including Species at Risk)
- Special Areas
- Indigenous Peoples and Community Values
- Commercial Fisheries and Other Ocean Users

The EIS assessed the potential effects of both routine activities and accidental events on each VC, as well as potential cumulative effects resulting from the effects from other past, present, or likely future activities and projects. BHP conducted studies to support the environmental effects assessment: drill mud dispersion modelling (Appendix D); underwater sound assessment (Appendix E); and oil spill fate and trajectory modelling (Appendix F).

Activities associated with the BHP Project are similar to those assessed for other recent exploration drilling projects Based on these Project activities, the potential environmental effects of routine Project activities that have been specifically identified and considered in this assessment, include:

- Presence and operation of a mobile offshore drilling unit (MODU) (including drilling, associated safety zone, lights, sound, and geotechnical / geophysical surveys)
- Vertical seismic profiling (VSP)
- Discharges and emissions (e.g., drill muds and cuttings, liquid discharges)
- Well testing and flaring (including air emissions)
- Well decommissioning and abandonment or suspension
- Supply and servicing operations (including helicopter transportation and PSV operations)

Also identified and considered within the scope of the Project are non-routine events (i.e., accidental events or malfunctions (Chapter 15)) which includes:

- Blowouts (uncontrolled release of hydrocarbons during drilling)
- MODU and vessel batch spills and releases (e.g., hydraulic fluid, drilling mud, diesel)

Accidental releases, or “spills”, have the potential to occur in the offshore (e.g., during drilling) or nearshore (e.g., during PSV transit) environment.

The environmental effects assessment for each VC examines the degree and nature of change to, and resulting effects on, the existing environment that may occur as a result of planned Project activities. The characterization of range of magnitude (compared with natural variability) considers the reasonable worst-case scenario and is therefore considered to provide a conservative indication of effects.

Mitigation has been proposed to reduce or eliminate adverse environmental effects to components within the scope of the Project. They include engineering design, standard mitigation measures, and best management practices as well as VC-specific mitigation measures. BHP will implement and adhere to relevant environmental mitigation requirements outlined in applicable legislation and regulations, including commitments made in this EIS, and eventually required as enforceable conditions of an EA approval. Environmental mitigation and compliance requirements will be implemented and adhered to by Project contractors and subcontractors as it applies to their specific work scopes. This will be enforced through relevant commercial and contractual arrangements with these providers or goods and services to the Project. With the implementation of these proposed mitigation measures, residual adverse environmental effects of routine Project activities and components are predicted to be not significant for all VCs.

In the unlikely event of a Project-related accidental event resulting in the large-scale release of oil into the marine environment, a significant adverse effect is predicted for marine and migratory birds and Indigenous peoples and communities under certain circumstances. The magnitude and extent of potential effects would be reduced with the application of spill response measures (see Section 15.5); therefore, the risk of adverse effects would be reduced.

BHP is committed to working closely with the local business community, governments, educational and training facilities, and various other stakeholders to effectively implement the Project Benefits Plan and achieve a positive outcome. Activities associated with the BHP exploration drilling program are expected to make a substantial positive contribution to the economy of Newfoundland and Labrador. Many potential adverse environmental effects identified in this EIS can be managed effectively with standard operating procedures and standard mitigation measures. These and/or other planning and management measures, in combination with BHP's own policies, principles, and environmental management plans and procedures, will allow the Project to be planned and completed in a manner that avoids or reduces potential environmental effects. Overall, with the implementation of mitigation, it is concluded that the routine activities associated with the Project are not likely to result in significant adverse residual environmental effects, including cumulative environmental effects.

A table of concordance is appended (Appendix B) to demonstrate compliance with the EIS Guidelines (Appendix A); and indicates where in the EIS document requirements have been addressed.

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Abbreviations

°	degree
°C	degrees Celsius
µg/L	Micrograms per litre
µm	micrometer
µPa	micropascal
^{137}Cs	Cesium 137
1SW	One Sea-Winter
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
AC	Alternating Current
ACSS	Atlantic Canada Shorebird Survey
ACW	Approval to Alter the Condition of a Well
ADCP	Acoustic Doppler Current Profiler
ADW	Approval to Drill a Well
AGC	Atlantic Groundfish Council
AICFI	Atlantic Integrated Commercial Fisheries Initiative
AIOC	Alderon Iron Ore Corp
AIP	Agreement-in-Principle
AMIK	Agence Mamu Innu Kaikusseth
ANSMC	Assembly of Nova Scotia Mi'kmaq Chiefs
APGN	Agreement-in-Principle of General Nature
API	American Petroleum Institute
AR5	Fifth Assessment Report
ASM	American Society for Microbiology
ASP	Association of Seafood Producers
AZMP	Atlantic Zone Monitoring Program
bbl	barrel
BdN	Bay du Nord

BHP	BHP Petroleum (New Ventures) Corporation
BIO	Bedford Institute of Oceanography
BML	below mud line
BMP	best management practices
BOP	blowout preventer
CAC	criteria air contaminant
CAD	Canadian dollars
CAM	Conseil des Atikamekws et des Montagnais
CAPP	Canadian Association of Petroleum Producers
CBD	Convention on Biological Diversity
CBD EBSA	(United Nations) Convention on Biological Diversity Ecologically or Biologically Significant Area
CBTZ	Cumberland Belt Transform Zone
CCG	Canadian Coast Guard
CCO	Chief Conservation Officer
CDPDJ	Commission des droits de la personne et des droits de la jeunesse
CEA Agency	Canadian Environmental Assessment Agency
CEAA	*Canadian Environmental Assessment Act*
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
CECOM	Canadian East Coast Ocean Model
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEM	Conservation and Enforcement Measures
CEPA 1999	*Canadian Environmental Protection Act, 1999*
CER	Canada Energy Regulator
CFA	Crab Fishing Area
CGFZ	Charlie-Gibbs Fracture Zone,
CH_4	methane
CI	confidence interval
CIE	Conseil des Innu de Ekuanitshit
CIS	Canadian Ice Service
cm	centimetre
cm/s	centimetre per second

CMIP5	Coupled Model Intercomparison Project
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CNSOPB	Canada-Nova Scotia Offshore Petroleum Board
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	carbon dioxide equivalent
COOGER	Centre for Offshore Oil, Gas and Energy Research
COSEWIC	Committee on the status of Endangered Wildlife in Canada
CPAWS	Canadian Parks and Wilderness Society
CRA	commercial, recreational, or Aboriginal
CSAS	Canadian Science Advisory Secretariat
CTD	Conductivity, Temperature, Depth
CV	Coefficient of Variation
CWS	Canadian Wildlife Service
D&C	drilling and completions
dB	decibel
dB re 1 μPa	decibel reference value 1 micropascal
DFO	Fisheries and Oceans Canada
DHC	dissolved hydrocarbon
Div.	Division(s)
DNA	deoxyribonucleic acid
DND	Department of National Defence
DP	dynamic positioning
DU	Designatable Unit
DWBC	Deep Western Boundary Current
DWH	Deepwater Horizon
EA	environmental assessment
EBSA	Ecologically or Biologically Significant Area
EC50	half maximal effective concentration
ECCC	Environment and Climate Change Canada
ECMWF	European Centre for Medium-Range Weather Forecasts
ECRC	Eastern Canada Response Corporation

ECSAS	Eastern Canada Seabirds at Sea
EEM	Environmental Effects Monitoring
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EIS Guidelines	Guidelines for the Preparation of an Environmental Impact Statement pursuant to the *Canadian Environmental Assessment Act, 2012*
EL	Exploration License
ELT	Executive Leadership Team
EMPAAC	Eastport Marine Protected Areas Advisory Committee
EMT	Emergency Management Team
EPP	Environmental Protection Plan
ERC	Environmental Research Consulting
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESRF	Environmental Studies Research Fund
ESS	Ecologically Significant Species
EU	European Union
FAO	Food and Agriculture Organization
FCA	Fisheries Closure Area
FFAW-Unifor	Fish, Food and Allied Workers-Unifor
fHsHi	High Wave Day Frequency
fHsRo	Rough Wave Day Frequency
FLO	Fisheries Liaison Officer
Floc	flocculant
FNI	Federation of Newfoundland Indians
FPSO	floating, production storage, and offloading [vessel]
FRT	Field Response Team
FSC	food, social and ceremonial
FTWT	Formation Testing While Tripping
FY	First-year
g	gram
g/m²	grams per square metre

GBR	geohazard baseline review
GBS	gravity-based structure
GCM	Global Climate Model
GDP	gross domestic product
GFD	Gesgapegiag Fisheries Department
GHG	greenhouse gas
GHGRP	Greenhouse Gas Emissions Reporting Program
GLODAP	Global Ocean Data Analysis Project
GNL	Government of Newfoundland and Labrador
GOMO	Guidelines for Offshore Marine Operations
GPS	global positioning system
ha	hectare
HAZID	hazard Identification
HBC	Hudson's Bay Company
HMDC	Hibernia Management and Development Company Ltd.
HQP	Hydro-Quebec Production
hr	hour
Hs	Significant Wave Height
HSE	Health, Safety and Environment
HSEC	Health, Safety, Environment, and Community
HSEMS	Health, Safety and Environment Management System
HURDAT2	Atlantic Hurricane Database
HV-GB	Happy Valley-Goose Bay
Hz	hertz
IAA	*Impact Assessment Act*
IADC	International Association of Drilling Contractors
IBA	Important Bird Area
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICMM	International Council on Mining and Metals
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
ICS	Incident Command Systems
IIAS	Intergovernmental and Indigenous Affairs Secretariat

IIP	International Ice Patrol
IMA	Integrated Management Area
IMO	International Maritime Organization
IMP	Incident Management Plan
IMT	Incident Management Team
in^3	cubic inch
INAC	Indigenous and Northern Affairs Canada
IOC	Iron Ore Company of Canada
IOGP	International Association of Oil and Gas Producers
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
IPTT	Interval Pressure Transient Testing
IR	Information Requirement
IRD	ice-rafted detritus
ISO	International Standards Organization
ITOPF	International Tankers Owners Pollution Federation Limited
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
IWCF	International Well Control Forum
K	kelvins
kg	kilogram
kHz	kiloHertz
km	kilometre
km/h	kilometres per hour
km^2	square kilometre
KMKNO	Kwilmu'kw Maw-klusuaqn Negotiation Office
kW	kiloWatt
L	litre
LAA	Local Assessment Area
LFA	Lobster Fishing Area
LIA	Labrador Inuit Association
LIL	Labrador Inuit Lands

LILCA	Labrador Inuit Land Claims Agreement
LISA	Labrador Inuit Settlement Area
LMG	Listuguj Mi'gmaq Government
LMRP	lower marine riser package
LWD	logging / testing while drilling
m	metre
m/s	metre per second
m^2	square metre
m^3	cubic metre
m^3/d	cubic metre per day
MAE	major accident event
MAMKA	Mi'kmaq Alsumk Moiwimsikik Koqoey Association
MANICE	Manual of Ice
MANMAR	Manual of Marine Observations
MARLANT	Maritime Forces Atlantic
MARPOL	International Convention for the Prevention of Pollution from Ships
MBCA	*Migratory Birds Convention Act, 1994*
MBS	Migratory Bird Sanctuary
MCF	Mi'kmaq Commercial Fisheries Incorporated
MCPEI	Mi'kmaq Confederacy of Prince Edward Island
MFN	Miawpukek First Nation
mg	milligram
mg/L	milligram per litre
MGS	Membertou Geomatics Solutions
MICT	Regroupement Mamit Innuat Tribal Council
mL/L	milliliter per liter
Mm	millimetre
MMAFMA	Mi'gmaq Maliseet Aboriginal Fisheries Management Association
MMO	Marine Mammal Observer
MMS	Mi'gmawei Mawiomi Secretariat
Mn	manganese
MODIS	Moderate Resolution Imaging Spectroradiometer

MODU	mobile offshore drilling unit
MOG	Micmacs of Gesgapegiag
MPA	Marine Protected Area
MPI-ESM-MR	Max-Planck-Institute Earth System Model Mixed Resolution
MRCN	Musée régional de la Côte-Nord
MRI	Marshall Response Initiative
MSC50	Meteorological Service of Canada, Wind and Wave Hindcast
MSW	multi sea-winter
MTD	Mass Transport Deposits
MTI	Mi'gmawe'l Tplu'tagnn Inc.
N	north
N2O	nitrous oxide
NAD83	North American 1983 Datum
NAFO	Northwest Atlantic Fisheries Organization
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NAVWARN	Navigational Warning, issued by Canadian Coast Guard
NB	New Brunswick
NCC	NunatuKavut Community Council
NDC	Nunacor Development Corporation
NEB	National Energy Board
NEBA	Net Environment Benefit Assessment
NEREUS	Newfoundland and Labrador Expended Research on Ecosystem-relevant but Under-surveyed Splicers
NESS	Nalcor Exploration Strategy System
NG	Nunatsiavut Government
ng/L	nanogram per liter
NGC	Nunatsiavut Group of Companies
NGO	non-governmental organization
NHC	National Hurricane Centre
NHS	National Historic Site
NL	Newfoundland and Labrador

NL ESA	Newfoundland and Labrador *Endangered Species Act*
NLDEC	Newfoundland and Labrador Department of Environment and Conservation
nm	nanometre
NMCA	National Marine Conservation Area
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOTMAR	Notice to Mariners, issued by Canadian Coast Guard
NOx	nitrogen oxides
NPRI	National Pollutant Release Inventory
NRA	NAFO Regulatory Area
NRC	National Research Council
NRCan	Natural Resources Canada
NRDA	Natural Resource Damage Assessment
NS	Nova Scotia
NS OAA	Nova Scotia Office of Aboriginal Affairs
NTU	nephelometric turbidity units
OA	Operations Authorization
OBIS	Ocean Biogeographic Information System
OCI	Ocean Choice International
OCNS	Offshore Chemical Notification Scheme
OCSG	Offshore Chemical Selection Guidelines
ODI	Ocean Data Inventory
OSD	Ocean Sciences Division
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OSRL	Oil Spill Response Limited
OSRP	Oil Spill Response Plan
OWRP	Oiled Wildlife Response Plan
OWTG	Offshore Waste Treatment Guidelines
PA	Project Area
PAH	polycyclic aromatic hydrocarbon
PB / GB	Placentia Bay / Grand Bank

PB / GB IMA	Placentia Bay / Grand Banks Integrated Management Area
PCA	Parks Canada Agency
PCB	polychlorinated biphenyl
PCMDI	Program for Climate Model Diagnosis and Intercomparison
PEI	Prince Edward Island
PERD	Program on Energy Research and Development
PIROP	programme intégré de recherches sur les oiseaux pélagiques
PL	Production Licence
PLONOR	pose little or no risk to the environment
PM	particulate matter
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PNA	Parks and Natural Areas Division
PNET	predicted no effect threshold
psi	pounds per square inch
PSU or psu	practical salinity unit
PSV	Project support vessel
PTS	permanent threshold shift
PTW	Permit to Work
PVT	pressure / volume / temperature
QC	Quebec
QMFN	Qalipu Mi'kmaq First Nation
QMFNB	Qalipu Mi'kmaq First Nation Band
$R_{95\%}$	the range to the given sound level after 5% of the farthest points were excluded
RAA	Regional Assessment Area
RCM	recording current meter
RCMP	Royal Canadian Mounted Police
RCP	representative concentration pathway
RDCC	Resource Development Consultation Coordinators
R_{max}	the maximum range to the given sound level over all azimuths
rms	root-mean-square
ROV	remotely operated vehicle

ROV	remotely operated vehicle
RV	research vessel
s	second
SAR	species at risk
SARA	*Species at Risk Act*
SBA	Sensitive Benthic Area
SBM	synthetic-based mud
SCAT	shoreline clean-up assessment technique
SCCP	Source Control Contingency Plan
SDL	Significant Discovery Licence
SDS	Safety Data Sheet
SEA	Strategic Environmental Assessment
SEL	sound exposure level
SER	Seabird Ecological Reserve
SERPENT	Scientific and Environmental ROV Partnership using Existing Industrial Technology
SFA	Shrimp Fishing Area
SiBA	Significant Benthic Area
SIMA	Spill Impact Mitigation Assessment
SO_2	sulphur dioxide
SOCC	species of conservation concern
SOCP	Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment
SOLAS	International Convention for the Safety of Life at Sea
SOPEP	Ship Oil Pollution Emergency Plan
SO_X	sulphur dioxides
sp	Species
SPL	sound pressure level
SPL_{peak}	peak sound pressure level
SPLs	sound pressure levels
spp.	several species
SST	sea surface temperature
t	metric tonne

TAC	total allowable catch
THC	total hydrocarbon concentration
TLH	Trans Labrador Highway
TNASS	Trans North Atlantic Sightings Survey
Tp	peak wave period
TPM	total particulate matter
TSS	total suspended solids
TTS	temporary threshold shift
TVD	true vertical depth
UME	unusual mortality event
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USDOI MMS	United States Department of the Interior Mineral Management Service
UXO	unexploded ordinance
VC	Valued Component
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System
VOCs	volatile organic compounds
VSP	vertical seismic profiling
VTR	vessel transit route
WAF	water accommodated fractions
WBM	water-based mud
WMP	Waste Management Plan
WNNB	Wolastoqey Nation of New Brunswick
WOCE	World Ocean Circulation Experiment
WSD	Wells and Seismic Delivery
$\delta^{13}C$	Signature of Carbon-13 (stable isotope)
µl/L	microliter per liter

1.0 INTRODUCTION

BHP Petroleum (New Ventures) Corporation (BHP) is proposing to undertake an exploration drilling program within the areas of its existing offshore exploration licences (ELs). The ELs are located in the Orphan Basin, approximately 350 kilometres (km) northeast of St. John's, Newfoundland and Labrador (NL), in the Northwest Atlantic Ocean. Over the term of the ELs (2019-2028), the BHP Canada Exploration Drilling Project (herein referred to as the "Project") will include drilling of up to 20 wells, with an initial well to be drilled as early as 2021, pending regulatory approval.

In Eastern Canada, BHP's current offshore interests include two existing ELs in the Orphan Basin Area, EL 1157 and EL 1158 (Figure 1-1). These two ELs were issued to BHP, as the sole interest holder (Table 1.1), by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) in January 2019. The term of these ELs extends from January 15, 2019 to January 15, 2028. BHP will serve as the operator for this exploration drilling program.

Table 1.1 Licence Size and Interests

EL	Size (ha)	Interest Holder
1157	269,799	BHP (100%)
1158	273,579	BHP (100%)

The drilling, testing, and abandonment of offshore exploratory wells in the first drilling program, in an area set out in one or more of the ELs issued, requires review and approval by the Canadian Environmental Assessment Agency (CEA Agency) per section 10 of the *Regulations Designating Physical Activities* under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012). This Environmental Impact Statement (EIS) was developed following the published project-specific guidelines (CEA Agency 2019). Pursuant to the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* and the *Canada-Newfoundland Atlantic Accord Implementation Act* (the Accord Acts), the C-NLOPB also requires a project-specific environmental assessment (EA) for offshore oil and gas activities, including the drilling of exploration wells. The EIS Guidelines (CEA Agency 2019) and the C-NLOPB Accord Acts EA requirements will both be satisfied by the preparation of this EIS.

BHP is aware of the planned Regional Assessment of Offshore Oil and Gas Exploratory Drilling East of NL pursuant to CEAA 2012, which is intended to eliminate the need for a specific Project Description to streamline the process. BHP is participating in the regional assessment through the Canadian Association of Petroleum Producers (CAPP).

1.1 Project Overview

During the term of the ELs, BHP proposes to drill up to 20 exploration wells in total, with between one and ten wells on either, or both, EL 1157 and EL 1158. The ELs are located offshore eastern Newfoundland in the Orphan Basin area, with the ELs both inside and outside Canada's 200 nautical mile Exclusive Economic Zone (EEZ) (Figure 1-1). Water depths in the ELs range from approximately 1,175 to 2,575 metres (m). Drilling operations carried out as part of the Project will be conducted within the defined boundaries of the ELs, but specific well site numbers, types, and locations will be determined as Project planning activities continue.

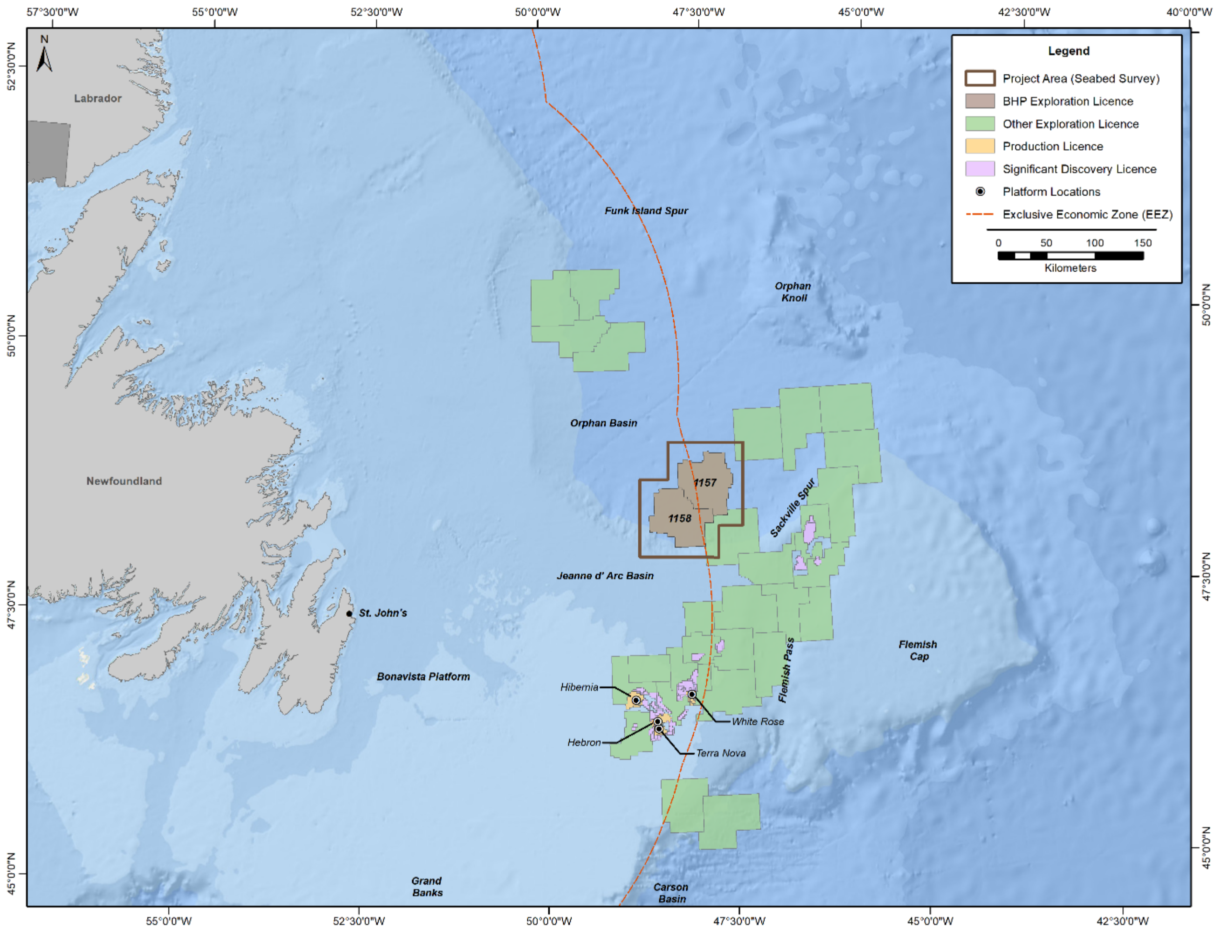

Figure 1-1 Project Location

Wells will be drilled by a mobile offshore drilling unit (MODU). The specific type of MODU used for the Project will be determined as Project planning continues but will be either a semi-submersible rig or a drillship. It is anticipated that the analysis of initial well results will be used to inform the execution strategy for subsequent wells. Depending on availability, the type of MODU may change during the temporal scope of the Project. This is referred to as a multiple phase approach for exploration drilling.

A fleet of Project support vessels (PSVs) and helicopters will provide logistics, stand-by, supply, and operational support and will be based out of existing, onshore facilities in Eastern NL. The scope of this EIS does not include onshore activities at these shore-based facilities.

1.2 Scope of the EIS

The assessment of the Project that is within the scope of the EIS, in accordance with the EIS Guidelines (Appendix A) includes:

- MODU mobilization and drilling
  - Mobilization, operation and demobilization of the MODU
  - Establishment of a safety zone
  - Light and sound emissions associated with MODU presence and operation
  - Waste and water management, including discharge of drill muds and cuttings, and other discharges and emissions
  - Geophysical surveys and/or geotechnical surveys
    - If a well is successful (i.e., hydrocarbons are discovered), vessels may be required to complete geophysical surveys (high resolution geophysical data acquisition) and geotechnical sampling (geotechnical coring)
- Vertical seismic profiling (VSP) operations
- Well evaluation and testing
- Well decommissioning and abandonment or suspension
- Supply and servicing
  - Loading, refueling and operation of PSVs (for re-supply and transfer of materials, fuel and equipment; on-site safety during drilling activities; and transit between the supply base and the MODU)
  - PSVs will also be used for ice management that may be required during the annual ice season (including icebergs) in offshore eastern Newfoundland (typically between March to June). Ice management processes will include established procedures for iceberg towing and deflection, and if required, procedures for the safe disconnect and movement of the drilling unit while leaving the well in a safe condition
  - Helicopter support (for crew transport and delivery of supplies and equipment)

Descriptions of additional components or activities, beyond the scope of the EIS guidelines, may be provided in certain chapters to provide a broader context for the Project. Although well locations are not known at this stage of Project development, each well in the program will be subject to the C-NLOPB's regulatory approval process, as described in Section 1.5.1, and will include confirmation and finalization of exact well locations.

Spatial boundaries are used to define the scope of the EIS for the evaluation of the potential adverse environmental effects that could be caused by the Project. These are defined at three geographic scales: the Project Area; Local Assessment Area (LAA); and Regional Assessment Area (RAA). The Project Area refers to the immediate area in which Project activities and components may occur, including direct physical disturbance to the marine benthic environment, plus a 20 km buffer (Figure 1-1). The 20-km buffer has been used to capture discharges and emissions from routine activities that may extend outside the EL if drilling were to occur near the edge of an EL (versus the middle of an EL). A LAA and RAA have been defined to assess potential environmental effects that may occur beyond the Project Area. The RAA is defined in more detail in Chapter 4 of this EIS; the LAA is defined specifically for each VC and are described in Chapters 8 through 13.

The temporal scope of the Project includes the term of the ELs (2019-2028) and the Project activities (including well drilling, testing, abandonment, and associated activities) that may occur during that time. Although BHP prefers to execute Project activities during ice-free months, this EIS assumes that within this nine-year period activities may occur year-round.

Additional detail of the Project components and activities is provided in Chapter 2 of this EIS, including overall need, purpose and justification for the Project, location, schedule, potential emissions and their management, Project alternatives, and overall environmental planning and management systems.

1.3 Proponent Information

1.3.1 Proponent Contact Information

BHP established a local office in St. John's, NL in 2019. The principal BHP contacts concerning this Project and its EA review are as follows:

Regional Manager:
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1.3.2 BHP Operations

BHP is a world-leading resources company in minerals and oil and gas, with operations primarily in the Americas and Australia. Global headquarters for BHP are in Melbourne, Australia with offices around the globe. BHP's Petroleum unit, based in Houston, Texas, offers crude oil, hydrocarbons, and liquefied natural gas exploration and production services. BHP has a unique perspective on the extraordinary potential of natural resources to provide the essential building blocks of progress. BHP's purpose is to create long-term shareholder value through the discovery, acquisition, development, and marketing of natural resources. BHP's strategy is to own and operate large, long-life, low-cost, expandable, upstream assets diversified by commodity, geography and market.

BHP's Petroleum unit comprises conventional oil and gas operations, and includes exploration, development, and production activities. BHP has a high-quality resource base concentrated in the United States (US) and Australia, with core production operations consisting of conventional assets located in the US Gulf of Mexico, Australia, and Trinidad and Tobago. BHP produces crude oil and condensate, gas and natural gas liquids that are sold on the international spot market or delivered domestically under contracts with varying terms, depending on the location of the asset. BHP also has interests in offshore assets managed by other operators located in Africa, the Gulf of Mexico, and Australia.

BHP's exploration strategy is to focus on material opportunities, at a high working interest, with a bias for liquids and operatorship. Exploration programs between 2016 and 2019 are provided in Table 1.2. These programs have been located exclusively in water depths in excess of 1,000 m, with BHP acting as the operator for 14 of the 16 programs.

Table 1.2 BHP Petroleum Exploration Activities 2016 to 2019

Well	Location	Target	BHP equity	Spud date	Water depth	Total well depth
LeClerc-1	Trinidad & Tobago Block 5	Oil	65% (BHP Operator)	21 May 2016	1,800 m	5,771 m
LeClerc-ST1	Trinidad & Tobago Block 5	Oil	65% (BHP Operator)	6 July 2016	1,800 m	6,973 m
Caicos-1	US Gulf of Mexico GC564	Oil	100% (BHP Operator)	21 June 2016	1,288 m	9,19 8m
Burrokeet-1	Trinidad & Tobago Block 23a	Oil	70% (BHP Operator)	8 Aug 2016	1,923 m	3,337 m
Burokeet-2	Trinidad & Tobago Block 23a	Oil	70% (BHP Operator)	18 Aug 2016	1,923 m	7,348 m
Wildling-1	US Gulf of Mexico GC520	Oil	100% (BHP Operator)	8 Jan 2017	1,230 m	5,950 m
Wildling-2	US Gulf of Mexico GC520	Oil	100% (BHP Operator)	15 Apr 2017	1,267 m	10,205 m
Wildling-2 ST01	US Gulf of Mexico GC520	Oil	100% (BHP Operator)	11 Aug 2017	1,267 m	10,177 m
Scimitar-1	US Gulf of Mexico GC392	Oil	65% (BHP Operator)	1 Oct 2017	1,289 m	9,836 m
Scimitar-1 ST01	US Gulf of Mexico GC392	Oil	85% (BHP Operator)	23 Jan 2018	1,289 m	8,246 m
Samurai-2	US Gulf of Mexico GC432	Oil	50% (Murphy Operator)	16 Apr 2018	1,088 m	9,777 m
Victoria-1	Trinidad & Tobago Block 5	Gas	65% (BHP Operator)	12 June 2018	1,828 m	2,545 m
Samurai-2 ST01	US Gulf of Mexico GC476	Oil	50% (Murphy Operator)	25 Aug 2018	1,088 m	10,088 m
Bongos-1	Trinidad & Tobago Block 14	Gas	70% (BHP Operator)	20 July 2018	1,909 m	2,469 m
Bongos-2	Trinidad & Tobago Block 14	Gas	70% (BHP Operator)	22 July 2018	1,910 m	5,151 m
Conception - 1	Trinidad & Tobago Block 5	Gas	65% (BHP Operator)	30 Sept 2018	1,721 m	3,506 m
TRION-2 DEL	Mexico Block AE-0093	Oil	60% (BHP Operator)	14 Nov 2018	2,380 m	4,940 m (ST)
Tuk-1	Trinidad & Tobago Block 23a	Gas	70% (BHP Operator)	28 Feb 2019	1,954 m	4,510 m
Bélé-1	Trinidad & Tobago Block 23a	Gas	70% (BHP Operator)	3 March 2019	2,102m	3,982 m
Hi-Hat- 1	Trinidad & Tobago Block 14	Gas	70% (BHP Operator)	5 March 2019	1,782 m	3,804 m

1.3.2.1 Health, Safety, Environment, and Community

Sustainability is one of the core values set out in the BHP Charter (Figure 1-2). To BHP, sustainability means putting health and safety first, being environmentally responsible, and supporting host communities. The wellbeing of BHP's people, the community, and the environment is considered in everything that it does.

BHP's highest priority is the safety of those impacted by its operations, including BHP employees, contractors, and the communities in which it operates. BHP achieves nothing if it does not do it safely.

Recognizing that BHP's operations can impact the health of its people, BHP sets clear requirements to manage and protect the health and wellbeing of its workforce, now and into the future. BHP looks to create a culture of care and trusted relationships with its people through strong leadership and open communication.

BHP aims to limit the environmental effects from its activities and work in partnership with others to support environmental resilience.

BHP seeks to build good relationships with its stakeholders based on mutual respect, open and ongoing communications, and transparency over its activities. BHP supports the development of diversified and resilient local economies that contribute to improved quality of life beyond the life of BHP's operations.

"Our Requirements" are the standards that give effect to the mandatory requirements arising from the BHP Operating Model as approved by the Executive Leadership Team. Our Requirements describe the mandatory minimum performance requirements and accountabilities for Group-wide Health, Safety, Environment, and Community (HSEC)-related performance requirements, business obligations, processes, functions, and activities across BHP. More Information about BHP's "Our Requirements" is provided in Table 1.3.

BHP

Our Charter

We are BHP, a leading global resources company.

Our Purpose

To bring people and resources together to build a better world.

Our Strategy

Our strategy is to have the best capabilities, best commodities and best assets, to create long-term value and high returns.

Our Values

Sustainability
Putting health and safety first, being environmentally responsible and supporting our communities.

Integrity
Doing what is right and doing what we say we will do.

Respect
Embracing openness, trust, teamwork, diversity and relationships that are mutually beneficial.

Performance
Achieving superior business results by stretching our capabilities.

Simplicity
Focusing our efforts on the things that matter most.

Accountability
Defining and accepting responsibility and delivering on our commitments.

We are successful when:

Our people start each day with a sense of purpose and end the day with a sense of accomplishment.

Our teams are inclusive and diverse.

Our communities, customers and suppliers value their relationships with us.

Our asset portfolio is world-class and sustainably developed.

Our operational discipline and financial strength enables our future growth.

Our shareholders receive a superior return on their investment.

<original signed by>

Mike Henry
Chief Executive Officer

February 2020

Figure 1-2 BHP's Charter

Table 1.3 BHP's – Our Requirements

Our Requirements for Aviation	Provides the framework for aviation relating to safety expectations, technical requirements, and a common set of critical controls.
Our Requirements for Business Conduct	Our Requirements for Business Conduct support Our Charter and the Code of Business Conduct and sets out what we all need to do to meet our ethical and legal obligations.
Our Requirements for Communications, Community and External Engagement	Provides the framework for engaging with our stakeholders in a consistent way including government, media, employees, equity analysts, investors and host communities, and is essential to build, protect and enhance our reputation, licence to operate and meet regulatory requirements.
Our Requirements for Risk Management	Provides the framework for risk management relating to climate change and material health, safety, environmental, and community risks.
Our Requirements for Environment and Climate Change	Provides the framework for demonstrating our environmental responsibility by minimizing impacts and contributing to enduring environmental benefits.
Our Requirements for Health	Provides the framework for Health relating to protecting our employees and contractors' health from workplace exposures.
Our Requirements for Health, Safety, Environment and Community Event and Investigation Management	Provides the framework for reporting events, conducting quality investigations and sharing and applying investigation lessons, to eliminate repeat events in our business and close identified gaps in our HSEC framework.
Our Requirements for Health, Safety, Environment and Community Reporting	Provides the framework for reporting, relating to identification and reporting data, that reflects our impact on the supporting workforce and environment.
Our Requirements for Information Governance and Controlled Documents	Provides the framework for Effectively managing records and information.
Our Requirements for Internal Audit	Provides the framework for Internal audits managed by Risk Assessment and Assurance to give assurance to the C-NLOPB, Chief Executive Officer and Executive Leadership Team on the effectiveness of our governance, risk management, and internal control environment.
Our Requirements for Safety	Provides the framework for keeping our people safe.
Our Requirements for Security and Emergency Management	Provides the framework for crisis and emergency management planning.
Our Requirements for Supply	Provides the framework for managing goods and services throughout a project lifecycle.

1.3.3 EIS Project Team

The preparation of this EIS involved BHP's global expertise in exploration drilling with Stantec Consulting Ltd.'s (Stantec) extensive experience conducting EAs in NL, Canada, and internationally.

Well design and operations, drilling wastes and discharges (including drill waste and oil spill modelling inputs), regulatory compliance, spill contingency and response, and communications, involved specialized expertise from BHP's in-house scientists and engineers.

Overall project management for the EIS was provided by Stantec Consulting Ltd. Technical input was provided by the following consultants, and a list of key team members is provided in Appendix C:

- Jay Hartling Consulting Limited
- Wood PLC
- LGL Limited
- RPS Group
- JASCO Applied Sciences

1.4 Benefits of the Project

BHP agrees with the principle that NL should be the primary beneficiary of its offshore resources, and consideration of Canada NL benefits will factor into the planning and execution stages of the program. Activities associated with the BHP exploration drilling program are expected to make a substantial positive contribution to the economy of NL. The project is also expected to contribute to the local pool of knowledge related to deep water drilling technology in the NL offshore that could benefit future drilling programs.

1.4.1 Energy Diversity and Sustainability

Under current plausible scenarios, fossil fuels will continue to be a substantial part of the energy mix for decades. Exploration in the near to midterm time frame is essential to ensuring a stable, reliable and competitively priced supply of energy as the world re-adjusts current consumption rates and moves towards reducing carbon emissions. BHP accepts the Intergovernmental Panel on Climate Change (IPCC) assessment of climate change science, which has found that warming of the climate is unequivocal, the human influence is clear and physical impacts are unavoidable. BHP believes there needs to be an acceleration of effort to drive energy efficiency, develop and deploy low emissions technology and adapt to the impacts of climate change. It is the aim to avoid or, where this is not possible, reduce impacts, while contributing to lasting environmental benefits across the regions where BHP operates. In addition to direct environmental management actions, the company pursues opportunities, such as conservation, to deliver lasting environmental benefits. Climate change is a global challenge that requires a collaborative market and policy response. Playing a part in responding to climate change is a priority governance and strategic issue for BHP. The company`s climate change strategy focuses on reducing operational greenhouse gas (GHG) emissions, investing in low emissions technologies, promoting product stewardship, managing climate-related risk and opportunity, and working with others to enhance the global policy and market response.

The exploration program proposed by BHP is consistent with the company's long-term sustainability strategy. It is also fully aligned with the goals and objectives of the Government of Newfoundland and Labrador's Energy Plan and The Way Forward on Oil and Gas - Advance 2030. Both documents recognize the need for continuous exploration as a key component to a healthy and sustainable industry.

1.4.2 Economic and Employment Benefits

The oil and gas industry in NL accounted for approximately 15.1% of the Province`s gross domestic product in 2016. Direct employment in 2017 was approximately 5,300 person years[1]. The majority of this is attributed to activities in support of the four producing platforms (Hibernia, Terra Nova, White Rose and Hebron). Exploration programs, such as BHP's, provide valuable employment and procurement opportunities over their duration. Equally important, exploration programs provide international validation of the potential for additional discoveries in the NL offshore and the long-term viability of the industry in the province.

BHP was successful in its bid for two parcels in the 2018 Eastern Newfoundland Region land sale. The company bid a total of $822,042,400 (CAD) to carry out exploration activities on two ELs over the initial six years of the nine-year licences terms. The Project could involve the drilling of up to 20 wells from 2019 to 2028. The Project is proposing to contract a mobile drilling unit which will be crewed with between 120 to 150 people. The type of vessel could be either a semi-submersible rig or a specialized drill ship. Some of the numerous contracts required to support the drilling operations will include shore base facility, PSVs, helicopter services, medical services, tubulars, drilling fluids and services, warehousing and customs brokerage, weather forecasting, waste management, regulatory training courses and ice management. These contracts will result in the employment of many people possessing a wide range of skills and knowledge including technical, professional, management and administrative. BHP has established an office in St. John's with a contingent to manage the drilling program. Employment opportunities related to the Project will be communicated on a timely basis using various media strategies such as dedicated Project website, social media, and popular career search sites.

1.4.3 Canada NL Exploration Benefits Plan

BHP is committed to fulfilling its obligations with respect to the statutory requirements outlined in section 45 of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*. Section 45 (2) of this Act requires that before work or activity is undertaken, a Canada-Newfoundland and Labrador benefits plan must be submitted and approved by the C-NLOPB. BHP has a Benefits Plan approved by the C-NLOPB. The exploration benefits plan establishes the policies and procedures to ensure statutory requirements are met and employment and procurement opportunities are maximized to the extent possible. Specifically, BHP commits to providing manufacturers, consultants,

[1] Person years of employment is a type of measurement that takes into account both the number of people working on a project and the amount of time each person spends working on the project. For example, a project that employed 1,000 people for 1 year would contain 1,000 person years of employment. A project that employed 100 people for 10 years would also contain 1000 person years of employment.

contractors, and service companies in the province and other parts of Canada with a fair opportunity to participate on a competitive basis in the supply of goods and services that will be required for the exploration drilling program. BHP also commits to give first consideration for employment and training, consistent with the Canadian Charter of Rights and Freedoms, to individuals resident in the province. BHP recognizes that the statutory requirements will also extend to its contractors and sub-contractors, and as such BHP will establish process and procedures to ensure compliance. BHP commits to working closely with the local business community, governments, educational and training facilities and various other stakeholders to effectively steward the benefits plan and achieve a positive outcome.

1.5 Regulatory Framework and the Role of Government

The following subsections outline the approvals and authorizations under the pertinent regulatory processes required for the Project.

1.5.1 Offshore Regulatory Framework

The C-NLOPB, a joint federal-provincial agency, is responsible for regulating petroleum activities in the NL offshore, and report to the federal and provincial Ministers of Natural Resources. To promote social and economic benefits associated with petroleum exploitation, the Accord Acts were signed in 1986 by the Government of Canada and the Province of NL. The Accord Acts, administered by the C-NLOPB, allow for joint management of offshore oil and gas activities in the region.

Under the Accord Acts, the C-NLOPB manages the rights issuance process on behalf of the federal and provincial governments. Responsibilities of the C-NLOPB include issuing and administering licences for petroleum and exploration (and development) rights; administering statutory requirements regulating offshore exploration, development, and production; and approves Canada-NL benefits and development plans. This involves the management and conservation of offshore petroleum resources, while protecting the environment, the health and safety of offshore workers, and enhancing employment and industrial / economic benefits for NL residents and Canadians.

The C-NLOPB's decision-making processes regarding offshore petroleum activities are governed by a variety of legislation, regulations, guidelines, and memoranda of understanding. An Operations Authorization (OA) is required for exploration drilling programs under the Accord Acts. Prior to issuing an OA, the C-NLOPB requires the following to be submitted:

- An EA Report
- A Canada-Newfoundland and Labrador Benefits Plan
- A Safety Plan
- An Environmental Protection Plan (EPP) (including a Waste Management Plan)
- Emergency Response and Spill Contingency Plans
- Regulatory Financial Responsibility Requirements
- Appropriate certificates of fitness for the equipment proposed for use in the activities

A separate Approval to Drill a Well (ADW) is required for each well in a drilling program, which involves specific details about the drilling program and well design. Specific exploration or development activities are governed by several regulations under the Accord Acts. There are also various guidelines which address environmental, health, safety, and economic aspects of offshore petroleum exploration and development activities, some of which have been jointly developed with the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) and the Canada Energy Regulator (CER) (formerly the National Energy Board [NEB]). Of particular relevance to the EA of this Project are:

- The Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017a)
- The Offshore Waste Treatment Guidelines (OWTG) (NEB et al. 2010)
- The Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands (OCSG) (NEB et al. 2009)

Table 1.4 summarizes key relevant regulations and guidelines that fall under the jurisdiction of the C-NLOPB. This list is intended to be indicative of requirements relevant to this EIS and Project planning but is not intended to represent an exhaustive list of legal and regulatory requirements. These regulations may change during the temporal scope of the Project. BHP will consult with regulators to stay informed of potential changes and updates and will comply with the latest regulation / guidelines at the time of implementation.

Table 1.4 Summary of Key Relevant Offshore Legislation and Guidelines

Legislation / Guideline	Regulatory Authority	Overview	Potentially Applicable Permitting Requirement(s)
Accord Acts (S.C. 1987, c. 3 and R.S.N.L. 1990, c. C-2)	Natural Resources Canada / NL Department of Municipalities and Environment	The C-NLOPB is responsible for interpreting, applying and overseeing provisions of the Accord Acts to the activities of operators in the Canada-NL Offshore Area. The C-NLOPB's role is to manage and conserve the petroleum resources offshore NL in a manner that protects health, safety, and the environment while enhancing economic benefits. Various regulations are established under the Accord Acts in order to govern specific petroleum exploration and development activities.	The regulatory approvals and authorizations identified below may also be required pursuant to section 138(1)(b) of the *Canada-Newfoundland Atlantic Accord Implementation Act* and section 134(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* and the various regulations made under the Accord Acts.
Newfoundland Offshore Petroleum Drilling and Production Regulations (and associated Guidelines)	C-NLOPB	Compliance to these regulations are required when conducting exploratory drilling for and/or production of petroleum, including: • *Certificate of Fitness Regulations* • *Drilling and Production Regulations* • *Marine Installations and Structures Transitional Regulations* • *Marine Installations and Structures Occupational Health*	An OA and an ADW are the primary regulatory approvals necessary to conduct an offshore drilling program, pursuant to the Accord Acts and these regulations. Specific regulations and requirements are detailed below.

Table 1.4 Summary of Key Relevant Offshore Legislation and Guidelines

Legislation / Guideline	Regulatory Authority	Overview	Potentially Applicable Permitting Requirement(s)
		and Safety Transitional Regulations • *Offshore Petroleum Administrative Monetary Penalties Regulations* • *Offshore Petroleum Cost Recovery Regulations* • *Offshore Petroleum Financial Requirements Regulations* • *Oil and Gas Operations Regulations* • *Petroleum Geophysical Operations Regulations* • *Petroleum Installations Regulations* • Safety Plan Guidelines • Incident Reporting and Investigation Guidelines • Physical Environmental Programs Guidelines • Measures to Protect and Monitor Seabirds in Petroleum-Related Activity in the Canada-Newfoundland and Labrador Offshore Area	
Newfoundland Offshore Certificate of Fitness Regulations	C-NLOPB	The requirements for the issuance of a Certificate of Fitness to support an authorization for petroleum exploration in the NL offshore area are outlined in these regulations. The regulations ensure that the equipment and/or installation of exploratory equipment is fit for its purposes and are can be safely operated without threat to persons or the environment in a specified location and timeframe.	Each MODU will require a Certificate of Fitness.

Table 1.4 Summary of Key Relevant Offshore Legislation and Guidelines

Legislation / Guideline	Regulatory Authority	Overview	Potentially Applicable Permitting Requirement(s)
Offshore Waste Treatment Guidelines (OWTG)	CER / C-NLOPB / CNSOPB	Outlined in these guidelines are recommended practices for the management of waste materials from oil and gas drilling and production facilities operating in the Canada-NL Offshore Area. The preparation of the OWTG considers the offshore waste / effluent management approaches of other jurisdictions, as well as available waste treatment technologies, environmental compliance requirements, and the results of environmental effects monitoring (EEM) programs in Canada and internationally. The OWTG specify performance expectations for the following types of discharges: • Emissions to air • Drilling muds and solids • Bilge water, ballast water and deck drainage • Well treatment fluids • Cooling water • Desalination brine • Sewage and food wastes • Water for testing of fire control systems • Naturally occurring radioactive material	Adherence to OWTG
Offshore Chemical Selection Guidelines (OCSG)	CER / C-NLOPB / CNSOPB	These guidelines provide a framework for chemical selection that reduces the potential for environmental effects from the discharge of chemicals used in offshore drilling and production operations. An operator must meet the minimum expectations outlined in the OCSG as part of the authorization for work or activity related to offshore oil and gas exploration and production. Chemicals intended for discharge to the marine environment must meet one of the following: • Be included on the Oslo and Paris Commissions Pose Little or No Risk to the Environment List • Meet certain requirements for hazard classification under the Offshore Chemical Notification Scheme	Adherence to OCSG

Table 1.4 Summary of Key Relevant Offshore Legislation and Guidelines

Legislation / Guideline	Regulatory Authority	Overview	Potentially Applicable Permitting Requirement(s)
		• Pass a Microtox test (i.e., toxicity bioassay) • Undergo a chemical-specific hazard assessment in accordance with United Kingdom Offshore Chemical Notification Scheme models and/or • Have the risk of its use justified through demonstration to the C-NLOPB that discharge of the chemical will meet OCSG objectives.	
Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (Compensation Guidelines) (C-NLOPB and CNSOPB 2017b)	C-NLOPB / CNSOPB	These guidelines describe compensation sources available to potential claimants for loss or damage related to petroleum activity offshore NL and Nova Scotia; and outline the regulatory and administrative roles which the C-NLOPB exercise respecting compensation payments for actual loss or damage directly attributable to offshore operators.	Adherence to Compensation Guidelines
Environmental Protection Plan (EPP) Guidelines (NEB et al. 2011)	C-NLOPB / CNSOPB / CER	These guidelines assist an operator in the development of an Environmental Protection Plan (EPP) that meets the requirements of the Accord Acts and associated regulations and the objective of protection of the environment from its proposed work or activity.	Adherence to Environmental Protection Plan Guidelines
Drilling and Production Guidelines (updated August 2017)	C-NLOPB	These guidelines were developed and implemented by the C-NLOPB and CNSOPB to provide criteria for compliance requirements for operators planning to conduct offshore drilling activities on the east coast of Canada. Offshore oil and gas activities that involve drilling (including exploration and production) must be in compliance with the Drilling and Production Guidelines, in order to attain an ADW and an OA. These guidelines are based on past experiences in offshore oil and gas, legislation from the C-NLOPB, and from industry best practice. These guidelines provide direction and compliance standards for offshore exploration drilling, including, but not limited to: • well approval applications	Adherence to Drilling and Production Guidelines

Table 1.4 Summary of Key Relevant Offshore Legislation and Guidelines

Legislation / Guideline	Regulatory Authority	Overview	Potentially Applicable Permitting Requirement(s)
		• well installations, facilities, support craft • drilling fluid systems • riser specifications • drilling practices • formation flow testing equipment • well control • well casing and cementing design and processes • well abandonment • flaring • surveys • reporting and data requirements The guidelines also cover aspects of production activities, should production be planned in the case of a discovery.	
Canada-Newfoundland and Labrador Exploration Benefits Plan Guidance	C-NLOPB	This document provides an operator engaged in petroleum exploration activities, including geophysical, geotechnical, and drilling, in the Canada-NL Offshore Area with guidance for the preparation of a Canada-Newfoundland and Labrador Benefits Plan (Benefits Plan) which is required under section 45 of the Accord Acts. The guidance also addresses related contracting, expenditure, and employment reporting requirements.	Adherence to Guidance
Geophysical, Geological, Environmental and Geotechnical Program Guidelines (updated June 2019)	C-NLOPB	These Guidelines have been prepared to assist Applicants who wish to conduct geophysical, geological, geotechnical, or environmental programs within the offshore area.	Adherence to Guidelines and associated Geophysical Program Authorization
Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (SOCP)	Fisheries and Oceans Canada (DFO) / Environment and Climate Change Canada (ECCC) / C-NLOPB / CNSOPB	The SOCP specifies the minimum mitigation requirements that must be met during the planning and conduct of marine seismic surveys, in order to reduce effects on life in the oceans. These mitigation measures are also typically applied to walk-away VSP operations and well site surveys. These mitigation requirements focus on planning and monitoring measures to avoid interactions with marine mammal and sea turtle species at risk where possible and reduce adverse effects on species at risk and marine populations.	Adherence to SOCP

Table 1.4 Summary of Key Relevant Offshore Legislation and Guidelines

Legislation / Guideline	Regulatory Authority	Overview	Potentially Applicable Permitting Requirement(s)
Guidelines Respecting Financial Requirements (amended August 2017)	C-NLOPB	Operators wishing to conduct work or activity in the Canada-NL Offshore Area are required to provide proof of financial responsibility in a form and amount satisfactory to the C-NLOPB. These regulations and guidelines provide guidance to operators in providing proof of financial requirements regarding authorization being sought for work or activity relating to drilling, development, decommissioning or other operations in the offshore areas.	Adherence to Guidelines
Other Guidelines	C-NLOPB	Other Guidelines administrated by the C-NLOPB that do or may apply to aspects of offshore exploration programs such as those being proposed as part of this Project include: • Measures to Project and Monitor Seabirds in Petroleum-Related Activity in the Canada – Newfoundland and Labrador Offshore Area • Atlantic Canada Standby Vessel Guidelines • Cost Recovery Guidelines • Data Acquisition and Reporting Guidelines • Incident Reporting and Investigation Guidelines • Measurement Under Drilling and Production Regulations • Monitoring and Reporting • Physical Environmental Programs • Research and Development Expenditures • Safety Plan Guidelines • Transboundary Crewing	Adherence to Guidelines as applicable

1.5.2 Environmental Assessment Requirements

Under certain circumstances, offshore exploration drilling is a designated physical activity subject to the requirements of the CEAA 2012. Section 10 of the *Regulations Designating Physical Activities* under CEAA 2012 includes:

> *The drilling, testing and abandonment of offshore exploratory wells in the first drilling program in an area set out in one or more exploration licences issued in accordance with the Canada-Newfoundland Atlantic Accord Implementation Act or the Canada-Nova Scotia Petroleum Resources Accord Implementation Act.*

The Project will constitute the first drilling, testing, and abandonment of an offshore exploration well within each of the ELs issued to BHP by the C-NLOPB. The CEA Agency determined the requirement for an EA process, under CEAA 2012, and provided EIS Guidelines (Appendix A) to BHP, following submission of the Project Description document (BHP 2019). The EIS Guidelines provide direction in the preparation of this EIS document. C-NLOPB requirements for an EA as part of the OA review process under the Accord Acts will also be satisfied by the completion of this EIS.

Although at the time of submission the new federal *Impact Assessment Act* (IAA) has been implemented, the Project is proceeding under CEAA 2012. Subsection 181(1) of the IAA allows the EA of a designated project by the CEA Agency commenced under CEAA 2012 to continue under that process as long as the notice of commencement was posted before the IAA was enacted (August 28, 2019). Proponents whose projects meet these criteria are permitted to decide if they would prefer to proceed under the CEAA 2012 or IAA process. BHP received it’s notice of commencement on June 28, 2019 and has chosen to remain under the CEAA 2012 process.

1.5.3 Other Applicable Regulatory Requirements

The lands within Canada’s 200 nm EEZ or to the edge of the continental margin are considered the NL offshore area, as defined by the Accord Acts, and are regulated by the C-NLOPB. The Project will be carried out on federal lands under the jurisdiction of the C-NLOPB, as CEAA 2012 defines federal lands as those lands that include the continental shelf of Canada. There is no federal funding involved in this Project.

The Project is potentially subject to various federal legislative and regulatory requirements (Table 1.5), in addition to the OA and ADW from the C-NLOPB pursuant to the Accord Acts, and EA approval under CEAA 2012.

Table 1.5 Summary of Other Potentially Relevant Federal and Provincial Legislation

Legislation	Regulatory Authority	Relevance	Potentially Applicable Permitting Requirement(s)
Canada Oil and Gas Operations Act (R.S., 1985, c. O-7)	Natural Resources Canada	In respect of the exploration for and exploitation of oil and gas, this Act is intended to promote: (a) safety, particularly by encouraging persons exploring for and exploiting oil or gas to maintain a prudent system for achieving safety; (b) the protection of the environment; (c) the safety of navigation in navigable waters; (d) the conservation of oil and gas resources; (e) joint production arrangements; (f) economically efficient infrastructures.	Specific permitting requirements are not anticipated under this legislation. However, new legislation (*Energy Safety and Security Act*; *Regulations Establishing a List of Spill-treating Agents*) will have implications for spill prevention and response (see below).
Canada Shipping Act, 2001	Transport Canada	The *Canada Shipping Act*, 2001 set out the requirements for safety in marine transportation and the protection of the marine environment from damage due to navigation and shipping activities.	Compliance with the Act and its associated regulations is required by PSVs (and the MODU, while in transit).
Canadian Environmental Protection Act, 1999 (CEPA 1999)	ECCC	CEPA,1999 pertains to pollution prevention and the protection of the environment and human health to contribute to sustainable development. Among other items, CEPA 1999 provides a wide range of tools to manage toxic substances, and other pollution and wastes, including disposal at sea.	Disposal at Sea Permit (under the *Disposal at Sea Regulations* pursuant to CEPA 1999) is not anticipated to be required in support of the Project as they have not been required in the past for exploration drilling projects.
Energy Safety and Security Act (S.C. 2015, c. 4)	Natural Resources Canada	The *Energy Safety and Security Act* aims to strengthen the safety and security of offshore oil production through improved oil spill prevention, response, accountability, and transparency and amends the Accord Acts and the *Canadian Oil and Gas Operations Act* with the intent of updating, strengthening and increasing the level of transparency of the liability regime that is applicable to spills and debris in the offshore areas. The Act also promotes harmonization of the EA process for offshore oil and gas projects and includes provisions to allow the offshore petroleum boards to enable them to conduct EAs under CEAA 2012.	Financial Responsibility and Financial Resources requirements have increased. Specific additional relevance to be determined, but likely to have specific implications for spill prevention and response.

Table 1.5 Summary of Other Potentially Relevant Federal and Provincial Legislation

Legislation	Regulatory Authority	Relevance	Potentially Applicable Permitting Requirement(s)
Fisheries Act	DFO / ECCC (administers section 36, specifically)	The updated *Fisheries Act* contains provisions for the protection of all fish and fish habitats, restores the prohibition against harmful alteration, disruption or destruction (HADD) of fish habitat, prohibits activities that cause the "death of fish" (other than fishing activities), considers the cumulative effects of development activities, and provides improved protection of highly productive, sensitive, rare or unique fish and/or fish habitats	Authorization from the Minister of Fisheries and Oceans under section 35(2) of the *Fisheries Act* has not been required in the past for offshore exploration drilling projects. A HADD Authorization may now be required.
Migratory Birds Convention Act, 1994 (MBCA 1994)	ECCC	Under the MBCA 1994, it is illegal to kill migratory bird species not listed as game birds or destroy their eggs or young. The Act also prohibits the deposit of oil, oil wastes or other substance harmful to migratory birds in waters or area frequented by migratory birds.	A Migratory Bird Handling Permit will likely be required under section 4(1) of the *Migratory Birds Regulations* pursuant to the MBCA 1994 to permit the salvage of stranded birds on offshore vessels during the Project.
Canadian Navigable Waters Act (CNWA)	Transport Canada	The CNWA came into force in August 2019 and replaced the former *Navigable Protection Act*. The CNWA applies to anyone planning something that will affect navigation in navigable waters. The CNWA has been expanded to regulate major works and obstructions on all navigable waters, even those not on the schedule and creates a new category for "major" works. "Major works" are those likely to substantially interfere with navigation and will require approval from Transport Canada. Transport Canada administers the CNWA through the Navigation Protection Program.	No applicable permitting requirements have been identified for the Project, as the Project Area is located offshore, outside of the Scheduled Waters specified in the NPA.
Oceans Act	DFO	The *Oceans Act* provides for the integrated planning and management of ocean activities and legislates the marine protected areas program, integrated management program, and marine ecosystem health program. Marine protected areas are designated under the authority of the *Oceans Act*.	No applicable permitting requirements have been identified for the Project.

Table 1.5 Summary of Other Potentially Relevant Federal and Provincial Legislation

Legislation	Regulatory Authority	Relevance	Potentially Applicable Permitting Requirement(s)
Species at Risk Act (SARA)	DFO / ECCC / Parks Canada	SARA is intended to protect species at risk in Canada and their "critical habitat" (as defined by SARA). Section 32 of SARA provides a complete list of prohibitions. The main provisions of the Act are scientific assessment and listing of species, species recovery, protection of critical habitat, compensation, permits and enforcement. The Act also provides for development of official recovery plans for species found to be most at risk, and management plans for species of special concern. Under SARA, operators are required to complete an assessment of the environment and demonstrate that no harm will occur to listed species, their residences or critical habitat or identify adverse effects on specific listed wildlife species and their critical habitat, followed by the identification of mitigation measures to avoid or reduce effects. Activities must be in compliance with SARA.	Under certain circumstances, the Minister of Fisheries and Oceans may issue a permit under section 73 of SARA authorizing an activity that has potential to affect a listed aquatic species, its identified critical habitat, or the residences of its individuals. However, such a permit is not anticipated to be required in support of this Project.
Regulations Establishing a List of Spill treating Agents (SOR/2016-108)	ECCC	The Minister of the Environment has determined that certain spill-treating agents (as listed in the Regulations) are acceptable for use in Canada's offshore. As a result, the C-NLOPB is able to authorize the use of one or more of the two spill-treating agent products listed in Schedule 1 of the Regulations to respond to an oil spill.	Specific implications for spill prevention and response, should BHP request to deploy dispersants in the unlikely event of an oil spill.
NL *Endangered Species Act* (NL ESA)	NL Department of Fisheries and Land Resources	The NL ESA provides special protection for native plant and animal species considered to be endangered, threatened or vulnerable in the province.	No applicable permitting requirements have been identified for the Project.
Seabird Ecological Reserve Regulations (NLR 66/97)	NL Department of Fisheries and Land Resources	These regulations prohibit or limit industrial development and certain activities that can cause disturbance to breeding seabirds, including hiking, boat traffic and low-flying aircraft near the colonies during the breeding season, and the use of ATVs at all times.	PSVs and helicopters will comply with regulatory requirements. No applicable permitting requirements under the *Seabird Ecological Reserve Regulations* have been identified for the Project.

1.6 Applicable Guidelines and Resources

Other applicable guidelines and resources that the Project may be subject to, will be used to inform the EA process, including government guidelines, Indigenous engagement guidelines, and other relevant studies.

1.6.1 Government Guidelines and Resources

In addition to the EIS Guidelines (CEA Agency 2019) developed for the Project (Appendix A), the EIS preparation also used other guidance developed by the CEA Agency and federal government:

- The Operational Policy Statement, Addressing "Purpose of" and "Alternative Means" under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2015a) was consulted with respect to the assessment of Project alternatives (refer to Section 2.8)
- The Operational Policy Statement, Determining Whether a Designated Project is Likely to Cause Significant Environmental Effects under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2015b) was considered in defining criteria or established thresholds for determining the significance of residual adverse environmental effects
- The Operational Policy Statement, Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2016a) was taken into consideration during the development of the cumulative effects assessment scope and methods
- The Agency's Technical Guidance for Assessing Physical and Cultural Heritage or any Structure, Site or Thing that is of Historical, Archaeological, Paleontological or Architectural Significance under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2015c) was consulted with respect to the consideration of effects on heritage and culture
- The Agency's Technical Guidance for Assessing the Current Use of Lands and Resources for Traditional Purposes under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2016b) was consulted with respect to the consideration of effects on Indigenous Peoples
- Environment and Climate Change Canada-Canadian Wildlife Service's Oiled Birds Protocol and Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada (ECCC 2016)
- Health Canada's Useful Information for Environmental Assessments (Health Canada 2010) was consulted with respect to the consideration of effects on quality, noise and Aboriginal health

1.6.2 Aboriginal Policies and Guidelines

Pertinent guidelines which influenced the EA process with respect to Indigenous engagement include:

- Aboriginal Consultation and Accommodation - Updated Guidelines for Federal Officials to Fulfill the Duty to Consult (Aboriginal Affairs and Northern Development Canada 2011)
- Reference Guide: Considering Aboriginal Traditional Knowledge in Environmental Assessments Conducted Under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2015d)
- The Government of Newfoundland and Labrador's Aboriginal Consultation Policy on Land and Resource Development Decisions (Government of NL 2013)

1.6.3 Other Relevant Studies

There are approximately 35 years of environmental assessment of Newfoundland offshore oil and gas activities. Key studies relevant to the assessment of this Project include:

- West Flemish Pass Exploration Drilling Project Environmental Impact Statement (Chevron Canada 2019)
- The Newfoundland Orphan Basin Exploration Drilling Program Environmental Impact Statement (BP Canada Energy Group ULC 2018)
- Exploration Drilling Environmental Impact Statement (Husky Energy 2018)
- Orphan Basin Exploration Drilling Program Environmental Assessment (LGL 2005)
- Flemish Pass Exploration Drilling Project (Statoil Canada Ltd 2017)
- Eastern Newfoundland Offshore Exploration Drilling Project (ExxonMobil Canada Properties 2017)
- Flemish Pass Exploration Drilling Project (Nexen Energy ULC 2018)
- Eastern Newfoundland Strategic Environmental Assessment (AMEC 2014)
- White Rose Extension Project Environmental Assessment (Husky Energy 2012)
- Environmental Assessment of Statoil Hydro Canada Ltd. Exploration and Appraisal / Delineation Drilling Program for Offshore Newfoundland, 2008-2016 (LGL 2008)
- Husky Delineation / Exploration Drilling Program for Jeanne d'Arc Basin Area, 2008-2017, Environmental Assessment (LGL 2007)
- Hebron Project Comprehensive Study Report (ExxonMobil Canada Properties 2011)

In the preparation of this EIS, the above reports, as well as other relevant studies, and peer-reviewed literature have been reviewed and referenced including the Strategic Environmental Assessment (SEA) (i.e., Eastern Newfoundland Strategic Environmental Assessment (AMEC 2014), completed by the C-NLOPB. The Project will take place on lands that are currently undergoing a regional assessment by the CEA Agency under sections 73-77 of CEAA 2012. The regional assessment was submitted to the Minister of ECCC in January 2019, but as of submission of this EIS, regulations regarding its use by offshore oil and gas proponents have not been enacted.

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2.0 PROJECT DESCRIPTION

This section provides key contextual information on the Project in support of this Environmental Impact Statement (EIS). This section provides the rationale and need for the Project, describes the location and nature of Project components and activities, including the management of emissions, discharges and other wastes that would likely be generated by the Project. This section also provides detail on required personnel, Project schedule, and examines alternative means for carrying out the Project. Information is also provided on BHP's environmental management systems, policies, and best practices.

2.1 Rationale and Need for the Project

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) awarded exploration rights to exploration licence (EL) 1157 and EL 1158 to BHP on January 15, 2019 with an aggregate work expenditure bid of $822,042,400 (CAD). BHP is currently the sole shareholder and operator for these ELs. The issuance of an EL confers the exclusive right to drill and test for petroleum within the EL. Exploration licenses issued by the C-NLOPB have a maximum nine-year term (consisting of two consecutive periods), when the interest owner is required to drill one exploratory well on or before the expiry date of Period I as a condition of obtaining tenure to Period II. Period I is six years from January 15, 2019 to January 15, 2025 and Period II immediately follows with an expiry date of January 15, 2028.Therefore, the temporal scope of the Project extends to 2028.

Important geological formations and hydrocarbon reserves are potentially present in the Orphan Basin covered by BHP's ELs. Geophysical data has been collected for the region, but exploration drilling is required to determine the presence, nature, and quantities of the potential hydrocarbon resources within the ELs. The exploration drilling program also presents an opportunity for BHP as operator, to fulfill their work expenditure commitments that must be met over the term of the EL period.

The exploration drilling Project is expected to result in economic, social, and technological benefits realized from local to national scales, as detailed in Section 1.4, including a potential contribution to energy diversity and supply. As oil and natural gas developments are expected to play an important part in meeting global energy demand for several decades, exploration, such as that proposed by BHP, is a critical activity to enable continued oil and gas discoveries and maintain production to meet demand.

2.2 Project Location

The Project is in offshore eastern Newfoundland in the Orphan Basin area. BHP is proposing to drill up to 20 exploration or appraisal wells (i.e., between one and ten wells in either, or both, ELs) within EL 1157 and EL 1158. The ELs cover an area of approximately 543,378 ha, and is located approximately 350 km from St. John's, Newfoundland (NL) (Figure 2-1). Water depths within EL 1157 and EL 1158 range between 1,175 and 2,575 m (Table 2.1). Corner coordinates for the Project Area and two ELs are provided in Tables 2.2 and 2.3.

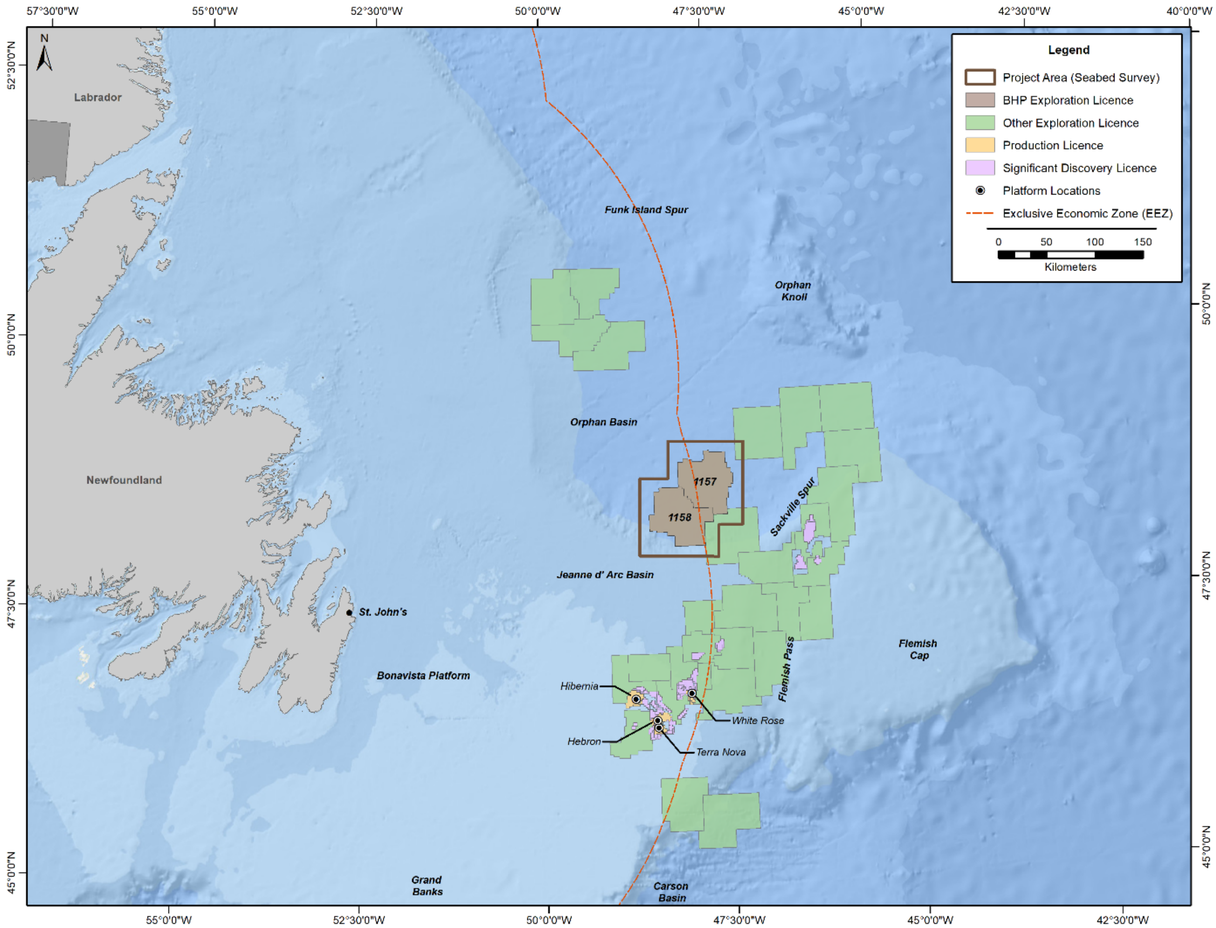


Figure 2-1 Project Location

Table 2.1 Summary of BHP Exploration Licence off Eastern Newfoundland

Exploration Licence	Approximate Distance from St. John's, NL (km)[A]	Licence Area (ha)	Approximate Water Depth (m)[B]	
			Max	Min
EL 1157	366	269,799	2,575	2,150
EL 1158	324	273,579	2,265	1,175

[A] Distance from the nearest point of the EL to St. John's
[B] Depth values taken from GEBCO, 2019 with a spatial resolution of 30 arc seconds

Table 2.2 Project Area and Exploration Licence Coordinates

Decimal Degrees		UTM, Zone 22, NAD83	
Latitude	Longitude	Easting	Northing
-47.0133	49.2067	790352	5458086
-47.0873	48.2562	790397	5352179
-47.4209	48.2672	765583	5352187
-47.4418	47.9651	765589	5318554
-48.8121	48.0014	663202	5318774
-48.7729	48.9048	663202	5419259
-48.3778	48.8965	692179	5419259
-48.3594	49.2454	692179	5458086

Table 2.3 Exploration Licence Coordinates

Exploration Licence	Degrees Minutes[1]	
	Latitude	Longitude
EL 1157	48°30'N	47°15'W
	48°30'N	47°30'W
	48°40'N	47°15'W
	48°40'N	47°30'W
	48°40'N	47°45'W
	48°40'N	48°00'W
	48°50'N	47°15'W
	48°50'N	47°30'W
	48°50'N	47°45'W
	48°50'N	48°00'W
	49°00'N	47°15'W
	49°00'N	47°30'W
	49°00'N	47°45'W
	49°00'N	48°00'W
	49°10'N	47°15'W
	49°10'N	47°30'W
EL 1158	48°20'N	47°45'W
	48°20'N	48°00'W
	48°20'N	48°15'W
	48°20'N	48°30'W
	48°30'N	47°30'W
	48°30'N	47°45'W
	48°30'N	48°00'W
	48°30'N	48°15'W
	48°30'N	48°30'W

Table 2.3 Exploration Licence Coordinates

Exploration Licence	Degrees Minutes[A]	
	Latitude	Longitude
EL 1158 (cont'd)	48°40'N	47°30'W
	48°40'N	47°45'W
	48°40'N	48°00'W
	48°40'N	48°15'W
	48°50'N	48°00'W
	48°50'N	48°15'W

Note:
Coordinates provided by C-NLOPB Land Registry,
[A] North American Datum 1927

The Project will take place on lands that are currently undergoing a regional assessment by the Canadian Environmental Assessment Agency (CEA Agency) under sections 73-77 of *Canadian Environmental Assessment Act, 2012* (CEAA 2012). The regional assessment was submitted to the Minister of Environment and Climate Change Canada (ECCC) in January 2020, but as of submission of this EIS regulations regarding its use by offshore oil and gas proponents have not been enacted. Information on the existing physical, biological, and socio-economic characteristics of the Project Area can be found in Chapters 5, 6 and 7, respectively.

As Project planning moves forward specific well site locations will be selected within the two ELs, which are contained within the Project Area (Figure 2-1) and Regional Assessment Area (RAA) boundaries (outlined in Chapter 4).

2.3 Project Components

The mobile offshore drilling unit (MODU) and offshore exploration wells are the main physical components of the Project. The Project also includes logistics support for servicing and supplying offshore activity. Logistics-related components include Project support vessels (PSVs) and helicopters for the transportation of personnel and equipment, the heliport and a supply base in eastern Newfoundland.

The offshore exploration well components are the only new infrastructure that will require construction as part of the Project. Other Project components, including the MODU, PSVs, helicopters, and supply base are pre-existing and will be used by the Project on a temporary basis through contractual arrangements.

2.3.1 Mobile Offshore Drilling Unit

The selection of the MODU generally depends on the nature of the physical environment of the well site (e.g., water depth, meteorological and physical oceanographic conditions), and logistical considerations (e.g., MODU availability). In deep waters, such as in the Orphan Basin, a semi-submersible drilling unit or drillship will be required (Figure 2-2). Jack-up rigs have also been used in the eastern Canadian offshore but are unable to operate in the water depth in the ELs. BHP has not yet selected the MODU that will be used to drill each well for the Project and it is likely that, in consideration of MODU availability over the life of the Project, different MODUs may be used, including both a semi-submersible drilling unit and/or a drillship, for separate drilling campaigns during the licence term.

Source Schofield Publishing 2007

Figure 2-2 Illustration of Drill Ship (front) and Semi-submersible (back)

2.3.1.1 Semi-Submersible Drilling Unit

A semi-submersible drilling unit is designed for drilling in rough seas and can either be towed to the drill site or move under their own power. The unit is characterized by a lower hull of separate pontoons with vertical columns supporting a large upper deck. The upper deck contains drilling equipment, equipment and material storage areas, and accommodation. During drilling operations, the lower hull is submerged to a selected depth using a ballast system. The semi-submersible's configuration reduces the environmental loading compared to a ship-shaped hull, providing a relatively stable platform for drilling operations.

Given the location and water depths of the Project, the selected MODU will employ a dynamic positioning (DP) system for positioning, rather than using anchors. During DP mode, the MODU maintains position using thrusters positioned on the hulls, which are controlled by a computerized DP system using global positioning system (GPS) and acoustic positioning data. This system is used to improve positioning accuracy and redundancy to keep the MODU in its intended position.

Figure 2-3 is a photo of the *West Aquarius*, a representative semi-submersible that has operated in the Canada-NL Offshore Area.

Source: Seadrill 2017

Figure 2-3 *West Aquarius Semi-Submersible*

2.3.1.2 Drillship

Drillships are the most mobile type of MODU and are typically used in areas with deep water. These ships contain complete drilling systems and are largely self-contained. They are able to operate in remote locations with limited support. Drillships are different from typical offshore vessels, such as cargo vessels, by the presence of a drilling package and a moon pool. The moon pool is an opening in the bottom of the hull, which allows direct access to the water, enabling drilling equipment on the vessel to connect to equipment on the seafloor to drill the well.

DP would be used to maintain position and rotate the ship over well center and to head the ship into prevailing weather, following shifts in wind or wave direction to reduce the pitch and roll motion.

Figure 2-4 is a photo of the Stena *IceMax*, owned by Stena Drilling, which has operated in the eastern Canadian offshore.

Source Stena Drilling 2017

Figure 2-4 Stena *IceMax* - Example of a Drill Ship

2.3.1.3 MODU Selection and Approval Process

BHP will select a MODU based on regulatory compliance, water depths, meteorological and physical oceanographic conditions, technical capabilities of the MODU, price competitiveness, and mobility requirements. The specific characteristics of MODUs used for this Project may vary depending on the specific well sites identified and other factors. A Certificate of Fitness will be obtained for the MODU from an independent third-party Certifying Authority before commencement of drilling operations in accordance with the *Newfoundland Offshore Certificate of Fitness Regulations*. At a minimum, the MODU must satisfy the operational requirements listed in Table 2.4.

Table 2.4 Operational requirements for MODU

Permanent Equipment	Purpose
Subsea Equipment	Includes well control equipment such as a blowout preventer (BOP), marine riser, and control system. BOPs are devices used to seal and control the release of formation fluids*. They are installed on the wellhead, located just above the mudline. The riser acts as a conduit from the BOP to the MODU.
Ballast Control	Used to maintain MODU stability during operations.
Station Keeping	DP maintains the position of the MODU under a range of environmental conditions. DP systems consist of thrusters (propellers) and sensors to monitor the weather conditions and MODU position. Thrusters are automatically controlled by the DP system.
Drilling Derrick	Support structure to contain the drilling rotating equipment and move the drill string in and out of the wellbore.
Drilling Package	Includes top drive, drawworks, rotary table, heave compensator, and tubular make up/handling equipment.

Table 2.4 Operational requirements for MODU

Permanent Equipment	Purpose
Power Generation System	Diesel-driven engines and alternating current (AC) generators which are used to operate the equipment on board the MODU. Includes MODU emergency power system.
Helicopter Deck and Refueling Station	Helideck for safe landings and departures of helicopters for transfer of personnel and equipment. Includes refueling station.
Cranes	To transfer equipment between MODU and PSVs and to move equipment safely around the MODU. Includes pedestal / revolving type and monorail overhead cranes.
Storage	Provides areas to house drilling equipment and materials. Includes bulk storage of liquids including drill water, synthetic base fluid, drilling fluid, fuel and solids such as bentonite, barite, and cement. Includes storage for petroleum products on board • Fuel oil tank (approximately 3,000 to 11,000 m³) • Base oil tank (approximately 650 m³) • Diesel oil service tanks (up to 6; total capacity approximately 300 m³) • Lube oil storage tanks (approximately 20 m³) • Helifuel storage tanks (up to 3 tanks store on MODU; 2,900 L capacity per tank)
Waste Management Facilities	Enables offshore treatment or temporary storage of waste before treatment or shipment back to shore for processing.
Emergency and Life Saving Equipment	Includes firefighting equipment, and lifeboats and rafts for emergency evacuation.
Solids Control / Fluids	Includes mud pumps, shale shakers, and high-pressure pipework circulating system.
Accommodation	Inclusive of welfare facilities, such as sleeping, washing, toilet and mess facilities, and recreational facilities and medical facilities. Accommodation facilities will be provided for a maximum of 180-200 persons on board. Potable water will be provided through an onboard desalinization unit and/or bottled water. Daily estimates for offshore potable water use range from approximately 27.2 m^3 to 136 m^3 for 200 persons, although the actual number of persons on board would likely be closer to 120-150.

* Formation fluids are liquid or gas that occurs in the pores of a rock or geological formation. Strata containing different fluids, such as various saturations of oil, gas and water, may be encountered in the process of drilling an oil or gas well (Schlumberger 2019).

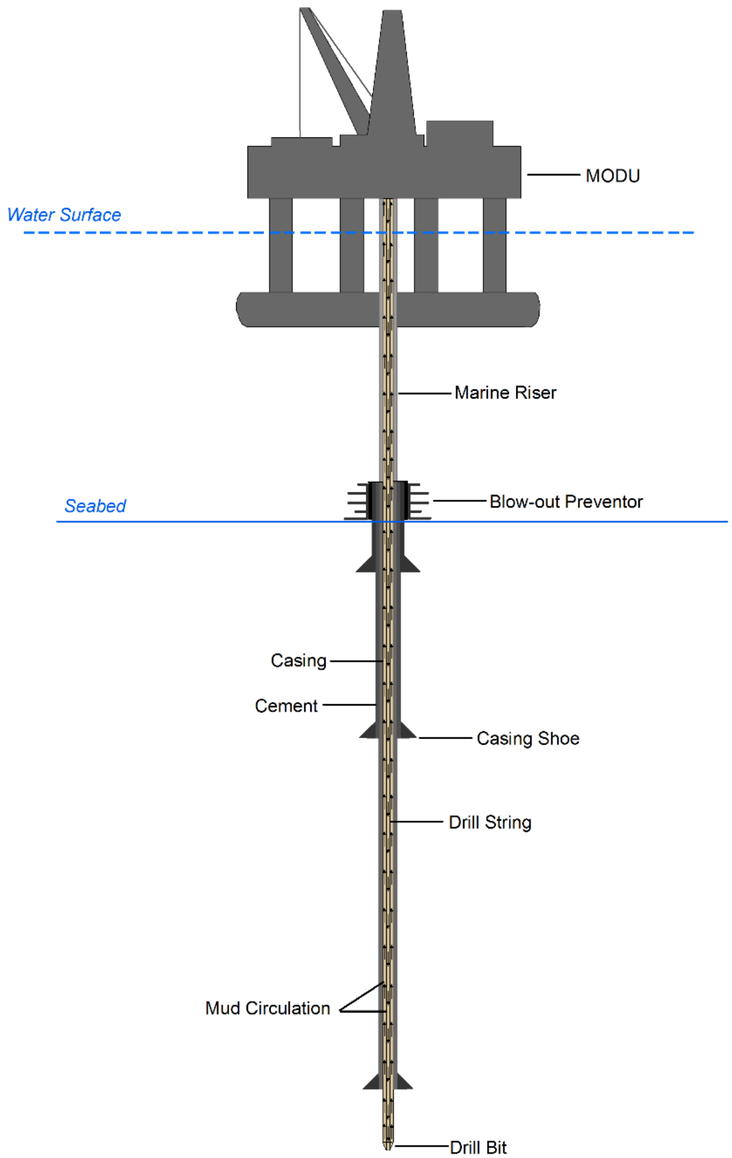
2.3.2 Offshore Exploration Wells

The Project includes drilling of up to 20 wells (exploration or appraisal) within the two ELs that comprise the Project Area over its 9-year duration (2019-2028), with an initial well as early as 2021. Specific well site locations are not currently defined and will be selected as Project planning and design activities move forward. Water depth, reservoir potential and geological properties are considerations in determining well location and design. As part of the operations authorization (OA) and approval to drill a well (ADW) applications, individual well designs will be submitted for approval to the C-NLOPB.

It is anticipated that each well will be drilled in sections over a period of 35 to 115 days, where each section is gradually reduced in size (Figure 2-5, Table 2.5). Once the sections are drilled, steel pipe or casing is inserted and cemented into place to line the wellbore. The casing is a series of pipes which give structure to the wellbore and preventing the formation from caving into the wellbore. The casing also helps to control formation fluids, pressure and manage drilling fluids. Additional details on drilling activities are provided in Section 2.4.1.2.

Table 2.5 Typical Well Design for Various Water Depths

Well Section Name	Hole Size	Casing / Liner Size	True Vertical Depth (TVD) below mudline	Drilling Fluid
Wells in 1,200 m water depth				
Conductor	42” (1,067 mm)	36” (914 mm)	±90 m	Seawater / Water-based mud (WBM)
Surface	26” (660 mm)	22” (559 mm)	±700 m	Seawater / WBM
Intermediate #1 *(contingency)*	21 ½” (546 mm) or 19” (483 mm)	18” (457 mm) or 16” (406 mm)	±1,700 m	Synthetic-based mud (SBM)
Intermediate #2	16 ½” (419 mm)	13 5/8” (346 mm) or 14”	±2,650 m	SBM
Intermediate #3 *(contingency)*	14” (356 mm)	11-7/8” (302 mm)	+/- 3,150 m	SBM
Production	12 ¼” (311 mm)	N/A	±3,350 m	SBM
Wells in 2,500 m water depth				
Conductor	42” (1,067 mm)	36” (914 mm)	±90 m	Seawater / WBM
Surface	26” (660 mm)	22” (559 mm)	±700 m	Seawater / WBM
Intermediate #1 *(contingency)*	21 ½” (546 mm) or 19” (483 mm)	18” (457 mm) or 16” (406 mm)	±1,700 m	SBM
Intermediate #2	16 ½” (419 mm)	13 5/8” (346 mm) or 14” (356 mm)	±2,650 m	SBM
Intermediate #3 *(contingency)*	14” (356 mm)	11-7/8” (302 mm)	+/- 3,150 m	SBM
Production	12 ¼” (311 mm)	N/A	±3,750 m	SBM



Note: For general illustration only, MODU and well components not to scale. (Additional intermediate casing strings/liners may be installed, depending on well-specific conditions and detailed well design). Diagram by Wood.

Figure 2-5 Conceptual Diagram of a Typical Offshore Exploration/Appraisal Well

2.3.3 Supply and Servicing

Supply and servicing provide transportation and movement of equipment and personnel to the MODU to maintain sufficient resources, including equipment and personnel, for reliable ongoing drilling operations. PSVs, helicopters, and shore-based facilities are the primary components for supply and servicing. Additional details on supply and servicing activities are provided in Section 2.4.5.

It is expected that offshore PSV and aircraft (helicopter) services for the Project will be based in eastern Newfoundland. In accordance with the EIS Guidelines (CEA Agency 2019), activity within the supply base is not considered within the scope of this EIS. Existing facilities will be used for these purposes, as well as for the supply and disposal of materials such as drilling fluids, for fueling and other supply, support and logistical functions. Aircraft support for the Project will be based at the St. John's International Airport.

These existing shore-based facilities are owned and operated by third-party service providers, service multiple operators and their activities, and operate in accordance with relevant regulatory requirements and approvals. Port facilities are certified as compliant port facilities under the *Marine Transportation Security Act*. Third-party services and support will be procured through a competitive bid process in accordance with the Accord Acts. It is not expected that the Project will result in BHP owned/operated or BHP-specific upgrades to such facilities, nor the development and use of new infrastructure at these established shorebase facilities. Helicopters and PSVs will be owned and operated by third-party service providers and will be used to support the Project on a temporary basis through contractual arrangements. The MODU will be equipped with a helideck for safe landings.

PSVs for the Project are not currently identified but will be selected for their capacity for supplies and equipment transportation, waste transportation, emergency response assistance, ice management, and safety zone monitoring around the MODU. Two or three PSVs will likely be required in total in service of the exploration drilling activities. A standby vessel will remain on at the MODU during drilling activities if operational assistance or emergency response support is required. Vessels will undergo inspections/audits inclusive of the C-NLOPB pre-authorization inspection process in preparation for the Project. Vessels used for standby will be compliant with Atlantic Canada Standby Vessel Guidelines (C-NLOPB and Canada Nova Scotia Offshore Petroleum Board (CNSOPB) 2018).

The PSVs used for the Project will be equipped for safe all-weather operations. Although it is BHP's preference to operate in ice-free months, measures will be in place to reduce icing hazards on PSVs including reducing speed in heavy seas, and covering deck machinery where possible, moving objects that may prevent deck drainage, making vessels as watertight as possible, and manual removal of ice if required (Fisheries and Oceans Canada (DFO) 2012). PSVs contracted by the Operator will be required to have valid marine certification (i.e., Certification of a PSV as a Passenger Vessel from Transport Canada) and meet regulatory requirements as set out by Canada and international organizations. PSVs will meet Operator marine-vessel vetting requirements and additional inspections / audits, including the C-NLOPB pre-authorization inspection process in preparation for the Project.

Helicopters will be used to transfer personnel and light supplies to and from the MODU and land. These will also be used for emergency support services, including medical evacuation from the MODU. Dedicated search and rescue helicopters will support response operations in the event of an emergency. Additional details on supply and servicing are provided in Section 2.4.5.

2.3.4 Well Control and Blowout Prevention

Mechanical measures and barriers (e.g., steel casing, drilling fluids, BOP, cement) will be implemented as part of the well design, and drilling and monitoring procedures, and are also used to control formation pressure. Formation pressures are managed to prevent a blowout that may occur when specific well control barriers have failed. A blowout is the uncontrolled flow of formation fluids that occurs when formation pressure exceeds the hydrostatic pressure applied to by the column of drilling fluid, followed by the failure of secondary well control measures to contain the formation pressure (e.g., BOP failure).

The BOP is a mechanical device designed to seal off the wellbore at the wellhead on the seafloor when required. The system is comprised of multiple ram types and annular preventers that are the closing and sealing component of the BOP. Rams are pistons that move horizontally across the top of the wellbore and create a seal around the drill string. Three types of rams that will be installed in the BOP include blind shear, casing shear, and pipe rams. Blind shear rams can be used to either to shear certain drill string components and for a wellbore seal or seal the wellbore when no pipe is present. Casing shear rams fulfill the same purpose but are used to shear casing. Pipe rams seal around the drill pipe when closed. Annular preventers are large rubber elements valves installed above the ram preventers that can also be used to physically close off the wellbore around various sizes of pipe.

The BOP is capable of being activated from various locations on the MODU and is used immediately upon indication of a well control event (called a well kick). A kick is the entry of formation fluid into the wellbore during drilling that may lead to a blowout if not controlled. The BOP will be pressure tested on the MODU deck before installation on the well, and then again following installation on the well to test the wellhead connection with the BOP and operability on the seafloor. In addition to the deck and installation tests, the BOP and other pressure control equipment are tested regularly and recorded in accordance with the Drilling and Production Guidelines (CNSOPB 2017).

When the BOP is installed, remotely operated vehicle (ROV) intervention capability for operating the BOP will also be tested by physically engaging the ROV control panels to test functionality. The BOP will only be removed once the well has been plugged and abandoned.

Additional details on blowout prevention and emergency response measures and strategies are presented in Section 15.5.

2.4 Project Activities

This section describes the routine activities associated with the Project. These are grouped at a high level into the following activities:

- Presence and Operation of the MODU
- Vertical seismic profiling (VSP)
- Well Testing and Flaring
- Well Decommissioning and Abandonment or Suspension
- Supply and Servicing Operations

Emissions, discharge, and waste will result from the Project. These are discussed in Section 2.7. Wellbore control and blowout prevention are discussed in Section 2.3.4, as well as in Chapter 15.

2.4.1 Presence and Operation of the MODU

2.4.1.1 MODU Mobilization and Presence

Before commencing offshore activities, the Project will require regulatory approvals including for each individual drilling campaign within it. After permits, regulatory approvals, and authorizations have been obtained, the MODU will be mobilized to the planned drilling location. In preparation for MODU arrival at the well location, positioning transponders may be placed on the seabed and met-ocean equipment (wave rider and current meters) may be deployed. The MODU will move self-propelled to the planned drilling location or through towing by PSVs. Positioning and stability operations will occur upon arrival at the drilling location and include MODU ballasting operations and use of the DP system to maintain position. The DP system monitors for on-site environmental conditions (e.g., currents, waves and wind) and compensates using a series of computer managed thrusters to maintain position above the wellhead.

Specific well site locations within the two ELs are not currently defined. Drill sites will be selected to optimize the potential discovery of hydrocarbon reservoirs, with sites located according to several factors, including:

- Geophysical data
- Geohazard data
- Seabed existing conditions, including environmental sensitivities and anthropogenic features
- Regional well data

Before drilling, a seabed survey will be carried out on the well site(s) to confirm if environmental (e.g., corals and sponges) or anthropogenic sensitivities are present (e.g., seabed cables). These data will also be used to inform discussions on monitoring associated with drilling waste discharges. This survey(s) will be regulated under a separate environmental assessment (EA) according to C-NLOPB requirements and not within the scope of the EIS.

If a well is successful (i.e., hydrocarbons are discovered), vessels may be required to complete geophysical surveys (high resolution geophysical data acquisition) and geotechnical sampling (geotechnical coring). This is included in the scope of the Project. Two dimensional / three dimensional (2D / 3D) seismic surveys are not planned as part of the Project.

Throughout the duration of an offshore drilling program in the Canada-NL Offshore Area, other marine vessel traffic is restricted within a defined area surrounding the drill unit as a safety precaution. As specified in the *Newfoundland Offshore Petroleum Drilling and Production Regulations*, this safety zone will be a 500 m radius of the MODU (approximately 1 km^2). The safety zone is monitored by a standby vessel, and Notices to Mariners and other measures are also used to continuously communicate the presence and nature of these drilling activities and associated safety zones to other vessels and marine operations in the area (see Chapter 3). These publications are not restricted to Canadian use and are accessible by members of the international community who may be navigating inside and outside the exclusive economic zone. Details of the safety zone will also be communicated during ongoing consultations with Indigenous and non-Indigenous fishers.

2.4.1.2 Drilling

After MODU mobilization and preparatory activities are completed, the offshore exploration well will then be progressively drilled in sections over a period of 35-115 days. In each drilled section, the well bore is gradually reduced in size (Figure 2-5). Once the sections are drilled, steel pipe or casing is installed and cemented into place to stabilize the well bore, isolate pressure / fluids and prevent drilling fluid losses. This process is described in the following steps:

1. Riserless Hole Sections: For the first two to three hole sections, there is no closed loop circulating system in place (no riser) so the drilling fluids and cuttings are circulated onto the seabed The drilling fluid is used to cool the bit and transport the drilled cuttings to the seabed, and typically seawater and/or water-based drilling mud (WBM) is used during the drilling of these riserless hole sections. The riserless hole sections are comprised of the following activities:
    a. The largest hole section, approximately 1 m in diameter, is drilled to approximately 100 m below mud line (BML)
    b. The conductor casing and low-pressure wellhead housing are installed and cemented into place. Generally, the top of cement is brought to the mudline (seabed)
    c. Sometimes a second conductor hole section is drilled below the conductor casing, but this is not usually required in this region
    d. Next, the 660 mm surface hole section is drilled, generally to depths of 700 to 1,000 m BML
    e. The surface casing and high-pressure wellhead housing are installed. The surface casing is cemented into place. Generally, the top of cement is brought to the mudline
    f. The BOP is run on the marine riser pipe and is connected to the wellhead system, creating a conduit between the MODU and the well. The BOP comprises a system of high-pressure valves that prevents water or hydrocarbons from escaping into the environment in the event of a loss of primary well control during drilling (see Section 2.3.4)
2. Riser Drilling: Once the riser is installed, the remainder of the hole sections may be drilled with WBM or SBM. The riser creates a conduit for the circulation of drilling fluids down the drill string, through the bottom hole assembly / drill bit, back up the open hole / casing annulus to the riser annulus and back to the MODU. Drilled cuttings are also transported back up the annulus to the MODU for processing. At various intervals, depending on pore pressure, formation fracture gradient and presence of geohazards, intermediate casing strings or liners are installed and cemented in place. Drilled cuttings and drilling mud fluid use, treatment and eventual disposal, as permitted by, and in accordance with, the Offshore Waste Treatment Guidelines (OWTG) (NEB et al. 2010), are discussed further in Section 2.7.2.

Drilling muds are used to lubricate and cool drill bits and holes and to circulate cuttings and transport them to the surface. Drilling fluids also help to maintain appropriate hydrostatic pressure in the well to overbalance formation pressure, providing the primary barrier for well control (BOP forms part of the secondary barrier). Various types of drilling muds are used. WBMs, which are mainly seawater with other additives including bentonite (clay), barite, and potassium chloride, are primarily used for riserless sections of a well. SBMs are generally used once the riser has been installed, though WBMs are used in some applications. Other approved chemicals are also added as required to achieve and control the required mud properties (Neff et al. 2000).

The initial “riserless” sections of a well bore are generally drilled using WBMs in which case mud and cuttings are returned to the seabed in accordance with the OWTG. Once the well conductor and surface hole sections are completed and the riser and BOP are installed, the deeper sections of the well bore are typically drilled using SBMs, which are returned to the drilling unit via the riser. Once onboard, drilled (i.e., rock) cuttings are removed from the drilling mud in successive separation stages. The fluids are reconditioned and reused until the well is abandoned, when the spent SBM is returned to shore for disposal. SBM-associated drill cuttings may be discharged at the drill site, in accordance with the OWTG, provided they are appropriately treated prior to discharge. Additional details on drilling waste and management are provided in Section 2.7.

The Project will not include installation of excavated drill centres or underwater construction activities with the installation of seabed or near-seabed components limited to the wellhead, BOP, and riser.

If a planned section total depth cannot be reached, contingency casing sections will be available and used. A contingency casing is an additional string inserted into the wellbore to enable drilling to the desired total depth. It is expected a well can be completed in four sections; however, there could be additional sections if contingencies are required to reach total well depth.

A geological sidetrack may be drilled for technical or opportunistic reasons. In the event of a sidetrack, a secondary wellbore will be initiated from the original wellbore using a similar approach as described above. The original wellbore will be abandoned using cement before starting to drill the sidetrack. The details and design of a sidetrack would be contingent on the results of the original well and therefore have not yet been finalized.

2.4.2 Vertical Seismic Profiling

VSP may be conducted to support correlation of previously collected seismic data to well data. It is often undertaken following completion of drilling to further characterize identified geological features and potential petroleum reserves. Specifically, this technique is used to obtain accurate time-to-depth ties to correlate seismic data to well depth.

VSP can be conducted in different ways including zero offset VSP and walk-away VSP (also called offset VSP) configurations. The zero offset VSP is undertaken by placing a string of receiver (geophones) down the well at pre-determined depths, with a seismic source (usually mid-sized airguns) suspended from the MODU (approximately 5 to 20 m below the water surface). Walk-away VSP involves placing a sound source on a vessel which then moves away while firing the sound source at pre-determined distances from the borehole receiver. The check-shots are recorded at multiple intervals down the well, and the resulting information assists in determining and confirming the depth of the drilled well and for reconciling drilling information with that obtained through seismic survey work. Between three and six seismic sound sources are typically used, with a volume of 150 to 250 cubic inches each. However, up to 12 sound sources may be used in a larger array. VSP surveys are typically short-term activities, usually lasting one to two days with sound source firing often limited to just a few hours.

Relative to surface seismic activities, VSP surveys typically use smaller sound sources that are placed several meters below the water surface, are more localized and are shorter duration. Underwater sound from VSP was modelled in support of the Project EA. Detail on sound emissions are provided in Section 2.7.5. VSP activities will be conducted in consideration of the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (SOCP; DFO 2007). The specific characteristics on frequency and air source array design of VSP surveys to be conducted as part of the Project will depend upon the individual well, the geological target, and objectives, and data requirements associated with the survey.

2.4.3 Well Testing and Flaring

If exploration drilling indicates the presence of hydrocarbons in the target formations, the well will be evaluated and possibly tested. Well evaluation is an important component of exploration drilling to determine the viability of a prospect and the commercial potential of the reservoirs.

2.4.3.1 Well Evaluation

During drilling, the well is monitored and evaluated using a variety of techniques for well formation logging, mud logging, drilling parameters evaluation, and subsurface pressure evaluation. Well formation logging, which is typically an ongoing process during exploration drilling programs, identifies rock types encountered and possible zones where hydrocarbons are present. Mud logging and evaluation of drill cuttings and mud gases are the primary methods of well formation zone logging. Additional evaluation is done by logging / testing, including logging / testing while drilling (LWD) / wireline well logging techniques that provide detailed rock formation and rock properties information.

2.4.3.2 Well Flow Testing

If significant hydrocarbons are indicated during an exploration well, reservoir evaluation would likely be conducted during the drilling of a subsequent appraisal well to establish the viability and commercial potential of the geological formation.

Well flow testing is a regulatory requirement under the *Newfoundland Offshore Petroleum Drilling and Production Regulations*, before converting an EL to a Significant Discovery Licence (SDL). This reservoir deliverability evaluation method would likely occur, post hydrocarbon discovery during the appraisal well drilling process or immediately thereafter, or possibly later by re-entering a suspended well.

If a well test is required, it will be subject to BHP's process for well test planning, which is designed to promote safe and efficient well test operations. A key requirement of these processes is the use of process safety design methods to ensure effective barriers are in place for the well test activity and an internal approval process for any well test activity and associated flaring. The internal approval process is designed to provide assurance that the minimum amount of flaring is carried out to obtain the needed data from the well test.

Where well testing is considered necessary, specialized equipment and services will be contracted to carry out the activity. Equipment used in the well test will be designed to safely control the maximum potential pressure that the reservoirs may be able to generate. The primary purposes of the specialized equipment, including conventional well test tooling, subsea safety systems, and temporary surface flow equipment, are:

- To provide a controlled flow path for the reservoir fluids to surface and flaring of hydrocarbons produced
- Provide downhole shut-in
- Facilitate "well killing" operations
- Convey data measurement instrumentation and sampling equipment as close to the formation being tested as practically possible

The primary mitigation measure for fast-acting isolation of the well during a flow test are subsea tools placed inside the BOP and flow control valves at surface on the MODU. If required, the subsea tools permit disconnection of the test string from the well, and allow emergency BOP functions (shearing, emergency disconnect) to be available during the test.

Formation fluids containing hydrocarbons will be flared using high-efficiency burners to allow for safe disposal. Flaring would be conducted with burners mounted on booms. A high-efficiency burner would be used for liquids, and a simple flare tip for gases. These efficient burners will allow for complete combustion, reducing likelihood for black smoke from the flare and drop-out of non-combusted hydrocarbons to the sea surface. Encountering produced water in the hydrocarbon target zones is not expected. If a water bearing zone is encountered, the formation flow test would be discontinued. In the unlikely event that produced water is encountered and requires handling, surface separators are used to separate water and hydrocarbons prior to flaring. The separated water will then be treated and disposed as per the OWTG (NEB et al 2010). This produced water could also be shipped to shore if offshore treatment is not feasible due to high hydrocarbon content, or limited storage capacity at surface.

BHP is always looking to identify and implement new ways of raising standards and improving productivity, safety, and environmental impact, as well as embracing new technologies. An alternative approach to flow testing with flaring is Interval Pressure Transient Testing (IPTT). In direct contrast to formation flow testing, where thousands of fluid barrels (bbls) are brought to surface in a controlled manner and flared, IPTT does not flow any fluid to surface, reducing the environmental impact. This alternative method offers a substantial reduction in safety risk by removing the exposure of personnel to pressurized surface equipment containing live hydrocarbons. The IPTT formation evaluation process involves deployment of a conventional wireline tool with dual-packer formation testers. The tool can selectively straddle a section of reservoir and provide the capability to conduct controlled downhole production tests, enable capture of the pressure / volume / temperature (PVT) qualities of reservoir fluid samples and acquire quality buildup data in only a few hours. The captured reservoir samples, generally on the order of liters, are then brought to surface in pressure contained and compensated sample chambers for additional analysis in an onshore controlled laboratory environment.

BHP will also evaluate other new technologies as they become available with the objective of reducing environmental impacts. If well testing alternatives are deemed inadequate, short periods of flaring totaling approximately 24 hours during a one to three-month window at the end of drilling operations may be required for a maximum of two wells. BHP will inform the C-NLOPB of plans for well test flaring as part of the ADW process and report on flaring to the C-NLOPB.

Section 2.7.1 provides a discussion of various atmospheric emissions that may be associated with the Project, including flaring activity, if required.

2.4.4 Well Decommissioning and Abandonment or Suspension

Offshore wells are typically decommissioned and abandoned when drilling and associated well evaluation is completed and approved by C-NLOPB. Approval may be included in the ADW or Approval to Alter the Condition of a Well (ACW) when completing or suspending, respectively. In both cases, information demonstrating compliance with the *Newfoundland Offshore Petroleum Drilling and Production Regulations* (or subsequent amended regulations) will be provided to C-NLOPB and a *Notification to Abandon/Suspend* or a *Notification to Complete* will be provided before abandoning, suspending or completing a well.

Well decommissioning and abandonment activities involve isolation of the well bore by placing cement plugs, potentially in combination with mechanical devices, at various depths. Consideration will be given to removing the wellhead from the seafloor if appropriate (given water depth and fishing activity), mechanical cutters would be used in this instance.

In addition to regulatory requirements, well decommissioning and suspension or abandonment for this Project will be carried out as per BHP's Well Integrity Standard. If planned, conventional well abandonment techniques such as those described above are ineffective for a particular well, alternative approaches may be required and will be investigated and implemented in consultation with relevant regulatory authorities and in compliance with applicable authorizations.

In some circumstances, the well may not be abandoned but suspended and re-entered for additional data acquisition and evaluation before final abandonment. A similar cement plugging program would be implemented, ensuring isolation of hydrocarbon-bearing intervals and is anticipated to take approximately two to three days per well. The casing / wellhead may be left in place for future use. Suspension and abandonment procedures are designed to isolate the well and prevent the release of wellbore fluids to the marine environment. BHP are required to provide detailed plans for monitoring suspended wells to the C-NLOPB and are also required to provide information regarding the suspension or abandonment methods to adequately isolate the wells, which in turn will prevent hydrocarbons from entering the environment. In instances where approvals are requested to leave the wellhead in place on the seabed, the remaining infrastructure would be approximately 4 m in height and occupy a footprint of less than 1 m^2. The wellhead position would be reported to the Canadian Hydrographic Services such that nautical charges can be updated.

2.4.5 Supply and Servicing

PSVs and helicopters are used to transport personnel, equipment, and materials to and from MODUs during offshore drilling programs. It is expected that offshore PSV and aircraft (helicopter) services for the Project will be based in Eastern Newfoundland to support logistical requirements for offshore operations. Supply base activities will be conducted by a third-party contractor and are outside the scope of this EIS. Personnel will be transported to and from the MODU by PSV or helicopter, according to work schedules and rotations, workforce numbers, distances and other factors. Additional details on supply and servicing components are provided in Section 2.3.3.

2.4.5.1 Project Support Vessel Operations

The MODU will be supported by a fleet of PSVs to re-supply the MODU with fuel, equipment, drilling mud, and other supplies during the drilling program, as well as removing waste. PSVs may also be used to transfer personnel if fog or sea state prevents helicopter operations. It is likely that two to three PSVs will be required, with one vessel continuously on stand-by at the MODU. It is anticipated that a single MODU operating at the site will require an average of three return transits per week by PSVs during the Project. Seasonally, ice management vessels may also be required.

Supporting vessels involved in Project activities will travel within existing shipping lanes where practical to reduce incremental marine disturbance. PSVs will essentially follow a straight-line approach between a MODU operating within an EL in the Project Area and an established port facility in eastern Newfoundland, a practice which is common in the oil and gas industry that has been active in this region for several decades. The straight-line approach accounts for potential safety issues (use of a consistent route) and fuel efficiency but may be altered if deemed necessary by the vessel captain (e.g., for avoidance of congregating marine mammals). Based on a typical service speed of approximately 10 to 12 knots, it is anticipated that a PSV could take approximately 20 to 22 hours to reach the Project area from an onshore supply base. Figure 2-6 illustrates key supply and support vessel and helicopter traffic routes related to existing oil production facilities off eastern Newfoundland, as well as a potential traffic route that may be used for this Project. This is provided for general information and illustrative purposes, recognizing that specific routes may vary at times based on the location of the active MODU(s), the shore-based facility being used, environmental conditions (including weather and ice), and other logistical factors. The MODU and PSVs used for the Project will meet operational and environmental requirements for associated exploration activities, including relevant environmental mitigation measures and safety and emergency response procedures. Vessels will follow applicable legislation and regulations and will be inspected by Transport Canada and approved for operation by the C-NLOPB before beginning Project-related work. They will have appropriate oil spill / pollution prevention and emergency response plans, and each will be compliant with International Convention for the Prevention of Pollution from Ships (MARPOL). Supplies will be loaded and unloaded onto PSVs using personnel and cranes for drilling materials and closed piping systems (e.g., pumps, hoses) for bulk powders, liquid supplies, and waste (e.g., drilling fluids). Marine gas oil, or diesel fuel, will be transferred to the MODU from shore via the PSVs as well. Fueling operations are anticipated to occur approximately once per week by a third-party contractor.

2.4.5.2 Aircraft Operations

Helicopters will be used for crew changes on a routine basis, and to support medical evacuation from the MODU and support search and rescue activities in the area, if required. Helicopter operations are anticipated to be run out of St. John's International Airport. It is estimated that there would be on average of seven transits per week to transfer crew and supplies to the MODU depending on weather conditions or other technical matters. Helicopter routes are anticipated to be direct from the St. John's airport to the Project Area. Flight distances are not expected to exceed 425 km, which is the distance between St. John's and the furthest boundary of the ELs. Standard altitude profiles are between 610 m and 2,743 m with, for separation purposes, an odd number altitude being flown on the eastbound flight and an even altitude being flown on the westbound flight. Flight times are expected to be up to approximately two to three hours to the ELs. Helicopters have not yet been contracted for the Project, however, helicopters typically used in our offshore areas generally have a maximum range of approximately 1,000 km without refuelling. Refuelling operations are expected to take place at St. John's International Airport; however, the MODU will be equipped with refuelling equipment.

Aviation is regulated by Transport Canada, including various applicable regulations and operational requirements for helicopter flight traffic. The C-NLOPB has also established and enforced specific operational and regulatory requirements for flight traffic associated with offshore oil and gas exploration and development activities. Military exclusion areas have also been identified and will be avoided as the helicopter flight paths are determined by the helicopter operators. Effects of helicopter traffic on wildlife will be mitigated through avoidance of bird colonies (refer to Section 9.3). The *Seabird Ecological Reserve Regulations,* 2015, that prohibit aircraft flights of less than 300 m altitude over ecological reserves during specified time periods will also be followed.

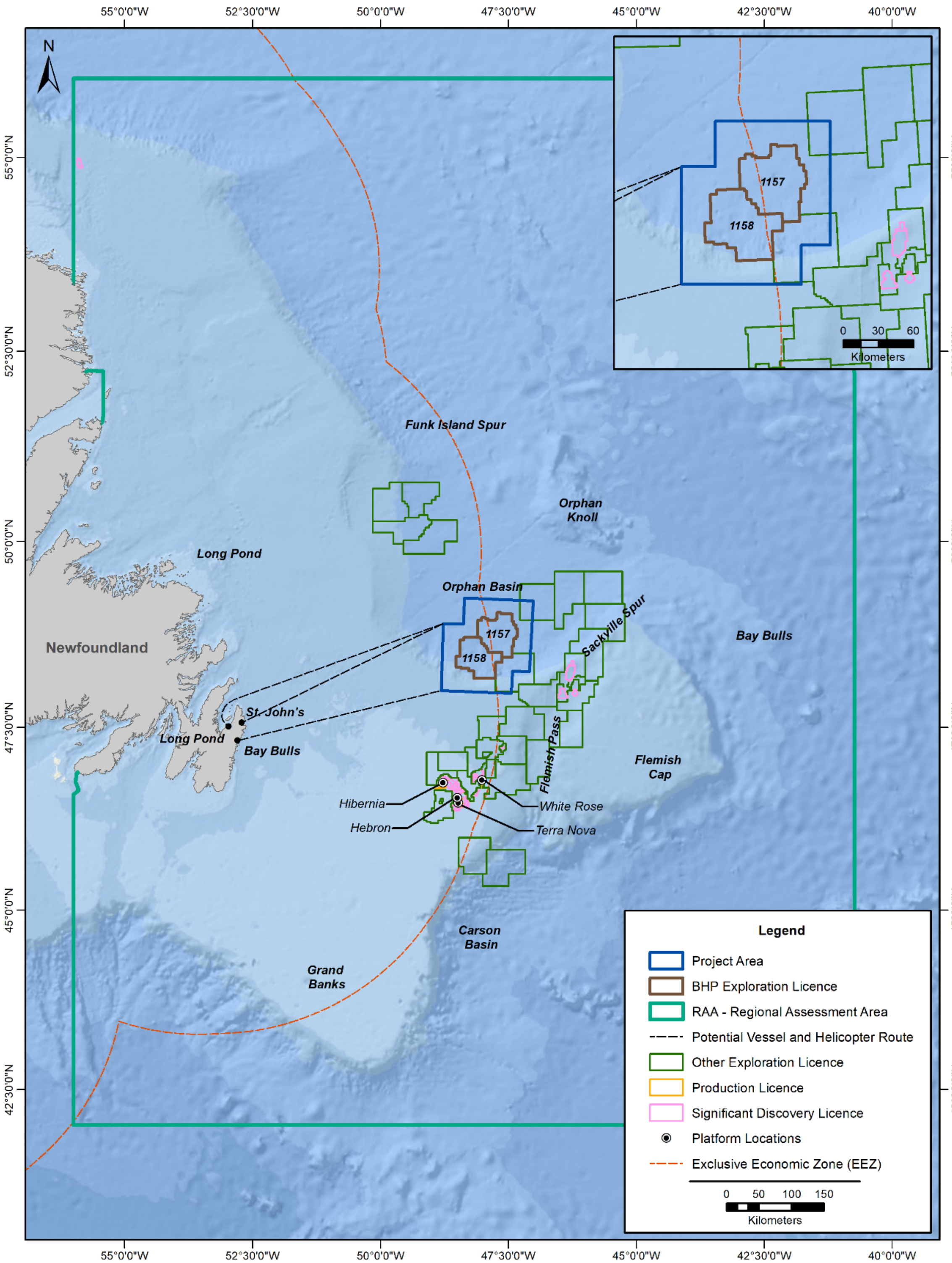


Figure 2-6 Potential Vessel and Helicopter Routes

BHP

2.5 Project Personnel

The Project will be managed by BHP through a multidisciplinary Project Team based in St. John's, NL, with support from BHP offices elsewhere, as required.

The Project Team will include members of BHP's Global Wells and Seismic Delivery Organization who are responsible for delivering a consistent and standardized approach to the delivery of wells-related activity across the company. This team will be responsible for planning and delivering the Project as a whole; however, contractors will also be engaged to carry out specific components of the work. Key contractors include: the drilling contractor, who will provide and operate the MODU; specialist third-party services providers who provide equipment and services to support drilling operations; and logistics contractors who provide and operate the supply base, PSVs, and helicopters.

As the Project progresses, the number of BHP and contractor personnel involved in the Project will change. The contractor providing the most personnel is the drilling contractor. During drilling operations, it is estimated that the number of personnel on-board the MODU will range from 120 to 180 people (including staff, drilling contractor and third-party services providers) who will work on board the MODU. This will include BHP personnel, such as drilling supervisors and drilling engineers, who will work offshore on the MODU.

Technical evaluation of subsurface characteristics will be defined by the Exploration team based in Houston. Working closely with the Integrated Well Planning team, the Houston Exploration team will coordinate the planning and design of the well across a variety of disciplines including drilling, engineering, operations, Health, Safety and Environment (HSE) and regulatory.

Offshore drilling contractor roles will include management positions, such as the Offshore Installation Manager, and Tool Pusher, who work with the drilling management team to deliver safe, reliable, compliant drilling operations. The drilling contractor team will also include roustabouts, technicians, and HSE personnel. Drilling contractor personnel will also support drilling operations from offices onshore including the Onshore Drilling Contractor Rig Manager, who is responsible for supervising the execution of the approved drilling program.

During the drilling program, the Drilling Supervisor, who reports to the Offshore Installation Manager, is responsible for coordinating the overall execution of the drilling program and providing oversight of well-related operations. The Drilling Supervisor interfaces with the drilling contractor's offshore leadership team to oversee drilling so that it is carried out safely and efficiently and complies with relevant regulations. The Drilling Supervisor reports to the Drilling Superintendent, who is based onshore and is responsible for supervising the execution of the approved drilling program.

Other contractors and subcontractors will be hired by BHP for the provision of specific and specialized services for the Project. This may include supply, mobilization and operation of the MODU, onshore supply base support, PSVs and aircraft, and provision of equipment and supplies.

2.6 Project Schedule

BHP proposes to commence exploration drilling with an initial well as early as 2021, pending applicable regulatory and corporate approvals, the identification of suitable drilling targets and other technical, logistical, and commercial considerations. Upon completion of these first well(s) and based on results, additional well site locations may be identified. It is currently anticipated that up to ten wells (exploration and possibly appraisal) may be drilled on both of the ELs, for a total of up to 20 wells being drilled during the term of the ELs (2019-2028). ELs issued by the C-NLOPB have a maximum nine-year term (consisting of two consecutive periods), when the interest owner is required to drill or spud and diligently pursue one exploratory well on or before the expiry date of Period I as a condition of obtaining tenure to Period II. Period I is six years commencing 15 January 2019 and Period II immediately follows Period I with an expiry date of 15 January 2028.

Planned exploration activities that comprise the Project may occur at various times of the year during any year between 2021 and 2028. Drilling activities may not be continuous and will be determined, in part, by MODU availability and previous wells' results. There may at times be up to two MODUs working in different parts of the Project Area simultaneously. It is expected that each well will require approximately 35 to 115 days for drilling, which will be followed by well decommissioning and abandonment or suspension. Wells designed for suspension and re-entry will be determined through further prospect evaluation. VSP operations are estimated to take approximately one to two days per well. Table 2.6 presents a preliminary schedule for initial well drilling.

Table 2.6 Planned Project Schedule for Initial Well Drilling Campaign

Task	2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Well Selection, Design, and Planning																
Stakeholder and Indigenous Engagement																
Regulatory Permitting																
Exploration Drilling																
Well Abandonment and Reporting																

2.7 Emissions, Discharges, and Waste Management

Potential emissions and discharges associated with offshore exploration drilling programs include sound, light and other atmospheric emissions (e.g., exhaust), liquid discharges, and hazardous and non-hazardous waste materials associated with the offshore MODU, support vessels and aircraft. This section provides an overview of these waste streams which are generated through routine Project activities, and the mechanisms through which they will be managed.

Throughout the Project, efforts will be made to reduce emissions and discharges. Waste will be managed and disposed according to regulatory requirements and applicable guidelines. Depending on the nature of wastes generated, they will be managed and disposed of directly offshore from the MODU and the PSVs or brought to shore for disposal. Offshore waste discharges and emissions associated with the Project (i.e., operational discharges and emissions from the MODU and PSVs) will be managed in accordance with relevant regulations and municipal bylaws as applicable, including the OWTG and the MARPOL, of which Canada has incorporated provisions under various sections of the *Canada Shipping Act* (2001). Waste not meeting legal conditions for discharge will not be discharged to the ocean; it will be brought to shore for disposal. As part of the OA application process with the C-NLOPB, a Waste Management Plan will be prepared before drilling operations.

The following sections provide an overview of potential environmental emissions, discharges and waste materials that may be associated with Project activities, with a description of how these will be managed.

2.7.1 Atmospheric Emissions

Atmospheric emissions of criteria air contaminants (CACs) and greenhouse gases (GHGs) would result from the following routine Project activities:

- Fuel combustion from the MODU, support vessels and helicopters
- Formation flow well testing (if required), including periods of flaring

Emissions from fuel combustion activity are likely to include carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxides (SO_X), nitrogen oxides (NO_X), nitrous oxide (N_2O), volatile organic compounds (VOCs), and particulate matter (PM). Air emissions from the Project are required to adhere to the *Newfoundland and Labrador Air Pollution Control Regulations*, National Ambient Air Quality Objectives, Canadian Ambient Air Quality Standards, and applicable regulations under MARPOL. Releases of GHGs from fuel combustion activity has the potential to affect emission reduction targets for GHGs that have been set or are being developed federally and provincially.

Marine engines are subject to NO_X limits set by the International Maritime Organization (IMO) of the United Nations, with Tier II limits applicable in 2011 and Tier III limits that became applicable in 2016 in Emission Control Areas. This includes the Canadian coast to the 200 nautical mile economic exclusion zone (EEZ) limit. The IMO is also responsible for development of mandatory measures to increase energy efficiency on ships and reduce sulphur amounts in fuel, a process that will reduce GHG emissions in the offshore. Ultra-low sulphur diesel fuel will be used for the Project wherever practicable and available. On January 1, 2015 the sulphur limit in fuel in the IMO designated Emission Control Areas in large marine diesel engines was reduced from 1.0% to 0.1% in accordance with the *Vessel Pollution and Dangerous Chemicals Regulations* under the *Canada Shipping Act*. Using ultra-low sulphur diesel instead of regular diesel will reduce the potential for adverse local air quality effects.

Atmospheric emissions from individual Project components are contingent on fuel consumption but will also depend on a variety of factors, including MODU and support vessel type and class, time of year, and the duration of active drilling and will therefore be variable throughout the Project.

Emissions of CACs and GHGs from the Project were estimated based on anticipated activity data and published emission factors. The emission factors used to estimate atmospheric emissions are presented in Table 2.7 and the estimated emissions from the individual Project components are presented in Table 2.8.

Table 2.7 Gaseous Emission Factors for the MODU, PSVs, Helicopter and Well Testing (Flaring)

Air Contaminant	Emission Factors			
	MODU[a,b]	PSVs[A, B]	Helicopters[B, C]	Well Testing[B,D]
CO	7.4 kg/tonne	7.4 kg/tonne	524.5 g/Landing and Take-off; 1.1 kg/hour during Transit	70.77 g/GJ Gas Flaring 0.60 kg/1000 L Oil Flaring
NO_X	78.5 kg/tonne	78.5 kg/tonne	1,066 g/Landing and Take-off; 10.6 kg/hour during Transit	15.53 g/GJ Gas Flaring 5.64 kg/1000 L Oil Flaring
SO_2	2 kg/tonne	2 kg/tonne	-	-
PM	1.5 kg/tonne	1.5 kg/tonne	28.9 g/Landing and Take-off; 0.271 kg/hour during Transit	27.40 g/GJ Gas Flaring 0.57 kg/1000 L Oil Flaring
VOC	2.8 kg/tonne	2.8 kg/tonne	419.1 g/Landing and Take-off; 0.91 kg/hour during Transit	31.96 g/GJ Gas Flaring 0.09 kg/1000 L Oil Flaring
CO_2	2,681 g/L	2,681 g/L	2,560 g/L	2,494 g/m^3 Gas Flaring 3.158 kg/L Oil Flaring
Methane (CH_4)	0.25 g/L	0.25 g/L	0.029 g/L	6.4 g/m^3 Gas Flaring 0.12 g/L Oil Flaring
N_2O	0.072 g/L	0.072 g/L	0.071 g/L	0.06 g/m^3 Gas Flaring 0.064 g/L Oil Flaring

Notes:
[A] European Environment Agency 2016
[B] ECCC 2019a
[C] Swiss Confederation 2015
[D] WCI 2010

Table 2.8 Estimated CAC and GHG Emissions for the MODU, PSVs, Helicopter and Well Testing (Flaring)

Source	MODU	PSVs	Helicopters	Well Testing	Total
Fuel Consumption (tonnes per well)	5,750	4.994	261	-	-
Volume of Gas Flared (cubic meters per day)	-	-	-	113,267	-
Volume of Oil Flared (cubic meters per day)	-	-	-	1,589	-
Number of Landings and Take-offs per Well	-	-	230	-	-

Table 2.8 Estimated CAC and GHG Emissions for the MODU, PSVs, Helicopter and Well Testing (Flaring)

Source	MODU	PSVs	Helicopters	Well Testing	Total
Assumed Transit Hours per Well	-	-	460	-	-
CO (tonnes per well)	6.33	42.6	0.63	1.27	51
NO_X (tonnes per well)	451	392	5.12	9.0	858
SO_2 (tonnes per well)	11.5	10	-	-	22
PM (tonnes per well)	8.63	7.49	0.13	1.02	17
VOC (tonnes per well)	16.1	14.0	0.51	0.3	31
CO_2 (tonnes CO_{2e} per well)	16,400	14,244	834	5,301	36,779
CH_4 (tonnes CO_{2e} per well)	38.2	33.2	0.24	22.9	95
N_2O (tonnes CO_{2e} per well)	131	114	6.90	32.3	284
Total GHG Emissions (tonnes CO_{2e} per well)	16,569	14,391	841	5,356	37,157

The MODU for the drilling program has not yet been selected and therefore exact fuel consumption data are not available. It is likely that several different MODUs will be used during the term of the ELs, including both a semi-submersible drilling unit and/or a drillship. As an example, the anticipated averaged daily fuel consumption for the West Aquarius or Stena Icemax MODUs, would be approximately 50 tonnes.

MODU operations will be supported by three PSVs, with three round trips per week to the well site, and one standby vessel on standby at the well site. The MODU will be located somewhere within the ELs. The furthest distance a PSV will travel is from the onshore supply base to the most distant boundary of the ELs, which is 425 km. The PSV emissions will depend on the type of vessel, the age of the vessel and the transit speed; however, it has been estimated that on average, the PSVs will consume approximately 120 to 144 tonnes of fuel per week during transit, plus 24 to 48 tonnes per week during offloading. The standby vessel is estimated to consume approximately 56 to 112 tonnes of fuel per week. The total fuel consumption for PSVs is therefore estimated to be 200 to 304 tonnes per week, or 28.6 to 43.4 tonnes per day.

One round-trip per day is anticipated for helicopters to transport crew to and from the MODU. The furthest distance that the helicopter will travel from St. John's to the MODU, is 435 km, based on the most distant boundary of the ELs. On average a helicopter would consume approximately 5,000 pounds of helifuel per day (2.27 tonnes of fuel per day) during a 115-day drilling program.

The estimated GHG emissions associated with operational drilling, vessel traffic, and helicopter traffic during exploratory drilling is 277 tonnes of carbon dioxide equivalent (CO_2e) emissions per day. Based on a 115-day drilling program per well drilled, that equates to approximately 31,802 tonnes CO_2e over the drilling program. Over the term of the EL, there could be between zero to two wells drilled per year. With that assumption, the annual GHG emissions resulting from the Project could range from 0 to approximately 63,603 tonnes CO_2e per year. These emissions represent approximately 0% to 0.61% of the total reported provincial GHG emissions for 2017 (10,500,000 tonnes CO_2e) and approximately 0% to 0.009% of the 2017 national emissions (716,000,000 tonnes CO_2e) (ECCC 2019b).

Well flow testing is not anticipated to be required during the initial phase of the Project (i.e., one to two wells). If well testing alternatives are deemed inadequate and the need for well flow testing is identified following well success in the initial wells, a well test program will be developed and executed on subsequent wells drilled as part of the primary term of the ELs. Atmospheric emissions will be generated from flaring activity if well flow testing is carried out.

Well flow testing, if it is conducted, has a duration that is typically short (limited to a period of 24-hrs) and occurs at the end of the drilling program. The activity within this period will vary and it is likely that flaring will be required intermittently. The duration of flaring activities for operational purposes, such as flushing or bleeding, with low flow rates, is typically 24-hours hours per flaring event. The amount of time flaring, if required, in a well flow test operation will be reduced where possible but will require sufficient time (approximately 24 hours of flaring) to collect necessary datasets. If well flow testing is required, it is anticipated that there is a single target containing hydrocarbons within each well which could be subject to a well flow test and up to two well flow tests could be completed over the duration of the licence period.

To estimate GHG emissions from a flaring event, it has been assumed that the maximum volume of oil brought to the surface and flared during a 24-hour well test would be 10,000 bbls (approx. 1,589 m^3), which would also result in approximately 113,267 m^3 of gas flared. During the life of the Project a maximum of two wells would be tested. The tonnes of CO_2e emitted from one target during a well flow test is therefore estimated to be 5,356.

Based on the assumption that a maximum of two wells would be tested over the duration of the Project and assuming, as a conservative approach, that two wells could be tested in one year, it is estimated that up to 10,712 tonnes of CO_{2e} per year could be released from flaring during well flow testing. The 2017 annual GHG emissions reported for Newfoundland and Labrador (NL) is 10,500 kilotonnes CO_{2e} per year (ECCC 2019a). The flaring event estimate represents approximately 0.1% of the province’s annual GHG emissions.

With the assumption that up to two wells could be drilled in one year for routine Project activities, and up to two wells tested per year for Project flaring (as a worse case assumption), the total GHG emissions (considering routine and Project activities) are estimated to be 74,314 tonnes CO_2e per year. This is approximately 0.71% of NL’s average annual emissions for 2017 and 0.01% of the 2017 national inventory. A summary of the estimate Project total GHG emissions and percentage of the provincial and national totals is provided in Table 2.9.

Table 2.9 Summary of Project GHG Emissions Comparison to Provincial and National Totals

Scale	GHG Emission Value
Provincial Reported GHG Emissions (2017)[A]	10,500 kilotonnes CO_{2e}
National Reported GHG Emissions (2017)[A]	716,000 kilotonnes CO_{2e}
Project Total (assumes two wells per year and includes only routine project activities)	63.603 kilotonnes CO_{2e}
% of Provincial Emissions	0.606%
% of National Emissions	0.009%
Project Total (assumes two wells per year and includes flaring)	74.315 kilotonnes CO_{2e}

Table 2.9 Summary of Project GHG Emissions Comparison to Provincial and National Totals

Scale	GHG Emission Value
% of Provincial Emissions	0.71%
% of National Emissions	0.01%
Notes: [A] ECCC 2019a	

The Government of NL set the following GHG reduction targets in the Climate Change Action Plan (Government of NL 2011): 10% below 1990 levels by 2020; and 75% to 85% below 2001 levels by 2050. The Project's CO_2e predictions represent a very minor increment to existing CO_2e levels for the Province, and it is therefore not expected that the Project's emissions will affect regional, provincial or federal emission targets.

BHP will adhere to federal and provincial compliance and reporting requirements for emissions which are currently being reviewed and updated by the federal and provincial governments.

2.7.2 Drilling Waste Discharges

Drilling activities for the Project will generate several waste streams including drill cuttings and fluids, and drilling cement. Drilling related waste streams will be treated and disposed of in accordance with the OWTG. Drilling fluids, or muds, are used to lubricate and cool drill bits and lift cuttings out of the wellbore to the surface, and to maintain appropriate hydrostatic pressure (Section 2.3.4). Various types of drilling muds are used including WBMs and SBMs. The drill cuttings from this activity are comprised of fragments of rocks generated as the drill bit moves downward through the rock layers.

WBMs are mainly comprised of either freshwater or seawater (approximately 75%) with other components such as bentonite (clay), barium sulphate (barite), and potassium chloride, and are primarily used for riserless sections of a well. Barite is added to the water in WBM to increase the weight or density of the drilling mud and thus help balance formation pressures within the well. Bentonite clay is also added as a viscosifier, to thicken the mud and suspend and carry drill cuttings to the surface. Various other substances, such as thinners, filtration control agents, and lubrication agents, may be added to achieve the required drilling properties of the fluid. The initial "riserless" sections of a well bore are drilled using WBMs in which case mud and cuttings are returned to the seabed.

Excess WBM may be discharged to the marine environment as per the OWTG. The majority of WBMs discharged are classified under the Offshore Chemical Notification Scheme (OCNS) as substances that pose little or no risk to the environment (PLONOR).

SBMs may be used once the riser has been installed, though WBMs are used in some applications. SBM is a water-in-oil emulsion that contains non-aqueous (water insoluble) fluids manufactured through chemical processes. This drilling fluid may be comprised of internal olefins, alpha olefins, polyalphaolefins, paraffins, esters, or blends of these materials. The same weighting materials used in WBMs to control density are typically added to SBMs, as well as other approved chemicals are also added as required to achieve and control the required mud properties (Neff et al. 2000). The selection process for chemicals added to the muds is described in Section 2.8.4.

In comparison to WBMs, SBMs can offer improved lubricity, thermal stability, wellbore integrity, and protection against gas hydrates in the well. SBMs are returned to the MODU via the riser. Once onboard, drilled (i.e., rock) cuttings are removed from the drilling mud in successive separation stages. As part of cuttings management, the MODU will be equipped with specialized solids control equipment including shale shakers to recover drilling fluids from the cuttings. The shale shakers system is comprised of a series of various sized mesh screens to separate out cuttings and recover drilling fluids that pass through. The system removes as much of the drilling fluids as possible from the cuttings for re-use in the drilling process. Additional solids control equipment, such as centrifuges, may be used depending on the drilling fluid basis of design, and geological characteristics for reconditioning of the drilling fluid for re-use. SBM-associated drill cuttings will be discharged at the drill site, meeting regulatory performance targets detailed within the OWTG. The concentration of SBM on cuttings will be monitored on the MODU for compliance with the regulations. In accordance with the OWTG, no excess or spent SBM will be discharged to the sea. Spent or excess SBM that cannot be re-used during drilling operations will be brought back to shore for disposal.

2.7.2.1 Drill Cuttings Deposition Modelled for the Project

To establish the expected deposition of drill waste from the drilling program, drill waste deposition modelling has been conducted. Since well site locations have not yet been selected, representative well sites were used for drill waste modelling (Table 2.10).

Table 2.10 Hypothetical Release Locations within the Orphan Basin Exploration Drilling Project Area

Site Name	Latitude	Longitude	Water Depth (m)
EL 1157	48°49'33.2" N	47°51'4.4" W	2,338
EL 1158	48°29'30.4" N	48°03'58.2" W	2,047

Operational discharges from planned drilling sections were modelled as seafloor or sea surface releases, with release rate and location of the discharges in the water column depending on each drilling stage. Each of these simulations were performed for two different seasons (fall and summer) to evaluate how ocean current variability in the region may affect the patterns of cuttings and mud dispersion.

Representative drilling schedules were provided to RPS by BHP to characterize discharges from five planned drilling sections at EL 1157 and EL 1158, respectively (Table 2.11). The first two sections will be drilled using seawater and WBM at both sites. The remainder of the drilling sections will require the use of SBM at both sites. The provided discharge schedule consists of a release of 792 m^3 of drill cuttings and 867 m^3 of drilling fluids (not including 6.9% by mass of synthetic oil that is retained on the cuttings) at each site over the duration of the anticipated drilling campaign. This schedule captures approximately two months of work at each simulated location and season, with 10.5 days of active discharge per simulation.

Table 2.11 Proposed Drilling Program for EL 1157 and EL 1158 (provided by BHP)

Section	Diameter (inches)	Drilling period		Drilling Duration (days)	Discharge Duration (days)	Cuttings Discharge		Drilling Fluid (Mud) Discharge[A]		Mud Type	Release Depth[B]
		Scheduled	Alternative Scheduled			vol (m^3)	rate (m^3/d)	vol (m^3)	rate (m^3/d)		
1	42	Summer	Fall	0.5	0.5	101	201	193	387	WBM	Seafloor
2	26	Summer	Fall	2	2	218	109	674	337	WBM	Seafloor
3	21.5	Summer	Fall	2	2	234	117	6.9% ROC	NA	SBM	Surface
4	16.5	Summer	Fall	2	2	172	86	6.9% ROC	NA	SBM	Surface
5	12.25	Summer	Fall	4	4	67	17	6.9% ROC	NA	SBM	Surface
Total				10.5	10.5	792		867*			

Each row defines drilling sections beginning at the sediment-water-interface (1) and extending down to the reservoir (5)

Notes:

[A] Cuttings from sections drilled with SBM were modelled with an additional 6.9% by weight of synthetic oil to account for base fluid that was assumed to be adhered to cuttings

[B] Releases were simulated at 5 m above seabed and 10 m below the sea surface

*Does not include 6.9% retained on cuttings (ROC) by mass of synthetic oil

During the initial phase of drilling (the first two sections in Table 2.11), cuttings and WBM are expected to be released directly to the seabed (assumed discharge was 5 m above the wellhead onto the seafloor). Subsequent sections will be drilled using SBM and cuttings will be returned to the MODU and cleaned prior to discharge. The direct release of bulk SBM was not expected to occur as part of operational drilling, although for modelling, it was presumed that synthetic oil, a fraction of the drilling fluid (approximately 6.9% by mass of the SBM cuttings), would remain adhered to cuttings drilled with SBM. The release of these combined surface returns (cuttings and adhered SBM) was simulated from a depth of 10 m below the sea surface at a continuous discharge rate.

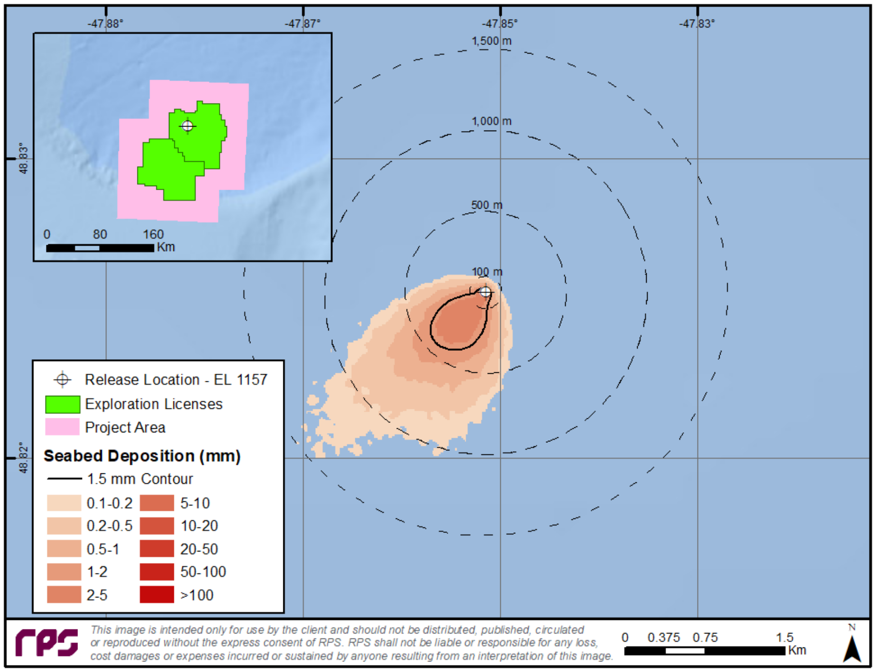
The schedule provided by BHP indicated an expected spud date in the summer. Because the drilling schedule may be delayed, a modelling strategy was developed to compare the potential differences in seabed deposits during different offshore conditions for the scheduled and alternative drilling periods. Two deterministic scenarios were performed at the theoretical well location using the MUDMAP dispersion model, each covering a period of approximately two months (spanning all active drilling stages and time necessary to allow for settling of fine particles):

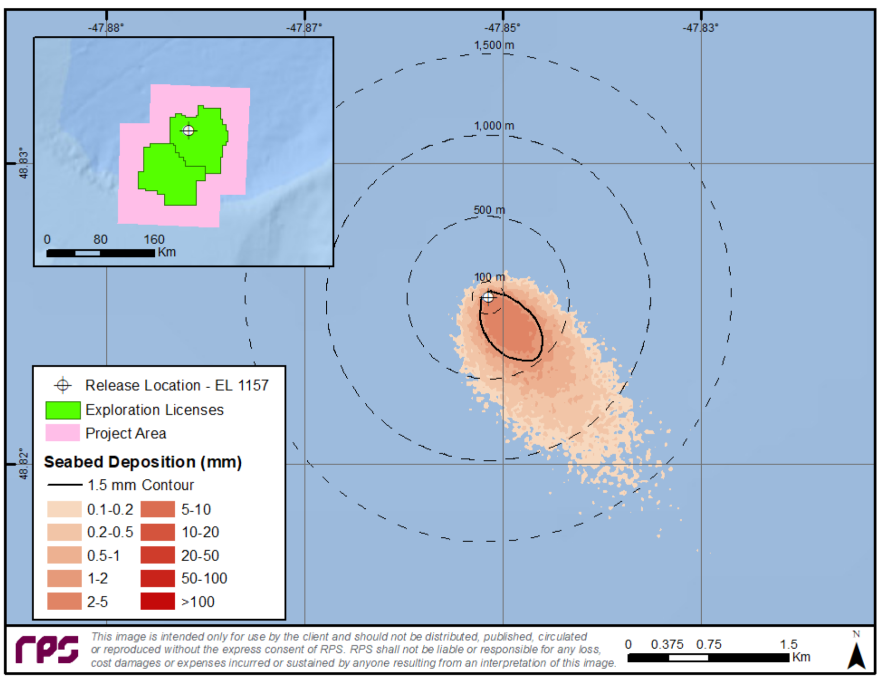
1. Scenario 1 - scheduled drilling period (Summer; July-August)
2. Scenario 2 - alternative drilling period (Fall; October-November)

Currents in the area are typically to the southeast but can be variable during portions of the year. RPS performed a qualitative review of the HYCOM time series between 2006-2012, comparing current statistics (speeds and directions) from each year at multiple depths for each modelled season. Current trends for the two model periods during 2012 were in agreement with the overall seven-year trend and were thus deemed suitable as a representative modelling period.

2.7.2.2 Model Results

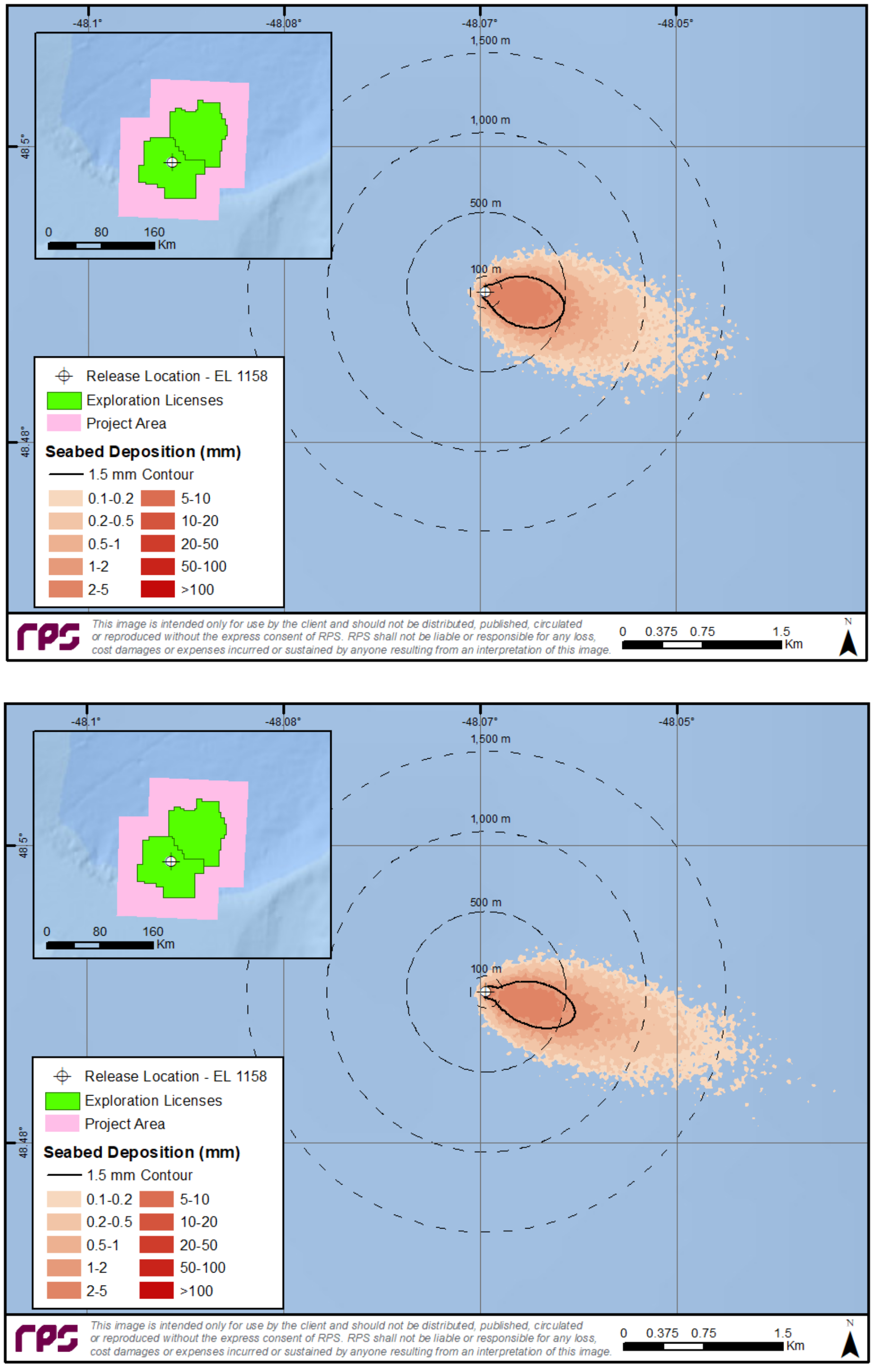
In each modelled case, the deposition of muds and cuttings from operational discharges onto the seabed was controlled by the settling velocity of particles, the currents within the water column, and the depth of the water column. Modelled operational discharges from site EL 1157 (2,338 m) (Figure 2-7) and site EL 1158 (2,047 m) (Figure 2-8) were predicted to produce a spatially confined depositional area of up 5.45 mm thick. The difference in depth between both sites did not substantially influence the seabed deposition patterns, because only the first two sections (released at seabed) contributed to measurable thicknesses on the seafloor. Slow settling velocities associated with the fine silts / clays, which make up the largest fraction of the cuttings drilled with SBM, allowed for greater dispersion before settling out.





The 1.5 mm contour is provided as a solid black line.

Figure 2-7 Predicted Thickness of Seabed Deposition of Discharged Mud and Cuttings (≥0.1 mm) Resulting from All Drilling Sections during the Scheduled Summer (top) Drilling Period and the Alternative Scheduled Fall (bottom) Drilling Period at EL 1157



The 1.5 mm contour is provided as a solid black line.

Figure 2-8 Predicted Thickness of Seabed Deposition of Discharged Mud and Cuttings (≥0.1 mm) Resulting from All Drilling Sections during the Scheduled Summer (top) Drilling Period and the Alternative Scheduled Fall (bottom) Drilling Period at EL 1158

Summer simulations (scheduled drilling) for both sites were predicted to have weaker subsurface current regimes with greater directional variability, when compared to the fall simulations. This resulted in slightly more radial footprints for summer simulations, when compared to the more elongated results in the fall simulations. However, each predicted depositional footprint was similar in shape, size, and depositional thickness. Depositional thicknesses at or above 0.1 mm was predicted to extend up to 1.83 km to the southwest at EL 1157 and 1.86 km to the southeast at EL 1158 (Table 2.12). In total, the area exceeding a depositional thickness of 0.1 mm was predicted to be less than 0.94 km² for EL 1157 and 0.85 km² for EL 1158 (Table 2.13).

Table 2.12 Maximum Distance of Thickness Contours (distance from release site) Predicted for Operational Discharge Simulations

Deposition Thickness (mm)	Maximum extent from release site (km)			
	1157		1158	
	Cumulative Summer	Cumulative Fall	Cumulative Summer	Cumulative Fall
≥0.1	1.83	2.08	1.86	2.28
≥1.5	0.36	0.45	0.47	0.58
≥6.5	0.00	0.00	0.00	0.00

Table 2.13 Areal Extent of Predicted Seabed Deposition (by thickness interval) for Operational Discharge Simulations in Summer and Fall

Deposition Thickness (mm)	Cumulative Area Exceeding (km²)			
	1157		1158	
	Summer	Fall	Summer	Fall
≥0.1	0.9338	0.8603	0.8471	0.8974
≥0.2	0.6110	0.5680	0.5429	0.6005
≥0.5	0.3266	0.3094	0.3113	0.3253
≥1	0.1783	0.1761	0.1831	0.1874
≥1.5	0.1092	0.1178	0.1241	0.1181
≥2	0.0648	0.0812	0.0867	0.0733
≥5	0.0000	0.0005	0.0000	0.0000
≥6.5	0.0000	0.0000	0.0000	0.0000
Maximum Thickness (mm)	**3.37**	**5.45**	**4.75**	**4.18**

The larger areal extent at EL 1157 was due to the variability of current direction during the summer season. During the first two sections of drilling, which was predicted to discharge approximately 60% of the total mass and of larger size fractions, there was a temporary shift in the currents from southeasterly to southwesterly. During all remaining drilling sections, where the remaining 40% of mass in the smaller size fractions was discharged, the currents returned to their predominant southeasterly direction. This resulted in a broader footprint that extended to the southwest. Depositional thicknesses at or above 1.5 mm were predicted to extend to the southwest up to approximately 0.36 km covering 0.11 km² at EL 1157 and to the southeast 0.47 km covering 0.12 km² at EL 1158. Maximum depositional thicknesses of 3.37 and 4.75 mm were predicted at EL 1157 and EL 1158, respectively. Again, the reduced distance, areal extent, and thickness predicted at EL 1157 is the result of the currents shifting direction over the course of drilling. Depositional thicknesses at or above 6.5 mm did not occur at either site or for either seasonal scenario.

Fall simulations (alternate drilling) for both sites were characterized by stronger subsurface current regimes, which led to slightly more elongated depositional footprints, when compared to summer scenarios. Depositional thicknesses at or above 0.1 mm were predicted to extend to the southeast for both locations up to approximately 2.08 km at EL 1157 and 2.28 km at EL 1158. In total, the area exceeding a depositional thickness of 0.1 mm was predicted to be less than 0.86 km² at EL 1157 and 0.90 km² at EL 1158. Depositional thicknesses at or above 1.5 mm were predicted to extend southeast up to approximately 0.45 km covering 0.12 km² at EL 1157 and 0.58 km covering 0.12 km² at EL 1158. Maximum depositional thicknesses of 5.45 and 4.18 mm were predicted at EL 1157 and EL 1158, respectively. Depositional thicknesses at or above 6.5 mm did not occur at either site or for either seasonal scenario.

The variations within predicted results between simulations were due to three main factors including: 1) settling velocity associated with different release substances, 2) current patterns (i.e. velocity) and 3) release height relative to the seabed. The discharges modelled in this study may be considered representative of other potential discharges in the Project Area, as the depth of the sites (approximately 2,000 m) are similar in depth to other potential sites within the Project Area. While this dispersion modelling targeted the most likely drilling window for the Project (July-August), it also focused on an alternate season (October-November) as well. These two targeted seasons may be used to bound the variability in depositional footprints and predicted results may be applicable outside of this temporal window.

2.7.2.3 Drilling Cement

Cement is a safety critical barrier in the well as it prevents the escape of hydrocarbons. Cement is pumped into the casing/wellbore annuli following the casing installation. Excess cement slurry and drilled (hard) cement will be discharged to the seabed during the initial phases of the well, which will be drilled without a riser. Use of excess cement confirms that the annular space has been filled during cementing operations. Before installation of the marine riser and BOP, excess cement may be discharged on the seabed surrounding the wellhead. The volume of cement discharged to the seafloor during the riserless sections of the well is estimated to be in the range of approximately 200 tonnes. Cement waste will be circulated back to the MODU following installation of the riser.

During commissioning, testing and cleaning of a cement unit, small volumes (approximately 1 to 2 m³) of cement may be discharged at the water surface. It is necessary to clean the cement unit after each operation to prevent cement from hardening in the mixing tanks and liners. Drilling cement would be discharged in accordance with the OWTG and Offshore Chemical Selection Guideline (OCSG). In the unlikely event of difficulties being encountered during cement job execution it may be operationally necessary to circulate cement slurry out of the well to prevent a potential loss of well integrity. In this scenario the slurry would be discharged if it meets the applicable regulatory standards for ocean discharge.

2.7.3 Liquid Discharges

Liquid wastes generated by offshore drilling activities include storage displacement, bilge, ballast, cooling, gray and black water, and possibly other materials. Some of these liquid wastes can be discharged directly from the MODU or PSVs in accordance with the OWTG, following treatment where necessary. Effluent discharge points for allowable marine discharges are typically located just below or above the sea surface on a MODU depending on equipment design. Liquid wastes not approved for discharge in OWTG such as waste chemicals, cooking oils, or lubricating oils, will be transported onshore for transfer to an approved disposal facility.

The OWTG specifies allowable chemical properties for offshore disposal to the marine environment and associated reporting requirements. Liquid discharges that do not meet applicable standards for ocean disposal are transported back to shore for disposal at approved facilities. A short description of the major liquid discharge streams and the way in which they will be managed and disposed is shown in Table 2.14.

Table 2.14 Potential Project-Related Liquid Discharges

Discharge	Source and Characterization	Waste Management
Well treatment and testing fluids	Well testing may be required as part of the Project to gather information about the subsurface characteristics. Depending on well success, formation fluids, including hydrocarbons and associated water have the potential to be brought to surface during a well test.	Hydrocarbons, such as gas, oil or formation water that are brought to surface as part of well test activity will be flared for safe disposal. Flaring will be via one of two horizontal burner booms, to either a high efficiency burner head for liquids, or simple open-ended gas flare tips for gases to reduce fall out of un-combusted hydrocarbons. Flaring, if required, will be optimized to the amount necessary to characterize the well potential and as necessary for the safety of the operation.
Produced Water	Produced water includes formation water encountered in a hydrocarbon bearing reservoir that are brought to the surface during well evaluation and testing processes.	Small amounts of produced water may be flared. If volumes of produced water are large, some produced water may be brought onto the MODU for separation and treatment so that it can be discharged according to the OWTG.
Bilge and deck drainage water	Deck drainage is water on deck surfaces of the MODU from precipitation, sea spray or MODU activities such as MODU wash-down, or from fire control system or equipment testing. Bilge water is seawater that does not drain off of the MODU and may seep or flow into parts of the MODU. Water may pass through pieces of equipment into other spaces of the MODU. Deck drainage and bilge water may be contaminated with hydrocarbons and other chemicals as it contacts equipment and machinery.	Deck drainage and bilge water will be discharged according to the OWTG which state that deck drainage and bilge water can only be discharged if the residual oil concentration of the water does not exceed 15 mg/L.

Table 2.14 Potential Project-Related Liquid Discharges

Discharge	Source and Characterization	Waste Management
Ballast water	Ballast water is used in MODU and PSVs to enhance stability and balance. Seawater is taken up or discharged when the cargo is loaded or unloaded, or when extra stability is needed to manage weather conditions. The water is typically stored in dedicated tanks on the vessel and does not usually become contaminated with hydrocarbons or chemicals. Depending on sailing history or operational practices of the vessel, ballast water may contain organisms and species from other areas.	Ballast water will be discharged according to IMO *Ballast Water Management Regulations* and Transport Canada's *Ballast Water Control and Management Regulations.* The MODU will carry out ballast tank flushing before arriving in Canadian waters.
Grey and black water	Black and grey water will be generated from washing, bathing, laundry and galley facilities onboard the MODU and PSVs. Grey water will be generated from washing and laundry facilities, and black water includes sewage water generated from the accommodation areas.	Sewage (black water) will be macerated through sewage treatment plants onboard the MODU and vessels before discharge in accordance with MARPOL and OWTG. Grey water will be discharged at sea as far as practical from the nearest land.
Cooling water	Cooling water is seawater that is pumped onto the MODU and passed over or through equipment such as machinery engines as part of cooling processes. Cooling water may be required on the MODU; however, volumes are likely to be low. Water may be treated through biocides or electrolysis before use.	Cooling water will be discharged according to the OWTG which states that biocides used in cooling water are selected according to the OCSG. Cooling water is likely to be warmer than the receiving waters upon discharge but will be rapidly dispersed, reaching ambient temperatures.
BOP fluids	Regular program of function testing and pressure testing the BOP mechanism is required for safe well operations. BOP fluids are released directly to the ocean during BOP installation and removal, ranging between 335 and 552 bbl. There is also potential for fluid release during operation, testing, and non-routine retrieval or an emergency event. BOP fluid is a mix of 96% fresh water with 4% approved control fluid which are seawater soluble.	BOP fluids and other discharges from the subsea control equipment will be discharged according to OWTG and OCSG.

2.7.4 Hazardous and Non-Hazardous Waste

Domestic waste materials generated by personnel on-board MODUs and support vessels is collected in dedicated waste receptacles and disposed of regularly, with materials being separated and recycled where possible. Food wastes will be disposed in compliance with MARPOL 73/78 Annex V (*Food Waste Regulations*). In particular, there will be no discharge of macerated food waste within 3 nautical miles of land. Solid wastes intended for disposal will be stored in dedicated waste containers, transported to shore and collected onshore by an approved waste contractor for transportation to an approved waste disposal facility. Non-hazardous wastes, such as other domestic wastes, packaging material, scrap metal, and other recyclables such as waste plastic for example, will be stored in designated areas on board the MODU. At scheduled intervals, waste will be transferred to the PSVs so that it can be transported to shore where it will be transferred to a third-party waste management contractor at an approved facility.

Hazardous waste materials that will or may be generated during Project activities, including spent and excess chemicals, chemical containers, spent absorbents and oily rags, batteries, and biomedical waste are stored in dedicated and appropriate waste receptacles for transportation to shore where it will be transferred to a third-party waste management contractor at an approved facility. Transfer of hazardous wastes will be conducted according to the *Transportation of Dangerous Goods Act*. Applicable approvals for the transportation, handling and temporary storage, of these hazardous wastes will be obtained as required.

Key regulatory guidance pertaining to offshore emissions, discharges and wastes, as well as disposal and treatment is provided in the OWTG. Offshore waste discharges for the Project will be managed in compliance with these Guidelines, as well as MARPOL. BHP is committed to establishing safe and environmentally responsible procedures for generation, storage, handling, transportation, treatment and disposal of waste materials generated throughout the course of the Project. BHP will employ appropriate techniques to reduce, reuse and recycle liquid and solid waste and reduce liquid and atmospheric emissions. Onshore and offshore waste discharges will be managed and disposed as per the Project's Environmental Protection Plan (EPP), Offshore Chemical Management Plan, and the Waste Management Plan. Waste types and volumes will be documented as per relevant regulatory requirements.

2.7.5 Sound Emissions

Underwater sound will be generated by the MODU, PSVs, and the airgun used during VSP operations. The MODU type and on-station positioning method (i.e., DP or mooring system) influences the level of underwater sound generated by a MODU. Environmental conditions (e.g., water depths, salinity, and temperature) will determine the extent to which sound travels.

2.7.5.1 Underwater Sound Modelled for the Project

JASCO Applied Sciences (Canada) (JASCO) modelled the underwater sounds associated with the Project activities by reviewing existing assessments of similar projects located offshore NL and Nova Scotia (NS). Sound source spectra representative of the planned Project activities are estimated based on assessments published in previous studies (Kyhn et al. 2014; Austin et al. 2016; Zykov 2016; Martin et al 2019). The acoustic environment is described and compared to the environmental parameters used in the underwater sound assessments for the Scotian Basin Exploration Drilling Project (Scotian Basin Project; Zykov 2016), the Nexen Energy ULC Flemish Pass Exploration Drilling Project (Flemish Pass Project; Matthews et al. 2017), and the BP Orphan Basin Exploration Drilling Program (BP Orphan Basin Project; Matthews et al. 2018) (Figure 2-9). Underwater acoustic propagation conditions for these three offshore projects are compared to those in EL 1157 (Site A) and EL 1158 (Site B), in February and August. Ambient sound levels and various contributors to the soundscape in the area are derived from data measured at two Environmental Studies Research Fund (ESRF) recording stations, near EL 1157 and EL 1158. Anthropogenic contributors to the soundscape (including vessel traffic, previous seismic surveys, and oil and gas extraction activity) and naturally occurring ambient sound contributors (including wind, other environmental phenomena, as well as fin whales) are discussed.

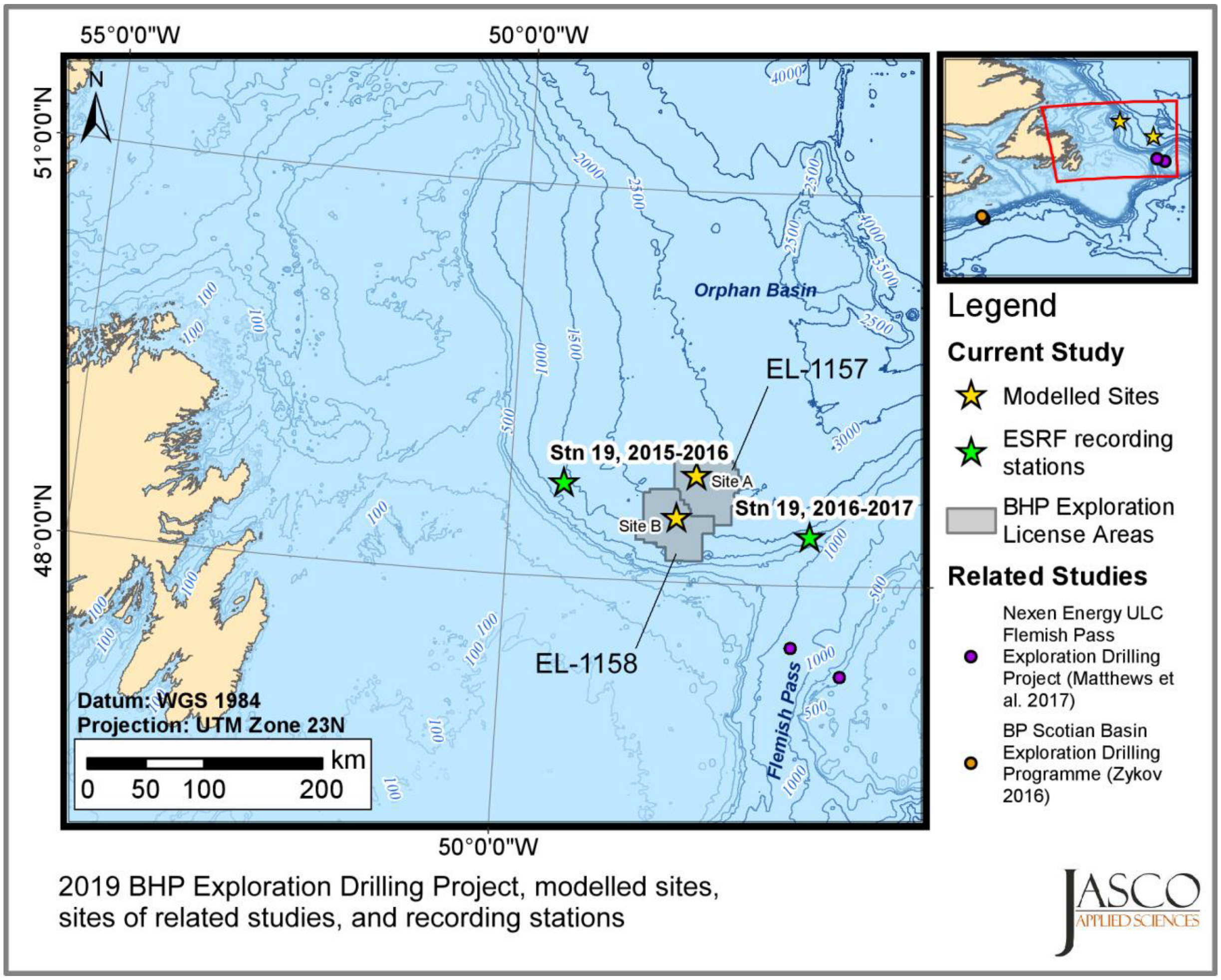


Figure 2-9 Overview of BHP ELs Coverage Area, the Modelled Sites A (EL 1157) and B (EL 1158), ESRF Recording Stations, and Modelled Sites of Related Studies

Underwater acoustic transmission loss from typical sound sources of the type planned to be in use for the Project was modelled for two seasonal extremes (summer and winter) at two modelling sites in the Project Area. Maximum received levels over depth, in the sound pressure level (SPL) and sound exposure level (SEL) metrics, and estimated SEL threshold distances for four marine mammal hearing groups were also quantified.

The accurate assessment of sound propagating away from the planned project activities will depend on the particulars of the equipment and activities. However, because of the similarities in operations and environmental parameters, underwater sound assessments for the Scotian Basin, the Flemish Pass, and the BP Orphan Basin exploration drilling projects, help provide a preliminary assessment of likely sound propagation features in the BHP Orphan Basin project. Based on sound monthly-averaged speed profiles in EL 1157 and EL 1158, distances to sound thresholds are expected to be shorter summer months (i.e., August) than in winter months (i.e., February). The February sound speed profile in both EL 1157 and EL 1158 features a deep surface duct (or half-channel) that results in longer distances than in August; this difference in distances is expected to persist throughout the oceanographic winter months (January-April). Based on the analysis of transmission loss coefficients for drillship and semi-submersible platforms in the BP Orphan Basin Project (Matthews 2018), similar distances to those in Flemish Pass, and those in August in the Scotian Basin are expected in EL 1157 and 1158. The transmission loss coefficients for the VSP operations indicate that distances to sound level isopleths in June in EL 1157 and 1158 should be similar to those in May in Flemish Pass, and longer than modelled in the Scotian Basin. These distances from VSP operations in EL 1157 and 1158 are expected to be shorter than in Flemish Pass and the Scotian Basin.

2.7.5.2 Model Results

The modelled acoustic fields were compared against various marine mammal impact criteria defined in terms of peak pressure and 24-hour SEL. For all sources, the ranges to the acoustic thresholds defined in terms of peak pressure were never greater than 0.28 km, the distances to the peak pressure thresholds were all less than 0.06 km. For all the vessel and MODU sources, the peak pressure was well under the thresholds for temporary threshold shift (TTS) and permanent threshold shift (PTS) onset at less than 15 m from the source.

For the distances to the 24-hour SEL impact criteria, the largest distances are seen from the airgun array and the generic drillship. For the thresholds for PTS onset, the largest distance was 0.59 km, which was for the low-frequency cetacean National Fisheries and Marine Service (NFMS) (2018) criteria for the airgun array at Site B (EL 1158) in August; this scenario also had the largest distance to the threshold for TTS onset of 6.2 km. However, almost as far that largest distance, this same scenario (airgun array, Site B (EL 1158), August) yielded a maximum distance to NFMS criteria (for PTS and TTS onset for phocid pinnipeds) of 0.07 and 0.4 km, respectively.

Most of the threshold distances for the vessel and MODU sources are much lower than those for the VSP source, although the generic drillship does yield a maximum PTS-onset distance of 0.28 km for the high-frequency cetacean National Marine Fisheries Service ([NMFS] 2018) criteria at Site A (EL 1157) in February, and a corresponding maximum TTS-onset distance of 5.5 km. In all modelled scenarios, the maximum PTS onset distance never exceeded 0.6 km.

Based on the analysis of important contributors to the ambient soundscape in the region, sound levels associated with the Project activities are expected to dominate the soundscape within distances of 10 to 40 km from the MODU, during the course of the activities. VSP operations are expected to contribute to the ambient sound levels to a lesser extent than seismic surveys because of their shorter operational timeframe and lower source levels. The relative contribution to the ambient soundscape will depend on the specifications of the Project activities, as well as the possible presence of other simultaneous contributors in the region.

A summary of expected source levels and transmission loss for a VSP survey, vessels and a semi-submersible platform is presented in the following sections; refer to Appendix E for more information.

VSP

The SEL threshold impact criteria require estimating the SEL over a 24-hour period. For these scenarios it is assumed that the sound source is stationary and operated continuously (at a fixed pulse rate) over this whole period; in 24 hours, 225 firings (shots) of the airgun array were modelled at Site A and 363 shots at Site B.

Maximum range to the PTS / TTS onset thresholds defined for the peak pressure field are presented in Table 2.15. The largest estimated distance to threshold is for the high-frequency cetaceans in August: 0.12 km to PTS threshold and 0.28 km to TTS threshold (the results are the same for Sites A and B); the February estimate is only slightly less. All the other cases have distance to PTS threshold of 40 m or less (and distance to TTS threshold of 60 m or less). Figures illustrating the SPL field for both sites during the two months are provided as Figures 33 and 34 in Appendix E.

Table 2.15 Maximum Horizontal Distances (in km) from the VSP Source to PTS- and TTS-onset Thresholds Defined for the Peak Pressure Field (NMFS 2018) for Each Site for February and August Propagation Conditions

Marine mammal group	PTS-onset					TTS-onset				
	Peak pres. (dB re 1 µPa)	Site A		Site B		Peak pres. (dB re 1 µPa)	Site A		Site B	
		Feb Rmax (km)	Aug Rmax (km)	Feb Rmax (km)	Aug Rmax (km)		Feb Rmax (km)	Aug Rmax (km)	Feb Rmax (km)	Aug Rmax (km)
Low-frequency cetaceans	219	0.04	0.04	0.04	0.04	213	0.06	0.06	0.06	0.06
Mid-frequency cetaceans	230	< 0.02	< 0.02	< 0.02	< 0.02	224	< 0.02	< 0.02	< 0.02	< 0.02
High-frequency cetaceans	202	0.12	0.12	0.12	0.12	196	0.26	0.28	0.26	0.28
Phocid pinnipeds (underwater)	218	0.04	0.04	0.04	0.04	212	0.06	0.06	0.06	0.06

The ranges to specific thresholds based on the M-weighted sound fields are provided in Table 10 and Figures 37 and 38 of Appendix E.

Vessels

The vessel operations were modelled at each of the two sites (A and B) for the propagation conditions of February and August, representing the range in sound propagation conditions over the course of a year. Sound propagation was modelled for the frequency range from 10 to 25,000 Hz along 72 transects at each site up to a range of 100 km from the source. For the simplicity of the interpretation, each vessel was represented by a point source of acoustic energy at a specific source depth.

The vessels are non-impulsive noise sources. The predicted distances to specific SPLs were computed from the maximum-over-depth sound fields. Two distances relative to the source are reported for each sound level: (1) R_{max}, the maximum range at which the given sound level was encountered in the modelled maximum-over-depth sound field, and (2) $R_{95\%}$, the maximum range at which the given sound level was encountered after excluding 5% of the farthest such points.

The distances to the SPL values from 210 to 120 dB re 1 µPa, in 10 dB steps, are presented in Tables 12.16 to 12.18 for the February and August propagation conditions at each site. The corresponding contour maps of the estimated SPL fields are presented in Figures 39 to 44 in Appendix E. The maximum ranges to the specific TTS- and PTS-onset thresholds were estimated for each marine mammal group using M-weighting functions as defined in NMFS (2018) for non-impulsive noise sources. The calculations were performed for February and August propagation conditions, which represent the range in propagation conditions over the course of a year.

Table 2.16 Maximum (R_{max}, km) and 95% ($R_{95\%}$, km) Horizontal Distances from the Generic Drillship Source to Modelled Maximum-over-depth SPL Thresholds at Each Modelled Site for February and August Propagation Conditions

SPL (dB re 1 µPa)	Site A				Site B			
	February		August		February		August	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
210	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
190	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
180	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
170	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
160	0.095	0.094	0.092	0.092	0.095	0.094	0.092	0.092
150	0.304	0.297	0.314	0.308	0.305	0.298	0.316	0.308
140	0.983	0.955	1.05	1.02	0.986	0.955	1.06	1.03
130	6.32	6.19	3.38	3.28	6.57	6.37	5.66	5.42
120	53.6	47.7	26.9	17.5	65.0	60.9	26.6	17.4

Table 2.17 Maximum (R_{max}, km) and 95% ($R_{95\%}$, km) Horizontal Distances from the Representative Drillship Source to Modelled Maximum-over-depth SPL Thresholds at Each Modelled Site for February and August Propagation Conditions

SPL (dB re 1 µPa)	Site A				Site B			
	February		August		February		August	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
210	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 2.17 Maximum (R_{max}, km) and 95% ($R_{95\%}$, km) Horizontal Distances from the Representative Drillship Source to Modelled Maximum-over-depth SPL Thresholds at Each Modelled Site for February and August Propagation Conditions

SPL (dB re 1 µPa)	Site A				Site B			
	February		August		February		August	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
190	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
180	0.010	0.010	0.014	0.014	0.010	0.010	0.014	0.014
170	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
160	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
150	0.155	0.151	0.160	0.143	0.156	0.151	0.161	0.144
140	0.508	0.495	0.542	0.529	0.512	0.500	0.538	0.523
130	5.49	5.44	2.06	2.01	4.75	4.67	2.06	2.01
120	24.46	23.93	10.31	9.88	30.73	30.1	9.54	8.96

Table 2.18 Maximum (R_{max}, km) and 95% ($R_{95\%}$, km) Horizontal Distances from the Representative PSV Source to Modelled Maximum-over-depth SPL Thresholds at Each Modelled Site for February and August Propagation Conditions

SPL (dB re 1 µPa)	Site A				Site B			
	February		August		February		August	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
210	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
190	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
180	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
170	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
160	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
150	0.103	0.100	0.100	0.100	0.103	0.100	0.100	0.100
140	0.331	0.322	0.332	0.324	0.331	0.323	0.334	0.326
130	1.05	1.02	1.07	1.04	1.05	1.02	1.07	1.04
120	5.56	5.46	3.43	3.34	5.80	5.65	6.05	5.74

The predicted maximum distances to specific 24-hour SEL marine mammal impact criteria threshold levels were computed from the maximum-over-depth sound fields. Two distances relative to the source are reported for each sound level: (1) R_{max}, the maximum range at which the given threshold level was encountered in the modelled maximum-over-depth sound field, and (2) $R_{95\%}$, the maximum range at which the given threshold level was encountered after excluding 5% of the farthest such points. These results are presented in Tables 14 to 16 and Figures 45 to 50 in Appendix E.

Semi-submersible Platform

The underwater sounds radiated by semi-submersible drilling operations are generally non-impulsive. The distances to the SPL values from 210 to 120 dB re 1 µPa, in 10 dB steps, are presented in Table 2.19 for the February and August propagation conditions at each site. Vertical slice plots and contour figures are presented in Figures 51 to 56 and Figures 57 and 58, respectively, in Appendix E. The resultant maximum-over-depth 24-hour SEL fields are presented in Table 18 and Figures 59 and 60 in Appendix E.

Table 2.19 Maximum (R_{max}, km) and 95% ($R_{95\%}$, km) Horizontal Distances from the Representative Semi-submersible Source to Modelled Maximum-over-depth SPL Thresholds at Each Modelled Site for February and August Propagation Conditions

SPL (dB re 1 µPa)	Site A				Site B			
	February		August		February		August	
	R*max* (km)	R*95%* (km)	R*max* (km)	R*95%* (km)	R*max* (km)	R*95%* (km)	R*max* (km)	R*95%* (km)
210	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
190	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
180	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
170	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
160	0.100	0.100	0.099	0.095	0.102	0.100	0.099	0.099
150	0.324	0.316	0.328	0.320	0.325	0.316	0.349	0.340
140	1.10	1.07	1.40	1.37	1.12	1.08	1.42	1.38
130	11.9	11.6	4.36	4.24	16.0	15.4	4.21	4.06
120	>100	97.4	36.2	35.7	>100.0	97.4	36.2	34.5

2.7.5.3 Atmospheric Sound

Atmospheric sound will be generated by various aspects of the Project including through operation of the MODU, aircraft, and PSVs. Atmospheric sound for these operations is considered relatively low because of their localized nature, the transient for travelling aircraft and PSVs, and distance to human or other receptors. For example, the closest offshore operation is the White Rose floating production storage and offloading (FPSO) that is approximately 153 km from the nearest EL. Sound levels from in-air Project sources are limited underwater because of the low transmission of atmospheric sound to underwater environments, and likely mask effects of atmospheric sound by underwater sound emissions. While helicopter traffic associated with the Project sound will be transient, short term (minutes) sound emissions will be perceived to be higher during take-off and landing at the existing operational airport (St. John's International Airport) and on the MODU because of proximity to communities or other human receptors. Effects of helicopter traffic (including atmospheric sound) on wildlife will be mitigated through avoidance of bird colonies (see Section 9.3).

2.7.6 Light and Thermal Emissions

Light and thermal emissions will be generated by various sources from the Project. MODU and PSV navigation and deck artificial lighting will be operating 24 hours a day throughout drilling and vessel operations for maritime and crew safety. Flaring activity during well flow testing, if required, will generate light and thermal emissions on the MODU. Well flow testing, if it occurs, will be carried out on a temporary basis at the end of drilling operations on a maximum of two wells. It is possible that there could be several, intermittent, short periods of flaring totaling approximately 24 hours during a one to three-month window at the end of drilling operations. Thermal emissions in water may also be generated in association with discharged produced water during well flow testing.

The Project will therefore result in an increase in night-time light levels, particularly within the Project Area where the MODU will be the only structure and will be illuminated at night. The existing condition of the night sky in the Project Area is assumed to be a dark-sky site given the lack of offshore platforms in the vicinity of the Project and low level of vessel traffic activity in the area.

2.8 Alternative Means of Carrying out the Project

The EA is a valuable planning tool that is used to inform and influence Project design and proactively address the potential environmental outcomes of the development activities. Therefore, as required under section 19(1)(g) of CEAA 2012, the EA of a designated project must consider alternative means of carrying out the project that are considered technically and economically feasible and include the environmental effects of such alternative means. The approach to review of alternative means is consistent with the CEA Agency's (CEA Agency 2015) Operational Policy Statement for Addressing "Purpose of" and "Alternative Means" under CEAA 2012.

2.8.1 Identification and Evaluation of Alternatives

An analysis of alternative means for the following Project components and activities is required by the EIS Guidelines (CEA Agency 2019) and requires the analysis of alternative means for the following Project components and activities:

- Drilling fluid selection (e.g., WBM or SBM)
- MODU selection
- Drilling waste management
- Water management and effluent discharge
- Alternative lighting options for the MODU (including flaring) to reduce attraction and associated mortality of birds

A consideration of regulatory acceptability, technical feasibility and economic feasibility, as well as the environmental effects (where applicable) of each alternative means is described for each option (Table 2.20).

Table 2.20 Alternative Means Assessment Descriptors

Descriptor	Definition
Regulatory Acceptability	• Acceptable considering applicable regulatory guidelines and frameworks
Technical Feasibility	• Feasible considering criteria which could influence safe, reliable, and efficient operations • Technology must be available and proven for use in a similar environment and activity set (i.e., offshore drilling in deep water), and cannot compromise personnel and process safety for it to be considered
Economic Feasibility	• Feasible considering capital and operational project expenditure, and opportunity cost. • Project expenditure can be impacted directly (e.g., equipment and personnel requirements) and indirectly (e.g., schedule delays)
Potential Environmental Considerations	• Consideration of potential environmental effects on valued components (VCs) • Considers applicable regulatory guidelines and frameworks for reducing environmental effects and applicable mitigation measures
Preferred Option	• The preferred alternative means in consideration of legal acceptability, technical feasibility, economic feasibility, and potential environmental considerations • The preferred alternative means forms the basis for the Project to be assessed

Each option for the alternative means is summarized in a tabular format. The preferred alternative means form the basis for the Project to be assessed (i.e., assumed to be the base case that is assessed for environmental effects in Chapters 8 to 14 of this EIS).

2.8.2 Drilling Fluids Selection

Several types of drilling fluids are use in the drilling of offshore wells off NL, including WBMs and SBMs. Initial drilling phases of an offshore exploration or appraisal well typically use WBM. SBMs are generally used once the riser has been installed and are characterized by being more efficient in drilling operations through challenging geological conditions. A specific SBM drilling fluid has not yet been identified for the Project. Both types of mud are acceptable to local regulators, providing the components of the mud are selected according to the OCSG and disposal is carried out according to the OWTG.

A summary of the comparison drilling fluid options is presented in Table 2.21. Although there are technical and economic advantages to using SBM, it cannot be used for riserless sections of the well. Therefore, the preferred option is to use WBM and SBM while drilling different sections of the well and the EIS considers the use of both WBM and SBM in the effects assessment.

Table 2.21 Summary of Drilling Fluid Alternatives Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
WBM	YES Acceptable for use in accordance with regulatory requirements (i.e., OCSG)	YES Technically feasible for drilling initial hole sections Technically inferior in drilling deeper sections of well	YES Economically feasible for initial hole sections when drilling Economically inferior in deeper sections of well. Probability of increased non-productive time and cost associated with drilling deeper sections of well	Considered acceptable for drilling initial and deeper sections provided appropriate controls are in place and chemicals are selected in accordance with OCSG	✓ Use of WBM for drilling initial hole sections when drilling without riser installed
SBM	YES Acceptable for use in accordance with regulatory requirements (i.e., OCSG)	YES Technically feasible and superior for drilling deeper sections of well	YES Economically feasible for drilling deeper sections of well	Not considered acceptable for drilling initial sections. SBM cannot be used for riserless drilling where the cuttings are disposed directly on the seafloor (See Section 2.4.1.2) Considered acceptable for deeper sections provided appropriate controls are in place and chemicals are selected in accordance with OCSG	✓ Use of SBM for drilling deeper hole sections when riser installed

2.8.3 MODU Selection

A jack-up rig, a semi-submersible drilling unit, and a drillship are the three main types of MODUs for offshore drilling. BHP has not yet selected the MODU that will be used to drill the wells for the Project. In consideration of the water depths in the ELs (approximately 1,175 to 2,575 m), a jack-up rig is not a technically feasible option and is not assessed as an alternative. Jack-up rigs are typically used in relatively shallow water depths of less than 100 m. Therefore, either a semi-submersible drilling unit or a drillship will be used. Section 2.3.1 describes the MODU selection and approval process. Both a semi-submersible MODU and drillship are considered technically and economically feasible options and would have comparable environmental effects (e.g., lighting, emissions, discharges, underwater sound). The EIS therefore considers both MODU options in the effects assessment. A summary of the comparison between MODU options is presented in Table 2.22. Furthermore, there may be different types of MODUs actively engaged in drilling activities in the Project Area over the life of the Project.

Table 2.22 Summary of MODU Alternatives Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
Semi-submersible Drilling Unit	YES Acceptable for use following issuance of Certificate of Fitness	YES Suitable for working in deep-water environment of ELs.	YES Economically feasible for Project	MODU be can be used in an environmentally acceptable manner provided that appropriate approvals and mitigation measures are implemented Comparable environmental effects in terms of lighting, emissions, discharges and underwater sound	✓ Semi-submersibles may be used for the Project
Drillship	YES Acceptable for use following issuance of Certificate of Fitness	YES Suitable for working in deep-water environment of ELs. However less suited to harsh environment than semi	YES Economically feasible for Project. More prone to weather related downtime than a semi	MODU can be used in an environmentally acceptable manner provided that appropriate approvals and mitigation measures are implemented Comparable environmental effects in terms of lighting, emissions, discharges and underwater sound	✓ Drillships may be used for the Project
Jack-up Rig	YES Acceptable for use following issuance of Certificate of Fitness	NO Not technically feasible considering the Project water depths	Not assessed as option is not technically feasible		✗ Jack-up rigs will not be used for the Project

2.8.3.1 Drilling Waste Management

Drilling waste management options considered for the Project include at-sea disposal, offshore reinjection, and onshore disposal.

Additional details on drilling fluids, cuttings, and associated waste materials and management are provided in Section 2.4.1.2 and 2.7.2. Drilling related waste streams will be reduced where feasible and treated and disposed of in accordance with the OWTG. The assessment of drilling waste management alternatives varies depending on the type of drilling fluid used (e.g., WBM or SBM). For both these drilling fluids and associated cuttings, at-sea disposal is a regulatory-acceptable method of waste management as described in Section 2.7.2 following appropriate treatment (if required) before disposal. As the initial well sections are drilled without a riser in place, the WBMs and associated cuttings that are used in and result from these drilling activities are discharged directly to the seabed provided they meet regulatory guidelines. As WBM associated cuttings cannot be returned to the MODU for storage and disposal during initial drilling, alternative waste management options such as onshore disposal and reinjection are not technically feasible.

Drill fluids and cuttings can be returned to the surface and on to the MODU for recovery and reuse after the riser and blow-out preventer are installed and in place. SBM drill cuttings waste management options for consideration include at-sea disposal, offshore reinjection, and onshore disposal. Once SBM associated cuttings are onboard, drill cuttings are removed from the drilling mud in successive separation stages. As part of cuttings management, the MODU will be equipped with specialized solids control equipment to recover drilling fluids from the cuttings. SBM-associated drill cuttings will be discharged at the drill site, once the performance targets within the OWTG, are met.

An alternative method of offshore disposal is cuttings reinjection. Reinjection involves processing cuttings waste into a slurry and then pumping them into a dedicated well designed for reinjection. Although reinjection from a fixed wellhead platform is well proven, subsea injection from MODUs is limited and not practical. Subsea injection equipment is highly specialized requiring a flexible injection riser and specially designed wellhead. As reinjection has only been developed for water depths of approximately 300 m, there may ultimately be technological limitations for deep-water applications. This option would also have added complexity and cost of associated equipment and large storage capacity required for the MODU. Therefore, reinjection of cuttings in a dedicated disposal well is not considered to be a technically or economically feasible alternative for an exploration drilling program.

Onshore disposal is another option for disposal. Onshore disposal of SBM cuttings would require storage on the MODU and shipment to shore via a PSV to an approved waste management facility for treatment and disposal. Currently, there are no approved waste management facilities in NL for treatment and disposal of SBMs. Therefore, the drilling waste would require shipment to an out-of-province facility. This drilling waste management option reduces potential offshore environmental effects, however there are potential onshore environmental effects associated with increased atmospheric emissions from transportation, and habitat alteration from onshore treatment and disposal. It is anticipated that this option will result in increased costs to the Project associated with additional transportation, storage, and treatment costs. This option is further made economically inferior because of potential operational risk associated with waste management facility and PSV availability. Delays to PSV collection and transport of cuttings may result in reaching cuttings storage capacity on the MODU, therefore requiring cessation of drilling operations. There are also potential additional health, safety, and environmental risks associated with respect to onshore disposal because of additional truck and vessel traffic, and additional exposure and handling of material.

A summary of the comparison of drilling waste management options is presented in Table 2.23. Discharge to the water column following treatment (where applicable) is the preferred option for both SBM and WBM cuttings. WBM cuttings and associated fluid will be discharged to the seafloor as permitted by the OWTG as there is no mechanism for returning cuttings to the MODU during the riserless phase. The SBM fluids are reconditioned and reused until the well is abandoned, when the spent SBM is returned to shore for disposal. The EIS considers the environmental effects associated with at-sea disposal of SBM and WBMs.

Table 2.23 Summary of Drilling Waste Management Alternatives Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
At-sea Disposal (WBM)	YES Acceptable for use in accordance with regulatory requirements (i.e., OWTG)	YES Only technically feasible option for WBM cuttings during the riserless section	YES Economically feasible for Project	Localized environmental effects on the seafloor within cuttings footprint	✓ At-sea disposal of WBM cuttings during riserless drilling
At-sea Disposal (SBM)	YES Acceptable for use in accordance with regulatory requirements (i.e., OWTG)	YES Technically feasible for Project	YES Economically feasible for Project	Localized environmental effects on the seafloor within cuttings footprint	✓ At-sea disposal of SBM cuttings following treatment
Reinjection (WBM)	YES Acceptable for use in accordance with regulatory requirements (i.e., OWTG)	NO During riserless drilling cuttings cannot be returned to MODU for collection and alternate disposal	Not further assessed as option is not technically feasible		✗ Not considered as an option as not technically feasible
Reinjection (SBM)	YES Acceptable for use in accordance with regulatory requirements (i.e., OWTG)	NO Not developed for deep-water applications	NO Economically inferior because of complexity and costs associated with specialized equipment	Reduced potential offshore environmental effects	✗ Considered not technically or economically feasible
Onshore Disposal (WBM)	YES Acceptable for use in accordance with regulatory requirements (i.e., OWTG)	NO During riserless drilling cuttings cannot be returned to MODU for collection and alternate disposal	Not further assessed as option is not technically feasible		✗ Not considered as an option as not technically feasible

Table 2.23 Summary of Drilling Waste Management Alternatives Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
Onshore Disposal (SBM)	YES Acceptable for use in accordance with regulatory requirements (i.e., OWTG)	YES Storage of drilling wastes on MODU before shipment by PSV to approved waste management facility for treatment and disposal	YES Economically inferior for cuttings because of increased transportation costs and operational delays	Reduced potential offshore environmental effects Increased potential onshore environmental effects associated with atmospheric emissions from transportation, and habitat alteration from onshore treatment and disposal	✓ Spent SBM is returned to shore for disposal or re-use ✗ SBM cuttings disposal considered economically inferior. Potential for increased onshore environmental effects

2.8.3.2 Water Management and Location of Effluent Discharge Points

Liquid waste management options considered for this Project is dependent on the specific liquid waste and includes at-sea disposal, flaring (well treatment and testing fluids, produced water) and onshore disposal. Additional details on liquid wastes and associated management are provided in Section 2.7. A summary of the comparison of water management options is presented in Table 2.24. Liquid related waste streams will be reduced where feasible and treated and disposed of in accordance with the OWTG. Liquid wastes, not approved for discharge in the OWTG such as waste chemicals, cooking oils, or lubricating oils, will be transported onshore for transfer to an approved disposal facility. Liquid wastes that conform to the OWTG will be discharged from the MODU to the marine environment.

Effluent discharge points on a MODU are typically just below or above the sea surface. As specific discharge points are dependent on the design of the contracted MODU; these locations are fixed and cannot be re-configured. Before commencement of the drilling program, a Certificate of Fitness will be obtained for the MODU from an independent third-party Certifying Authority (see Section 2.3.1.3) which will include confirmation that effluent discharge and water management systems comply with relevant legislation.

Table 2.24 Summary of Water Management and Effluent Discharge Points Alternatives Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
At-sea Disposal	YES Acceptable for specific liquid wastes in accordance with regulatory requirements (i.e., OWTG, MARPOL)	YES Technically feasible for Project	YES Economically feasible for Project	Localized environmental effects that are considered acceptable provided appropriate treatment and disposal in accordance with regulatory requirements	✓ Discharge of bilge and deck drainage water, ballast water, grey and black water, and cooling water in accordance with regulatory requirements
Flaring (Well treatment and testing fluids, Produced Water)	YES Acceptable for specific liquid wastes in accordance with regulatory requirements	YES Technically feasible for Project	YES Economically feasible for Project	Localized environmental effects associated light and thermal emissions	✓ Well treatment and testing fluids will be flared for safe disposal. Small amounts of produced water may be flared
Onshore Disposal	YES Acceptable for specific liquid wastes in accordance with regulatory requirements (i.e., OWTG, MARPOL)	YES Technically feasible for Project	YES Economically feasible for Project	Reduced potential offshore environmental effects Increased potential onshore environmental effects associated with atmospheric emissions from transportation	✓ Liquid wastes not approved for discharge in OWTG transported onshore for treatment and disposal
Effluent Discharge Points	Options not considered as specific discharge points are fixed based on MODU design and cannot be re-configured. Confirmation that effluent discharge and water management systems comply with relevant legislation during application for Certificate of Fitness.				

2.8.3.3 Offshore Vessel Lighting (including Flaring)

On-board lighting will be required for Project activities occurring at night for maritime safety and crew safety. Lighting is also in place and activated on MODUs, PSVs and aircraft for navigation, safety, and regulatory compliance reasons. Therefore, no or limited lighting is not further assessed. Lighting alternatives considered include standard lighting and spectral modified lighting.

Spectral modified lighting has been tested on offshore platforms and has demonstrated a reduced effect on marine birds in the North Sea; particularly the use of green and blue light (Marquenie et al. 2013, 2014). Spectral modified lighting has satisfied regulatory requirements in a number of regions, including in the Netherlands, Germany and in the United States. However, this option is not considered technically or economically feasible considering implementation in the offshore oil and gas industry has been restricted by commercial availability, limited capability in extreme weather, safety concerns around helicopter approach and landing, and lower energy efficiency (Poot et al. 2008; Marquenie et al. 2014). The MODU and PSVs selected for the Project will be contracted through a third-party contractor and selected in consideration of technical capabilities and safety. BHP is not aware of operating MODUs or PSVs operating in the NL offshore that are currently equipped with spectral modified lighting that have the technical capability to support the Project.

A summary of the comparison of lighting alternatives options is presented in Table 2.25. Lighting will be reduced as practically feasible to the extent that it does not affect crew and vessel safety, nor the safety of other marine vessels and activities. The EIS considers the environmental effects associated with standard MODU lighting (see Chapter 10).

Table 2.25 Summary of Lighting Alternatives Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
Standard Lighting	YES Lighting required for navigation, safety, and regulatory compliance reasons	YES Technically feasible for Project	YES Economically feasible for Project	Potential localized effects on marine and migratory birds	✓ Standard lighting will be used for the Project
Spectral Modified Lighting	YES Lighting required for navigation, safety, and regulatory compliance reasons	NO Limited capabilities in extreme weather, lower energy efficiency, helicopter safety concerns	NO Not commercially viable	Potential reduced effects on marine and migratory birds	✗ Considered not technically or economically feasible

Flaring, if required, will contribute to light, thermal, and atmospheric emissions, with potential for effects on marine and migratory birds. Flaring is associated with well testing and evaluation that is required by the C-NLOPB to declare a significant discovery and to convert an EL to an SDL. Additional information on well testing and evaluation is detailed in Section 2.4.3. Flaring strategies considered include not flaring, IPTT, reduced flaring, and flaring as required. If BHP intends to flare, it will notify the C-NLOPB in accordance with “Measures to Protect and Monitor Seabirds in Petroleum-Related Activity in the Canada-NL Offshore Area”. During well flow testing, flaring is required to safely dispose of hydrocarbons that may come to the surface. Therefore, no flaring is not considered an option for well testing as it does not meet regulatory acceptability.

If flaring is required, it is expected to be brief and intermittent, with short periods of flaring totaling approximately 24 hours during a one to three-month window at the end of drilling operations. Flaring activities will be conducted in accordance with regulatory requirements and in instances where IPTT is not appropriate for data collection. When flaring, BHP will use a water curtain to protect personnel and equipment on the MODU by limiting the transfer of radiated heat from the flare, thereby mitigating risk of fire. A secondary benefit of a water curtain may be potential deterrence of birds from the general vicinity of the flare based on the positioning of the water curtain. A water curtain could therefore be a technically and economically feasible option as a flare shield to reduce adverse effects of flaring on birds.

Reduced flaring considers limiting the activity outside of higher risk attraction periods for marine and migratory birds including nighttime and during low-visibility periods (i.e., fog, inclement weather). However, well flow restriction to certain test periods based on weather conditions may compromise the data gathered during the well test. Prolonged well test activity from insufficient data collection may also increase operational costs and risks.

IPTT is an option where flaring is not carried out as part of the well test. However, an IPTT may not provide the same data as formation flow testing with flaring and therefore may not be a suitable alternative in all cases. Insufficient data collection could also increase operational costs if further testing is required. Although this well test option is technically and economically inferior to flaring alternatives, it will be considered on a case by case basis so that testing meets C-NLOPB requirements as it reduces potential effects on marine and migratory birds.

BHP continually seeks opportunities to identify and implement new ways of raising standards and improving productivity, safety, environmental impact, and embrace new technologies. Formation Testing While Tripping (FTWT) is a pipe conveyed well flow test technology that is patented by Schlumberger and Statoil (now Equinor). For this reason, this particular technology cannot be specifically used unless it becomes widely available to the industry. BHP will continue to evaluate new technologies as alternatives to flaring and IPTT.

A summary of flaring alternatives is provided in Table 2.26. The analysis of Project effects assumes there will be flaring during well testing as required.

Table 2.26 Summary of Flaring Alternative Analysis

Options	Regulatory Acceptability	Technically Feasibility	Economic Feasibility	Potential Environmental Considerations	Preferred Option
No Flaring	NO Not acceptable because of regulatory and safety requirements	Not further assessed as option does not have regulatory acceptability			✗ Not considered as option does not have regulatory acceptability
IPTT	YES Acceptable in accordance with regulatory requirements	YES Technically inferior as may not fulfill C-NLOPB data requirements in all cases	YES Economically inferior with extended schedule associated with inferior data collection	No potential atmospheric effects on marine and migratory birds	✓ Conducted on case by case basis
Reduced Flaring (no flaring during night or inclement weather)	YES Acceptable in accordance with regulatory requirements	YES Technically inferior with potential compromised data from formation flow test	YES Economically inferior with potential schedule extension	Reduced potential atmospheric effects on marine and migratory birds	✗ Technically and economically inferior to other options
Flaring as required	YES Acceptable in accordance with regulatory requirements	YES Technically feasible for Project	YES Economically feasible for Project	Potential localized atmospheric effects on marine and migratory birds	✓ Conducted when IPTT is not appropriate for data collection

2.8.4 Chemical Management

Specific drill fluids and other chemicals and materials have yet to be identified or selected for the Project. A drilling fluid and cementing contractor for the Project has not yet been selected, and the drilling fluid basis of design for the wells is under development. Therefore, potential alternatives have not yet been identified and BHP is unable to evaluate and select alternative chemicals as part the EA process.

As Project planning continues, BHP and its contractors will follow chemical management and selection processes to define the ways in which chemicals will be chosen and used. Chemical management processes will be defined before the start of drilling activity and will be conducted in accordance with applicable legislation as summarized in Table 2.27.

Table 2.27 Applicable Offshore Chemical Management Legislation and Guidelines

Legislation	Regulatory Authority	Relevance
Canadian Environmental Protection Act, 1999 (CEPA)	ECCC	Provides for the notification and control of certain manufactured and imported substances The Domestic Substances List is a list of substances approved for use in Canada Schedule 1 includes a list of substances that are considered toxic and subsequent restrictions or phase out requirements
Fisheries Act	DFO; ECCC	Prohibits the deposition of toxic or harmful substances into waters containing fish
Hazardous Product Act	Health Canada	Standards for chemical classification and hazard communication
International Convention for the Prevention of Pollution from Ships (MARPOL)	IMO	International convention covering prevention of pollution to the marine environment from ship operational activities or accidental events
Migratory Birds Convention Act, 1994 (MBCA)	ECCC	Prohibits the deposition of harmful substances in waters or areas frequented by migratory birds
Pest Control Products Act	Health Canada	Regulates the importation, sale and use of pest control products, including products used as biocides offshore
Offshore Chemical Notification Scheme (OCNS)	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	Registry of chemicals used for offshore oil and gas applications in United Kingdom and Netherlands waters
Offshore Chemical Selection Guidelines (OCSG)	C-NLOPB	Framework for the selection of drilling and production chemicals for use and possible discharge in offshore areas
Offshore Waste Treatment Guidelines (OWTG)	National Energy Board; C-NLOPB; CNSOPB	Recommended practices for managing waste materials from offshore petroleum drilling and production operations Waste material discharged as outlined in the guidelines are not expected to cause significant adverse environmental effects
Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) Pose Little or No Risk (PLONOR) List	OSPAR Commission	Listing of substances whose use and discharge offshore are considered to PLONOR based on expert judgment by competent national authorities These chemicals are considered to not need to be strongly regulated

Selection of drilling chemicals will, at minimum, be in accordance with the OCSG which establishes a procedure and criteria for offshore chemical selection. The objective of the guidelines is to promote the selection of lower toxicity chemicals to reduce the potential environmental effect of a discharge where technically feasible. BHP will also develop a Chemical Screening and Management Plan that will used to evaluate prospective chemicals and meet or exceed regulatory requirements.

2.8.4.1 Proposal for Use: Initial Screening and Regulatory Controls Identification

Chemicals proposed for use on the Project will be screened to determine if there are restrictions for use by applicable legislation (Table 2.27). Screening will look at specific aspects of the chemical's use including the volume required and discharge assumptions.

Based on the regulations there are restrictions, controls, and prohibitions, in agreement with applicable regulatory agencies, placed on:

- Biocide chemicals
- Chemicals not previously approved for use in Canada (i.e., are not registered on the Domestic Substances List) or have not been used previously for the proposed purpose
- Chemicals identified as toxic under Schedule 1 of CEPA. In the event that a chemical is proposed for use that is listed under Schedule 1 of CEPA, BHP will consider alternative means of operation, and/or will evaluate less toxic alternatives

2.8.4.2 Chemicals Intended for Marine Discharge: Toxicity Assessment

After initial screening to flag restrictions / prohibitions, BHP will conduct a further assessment for chemicals proposed for use and discharge to the marine environment. In accordance with the OCSG chemical selection framework (NEB et al. 2009), chemicals intended for discharge to the marine environment must:

- Be included on the OSPAR PLONOR list
- Meet certain hazard classification requirements under the OCNS
- Pass a toxicity bioassay (Microtox test:half maximal effective concentration (EC50))
- Undergo a chemical specific hazard assessment under the OCNS
- Be an accepted chemical for use by the C-NLOPB based on BHP provided justification that discharge of the chemical will meet OCSG objectives

Each of these criterion as listed above is reviewed for applicability before proceeding to the next step. This assessment process evaluates the potential toxicity of proposed chemicals (and chemical constituents as applicable), and to establish if additional restrictions, controls or prohibitions are required. The OCSG apply to the following chemical categories that may be used as part of the Project. Not all of the chemicals under categories listed below would be intended for discharge into the marine environment:

- Drilling fluids, including sweeps and displacement fluids
- Cementing
- BOP fluids
- ROV fluids
- MODU washes, pipe dopes, and hydraulic fluids used to control wellheads and BOPs

The specific types and volumes of chemicals to be used are not currently known. A Safety Data Sheet (SDS) will be available for chemicals present on the PSVs and MODU. The inventory of chemicals on board the MODU will be monitored regularly and an annual report will be submitted to the C-NLOPB to outline each chemical used including the hazard rating, quantity used, and its ultimate fate.

The OCSG do not apply to the following categories of chemicals:

- The selection of domestic chemicals and other chemicals that are used on an installation that are not directly associated with drilling activities, such as those used for accommodations, catering, equipment and facility maintenance (e.g., lubricants, paints), safety systems, and laboratory operations
- The selection of chemicals that are used on PSVs and helicopters

2.9 Environmental Management

BHP has a clear goal to facilitate sustainable development and is committed to reducing environmental effects. This section introduces BHP's Our Requirements that describe the mandatory minimum performance requirements and accountabilities, business obligations, processes, functions, and activities across BHP.

BHP will implement and adhere to relevant environmental mitigation requirements outlined in applicable legislation and regulations, including commitments made in this EIS, and eventually required as enforceable conditions of an EA approval. Environmental mitigation and compliance requirements will be implemented and adhered to by Project contractors and subcontractors as it applies to their specific work scopes. This will be enforced through relevant commercial and contractual arrangements with these providers or goods and services to the Project.

2.9.1 Health, Safety, Environment, and Community

To BHP, sustainability means putting health and safety first, being environmentally responsible and supporting communities. The wellbeing of BHP's people, the community, and the environment is considered in everything that it does.

BHP's highest priority is the safety of those affected by its operations, including BHP employees, contractors, and the communities in which it operates. BHP achieves nothing if it does not do it safely.

Recognizing that BHP's operations can affect the health of its people, BHP sets clear requirements to manage and protect the health and wellbeing of its workforce, now and into the future. BHP looks to create a culture of care and trusted relationships with its people through strong leadership and open communication.

BHP aims to reduce the environmental effects from its activities and work in partnership with others to support environmental resilience.

BHP seeks to build good relationships with its stakeholders based on mutual respect, open and ongoing communications and transparency over its activities. BHP supports the development of diversified and resilient local economies that contribute to improved quality of life beyond the life of BHP's operations.

Our Requirements are the standards that give effect to the mandatory requirements arising from the BHP Operating Model as approved by the Executive Leadership Team (ELT). Our Requirements describe the mandatory minimum performance requirements and accountabilities for Group-wide Health, Safety, Environment and Community related performance requirements, business obligations, processes, functions, and activities across BHP. More Information about BHP's Our Requirements is provided in Section 1.3.2, Table 1.3.

2.9.2 BHP's Health, Safety and Environment Management System

BHP's Health, Safety and Environment Management System (HSEMS) establishes the HSE requirements for BHP projects and operations. BHP's HSEMS sets out requirement, standards, procedures and tools to manage the environmental, social, and human rights risks and impacts of projects undertaken by BHP.

Effective implementation of the HSEMS that delivers improved environmental performance is required to support BHP's Charter value of putting health and safety first, being environmentally responsible and supporting our communities.

The HSEMS helps BHP to manage and reduce risks throughout its activities globally, as well as reduce the environmental impact of its operating activities. It sets out consistent principles and processes that are applied across BHP Group.

The HSEMS includes requirements and guidance for the identification and management of environmental and social impacts within BHP operations. These include topics such as management of waste, climate change, and cultural heritage.

BHP's ability to be a safe and responsible operator depends, in part, on the capability and performance of contractors and suppliers. Contractors and suppliers can make up a major part of the workforce throughout the life of a project or operation.

BHP's HSEMS also defines requirements and practices for working with Contractors. Contracts will include clear and consistent information, setting out specific details of BHP's expectations. Contracts will be awarded following a bidding and contract tender evaluation process, which will take account of factors such as safety, technical quality, and cost. Contractors and subcontractors will be required to demonstrate conformance with the requirements that have been established, including HSE standards and performance requirements. Bridging documents are necessary in some cases to define how BHP's safety management systems and those of contractors will co-exist to manage risk on a site.

Contractors, such as drilling and third-party contractors, will be accountable for the development and delivery of their safety management systems. Contractors will be responsible for carrying out self-verification activity to assess conformance with their contractual requirements. Contractor safety performance is assessed and reviewed by BHP using a number of leading and lagging indicators. BHP will carry out reviews and assurance activity throughout the duration of the contract.

2.9.3 Health, Safety and Environment Management Planning

BHP will develop environmental management plans in accordance with corporate and regulatory requirements. These plans will be designed to verify that appropriate mitigative measures and controls have been implemented to reduce the potential for environmental effects. The Environmental management plans will also provide defined action and emergency response plans to protect human and environmental health and safety. As part of Project planning and as a requirement of the C-NLOPB OA process, BHP will submit the following documents to the C-NLOPB for review and approval:

- EPP
- Safety Plan
- Incident Management Plan (IMP)
- Oil Spill Response Plan (OSRP), including a Spill Impact Mitigation Assessment (SIMA)
- Canada-Newfoundland and Labrador Benefits Plan (see Section 1.4.3)

2.9.3.1 Environmental Protection Plan

In accordance with the EPP Guidelines (NEB et al. 2011a), the EPP is a project-specific document, and will identify environmentally critical components, and summarize environmental protection measures and commitments made as part of the EA and subsequent approval processes with the C-NLOPB. The EPP will also serve to communicate Project requirements and commitments for environmental management and protection to Project personnel, contractors, subcontractors, regulatory agencies, and stakeholders. This includes personnel roles and responsibilities, monitoring requirements, reporting, and notification procedures to regulators and stakeholders. The EPP will also describe BHP's global requirements and how they will be implemented for the Project.

2.9.3.2 Safety Plan

In accordance with the Safety Plan Guidelines (NEB et al. 2011b), the Safety Plan will communicate Project requirements and commitments for health and safety to Project personnel, contractors, subcontractors, regulatory agencies, and stakeholders. This includes hazard identification, risk management, and competency of personnel, incident reporting and investigation, and compliance and performance monitoring. It will also identify engineering controls and equipment critical to safety including a system for inspection, testing, and maintenance.

2.9.3.3 Incident Management Plan

Based on hazard and risk assessments for the Project, the IMP will describe response measures to a potential emergency event regardless of size, complexity or type of incident. This will include response organization roles and responsibilities, and notification and reporting procedures. The IMP will be an umbrella document containing the plans that form the Project's emergency response documentation. It will provide details of BHPs onshore response support to the incident site and will be linked to the site-specific MODU Emergency Response Plan. The IMP will describe the Incident Command System structure and will detail alignment with federal and provincial regulators as per the structure in place with the C-NLOPB.

2.9.3.4 Oil Spill Response Plan and Spill Impact Mitigation Assessment

The OSRP provides tactical and strategic guidance regarding response management, capabilities and resources in the unlikely event of an oil spill. This will include response strategies for a range of potential spill scenarios including worst credible-case discharge based on hazard and risk assessments for the Project. Each scenario will consider the following:

- Type and amount of material potentially spilled
- Fate and transport of the spilled material
- Potential effects of the spill across seasonal scenarios
- Presence of environmental and socio-economic sensitivities

The notification, activation and mobilization procedures to be followed if an unintended release occurs will be outlined in the OSRP. It will identify oil spill response personnel, their roles and responsibilities, including response training and exercise programs. The OSRP will describe the location, mobilization, and deployment of equipment and personnel and will include information about how to monitor and predict spill movement to facilitate an effective response. The OSRP will also include tactical response measures for safely responding to different spill scenarios A Wildlife Response Plan will also be developed as part of the OSRP. Source Control Contingency Plans (SCCPs) will supplement the OSRP and will include specific details on how to respond to a major spill event such as a blowout incident.

The development of the strategies in the OSRP will be based on the results of a Project-specific SIMA (also referred to as a Net Environmental Benefits Analysis). This SIMA will assess the benefits and downsides of various response tactics in consideration of feasibility and effectiveness of implementation in different spill scenarios and environmental conditions. As an important part of contingency planning, SIMA can also be used to support exercises, drills, and training.

2.9.4 Standard Mitigative Measures and Best Practices

A summary of standard mitigation measures to be implemented by BHP on this Project is provided in Table 2.28. These mitigation measures have been routinely and successfully applied to similar oil and gas exploration programs off NL and elsewhere in eastern Canada. Many potential adverse environmental effects identified in this EIS can be managed effectively with standard operating procedures and standard mitigation measures. Adherence to key guidelines such as the OWTG and OCSG, along with MARPOL requirements, will reduce or eliminate adverse environmental effects resulting from waste discharges on the marine environment. Adherence to the SOCP (DFO 2007) during VSP surveys will reduce adverse environmental effects on marine fish, mammals, and sea turtles. Where necessary, site- or Project-specific mitigation measures have also been proposed in this EIS.

These and/or other planning and management measures, in combination with BHP's own policies, principles, and environmental management plans and procedures, will allow the Project to be planned and completed in a manner that avoids or reduces potential environmental effects.

Ongoing consultation and engagement with Indigenous communities, fisheries stakeholders, and regulatory agencies throughout the planning and implementation of the Project will also help to identify appropriate mitigation measures. Standard and specific mitigation will also be incorporated into the Project EPP.

Table 2.28 BHP Canada Exploration Drilling Program (2019-2028) EIS - Standard Mitigation Measures

General Mitigation Measures
Contractors and subcontractors shall be required to demonstrate conformance with the HSE standard and performance requirements that have been established by BHP.
BHP will ensure a Certificate of Fitness from an independent third-party Certifying Authority for the MODU has been obtained prior to commencement of drilling operations in accordance with the C-NLOPB's *Offshore Certificate of Fitness Regulations*.
The observation, forecasting and reporting of physical environment data will be conducted in accordance with the Offshore Physical Environment Guidelines (NEB et al. 2008).
BHP and contractors working on the Project will regularly monitor weather forecasts to forewarn PSVs, helicopters, and the MODU of inclement weather or heavy fog before it poses a risk to their activities and operations. Extreme weather conditions that are outside the operating limits of PSVs or helicopters will be avoided if possible. Captains / Pilots will have the authority and obligation to suspend or modify operations in case of adverse weather or poor visibility that compromises the safety of PSV, helicopter, or MODU operations.
Icing conditions and accumulation rates on PSVs, helicopters, and the MODU will be monitored during fall and winter operations, particularly when gale-force winds may be combined with air temperatures below -2°C (DFO 2012).
In accordance with the Offshore Physical Environmental Guidelines (NEB et al. 2008), a Project-specific Ice Management Plan will be developed to include procedures related to ice detection, monitoring and assessment, as well as the physical management of icebergs, and will outline procedures for the implementation of disconnection and movement of the MODU due to presence of an iceberg. The Ice Management Plan will be submitted to the C-NLOPB for acceptance as part of the OA process.
The MODU and equipment will be designed to withstand potential environmental loads in accordance with the *Newfoundland Offshore Certificate of Fitness Regulations* and will be able to quickly and safely disconnect from the well as required to mitigate potential risks.
The Project will comply with Canadian regulations and international standards (where applicable) to mitigate risks associated with extreme weather and oceanographic conditions. These regulations and standards include considerations and requirements related to operations in various environmental conditions (e.g., average and extreme ambient temperatures, precipitation, ice accretion, wind, waves, tides, currents, sea ice, icebergs, and combinations thereof).
Safe work practices will be implemented to reduce exposure of personnel to lightning risk (e.g., restriction of access to external areas on the MODU or PSV during thunder and lightning events).
BHP will require the Drilling Contractor to provide details of the safety zone to the Marine Communication and Traffic Services for broadcasting and publishing in the Navigational Warning (NAVWARN) and Notices to Mariners (NOTMAR) systems.
Project-related damage to fishing gear will be compensated in accordance with industry best practices in the NL offshore and relevant industry guidance material such as the Geophysical, Geological, Environmental, and Geotechnical Program Guidelines (C-NLOPB 2019), the Canadian East Coast Offshore Operators Non-attributable Fisheries Damage Compensation Program (CAPP 2007), and the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activities (C-NLOPB and CNSOPB 2017) which apply when gear loss or damage occurs because of a spill or authorized discharge, emission or escape of petroleum.

Table 2.28 BHP Canada Exploration Drilling Program (2019-2028) EIS - Standard Mitigation Measures

Presence and Operation of the MODU
To maintain navigational safety during the Project, obstruction lights, navigation lights, and foghorns will be kept in working condition on board the MODU and PSVs. Radio communication systems will be in place and in working order for contacting other marine vessels as necessary.
The MODU will be equipped with local communication equipment to enable radio communication between the PSVs and the MODU's bridge. Communication channels will also be put in place for internet access and enable communication between the MODU and shore.
In accordance with the *Newfoundland Offshore Petroleum Drilling and Production Regulations*, a safety (exclusion) zone (estimated to be a 500-m radius) will be established around the MODU within which non-Project related vessels are prohibited.
Prior to drilling activity, BHP will conduct a comprehensive well-site specific geohazard review using high-quality reprocessed 3D seismic data for the geohazards assessment.
BHP will conduct a visual seabed survey in the vicinity of wells sites confirming the absence of shipwrecks, debris on the seafloor, unexploded ordnance and sensitive environmental features, such as habitat-forming corals or species at risk (SAR) to be used in conjunction with the geohazard assessment based on existing data. The survey will be developed in consultation with the C-NLOPB and DFO and will be carried out prior to drilling under a separate environmental approval by the C-NLOPB. If substantial environmental or anthropogenic sensitivities are identified during the survey, BHP will move the well site to avoid affecting them if it is feasible to do so. If it is not feasible, BHP will consult with the C-NLOPB and DFO to determine an appropriate course of action.
Lighting will be limited to the extent that worker safety and safe operations is not compromised. Measures may include avoiding use of unnecessary lighting, shading, and directing lights towards the deck.
PSV and MODU contractors will have a Maintenance Management System designed to direct the maintenance and efficient operation of the vessels and MODU, and all equipment.
Waste Management
Air emissions from the Project will adhere to applicable regulations and standards including the NL *Air Pollution Control Regulations*, National Ambient Air Quality Objectives, Canadian Ambient Air Quality Standards, regulations under MARPOL and the intent of the Global Gas Flaring Reduction Partnership.
Offshore waste discharges and emissions associated with the Project (i.e., operational discharges and emissions from the MODU and PSVs) will be managed in accordance with relevant regulations and municipal bylaws as applicable, including the OWTG) (NEB et al. 2010) and MARPOL, of which Canada has incorporated provisions under various sections of the *Canada Shipping Act*. Waste discharges not meeting legal requirements will not be discharged to the ocean and will be brought to shore for disposal. The development and implementation of a Project-specific EPP and waste management plan (WMP) will be designed to prevent unauthorized waste discharges.
Selection of drilling chemicals will be in accordance with the OCSG for Drilling and Production Activities on Frontier Lands (NEB et al. 2009), which provides a framework for chemical selection to reduce potential for environmental effects. During planning of drilling activities, where feasible, lower toxicity drilling muds and biodegradable and environmentally friendly additives within muds and cements will be preferentially used. Where feasible the chemical components of the drilling fluids will be those that have been rated as being least hazardous under the OCNS scheme and PLONOR by the OSPAR (refer to Section 2.8.2 for more information on chemical selection).

Table 2.28 BHP Canada Exploration Drilling Program (2019-2028) EIS - Standard Mitigation Measures

Discharges of SBM mud and cuttings will be managed in accordance with the OWTG. SBM cuttings will only be discharged once the performance targets in OWTG of 6.9 g/100 g or less oil on wet solids can be satisfied. The concentration of synthetic oil on cuttings will be monitored on the MODU for compliance with the OWTG. In accordance with OWTG, no excess or spent SBM will be discharged to the sea. Spent or excess SBM that cannot be re-used during drilling operations will be brought back to shore for disposal (refer to Section 2.8.3.1 for details on drilling waste management).
If during testing the well starts to flow water, the test will cease. Any produced water that is retained in the surface separation equipment will be either brought to shore for disposal or routed through the MODU oil/water separator for disposal so that it can be discharged in line with the OWTG.
Deck drainage and bilge water will be discharged according to the OWTG which states that deck drainage and bilge water can only be discharged if the residual oil concentration of the water does not exceed 15 mg/L.
Ballast water will be discharged according to the International Maritime Organization (IMO) *Ballast Water Management Regulations* and Transport Canada's *Ballast Water Control and Management Regulations.* The MODU will carry out ballast tank flushing prior to arriving in Canadian waters.
Putrescible solid waste, specifically food waste generated offshore on the MODU and PSVs, will be disposed of according to OWTG and MARPOL requirements. Food waste will be macerated so that particles are less than 6 mm in diameter and then discharged. There will be no discharge of macerated food waste within 3 nautical miles from land.
Sewage will be macerated prior to discharge. In line with the OWTG and MARPOL requirements, sewage will be macerated so that particles are less than 6 mm in size prior to discharge.
Cooling water will be discharged in line with the OWTG which states that biocides used in cooling water are selected in line with a chemical management system developed in line with the OCSG.
BOP fluids and other discharges from the subsea control equipment will be discharged according to OWTG and OCSG.
Liquid wastes, not approved for discharge in OWTG such as waste chemicals, cooking oils or lubricating oils, will be transported onshore for transfer to an approved disposal facility.
Waste generated offshore on the MODU and PSVs will be handled and disposed of in accordance with relevant regulations and municipal bylaws. Waste management plans and procedures will be developed and implemented to prevent unauthorized waste discharges and transfers.
Biomedical waste will be collected onboard by the medical professional and stored in special containers before being sent to land for incineration.
Transfer of hazardous wastes will be conducted according to the *Transportation of Dangerous Goods Act.* Applicable approvals for the transportation, handling and temporary storage, of these hazardous wastes will be obtained as required.
Information on the releases, wastes and discharges will be reported as part of a regular environmental reporting program in accordance with regulatory requirements as described in the OWTG.
VSP Surveys
VSP activity will be planned and conducted in consideration of the Statement of *Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* (DFO 2007). A ramp-up procedure (i.e., gradually increasing seismic source elements over a period of approximately 30 minutes until the operating level is achieved) will be implemented before VSP activity begins.

Table 2.28 BHP Canada Exploration Drilling Program (2019-2028) EIS - Standard Mitigation Measures

Supply and Servicing Operations
PSVs will follow established shipping routes where they exist (i.e., in proximity to shore).
In order to reduce the potential for vessel collisions during transiting activities outside the Project Area, PSVs will reduce speed to a maximum of 13 km/hour (7 knots) when marine mammals or sea turtles are observed or reported within 400 m of a PSV, except if not feasible for safety reasons.
If a vessel collision with a marine mammal or sea turtle occurs, BHP will contact the C-NLOPB, DFO's Canadian Coast Guard Regional Operations Centre, Indigenous groups, and other relevant authorities as soon as reasonably practicable but no later than 24 hours following the collision.
Lighting on PSVs will be limited to the extent that worker safety and safe operations is not compromised. Measures may include avoiding use of unnecessary lighting, shading, and directing lights towards the deck.
The PSVs selected for this Project will be equipped for safe all-weather operations, including stability in rough sea conditions and inclement weather. In addition, measures to reduce superstructure icing hazards on PSVs will be implemented as necessary and may include (DFO 2012): • Reducing vessel speed in heavy seas • Placing gear below deck and covering deck machinery, if possible • Moving objects that may prevent water drainage from the deck • Making the ship as watertight as possible • Manual removal of ice if required under severe icing conditions
A PSV will remain on standby at the MODU at all times in the event that operational assistance or emergency response support is required. PSVs performing standby duties will have a Canadian Standby Certificate.
PSVs will undergo BHP's internal verification process as well as additional external inspections / audits inclusive of the C-NLOPB pre-authorization inspection process in preparation for the Project.
Well Abandonment
BHP plans to conduct a post-drilling visual survey of the seafloor using a remotely operated vehicle (ROV) after drilling activities to assess the visual extent of sediment dispersion and validate the modelling for the discharges of drill mud and cuttings.
Once wells have been drilled to TVD and well evaluation programs completed (if applicable), the well will be plugged and abandoned in line with applicable BHP practices and C-NLOPB requirements. The final well abandonment program has not yet been finalized; however, these details will be confirmed to the C-NLOPB as planning for the Project continues.

Additional mitigation measures specific to VCs assessed in this EIS are presented in Chapters 8 to 16. Spill prevention and response measures are discussed in Chapter 15. A complete summary of mitigative commitments presented in this EIS is included in Chapter 17.

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3.0 CONSULTATION AND ENGAGEMENT

BHP recognizes the importance of proactive and systematic engagement with an emphasis on dialogue, inclusion, transparency, accountability and respect. We listen to concerns and expectations so that we may enhance our understanding of impacts and opportunities, enable timely and culturally appropriate delivery of our communications, and take actions where we can.

To support our engagements, we conduct rights-holder and stakeholder identification and analysis to identify and describe the interests and relationships of those people and/or groups. As we engage, we work to provide the relevant information for each group and incorporate their feedback on that information into our plans and actions. The following sections describe this approach in more detail.

3.1 Government Departments and Agencies

For confirmation of specific regulatory requirements / processes and/or data requests, regulatory stakeholders are typically engaged. Key regulatory stakeholders for the Project are:

- Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB)
- Government of Canada
  - Canadian Environmental Assessment Agency (CEA Agency)
  - Fisheries and Oceans Canada (DFO)
  - Environment and Climate Change Canada (ECCC)
  - Canadian Coast Guard
  - Natural Resources Canada (NRCan)
  - Department of National Defence (DND)
  - Transport Canada
- Government of NL
  - Municipal Affairs and Environment
  - Fisheries and Land Resources
  - Natural Resources

In the planning and developing of the environmental impact statement (EIS), to date, BHP has obtained relevant existing environment information and/or guidance in assessment methods and approach through consultation with multiple stakeholders, including the CEA Agency, C-NLOPB, DFO, ECCC (including the Canadian Wildlife Service [CWS]), NRCan, Transport Canada, DND, Health Canada, and the Newfoundland and Labrador (NL) Department of Natural Resources. A log of Project-related consultation with government departments and agencies is provided in Table 3.1. The review process of the Project Description and EIS guidelines also involved participation of these same government departments and agencies. Comments provided during these review processes and meetings were taken into consideration during the preparation of the EIS. A summary of the topics of interest / concern provided from government departments and agencies is provided in Table 3.2.

Table 3.1 Communications with Government Departments and Agencies

Date	Method	Purpose
CEA Agency		
February 28, 2019	Meeting	Introduction to BHP and project team; overview of planned activities , the Project and federal EA process and Project Description
May 22, 2019	Meeting	CEAA industry introduction of regional assessment
June 18, 2019	Meeting	Oil spill modelling domain overview
July 10, 2019	Workshop	Oil spill modelling workshop
C-NLOPB		
June 20, 2018	Meeting	Introduction to BHP
November 17, 2018	Meeting	Review of new safety regulations, and discussion of the duty to consult, and local representation
January 16, 2019	Meeting	General discussion on who BHP is and the plans in the region
May 2, 2019	Meeting	Discussion on BHP's Exploration Plan, Data Reprocessing and Geohazard Survey
May 23, 2019	Meeting	Benefits Plan discussions
June 18, 2019	Meeting	Oil spill modelling domain overview
June 19, 2019	Meeting	BHP general Project update
July 10, 2019	Workshop	Oil spill modelling workshop
August 21, 2019	Meeting	BHP general Project update
November 5, 2019	Meeting	BHP general Project update
December 13, 2019	Meeting	Discussion of coral / sponge seabed survey
DFO		
July 10, 2019	Workshop	Oil spill modelling workshop
December 13, 2019	Meeting	Discussion of coral / sponge seabed survey
Hon. Bernadette Jordan, Federal Minister of Fisheries, Oceans and the Canadian Coast Guard		
January 15, 2020	Letter	BHP introduction and meeting request
ECCC		
July 10, 2019	Workshop	Oil spill modelling workshop
NRCan		
July 10, 2019	Workshop	Oil spill modelling workshop
Transport Canada		
January 15, 2020	Letter	BHP introduction and inviting comments
DND		
January 15, 2020	Letter	BHP introduction and inviting comments
DND – Joint Rescue Coordination Centre		
January 15, 2020	Letter	BHP introduction and meeting request
Honourable Carolyn Bennett, Federal Minister of Crown-Indigenous Relations		
January 15, 2020	Letter	BHP introduction and inviting comments

Table 3.1 Communications with Government Departments and Agencies

Date	Method	Purpose
Health Canada		
January 15, 2020	Letter	BHP introduction and inviting comments
Canadian Coast Guard Auxiliary		
January 15, 2020	Letter	BHP introduction and meeting request
NL Department of Natural Resources		
January 17, 2019	Meeting	Project introduction
December 3, 2019	Meeting	Project update
NL Department of Natural Resources - Major Capital Projects		
January 15, 2020	Letter	BHP introduction and meeting request
NL Department of Fisheries and Land Resources		
January 15, 2020	Letter	BHP introduction and meeting request
NL Department of Municipal Affairs and Environment		
January 15, 2020	Letter	BHP introduction and meeting request
Service NL		
January 15, 2020	Letter	BHP introduction and inviting comments
Nature NL (ENGO)		
January 15, 2020	Letter	BHP introduction and inviting comments

Table 3.2 Topics of Interest / Concern from Government Departments

CONCERNS EXPRESSED BY GOVERNEMT DEPARTMENTS
Spill response and control capabilities: • Wells should be designed for worst case scenarios • There should be contingency in Project design • Capping stack and relief well timelines are a key area of interest *Action / Mitigation*: • BHP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. See Section 15.1.3 of the EIS for information on BHP's approach to risk management, Section 15.5.2 of the EIS for specific information on well control and blowout prevention, and Section 15.5 of the EIS for a description of BHP's contingency planning and emergency response measures
Ongoing communication: • Important to contact DFO regarding timing and location of planned DFO research surveys • Maintain ongoing communications with NAFO Secretariat through DFO *Action / Mitigation*: • BHP will maintain ongoing communications with the NAFO Secretariat, through DFO as the Canadian representative, regarding planned Project activities, including timely communication of drilling locations, safety zone, and decommissioned well sites • BHP will contact DFO about timing and locations of planned DFO research surveys

BHP is planning to host a meeting with regulatory agencies in the Spring 2020 after submission of the EIS to present an overview of the and the results of spill modelling.–BHP will also continue to consult with government departments and agencies throughout the EIS review process and during preparation of follow-up and monitoring programs.

3.2 Indigenous Groups

BHP recognizes the traditional rights of Indigenous peoples and acknowledge their right to maintain their cultures, identifies, traditions and customs. We understand that Indigenous peoples often have profound and special connections to, and identification with, lands and waters and that these are tied to their physical, spiritual, cultural and economic well-being.

Our approach to engaging Indigenous peoples is articulated in the BHP Indigenous Peoples Policy Statement. This frames our approach to engaging with Indigenous Peoples with respect to new operations or major capital projects that are located on lands traditionally owned by or under customary use of Indigenous Peoples and which have potential to have adverse impacts on Indigenous peoples. This commitment includes:

- Undertaking participatory and inclusive social and environmental impact assessments
- Seeking to agree on and document engagement and consultation plans with potentially impacted Indigenous Peoples
- Working to obtain the consent of Indigenous Peoples to BHP activities consistent with the ICMM Position Statement

This commitment will be satisfied through compliance with domestic laws or completion of host government regulatory processes where they are consistent with the objectives of the International Council on Mining and Metals (ICMM) Position Statement as determined by the BHP Chief Legal Counsel.

Where the consent of Indigenous Peoples is not forthcoming despite the best efforts of all parties, in balancing the rights and interests of Indigenous Peoples with the wider population, governments might determine that a project should proceed and specify the conditions that should apply. In such circumstances, BHP will determine whether it will remain involved with a project.

Consistent with the ICMM Position Statement, this BHP policy:

- Applies to new operations or major capital projects for which approvals and permitting process have not commenced prior to May 2015
- Seeks consent processes which are based on good faith negotiation and which do not confer veto rights to individuals or sub-groups, nor require unanimous support from potentially impacted Indigenous Peoples unless legally mandated

Through successful implementation of this policy BHP aims to be a partner of choice for Indigenous Peoples through which our relationships contribute to their economic, social and cultural empowerment.

In Canada, BHP is committed to building long-term trusting and mutually beneficial relationships with the Indigenous rights-holders of the region. We believe in ongoing engagements that are inclusive, respectful, transparent, and that acknowledge each parties' concerns, priorities, and accountabilities.

For this particular EA, our analysis indicates that there are several Indigenous communities in Newfoundland-Labrador (NL), Nova Scotia (NS), Prince Edward Island (PEI), New Brunswick (NB), and Quebec that have interests in the Project. There are several communities that hold commercial communal fishing license for NAFO Divisions that overlap the Project Area, although engagement to date implies that fishing is not currently active in the Project Area under these licenses. There are no documented food, social and ceremonial (FSC) licenses within or near the Project Area. However, interactions between the Project's activities (routine or unplanned) and species harvested for commercial or FSC purposes outside the Project Area may potentially occur during species migration to traditional fishing grounds. There is also the potential for the presence of species at risk and/or species of cultural importance in the Project Area (e.g., Atlantic salmon). Thus, we further acknowledge the rights of Indigenous communities to provide feedback on the Project.

The EIS Guidelines (Section 5.1) specify that BHP engage the following Indigenous groups:

Newfoundland and Labrador

- Labrador Inuit (Nunatsiavut Government)
- Labrador Innu (Innu Nation)
- NunatuKavut Community Council (NCC)
- Qalipu Mi'kmaq First Nation Band (QMFNB)
- Miawpukek First Nation (MFN)

Nova Scotia

- Assembly of Nova Scotia Mi'kmaq Chiefs (ANSMC) through the Kwilmu'kw Maw-klusuaqn Negotation Office (KMKNO), which represents the following 11 Mi'kmaq First Nations in Nova Scotia in consultation and engagement (letters were sent to individual communities; follow-up occurred with the KMKNO):
  - Acadia First Nation
  - Annapolis Valley First Nation
  - Bear River First Nation
  - Eskasoni First Nation
  - Glooscap First Nation
  - Membertou First Nation
  - Paqtnkek Mi'kmaw Nation
  - Pictou Landing First Nation
  - Potlotek First Nation
  - Wagmatcook First Nation
  - We'koqmaq First Nation
- Sipekne'katik First Nation
- Millbrook First Nation

Prince Edward Island

- L'Nuey (formerly Mi'kmaq Confederacy of PEI [MCPEI]), which represents the following Mi'kmaq First Nations in consultation (introductory letters were sent to individual communities; follow-up occurred with MCPEI):
  - Abegweit First Nation
  - Lennox Island First Nation

New Brunswick

- Mi'gmawe'l Tplu'taqnn Inc. (MTI), which represents the following Mi'kmaq First Nation groups:
  - Fort Folly First Nation
  - Eel Ground First Nation
  - Pabineau First Nation
  - Esgenoôpetitj First Nation
  - Buctouche First Nation
  - Indian Island First Nation
  - Eel River Bar First Nation
  - Metepnagiag Mi'kmaq First Nation
- Elsipogtog First Nation
- Wolastoqey Nation in New Brunswick (WNNB), which coordinates consultation with the following six Wolastokivik (Maliseet) First Nations (introductory letters were sent to individual communities; follow up occurred with the WNNB):
  - Kingsclear First Nation
  - Madawaska Maliseet First Nation
  - Oromocto First Nation
  - St. Mary's First Nation
  - Tobique First Nation
  - Woodstock First Nation
- Peskotomuhkati Nation at Skutik (Passamaquoddy)

Quebec

- Mi'gmawei Mawiomi Secretariat (MMS), which represents the following Mi'gmaq First Nation groups:
  - Micmas of Gesgapegiag
  - La Nation Micmac de Gespeg
  - Listuguj Mi'gmaq Government
- Les Innus de Ekuanitshit
- Innu First Nation of Nutashkuan

Figures 7-58 and 7-59 in Section 7.4 show the locations of the Indigenous communities. Community profiles for each of these Indigenous groups are also presented in Section 7.4. Engagement with Indigenous groups was initiated via letter by BHP on March 28, 2019 to introduce the Project and inquire about potential interests and concerns. In July 2019, BHP followed up on the initial request with a second letter acknowledging and outlining the Indigenous interests and concerns that had been brought forward to date, and invited Indigenous groups to attend a series of workshops in September 2019 to discuss interests and concerns.

Three workshops were held in September across the Atlantic Region in St. John's, Moncton, and Quebec City. The workshops provided an opportunity for mutual information exchange and dialogue regarding the following topics: introduction to company, Indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.

Following the workshops, BHP incorporated actions and mitigation measures into its plans to address concerns and interests raised where able and have addressed and documented those actions in this EIS (Section 3.2.7).

Going forward, BHP will use a variety of engagement methods to inform and involve identified Indigenous groups, as requested and based on the preference of the Indigenous groups, such as:

- Written and visual communications (letters, emails)
- Phone calls
- Information updates and bulletins
- Face-to-face meetings and workshops

BHP is aware that there are several other similar offshore exploration drilling EAs at various stages of environmental assessment under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012. BHP understands the importance of recognizing and learning from ongoing engagement with Indigenous groups and has joined with other operators to collaborate on current and future engagement to reduce burdens that may be caused by multiple engagement requests from multiple operators to Indigenous groups. BHP will coordinate opportunities for engagement with the exploratory drilling programs in the Flemish Pass and Orphan and Jeanne d'Arc Basins, including Husky Oil Operations, CNOOC Petroleum North America ULC (formerly Nexen Energy ULC), Suncor Energy, BP, Equinor (formerly Statoil), Chevron Canada, and ExxonMobil Canada.

Each of the identified Indigenous groups has and will continue to be notified by the CEA Agency about the steps in the EIS development process and of opportunities to review key documents. BHP remains available to meet with interested Indigenous groups to discuss details of their exploration drilling program, and concerns and interests they raise. We are committed to seek regular engagement as long as we have a presence in the region, ensuring that rights-holders and stakeholders are consistently informed on matters of importance to them and maintain transparency regarding our business planning.

A description of engagement activities with each Indigenous group is presented below, along with a summary of key issues and concerns raised by Indigenous groups to date.

3.2.1 Newfoundland and Labrador Indigenous Groups

A summary of engagement with NL Indigenous groups is provided in Table 3.3.

Table 3.3 Summary of Engagement with NL Indigenous Groups

Date	Engagement Activity	Details
Nunatsiavut Government		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 10, 2019	Incoming email	NG unable to attend workshop.
November 11, 2019	Outgoing email	Follow-up to St. John's workshop – provided meeting summary and presentations.
Innu Nation		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 26, 2019	Incoming email	Confirmed attendance at St. John's workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 23, 2019	Workshop: St. John's	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to St. John's workshop – provided meeting summary and presentations.
NCC		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 30, 2019	Incoming email	Confirmed attendance at St. John's workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 23, 2019	Workshop: St. John's	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to St. John's workshop – provided meeting summary and presentations.

Table 3.3 Summary of Engagement with NL Indigenous Groups

Date	Engagement Activity	Details
QMFNB		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 26, 2019	Incoming email	Confirmed attendance at St. John's workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 23, 2019	Workshop: St. John's	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to St. John's workshop – provided meeting summary and presentations.
MFN		
March 28, 2019	Outgoing letter	Introduced the project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 12, 2019	Incoming email	Confirmed interest in attending St. John's workshop.
August 20, 2019	Incoming email	Confirmed MFN unable to attend workshops.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
August 20 – October 10, 2019	Email exchange	Series of emails seeking a date to meet with MFN.

3.2.2 Nova Scotia Indigenous Groups

A summary of engagement with NS Indigenous groups is provided in Table 3.4.

Table 3.4 Summary of Engagement with NS Indigenous Groups

Date	Engagement Activity	Details
KMKNO: representing the Assembly of Nova Scotia Mi'kmaq Chiefs (11 of the 13 Nova Scotia Mi'kmaq communities) in consultation and engagement. Those communities are Acadia, Annapolis Valley, Bear River, Eskasoni, Glooscap, Membertou, Paqtn'kek, Potlotek, Pictou Landing, We'koqma'q and Wagmatcook First Nations		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.

Table 3.4 Summary of Engagement with NS Indigenous Groups

Date	Engagement Activity	Details
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 8, 2019	Incoming email	Confirmed attendance at oncton workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 25, 2019	Workshop: Moncton	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.
Sipekne'katik First Nation: Sipekne'katik First Nation Chief and Council represent their community in consultation and engagement		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.
Millbrook First Nation: Millbrook First Nation Chief and Council represent their community in consultation and engagement		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.

3.2.3 Prince Edward Island Indigenous Groups

A summary of engagement with PEI Indigenous groups is provided in Table 3.5.

Table 3.5 Summary of Engagement with PEI Indigenous Groups

Date	Engagement Activity	Details
L'Nuey Epekwitk Mi'kmaq Rights Initiative (formerly MCPEI) – coordinates consultation and engagement on behalf of the two Mi'kmaq First Nations in PEI - Abegweit and Lennox Island		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 13, 2019	Incoming email	MCPEI unable to attend workshop.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.

3.2.4 New Brunswick Indigenous Groups

A summary of engagement with NB Indigenous groups is provided in Table 3.6.

Table 3.6 Summary of Engagement with NB Indigenous Groups

Date	Engagement Activity	Details
MTI: represent the following eight Mi'kmaq communities in New Brunswick in consultation/engagement: Amlamgog (Fort Folly), Natoaganeg (Eel Ground), Oinpegitjoig (Pabineau), Esgenoôpetitj (Burnt Church), Tjipõgtõtjg (Bouctouche), L'nui Menikuk (Indian Island), Ugpi'ganjig (Eel River Bar) and Metepenagiag (Red Bank)		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 8, 2019	Incoming email	Confirmed attendance at Moncton workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 25, 2019	Workshop: Moncton	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.
Elsipogtog First Nation is represented by Kopit Lodge in consultation and engagement		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.

Table 3.6 Summary of Engagement with NB Indigenous Groups

Date	Engagement Activity	Details
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.
WNNB: supports the following Wolastoqey nations in New Brunswick in consultation and engagement: Matawaskiye (Madawaska), Pilick (Kingsclear), Welamukotuk (Oromocto), Sitansisk (St. Mary's), Neqotkuk (Tobique) and Wotstak (Woodstock)		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 7, 2019	Incoming email	Confirmed attendance at Moncton workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 25, 2019	Workshop: Moncton	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.
Peskotomuhkati Nation at Skutik (Passamaquoddy)		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 19, 2019	Incoming email	Confirmed attendance at Moncton workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 25, 2019	Workshop: Moncton	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.

3.2.5 Québec Indigenous Groups

A summary of engagement with QC Indigenous groups is provided in Table 3.7.

Table 3.7 Summary of Engagement with QC Indigenous Groups

Date	Engagement Activity	Details
MMS: Ango'temq Nm'Tginen Directorate coordinates consultation on behalf of the three Mi'kmaq communities in Quebec - Listiguj, Gespeg and Gesgapegiag		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 15, 2019	Incoming email	Confirmed attendance at Quebec City workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
September 25, 2019	Workshop: Moncton	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups. (Note – MMS representatives attended Moncton workshop).
November 11, 2019	Outgoing email	Follow-up to Moncton workshop – provided meeting summary and presentations.
Les Innus de Ekuanitshit		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.
November 11, 2019	Outgoing email	Follow-up to Quebec City workshop – provided meeting summary and presentations.
Innu First Nation of Nutashkuan		
March 28, 2019	Outgoing letter	Introduced the Project and requested comments.
July 23, 2019	Outgoing letter	Provided Project update; invited Indigenous groups to a series of proposed workshops in St. John's, Moncton and Quebec City in September and provided proposed agenda for feedback; outlined known issues of concern to Indigenous groups brought forward through previous exploration drilling EA's.
August 8, 2019	Incoming email	Confirmed attendance at Quebec City workshop.
September 10, 2019	Outgoing email	Provided details of workshops and final agenda.

Table 3.7 Summary of Engagement with QC Indigenous Groups

Date	Engagement Activity	Details
September 27, 2019	Workshop: Quebec City	Information exchange and dialogue regarding the following topics: introduction to company, indigenous knowledge and social value, approach to the EIS, emergency preparedness and response, well control strategies, environmental monitoring, cumulative effects and ongoing communication with Indigenous groups.
November 11, 2019	Outgoing email	Follow-up to Quebec City workshop – provided meeting summary and presentations.

3.2.6 Other Indigenous Organizations

As of January 31, 2020, BHP has received no correspondence from other Indigenous organizations.

3.2.7 Topics of Interest and Concerns Raised by Indigenous Groups

Leading up to the development of the EIS, BHP engaged with Indigenous rights-holders to discuss the environmental assessment and exploration drilling program through a series of jointly-organized (BHP, Chevron, Suncor) workshops in St. John’s, Moncton and Quebec City in September 2019; and, to provide written feedback. BHP also gathered information regarding concerns and interests previously expressed by Indigenous groups during environmental assessments on exploration drilling programs by other oil and gas operators.

During previous engagement for other offshore Newfoundland and Labrador oil and gas activities, Indigenous groups have communicated that their interests and concerns extend beyond potential interactions and effects on commercial communal and FSC fishing practices. Several species that could occur in the eastern NL offshore area (and potentially interact with Project activities) are also of cultural or spiritual importance to Indigenous peoples. These may include species that have been traditionally harvested for food, medicinal, social or ceremonial purposes, and may hold other cultural value. The concerns also relate to species that have value as contributing to ecosystem sustainability and which, if adversely impacted, could potentially affect Indigenous rights.

Indigenous groups in the Atlantic region share a number of broader concerns that may not be captured within the evaluative structure of this EIS. The main concerns discussed with Indigenous groups at September 2019 workshops in St. John’s, Moncton and Quebec City are outlined in Table 3.8, and more generally reflect concerns and interests expressed to date by Indigenous groups that have participated in direct engagement, and reviews of previous EIS and requests for information during various environmental assessment processes.

Table 3.8 Main Concerns Expressed during September 2019 Workshops with Indigenous Groups

CONCERNS EXPRESSED BY INDIGENOUS GROUPS
Atlantic Salmon (and other culturally important species): • Potential impacts of exploration drilling (both operations and potential accidents) on Atlantic salmon populations that may migrate and over-winter in the Project Area. These populations return to their natal rivers and streams where they could be harvested for traditional purposes (FSC). Some of these populations are listed under the Species at Risk Act (SARA), and in many cases, Indigenous communities do not harvest for FSC purposes, due to ecological concerns. • Other culturally important species of concern to Indigenous groups include American eel, swordfish, tuna, ground fish, lobster, crab, sea turtles, sharks and marine mammals. *Action / Mitigation*: • BHP recognizes the importance of salmon to Indigenous groups in the Atlantic region, as well as the uncertainty associated with the known presence and activities of Atlantic salmon in the Project Area. BHP, along with other oil and gas companies are required to provide funding to the Environmental Science Research Fund (ESRF) for studies related to environmental and social issues related to decision-making for oil and gas projects. The ESRF has released an expression of interest for research in this area that involves Indigenous peoples.
Potential Impacts to Indigenous Fisheries: • Impacts from operations and potential incidents or spills that may result in adverse environmental effects on traditional, commercial and commercial communal fisheries. For example – many concerns and questions were raised regarding behavioural impacts on Atlantic salmon and other species of operations - such as underwater noise, light, vibration and changes to water quality. *Action / Mitigation*: • BHP will continue to engage with Indigenous groups throughout the exploration drilling program and provide information related to operational activity, and the results of environmental monitoring. BHP will develop a communication protocol with Indigenous groups to provide regular updates during operations, and to inform Indigenous groups in the event of an emergency. • While there are no active fisheries in the immediate Project Area, BHP will continue to work with Indigenous fishers to reduce potential effects on their ability to exercise their rights to fish.
Cumulative Effects: • There is a perceived lack of a comprehensive approach to analyzing, understanding and addressing the potential for cumulative impacts of so many proposed projects in the region on the environment, and on Indigenous rights. It is anticipated that the current Regional Assessment underway in Atlantic Canada will address cumulative effects. Indigenous groups expressed interest in third-party, independent technical experts leading the Regional Assessment. *Action / Mitigation*: • BHP is advocating for and participating in the Regional Assessment where a more regional and multi-faceted approach is being taken to examining cumulative effects of multiple projects and interactions with other ocean users. BHP will apply applicable new learnings from the regional assessment to their exploration drilling project.
Indigenous Knowledge: • The Environmental Impact Statement (EIS) and Project implementation should consider and integrate Indigenous traditional and ecological knowledge regarding aquatic, nearshore and offshore environments. • Indigenous Groups expressed general disappointment with the work that has been done to date, as Indigenous Knowledge studies have typically been too narrowly focused and do not take into account the full regional history, current and ongoing changes within the communities, and potential future aspirations. There is a preference for more holistic inclusion of Indigenous Knowledge throughout the regulatory process. • Indigenous Groups also recognize the complexity and sensitivity of gathering and applying or integrating Indigenous Knowledge in EIS and further, to operations – particularly in an area as geographically and culturally diverse as the Atlantic region. Many issues must be considered, for example, confidentiality and protection of information, where that information is managed and maintained, and by whom.

Table 3.8 Main Concerns Expressed during September 2019 Workshops with Indigenous Groups

CONCERNS EXPRESSED BY INDIGENOUS GROUPS
Action / Mitigation: • BHP has endeavoured to gather Indigenous Knowledge, where appropriate and available, and recognizes the importance of considering Indigenous Knowledge in its operations. BHP is actively supporting an Atlantic-wide proposal to fund a number of regional Indigenous Knowledge studies through the ESRF.
Environmental Monitoring and Management: • In addition to concerns regarding potential impacts to fishing and fishing rights, Indigenous Groups have concerns regarding effects of exploration drilling operations on the marine environment, including changes to water quality, fish and fish habitat, marine plants, migratory birds and marine mammals and increased contributions to atmospheric emissions. • Indigenous groups would like to see comprehensive monitoring and follow-up programs, including research and data collection related to impacts on Indigenous groups – e.g., fish and fish habitat, birds and marine mammals. Indigenous groups requested being involved with environmental monitoring; and, to be kept informed of results of environmental monitoring programs throughout the exploration drilling program, and in the event of an incident or spill that may result in adverse environmental effects. • Indigenous Groups would also like to see more industry funding go towards environmental research that studies the ecosystems and habitats holistically, and tracks data and knowledge over time. Recommended partnerships included regional universities, who may also be able to share raw data, video footage, and photographs with interested groups following research projects. *Actions / Mitigation Measures*: • Potential impacts to the environment are addressed through the EIS's analysis of valued components. Please refer to chapters 8 to 13. • During operations, BHP will share the results of environmental monitoring with Indigenous groups through monthly operational updates. At the conclusion of exploration drilling, and once results are available, BHP will share final environmental monitoring results with Indigenous groups. BHP will also explore partnerships with Indigenous groups, local universities including Memorial University, and other independent research groups to collaboratively further the environmental knowledge base in the region.
Compensation: • A 'best practice approach' was discussed for compensation, and while all parties acknowledge the CNLOPB guidelines for loss or damage to fishing gear and vessels, all parties also acknowledge the challenges of valuing the losses with spiritual, cultural or social importance. For example, commercial communal fisheries are different than "regular" commercial licenses as ownership is often shared across the community and not transferable, and the profits often sustain employment, programs and services, and community infrastructure. • Indigenous Groups also indicated that "perceived" impacts are important to consider following an incident. For example, if there is a community perception that fish are tainted following an oil spill, this can result in a lower market value and sales revenues for the commercial communal fisheries. • If a compensation plan is required, the parties involved should give additional thought to ensuring that remediation efforts reach the most marginalized people of the community. *Actions / Mitigation Measures*: • In addition to adopting the CNLOPB guidelines, where Indigenous Groups are involved BHP would take a case-by-case approach and seek to co-design a compensation negotiation process with the affected community in accordance with their institutions, decision making processes, and norms. The Company and community would then work through this process together to identify the appropriate compensation plan.
Oil Spill Response: • A number of concerns have been expressed by Indigenous groups regarding oil spill response, including: - Concerns about oil reaching shoreline, impacting fisheries and traditional territories. - Companies need to demonstrate the accuracy of probability calculation and trajectories of oil spills. - Capping stacks – a capping stack located and maintained in Atlantic Canada. - How can Indigenous groups/communities be involved in emergency response?

Table 3.8 Main Concerns Expressed during September 2019 Workshops with Indigenous Groups

CONCERNS EXPRESSED BY INDIGENOUS GROUPS
- Concerns expressed regarding contamination or fish taint from an oil spill and how this impacts not only consumption, but also perception and cultural norms. • BHP and Indigenous groups discussed emergency preparedness and oil spill response in detail in the workshops, including management practices, oil spill modelling, capping stacks and other technology, and the oil spill response Incident Command System (ICS). *Actions / Mitigation Measures*: • BHP is building upon the previous efforts of the oil and gas industry to create capacity and awareness of industry and company standards to prevent and respond to an emergency. We will advocate for Indigenous communities' participation in future oil spill response planning and response exercises. BHP will develop an Indigenous Fisheries Communications Plan in consultation with Indigenous groups that includes a protocol for communicating with Indigenous groups during operations, and in the event of an emergency.
Communication and Ongoing Involvement of Indigenous Groups: • Indigenous groups would like to be actively informed of activities and outcomes during exploration and operations, and in the event of an incident or spill that may result in adverse environmental effects. In the event of an incident, information requested on a regular basis includes near misses with detail on what happened or how it was prevented, what the impacts were or could have been, and what measure are being taken to mitigate or prevent again. Written communications via email were noted to be sufficient, with follow up information on a public website also appropriate. • Indigenous groups referenced challenges with engagement fatigue, given the number of oil and gas operators as well as other industries requesting engagement. While a preferred method of direct engagement is workshop sessions, Indigenous groups request that companies collaborate on sessions. *Action / Mitigation*: • BHP will develop an Indigenous Fisheries Communication Plan in consultation with Indigenous groups, that takes the information referenced into account, to outline a process and content for regular operational updates during the drilling campaign, as well as outreach to Indigenous groups in the unlikely event of an emergency.

3.3 Fisheries Stakeholders

Early and ongoing consultation with the fishing industry is a key form of mitigation of potential effects of the Project on fisheries. When identifying potential fisheries stakeholders and scheduling meetings, it is important to consider the location and timing of fishing activities. The following is a list of initial fisheries stakeholders engaged, or to be engaged, for the Project:

- Fish, Food and Allied Workers-Unifor (FFAW-Unifor)
- Association of Seafood Producers (ASP)
- Ocean Choice International (OCI)
- Atlantic Groundfish Council (AGC)
- Canadian Association of Prawn Producers
- Mi'kmaq Alsumk Mowimskik Kaqoey Association (MAMKA)

One Ocean, which acts as a liaison between the oil and gas and fishing industries, has developed a protocol that provides guidance on consultation approach.

Table 3.9 provides a summary of engagement with fisheries stakeholders. Questions and concerns are summarized in Table 3.10.

Table 3.9 Summary of Engagement with Fisheries Stakeholders

Date	Type of Engagement	Purpose
One Ocean		
January 17, 2019	Meeting	Project introduction. Discussion included the EA process, hazard assessment, consultation and communications with the fishing industry, available information on standard mitigation measures, use of fisheries liaison officers, local benefits and diversity and inclusion
May 19, 2019	Email	Notification of Project registration with the CEA Agency
FFAW-Unifor		
February 28, 2019	Meeting	Introduction to the Project, including an overview of planned activities and timing
May 19, 2019	Email	Notification of Project registration with the CEA Agency
August 22, 2019	Email	Notice of Canadian Environmental Assessment Agency Bulletin - BHP Federal Environmental Assessment Participation Funding
OCI		
March 29, 2019	Email	Introduction to the Project, including an overview of planned activities and timing
May 19, 2019	Email	Notification of Project registration with the CEA Agency
August 22, 2019	Email	Notice of Canadian Environmental Assessment Agency Bulletin - BHP Federal Environmental Assessment Participation Funding
ASP		
March 29, 2019	Email	Introduction to the Project, including an overview of planned activities and timing
May 19, 2019	Email	Notification of Project registration with the CEA Agency
August 22, 2019	Email	Notice of Canadian Environmental Assessment Agency Bulletin - BHP Federal Environmental Assessment Participation Funding
Canadian Association of Prawn Producers		
March 29, 2019	Email	Introduction to the Project, including an overview of planned activities and timing
May 19, 2019	Email	Notification of Project registration with the CEA Agency
August 22, 2019	Email	Notice of Canadian Environmental Assessment Agency Bulletin - BHP Federal Environmental Assessment Participation Funding
AGC		
March 29, 2019	Email	Introduction to the Project, including an overview of planned activities and timing
May 19, 2019	Email	Notification of Project registration with the CEA Agency
August 22, 2019	Email	Notice of Canadian Environmental Assessment Agency Bulletin - BHP Federal Environmental Assessment Participation Funding
MAMKA		
April 4, 2019	Email	Introduction to the Project, including an overview of planned activities and timing
May 19, 2019	Email	Notification of Project registration with the CEA Agency

Table 3.10 Summary of Issues and Concerns – Fisheries Stakeholders

CONCERNS EXPRESSED BY FISHERIES STAKEHOLDERS
Ongoing Communication: • Fisheries should be engaged through One Ocean early in the process • Logistic information should be provided to fisheries regarding schedule *Action / Mitigation*: • BHP will continue to engage commercial fisheries groups and relevant enterprises to share Project details and fisheries information, and to determine the need for a fisheries liaison officer during mobilization and demobilization of the MODU, with reference to the One Ocean Risk Management Matrix Guidelines (One Ocean n.d.). A Fisheries Communication Plan will be used to facilitate coordinated communication with fishers, including details about planned activities and the safety (exclusion) zone
Impacts to fisheries: • Concern regarding the MODU and PSV moving through fishing gear • Potential effects from spills and impact on tainted product *Action / Mitigation*: • BHP will continue to engage commercial fisheries groups and relevant enterprises to share Project details and fisheries information, and to determine the need for a fisheries liaison officer during mobilization and demobilization of the MODU, with reference to the One Ocean Risk Management Matrix Guidelines (One Ocean n.d.). A Fisheries Communication Plan will be used to facilitate coordinated communication with fishers, including details about planned activities and the safety (exclusion) zone • Project-related damage to fishing gear will be compensated in accordance with industry best practices in the NL offshore and relevant industry guidance material such as the Geophysical, Geological, Environmental, and Geotechnical Program Guidelines (C-NLOPB 2019), the Canadian East Coast Offshore Operators Non-attributable Fisheries Damage Compensation Program (CAPP 2007), and the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activities (C-NLOPB and CNSOPB 2017) which apply when gear loss or damage occurs because of a spill or authorized discharge, emission or escape of petroleum

3.4 Other Public Stakeholder Groups

Other public stakeholders include industry associations and non-governmental organizations (NGOs). BHP will monitor activities and communications generated by these groups and participate in local industry events as appropriate, including supplier information sessions, seminars, and conferences. Engagement with public stakeholders will primarily be through BHP’s external website, where pertinent Project information will be available.

4.0 ENVIRONMENTAL ASSESSMENT METHODS

The methods used to assess the effects of routine Project activities and accidental events, as well as the potential cumulative effects of the Project, are outlined in this chapter. In consideration of the requirements of the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and guidance issued by the Canadian Environmental Assessment Agency (CEA Agency), the environmental assessment (EA) methods used to prepare this environmental impact statement (EIS) have been developed by Stantec. Previous offshore exploration project assessments within the Newfoundland and Nova Scotian offshore areas have been prepared using these methods and have been reviewed and approved by the CEA Agency or are currently under review. The Information Requirement (IR) stage of these previous offshore exploration EAs have provided feedback from regulators and stakeholders and given additional guidance, which has been taken into consideration during this Project and assessment.

These methods follow the guiding principles and specific requirements as set out in the Project-specific Guidelines, "Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012" BHP Exploration Drilling Project (EIS Guidelines), issued by the CEA Agency on 28 June 2019 (see Appendix A). The importance of EA as a planning and decision-making tool is emphasized in these guiding principles. This EIS identifies Project-specific sensitivities and mitigation measures, including environmental design features, in addition to what is known about the potential environmental effects of offshore exploration activities.

Meaningful public participation and engagement with Indigenous groups is also included in the guiding principles. As described in Chapter 3, BHP recognizes the importance of early and ongoing Indigenous and stakeholder engagement that continues over the life of the Project. It is important to BHP to operate in Newfoundland and Labrador (NL) by building relationships with Indigenous groups and key stakeholders. BHP is committed to collaborating with Indigenous peoples of Canada and communities to build long term trusting and mutually beneficial relationships based on the principles of inclusion, transparency, respect, and accountability.

4.1 Scope of the Environmental Assessment

This EIS has been prepared in accordance with the requirements of CEAA 2012, the EIS Guidelines, and other generic EA guidance documents issued by the CEA Agency. Project-specific guidelines and the location within this EIS where these requirements have been addressed are outlined in the table of concordance included in the Executive Summary. Detail on the scope of the Project, scope of the factors to be considered, the selection of valued components (VCs) to be considered, and the spatial and temporal boundaries are provided below.

4.1.1 Scope of the Project

The scope of the Project was first defined in the Project Description submitted by BHP to the CEA Agency on 9 May 2019 and is further discussed in Chapter 2 of this EIS. BHP proposes to drill up to 20 exploration or appraisal wells within exploration licences (ELs) 1157 and 1158. Project activities will include drilling within EL 1157 and EL 1158; vertical seismic profiling (VSP); well testing; eventual well decommissioning and abandonment (or suspension) procedures; and associated supply and service activities.

The following Project activities to be assessed, within the scope of the Project therefore includes:

- Presence and operation of the mobile offshore drilling unit (MODU)
  - Mobilization, operation and demobilization of the MODU
  - Establishment of a safety zone
  - Light and sound emissions associated with MODU presence and operation
  - Waste and water management, including discharge of drill muds and cuttings, and other discharges and emissions
  - Geophysical surveys and/or geotechnical surveys
    - If a well is successful (i.e., hydrocarbons are discovered), vessels may be required to complete geophysical surveys (high resolution geophysical data acquisition) and geotechnical sampling (geotechnical coring)
- VSP operations
- Well testing and flaring
- Well decommissioning and abandonment or suspension
- Supply and servicing operations
  - Loading, refueling and operation of Project support vessels (PSVs) (for re-supply and transfer of materials, fuel and equipment; on-site safety during drilling activities; and transit between the supply base and the MODU)
  - PSVs will also be used for ice management that may be required during the annual ice season (including icebergs) in offshore eastern Newfoundland (typically between March to June). Ice management processes will include established procedures for iceberg towing and deflection, and if required, procedures for the safe disconnect and movement of the drilling unit while leaving the well in a safe condition
  - Helicopter support (for crew transport and delivery of supplies and equipment)

Predrill seabed remotely operated vehicle (ROV) survey(s) will be regulated under a separate EA according to Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB).

Based on these Project activities, the potential environmental effects of routine Project activities that have been specifically identified and considered in this assessment, include:

- Presence and operation of a MODU (including drilling, associated safety zone, lights, sound, and geotechnical / geophysical surveys)
- VSP
- Discharges and emissions (e.g., drill muds and cuttings, liquid discharges)
- Well testing and flaring (including air emissions)
- Well decommissioning and abandonment or suspension
- Supply and servicing operations (including helicopter transportation and PSV operations)

Also identified and considered within the scope of the Project are non-routine events (i.e., accidental events or malfunctions (Chapter 15)) which includes:

- Blowouts (uncontrolled release of hydrocarbons during drilling)
- MODU and vessel batch spills and releases (e.g., hydraulic fluid, drilling mud, diesel).

Accidental releases, or "spills", have the potential to occur in the offshore (e.g., during drilling) or nearshore (e.g., during PSV transit) environment.

4.1.2 Scope of the Factors to be Considered

The EA of a designated project, pursuant to section 19(1) of CEAA 2012 and reiterated in the EIS Guidelines, must consider:

- environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other physical activities that have been or will be carried out
- the significance of the effects referred to above
- comments from the public
- mitigation measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project
- the requirements of the follow-up program in respect of the project
- the purpose of the project
- alternative means of carrying out the project that are technically and economically feasible and the environmental effects of any such alternative means
- any change to the project that may be caused by the environment
- the results of any relevant regional study pursuant to CEAA 2012

The assessment focuses on the VCs identified in Section 4.1.3 in relation to section 5 of CEAA, 2012, as required by the EIS Guidelines. The scope of the factors to be considered focuses the EA on relevant issues and concerns. Under section 5(1) of CEAA 2012, the environmental effects that are to be addressed in relation to an act or thing, a physical activity, a designated project, or a project are:

a) a change that may be caused to the following components of the environment that are within the legislative authority of Parliament:
    i. fish as defined in section 2 of the *Fisheries Act* and fish habitat as defined in subsection 34(1) of that Act
    ii. aquatic species as defined in subsection 2(1) of the *Species at Risk Act* (SARA)
    iii. migratory birds as defined in subsection 2(1) of the *Migratory Birds Convention Act*, *1994*
    iv. any other component of the environment that is set out in Schedule 2 [of CEAA 2012]
b) a change that may be caused to the environment that would occur
    i. on federal lands
    ii. in a province other than the one in which the act or thing is done or where the physical activity, the designated project or the project is being carried out
    iii. outside Canada
c) with respect to Indigenous peoples, an effect occurring in Canada of any change that may be caused to the environment on:
    i. health and socio-economic conditions
    ii. physical and cultural heritage
    iii. the current use of lands and resources for traditional purposes

iv. any structure, site or thing that is of historical, archaeological, paleontological, or architectural significance

Certain additional environmental effects must be considered under section 5(2) of CEAA 2012 when carrying out a designated project requires a federal authority to exercise a power or perform a duty or function conferred on it under an Act of Parliament other than CEAA 2012. This applies to the Project. BHP will require authorizations from the C-NLOPB under the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Act* for the Project to proceed. No other authorizations are known to be required. Therefore, the following environmental effects have also been considered under section 5(2):

a) a change, other than those referred to in paragraphs 5(1)(a) and (b), that may be caused to the environment and that is directly linked or necessarily incidental to a federal authority's exercise of a power or performance of a duty or function that would permit the carrying out, in whole or in part, of the physical activity, the designated project or the project; and
b) an effect, other than those referred to in paragraph 5(1)(c), of any change referred to in paragraph (a) on:
    i. health and socio-economic conditions,
    ii. physical and cultural heritage, or
    iii. any structure, site or thing that is of historical, archaeological, paleontological, or architectural significance.

These categories of direct and indirect environmental effects have been considered in defining the scope of the EA, including the scope of factors to be considered.

4.1.3 Identification and Selection of Valued Components

The approach to identifying and selecting VCs for this Project was consistent with the requirements of CEAA 2012. The selection of VCs considered:

- Technical Knowledge of the Project (i.e., the nature and extent of Project components and activities) (Chapter 2)
- Requirements of CEAA 2012 and regulatory guidance including the Project-specific EIS Guidelines provided by the CEA Agency (2019) and included in Appendix A
- Discussions with regulatory agencies, technical experts, key stakeholders, public and Indigenous Groups during the pre-application process (Chapter 3)
- Existing conditions for the physical (Chapter 5), biological (Chapter 6) and socio-economic (Chapter 7)
- Ongoing consultation with Indigenous groups
- Ongoing consultation with key stakeholders
- Lessons learned from previous similar EAs, such as EA of StatoilHydro Canada Ltd. Exploration and Appraisal / Delineation Drilling Program for Offshore Newfoundland, 2008-2016 (LGL Limited 2008), Equinor's (formerly Statoil Canada Ltd.) Flemish Pass Exploration Drilling Program (Statoil 2017), ExxonMobil's Eastern Newfoundland Offshore Exploration Drilling Project (ExxonMobil 2017), CNOOC (formerly Nexen Energy ULC) Flemish Pass Exploration Drilling Project (Nexen Energy ULC 2018) Husky's Exploration Drilling Project (Husky 2018), and BP's Newfoundland Orphan Basin Exploration Drilling Project (BP Canada Energy Group ULC 2018), as well as the Eastern NL Strategic Environmental Assessment (SEA) (Amec 2014)
- Professional judgement based on the experience of the assessment team

The VCs selected for the EIS include the following:

- Marine Fish and Fish Habitat (including Species at Risk (SAR))
- Marine and Migratory Birds (including SAR)
- Marine Mammals and Sea Turtles (including SAR)
- Special Areas
- Indigenous Peoples and Communities
- Commercial Fisheries and Other Ocean Uses

This EIS describes the atmospheric environment (i.e., air quality, light and noise and greenhouse gas (GHG)) primarily in terms of physical pathways, and the effects related to these pathways are evaluated in the context of applicable receptor VCs. Air quality is discussed both in terms of Project related emissions (Section 2.7.1) and ambient conditions (Section 5.6). GHGs are discussed in Section 2.7.1. Light is discussed in Section 2.7.5.3. Underwater sound is discussed in Sections 2.7.5.1 and Appendix E, with atmospheric noise discussed in Section 2.7.5.2. The effects on the atmospheric environment are discussed in applicable VC sections, and therefore, it is not considered to be a stand-alone VC. For example, the effects of underwater noise on marine fish and marine mammals are discussed in Sections 8.3 and 10.3, respectively. The effects of light on marine fish and marine birds are discussed in Sections 8.3 and 9.3, respectively.

Additional candidate VCs were identified in the EIS Guidelines; however, were scoped out of the assessment and therefore not selected as VCs in this EIS. The rationale for exclusion is described in Table 4.1. Federal SAR are assessed in the Marine Fish and Fish Habitat VC, Marine and Migratory Birds VC, and the Marine Mammals and Sea Turtles VC, rather than a stand-alone VC. Marine plants are addressed, as relevant, in the Marine Fish and Fish Habitat VC.

The human environment candidate VC was not selected given the limited interactions between the human environment and Project activities (as demonstrated in Table 4.1). However, aspects of the human environment are described in the context of the existing socio-economic environment in Chapter 7 and relevant environmental effects assessed in the Commercial Fisheries and Other Ocean Uses VC (Chapter 12) and Indigenous Peoples and Communities VC (Chapter 13).

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
Atmospheric Environment (including Air Quality, Sound, and GHG Emissions)	Atmospheric environment and climate was not selected as a dedicated VC. Given the low magnitude of potential emissions (see Section 2.7.1), the environmental setting and existing regulatory standards, it has been determined that the potential environmental effects on atmospheric environment and climate do not warrant focused EA. Atmospheric discharges are described in Section 2.7.1 and potential changes to the atmospheric environment are assessed where applicable in the context of other VCs.	Atmospheric emissions of criteria air contaminants (CACs) and GHGs would result from routine Project activities. Air emissions from the Project are required to adhere to the *Newfoundland and Labrador Air Pollution Control Regulations*, National Ambient Air Quality Objectives, Canadian Ambient Air Quality Standards, and applicable regulations under MARPOL. Marine engines are subject to NO_X limits set by the International Maritime Organization (IMO) of the United Nations, with Tier II limits applicable in 2011 and Tier III limits that became applicable in 2016 in Emission Control Areas. On January 1, 2015 the sulphur limit in fuel in the IMO designated Emission Control Areas in large marine diesel engines was reduced from 1.0% to 0.1% in accordance with the *Vessel Pollution and Dangerous Chemicals Regulations* under the *Canada Shipping Act*. The Project Area does not contain receptors that would be sensitive to atmospheric emissions from Project activities and components due to its distance offshore and the limited atmospheric emissions predicted for the Project, as described in Section 2.7.1. Changes to the atmospheric environment (sound and light) are assessed in the context of the relevant biological VCs (i.e., receptors).	Section 2.7.1: Description of Project atmospheric emissions Sections 2.7.5 and 5.6: Changes related to ambient sound levels Section 5.8.1: Existing conditions regarding the atmospheric environment and climate Section 10.3: Project-related changes to atmospheric sound levels and associated effects on the Marine Mammals and Sea Turtles VC Section 9.3: Project-related changes to atmospheric sound and lighting levels and associated effects on the Marine and Migratory Birds VC Section 11.3: Project-related changes to atmospheric sound and lighting levels and associated effects on the Special Areas VC Chapter 16: Effects of the environment on the Project

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
Marine Environment	Marine Environment was not selected as a dedicated VC. Environmental effects on the marine environment are assessed in the context of more specific marine VCs (i.e., Marine Fish and Fish Habitat, Marine Mammals and Sea Turtles, Marine and Migratory Birds, Special Areas, and, Commercial Fisheries and Other Ocean Uses), to reduce redundancy and promote EA efficiency. Rather than as a stand-alone VC, the analysis of effects and mitigation can be more specific.	Project activities and components, as well as accidental events associated with the Project, have the potential to affect aspects of the marine environment. The Marine Fish and Fish Habitat VC assesses potential changes to the benthic environment. Potential changes to marine water quality are assessed in the context of the Marine Fish and Fish Habitat, Marine Mammals and Sea Turtles, Marine Birds, Special Areas, and Commercial Fisheries and other Ocean Uses VCs. Potential changes to underwater ambient noise and vibration levels are assessed in the context of the Marine Fish and Fish Habitat, Marine Mammal and Sea Turtles, Marine and Migratory Birds, Special Areas, and Commercial Fisheries and Other Ocean Uses VCs. Potential changes in mortality, injury or health, and habitat availability, quality and use for marine species are assessed in the context of the relevant biological VCs.	Chapters 5, 6, and 7: Description of biophysical and socio-economic aspects of the marine environment Chapter 8: Project-related environmental effects on the Marine Fish and Fish Habitat VC Chapter 9: Project-related environmental effects on the Migratory Birds VC Chapter 10: Project-related environmental effects on the Marine Mammals and Sea Turtles VC Chapter 11: Project-related environmental effects on the Special Areas VC Chapter 12: Project-related environmental effects on the Commercial Fisheries and Other Ocean Uses VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
Fish and Fish Habitat	The Marine Fish and Fish Habitat VC assesses environmental effects of the Project on fish (including applicable SAR and species of conservation concern [SOCC]) and fish habitat. The scope of this VC includes corals, sponges, and marine plants. This VC was selected based on its ecological importance, the socio-economic importance of commercial fisheries resources (i.e., target fish species), the legislated protection of fish and fish habitat and applicable SAR and SOCC, and the nature of potential Project-VC interactions.	Project activities and components, as well as accidental events associated with the Project, have the potential to affect fish habitat and/or several species of fish and corals (including SAR, SOCC and species targeted for harvesting), known to occur in and around the Project Area. During Indigenous and stakeholder engagement, Project effects on fish and fish habitat, including SAR and species of importance to commercial and subsistence fisheries (e.g., Atlantic salmon, Atlantic bluefin tuna, American eel) have been identified as an issue of concern (refer to Chapter 3). Fish and fish habitat are protected under the *Fisheries Act*. Section 5(1)(a) of CEAA 2012 requires consideration of Project-related environmental effects associated with a change to a component of the environment within the legislative authority of Parliament (e.g., fish and fish habitat as defined in the *Fisheries Act*, which includes corals, and aquatic species as defined in SARA, which includes marine plants).	Section 6.1: Existing conditions regarding fish and fish habitat Chapter 8: Project-related environmental effects on the Marine Fish and Fish Habitat VC Chapter 12: Project-related environmental effects on the Commercial Fisheries and Other Ocean Uses Chapter 13: Project-related environmental effects on the Indigenous Peoples and Communities VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events
Marine Plants	Marine Plants was not selected as a dedicated VC. It has been determined that environmental effects on marine plants do not warrant focused assessment as a dedicated VC, in consideration of the environmental setting and mitigation referred to in the next column. Potential changes to marine plants are assessed, as applicable, in the context of the Marine Fish and Fish Habitat and Special Areas VCs.	Marine plants, which are an important component of fish habitat, are not present in much of the Project Area as it is too deep and/or contains soft substrates that are not conducive to marine plants (AMEC 2014). However, relatively high abundance and diversity of marine plants exists in some areas, such as the Virgin Rocks Ecologically or Biologically Sensitive Area (EBSA) in the Regional Assessment Area (RAA) (AMEC 2014). Marine plants are also protected through planned mitigation measures for the protection of fish and fish habitat and special areas. It is therefore anticipated that mitigation proposed for the Marine Fish and Fish Habitat VC are sufficient to mitigate environmental effects on marine plants.	Section 6.1.4: Existing conditions for marine plants Section 6.4: Existing conditions for Special Areas

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
Migratory Birds and their Habitat	Environmental effects on migratory birds, including applicable SAR and SOCC and migratory bird habitat, are assessed in the Marine and Migratory Birds VC. This VC is included in consideration of its ecological importance, the legislated protection of marine and migratory birds and other applicable SAR and SOCC, concerns raised during Indigenous and stakeholder engagement, and the nature of potential Project-VC interactions.	Several species of marine and migratory birds (including SAR and SOCC) are known to occur within the RAA and therefore, have potential to be affected by Project activities and components as well as potential accidental events. Project effects on marine and migratory birds have been identified as an issue of concern during Indigenous and stakeholder engagement (refer to Chapter 3). Migratory birds are protected under the *Migratory Birds Convention Act* (MBCA), and section 5(1)(a) of CEAA 2012 requires consideration of project-related environmental effects associated with a change to a component of the environment within the legislative authority of Parliament (e.g., migratory birds as defined in the MBCA).	Section 6.2: Existing conditions regarding marine and migratory birds Chapter 9: Project-related environmental effects on the Marine and Migratory Birds VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events
Species at Risk	No dedicated VC has been selected for SAR and SOCC. To reduce redundancy and promote EA efficiency, environmental effects on SAR and SOCC are assessed as part of the Marine Fish and Fish Habitat, Marine and Migratory Birds, and Marine Mammals and Sea Turtles VCs. Effects and/or mitigation specific to SAR and SOCC are discussed in each VC, as applicable.	SAR and SOCC include the following: • federally protected species listed as “endangered”, “threatened”, or of “special concern” on Schedule 1 of SARA, and their critical habitat • species assessed as “endangered”, “threatened”, or of “special concern” by the federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC) • species listed as “endangered”, “threatened”, or “vulnerable” under the *Endangered Species List Regulations* pursuant to the Newfoundland and Labrador *Endangered Species Act* (NL ESA), which are provincially protected Several SAR and SOCC are known to occur within the RAA, including fish, marine mammals, sea turtles, and marine and migratory birds, and have potential to be affected by routine Project activities as well as potential accidental events. Project effects on SAR and SOCC (particularly blue whale, North Atlantic right whale, Atlantic salmon and American eel) have been identified as an issue of concern during Indigenous and stakeholder engagement (refer to Chapter 3).	Sections 6.1.8, 6.2.4, 6.3.7: Summary of marine SAR and SOCC (including applicable species of fish, corals, mammals, turtles, and birds) with potential to be affected by the Project Chapter 8: Assessment of project-related environmental effects on fish and coral SAR and SOCC Chapter 9: Project-related environmental effects on marine and migratory bird SAR and SOCC Chapter 10: Assessment of project-related environmental effects on marine mammal and sea turtle SAR and SOCC

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
		SAR and SOCC may be more vulnerable to habitat changes or population levels than secure species. However, in general, potential environmental effects and mitigation measures taken to protect SAR and SOCC are also protective of secure species.	Chapter 14: Cumulative environmental effects Chapter 15: Accidental events
Marine Mammals	Environmental effects on marine mammals (including SAR and SOCC) are assessed in the Marine Mammals and Sea Turtles VC. This VC is included in consideration of its ecological importance, the legislated protection of applicable SAR, concerns raised during Indigenous and stakeholder engagement, and the nature of potential Project interactions. Marine mammals and sea turtles are considered within the same VC due to the similarities in their potential interactions with the Project.	Several species of marine mammals (including SAR and SOCC) are known to occur in the RAA and have potential to be affected by Project activities and components as well as potential accidental events. Project effects on marine mammals, have been identified as an issue of concern during Indigenous and stakeholder engagement (refer to Chapter 3). Section 5(1)(a) of CEAA 2012 requires consideration of project-related environmental effects associated with a change to a component of the environment within the legislative authority of Parliament (e.g., aquatic species as defined in SARA).	Section 6.3: Existing conditions regarding marine mammals Chapter 10: Project-related environmental effects on the Marine Mammals and Sea Turtles VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events
Sea Turtles	Environmental effects on sea turtles (including applicable SAR and SOCC) are assessed within the Marine Mammals and Sea Turtles VC. This VC is included in consideration of its ecological importance, the legislated protection of applicable SAR, and the nature of potential Project-VC interactions. Marine mammals and sea turtles are considered within the same VC due to the similarities in their potential interactions with the Project.	Sea turtles (including SAR and SOCC) are known to occur in the Project Area and have potential to be affected by Project activities and components as well as potential accidental events. Section 5(1)(a) of CEAA 2012 requires consideration of project-related environmental effects associated with a change to a component of the environment within the legislative authority of Parliament (e.g., aquatic species as defined in SARA).	Section 6.3: Existing conditions regarding sea turtles Chapter 10: Project-related environmental effects on the Marine Mammals and Sea Turtles VC Section 15.5: Environmental effects of potential accidental events Chapter 14: Cumulative environmental effects

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
Special Areas	Environmental effects on special areas are assessed within the Special Areas VC. This VC is included in consideration of its ecological and/or socio-economic importance, the legislated protection of applicable special areas, and the nature of potential Project-VC interactions.	Several Special Areas (i.e., areas designated as being of special interest due to their ecological and/or conservation sensitivities, including those protected under federal legislation) are known to occur in the RAA and have potential to be affected by Project activities and components as well as potential accidental events. Special areas provide important for certain SAR / SOCC.	Section 6.4: Existing conditions regarding Special Areas Chapter 11: Project-related environmental effects on the Special Areas VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events
Indigenous Peoples	Environmental effects on Indigenous peoples are assessed with respect to the Indigenous Peoples and Communities VC. This VC is included in consideration of Indigenous peoples that reside in NL, the Maritimes, and Quebec whose asserted or established Aboriginal or Treaty rights could potentially be affected by changes in the environment as a result of the Project.	There are several Indigenous groups residing in NL, the Maritimes, and Quebec; many of these groups have expressed concerns about potential adverse environmental effects of the Project (refer to Chapter 3). Indigenous commercial communal fishing activity have the potential to occur in the vicinity of the Project Area and therefore may be affected by Project activities and components as well as potential accidental events. Project activities may also interact with species traditionally harvested for food, social and ceremonial (FSC) purposes, particularly migratory species which may transit through the Project Area and be harvested elsewhere. Indigenous groups also expressed concern about potential adverse effects on Aboriginal rights and cultural, social, health and economic changes that could affect the quality of life within their communities. Section 5(1)(c) of CEAA, 2012 requires consideration of project-related environmental effects, with respect to Indigenous peoples, associated with a change to the environment health and socio-economic conditions, physical and cultural heritage, the current use of lands and resources for traditional purposes and any structure, site or thing that is of historical, archaeological, paleontological or architectural significance.	Chapter 3: Context for Indigenous organizations (including locations of reserves and communities) Section 7.4: Existing conditions regarding Indigenous resource use Chapter 13: Project-related environmental effects on Indigenous Peoples and Communities VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
Commercial Fisheries	Environmental effects on commercial fisheries are assessed in the Commercial Fisheries and Other Ocean Uses VC. This VC is included in consideration of its economic importance and the potential for Project-VC interactions.	Commercial fishing activity occurs near the Project Area and RAA and may be affected by Project activities and components as well as potential accidental events. Potential effects on commercial fisheries have been raised during stakeholder engagement.	Section 7.2: Existing conditions regarding commercial fisheries Chapter 12: Project-related environmental effects on the Commercial Fisheries and Other Ocean Uses VC Chapter 14: Cumulative environmental effects Chapter 15: Environmental effects of potential accidental events
Human Environment (e.g., recreational activities, other ocean uses, socio-economic conditions, human health, physical and cultural heritage, and rural and urban settings)	No dedicated VC has been selected for human environment. In consideration of the environmental setting and the mitigation referred to in the next column, environmental effects on recreational activities, human health and socio-economic conditions, physical and cultural heritage, rural and urban settings do not warrant focused assessment. However, in consideration of potential interactions between the Project and other ocean users (e.g., shipping, research, oil and gas, military activities, ocean infrastructure), other ocean users are assessed in the Commercial Fisheries and Other Ocean Uses VC.	Other ocean uses, including shipping, oil and gas activity, military activities, and research, occur within the RAA and have the potential to interact with Project components during routine and/or unplanned events. Recreational fisheries and other forms of recreation are not known to occur in the vicinity of the Project Area. These activities are generally located in the nearshore. However, mitigation measures for the Marine Fish and Fish Habitat VC, the Indigenous Peoples and Communities VC, and the Commercial Fisheries and Other Ocean Uses VC would be sufficient to mitigate environmental effects on recreational fisheries if applicable. Potential accidental events (i.e., spills) associated with the Project could result in contamination of fish species commonly harvested for human consumption through commercial, Indigenous, and/or recreational fisheries. However, in the event of an accidental spill that could potentially affect human health, measures would be taken (e.g., fisheries closures, exclusion zone) would be imposed thereby preventing contact with spilled oil and/or exposure to contaminated food sources. These potential effects are assessed in the context of the Indigenous Peoples and Communities VC, and the Commercial Fisheries and Other Ocean Uses VC.	Section 1.4: Benefits of the Project Section 2.7: Routine waste discharges and emissions associated with the Project Chapter 7 Existing conditions regarding human environment Chapter 12: Project-related environmental effects on the Commercial Fisheries and Other Ocean Uses VC Chapter 15: Spill response measures and Environmental effects of potential accidental events

Table 4.1 Rationale for Selection of Valued Components

Environmental Components Specified in Final EIS Guidelines	VC Determination	Basis for Inclusion or Exclusion as a VC	Relevant EIS Section Reference(s)
		Due to its distance offshore, the Project is not expected to interact with rural and urban settings along the Newfoundland coastline and unlikely to affect receptors that would be sensitive to atmospheric air or noise emissions from routine Project activities and components, or from potential accidental events. Project activities and components are not anticipated to result in changes to the environment that would affect human health. Emissions will be in accordance with allowable concentrations stated in the OWTG. Potential indirect Project effects with respect to Indigenous health are addressed in the Indigenous Peoples and Communities VC. Project activities and components are not anticipated to result in changes to the environment that would have an effect on physical and cultural heritage. There are no known shipwrecks or legacy sites within the Project Area. Information gathered pre-drill ROV site surveys in the Project Area will confirm the absence of geohazards (including cultural heritage resources on the seabed) before any seabed disturbance takes place. PSV and helicopter transport activities will not result in ground/seabed disturbance. Therefore, they will not affect heritage resources. The Project is expected to have economic benefits, including economic and contracting opportunities. Socio-economic benefits associated with the Project are discussed in Section 1.4.	

4.1.4 Spatial and Temporal Boundaries

Environmental effects are evaluated within spatial and temporal boundaries. Spatial boundaries are defined as the geographic extent of the measurable potential environmental, social, heritage and human effects of the Project (including project activities and components). The spatial boundaries include:

- **Project Area** (Figure 4-1): The Project Area is the boundary that encompasses the immediate area within which Project activities and components occur (EL 1157 and EL 1158) and incorporates an approximate 20 km buffer. Well locations have not been identified but will occur within the ELs in the Project Area. The Project Area is consistent across all VCs.
- **Local Assessment Area (LAA)**: The LAA is the maximum area within which environmental effects from routine Project activities and components can be predicted or measured with a reasonable degree of accuracy and confidence. It consists of the Project Area and adjacent areas where Project-related environmental effects are reasonably expected to occur based on available information including effects thresholds, predictive modelling and professional judgement. The LAA is defined for each VC.
- **Regional Assessment Area (RAA)** (Figure 4-1): The RAA is the area that establishes the context for determination of significance of Project residual environmental effects from Project activities and components. It is also the area within which potential cumulative effects – the residual effects from the proposed Project in combination with those of past, present and reasonably foreseeable projects – are assessed. Although the RAA is intended to be much broader than the LAA, which focuses on the extent of potential effects associated with routine Project activities for each VC, it is possible that effects from larger scale unplanned events (e.g., blowout) could extend beyond the RAA. The RAA is consistent for all VCs, except for the Indigenous Peoples and Communities VC which has a larger RAA to encompass the various Indigenous communities which have the potential to be affected by Project-related activities.

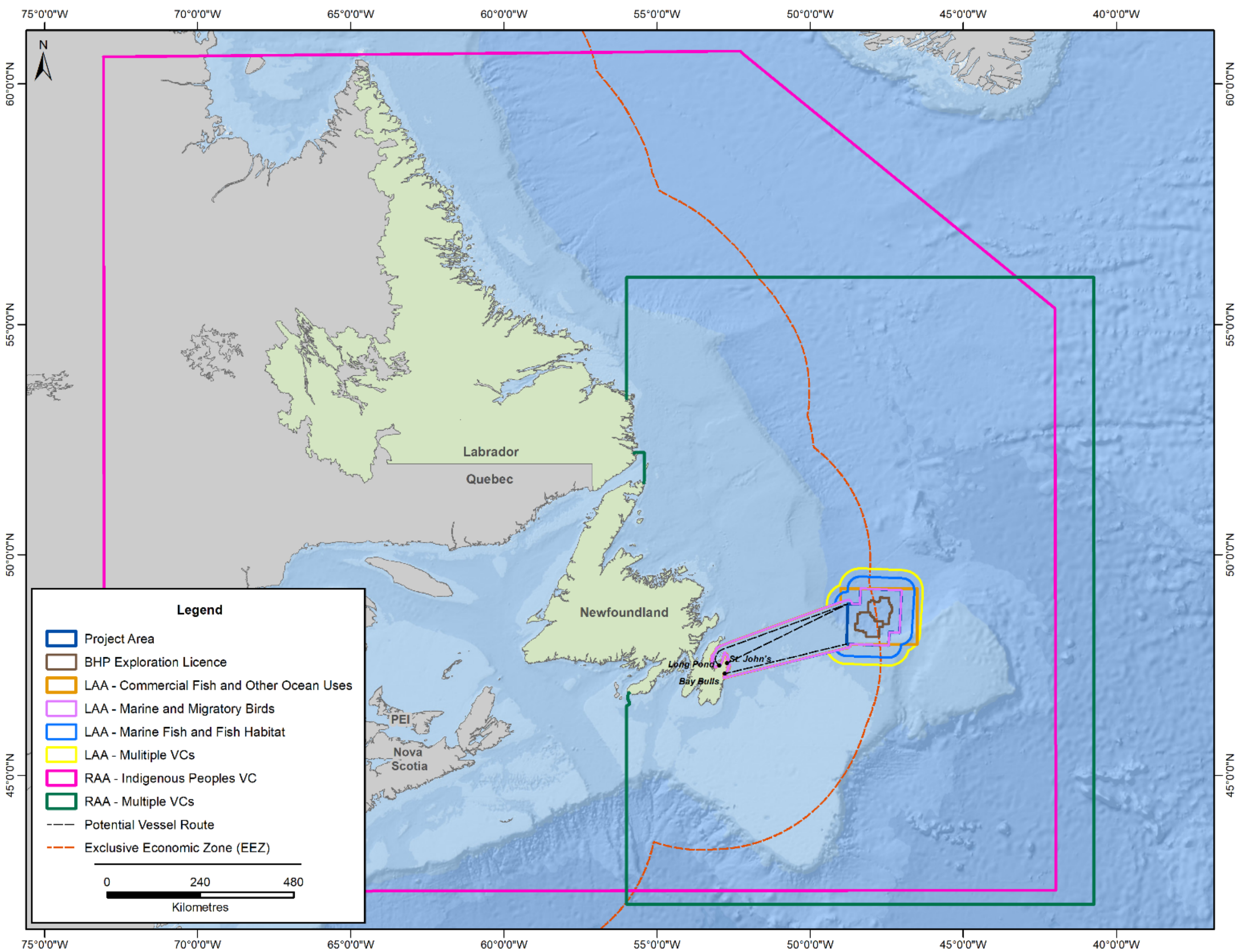

Figure 4-1 Project Area and Regional Assessment Areas

The temporal boundaries identify when an environmental effect may occur. Temporal boundaries to be assessed for the Project are based on specific project phases or activities and include all Project phases, such as well drilling, testing and abandonment.

Based on the current schedule as described in Section 2.6, the temporal boundaries for the assessment are:

- BHP proposes to commence exploration drilling with an initial well as early as 2021. Upon completion of these first well(s) and based on results, additional well site locations may be identified. It is currently anticipated that up to ten wells (exploration and possibly appraisal) may be drilled on both of the ELs, for a total of up to 20 wells being drilled during the term of the ELs (2019-2028)
- Drilling is expected to occur between May – November, although this EIS assumes year-round drilling as a precaution; it is anticipated that each well will require 35 to 115 days for drilling, evaluation, abandonment and/or suspension
- Well testing (if required, dependent on drilling results) could also occur at any time during the temporal scope of this EIS
- Wells may be decommissioned and abandoned at any time within the temporal boundaries

In addition to temporal boundaries of Project phases and activities, key temporal characteristics associated with VCs, such as spawning, migration, and fishing seasons, are also considered for assessment. These are described and included in the assessment of VCs, as applicable.

4.2 Environmental Effects Assessment (Planned Project Components and Activities)

The following subsections describe the approach and organization for the assessment of routine Project activities on each VC.

4.2.1 Study Boundaries

Each VC has been assigned spatial and temporal boundaries, described in Section 4.1.4, for environmental effects assessment.

4.2.2 Effects Evaluation Criteria (Characterization of Residual Effects)

To characterize the residual adverse effects of the Project on each VC, the following criteria are used: direction, magnitude, geographic extent, frequency, duration, reversibility, and ecological or socio-economic context. The definitions of these criteria, which are further customized in in each VC-specific assessment, are outlined in Table 4.2.

Table 4.2 Criteria Used to Support Environmental Effects Assessment

Criteria	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual environmental effect relative to existing conditions	Positive – a residual environmental effect that moves measurable parameters in a direction beneficial to [VC] relative to existing conditions Adverse – a residual environmental effect that moves measurable parameters in a direction detrimental to [VC] relative to existing conditions
Magnitude	The amount of change in measurable parameters or the VC relative to existing conditions	Negligible – no measurable change Biophysical VCs: Low – a detectable change but within the range of natural variability Moderate – a detectable change beyond the range of natural variability, but with no associated adverse effect on the viability of the affected population High – measurable change that exceeds the limits of natural variability, with an adverse effect on the viability of the affected population Socio-economic VCs: Low – A detectable change that is within the range of natural variability, with no associated adverse effect on the overall nature, intensity, quality / health or value of the affected component or activity Moderate - A detectable change that is beyond the range of natural variability, but with no associated adverse effect on the overall nature, intensity, quality / health or value of the affected component or activity High - A detectable change that is beyond the range of natural variability, with an adverse effect on the overall nature, intensity, quality / heath or value of the affected component or activity
Geographic Extent	The geographic area in which a residual environmental effect occurs	Project Area – residual environmental effects are restricted to the Project Area Local Assessment Area – residual environmental effects extend into the LAA Regional Assessment Area – residual environmental effects extend into the RAA
Frequency	Identifies how often the residual effect occurs during the Project	Unlikely event – effect is unlikely to occur Single event – effect occurs once Multiple irregular event – effect occurs at no set schedule Multiple regular event – effect occurs at regular intervals Continuous – effect occurs continuously
Duration	The time required until the measurable parameter or the VC returns to its existing condition, or the residual effect can no longer be measured or otherwise perceived	Short term - for duration of the activity, or for duration of accidental event Medium term - beyond duration of activity up to end of Project, or for duration of threshold exceedance of accidental event – weeks or months Long term - beyond Project duration of activity, or beyond the duration of threshold exceedance for accidental events - years Permanent - recovery to existing conditions unlikely

Table 4.2 Criteria Used to Support Environmental Effects Assessment

Criteria	Description	Quantitative Measure or Definition of Qualitative Categories
Reversibility	Pertains to whether a measurable parameter or the VC can return to its existing condition after the project activity ceases	Reversible – will recover to pre-Project conditions before or after Project completion Irreversible – permanent
Ecological or Socio-economic Context	Existing condition and trends in the area where residual environmental effects occur.	Undisturbed – The VC is relatively undisturbed in the RAA, not adversely affected by human activity, or is likely able to assimilate the additional change Disturbed – The VC has been previously disturbed by human development or human development is still present in the RAA, or the VC is likely not able to assimilate the additional change

4.2.3 Significance Definition

To identify the threshold beyond which a residual environmental effect would be considered significant, significance criteria or thresholds were developed for each VC. This involved consideration of whether the predicted residual environmental effects of the Project are adverse, significant, and likely. Guidance provided in the Operational Policy Statement, *Determining Whether a Designated Project is Likely to Cause Significant Environmental Effects Under the Canadian Environmental Assessment Act, 2012* (CEA Agency 2015) was used to define and determine significance criteria and thresholds for this Project. Where pre-established standards or thresholds do not exist, significance criteria have been defined qualitatively and justifications for the criteria provided.

4.2.4 Existing Conditions

To describe the setting of the Project, existing conditions of the marine physical environment (Chapter 5), marine biological environment (Chapter 6) and socio-economic environment (Chapter 7) are provided. Based on literature review and available data, these sections provide an understanding of the receiving environment.

4.2.5 Potential Environmental Changes, Effects, and Associated Parameters

The assessment of Project-related environmental effects involves the identification of potential environmental interactions between each VC and the Project and resulting effects of changes on the VC. An adverse environmental effect to the VC may occur, as a result of the Project, if an important aspect or characteristic of the VC is altered or disrupted. Each VC assessment identifies several associated parameters, defined as an important aspect or characteristic of the VC. An overview of the identified potential interactions between the VC and each of the routine Project components and activities are presented in Table 4.3.

Table 4.3 Potential Interactions between Planned Project Activities and Valued Components

Planned Activity	Valued Component					
	Marine Fish and Fish Habitat (including SAR)	Marine and Migratory Birds (including SAR)	Marine Mammals and Sea Turtles (including SAR)	Special Areas	Indigenous Peoples and Communities	Commercial Fisheries and Other Ocean Uses
Presence and Operation of a MODU (including drilling, associated safety zone, lights, and sound)	✓	✓	✓	✓	✓	✓
VSP	✓	✓	✓	✓	✓	✓
Discharges (e.g., drill muds / cuttings, liquid discharges)	✓	✓	✓	✓	✓	✓
Well Testing with Flaring (including air emissions)	✓	✓	-	-	✓	-
Well Decommissioning and Abandonment or Suspension	✓	-	✓	✓	✓	✓
Supply and Servicing (including helicopter transportation and PSV operation)	✓	✓	✓	✓	✓	✓

4.2.6 Environmental Effects Assessment and Mitigation

The environmental effects assessment for each VC evaluates the potential effects of planned Project activities by examining the degree and nature of change to, and resulting effects on, the existing environment. To predict potential effects of the Project, each VC is assessed considering existing conditions to establish sensitivity or resiliency of each VC to disturbance and/or change.

To reduce or eliminate potential adverse effects the implementation of mitigation measures is fully integrated into the effects assessment. Within each VC assessment, an explanation is provided as to how the mitigation will reduce, manage, or eliminate potential adverse effects on the VC. Mitigation may include documented practices, measures proven effective in the past, best management practices (BMPs), as well as measures developed specifically for the project. In some cases (e.g., fishing gear loss) compensation measures may be warranted.

To assess potential Project-related environmental changes to the VC, the effects assessment also considers relevant scientific literature, existing conditions and monitoring results, and other available applicable information sources (e.g., community, stakeholder, or Indigenous Knowledge). The focus of the effects assessment is on residual effects (i.e., those effects that remain after application of planned mitigation). Using the VC-specific significance definitions, stated within each VC section, the assessment evaluates the significance of these effects and summarizes the residual environmental effects of the Project's activities and components in a concluding paragraph in each VC section. If a significant adverse residual effect is predicted, then the likelihood of this occurrence is also discussed.

4.3 Project-Specific Modelling

Project-specific modelling studies were conducted by BHP to understand the fate and behavior of discharges and emissions from the Project. The models are applicable to various VC's effects assessment for the Project and are summarized below.

4.3.1 Drill Cuttings Dispersion Modelling

Drill cuttings dispersion modelling on the seabed allows for the assessment of operational discharge of cutting and muds from the drilling platform by characterizing the release of drill cuttings associated with drilling activities during the Project. The modelling, completed by RPS, simulated the dispersion of these discharges using RPS's MUDMAP modelling system. MUDMAP is a highly advanced three-dimensional plume model, used to evaluate potential environmental effects caused by marine discharges, such as drill cuttings and drilling muds. The model is discussed in Section 2.7.2.1 and additional detail is provided in Appendix D.

4.3.2 Underwater Sound Modelling

Underwater sound modelling for drilling activity and support vessels was completed by JASCO to determine the potential zone of influence on protected marine mammals, sea turtles, and fish species from exposure levels of sound received into the marine environment (see Section 2.7.5.1). The model included sound associated with the operation of the drilling installation and from a VSP survey. The results from the underwater sound modelling is provided in Appendix E.

4.3.3 Spill Trajectory Modelling and Probability Analysis

Spill trajectory modelling was conducted by RPS and considers the releases of crude oil from hypothetical blowouts and batch surface release scenarios (e.g., marine diesel from bunkering accidents) (see Chapter 15). RPS developed the OILMAPDeep model and SIMAP model to complete this analysis. The OILMAPDeep model characterizes the near-field blowout dynamics for a subsurface release of oil. The output data from OILMAPDeep is used as an input to the SIMAP model to simulate far-field oil trajectory and fate. RPS partnered with Environmental Research Consulting (ERC) to complete the probability analysis work. The results from the spill trajectory modelling and probability analysis are provided in Appendix F.

4.4 Cumulative Environmental Effects

The EIS assesses and evaluates cumulative environmental effects, as required under section 19(1) of CEAA 2012, that are likely to result from the Project in combination with other physical activities that have been or will be carried out near the Project, as well as the significance of these potential effects. A detailed description of the methods used, as well as the cumulative effects assessments for the VCs together are provided in Chapter 14, in accordance with the CEA Agency's (2016) Operational Policy Statement, *Assessing Cumulative Environmental Effects Under CEAA 2012*.

4.5 Accidental Events

Potential accidental events which may occur as a result of the Project, and the associated environmental effects, are assessed in Chapter 15. When assessing potential effects of accidental events, reasonable worst-case scenarios have been assumed as a precautionary approach. Mitigation measures and contingency plans are discussed, as well as a conclusion regarding the significance of residual environmental effects and their likelihood of occurrence.

4.6 Effects of the Environment on the Project

Chapter 16 assesses the effects of the environment on the Project. This section considers how potential effects on the environment (e.g., accidental events) could arise from local environmental conditions and natural hazards (e.g., extreme weather) which may adversely affect the Project. Potential adverse effects of the environment on a project are typically a function of project design and environmental conditions (e.g., geology, ice conditions) that could affect the project. Mitigation measures for these effects typically involve engineering and environmental design criteria, industry standards, and environmental monitoring.

4.7 References

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5.0 EXISTING PHYSICAL ENVIRONMENT

The Project Area, located off the Northeast Newfoundland slope in the Orphan Basin, encompasses ELs 1157 and 1158 and is approximately 15,775 km^2 in size. The exploration licenses (ELs 1157 and 1158) are in the southern portion of the West Orphan Basin just north of the Sackville Spur. The Regional Assessment Area (RAA) encompasses most of the eastern Newfoundland offshore area (Figure 5-1).

The following sections provide an overview of the relevant components of the physical environment within the Project Area and in surrounding areas including its geology (including seismicity and geohazards), climatology, air quality, oceanography, ambient noise, and ice conditions.

Of most relevance to the Environmental Impact Statement (EIS) is information on the physical environment that is used in assessing and evaluating the potential effects of the environment on the Project. This includes physical environment conditions that could affect Project planning and in-field Project Activities. For this reason, the primary focus of this section is on the Project Area itself.

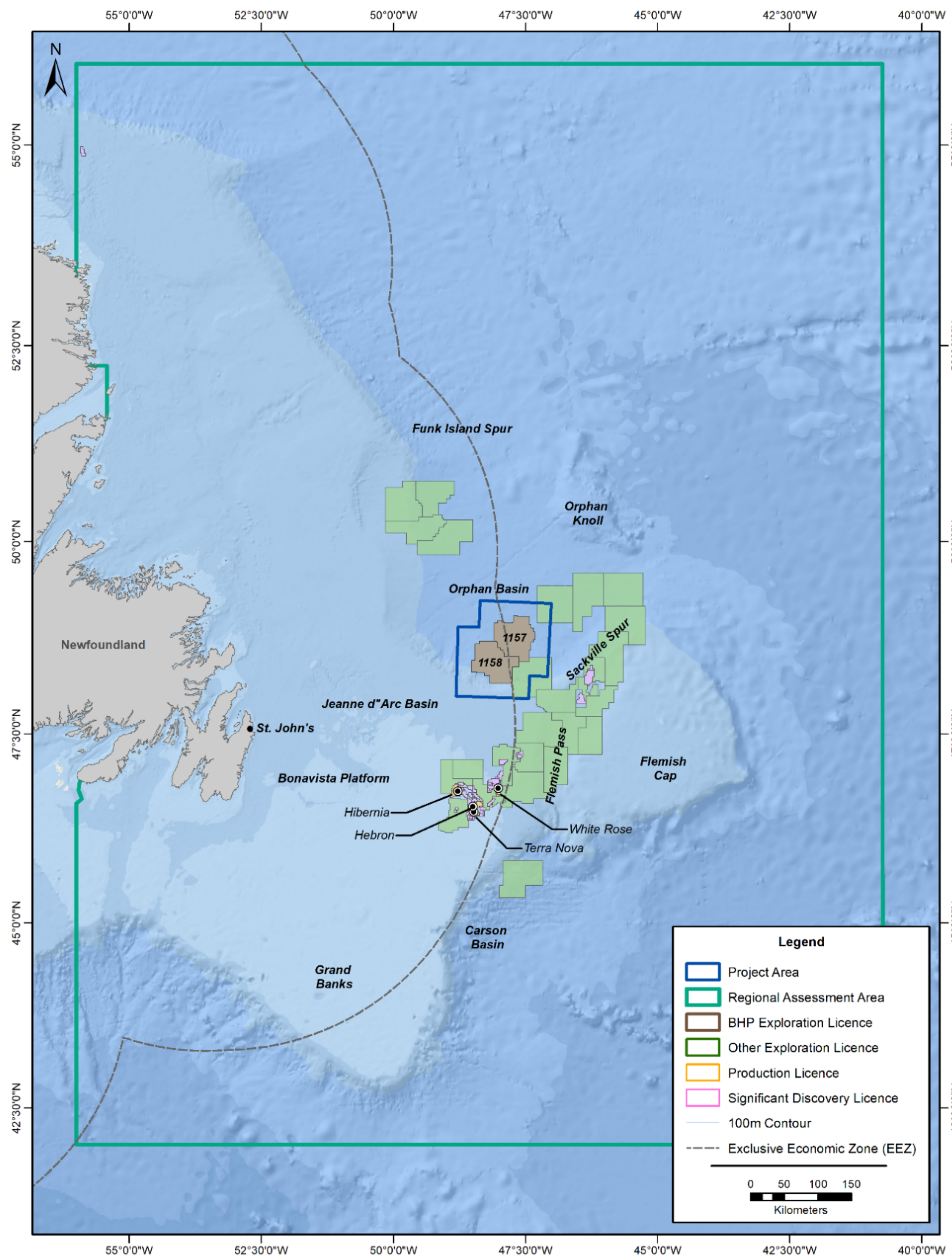


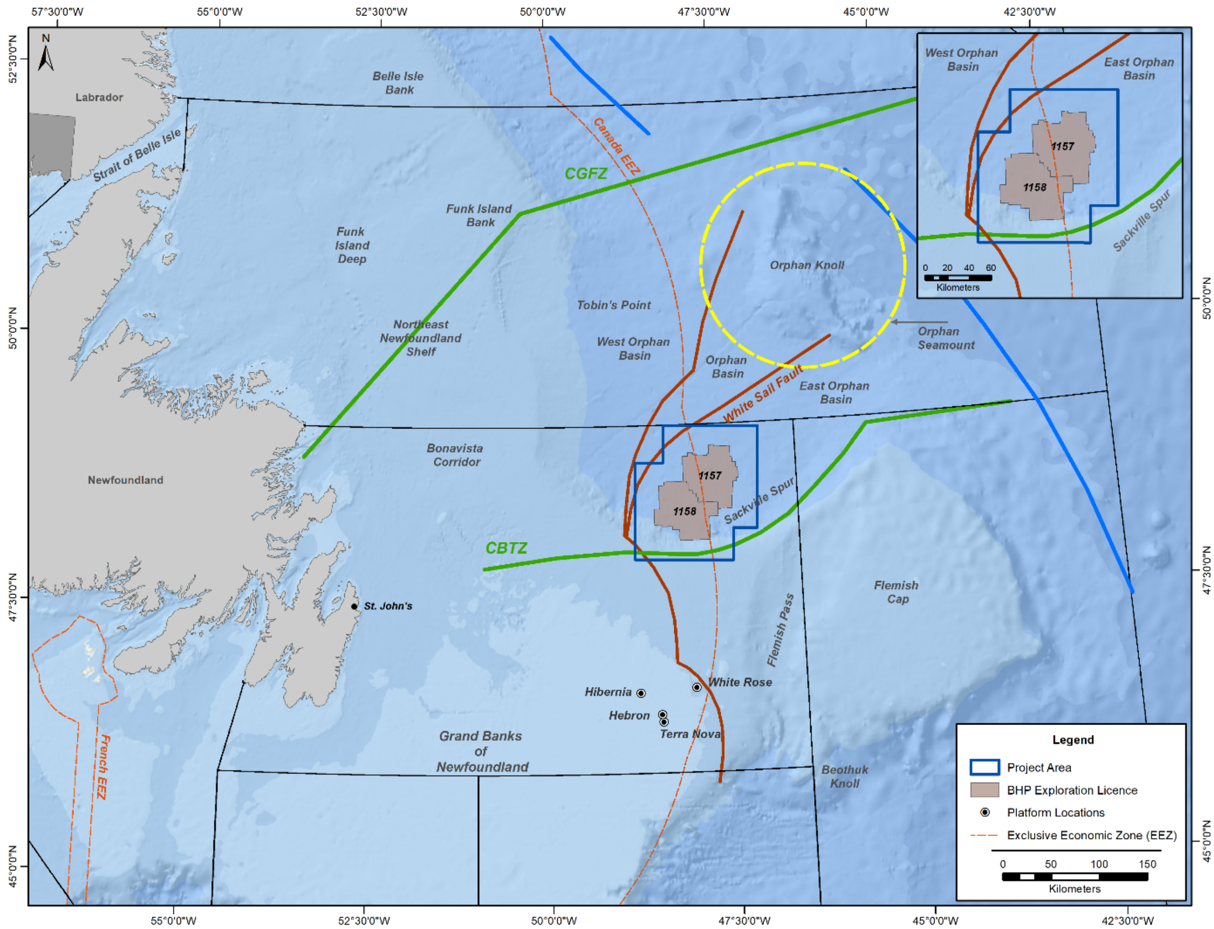
Figure 5-1 Location of Project Area and RAA

5.1 Geology and Geomorphology

The geology of the eastern Newfoundland continental shelf and slope area has a complex and dynamic history with its bedrock and surficial geology currently influenced by both natural and anthropogenic factors. The eastern Newfoundland continental shelf was formed by extension during the opening of the Atlantic Ocean during the Late Triassic to Cretaceous Periods (Fader et al. 1989). A combination of rifting and salt tectonics in the area created a series of Mesozoic rift basins; the main sedimentary basins in the area include the Orphan, Flemish Pass, Jeanne d'Arc, and Carson basins (Fader et al. 1989). The following sections provide an overview of the geology, seismicity, and geohazards of the Project Area and surrounding areas.

5.1.1 Bedrock Geology

The Orphan Basin is a wide non-volcanic rifted continental margin (Sibuet 1992; Enachescu 2006) approximately 160,000 km^2 in size (Enachescu et al. 2005), and is bounded by the Charlie-Gibbs Fracture Zone (CGFZ) to the north, the Continent-Ocean Boundary to the east, the Cumberland Belt Transfer Zone to the south, and the Bonavista Fault Zone to the west (see Figure 5-2) (Enachescu et al. 2005; Enachescu 2006). The White Sail Fault bisects the basin. The Orphan Knoll, in the East Orphan Basin, measures 190 km long and 90 km wide and rises from approximately 4,000 to 1,500 m water depth (Meredyk 2017) and is comprised of shallow water marine Paleozoic sediments overlain by Jurassic to Cretaceous sediments (Enachescu et al. 2005; AMEC 2014). Several mounds composed of exposed mid-Miocene bedded pelagic limestone bedrock have been documented on the Orphan Knoll (Meredyk 2017). These mounds were originally theorized to be carbonate reef mounds (Enachescu 2004). Additionally, several manganese (Mn) nodules have been recovered from the Orphan Knoll area (Meredyk 2017).



Modified from Source:Meredyk (2017). Note: CGFZ= Charlie-Gibbs Fracture Zone, CBTZ= Cumberland Belt Transform Zone

Figure 5-2 Basin Boundaries in the Orphan Basin and Notable Features in the Area

The Orphan Basin is described in two distinct regions (West and East) that underwent rifting at different times in its formation. Prior to the initiation of Mesozoic Era rifting, the Orphan Basin was part of a broad Paleozoic Era sedimentary platform within the Avalon terrane of the Appalachian orogenic system (Enachescu 2006). The first phase of rifting, as indicated by seismic stratigraphic relationships, began in the Triassic, and effected the East Orphan Basin (Enachescu 2006). This initial narrow rift (oriented northeast-southwest) expanded during the Late Triassic-Early Jurassic within the Tethys rift system, which extended from the Gulf of Mexico to the Barents Shelf and northern Europe (Enachescu 2006). The rift basin was reactivated, enlarged, and deepened during the Late Jurassic-Early Cretaceous Atlantic Ocean rifting phase, after a long thermal subsidence stage (Enachescu 2006). Extension and minor transtension continued during the Aptian-Albian rift phase and into several extensional episodes in the Late Cretaceous and Tertiary (Enachescu 2006). As a result of these extensional episodes, the architecture of the Orphan Basin is dominated by alternating ridges of basement block overlain by sediments and deep sub-basins, which are predominantly oriented northeast-southwest or north-south (Enachescu 2006). The evolution of Orphan Basin involved multiple tectonostratigraphic events that combined to influence the present-day basin morphology and sedimentary fill (Dafoe et al. 2013). Dafoe et al. (2013) provide a list of these events:

- Middle to Late Jurassic rifting, shallow marine deposition, and subsequent deformation
- Tithonian and Early Cretaceous rifting that propagated westward, with shallow marine to shelf deposition
- Development of the central Orphan High and deformation of Tithonian and Lower Cretaceous units around the time of Albian sequence boundary development
- Thinning of continental crust outside of Orphan Knoll and possible contemporaneous development of a major flooding surface in the Albian-Cenomanian
- Santonian sequence boundary development with late crustal faulting in northern Orphan Basin and north of the CGFZ, initiation of transitional crust with true oceanic crust development south of the CGFZ, and major subsidence of the basin in Maastrichtian-Paleocene time
- Magmatism in the northern Orphan Basin
- Tertiary basin filling and shelf-slope development

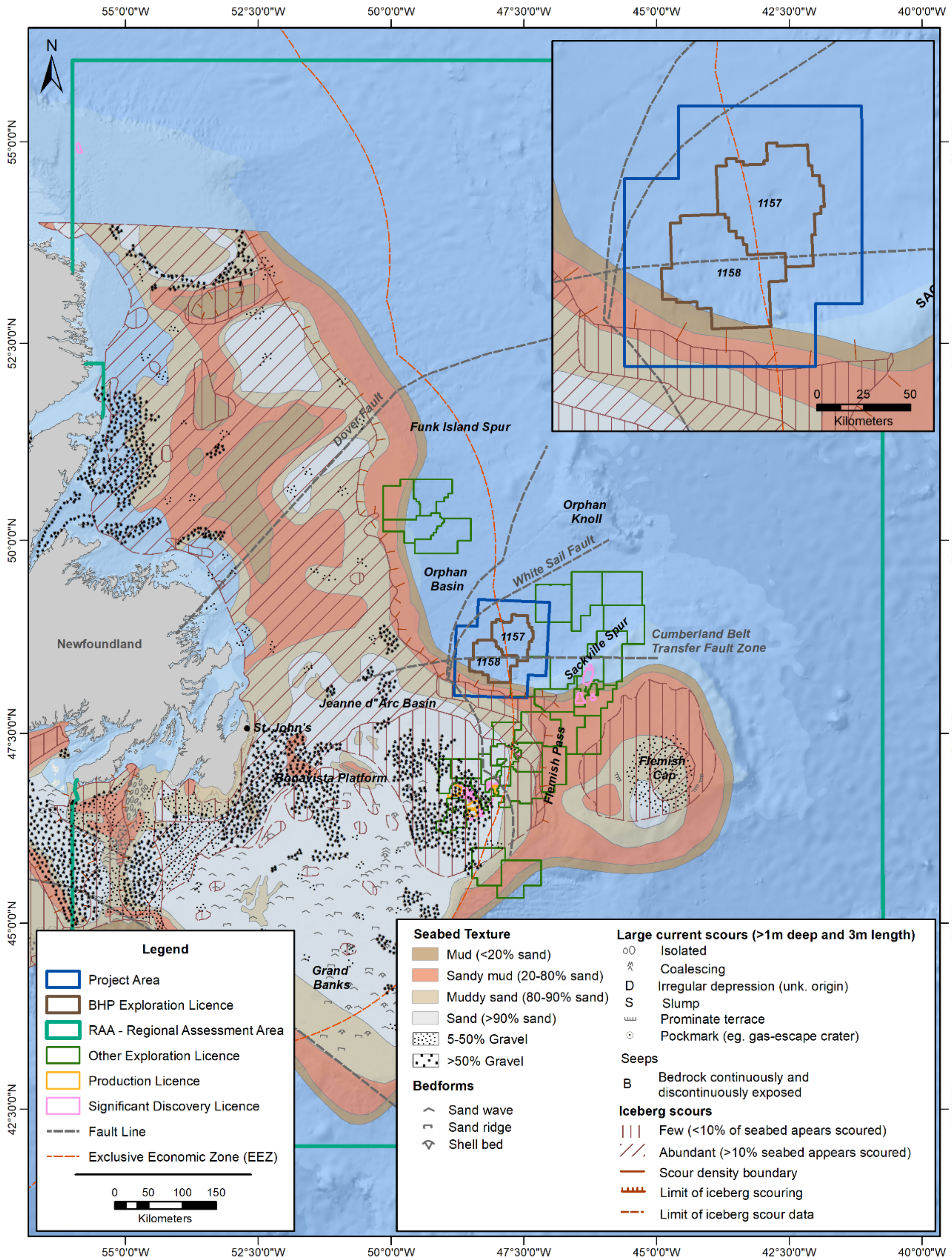
Considering petroleum potential, and relevant tectono-structural factors, the East Orphan Basin is older than the West Orphan Basin and is a Tethys rift state remnant with sedimentary fill from the Jurassic, Cretaceous, and probably Triassic (Enachescu 2006). The East Orphan Basin is situated in deep water (1,500 to 3,000 m) and is likely to be gas prone (Enachescu 2006). Tertiary cover is thick over West Orphan Basin (4 km) and relatively thin over the East Orphan Basin (2 km) (Enachescu 2006). These two main rift basins (the East and West Orphan Basin) are separated by a major crustal fault zone, the White Sail Fault, which dips eastward and penetrates deeply into the upper crust (Enachescu 2006).

5.1.2 Geomorphology and Surficial Geology

The geomorphology and surficial geology of the Project Area and surrounding areas is influenced by modern oceanographic processes and past glacial activity (Piper 1991). The topography of the Orphan Basin is highly diverse, as characterized by depth, location, and physiography. The Orphan Basin is in approximately 1,200 to 3,300 m water depth.

The surficial geology the continental margin of Eastern Canada (see Figure 5-3) and a description of the surficial geology of the Orphan Basin are presented below. The major geomorphic features in or near the Project Area are described in Table 5-1.

The eastern Canadian continental shelf surficial geology has been influenced by subsequent glaciations. Almost the entire upper continental slope off Eastern Canada is underlain by glacial till and in some places the till is buried up to tens of metres beneath Holocene sediments (Edinger et al. 2011). These tills are composed of sand or mud from reworked Pleistocene or Late Tertiary sediments and include a small portion of bedrock ranging in size from pebbles to boulders (Edinger et al. 2011). Iceberg scours from previous glaciation periods crisscross the project area (Cameron and Best 1985).



Source: Cameron and Best 1985

Figure 5-3 Surficial Geology in the RAA

Table 5.1 Major Geomorphic Features near the Project Area

Feature	Description
Orphan Knoll	Topographic high that rises 1,000 m above the Orphan Basin to the west, 1,600 m above the Orphan Basin to the south, and drops to 2,200 m to the Labrador Sea Abyssal Plain to the east. The knoll is oriented NNW-SSE and is approximately 75 km in breadth and 190 km long[A]
Orphan Basin	Sedimentary basin with sediment overlaying faulted basement[B]
Sackville Spur	Prominent contourite drift formed at the northern end of the Flemish Pass during the Neogene-Quaternary that has been incised by numerous canyons[C]
Jeanne d' Arc Basin	Sedimentary basin with sediments 20 km thick[B]
Central Ridge	Faulted intra-basin high separating the Jean d'Arc Basin and Flemish Pass Basin[D]
Flemish Pass	Sedimentary Basin that forms a terraced continuation of the East Orphan Basin[E]
Flemish Cap	Isolated continental basement high separated from the continental shelf by the Flemish Pass[F]
Sources: [A]Ruffman 2011; [B]Keen and Piper 1990; [C]Marshall et al. 2014; [D]Enachescu 2012; [E]Lowe et al. 2011; [F]King and Fader, 1985	

In general, eroded Quaternary sediments and authigenic carbonates are thought to be more common than eroded Tertiary bedrock along the shelf break and upper slope of Newfoundland and Labrador (NL) (Piper et al. 2005; Edinger et al. 2011). Authigenic carbonates refers to any carbonate mineral precipitated inorganically *in situ*, whether at the water-sediment interface or within sediment pore waters (Schrag et al. 2013) and may occur on Orphan Knoll (Enachescu 2004), although the exposed pinnacles of the Orphan Knoll could also be eroded remnants of Paleozoic bedrock (Parson et al. 1984; van Hinte et al. 1995).

While the Flemish Cap is not part of the Project Area, it is a notable geomorphic feature within the RAA (see Table 5.1 and Figure 5-1) and is located near the southeast tip of the Project Area. The Flemish Cap is an isolated piece of continental crust with a shallow Neoproterozoic granodiorite basement rock which is part of the Appalachian Orogen and overlaid by a veneer of Cretaceous sedimentary strata and Cenozoic sediments (King et al. 1986; Grant and McAlpine 1990; Weitzman et al. 2014).

The Flemish Pass Basin while also not part of the Project Area, is one of the main sedimentary basins in the RAA and is located near the southeastern tip of the Project Area. Geophysical evidence suggest that the Flemish Pass Basin forms a terraced continuation of the highly stretched and subsided East Orphan Basin, and both basins are interpreted to have similar geological histories during the Late Jurassic to Early Cretaceous (Lowe et al. 2011). The primary hydrocarbon reservoirs are in shallow marine and fluvial shale and sandstone that was deposited during the late Jurassic and early Cretaceous periods (Statoil Canada Ltd. 2017).

The surficial sediment throughout the Orphan Basin ranges from fine mud and clay to boulders and bedrock (LGL 2003). Quaternary deposits in the southern Orphan Basin include complex mass transport deposits (MTD) comprised of both glaciogenic debris flow and blocky MTD (Campbell 2005; Statoil Canada Ltd. 2017). A notable glaciogenic debris-flow deposits in the West Orphan Basin is the Trinity trough-mouth fan (Tripsanas and Piper 2008). Passing icebergs and ice-flows deposit hard and soft substrates in the form of ice-rafted detritus (IRD) in the basin (Shaw et al. 2006). The Project Area is in the southern portion of the West Orphan Basin. Results from seismic and piston cores taken in the West Orphan Basin near the Project

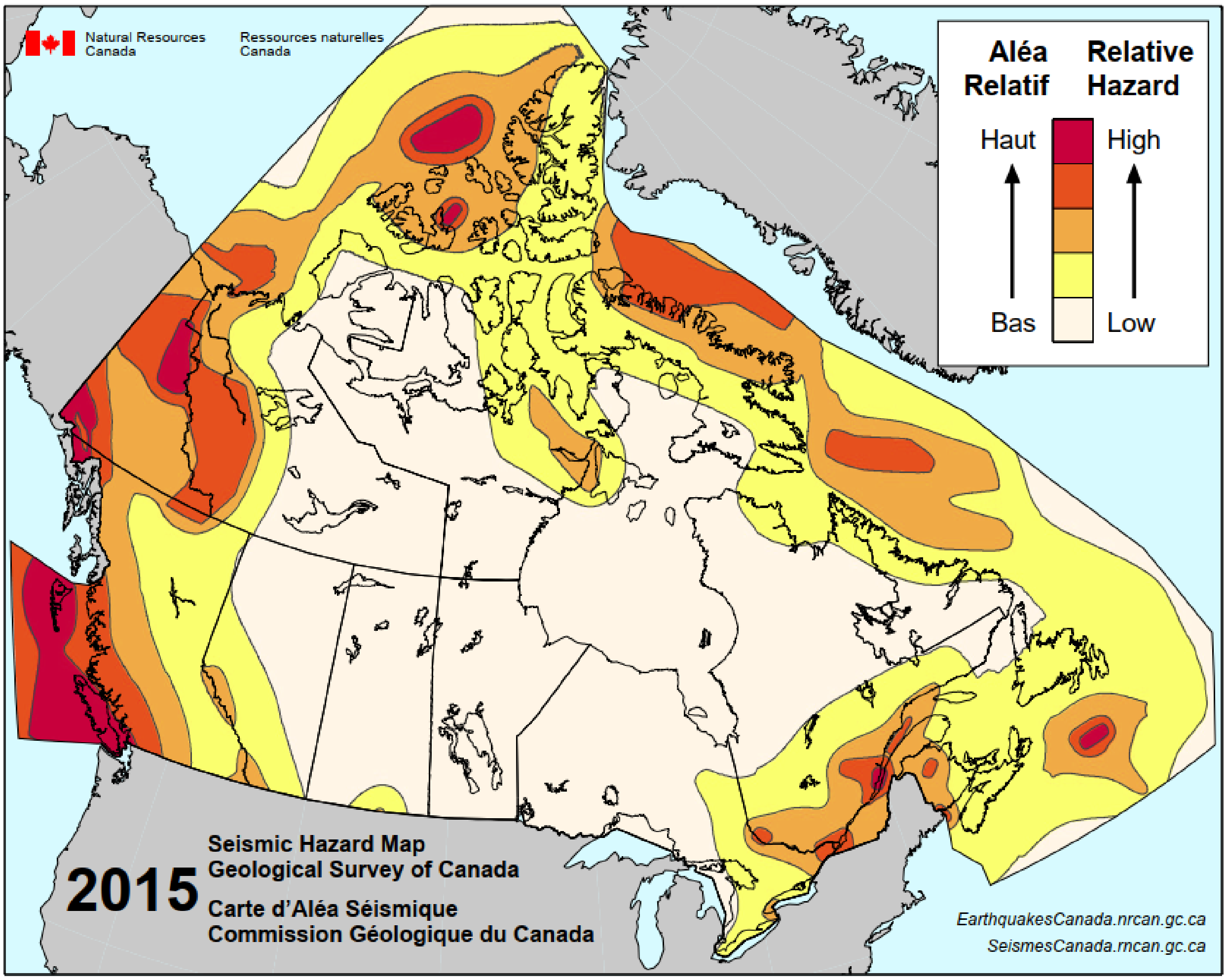
Area, indicate the surficial geology consists of stratified hemipelagic sediments overlaying debris-flow deposits consisting of eroded Mesozoic and Tertiary strata (Hiscott and Aksu 1996). The most recent debris-flow deposits formed during the last sea-level low-stands. The southwestern slope of the Orphan Basin is underlain by several MTD, large sediment drifts, and incised by several canyons (Piper et al. 2004). MTD in the southern Orphan Basin range in thickness form 2 m to 75 m (Campbell 2005).

5.1.3 Geohazards

5.1.3.1 Seismicity

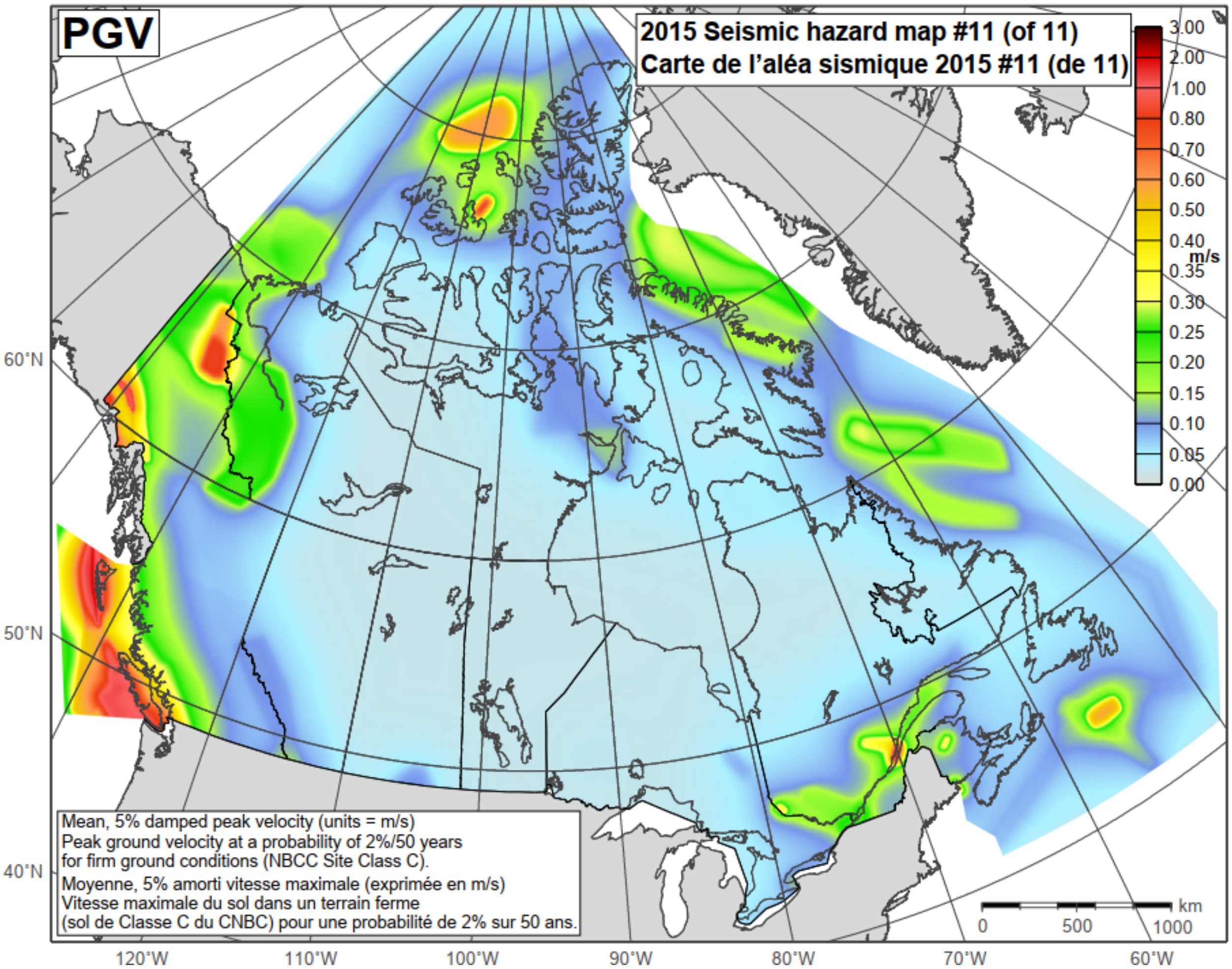
Canada's eastern continental margin is a relatively stable area of the North American Plate, and the seismic activity is relatively low (AMEC 2014). There are approximately 450 earthquakes that occur each year in Eastern Canada, and the majority of these have magnitudes between two and three (AMEC 2014).

The Seismicity Hazard Map of Canada (see Figure 5-4 and Figure 5-5) shows the probability of earthquake occurrences across Canada and indicates that the Project Area and RAA are classified as having a low to moderate seismic hazard (Natural Resources Canada [NRCan] 2019). According to the National Earthquake Database, 33 earthquakes have occurred in the RAA between 1985 and 2019 (Figure 5-6) (NRCan 2019). Of these, 22 had magnitudes of 2-4, and 11 of these had magnitudes of 4-4.7 (NRCan 2019). Thirteen of these earthquakes occurred within or bordering the Orphan Basin; eight of these had magnitudes of 2-4, and five had magnitudes of 4-4.7. There were no recorded earthquakes in ELs 1157 and 1158 in this timeframe. Most of the earthquake epicenters, as show in Figure 5-6, are in the northwest part of the West Orphan Basin. Prior to filing, there was only one earthquake recorded within Atlantic Canada (Saint John, New Brunswick) (NRCan 2019). In 2018, there were two earthquakes recorded (magnitude 3.6 and 4.1) to the west of the Orphan Basin and one in 2017 (magnitude 4.7) to the north of West Orphan Basin.



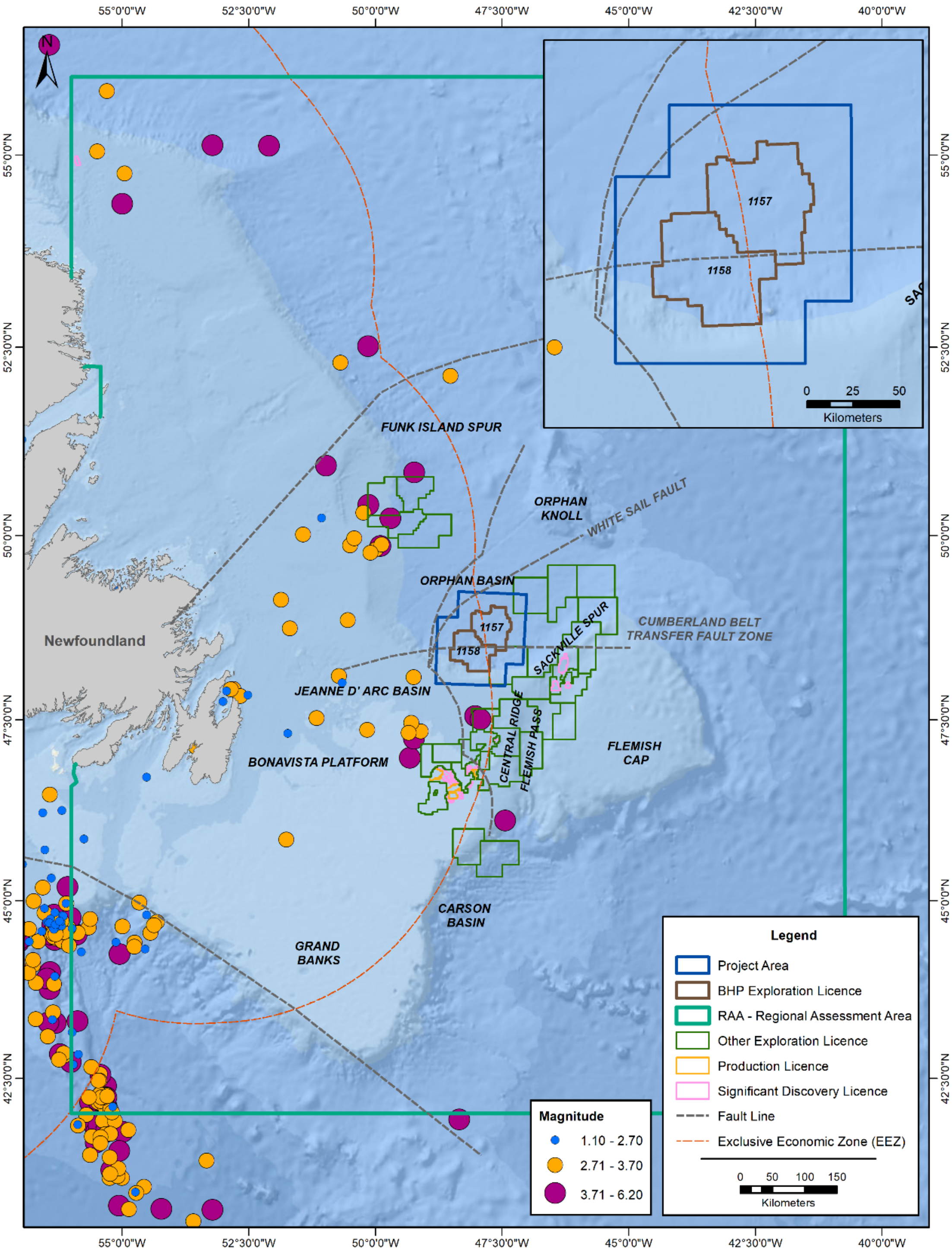
Source: NRCan 2019

Figure 5-4 Seismic Hazard Map for Earthquakes in Canada 2015



Source: NRCan 2019

Figure 5-5 Seismicity Hazard Map of Canada-Peak Ground Acceleration



Source: NRCan 2019

Figure 5-6 Earthquake Epicenters (1985 to 2019) in RAA

5.1.3.2 Slope Instability and Faulting

Sediment failure is essentially a consequence of gradient, magnitude of seismic acceleration, and sediment strength. Most continental margin sediments, except on slopes of more than a few degrees, are relatively stable and would require seismic accelerations associated with a large earthquake (magnitude of five or greater) to fail (Nadim et al. 2005). NRCan analysis indicates that in any given area offshore Eastern Canada, there is a risk of a major landslide every 20,000 years and a minor one may occur every few thousand years. Most of the large failures on the seabed date back more than 10,0000 years during periods of glaciations when large amounts of sediment were deposited directly onto the slope of the continental shelf (NRCan 2010). Many of the failures in the region are likely earthquake triggered, with some seismicity caused by post-glacial crustal rebound (Piper 2005). The estimated recurrence of earthquakes with magnitudes of seven is 30,000 years from seismological models and 40,000 years from the sediment failure record (Piper et al. 2019). The recurrence of large-scale seabed failures in the basin is on the order of 75,000 to 100,000 years (Campbell 2005). The MTDs on the southern Orphan Basin slopes could carry coarse sand and gravel to the basin floor and diapiric features present in the area could make them unstable (Campbell 2005).

Several normal faults exist beneath the sediments of the Orphan Basin (Keen et al. 1990).Faults within the Project Area include the CGFZ to the north, White Sail Fault (mid-basin) (Burton-Ferguson et al. 2006; Enachescu 2009), the Bonavista Fault to the west (Enachescu 2006), and in the south the Cumberland Belt Transform Zone (CBTZ).

5.1.3.3 Shallow Gas and Gas Hydrates

Shallow gas is widespread throughout the Flemish Pass and there is evidence for shallow gas in the Project Area and RAA (Cameron et al. 2014). Shallow gas could be a pre-conditioning factor linked to submarine landslides in permeable strata due to pore pressure build-up (Crutchley et al. 2016). The West Orphan Basin is gas prone based on geophysical interpretation and regional tectonics (Enachescu et al. 2004). Methane gas hydrates have been detected in the RAA, but not in the Project Area (Majorowicz and Osadetz 2002).

5.1.3.4 Tsunamis

Tsunami hazard along the Atlantic coast of Canada is relatively low, with very few tsunamis recorded. Tsunamis generated by displacement of the seafloor from active plate boundaries are unlikely as there are no such plates nearby; however, tsunamis could be generated by submarine landslides triggered by earthquakes. In a preliminary tsunami hazard assessment of the Canadian coastline, Leonard et al. (2010) assessment of the outer Atlantic coastline indicates an expected recurrence of tsunami runup exceeding 1.5 m approximately every 300 to 1,700 years. For a larger runup (over 3.0 m), the estimated recurrence interval is approximately 600 to 4,000 years. The authors of the study assumed that a mean local runup greater than 1.5 m could result from failures with an along-slope extent over 50 km, and a mean local runup of greater than 3.0 m may be produced from failures over 70 km in length. In the Orphan Basin, the expected recurrence interval of landslides with an extent of over 50 km is approximately 10,000 years. In the surrounding area, the Flemish pass could expect such landslides to occur with an average recurrence interval of approximately 21,000 years. Continental slope failures with extents greater than 70 km could be expected approximately every 11,500 years in the Orphan Basin and 45,000 years in the Flemish Pass.

5.2 Bathymetry

The bathymetry of the Project Area and surrounding regions is generally well known (Figure 5-7). The Project Area is located in the Orphan Basin, which lies off the Newfoundland Shelf approximately 300 km northeast of St. John's. Water depths in the Orphan Basin range from approximately 1,200 m at the edge of the continental shelf to as deep at 3,300 m south of the Orphan Knoll. The Orphan Knoll lies approximately 100 km to the northeast of the Project Area, in water depths of around 2,000 m, and is a bathymetric high in the centre of the Orphan Basin.

About 75 to 100 km to the southwest of the Project Area lies the Grand Banks, a region with average depths of approximately 75 m that extends to approximately 350 km east of St. John's to the 200 m depth contour, and then a further 50 km east to the 1,000 m depth contour. The Sackville Spur lies east of the Project Area and extends the nose of the Grand Banks at depths of up to 1,000 m to the northeast. To the east of the Grand Banks lies the Flemish Pass, with depths of almost 1,300 m. On the eastern side of the Flemish Pass, water depths rise again to the Flemish Cap, a large bathymetric feature of approximately 50,000 km² with depths rising back up to approximately 130 m. The Flemish Pass extends to the northeast, remaining at depths of approximately 1,000 to 1,100 m, and separates the Orphan Basin to the northwest and the Flemish Cap to the east. The Labrador Basin and deep ocean lie farther offshore to the north and east of the Orphan Basin and Flemish Cap, with depths from approximately 3,000 m to greater than 4,000 m.

The Project Area is approximately 15,775 km² in size and encompasses EL 1157 and 1158 with an approximate 20 km buffer. Within EL 1157, located to the northeast, depths range from approximately 2,150 to 2,575 m, while within EL 1158 to the southwest depths range from approximately 1,175 to 2,265 m. Along the southern boundary of the Project Area depths range from approximately 300 to 400 m and exceed 2,500 m at the northeastern boundary.

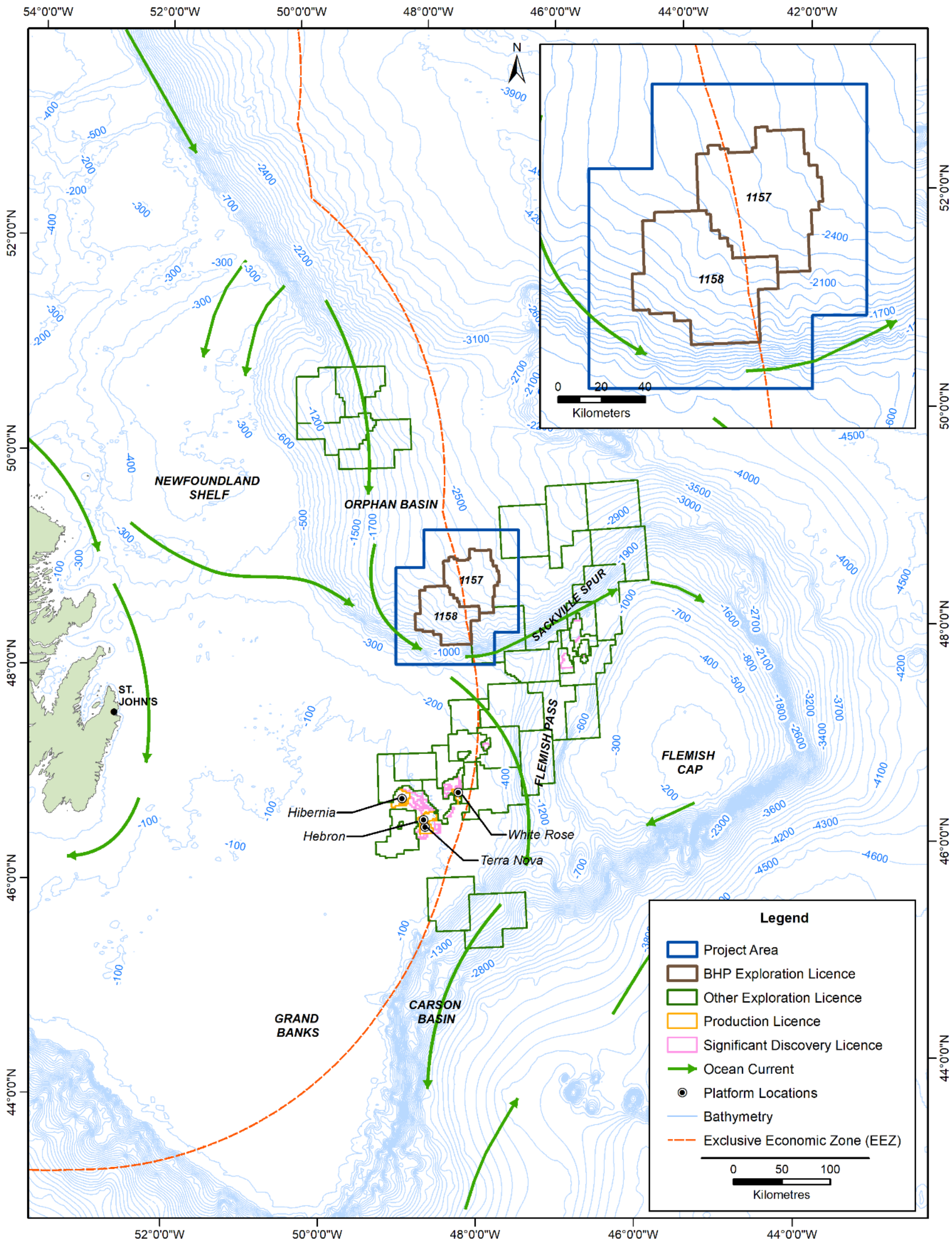


Figure 5-7 General Bathymetry and Ocean Current Circulation

5.3 Climatology

This section provides an overview of key climatological conditions including wind speed and direction, air temperature, precipitation and lightning, fog and visibility, and an overview of tropical systems. Additional details for the larger eastern NL Offshore Area and regions between St. John's and the Project Area are provided in the Eastern Newfoundland Strategic Environmental Assessment (SEA), Section 4.1 (AMEC 2014).

5.3.1 Wind Speed and Direction

The primary characterization of the wind climatology of the Project Area is provided with statistics derived from the most recent release of the Meteorological Service of Canada, Wind and Wave Hindcast (MSC50) wind and wave hindcast for the North Atlantic Ocean and which spans 1954 to 2015. Additional information is presented from one historical drilling campaign in the area with weather observations prepared, recorded, and distributed in the Manual of Marine Observations (MANMAR) format by offshore-based observers as a requirement of the Offshore Physical Environmental Guidelines (NEB et al. 2008). The reports are typically sent to shore-based forecasters every three hours on a 24/7 basis. The basis for marine weather observing in Canada is the MANMAR (Environment and Climate Change Canada (ECCC) 2017).

The MSC50 dataset includes hourly wind and wave parameters of the North Atlantic Ocean (Swail et al. 2006, DFO 2019a). The hindcast data were produced through the kinematic reanalysis of substantial tropical and extra-tropical storms in the north Atlantic. The dataset covers hourly wind and wave parameters and includes consideration of periods with sea ice coverage. Ice concentration data considered are mean monthly values through 1961 inclusive and Canadian Ice Service (CIS) mean weekly ice concentrations for 1962 onwards. Given the poorer resolution of ice information from 1954-1961, this period of the MSC50 dataset was excluded from the present analysis. The 1962-2015 periods are considered for waves and, for consistency, winds.

The overall resolution of MSC50 hindcast data grid points (nodes) is quite high, with one point every 0.1° latitude by 0.1° longitude (approximately 7.4 km east-west and 11.2 km north-south near 47°N). To provide a characterization over the Project Area, three node locations were selected: these are listed in Table 5.2 and shown in Figure 5-8. In addition to the MSC50 wind and wave hindcast data nodes, Figure 5-8 also shows the locations of Orphan Basin and ODI current (Section 5.5.2) and wave buoy (Section 5.5.1) measurements and previously drilled oil and gas exploration wells (C-NLOPB 2019).

Table 5.2 Location of the MSC50 Nodes Selected to Describe Wind and Wave Conditions

MSC50 Node	Latitude (°N)	Longitude (°W)	Water Depth (m)
M6014847	48.9	47.6	2,474
M6014204	48.5	48.4	1,758
M6013579	48.1	47.6	583

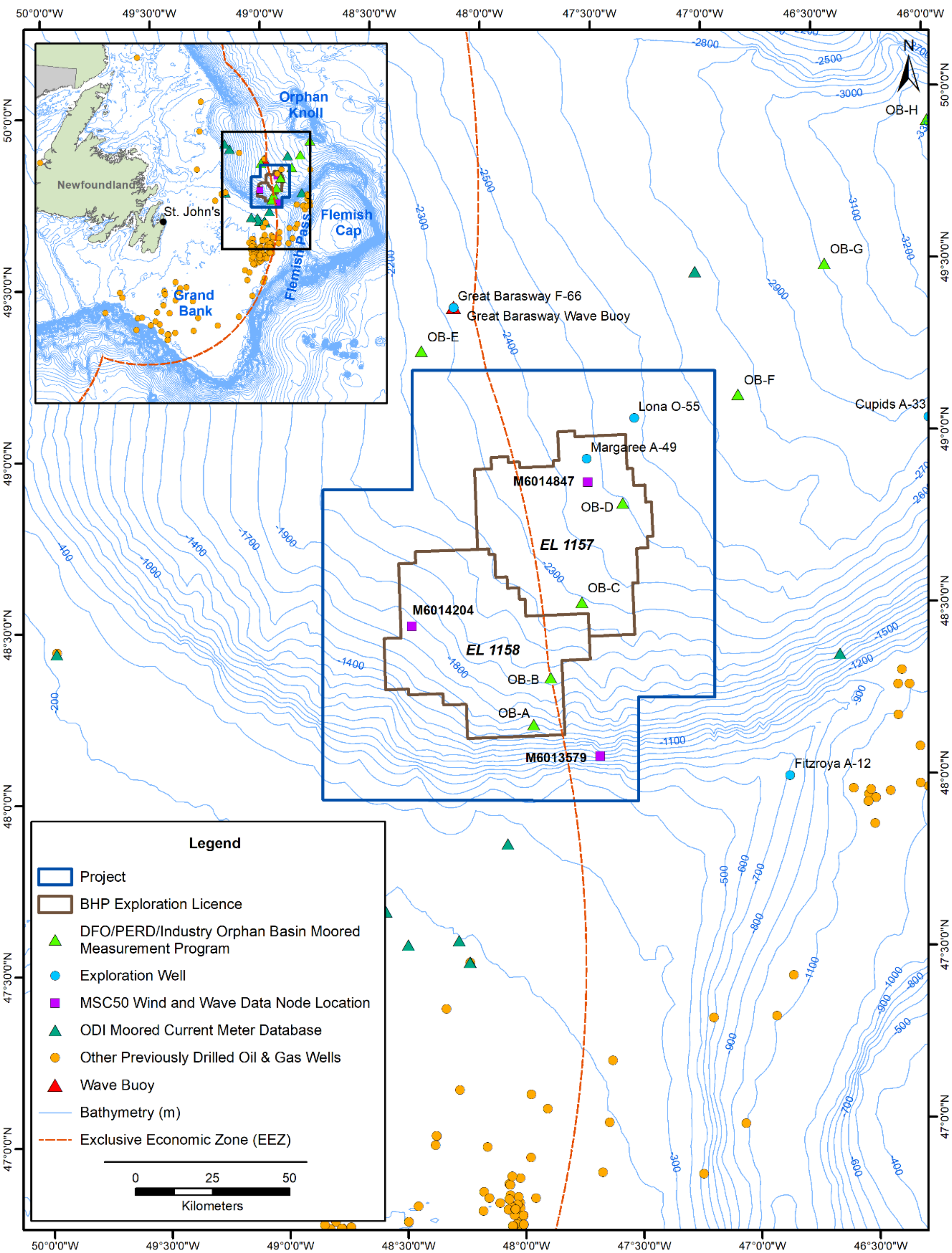


Figure 5-8 Met-Ocean Data Sources, Exploration Wells

The MSC50 wind speeds are 1-hour average wind speeds for a height of 10 m above sea level. Wind speed measurements are frequently averaged over shorter durations (e.g., 10 minutes for marine reports and two minutes for aviation, and a one-minute average is used for the categorization of tropical cyclones). Wind gusts are typically for one and three second durations. Several formulas (e.g., International Standards Organization (ISO) 2015) can be used to scale winds to averaging times less than one hour and for different reference elevations, (e.g., between 10 m and drilling installation anemometer height or vice versa). These are routinely applied in design criteria studies applying measured and hindcast wind data sets.

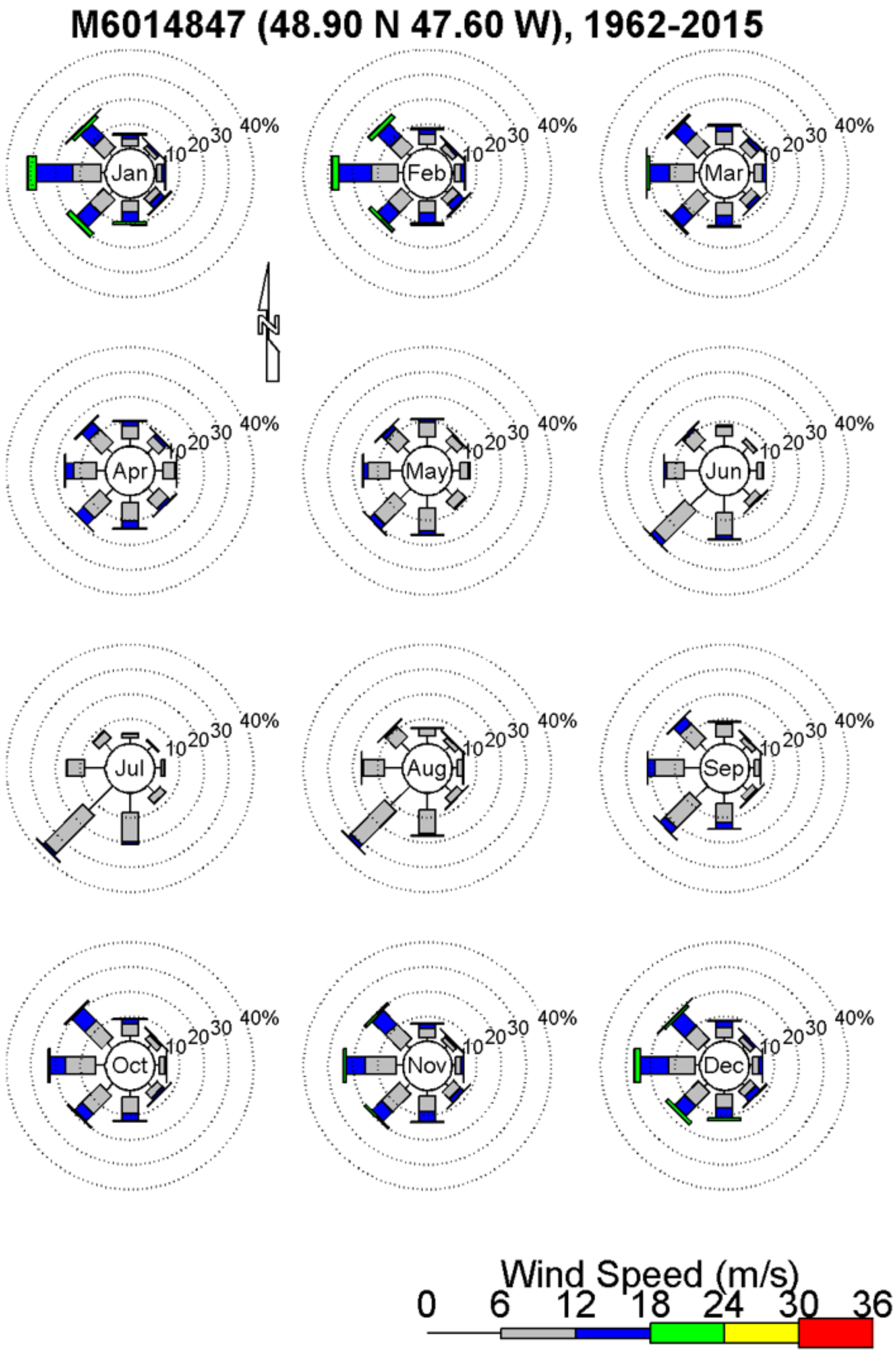
Wind conditions are summarized with monthly and annual statistics presented in Table 5.3. Based on the three nodes reported, conditions are generally uniform over the Project Area. Monthly mean hourly wind speeds range from 6.4 m/s in July to 12.1 m/s in January with winds most frequently from the west in fall and winter and from the west-southwest and south-southwest in spring and summer. Monthly maximum wind speeds range from 18.3 m/s in July (from the southwest and south) to 33.8 m/s in January (from the northwest and west).

Table 5.3 Monthly and Annual Wind Statistics, 1962-2015

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Wind Speed (m/s)													
M6014847	12.1	11.8	10.6	8.9	7.7	7.0	6.6	6.9	8.2	9.5	10.5	11.5	9.2
M6014204	11.7	11.5	10.3	8.7	7.4	6.8	6.4	6.7	8.0	9.3	10.2	11.2	9.0
M6013579	11.7	11.4	10.3	8.6	7.3	6.8	6.4	6.7	7.9	9.2	10.1	11.1	8.9
Most Frequent Direction (from)													
M6014847	W	W	W	WSW	WSW	SSW	SSW	SSW	WSW	W	W	W	WSW
M6014204	W	W	W	WSW	WSW	SSW	SSW	SSW	WSW	W	W	W	WSW
M6013579	W	W	W	WSW	WSW	SSW	SSW	WSW	WSW	W	W	W	WSW
Maximum Wind Speed (m/s)													
M6014847	33.8	29.6	30.2	25.7	25.5	23.6	18.3	22.5	28.8	29.7	27.4	30.5	33.8
M6014204	32.7	28.6	31.0	24.5	24.3	24.0	18.9	22.3	26.6	30.4	27.4	29.5	32.7
M6013579	33.5	29.9	29.2	26.3	24.8	23.7	18.5	26.9	27.9	32.2	26.7	29.2	33.5
Direction of Maximum Wind Speed (from)													
M6014847	NW	W	W	N	NW	NW	SW	NW	SE	SW	SW	NW	NW
M6014204	W	NW	NW	N	NW	NW	SW	N	SE	W	W	NW	W
M6013579	W	SW	NW	N	NW	NW	S	SE	S	S	W	NW	W
Source: based on DFO (2019a)													

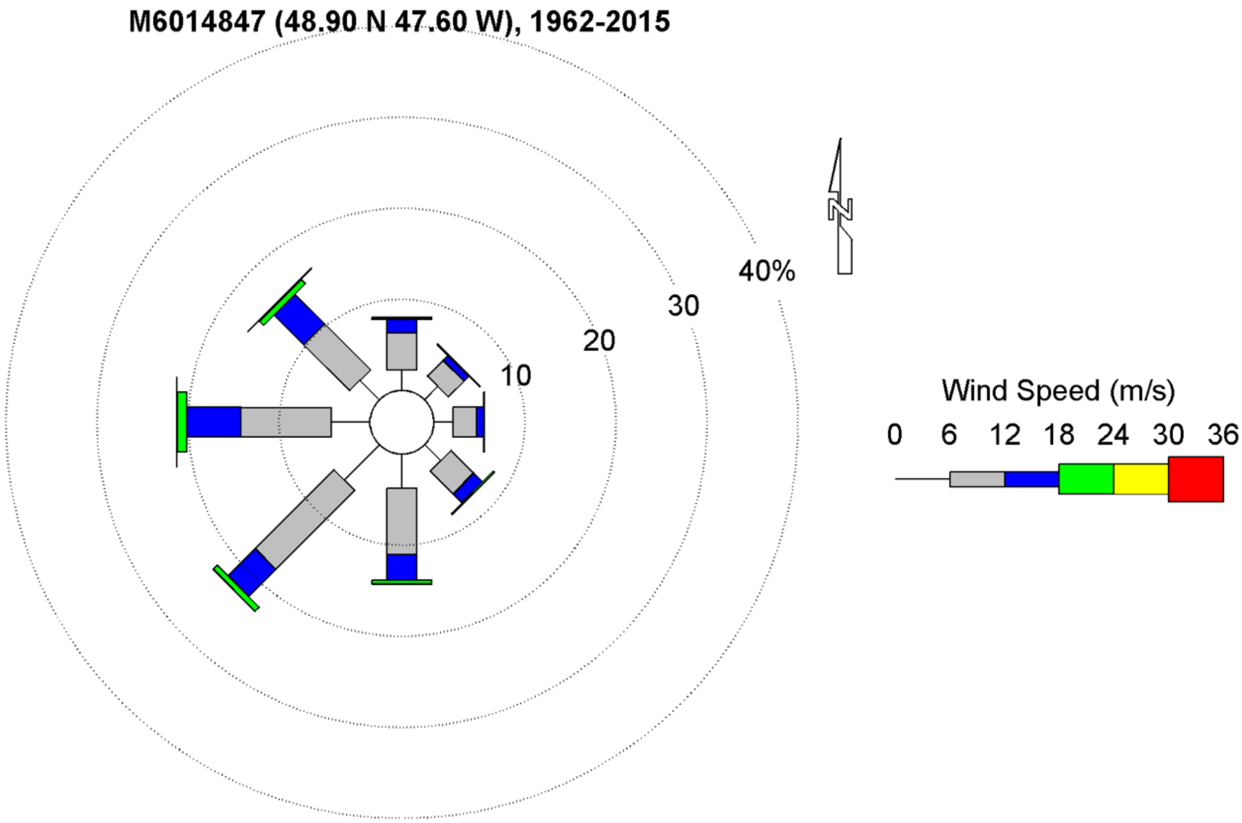
Inspection of both wind and wave statistics (discussed in Sections 5.3.1 and 5.5.1) and directional roses for the three MSC50 nodes considered for the Project Area indicates very little variation in wind and wave conditions between the three locations. Given conditions are comparable, one grid point node M6014847 (farthest north) is selected for presentation of wind and wave roses and for further discussion and illustration of regional wind conditions over the Project Area.

In July, at node M6014847, mean wind speeds are above 12 m/s (strong breeze) 3.6% of the time compared with 49.6% of the time in January. There is a single observation in July above 18 m/s (gale force) compared with winds exceeding 18 m/s for 10.3% of the time in January. Monthly and annual directional wind distributions for node M6014847 are shown in the wind roses of Figure 5-9 and Figure 5-10 respectively.



Source: Based on DFO (2019a)

Figure 5-9 Monthly Wind Roses, MSC50 Node M6014847, 1962–2015



Source: Based on DFO (2019a)

Figure 5-10 Annual Wind Rose, MSC50 Node M6014847, 1962–2015

A wind rose illustrates the percent frequency of distribution of wind direction and wind speed, for a given time period, e.g., annually, or a given month, as well as the distribution of wind speed within each directional sector or bar. Bars represent the total percentage frequency of winds observed from each direction. Each circle equals 10%, e.g., 10% of winds are from the south. The total bar length represents the total percent occurrence of winds from that direction, e.g., a bar of length 32% for August in Figure 5-9 pointing to the lower right represents 32% of winds that are from the southwest. A bar with six sections will therefore report a percentage of observations up to the largest wind speed range of 30 to 36 m/s.

The seasonal picture of predominantly southwest winds in the summer (winds from the southwest in July 37% of the time, and from the southwest quadrant 73% of the time) with a shift to stronger, more northwesterly winds in fall and winter (in January winds are from the west for 31% of the time and from the southwest through northwest quadrant for 68% of the time) is evident. Wind directions are more uniformly distributed during spring, e.g., in April ranging from 8% of winds being from the northeast to 18% from the southwest. Annually (Figure 5-10) winds are from the northeast and southeast quadrants each 13% of the time, and from the southwest and northwest each 37% of the time.

Wind speed statistics from the previously drilled Great Barasway F-66 exploration well, 20 km north of the Project Area, from 18 August 2006 to 22 April 2007, are presented in Table 5.4. Whereas the winds for MSC50 are representative of a 10 m elevation, winds from the Mobile Offshore Drilling Unit (MODU) Eirik

Raude were at an elevation of 82.5 m. The MODU mean wind speeds ranged from 10.5 m/s in September to 17.2 m/s in January, with maximum wind speeds of 20.6 m/s being reported in August and 39.6 m/s reported in January. It is noted that approximately 80% of these MANMAR observations were made during a portion of the day (i.e., at the synoptic hours of 0900, 1200, 1500, and 1800), as opposed to night. The MSC50 mean and maximum wind speeds for the corresponding dates are reported in Table 5.4. The ratios of MODU to MSC50 mean wind speeds range from approximately 1.1 to 1.4 while assuming a logarithmic profile (e.g., ISO 2005) a ratio of 80 m to 10 m winds is on the order of 1.25. The ratios of maximum wind speeds range from 0.9 to 1.5.

Table 5.4 Monthly Wind Statistics, Great Barasway F-66, MSC50 Node M6014847, 22 August 2006 to 22 April 2007

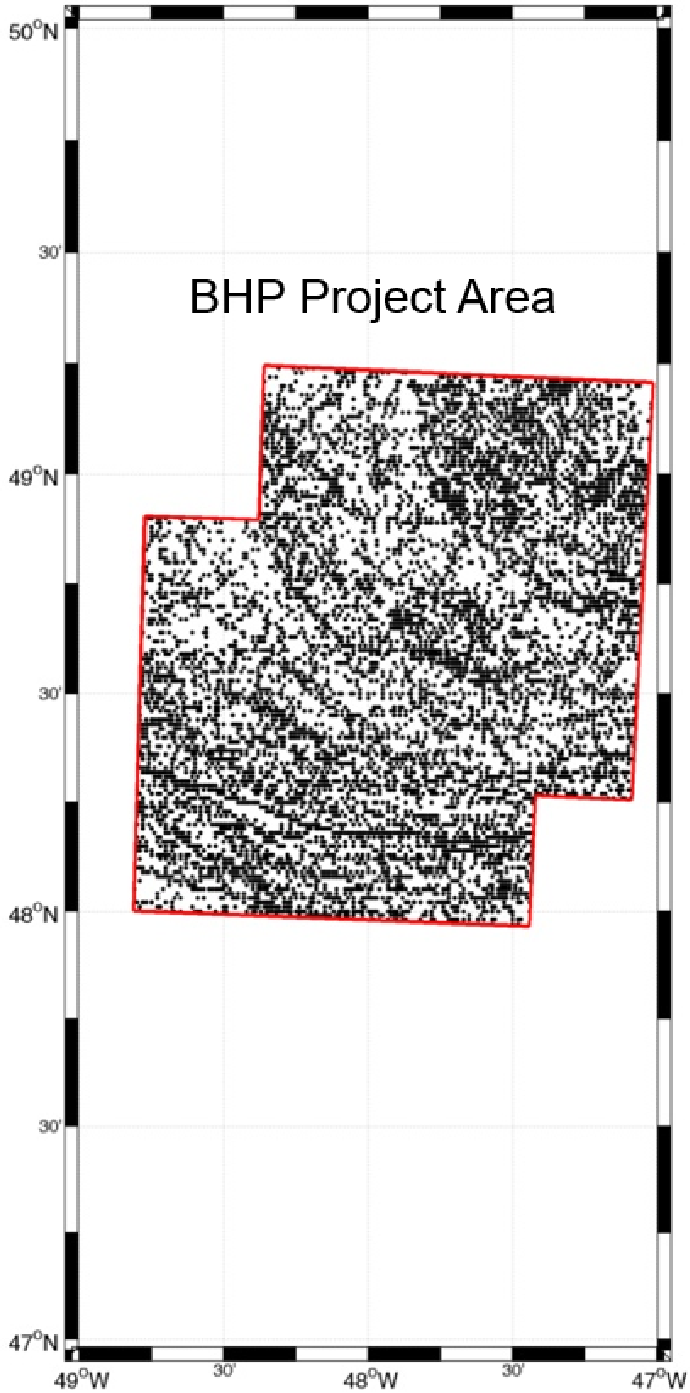
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Mean Wind Speed (m/s)											
Great Barasway F-66[A]	17.2	13.5	13.6	14.0	-	-	-	11.9	10.5	12.4	12.8	14.3
M6014847[B]	13.8	12.7	11.4	10.0	-	-	-	8.4	8.0	9.8	10.9	12.3
	Maximum Wind Speed (m/s)											
Great Barasway F-66[A]	39.6	23.2	30.9	28.3	-	-	-	20.6	24.2	26.8	29.3	30.9
M6014847[B]	27.0	26.9	20.4	18.9	-	-	-	22.4	23.1	18.9	20.9	24.2

[A] Data collected from Eirik Raude MODU at elevation of 82.5 m
[B] MSC50 data collected at elevation of 10 m
Source: Based on Research Data Archive et al. (2019), Platform ID=C6QE7 (Great Barasway), DFO (2019a) (M6014847)

5.3.2 Air Temperature

Atmospheric properties over the ocean surface, including air temperature, precipitation and visibility have been characterized using the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). ICOADS represents the most extensive available database of observations of atmospheric and sea conditions. The dataset consists of global marine observations recorded from 1662 to the present, compiled by the United States National Centre for Atmospheric Research (Freeman et al. 2017).

To characterize air temperature, precipitation and lightning, visibility and marine icing conditions, ICOADS observations within the Project Area, for the period 1 January 1980 to 21 May 2019 have been selected (Research Data Archive et al. 2019). The resultant data points shown in Figure 5-11 illustrate good spatial coverage of the Project Area. The monthly number of observations for the various climatology and marine icing parameters are listed in Table 5.5. Temporal coverage is also good, with observations present for each year from 1980 to 2019 and most year-months, the exception being several of the months since 2014 which are absent or just have several observations. Overall, this data set provides a good climatology characterization. The ICOADS variables used for reporting precipitation and marine icing (Sections 5.3.3 and 5.7.3) are shown in parentheses in the table header.



Source: Based on Research Data Archive et al. (2019)

Figure 5-11 Location of ICOADS Observations, Project Area, 1980-2019

Table 5.5 Number of ICOADS Observations, Project Area, 1980-2019

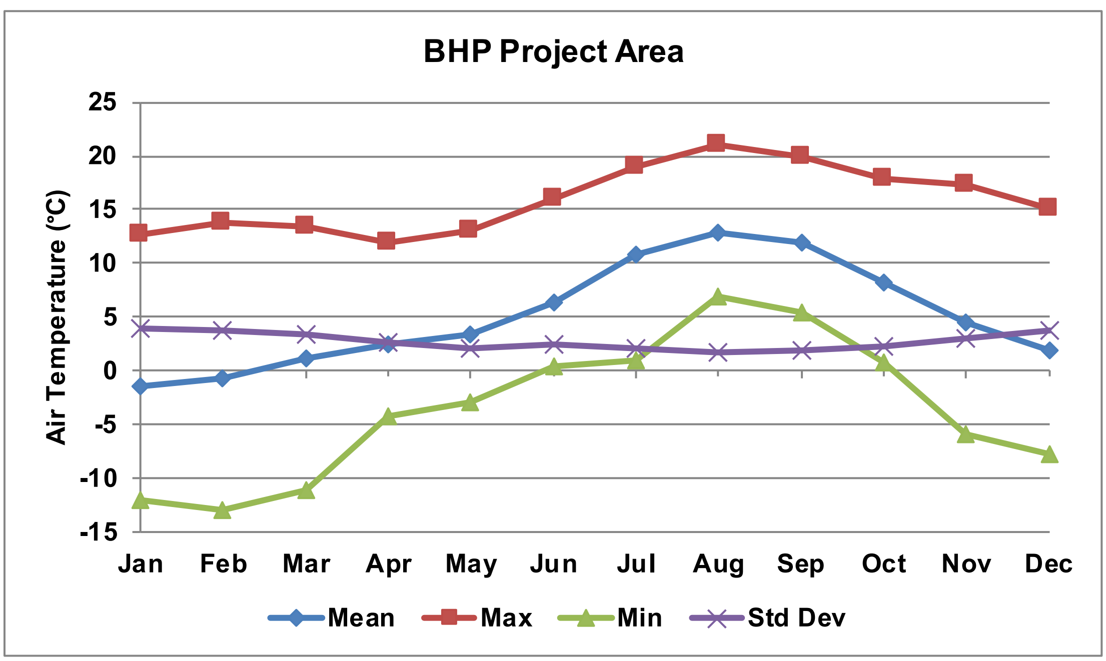
Month	Air Temperature	Precipitation (present weather)	Visibility	Marine Icing (air temperature, sea temperature and wind)
Jan	893	356	453	524
Feb	641	243	274	363
Mar	455	252	282	329
Apr	415	187	216	255
May	1154	272	294	546
Jun	468	208	242	355
Jul	628	210	242	281
Aug	1176	398	450	498
Sep	796	303	351	398
Oct	569	337	406	503
Nov	659	302	348	372
Dec	555	204	238	270
Total	**8409**	**3272**	**3796**	**4694**

Source: Based on Research Data Archive et al. (2019)

Monthly air temperature statistics for the Project Area are presented in Table 5.6 and Figure 5-12. Air temperature exhibits strong seasonal variations, with mean temperatures ranging from -1.4°C in January to 12.9°C in August. The coldest observed air temperature on record (-13.0°C) was in February with minimum temperatures of 0.4°C in June. The highest observed temperatures reached 21.0°C in August while the highest winter temperature was 13.7°C in February.

Table 5.6 Monthly Air Temperature (°C) Statistics (ICOADS), Project Area, 1980-2019

Month	Mean	Max	Min	SD	Number of Values
Jan	-1.4	12.7	-12.0	4.0	893
Feb	-0.7	13.7	-13.0	3.7	641
Mar	1.1	13.5	-11.0	3.5	455
Apr	2.4	12.0	-4.3	2.6	415
May	3.5	13.0	-3.0	2.1	1154
Jun	6.3	16.0	0.4	2.5	468
Jul	10.8	19.0	1.0	2.1	628
Aug	12.9	21.0	7.0	1.8	1176
Sep	11.9	20.0	5.5	2.0	796
Oct	8.3	17.8	0.8	2.4	569
Nov	4.5	17.4	-5.8	3.1	659
Dec	1.9	15.0	-7.8	3.8	555
Source: Based on Research Data Archive et al. (2019)					



Source: Based on Research Data Archive et al. (2019)

Figure 5-12 Monthly Air Temperature Statistics (ICOADS), Project Area, 1980-2019

5.3.3 Precipitation and Lightning

The ICOADS database contains observations of several precipitation types and thunderstorm occurrence. The weather state is recorded and categorized as an event based on the type (but not the amount) of precipitation during that event. The frequency of occurrence of the different precipitation types and thunderstorms have been calculated as a percentage of the total monthly and annual weather observations for the same data set described in Section 5.3.2 for air temperature, with observations spanning 1 January 1980 to 11 May 2019.

A degree of variability of precipitation patterns within localized regions of the overall Project Area is expected. The statistics shown below in Table 5.7 are the percentage of a certain distinct weather states (e.g., rain, thunderstorms, hail) for weather reports available on record for that month. The weather states have been consolidated from 50 different ICOADS classifications, separating (without overlap) rain from freezing rain and snow (although some overlap may exist between these states and mixed rain/snow, hail, and thunderstorm, which represent a small percentage of the data). The frequency of occurrence – or, the percent of time the given condition(s) occurs in a given month (or annually) - can most closely be characterized as representing unspecified periods of time, for a percentage of all days.

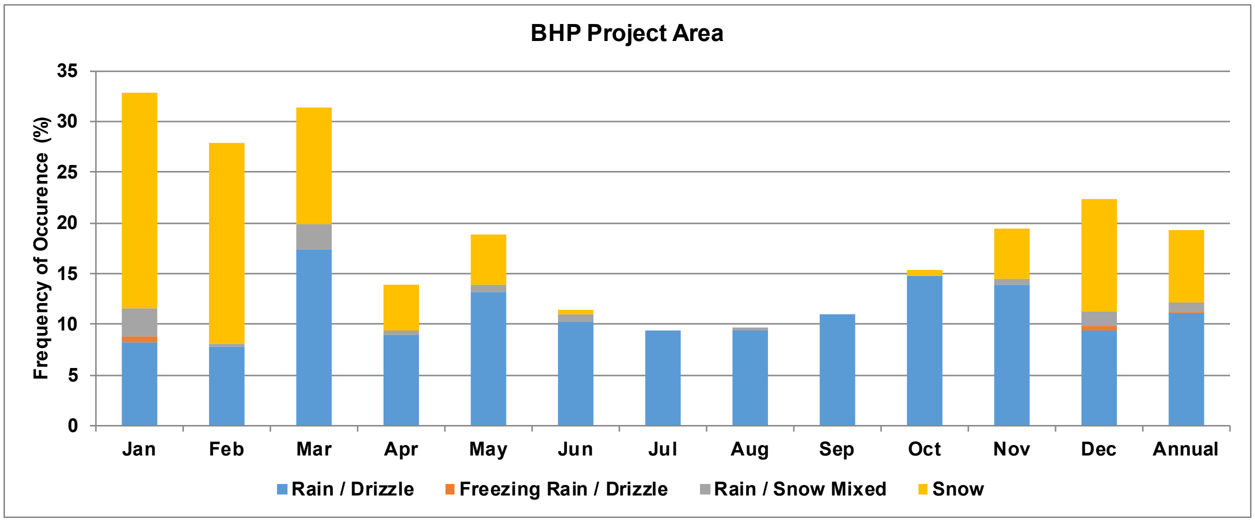
Table 5.7 Frequency of Occurrence (%) of Precipitation and Thunderstorms (ICOADS), Project Area, 1980-2019

Month	Rain / Drizzle	Freezing Rain / Drizzle	Rain / Snow Mixed	Snow	Hail	Thunderstorm
Jan	8.3	0.6	2.7	21.2	0.4	0.0
Feb	7.8	0.0	0.3	19.8	0.8	0.0
Mar	17.4	0.0	2.6	11.4	0.0	0.0
Apr	9.0	0.0	0.4	4.5	0.7	0.0
May	13.3	0.0	0.7	4.8	0.0	0.0
Jun	10.2	0.0	0.8	0.4	0.0	0.0
Jul	9.5	0.0	0.0	0.0	0.0	0.0
Aug	9.5	0.0	0.2	0.0	0.0	0.0 [A]
Sep	11.0	0.0	0.0	0.0	0.0	0.0
Oct	14.8	0.0	0.0	0.6	0.0	0.0
Nov	14.0	0.0	0.5	5.0	0.3	0.0
Dec	9.5	0.3	1.6	11.0	0.3	0.0
Annual	11.2	0.1	0.9	7.2	0.2	0.0

[A] There are two August past weather observations reporting thunderstorm
Source: Based on Research Data Archive et al. (2019)

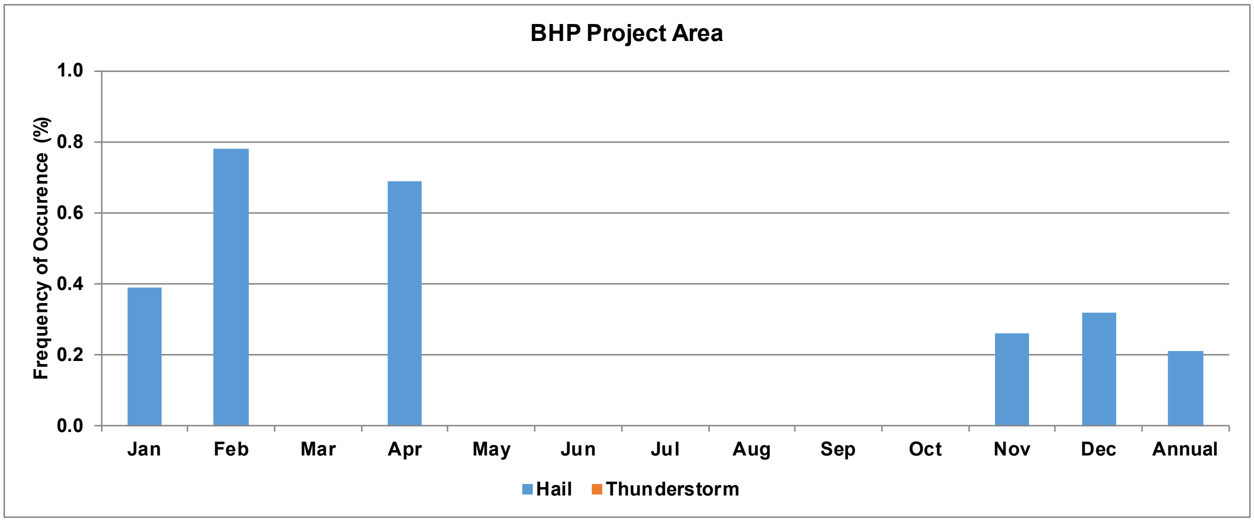
For the Project Area, the ICOADS data indicate that most of the observed precipitation events are in the form of rain, snow, and drizzle, while other precipitation types, such as mixed rain, freezing rain, and hail, occur far less frequently. Rain occurs approximately 8 to 17% of the time for all months of the year and is an annual occurrent 11% of the time. Snow is most likely to occur in January at 21% of the time but may reach 5% as early as November and as late as May, and is an annual occurrence 7% of the time

(Table 5.7, Figure 5-13). Freezing rain and hail are relatively infrequent in this area, being generally well below 1%. There are no recorded thunderstorm observations (Table 5.7; Figure 5-14).



Source: Based on Research Data Archive et al. (2019)

Figure 5-13 Frequency of Occurrence (%) of Precipitation by Type (ICOADS), Project Area, 1980-2019



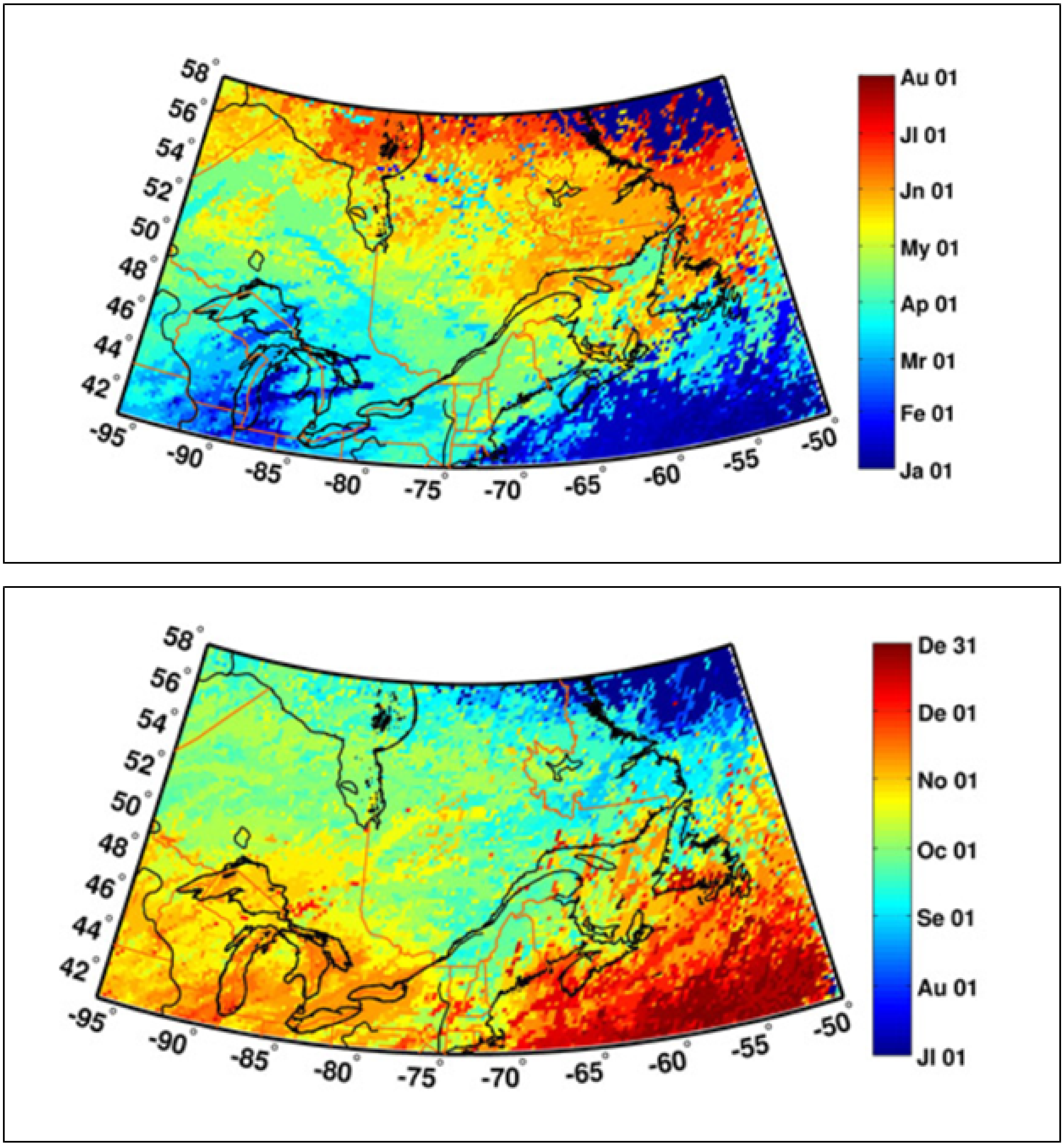
Source: Based on Research Data Archive et al. (2019)

Figure 5-14 Frequency of Occurrence (%) of Thunderstorm and Hail (ICOADS), Project Area, 1980-2019

Lightning is an electrical discharge most commonly produced in thunderstorms, usually accompanied by thunder. It occurs in clouds with vigorous convection where enough electrical charge is separated through the movement of cloud droplets and precipitation particles. By its nature, lightning is a localized phenomenon and, as a result, it is one which is difficult to accurately represent in numerical models. Measurements are available from the Canadian Lightning Detection Network; however, this is a land-based network, with coverage just to eastern NL (i.e., the Grand Banks and Orphan Basin are on the far eastern edge of the network).

The available lightning statistics from ECCC for eastern Canada provide some indication of conditions to the west of the Project Area (ECCC 2016). This includes average dates for the beginning and ending of lightning season for eastern Canada as shown in Figure 5-15. Lightning occurs virtually year-round offshore Newfoundland. During winter, stronger strikes are possible.

Inspection of the ICOADS data set for the Project Area shows no lightning observations.



Source: ECCC (2016)

Figure 5-15 Average Start (top) and End (bottom) Dates of the Lightning Season for Eastern Canada, 1999-2013

5.3.4 Fog and Visibility

The Project Area and surrounding areas have some of the highest occurrence rates of marine fog in North America, which in these regions is commonly of the advection type. Advection fog is formed when warm moist air flows over a cold surface, such as the cold northwest Atlantic Ocean, and persists for days or weeks. This type of fog is most prevalent in spring and summer. Visibility is affected by the presence of fog, the number of daylight hours, as well as frequency and type of precipitation.

Visibility from the ICOADS dataset (observations span 1 January 1980 to 11 May 2019) has been classified as very poor (<0.5 km), poor (0.5 to 1 km), fair (1 to 10 km) or good (greater than 10 km). For offshore flying, helicopters need visual confirmation at 0.25 nautical miles (approximately 500 m) out and need a visibility of 1 km, or greater, to land.

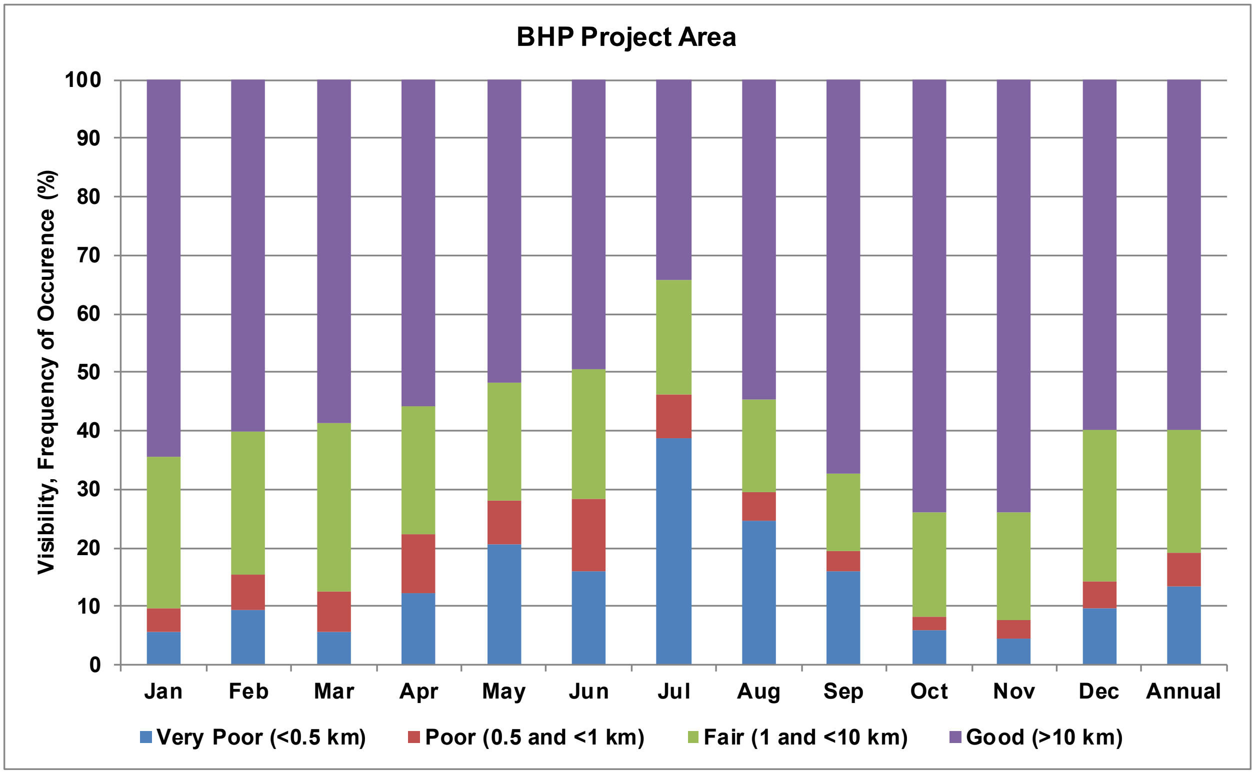
Fog and visibility conditions and seasonal variability are expected to vary across the Project Area.

As shown in Table 5.8 and Figure 5-16, visibility within the Project Area varies considerably throughout the year. Annually, visibility is very poor 13% of time, poor 6% of the time, fair 21% of the time, and good 60% of the time. The best visibility occurs during fall and winter when fair or good visibility (greater than 1 km) occurs approximately 85 to 93% of the time each month. In spring and summer poor visibility (less than 1 km) occurs from 20% (in September) to 46% (in July) of the time monthly, averaging 29% of the time during these months. Visibility is poorest in July with very poor visibility (<500 m) occurring 39% of the time.

Table 5.8 Monthly and Annual Frequencies (%) of Occurrence of Visibility (ICOADS), Project Area, 1980-2019

Month	Very Poor (<0.5 km)	Poor (0.5 – 1 km)	Fair (1 – 10 km)	Good (>10 km)
Jan	5.5	4.2	26.0	64.3
Feb	9.5	6.0	24.3	60.2
Mar	5.6	6.8	28.8	58.8
Apr	12.4	9.9	21.8	55.9
May	20.5	7.7	20.1	51.8
Jun	16.0	12.3	22.3	49.4
Jul	38.8	7.5	19.5	34.2
Aug	24.5	5.1	15.8	54.6
Sep	16.1	3.4	13.2	67.3
Oct	6.1	2.0	18.0	73.9
Nov	4.6	2.9	18.5	74.0
Dec	9.8	4.5	26.0	59.7
Annual	13.3	5.7	21.2	59.8

Source: Based on Research Data Archive et al. (2019)



Source: Based on Research Data Archive et al. (2019)

Figure 5-16 Frequency of Occurrence of Visibility (ICOADS), Project Area, 1980-2019

5.3.5 Tropical Systems

While hurricanes making landfall in NL are relatively rare occurrences, tropical systems, whether they are weakened hurricanes, tropical storms or post-tropical storms, affect portions of the province and the marine offshore once or twice each year on average. These storms are tropical cyclones, "the generic term for non-frontal synoptic scale low-pressure systems over tropical or sub-tropical waters with organized convection (i.e., thunderstorm activity) and definite cyclonic surface wind circulation" (Holland 1993). Tropical depressions are tropical cyclones with maximum sustained surface wind speeds of less than 34 knots (17 m/s, 39 mph). Once wind speeds reach at least 34 knots these tropical cyclones are typically called tropical systems, and at 64 knots (33 m/s, 74 mph) are called hurricanes.

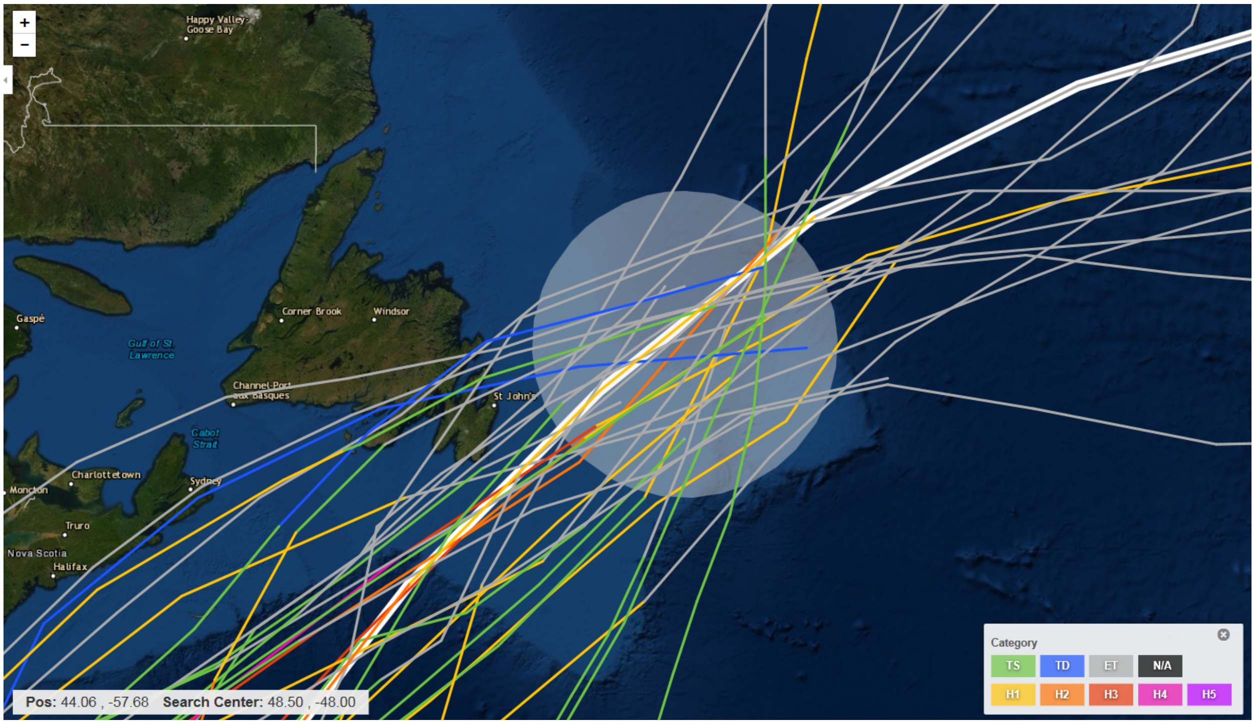
Hurricanes and tropical systems feed off warm ocean waters south of the Gulf Stream. Tropical systems tend to weaken considerably once they approach NL due to the colder water temperatures. On occasion, tropical storms and hurricanes maintain their strength or weaken slowly as they approach the province for various reasons. Two important possibilities for stronger tropical systems affecting this area are the forward speed of the system and sea surface temperature (SST) anomalies. If the tropical storm/hurricane is travelling at a higher than average speed, the system does not have time to weaken, despite the cooler waters entering its core. Also, if SST south of Newfoundland are warmer than average (especially late in the summer and in early fall), the storm may be able to survive slightly longer as it approaches Atlantic Canada.

Post-tropical storms are former tropical cyclones that no longer possess sufficient tropical characteristics to be considered a tropical cyclone yet can continue carrying heavy rains and high winds. One such class of post-tropical cyclone is an extra-tropical cyclone, a storm system that primarily gets its energy from the horizontal temperature contrasts that exist in the atmosphere. The storm obtains characteristics of extra-tropical (northern latitude) storms, developing frontal systems or merging with existing low pressure systems that have frontal systems. That is, the energy of the storm changes from being mainly due to the heat and moisture of the warm waters of the South Atlantic to energy due to cold versus warm air temperature contrasts. Extra-tropical cyclones often retain energy due to high moisture content and deep convection; this energy can be released into kinetic energy (winds) when a significant pool of cold air moves into the west side of the storm. For this reason, extra-tropical cyclones are often more volatile than 'typical' extra-tropical storms and can regenerate in intensity, often very rapidly.

Tropical systems can affect the Newfoundland offshore anytime during the Atlantic hurricane season (June 1 to November 30), but most activity generally occurs in the late summer to early fall. One of the main reasons for the increased activity during this time of year is the shift of the Bermuda High to the east, allowing systems over the Caribbean to track northward towards Atlantic Canada. The Bermuda High is a dominant ridge of high pressure over the Atlantic typically centred near Bermuda, which guides weather systems over the southern Atlantic Ocean towards the southeastern United States and provides the dominant southwesterly flow to Eastern Canada during the summer. The SST south of Newfoundland typically reach their peak in late September, allowing systems that approach from the south to maintain their strength as they track towards Newfoundland.

The tropical storm history near the Project Area is provided from inspection of the tropical cyclone re-analysis database HURDAT2 which includes best-track estimates at 6-hourly intervals for tropical cyclone activity in the North Atlantic for the period 1851 to 2017 (National Hurricane Centre (NHC) 2019a, NHC 2019b).

Figure 5-17 shows the historical tracks of tropical cyclones passing within 150 nautical miles (278 km) of a Project Area centre location of 48.5°N, 48.0°W, for the past 50 years of record, 1968 to 2017. Acknowledging the size of hurricanes can vary considerably, typical hurricanes may be on the order of 300 miles wide; based on analysis of 1999-2009 storms in the North Atlantic, Chavas et al. (2016) a mean storm size can be considered approximately 274 km (148 nautical miles).



Source: Based on NHC (2019b)

Figure 5-17 Tropical Cyclones Passing within 150 nautical miles of Project Area, 1968-2017

During this period 1968 to 2017, 34 storms passed through the selected region near the Project Area, 22 of them as extra-tropical cyclones. A storm summary is presented in Table 5.9 showing the dates of nearest approach and largest maximum sustained surface winds associated with any storm track position within the 150 nautical miles (approximated by 46.0° to 51.0°N, 44.25° to 51.75°W). The largest reported sustained surface wind speed for these storms is 85 knots (hurricane category 1) for Gladys (3 October 1975). The 34 storms include one in June, five in July, 10 each in August and September and eight in October. Seven of the 34 storms were of hurricane strength when they passed through the Project Area (within 150 nautical miles), Gonzalo in 2014 being the most recent, which passed directly through the Project Area during late morning to late afternoon 19 October 2014 (as shown with the white highlighted track in Figure 5-17 and shown in Figure 5-18). Prior to Gonzalo in 2014 the last hurricane tracking through the Project Area was Debby on the morning of 19 September 1982 with maximum sustained surface winds of 75 knots.

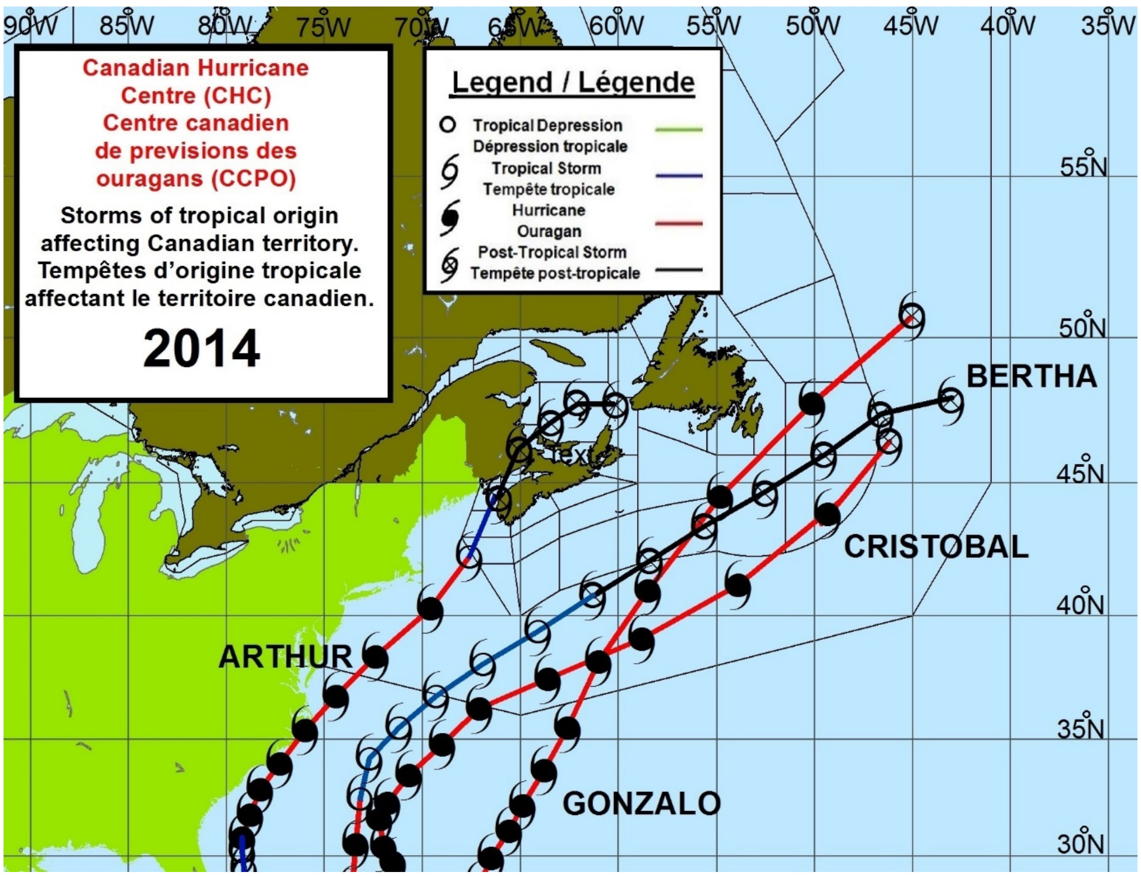
Table 5.9 Tropical Cyclones Passing within 150 nautical miles of Project Area, 1968-2017

Storm (status)	Jun	Jul	Aug	Sep	Oct
	Maximum sustained surface wind (knots)				
BLANCHE 1969 (EX)			50		
UNNAMED 1971 (HU)			75		
ARLENE 1971 (EX)		35			
GILDA 1973 (EX)					55
UNNAMED 1974 (EX)		40			
AMY 1975 (EX)		45			
GLADYS 1975 (HU)					85
CANDICE 1976 (HU)			65		
DOROTHY 1977 (EX)				50	
ELLA 1978 (HU)				80	
UNNAMED 1979 (TD)			25		
GEORGES 1980 (HU)				65	
DEBBY 1982 (HU)				75	
FELIX 1995 (TS)			50		
EARL 1998 (EX)				55	
FLOYD 1999 (EX)				40	
IRENE 1999 (EX)					80
DEAN 2001 (EX)			45		
GABRIELLE 2001 (EX)				60	
KATE 2003 (TS)					60
GASTON 2004 (EX)				45	
FRANKLIN 2005 (EX)		40			
OPHELIA 2005 (EX)				45	
ISAAC 2006 (EX)					55
FLORENCE 2006 (EX)				65	
UNNAMED 2006 (LO)		25			
ALBERTO 2006 (EX)	40				
CHANTAL 2007 (EX)			60		
LAURA 2008 (LO)					40
BILL 2009 (EX)			60		
OPHELIA 2011 (EX)					45
BERTHA 2014 (EX)			40		
GONZALO 2014 (HU)					70
CRISTOBAL 2014 (EX)			65		

Table 5.9 Tropical Cyclones Passing within 150 nautical miles of Project Area, 1968-2017

Storm (status)	Jun	Jul	Aug	Sep	Oct
	Maximum sustained surface wind (knots)				
Total	1	5	10	10	8

Source: based on NHC (2019a)
Status legend:
EX - Extratropical cyclone (of any intensity)
HU - Tropical cyclone of hurricane intensity (> 64 knots)
LO - A low that is neither a tropical cyclone, a subtropical cyclone, nor an extratropical cyclone (of any intensity)
SS - Subtropical cyclone of subtropical storm intensity (> 34 knots)
TD – Tropical cyclone of tropical depression intensity (< 34 knots)
TS - Tropical cyclone of tropical storm intensity (34-63 knots)

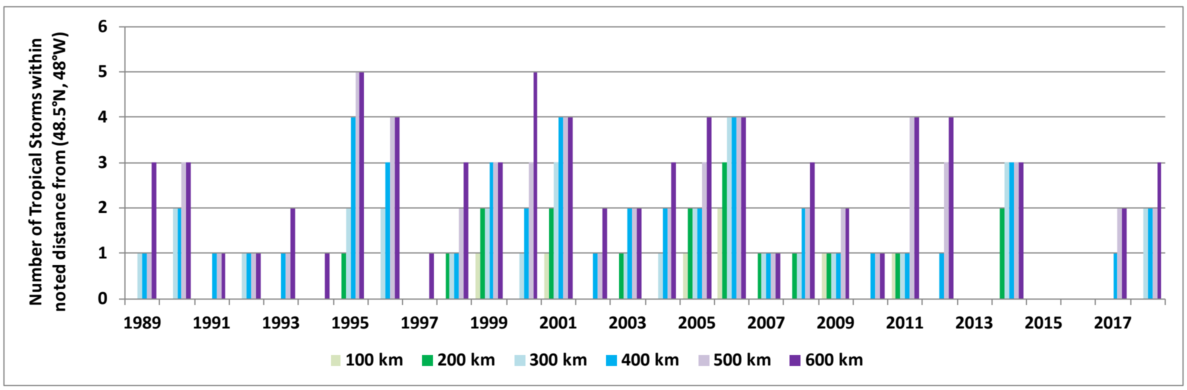


Source: Government of Canada (2019)

Figure 5-18 2014 Storm Tracks

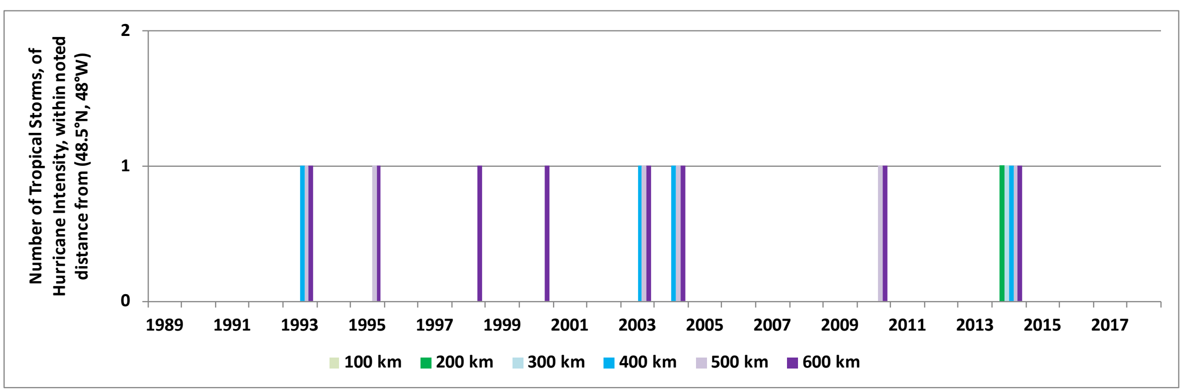
The most recent year with hurricanes in the Newfoundland Offshore was 2014 (Figure 5-18). Gonzalo passed directly over the Project Bay on 19 October as a category 1 hurricane. Cristobal passed farther southeast of the Project Area on 29 August as an extratropical cyclone (after transitioning from a category 1 hurricane over the southern Grand Banks) with wind speeds of 65 knots. Bertha passed through the region as an extratropical (or post-tropical) storm with speeds of 40 knots on 7 August.

Figure 5-19 reports storms passing within 100 to 600 km from the Project Area (centre location of 48.5°N, 48.0°W) within the past 30 years (1989 to 2018). A companion graph for hurricane strength storms (greater than 64 knots or 32.9 m/s) is presented in Figure 5-20. Note that the distances are calculated based solely on the series of storm track points, typically every six hours. These points may be at greater distances from the Project Area centre location yielding larger distances to those points whereas the track itself (e.g., an interpolation of the six hourly track positions) frequently passes much closer. For example, as shown in Figure 5-18, Gonzalo tracks directly over the Project Area, yet the nearest observation is 174 km to the southwest, thereby yielding the count of one hurricane within 200 km in 2014. A storm is counted in each applicable distance bin, e.g., in Figure 5-20, 2014 Hurricane Cristobal accounts for the five counts being within 600, 500, 400, 300 and 200 km.



Source: Based on NHC (2019a)

Figure 5-19 Number of Tropical Cyclones Passing Within Select Distances of the Project Area



Source: Based on NHC (2019a)

Figure 5-20 Number of Hurricanes Passing Within Select Distances of the Project Area

During the past 30 years there have been a total of seven storms within 100 km, 32 storms within 300 km and 74 within 600 km. During the same period, based on this tabulation as noted above, there have been no hurricanes within 100 km, four within 400 km and eight within 600 km.

5.4 Air Quality

There is no site-specific ambient air quality data for the Project Area, however the air quality in the Eastern NL offshore is anticipated to be good. The Project Area and surrounding areas experience occasional exposure to exhaust products from a variety of sources, including offshore oil production facilities (Hibernia, Terra Nova, White Rose, and Hebron, located in the Jeanne d'Arc Basin), helicopters, supply vessels and other marine traffic. In addition, the general area is subject to long-range transport of air contaminants from the United States (originating from the Northeast Seaboard and industrial Midwest) (ExxonMobil Canada Properties 2011).

To characterize the existing ambient air quality surrounding the Project Area, data was acquired from the National Pollutant Release Inventory (NPRI) Reporting program for criteria air contaminants (i.e., carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), total particulate matter (TPM), particulate matter less than 10 and 2.5 microns in diameter ($PM_{2.5}$, PM_{10}), and volatile organic compounds (VOCs).

The NPRI program is legislated under the *Canadian Environmental Protection Act* (CEPA), and requires each facility meeting specified reporting triggers, to report their emissions to ECCC on an annual basis. An overview of the emissions reported from the operation of Hebron, Hibernia, White Rose, and Terra Nova for the 2017 reporting year (the most recent such data available) are provided in Table 5.10.

Table 5.10 2017 Facility Reported CAC Emissions (NPRI Reporting) – Newfoundland and Labrador Offshore Area Production Platforms

Facility	Air Emissions (tonnes/year)					
	CO	NO_2	TPM	PM_{10}	$PM_{2.5}$	VOC
Hibernia	1,740	1,113	175	174	174	1,005
Terra Nova	694	2,183	208	204	204	2,642
White Rose (Sea Rose FPSO)	505	2,782	130	130	130	422
Hebron	141	53	17	16	16	58

Source: ECCC (2019a)
Note: SO_2 (and hydrogen sulphide) emissions have not been reported as the Jeanne d'Arc Basin is not known to contain sour gas.

Emissions of greenhouse gas (GHGs) from the operation of the existing offshore oil production platforms are also reported on an annual basis to ECCC, through the Greenhouse Gas Emissions Reporting Program (GHGRP). An overview of the 2017 reported emissions for each of the existing production platforms are provided in Table 5.11.

Table 5.11 2017 Facility Reported GHG Emissions (GHGRP) – Newfoundland and Labrador Offshore Area Production Platforms

Facility	GHG Emissions (tonnes CO_2 eq/year)			
	CO_2	CH_4	N_2O	Total
Terra Nova	587,587	32,444	9,774	629,806
Hibernia	536,172	41,475	3,298	580,945
White Rose	378,666	26,968	12,447	418,081
Hebron	22,732	4,547	404	27,684

Source ECCC (2019b)
Key:
CO_2: Carbon dioxide
CH_4: Methane
N_2O: Nitrous oxide
CO_2 eq/year: Carbon dioxide equivalent per year

As mentioned above, occasional influences from marine vessel traffic in the Project Area would also affect the air quality at the Project site. Such emissions however are regulated by the International Maritime Organization (IMO) through the International Convention for the Prevention of Pollution from Ships (MARPOL).

5.5 Oceanography

This section provides an overview of oceanographic conditions including waves, ocean currents, extreme winds and waves, seawater properties (temperature, salinity), tides and storm surge.

5.5.1 Waves

The wave climate within the Project Area has been characterized by descriptive statistics derived from the MSC50 wind and wave hindcast dataset (DFO 2019a). The wave hindcast was conducted by using the wind field reanalysis to force a third-generation wave model (Swail et al. 2006) over the north Atlantic Ocean. The model used was Oceanweather's OWI-3G, adopted onto a 0.5 degree grid on a basin-wide scale. Inscribed in the 0.5 degree model was a further refined 0.1 degree shallow water implementation of the OWI-3G model, which allowed for shallow water effects to be accounted for in the maritime region. The MSC50 methodology and results have been extensively documented and validated (Swail and Cox 2000; Woolf et al. 2002; Caires et al. 2004).

As presented earlier for wind conditions, three MSC50 grid point locations were selected to provide a representative illustration of conditions over the Project Area (see Figure 5-8). As noted in Section 5.3.1 for winds, inspection of the wave statistics and directional roses for the three MSC50 nodes considered for the Project Area indicates very little variation in wave conditions between the three locations. Following statistical summary presentations for the three nodes, given the comparable conditions, one grid point node M6014847 (farthest north) is selected for presentation of wave roses and for further discussion and illustration of regional wave conditions over the Project Area. This provides an overview for general illustration and EA purposes.

The wave climate is described in terms of the significant wave height (Hs, defined as four times the square root of the total variance of the wave energy spectrum), and the peak wave spectral period (Tp, defined as the period of waves with the highest contribution to the energy spectrum). Ocean waves are created by wind at the air / water interface. Winds are caused by dominant local and regional weather systems and exhibit a pronounced seasonal variability. Wind waves (or sea) will be generated in the immediate area of wind, typically have periods of less than 1 s to 9 s, wavelengths up to 130 m, developing quickly within an hour. Swells are remnants of the wind waves after they propagate away from where they were generated, contain a lot of wave energy and can take days to subside. Swell periods are typically in the 9 to 15 s range or up to 30 s for long swell with wavelengths up to several hundred metres. The range of wave periods for wind waves and swells overlap considerably with wind waves having periods up to 15 s for large wind speeds, while swells of 5 s are possible.

Table 5.12 presents monthly wave height and wave period statistics for the three MSC50 nodes, listed from north to south. Mean wave heights range from approximately 1.8 m in July to 4.5 m in January (Table 5.12). The most severe sea states occur in December and January with maximum significant wave heights of up to 15.0 m in February and 14.9 m in December. These maximum wave heights are reported for directions from the northwest through southwest, with associated peak wave periods of 16 to 17 s. In contrast, maximum significant wave heights are less than half (approximately 6.5 m) in July, with associated peak periods of 11 to 12 s.

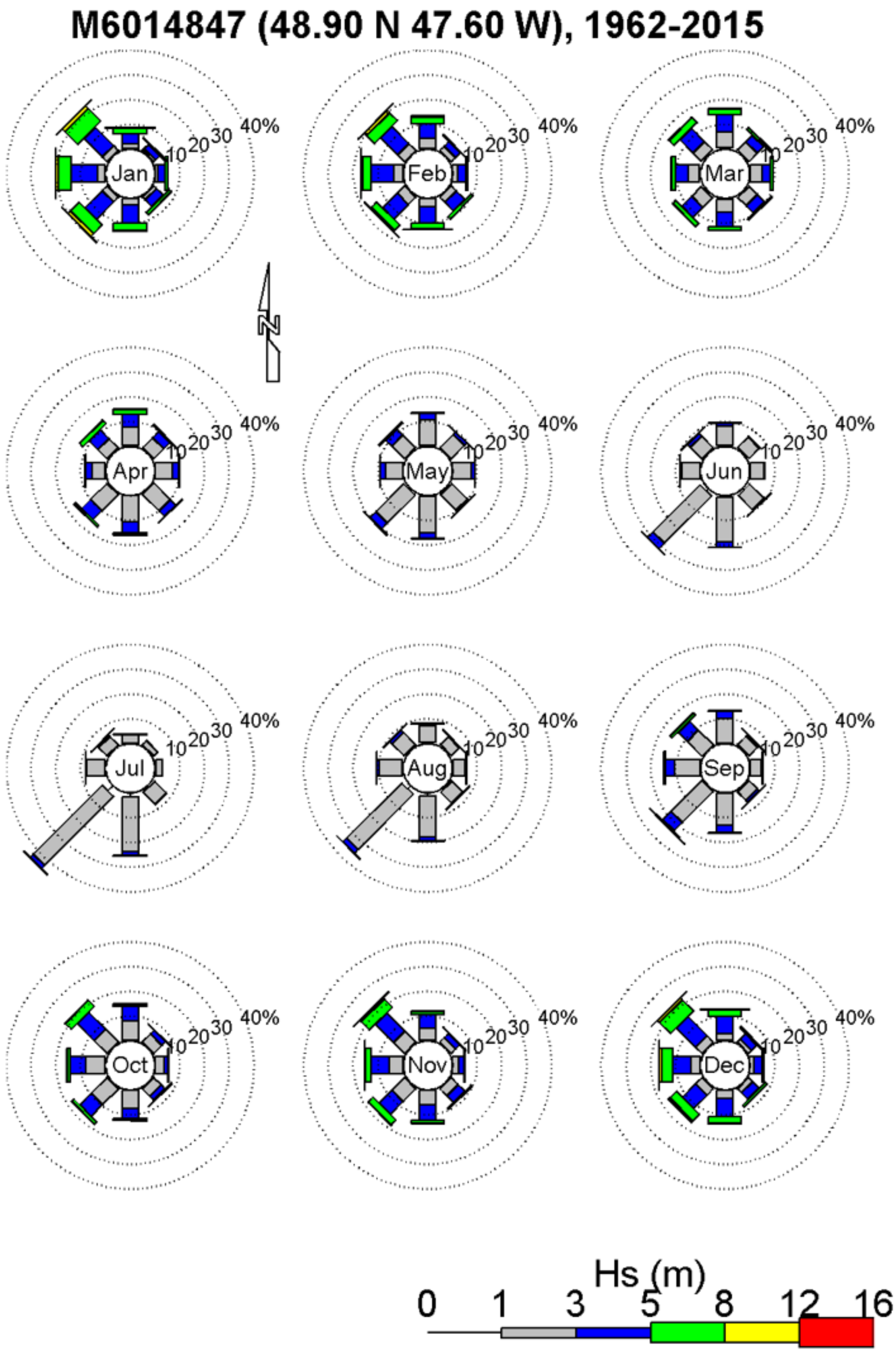
Table 5.12 Monthly and Annual Wave Statistics, 1962-2015

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Hs (m)													
M6014847	4.5	4.1	3.4	2.9	2.3	2.0	1.8	1.9	2.6	3.2	3.6	4.3	3.0
M6014204	4.3	3.6	2.8	2.6	2.2	2.0	1.7	1.9	2.5	3.1	3.5	4.1	2.9
M6013579	4.4	3.8	3.0	2.8	2.3	2.0	1.8	1.9	2.5	3.1	3.5	4.2	2.9
Mean Tp (s)													
M6014847	10.5	10.1	9.6	9.3	8.5	8.0	7.7	7.8	8.9	9.5	9.8	10.4	9.2
M6014204	10.4	9.0	8.2	8.7	8.5	8.0	7.7	7.8	8.9	9.4	9.8	10.4	8.9
M6013579	10.5	9.5	8.8	9.2	8.6	8.1	7.8	7.9	8.9	9.5	9.8	10.5	9.1
Most Frequent Direction (from)													
M6014847	NW	NW	N	S	SW	SW	SW	SW	SW	NW	NW	NW	SW
M6014204	NW	NW	N	S	SW	SW	SW	SW	SW	NW	NW	NW	SW
M6013579	W	NW	SW	SW	SW	SW	SW	SW	SW	NW	NW	NW	SW
Maximum Hs (m)													
M6014847	14.1	13.9	11.9	11.0	11.6	10.3	6.4	7.3	12.6	11.7	13.0	14.9	14.9
M6014204	13.8	13.7	10.5	10.8	11.2	10.3	6.5	8.1	12.2	11.4	12.4	14.1	14.1
M6013579	13.8	15.0	11.3	11.0	11.4	10.5	6.3	7.6	13.5	12.0	12.6	14.3	15.0

Table 5.12 Monthly and Annual Wave Statistics, 1962-2015

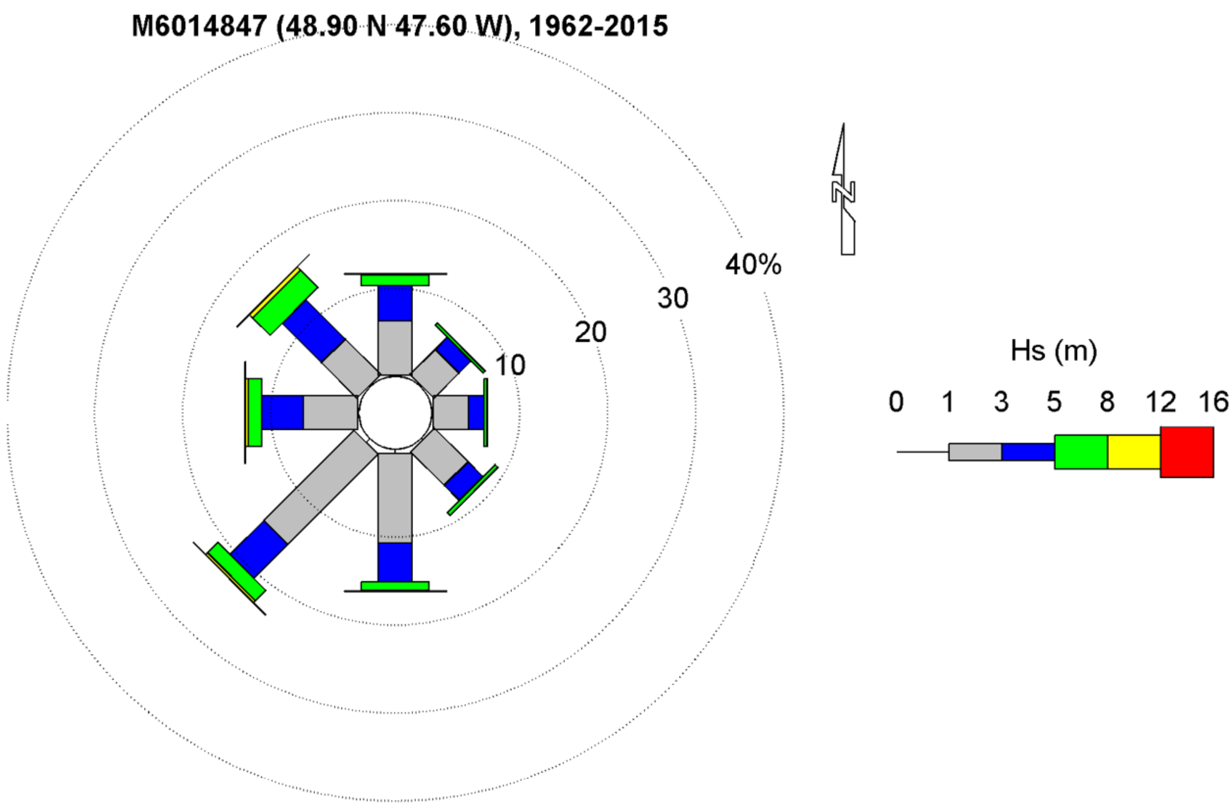
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Tp of Maximum Hs (s)													
M6014847	15.9	16.4	13.5	14.0	14.0	13.1	11.2	12.0	14.5	14.4	14.9	15.8	15.8
M6014204	15.7	16.1	14.3	13.9	14.1	13.2	11.8	11.5	15.5	14.2	14.3	15.8	15.8
M6013579	15.6	16.7	13.1	13.8	14.0	13.5	11.8	11.2	15.6	14.5	14.4	15.8	16.7
Maximum Tp (s)													
M6014847	17.2	16.8	16.8	16.4	17.4	21.0	17.3	18.9	17.3	17.5	15.9	17.2	21.0
M6014204	16.9	17.1	18.4	16.1	17.4	21.0	17.3	18.2	17.3	17.6	15.9	17.0	21.0
M6013579	17.3	17.5	17.6	17.0	17.4	20.9	17.4	18.6	17.6	17.6	16.0	17.3	20.9
Direction of Maximum Hs (from)													
M6014847	W	S	NW	NW	NW	NW	SW	NW	SW	SW	W	NW	NW
M6014204	W	S	N	NW	NW	NW	NW	N	S	SW	W	N	N
M6013579	W	SW	NW	NW	NW	NW	NW	N	SW	SW	W	N	SW
Source: Based on DFO (2019a)													

Monthly and annual wave roses for node M6014847 are shown in Figure 5-21 and Figure 5-22. A general description of roses is provided in Section 5.3.1 for the directional distribution of winds; wave roses for the directional distribution of Hs can be similarly interpreted.



Source: Based on DFO (2019a)

Figure 5-21 Monthly Wave Roses, MSC50 Node M6014847, 1962–2015



Source: Based on DFO (2019a)

Figure 5-22 Annual Wave Rose, MSC50 Node M6014847, 1962–2015

Waves are predominantly from the southwest in the summer. For example, in July, waves are from the southwest 44% of the time (from the southwest quadrant south through west) 78% of the time. July waves are 3 m or less approximately 95% of the time. In fall and winter, waves become increasingly from the northwest. In January waves are from the northwest quadrant (west through north) 51% of the time and exceed 8 m approximately 5% of the time and exceed 12 m approximately 0.2% of the time. Annually, waves are from the southwest 23% of the time, from the east (northeast through southeast) just 21% of the time. Significant wave heights are below 3 m for 58% of the time and exceed 5 m for 11% of the time.

Hs values are in the 1 to 5 m range, annually, 87% of the time; Tp values are in the 5 to 16 s range 94% of the time.

Swell conditions for node M6014847 are presented in Table 5.13. Whereas the overall sea conditions (primary wind wave and secondary swell) are predominantly from the northwest in fall and winter, swells are predominantly from the north. Monthly mean swell heights range from 1.1 m in July to 2.5 m in December and January, with monthly maximum values of 4.3 m in July and 10.5 m in September.

Table 5.13 Monthly and Annual Swell Statistics, 1962-2015

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Swell Hs (m)													
M6014847	2.5	2.3	2.0	1.9	1.5	1.3	1.1	1.2	1.6	1.9	2.1	2.5	1.8
Mean Swell Tp (s)													
M6014847	10.5	10.1	9.6	9.3	8.5	8.0	7.7	7.8	8.9	9.5	9.8	10.4	9.2
Most Frequent Direction (from)													
M6014847	N	N	N	N	S	SW	SW	SW	N	N	N	N	N
Maximum Swell Hs (m)													
M6014847	8.2	7.8	7.7	6.5	5.6	4.9	4.3	5.2	10.5	6.8	6.9	8.3	10.5
Source: Based on DFO (2019a)													

Wave buoy measurements exist from a 90 cm waverider buoy deployed at the previously drilled Great Barasway F-66 exploration well (Figure 5-8), 20 km north of the Project Area, in a water depth of 2,330 m from 18 September 2006 to 7 April 2007 (DFO 2019b). The wave buoy sampled at 2.56 Hz and measured 20-minute records of sea surface elevation every half hour. Monthly statistics of the derived Hs and Tp are presented in Table 5.14. Monthly mean significant wave heights are comparable for most months and within 0.5 m for January and March; the MSC50 values being slightly larger. Monthly maximum Hs values are comparable in most of the coincident months though with maximum values for the MSC50 in December and January approximately 1.5 m larger than the measured values. Monthly mean peak wave periods range from approximately 9 to 11 s and are comparable between the two data sources. Monthly maximum peak wave periods range from 12.5 to 16.7 s with the MSC50 values generally being approximately 0.5 to 1.5 s larger for most months: the largest Tp value being 16.7 s recorded on 11 December with a wave of Hs equal to 5 m.

Table 5.14 Monthly Wave Statistics, Great Barasway F-66, MSC50 Node M6014847,18 Sep 2006 to 7 April 2007

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Mean Hs (m)											
Great Barasway F-66	4.9	4.5	3.4	3.5	-	-	-	-	3.0	3.4	3.4	4.2
M6014847	5.4	4.7	3.9	3.7	-	-	-	-	3.0	3.4	3.7	4.5
	Maximum Hs (m)											
Great Barasway F-66	10.0	9.9	7.2	7.8	-	-	-	-	5.5	7.1	8.2	8.4
M6014847	11.4	10.0	7.4	5.6	-	-	-	-	5.0	6.8	8.5	9.8
	Mean Tp (s)											
Great Barasway F-66	10.1	10.2	9.1	9.6	-	-	-	-	10.4	8.9	9.7	9.9
M6014847	11.1	10.7	10.1	10.5	--	-	-	-	10.7	9.7	9.7	10.5
	Maximum Tp (s)											
Great Barasway F-66	14.3	14.3	12.5	12.5	-	-	-	-	14.3	12.5	14.3	16.7
M6014847	14.7	16.1	14.2	13.0	-	-	-	-	15.3	12.7	14.2	14.5
Source: Based on DFO (2019a) (M6014847), DFO (2019b) (Great Barasway)												

5.5.2 Ocean Currents

The southward flowing cold Labrador Current dominates the general circulation over the eastern NL Offshore Area. The Labrador Current is divided into two streams: 1) an inshore branch that flows along the coast on the continental shelf; and 2) an offshore branch that flows along the outer edge of the Grand Banks (Figure 5-7). The Labrador Current's inshore branch tends to flow mainly in the Avalon Channel along the coast of the Avalon Peninsula but may sometimes also spread farther out on the Grand Banks. The offshore branch flows over the upper Continental Slope at depth, and through the 1,300 m deep Flemish Pass. The offshore Labrador Current (which remains bathymetrically trapped over the upper Continental Slope) has average speeds of approximately 40 cm/s carrying approximately 85% of the total transport, mainly between the 400 m and 1,200 m isobaths (Lazier and Wright 1993).

Near the Project Area, in the vicinity of the Orphan Basin, the Labrador Current divides into two branches with the main branch flowing southwards as Slope Water Current along the eastern edge of the Grand Banks and the side branch flowing up to the east-northeast clockwise past the Sackville Spur and north-eastward around the Flemish Cap.

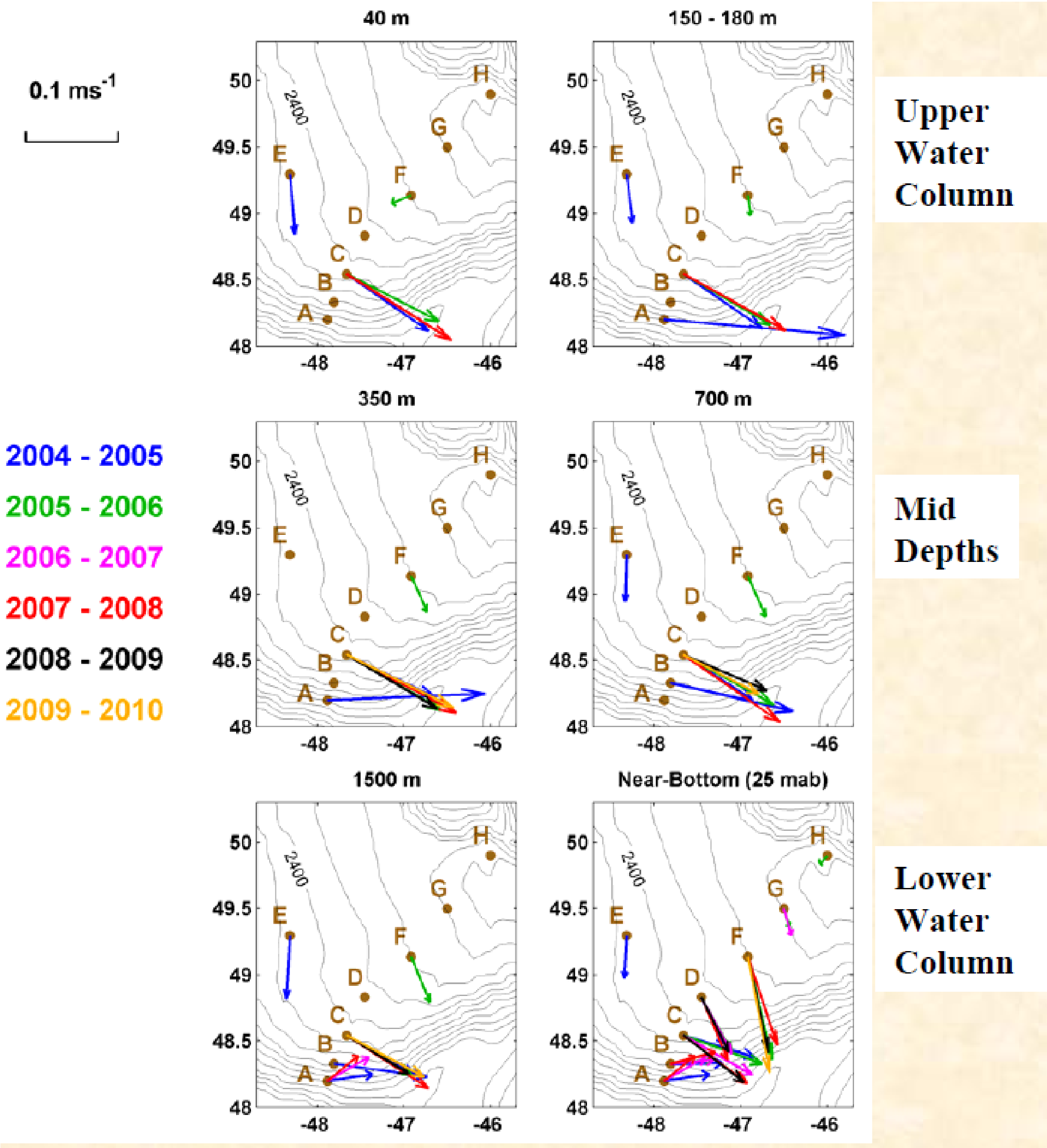
5.5.2.1 Orphan Basin Program

The Ocean Sciences Division (OSD) of Fisheries and Oceans Canada (DFO) at the Bedford Institute of Oceanography (BIO) has completed a multi-year moored current measurement program with cross-slope coverage at eight sites in the Orphan Basin, during the period from June 2004 to May 2010 (BIO 2015;

Geshelin and Loder 2007; Geshelin et al. 2006; Loder et al. 2011). The project has been funded by the Program on Energy Research and Development (PERD), with additional support provided by ExxonMobil Canada Limited and partners for the 2005-07 moorings.

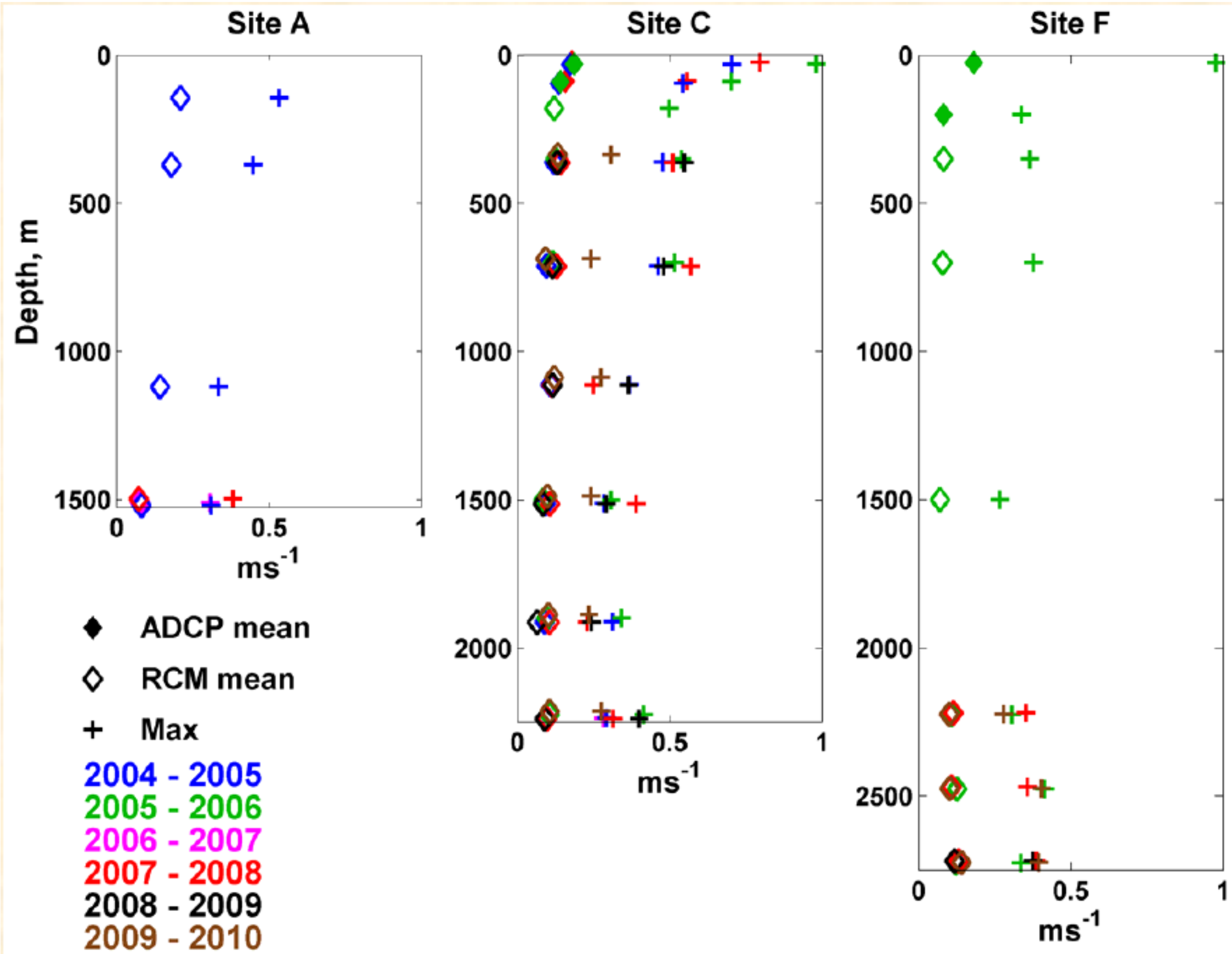
The mooring locations are shown as OB-A through OB-H in Figure 5-8. Mooring locations OB-A to OB-D lie within the Project Area. A combination of Acoustic Doppler Current Profiler (ADCP) and Recording Current Meter (RCM) instruments (recording hourly) were deployed in four full depth and four near-bottom moorings for 2004 to 2010 and five near-bottom or near-bottom and mid-depth moorings were deployed for 2008 to 2010. The moored current measurement programs at representative locations were complemented by Conductivity, Temperature, Depth (CTD)/ADCP sections and other data, analyses and modelling.

Key measurements from the program include annual mean current velocities (Figure 5-23) and mean and maximum current speeds at select instrument depths (Figure 5-24) at each location along this Orphan Basin line. Measured current speeds are approximately 5 to 15 cm/s, with regional flow, as shown in Figure 5-23, along the isobaths to the east through south. Currents at greater depths will be steered around the Flemish Cap and east while shallower currents will make their way through the Flemish Pass, thereby making their way ‘equatorward’ with the Labrador Current and Deep Western Boundary Current (DWBC). Annual mean current speeds in the upper water column (40 and 180 m) are between 7 and 17 cm/s. At the upper and mid depths (350 and 700 m) mean speeds are strongest at OB-A to OB-C in the 8 to 18 cm/s range and associated with the Labrador Current. Near the bottom the strongest currents measured along the Orphan Basin Line are mid-basin from OB-C to OB-F (Geshelin and Loder 2007; Geshelin et al. 2006; Loder et al. 2011).



Source: Loder et al. (2011)

Figure 5-23 Orphan Basin Annual-Mean Currents: June 2004-May 2010

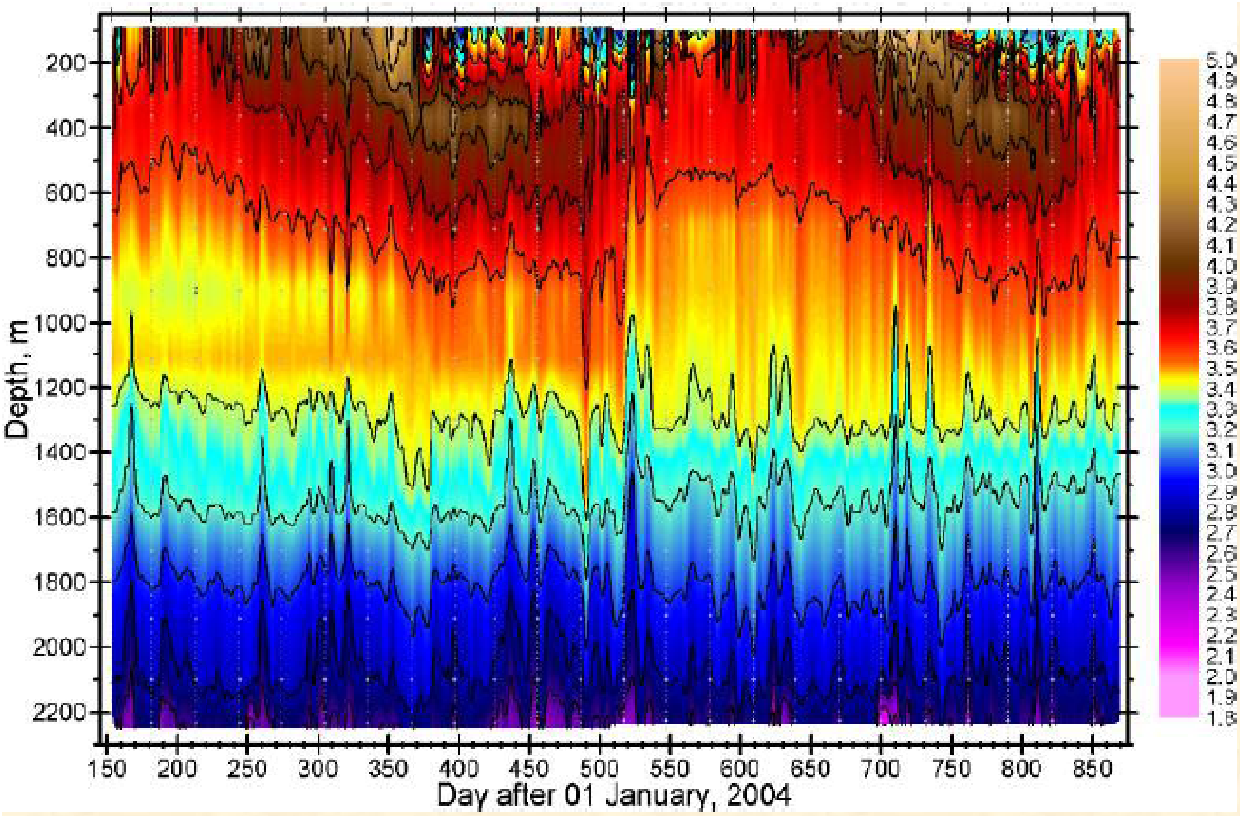


Source: Loder et al. (2011)

Figure 5-24 Mean and Maximum Current Speeds on Orphan Basin Line: 2004-10

Maximum current speeds at sites OB-A (water depth of 1,545 m) and OB-C (water depth of 2,261 m), located in the Project Area, together with site OB-F to the northeast are shown in Figure 5-24. Maximum speeds at OB-A (from the first 2004-2005 deployment) range from 70 cm/s at 30 m, to 45 cm/s at 370 m, 33 cm/s at 1120 m and 31 cm/s at 1520 m; while at OB-C maximum current speeds range from 70 to 80 cm/s near the surface, to generally approximately 50 cm/s at 360 m to 28 to 41 cm/s near-bottom.

The program also found isolated occurrence of tall eddies extending over the water column, primarily at OB-F but also at OB-C, and not readily apparent in water depths less than 2,100 m. These are probably of topographic origin to the north that drift southeast-ward with the mean current. From four to six were observed to occur intermittently per year for a given site. These enhance the current speeds over much of the water column, up to 50 cm/s, with strongest currents at mid-depth. Figure 5-25 shows the presence of some eddies at OB-C extending over the water column with other ‘events’ concentrated in the interior or near-bottom (sea temperature in °C is shown).



Source: Loder et al. (2011)

Figure 5-25 Occurrence of Tall Eddies at OB-C: Jun 2004 – May 2006

5.5.2.2 ODI Database

A query of the BIO Ocean Data Inventory (ODI) database (Gregory 2004) for the area 47°N to 50°N, 46°W to 50°W (DFO 2019c) returned 13 mooring locations, as shown in Figure 5-8; however, none in the Project Area, the closest being 15 km to the south of the Project Area. The Orphan Basin program remains the primary and best data set for description and understanding of the currents and hydrodynamics variability in this region.

5.5.2.3 WebDrogue CECOM and WebTide

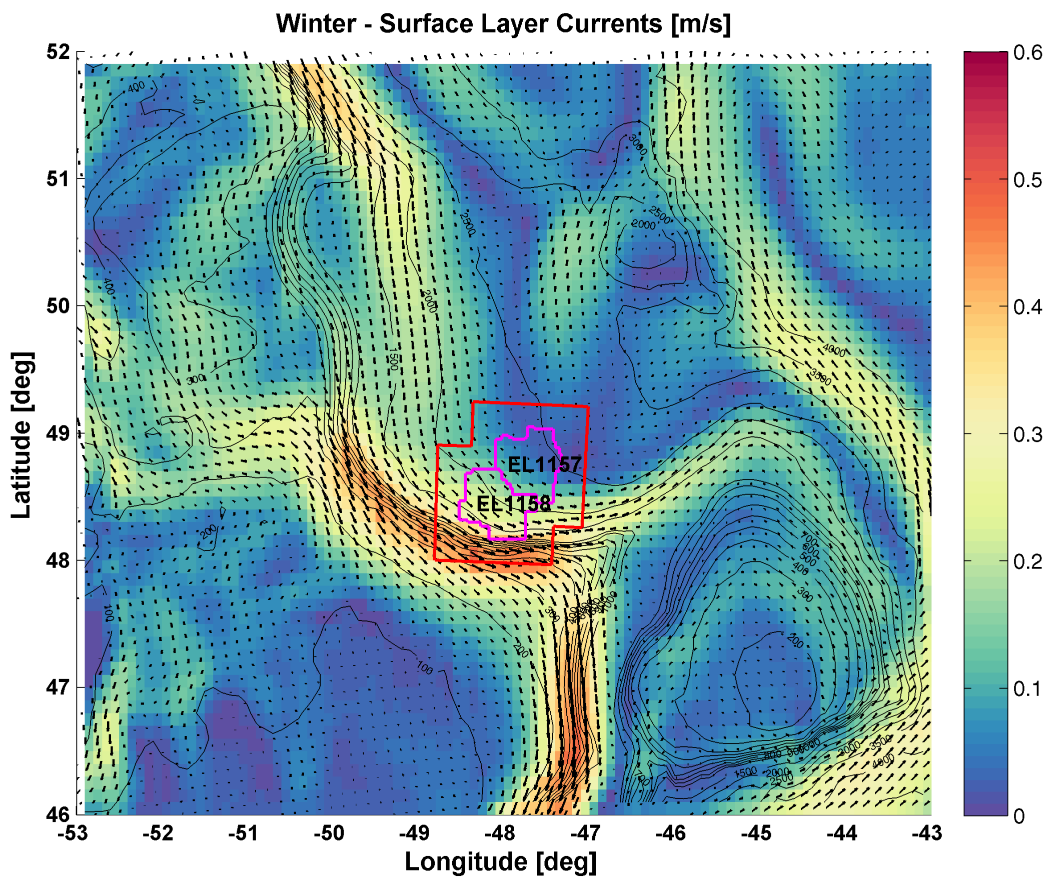
A further illustration of currents in the Project Area is afforded with the WebDrogue CECOM (Canadian East Coast Ocean Model) model (DFO 2015a), and tidal predictions for a full year derived from the WebTide model (DFO 2015b).

Wu et al. (2012) conducted an extensive comparison of the CECOM model results and 11 years of observational data, including both qualitative visual comparisons, and quantitative methods based on statistical analysis. Their comparisons indicated that the main circulation features from the observations were successfully reproduced by the model. Furthermore, the comparison indicated particularly good levels of agreement between model and observations in the regions of the Labrador Shelf, Newfoundland Shelf, and the Flemish Pass, with a mean correlation coefficient of 0.91 (ideal value is 1) across the seasons and depths within the Flemish Pass, and an average ratio of kinetic energy difference to the observations of 0.12 (where a lower value is better, and the value of 0.5 indicates "a fair agreement").

The models yield currents at five depth levels: surface, 100 m, 500 m, 1,000 m and bottom. Winter and summer conditions are shown for surface, 100 m, and bottom depths in Figure 5-26 to Figure 5-31. Modelled surface current speeds are approximately 40 to 45 cm/s over the southern portion of the Project Area in winter, approximately 35 cm/s in the summer. Surface current speeds in winter and summer are approximately 20 to 30 cm/s over the central portion of the Project Area and generally 10 cm/s or less over the northern portion of the Project Area. Mean currents are predominantly to the east, slightly to the southeast farther north in the Project Area.

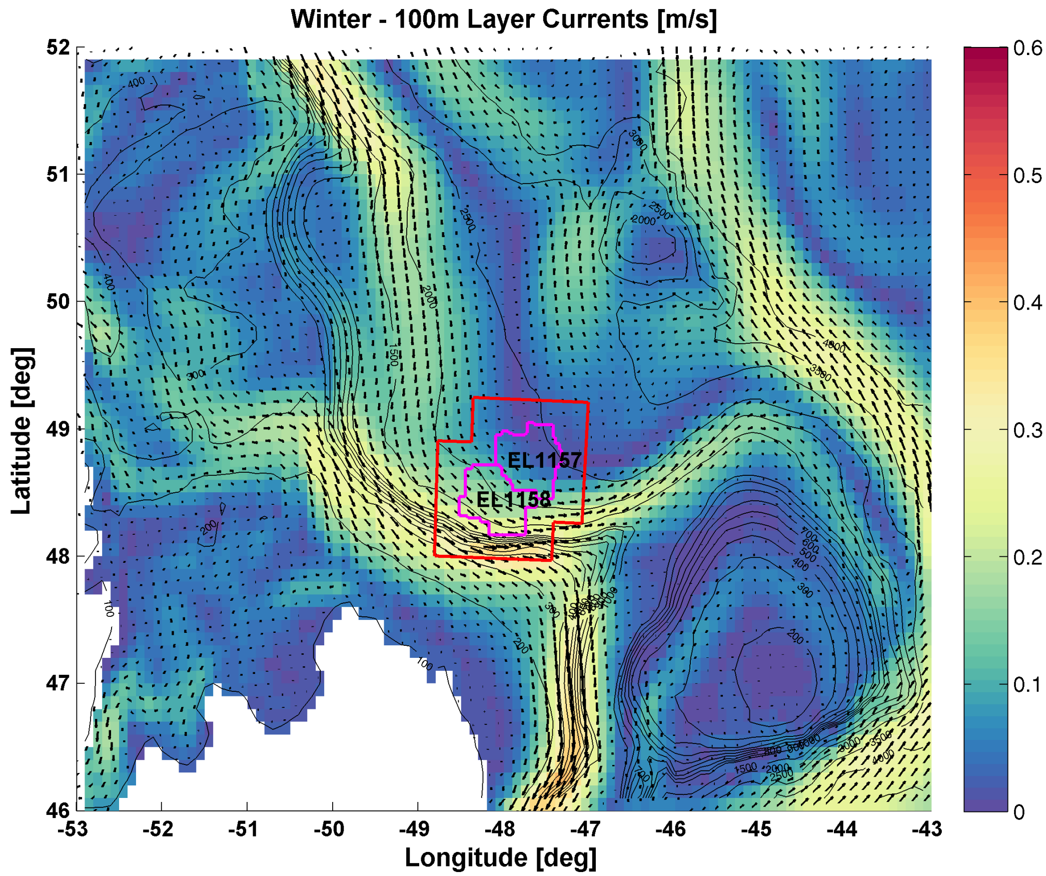
At 100 m the modelled current speeds in the southern portion of the Project Area are more consistent between winter and summer at approximately 30 to 35 cm/s, approximately 20 cm/s in the central portion and less than 10 cm/s to the north. Predominant current directions are to the east and southeast.

Near-bottom modelled current speeds in the southern portion of the Project Area are in the 15 to 20 cm/s range, approximately 8 cm/s in the central portion and approximately 5 cm/s to the north. Predominant current directions in the southeastern portion of the Project Area turn to the east-northeast to align with the Sackville Spur.



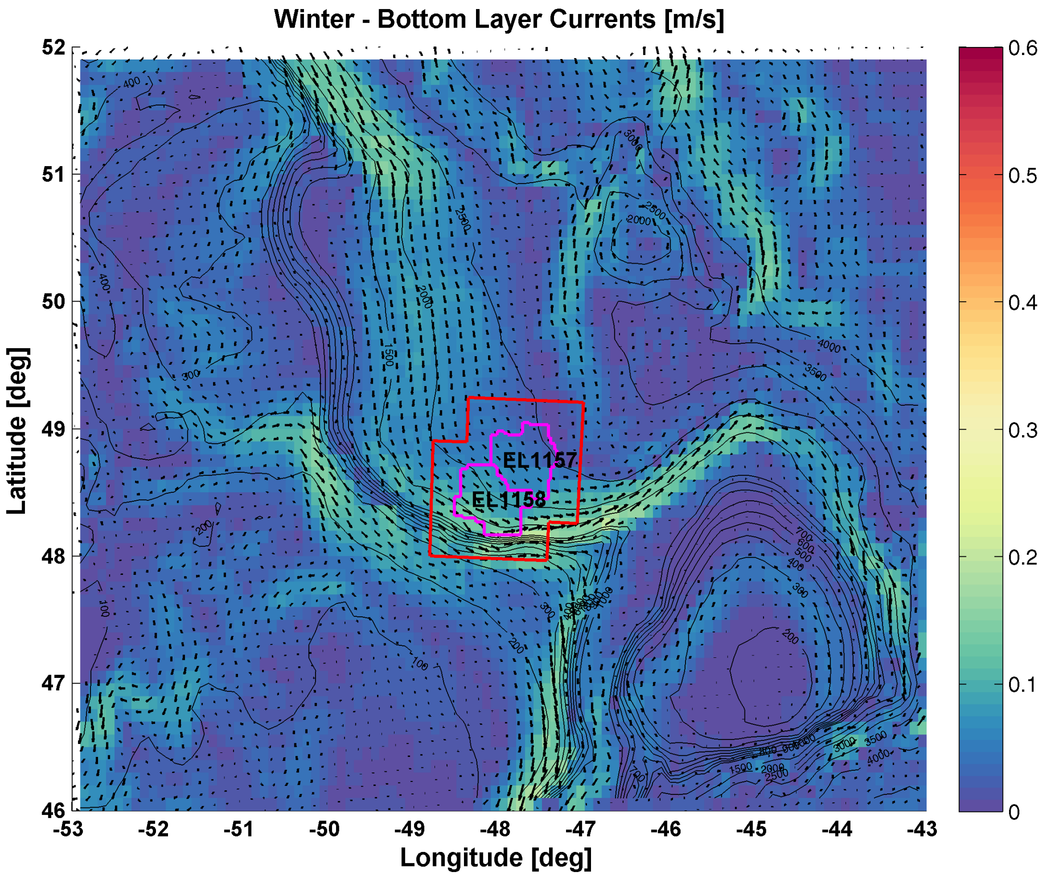
Source: Based on WebDrogue CECOM (DFO 2015a), WebTide (DFO 2015b)

Figure 5-26 Winter, Surface Currents



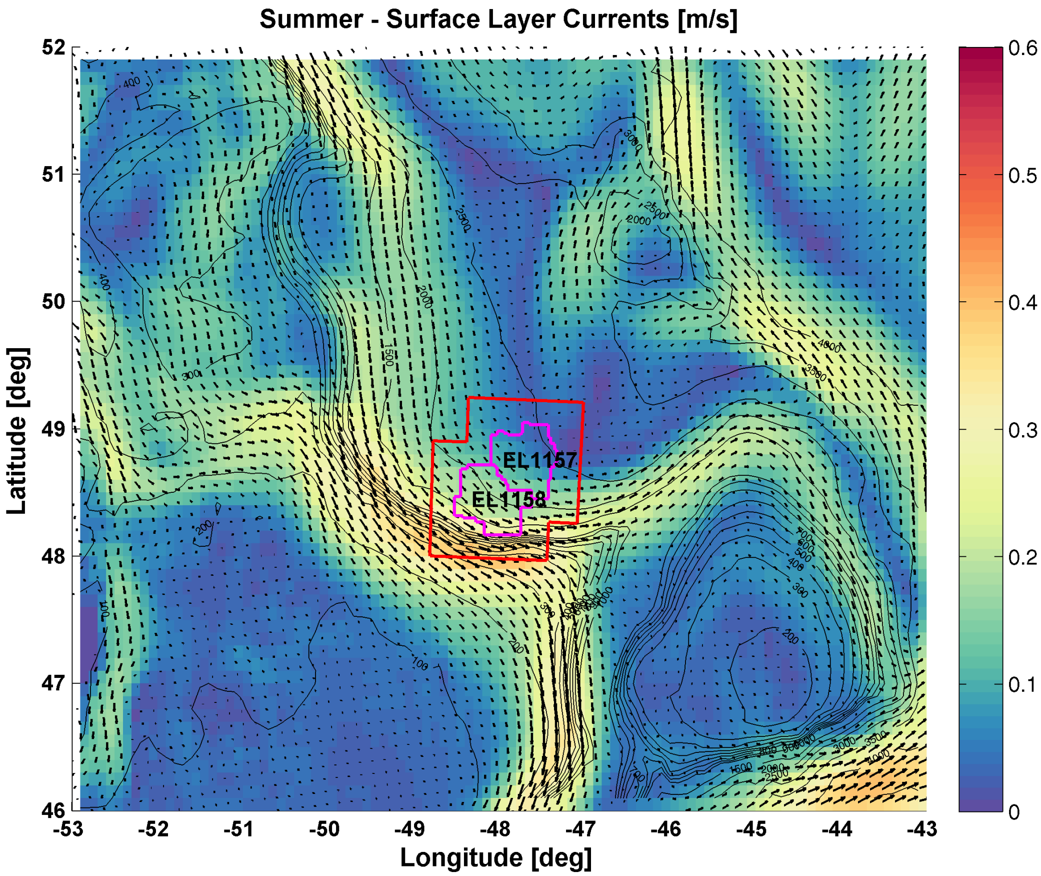
Source: Based on WebDrogue CECOM (DFO 2015a), WebTide (DFO 2015b)

Figure 5-27 Winter, 100 m Currents



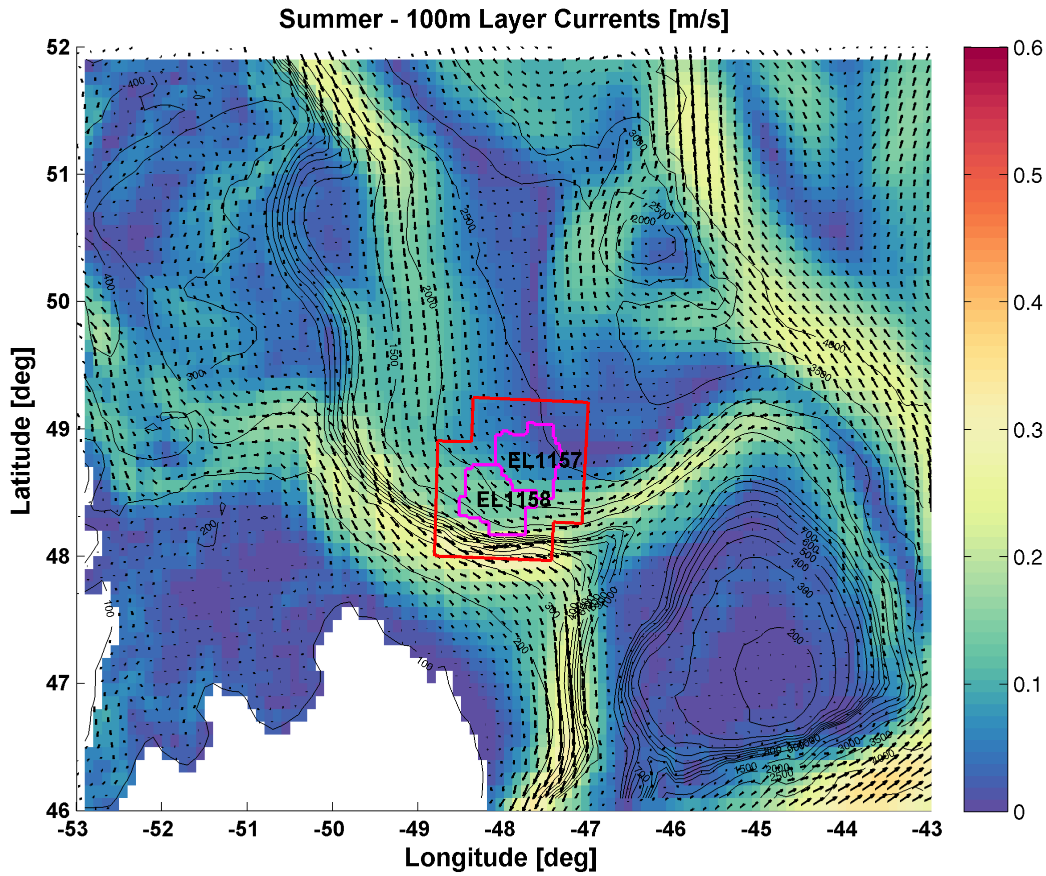
Source: Based on WebDrogue CECOM (DFO 2015a), WebTide (DFO 2015b)

Figure 5-28 Winter Bottom Currents



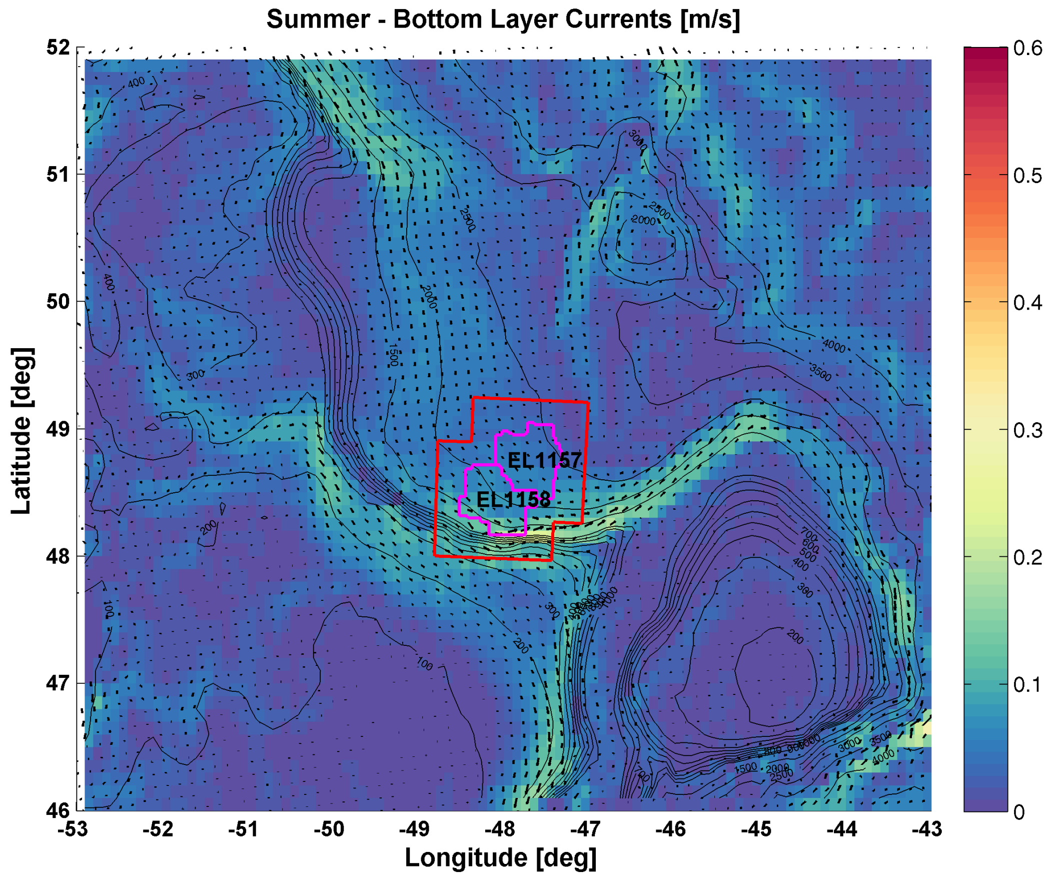
Source: Based on WebDrogue CECOM (DFO 2015a), WebTide (DFO 2015b)

Figure 5-29 Summer, Surface Currents



Source: Based on WebDrogue CECOM (DFO 2015a), WebTide (DFO 2015b)

Figure 5-30 Summer, 100 m Currents



Source: Based on WebDrogue CECOM (DFO 2015a), WebTide (DFO 2015b)

Figure 5-31 Summer, Bottom Currents

5.5.3 Extreme Events

To estimate extreme wind and wave conditions, extremal analysis was performed with the MSC50 node M6014847 (see also Sections 5.3.1, 5.5.1) to determine the highest expected values for wind speed, and significant wave height. The analysis was based on the Gumbel distribution to which the data were fitted using the maximum likelihood method. The analysis includes both tropical and extra-tropical storms over the entire period. The Gumbel fit is done using the maximum likelihood method. Lower and upper 95% confidence intervals are calculated.

Extreme values were estimated for four different return periods: 1, 10, 50 and 100 years (Table 5.15). In the Project Area, extreme wind speeds range from 25.8 m/s to 34.7 m/s for the 1-year and 100-year return periods respectively, while extreme significant wave heights range from 11.3 m to 15.3 m.

Table 5.15 Extreme Wind and Wave Estimates, MSC50 Node M6014847, 1962–2015

Return Period (years)	1	10	50	100
Wind Speed (m/s)	25.8 +/- 0.3	30.1 +/- 1.1	33.4 +/- 1.6	34.7 +/- 1.8
Significant Wave Height (m)	11.3 +/- 0.2	13.3 +/- 0.4	14.7 +/- 0.5	15.3 +/- 0.5
Source: Based on DFO (2019a)				

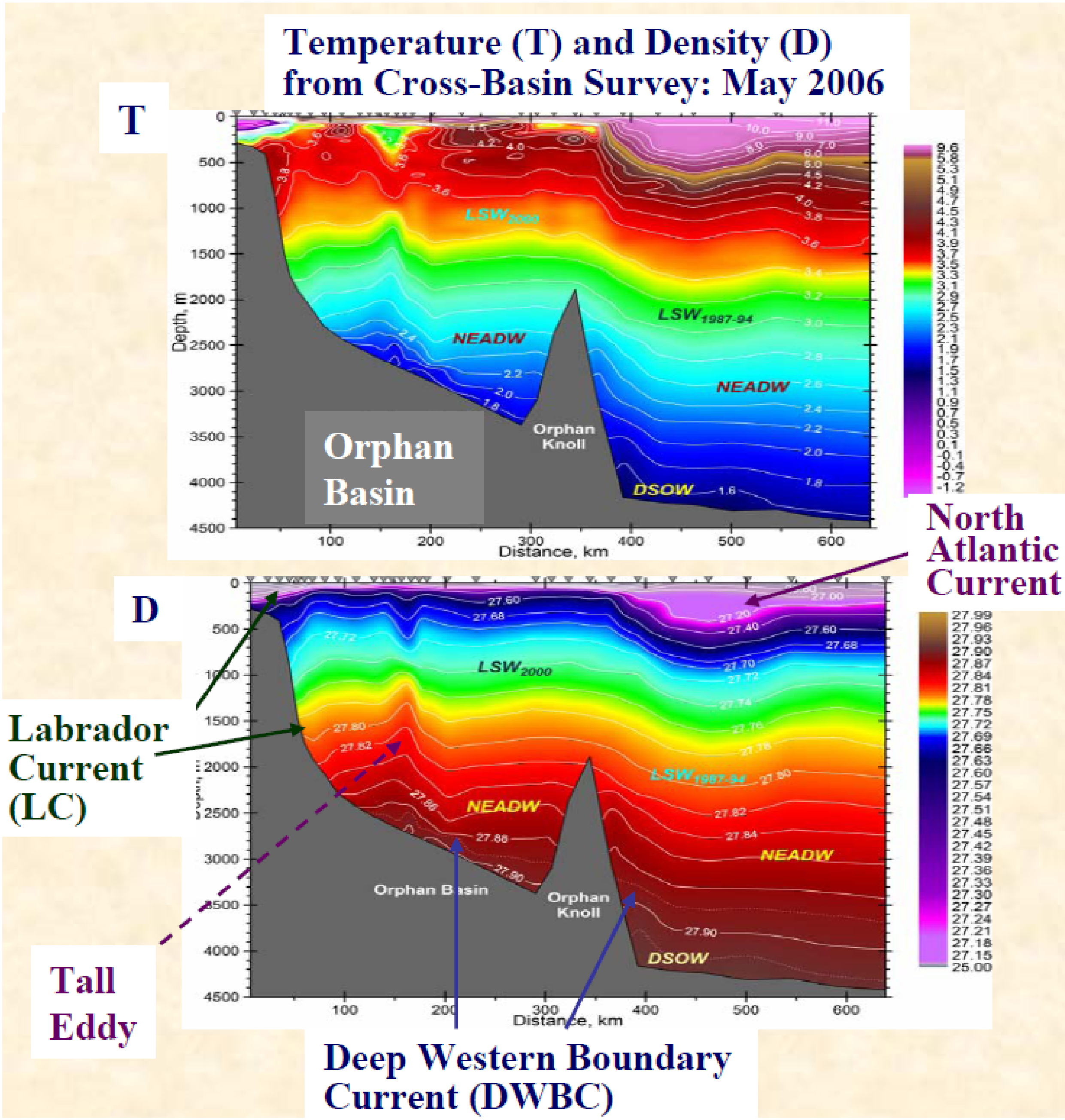
5.5.4 Seawater Properties (Temperature, Salinity, pH, Turbidity)

Statistical summaries of sea temperature and salinity are presented from two sources. These include measurements from the DFO/PERD/Industry Orphan Basin Moored Measurement Program along an Orphan Basin line, as described in Section 5.5.2, and a regional characterization provided using the hydrographic database of the ODI of BIO (DFO 2019d) which was queried for the Project Area for depths down to 3,000 m.

5.5.4.1 Orphan Basin Program

Deployment length sea temperature and salinity statistics from Orphan Basin program deployment phases 1 to 3 (June 2004 to May 2005, May 2005 to May 2006, May 2006 to May 2007, respectively) have been assessed ("Orphan_Basin_phase_1/2/3_full_rec_stats", J. Loder, pers. comm.).

Mean temperatures range from 3.0°C near-bottom at a depth of 2,475 m at OB-D to 4.0°C at 370 m at OB-A. Minimum temperatures range from 1.0°C at 120 m to 3.6°C at 520 m both at OB-A. Maximum temperatures range from 2.6°C at 2,475 m at OB-D to 6.2°C at 110 at OB-C. The range of salinity measured is bracketed by lower values at OB-A near the surface at 120 m: mean, minimum and maximum values of 34.6, 33.7 and 34.9 PSU (practical salinity unit); and more saline water at OB-D near-bottom at 2,473 m: mean, minimum and maximum values of 35.4, 35.3 and 35.5 PSU.A cross-basin view of temperature (°C) and density, σ_t, for May 2006, from the Orphan Basin program is shown in Figure 5-32. In the figure, the Project Area extends from the 300 m depth contour at distance 0 km on the x-axis scale to approximately 200 km. A cold region of Labrador Current waters, with temperatures down to approximately -1°C, over the upper water column (to approximately 200 m) is evident out to water depths of approximately 1,800 m. Temperatures over the same depths out to the northeast border of the Project Area, approximately 200 km, generally range between 3 and 4°C with warmer temperatures above 9°C observed at the surface. Temperatures range from 3.5°C to 3.8°C at mid-depths of 750 m, to 3°C at 1,500 m and 1.8°C near-bottom.

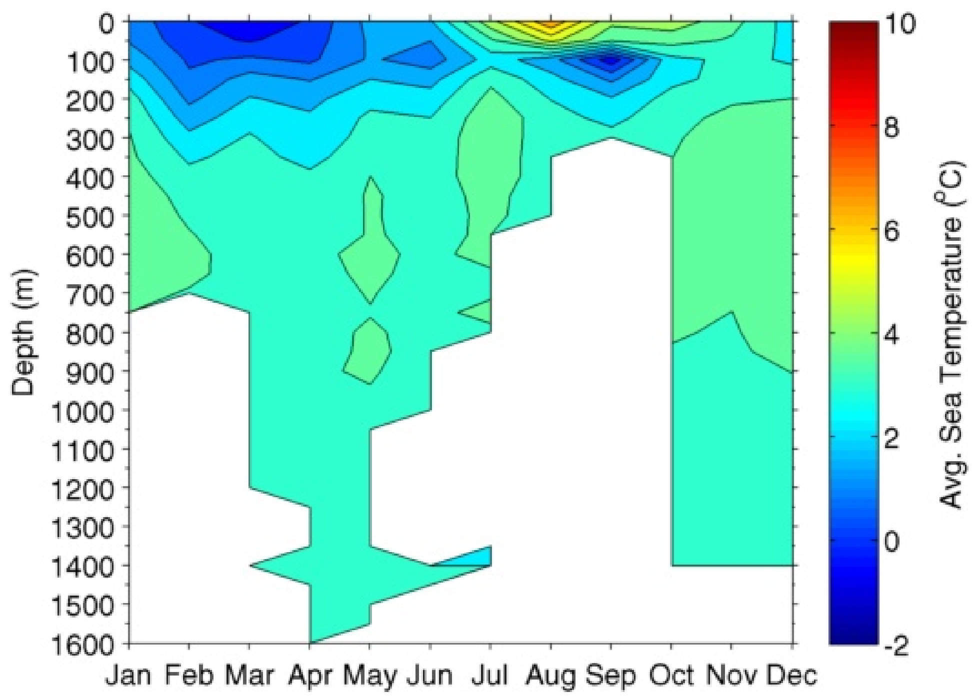


Source: Loder et al. (2011)

Figure 5-32 Orphan Basin Temperature and Density: May 2006

5.5.4.2 ODI Hydrographic Database

Depth contours of monthly mean sea temperature for the Project Area based on the ODI database (DFO 2019d) are presented in Figure 5-33. The data query used 50 m bin size averaging and returned 4,070 results for temperature. Not all months or depths are well-sampled. For example, May and June account for 38% of the observations, while February and July through September have less than 100 values. Surface waters are typically better sampled than deeper waters, e.g., 51% of the measurements being above 300 m and 95% being above 1,250 m. With typically less than three values for each depth bin for any given month below 1,600 m, and those primarily limited to May, to provide a good resolution, results presented here focus on depths above 1,600 m.



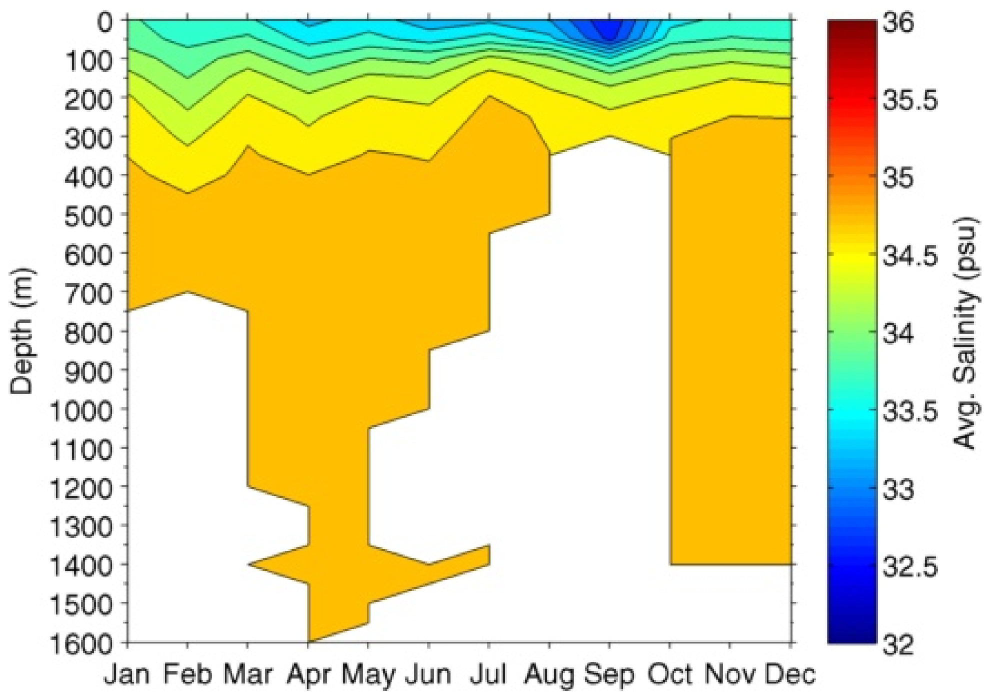
Source: Based on DFO (2019d)

Figure 5-33 Monthly Average Sea Temperature

Mean sea temperatures at the surface range from -0.5°C in March to 7.0°C in August, and over the upper 150 m average 2.3°C annually. Minimum temperatures in the upper 150 m from January through May range from -1.8 to 0.5°C and average -0.8°C. At 200 m and below, average temperatures range from 0.3°C in at 200 m in April to 3.8°C at 750 m in July and average 3°C annual between 200 1,600 m. Maximum temperatures in the upper 150 m range from -0.3°C at 100 m in September to 10.1°C at the surface in August, and average 4.3°C annually. Maximum temperatures at 200 m and below average 3°C with several observations of 3.6 to 3.8°C in February, July, October and November at depths between 400 and 1,400 m.

As a companion to the sea temperature, Figure 5-34 presents a depth contour of monthly mean salinity for the Project Area. Salinity is on average generally uniform during the year for a given depth, August and

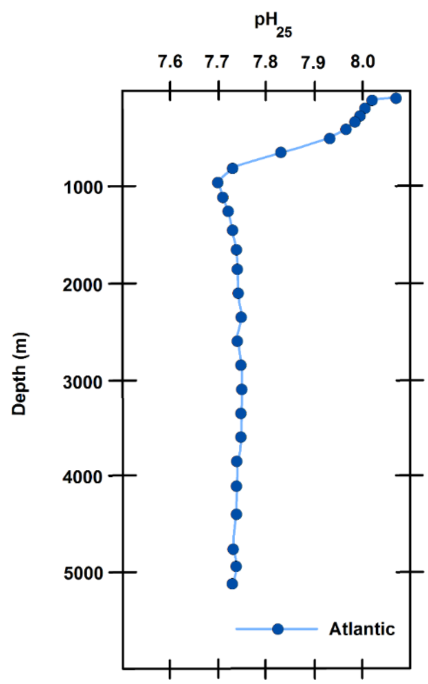
September being an exception with fresher water present in the upper 100 m. Sea surface salinities range from a minimum of 32.1 PSU in September to a maximum of 33.9 PSU in January and average 33.5 annually. The average salinity annually down to 200 m is 34 PSU. Below 200 m down to 1,600 m salinity ranges between 34.2 to 34.9 PSU and averages 34.8 PSU.



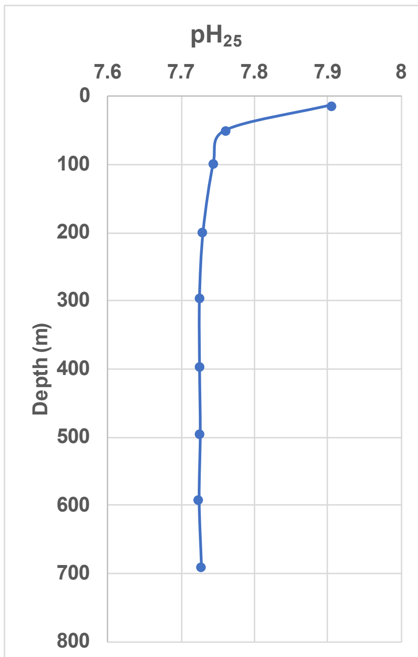
Source: Based on DFO (2019d)

Figure 5-34 Monthly Average Salinity

Measurements for pH data are scarce for the Project Area and limited in both temporal and spatial resolution. Two data sources are noted. One characterization comes from on data collected from the World Ocean Circulation Experiment (WOCE) database for the entirety of the Atlantic Ocean. Figure 5-35 (left panel) shows that surface waters in the Atlantic Ocean have a pH (adjusted to 25°C temperature) range of 8.0 to 8.1, which decreases to approximately 7.7 at 1,000 m depth, then remaining stable to the ocean floor. A second data source from the Global Ocean Data Analysis Project (GLODAP) dataset (Olsen et al. 2019) is a May 2001 cruise 49, location 107 at 48.5°N, 45.0°W approximately 150 km east of the Project Area. The pH profile from this cruise shows surface waters with a pH around 7.9, which decreases to approximately 7.7 at 700 m depth.



A)



B)

Source: A) based on Wallace (1997); B) based on Olsen et al. (2019)

Figure 5-35 pH for the Atlantic Ocean, A) from the WOCE; B) from GLODAP Cruise May 2001

Turbidity data are similarly scarce for the Project Area. Data are available from National Oceanic and Atmospheric Administration (NOAA), from a cruise in March of 2011 in an area north of Flemish Pass (Ullman et al. 2013). From this cruise, turbidity is approximately 0.2 to 0.3 nephelometric turbidity units (NTU) in near-surface waters and steadily decreases to below 0.01 at 200 m and deeper.

5.5.5 Tides

Water level variations due to tides in the Project Area are generally quite predictable. Several models are available for the prediction of water levels at specific locations where the tidal constituents are known or can be extrapolated from other locations.

Using the WebTide model (DFO 2015b, Dupont et al. 2002), based on tidal modeling studies conducted by DFO, tidal water levels are computed for the Project Area at the same location of the referenced MSC50 node (used for wind and wave analysis). These results are presented in Table 5.16.

Table 5.16 Tidal Predictions

Project Area Location	Tidal Constituent	Constituent Amplitude (cm)	Phase (deg GMT)
48.9°N, 47.6°W	M_2	17.2	311.6
	K_1	9.2	158.8
	N_2	3.4	298.4
	S_2	8.7	350.2
	O_1	5.9	124.5

Source: Based on WebTide (DFO 2015b)
Key:
degrees Greenwich Mean Time

The contribution of each tidal constituent to the observed tidal range during a full tidal cycle is twice its amplitude. The largest contribution comes from M_2, the principal lunar semidiurnal constituent, followed by K_1, the diurnal, luni-solar diurnal and S_2, the solar semidiurnal constituents. The other components have a relatively smaller contribution toward the observed tides. Overall, the water levels exhibit a semidiurnal pattern of two high tides and two low tides per day, with one set of tides having a higher tidal range than the other.

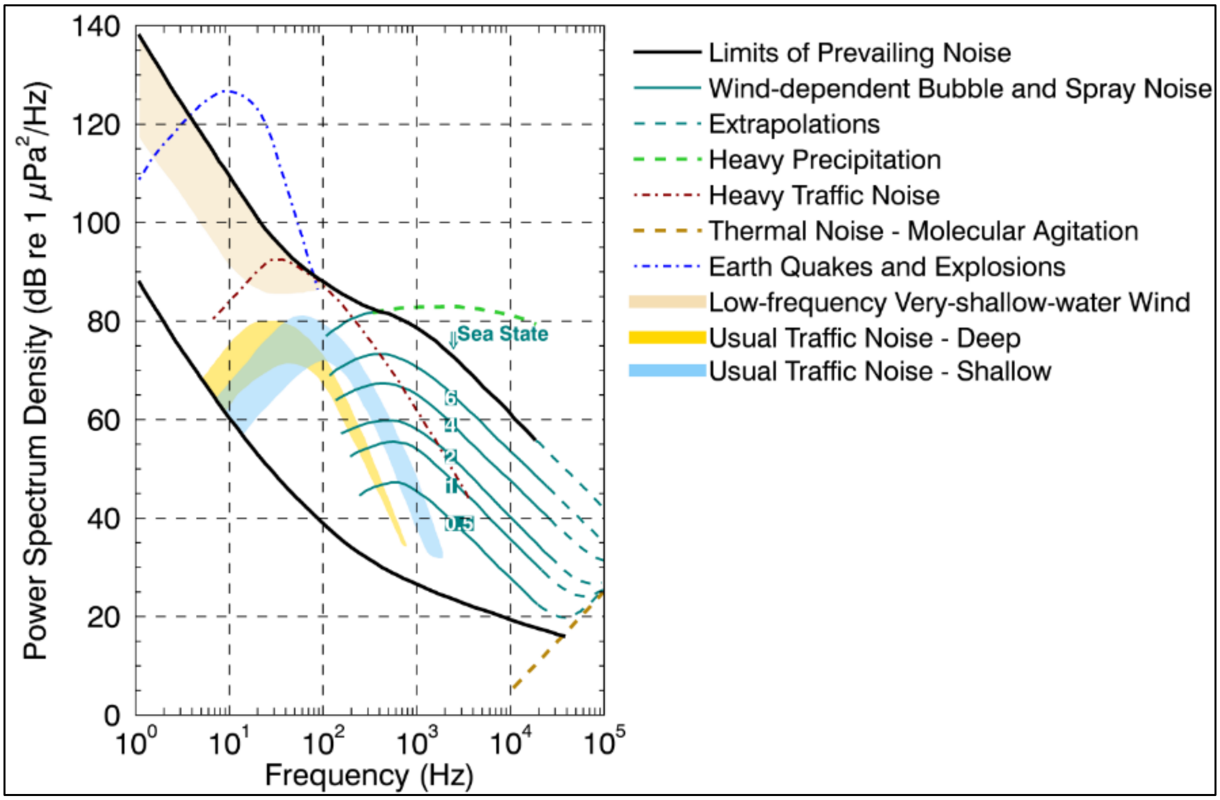
5.5.6 Storm Surge

Storm surge is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. Storm surge amplitudes can be high in coastal areas, but surges with comparatively smaller amplitudes can also occur offshore, away from the coastline. A hazard from storm surges is elevated mean water levels, specifically when they occur at high tide. Extreme storm surge calculations based on a study by Bernier and Thompson (2006), which used a hindcast of water levels over 40 years, calculated a potential 100-yr storm surge of 90 cm in the northwest Atlantic at the location of the MSC50 M6014847 data point, 48.9°N, 47.6°W with a 10,000-yr storm surge of 1.2 m.

5.6 Ambient Sound

Sound from a point source emanates in a spherical pattern until it reaches the sea surface or seabed, at which point the spreading becomes cylindrical. Seabed conditions and bathymetry of the Project Area are discussed in Sections 5.1 and 5.2, respectively. Underwater sound modelling was conducted for this Project (Alavizadeh and Deveau 2019) and is provided in Appendix E.

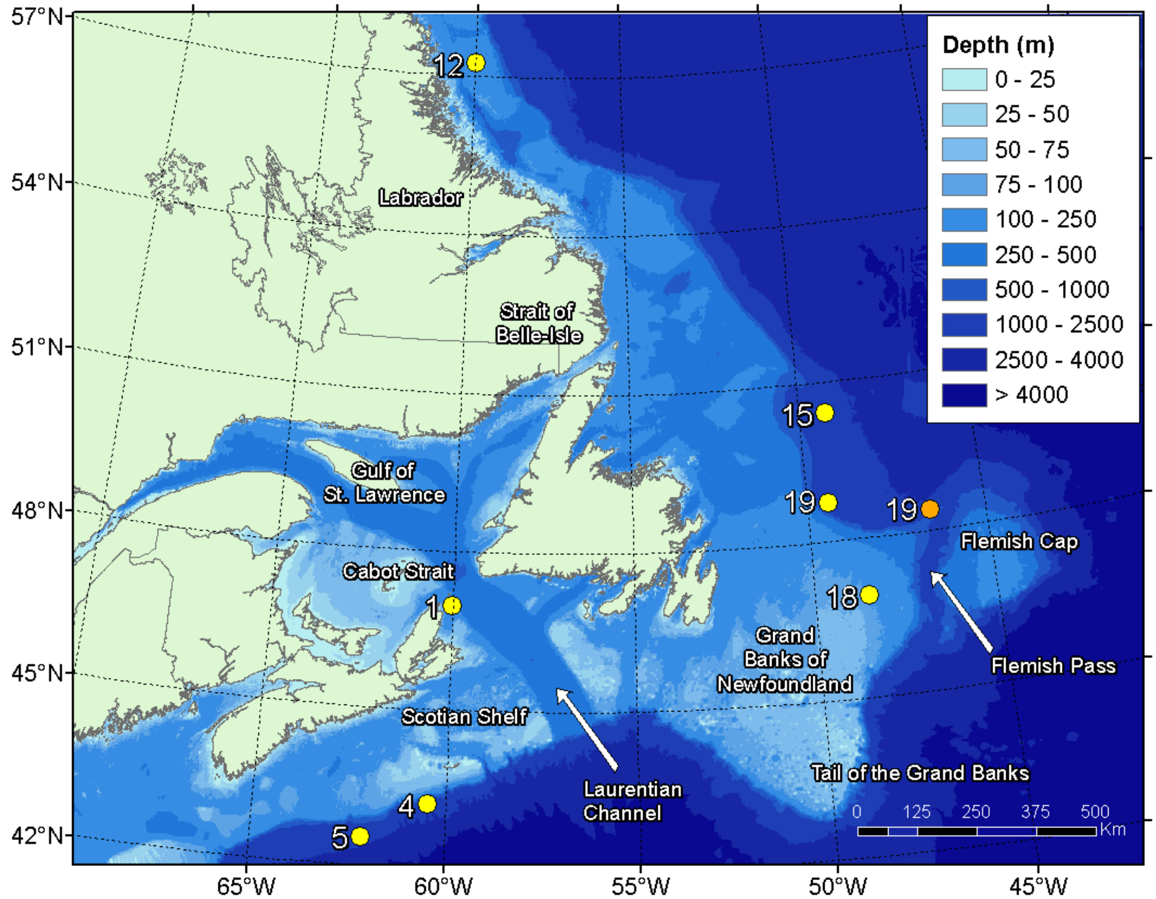
Natural and anthropogenic sources combine to create the ambient soundscape in the ocean (refer to Figure 5-36). The primary physical environment sources of sound are sea ice (main contributor), precipitation (a common contributor; typically concentrated at frequencies above 500 Hz), and wind. Earthquakes and other geological events can also contribute low frequencies (<100 Hz) to the ambient soundscape. Anthropogenic sources of sound include vessel traffic, fishing activities (other than fishing vessel movement), and oil and gas exploration and extraction (including air traffic / helicopters) (Delarue et al. 2018).



Source: Adapted from Wenz (1962), in Delarue et al. 2018

Figure 5-36 Wenz Curves Describing Pressure Spectral Density Levels of Marine Ambient Noise from Weather, Wind, Geologic Activity, and Commercial Shipping

The Environmental Studies Research Fund (ESRF) conducted a two-year (2015-2017) recording program in shallow and deep water to characterize the underwater soundscape of the eastern Canadian offshore and the occurrence of marine mammals (Delarue et al. 2018). The study involved deployment of 20 acoustic recorders from Nain Bank on the Labrador Shelf to Dawson Canyon off Halifax, NS (Figure 5-37). Station 19 (orange dot in Figure 5-37, moved in 2016 due to repeated summer sightings of northern bottlenose whale in the Sackville Spur area) is the closest station to the Project Area.



Source: Delarue et al. 2018
Note: The orange dot represents the location of Station 19 in 2016-2017

Figure 5-37 Key ESRF Study Station Locations for Ambient Marine Noise

Station 19 was deployed in the southeastern part of Orphan Basin (at a depth of 1,547 m). The maximum and minimum broadband sound pressure levels (SPLs) measured at Station 19 in 2016-2017 were 157.6 and 95.5 dB re 1 μPa, respectively. The two main soundscape features were fin whale calls and seismic survey activity from July to October (Delarue et al. 2018).

Fin whales were detected between September and mid-March (although these were masked until seismic surveys ended in late October) and were the main source of identifiable sound. On the Grand Banks, fin whales sing from October to March and the total sound level across the Grand Banks can increase by 5 to 10 dB (in the 10 to 45 Hz band) by their notes. Vessel traffic is typically a transient sound source that is detectable over a period of several hours. Sounds from vessels (including DP MODUs) are continuously present closer to oil and gas activities (both exploration and production facilities) (Matthews et al. 2018). Additional information on soundscape features identified at Station 19 are summarized in Section 4.6.2 of Appendix E.

Seismic surveys were a dominant sound source, despite being more than 100 km from the recorders. The peak frequency of sound from seismic source arrays is near 50 Hz (Dragoset 1984); however, the frequency range increases as the source vessel gets closer to a measurement location. The measurements reported in Delarue et al (2018) included energy up to 1 kHz. This sound source is variable in space and time depending on where the seismic source is located. It is expected that 2D and 3D seismic surveys will continue off Newfoundland for the foreseeable future each summer.

5.7 Ice Conditions

5.7.1 Sea Ice

This section provides an overview of the sea (drift or pack) ice conditions most likely to be encountered in the Project Area. Information is drawn from the CIS Sea Ice Climatic Atlas for the East Coast 1981-2010 (CIS 2011). The atlas includes three key separate statistical analyses of conditions: i) frequency of presence of sea ice; ii) median of ice concentration when ice is present, and iii) median of predominant ice type when ice is present. Thickness can be inferred from ice type. The 1980-2010 atlas provides the most recent and comprehensive climatology description of sea ice conditions in the region.

Given that the CIS Regional Ice Charts are not always prepared on the same dates each year, a seven-day period centered on historical dates is used in the ice atlas. The atlas climate data represent information from charts within three days on either side of the historical date. For example, the chart for historical date 15 January is representative for the period 12 to 18 January.

As noted in the ice atlas, variations in the extent of ice over East Coast waters, and hence the Project Area, are great due to both winds and temperatures being effective in changing the location of the ice edge. A large variability in sea ice conditions can therefore be experienced from year to year, and in a given year, on time scales of days to weeks and over comparatively small geographic scales of tens of kilometres.

To characterize overall conditions, the sea ice is described for four representative “quadrants” over the Project Area. An approximate midpoint of each quadrant was selected (as illustrated in Figure 5-38), which was overlaid on each of the weekly atlas charts. The corresponding frequency of ice presence, ice concentration and ice type was noted for all weeks across the four regions. The resulting tabulations are presented in Table 5.17 to Table 5.19. To accompany Table 5.18 for median ice concentration, when ice is present, Figure 5-39 (derived from the MANICE [Manual of Ice] publication [CIS 2005]) illustrates the scale in which ice concentration is reported, from open water (ice concentration of less than 1/10) to compact/consolidated ice (10/10 concentration). To accompany Table 5.19, for median of predominant ice type, when ice is present, Table 5.20 from MANICE (CIS 2005) lists the stages of sea ice development that occur together with their associated thickness.

Values are colour-coded to show at a glance the weekly change in ice conditions for the four locations of the Project Area: northwest, northeast, southwest and southeast. It is emphasized that, for simplicity, these tables report just one value for each of the four regions whereas conditions may vary considerably across any given region. While some of the variation in conditions near these midpoints and in a given region is discussed below, for a higher resolution study the atlas (CIS 2011) should be consulted. It is further noted that conditions reported here are from climatology and each year will be different.

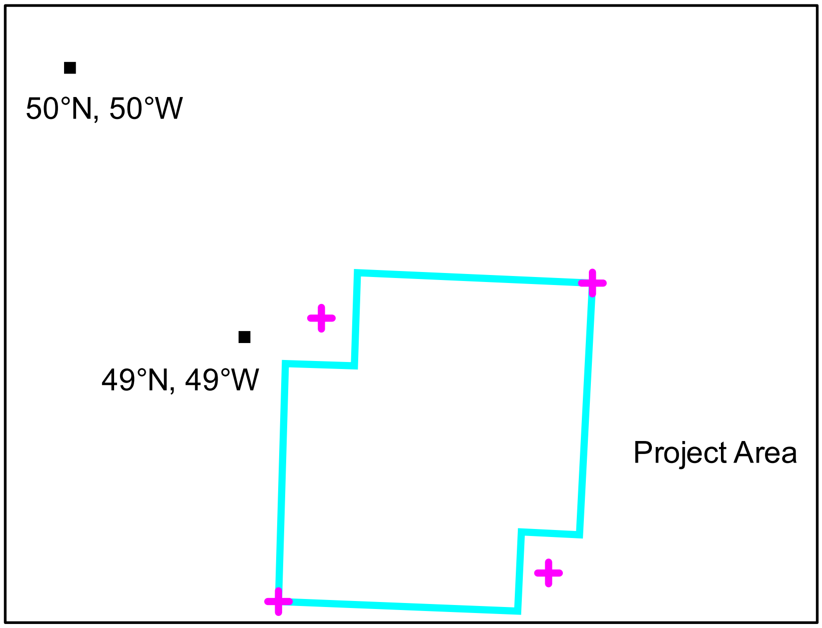


Figure 5-38 Project Area Locations (+) Used for Sea Ice Characterization

Table 5.17 Frequency of Presence of Sea Ice (%)

Frequency of Presence of Sea Ice (%)

Week	Project Area - Northwest	Project Area - Northeast	Project Area - Southwest	Project Area - Southeast
Jan 08	0%	0%	0%	0%
Jan 15	0%	0%	1-15%	1-15%
Jan 22	0%	0%	1-15%	0%
Jan 29	1-15%	0%	1-15%	1-15%
Feb 05	1-15%	0%	16-33%	1-15%
Feb 12	16-33%	0%	16-33%	16-33%
Feb 19	16-33%	0%	34-50%	16-33%
Feb 26	1-15%	1-15%	34-50%	16-33%
Mar 05	1-15%	0%	34-50%	16-33%
Mar 12	1-15%	1-15%	34-50%	1-15%
Mar 19	1-15%	0%	34-50%	16-33%
Mar 26	16-33%	0%	34-50%	1-15%
Apr 02	1-15%	0%	34-50%	16-33%
Apr 09	1-15%	0%	16-33%	1-15%
Apr 16	1-15%	0%	1-15%	1-15%
Apr 23	0%	0%	16-33%	0%
Apr 30	1-15%	0%	1-15%	1-15%
May 07	0%	0%	1-15%	0%
May 14	0%	0%	0%	0%
May 21	0%	0%	1-15%	0%
May 28	0%	0%	1-15%	0%
Jun 04	0%	0%	0%	0%

Legend

0%	51-66%
1-15%	67-84%
16-33%	85-99%
34-50%	100%

Source: based on CIS 2011

Table 5.18 Median of Ice Concentration, When Ice is Present

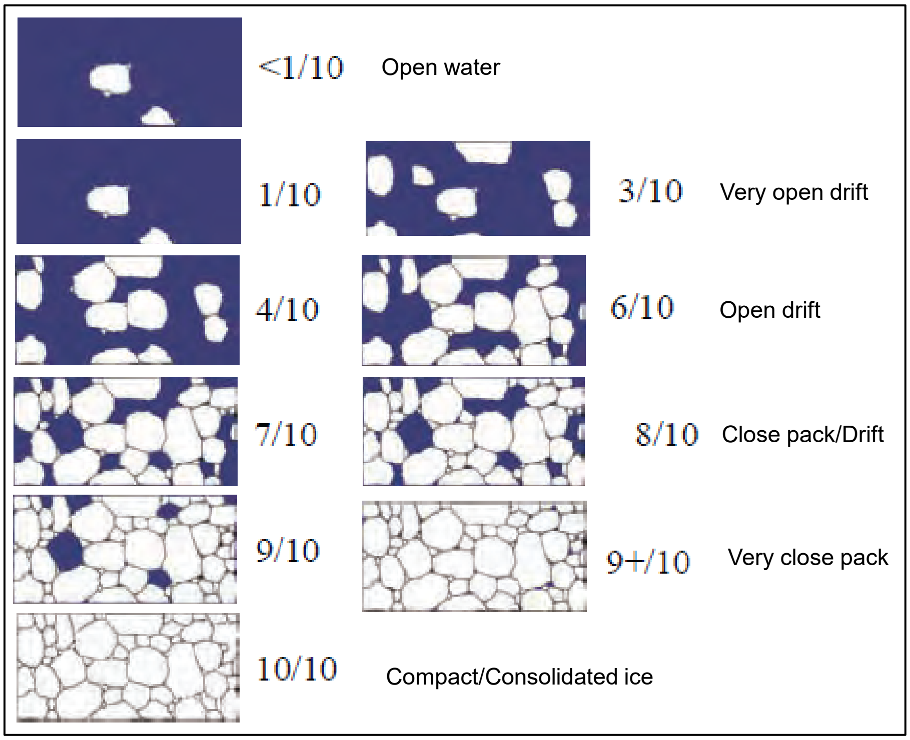
Median of Ice Concentration When Ice is Present

Week	Project Area - Northwest	Project Area - Northeast	Project Area - Southwest	Project Area - Southeast
Jan 08	less than 1/10	less than 1/10	less than 1/10	less than 1/10
Jan 15	less than 1/10	less than 1/10	1-3/10	1-3/10
Jan 22	less than 1/10	less than 1/10	9-9+1/0	less than 1/10
Jan 29	7-8/10	less than 1/10	7-8/10	7-8/10
Feb 05	4-6/10	less than 1/10	4-6/10	9-9+1/0
Feb 12	4-6/10	less than 1/10	7-8/10	4-6/10
Feb 19	7-8/10	less than 1/10	7-8/10	7-8/10
Feb 26	9-9+1/0	4-6/10	7-8/10	7-8/10
Mar 05	4-6/10	less than 1/10	7-8/10	1-3/10
Mar 12	4-6/10	1-3/10	7-8/10	7-8/10
Mar 19	1-3/10	less than 1/10	7-8/10	7-8/10
Mar 26	4-6/10	less than 1/10	7-8/10	7-8/10
Apr 02	1-3/10	less than 1/10	7-8/10	7-8/10
Apr 09	9-9+1/0	less than 1/10	4-6/10	1-3/10
Apr 16	7-8/10	less than 1/10	1-3/10	4-6/10
Apr 23	less than 1/10	less than 1/10	4-6/10	less than 1/10
Apr 30	1-3/10	less than 1/10	1-3/10	1-3/10
May 07	less than 1/10	less than 1/10	1-3/10	less than 1/10
May 14	less than 1/10	less than 1/10	less than 1/10	less than 1/10
May 21	less than 1/10	less than 1/10	1-3/10	less than 1/10
May 28	less than 1/10	less than 1/10	1-3/10	less than 1/10
Jun 04	less than 1/10	less than 1/10	less than 1/10	less than 1/10

Legend

(blue)	less than 1/10	(orange)	7-8/10
(green)	1-3/10	(red)	9-9+1/0
(yellow)	4-6/10	(grey)	10/10

Source: based on CIS 2011



Source: CIS (2005)

Figure 5-39 Ice Concentrations from an Aerial Perspective

Table 5.19 Median of Predominant Ice Type, When Ice is Present

Week	Median of Predominant Ice Type When Ice is Present			
	Project Area - Northwest	Project Area - Northeast	Project Area - Southwest	Project Area - Southeast
Jan 08	Open or Bergy Water	Open or Bergy Water	Open or Bergy Water	Open or Bergy Water
Jan 15	Open or Bergy Water	Open or Bergy Water	Grey-White Ice	Grey-White Ice
Jan 22	Open or Bergy Water	Open or Bergy Water	Grey Ice	Open or Bergy Water
Jan 29	Grey Ice	Open or Bergy Water	Grey Ice	Grey-White Ice
Feb 05	Grey-White Ice	Open or Bergy Water	Grey Ice	Grey-White Ice
Feb 12	Grey Ice	Open or Bergy Water	Grey-White Ice	Grey-White Ice
Feb 19	Thin FY Ice	Open or Bergy Water	Grey-White Ice	Thin FY Ice
Feb 26	Thin FY Ice	Thin FY Ice	Thin FY Ice	Thin FY Ice
Mar 05	Thin FY Ice	Open or Bergy Water	Thin FY Ice	Thin FY Ice
Mar 12	Thin FY Ice	Thin FY Ice	Thin FY Ice	Thin FY Ice
Mar 19	Medium FY Ice	Open or Bergy Water	Thin FY Ice	Medium FY Ice
Mar 26	Thin FY Ice	Open or Bergy Water	Medium FY Ice	Thin FY Ice
Apr 02	Thin FY Ice	Open or Bergy Water	Thin FY Ice	Thin FY Ice
Apr 09	Thick FY Ice	Open or Bergy Water	Medium FY Ice	Medium FY Ice
Apr 16	Thick FY Ice	Open or Bergy Water	Medium FY Ice	Thin FY Ice
Apr 23	Open or Bergy Water	Open or Bergy Water	Thick FY Ice	Open or Bergy Water
Apr 30	Medium FY Ice	Open or Bergy Water	Thick FY Ice	Old Ice
May 07	Open or Bergy Water	Open or Bergy Water	Thick FY Ice	Open or Bergy Water
May 14	Open or Bergy Water	Open or Bergy Water	Open or Bergy Water	Open or Bergy Water
May 21	Open or Bergy Water	Open or Bergy Water	Thick FY Ice	Open or Bergy Water
May 28	Open or Bergy Water	Open or Bergy Water	Thick FY Ice	Open or Bergy Water
Jun 04	Open or Bergy Water	Open or Bergy Water	Open or Bergy Water	Open or Bergy Water

Legend

Open or Bergy Water	Thin FY Ice
New Ice	Medium FY Ice
Grey Ice	Thick FY Ice
Grey-White Ice	Old Ice

Source: based on CIS 2011

Table 5.20 Stage of Development, Sea Ice

Description	Thickness
New	<10 cm
Grey	10-15 cm
Grey-white	15-30 cm
First-year	≥30 cm
Thin first-year	30-70 cm
Medium first-year	70-120 cm
Thick first-year	>120 cm
Source: CIS (2005)	

In general, for this part of the Northwest Atlantic Ocean, for a given week during the ice season, the sea ice is more likely of greater concentration and thickness in the western portions and less severe farther offshore to the east. With passing weeks, as the ice advances, there is potential that thicker sea ice to the west and north will continue to drift farther offshore (south and east).

There is potential for landfast ice nearshore. Landfast ice forms and remains fast along the coast and can extend from a few metres to several hundred kilometres offshore. Landfast ice has the potential to influence conditions for vessel traffic near to St. John's; however, it is unlikely to be a factor in the Project Area itself.

5.7.1.1 Southwestern Quadrant

Within the Project Area, sea ice is most prevalent over the southwestern quadrant as this region sees the greatest influx of ice that drifts south from Labrador and the northeast coast of Newfoundland and east over the Newfoundland Shelf, Orphan Basin and Flemish Pass. The following discussions are with reference to Table 5.17 to Table 5.19.

Ice is present here as early as the week of 15 January and as late as the last week of May, although in May it is only in the form of small intrusions into the western portion of the Project Area. During the last half of January the frequency of presence of sea ice is 1 to 15%, or about as frequent as every six or seven years. The likelihood of ice presence increases to 16 to 33% the first two weeks of February, can then be expected up to one-half of the time until the first week of April, and is then less likely at 1 to 15% most weeks until the end of May and just in patches over the southwest portion of the Project Area.

When ice is present, the median ice concentration over the southwest quadrant of the Project Area the week of 15 January is 1 to 3/10 and increases to 4 to 6/10 or as great as 9 to 9+1/10 the week of 22 January. From late January through the first week of April, the median ice concentration is at least 4 to 6/10 and most weeks as great as 7 to 8/10. For the remainder of April, when present, median ice concentrations are 1 to 3/10 and 4 to 6/10. By May any small areas of ice are 1 to 3/10 median ice concentration.

The median of the predominant ice type, when ice is present, from mid-January to mid-February ranges from grey ice (10-15 cm) to grey-white ice (15-30 cm). From the end of February through mid-late March, ice is predominantly thin first-year (FY) ice (ice of not more than one winter's growth, 30-70 cm). Medium FY ice (70-120 cm) becomes the predominant ice type over most of the southwest quadrant of the Project

Area through mid-late April with Thick FY ice (>120 cm) occurring by early April. Thick FY ice is the predominant ice type, when ice is present, through the end of April and then, just in small portions over the southwest in otherwise open water, until the end of May. Some areas of old ice (ice that has survived at least one summer's melt; second year ice will be generally thicker than FY ice) may be encountered over the central portions of the Project Area the latter half of April in concentrations of 1 to 3/10.

5.7.1.2 Northwestern Quadrant

Over the northwestern quadrant of the Project Area, there is a 1 to 15% likelihood of sea ice in a given week from the end of January to the end of April: during the week of 23 April the quadrant is generally ice free. During the middle of February and last week of March the likelihood increases to 16 to 33%. During the week of 2 July, the atlas reports a 1 to 15% likelihood of old ice in concentrations of 1 to 3/10. From the end of January through the end of March median ice concentrations when ice is present are variable across the northwest quadrant in any week generally ranging from 1 to 3/10 concentration up to 7 to 8/10. Median ice concentrations as large as 9 to 9+/10 have been encountered here during the last two weeks of February and over some very small areas of the quadrant during the first two weeks of April, otherwise median concentrations are unlikely to exceed 1 to 3/10.

The median of predominant ice type when ice is present from late January to the second week of February is grey or grey-white ice and then through to the first week of April becomes thin FY ice. Some medium FY ice is present in the quadrant as early as mid-March and by the first two weeks in April when ice is present, the predominant ice type is thick FY ice with some areas of old ice. The potential for old ice exists during the middle and end of April across the central one third of the Project Area.

5.7.1.3 Southeastern Quadrant

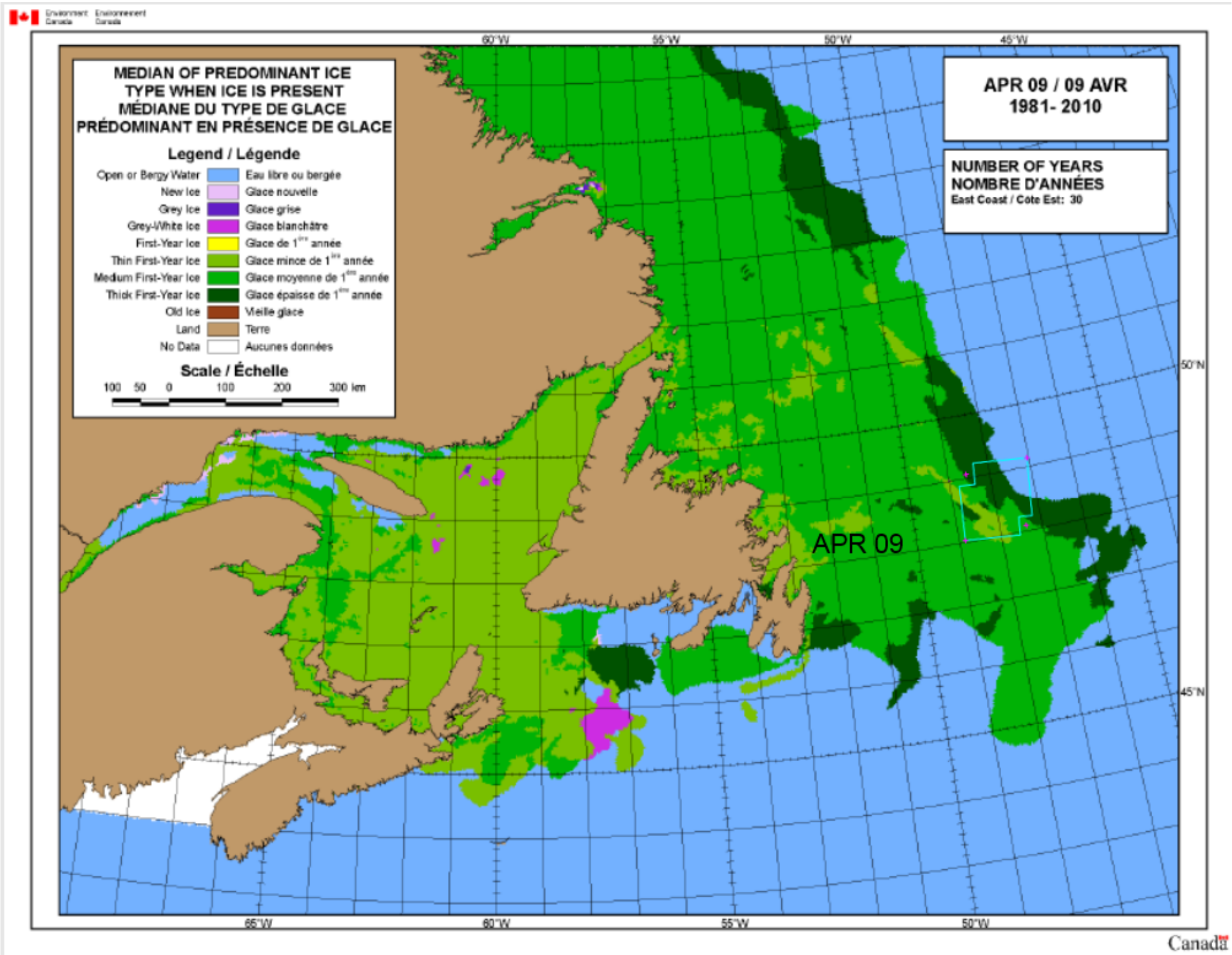
The likelihood of sea ice presence in the southeastern quadrant of the Project Area is slightly less than for the southwestern quadrant, being 1 to 15% through the week of 5 February and increasing to 16 to 33% most weeks until the week of 2 April. Subsequently, the frequency of sea ice presence drops to 1 to 15% of the time or is zero percent until the end of April. While there are some areas in the very southeastern tip of the Project Area as early as the week of 5 February with a median ice concentration of 9 to 9+/10, the median ice concentration when ice is present can range from 1 to 3/10, to 7 to 8/10 most weeks until the first week of April. The median ice concentration, when ice is present is 4 to 6/10 or less subsequently.

The median of predominant ice type when ice is present from mid-January to the second week of February is grey or grey-white ice and then, similar to the southwestern quadrant, is thin to medium FY ice until the end mid-April. Some thick FY ice is present to the east in the quadrant the week of 9 April followed by some old ice which is the median of the predominant ice type when present for the week of 16 April. The quadrant is generally free by the first week of May.

5.7.1.4 Northeastern Quadrant

Based on the atlas, sea ice in the northeastern quadrant of the Project Area is infrequent with a likelihood of occurrence of 1 to 15%, occurring from the end of February to mid-March, predominantly as thin FY ice and in concentrations of 1 to 3/10 and 4 to 6/10.

The week of 9 April (illustrated in Figure 5-40) shows the median of predominant ice type when the ice season is at its peak in terms of ice extent with presence of thick FY ice (>120 cm) over the Project Area.



Source: CIS (2011)

Figure 5-40 Median of Predominant Ice Type When Ice Is Present, Week of Apr 9

Further information on regional ice conditions in this area is provided in the Eastern Newfoundland SEA (AMEC 2014), Section 4.1.5 of the SEA.

5.7.2 Icebergs

The east coast of NL extending out to and including the Project Area frequently experiences icebergs in their journeys south from the fjords of Greenland. Icebergs are masses of freshwater ice which calve each year from the glaciers along west Greenland. A small number of icebergs originate from east Greenland. Icebergs are moved by both the wind and ocean currents, and typically spend one to three years travelling a distance up to approximately 2,900 km (1,800 miles) to the waters of NL. The West Greenland and Labrador Currents are major ocean currents, which move the icebergs around the Davis Strait, along the coast of Labrador, to the northern bays of NL, and to the Flemish Pass and the Grand Banks.

Icebergs will deteriorate in their drift southwards due to warmer sea temperatures and wave erosion. For example, the number of days required to melt a 100 m length iceberg ranges from 179 days at a SST of -1°C to 12 days at 6°C and five days at 15°C; this assumes a wave height of approximately 2 m, wave period of 10 s and relative drift velocity of 25 cm/s (US Coast Guard Navigation Center 2009). Icebergs in sea ice may be less subject to wave erosion. Smaller icebergs are more difficult to detect in sea ice.

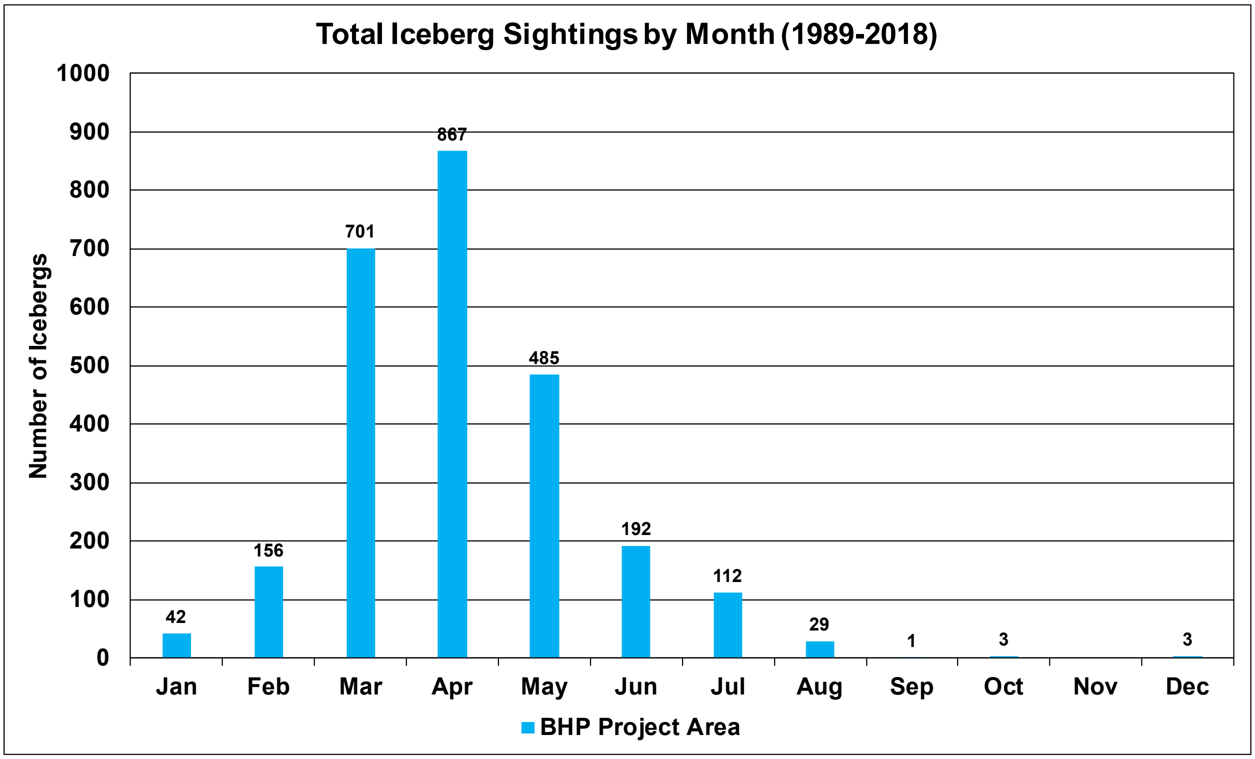
While each year is different, icebergs will typically appear offshore Newfoundland by February or March. Easterly and northeasterly winds will have the effect of moving icebergs towards the Newfoundland coast. Their usual path is southward with the ocean currents. The summary of iceberg sightings for the Project Area presented here is based on two data sets. The comprehensive National Research Council-Program of Energy Research and Development (NRC-PERD) Iceberg Sighting Database (Sudom et al. 2014; NRC 2019) contains iceberg sightings from various sources including industry, aircraft and ship, and include radar, visual and measured observations. The latest version of the database contains icebergs through 2018. Confidential observations acquired by PAL Aerospace for the east coast operators for 2014 onwards are excluded from this analysis; observations from 2014 through 2018 are from the International Ice Patrol (IIP).

Statistics for observations for the past 30 years, 1989-2018, are reported. Iceberg re-sightings in the database are ignored; the first observation of an iceberg in the Project Area is included.

Iceberg size classes range from growlers (less than 1 m above water, less than 5 m in length and mass approximately 0.001 Mt) to very large icebergs (greater than 75 m in height, greater than 200 m in length, and mass over 10 Mt) (Figure 2.3 in CIS 2005). Icebergs of unknown size are also reported.

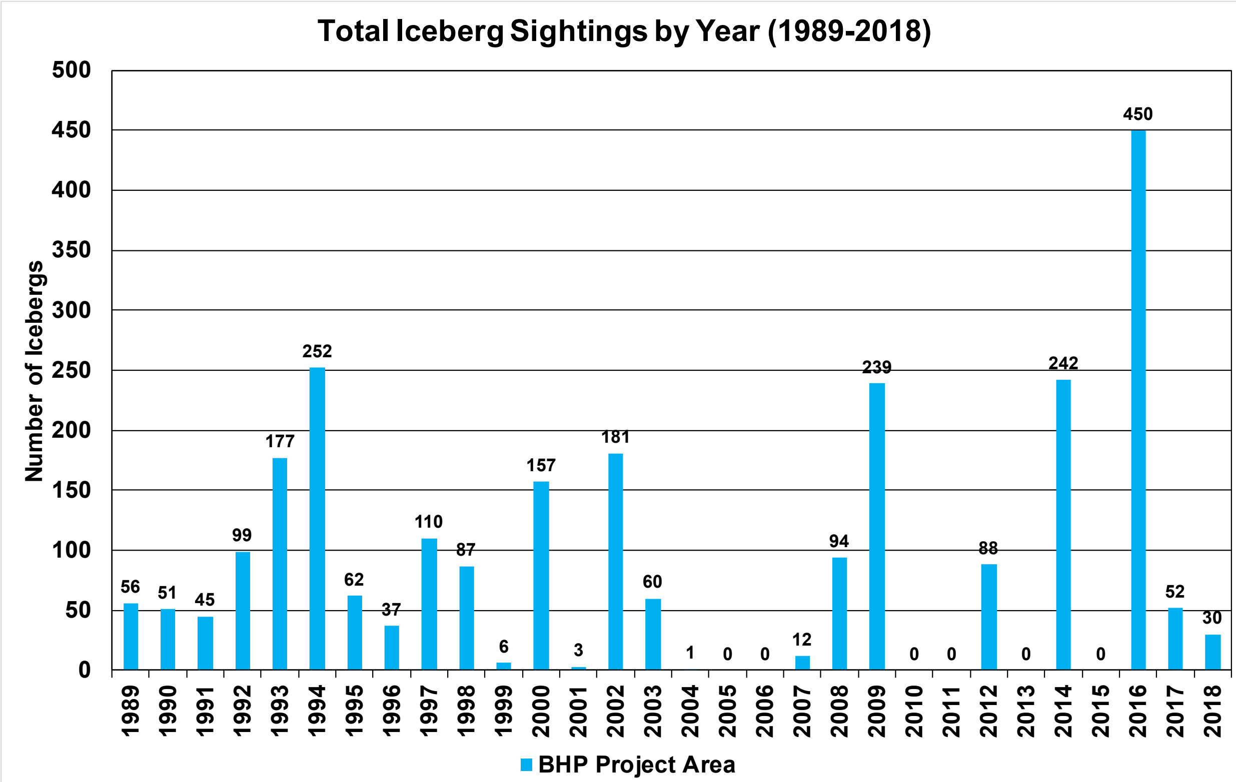
The query of the NRC-PERD plus IIP databases, for the years 1989 to 2018, yields a total of 2,591 icebergs for the Project Area. Statistics for the number of icebergs by month and by year are presented in Figure 5-41 and Figure 5-42. A companion Table 5.21 reports iceberg counts by month and year.

Icebergs have been observed in the Project Area in all months except November. The greatest number, 2,053 or 79%, occur from March through May. The vast majority, 2,513 or 97%, of iceberg observations occur from February to July (Figure 5-41).



Source: Based on NRC (2019)

Figure 5-41 Iceberg Sightings by Month (1989-2018)



Source: Based on NRC (2019)

Figure 5-42 Iceberg Sightings by Year (1989-2018)

Table 5.21 Iceberg Sightings by Month and Year, Project Area (1989-2018)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1989	0	13	13	14	7	8	1	0	0	0	0	0	56	2.2%
1990	0	5	4	14	13	9	4	2	0	0	0	0	51	2.0%
1991	0	8	0	0	9	12	15	1	0	0	0	0	45	1.7%
1992	0	4	10	19	8	26	8	19	1	3	0	1	99	3.8%
1993	42	41	64	7	12	8	3	0	0	0	0	0	177	6.8%
1994	0	12	77	63	32	28	35	5	0	0	0	0	252	9.7%
1995	0	15	25	8	2	5	6	1	0	0	0	0	62	2.4%
1996	0	3	0	4	13	7	10	0	0	0	0	0	37	1.4%
1997	0	15	62	21	10	0	2	0	0	0	0	0	110	4.2%
1998	0	1	0	20	57	9	0	0	0	0	0	0	87	3.4%
1999	0	0	0	0	1	5	0	0	0	0	0	0	6	0.2%
2000	0	5	30	87	33	2	0	0	0	0	0	0	157	6.1%
2001	0	0	0	0	1	2	0	0	0	0	0	0	3	0.1%
2002	0	2	33	97	41	8	0	0	0	0	0	0	181	7.0%

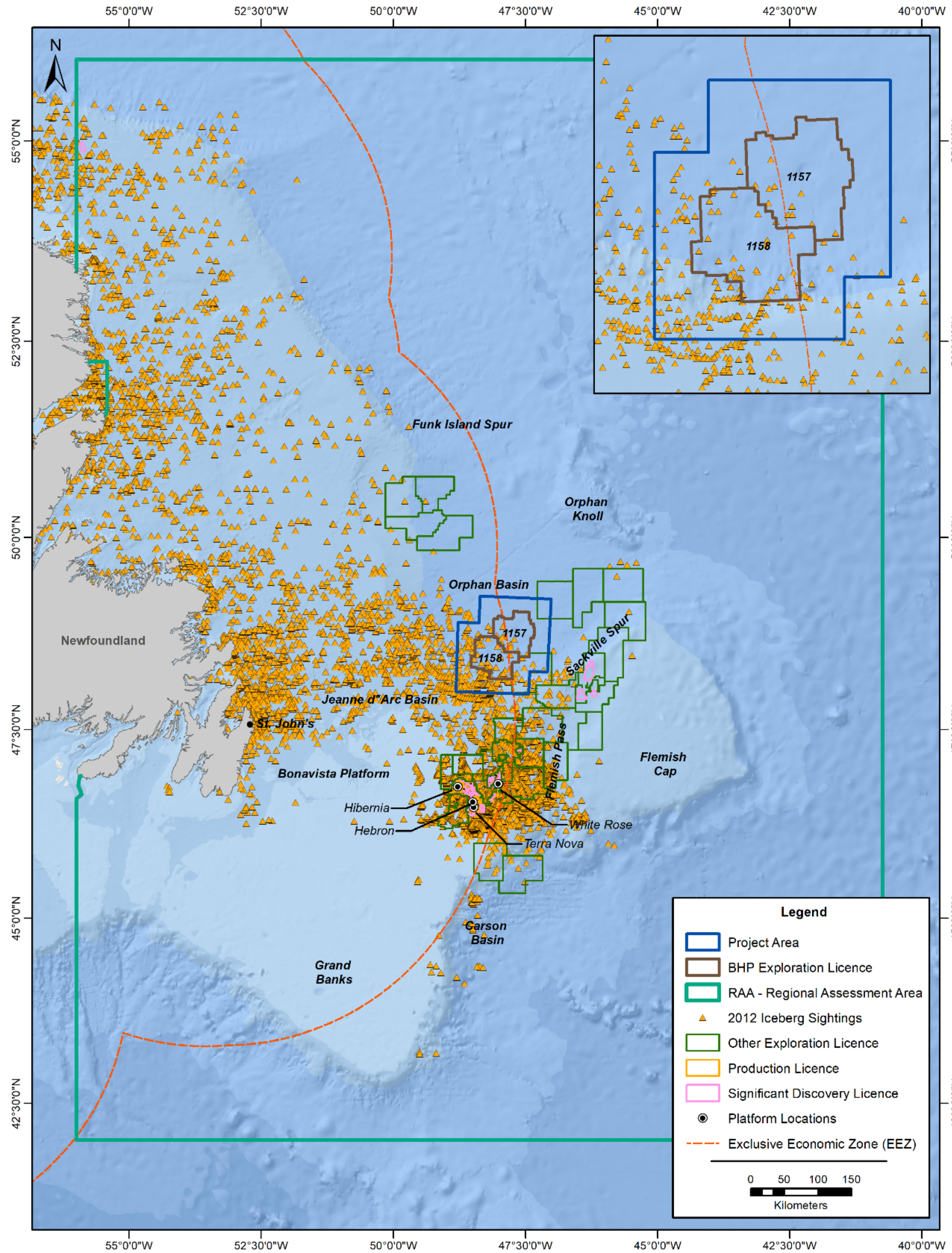
Table 5.21 Iceberg Sightings by Month and Year, Project Area (1989-2018)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
2003	0	0	4	26	27	2	1	0	0	0	0	0	60	2.3%
2004	0	0	0	0	0	0	1	0	0	0	0	0	1	0.04%
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2007	0	0	0	0	3	2	6	1	0	0	0	0	12	0.5%
2008	0	0	27	63	1	3	0	0	0	0	0	0	94	3.6%
2009	0	3	47	26	117	34	12	0	0	0	0	0	239	9.2%
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2012	0	0	0	66	22	0	0	0	0	0	0	0	88	3.4%
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2014	0	21	92	124	2	0	3	0	0	0	0	0	242	9.3%
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2016	0	6	169	198	55	16	4	0	0	0	0	2	450	17.4%
2017	0	1	43	6	0	1	1	0	0	0	0	0	52	2.0%
2018	0	1	1	4	19	5	0	0	0	0	0	0	30	1.2%
Total	42	156	701	867	485	192	112	29	1	3	0	3	2,591	
%	1.6%	6.0%	27.1%	33.5%	18.7%	7.4%	4.3%	1.1%	0.04%	0.1%	0.0%	0.1%		
Source Based on NRC (2019)														

Although the monthly iceberg totals are largest in March and April, icebergs have been present most frequently in May for 22 of the 30 years, compared with 19 of the 30 years in April. April's total of icebergs sighted, 867, is the largest monthly total and one third of the total icebergs observed in the Project Area from 1989 to 2018. The 42 January icebergs occurred in 1993; most of the August, the one September iceberg and the 3 October icebergs occurred in 1992.

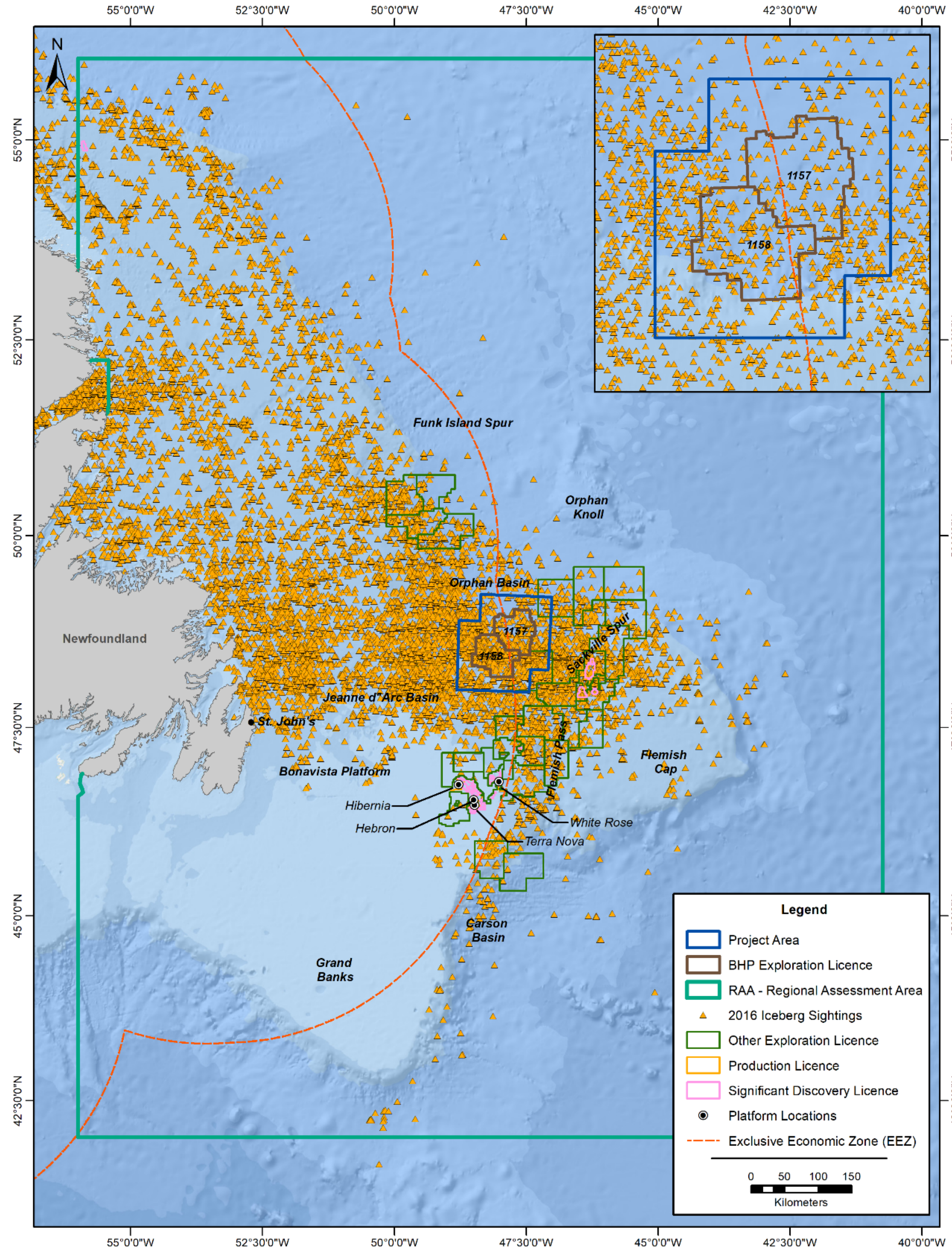
Icebergs were present in the Project Area for 24 of the past 30 years with the greatest number of 450 in 2016 (Figure 5-40) and an annual average of 86. The median number of icebergs each year is 54.

An illustration of a recent 'typical' average iceberg year for the Project Area is shown in Figure 5-43 for 2012 (with 88 icebergs in the Project Area compared with the 30 year historical mean of 86) where iceberg sightings (including re-sightings) are illustrated. A maximum or 'extreme' iceberg year, 2016, with a total of 450 icebergs, is shown in Figure 5-44. As illustrated in the general distribution of icebergs is to the southwestern half of the Project Area, with increased numbers to the northeast during a heavier iceberg season.



Source Based on NRC (2019)

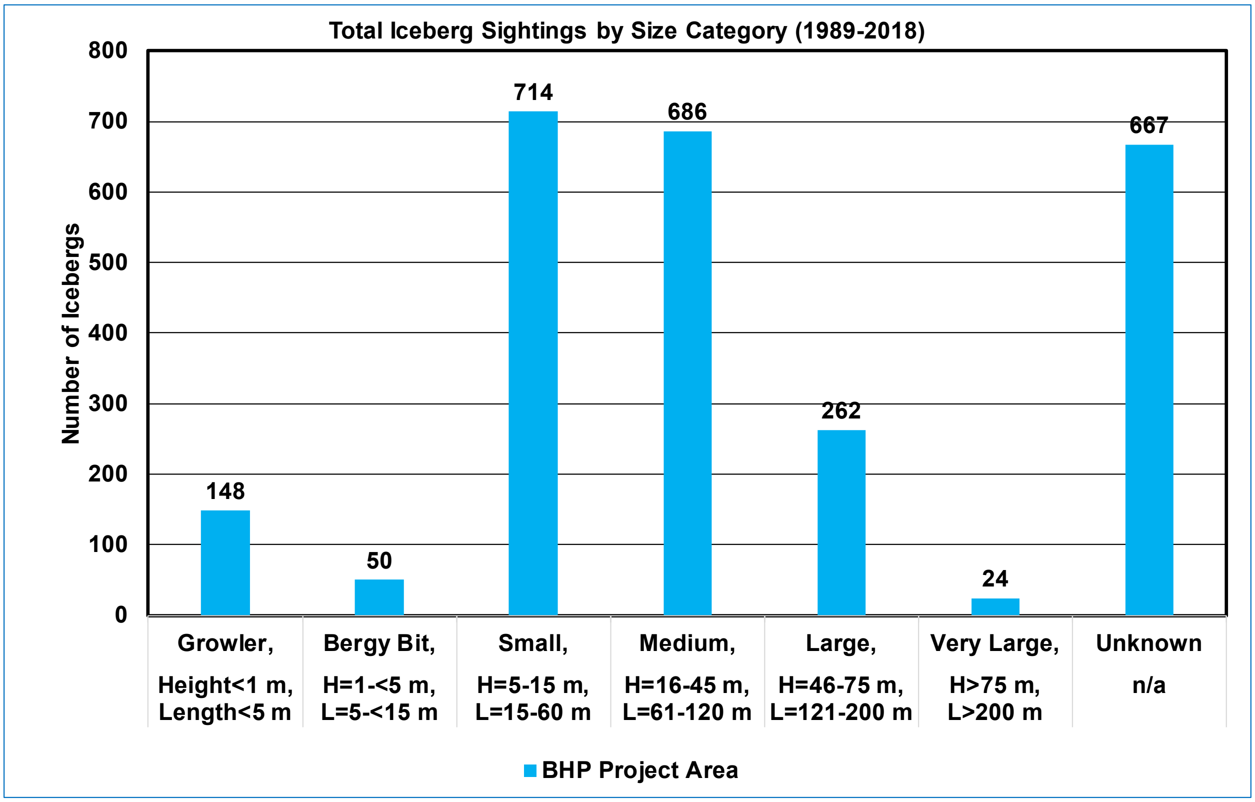
Figure 5-43 Recorded Icebergs Sightings in 2012 ("typical"), Newfoundland Offshore



Source: Based on NRC (2019)

Figure 5-44 Recorded Icebergs Sightings in 2016 (“extreme”), Newfoundland Offshore

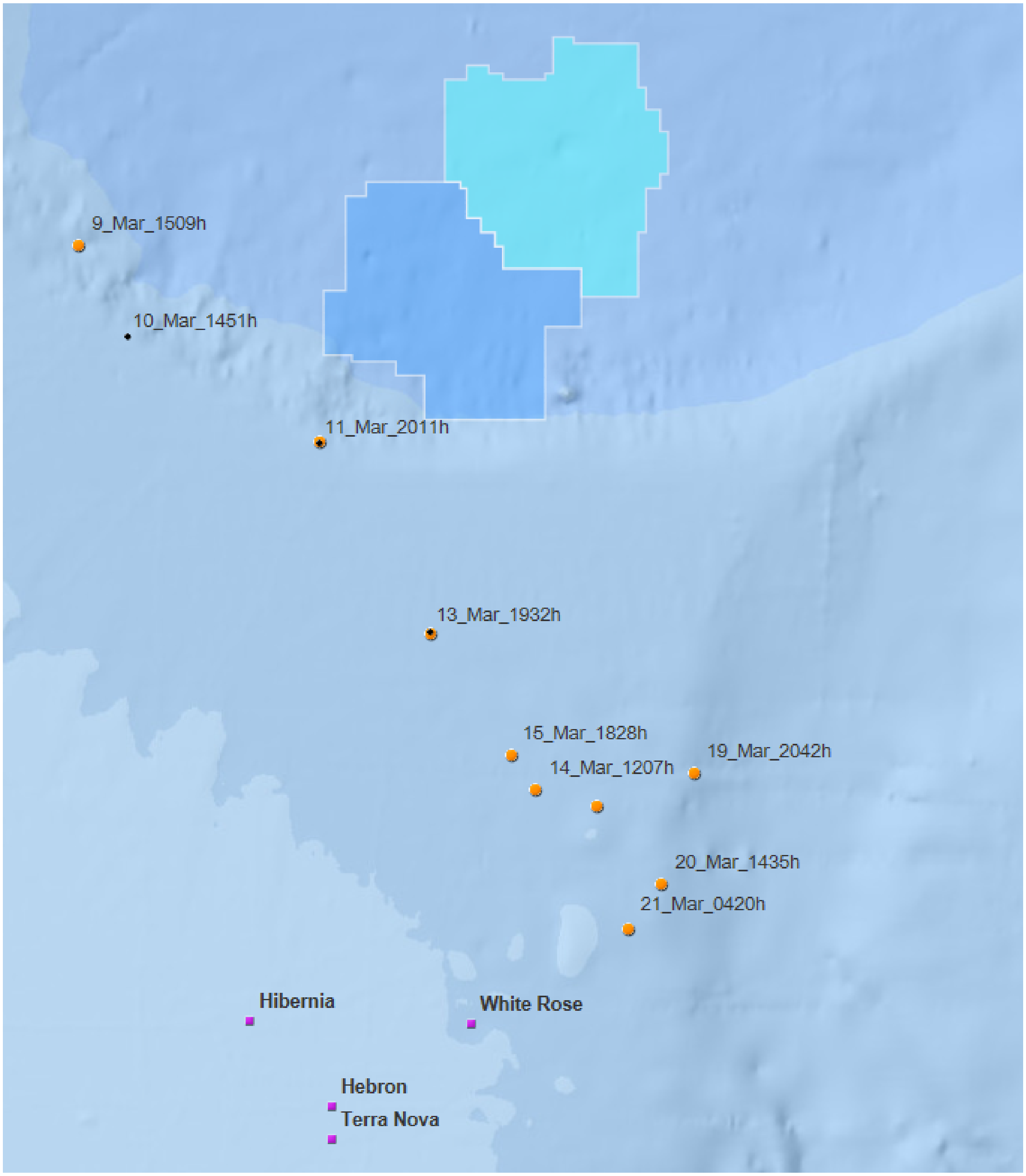
A total of 98% of the iceberg observations have a size reported. In instances where there are multiple sightings of the same iceberg and different sizes are reported, the largest size is used (e.g., for an iceberg with size values of unknown, small and medium, the medium size class is selected). Icebergs of size 'general' have been grouped with those of unknown size. The iceberg size distribution is shown in Figure 5-45. Of the 2,551 icebergs in the Project Area, from the 1989 to 2018 query, where size is known, 10.5% are growlers or bergy bits, 74% are small or medium, 13.9% are large, and 1.3% (24 icebergs) are very large.



Source: Based on NRC (2019)

Figure 5-45 Iceberg Sightings by Size Category (1989-2018)

The largest iceberg in the database is a drydock (an iceberg eroded such that a large U shape slot is formed with twin columns or pinnacles. The slot extends under the waterline or close to it) iceberg with estimated measurements of length 230 m, width 122 m, height 41 m, draft 151 m and mass 1.2 Mt. This iceberg was observed 11 March 2000 approximately 24 km northeast of the southwest corner of the Project Area. The iceberg's drift track for the period 9 to 21 March is illustrated in Figure 5-46 with a southeasterly drift along the Newfoundland Shelf and across the northern Grand Banks.



Source: Based on NRC (2019)

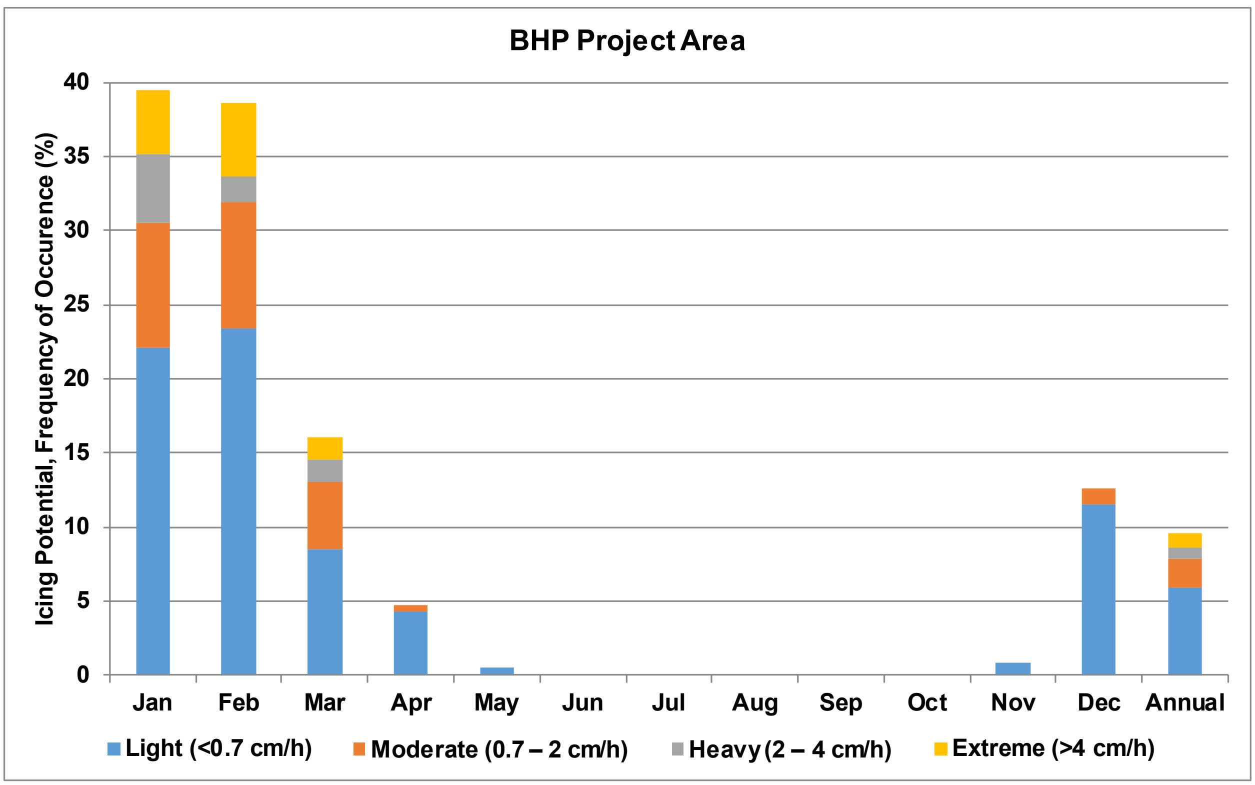
Figure 5-46 Large Iceberg 3 Drift Trajectory, 9-21 March 2000

5.7.3 Marine Icing

Marine icing, most frequently from freezing spray, is a marine condition that can hinder and limit shipboard or production installation activities and increase a vessel's weight and alter its centre of gravity. Freezing spray is most likely to occur from November through April. Air temperatures must be lower than -2°C to produce freezing spray in saltwater. Icing conditions worsen with colder temperatures, high winds, and large waves (Bowyer 1995).

A standardized way to determine the potential ice build-up rate has been developed by Overland (1990), which bases an algorithm on empirical observations and the heat balance equation of an icing surface. This algorithm has been used to derive estimates of icing potential by using concurrent air and sea temperature and wind speed data from ICOADS. The results have been sorted into four different categories based on the severity (light, moderate, heavy, and extreme), and are summarized below.

The icing potential for vessels in the Project Area (Figure 5-47) is greatest in January and February approaching 40%, with a 16% likelihood in March, 13% in December and less than 5% in April. The frequency of occurrence for moderate, heavy, or extreme icing potential is greatest in January and February at 17.4 and 15.2% respectively. Extreme icing potential is greatest in February at 5%. No icing potential is reported for June through October. Annually, the frequency of occurrence of icing is 9.6% with 5.9% of that being light icing.



Source: Based on Research Data Archive et al. (2019)

Figure 5-47 Icing Potential (ICOADS), Project Area, 1980-2019

5.8 Climate Change

Climate change refers to a long-term change in the magnitude, variability and timing of the various elements of Earth's climate system, including the atmosphere, ocean and cryosphere. Global scale scientific assessments regularly conducted by the Intergovernmental Panel on Climate Change (IPCC) indicate climate change is one of the defining challenges of the 21st century (Bush and Lemmen 2018). While climate change will likely have some influence on the aspects of the climate system on a global scale, the magnitude and timing of these impacts will vary regionally.

Most scientific studies of climate change rely on model-generated projections from Global Climate Models (GCMs), which are dynamical system-based models of complex interactions between physical processes in the atmosphere, ocean, cryosphere and land surface. Emissions of GHGs from human activity will largely determine the magnitude of climate change over the next century. Four Representative Concentration Pathways (RCPs) were adopted by the IPCC for its Fifth Assessment Report (AR5) to describe alternative trajectories for GHG emissions and the resulting atmospheric GHG concentrations from the year 2000 to 2100.Climate change projections discussed herein are primarily based on RCP 4.5 (a moderate emissions scenario that would require substantial reductions from current emission levels) and RCP 8.5 (a high, or business-as-usual, emissions scenario).

GCMs produce results at a coarse resolution (e.g., between 80 to 400 km), which are then downscaled to finer spatial scales (e.g., 10 to 50 km). As each GCM provides a slightly different conceptualization of the earth-atmosphere system, the IPCC recommends using an ensemble of models which would be capable of providing a better characterization of the future and its uncertainty than any single model.

It is best practice to take a regional perspective to account for uncertainty and this section discusses general climate change considerations relevant to the Orphan Basin and offshore NL and is organized according to atmospheric variables (wind, temperature, precipitation and storms), oceanographic variables (ocean-water temperatures, waves, currents and sea level), and cryospheric variables (sea ice and icebergs).

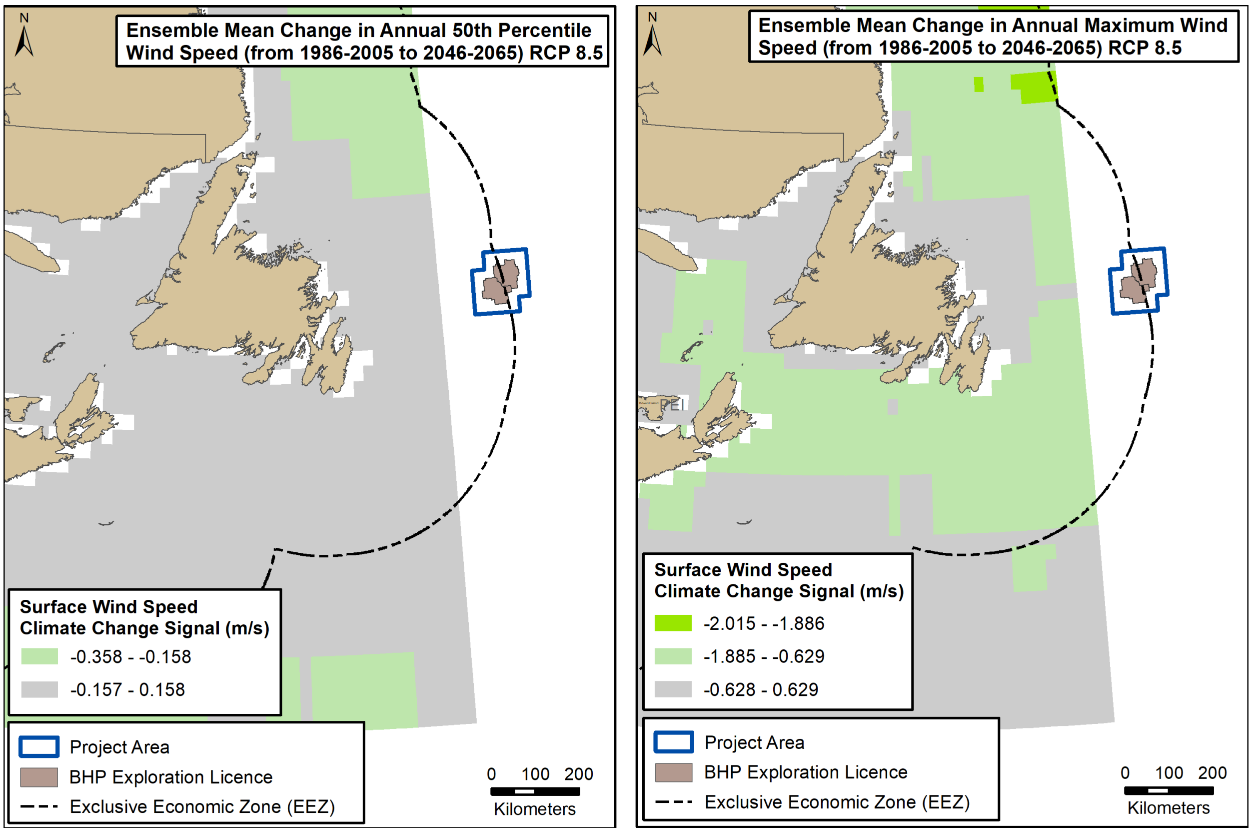
5.8.1 Atmospheric Climate Changes

5.8.1.1 Wind

Confidence over global estimates of changes to surface wind speed is low in comparison to other variables (e.g., temperature and precipitation), in part due to limited evidence (e.g., sparse observations and challenges associated with the integration and assessment of early marine observations and instrument records) (Hartmann et al. 2013; Bush and Lemmen 2018).

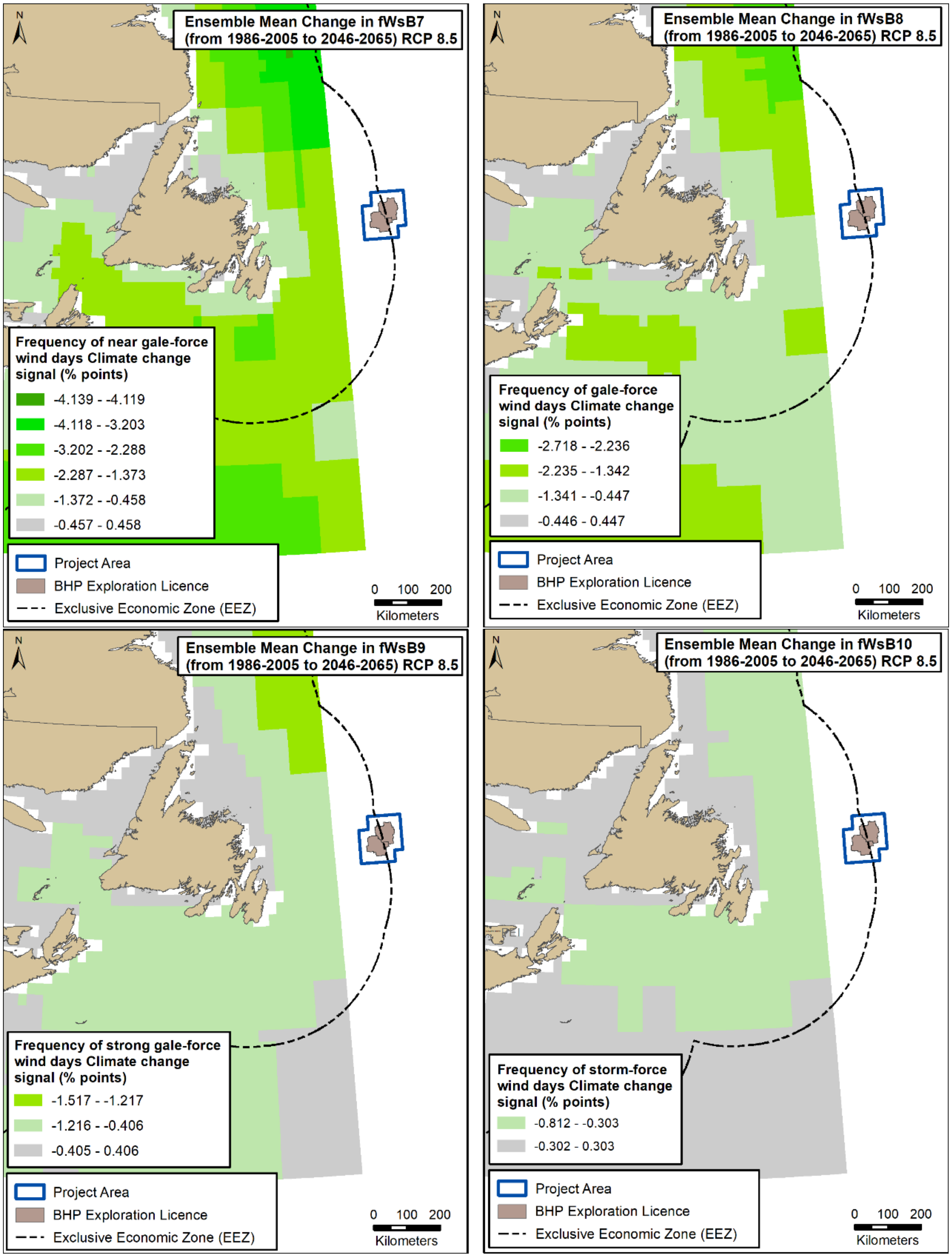
Regional studies have attempted to estimate how other atmospheric changes (e.g., air temperature) may impact wind speed and direction. Cheng et al. (2014) indicate the frequency of high-speed hourly wind gusts in Atlantic Canada could increase under both medium and high GHG emissions scenarios by the mid-21st century (e.g., the frequency of gusts over 90 km/h could double and the frequency of gusts over 70 km/h could increase by approximately 20 percent).

In a more recent study using the latest generation GCMs and emissions scenarios (AMEC Foster Wheeler 2017a), median and maximum annual sustained (hourly average) wind speeds were projected to decrease slightly or remain unchanged over the coming decades along main transport routes adjacent to the Project Area, as shown in Figure 5-48 and Figure 5-49. The AMEC Foster Wheeler (2017a) report also found that mean monthly wind directions are not expected to deviate from present day. Although the Project Area is outside of the modeling domain, given the high spatial consistency in the analysis results, it can be inferred that the projected impacts of climate change on wind speed in the project area will be similarly negligible.



Source: AMEC Foster Wheeler (2017a)

Figure 5-48 Projected Changes in Median (Left) and Maximum (Right) Annual Sustained Wind Speeds for the Mid-21st Century, Using Six-Member Climate Model Ensemble Forced by the RCP 8.5 Greenhouse Gas Emissions Scenario



Source: AmecAMEC Foster Wheeler (2017a)

Figure 5-49 Projected Changes in the Annual Percentage of Days When Daily Max Wind Speed Is >14.4 m/s (fWsB7, Top Left), >17.2 m/s (fWsB8, Top Right), >20.8 m/s (fWsB9, Bottom Left), and >24.7 m/s (fWsB10, Bottom Right)

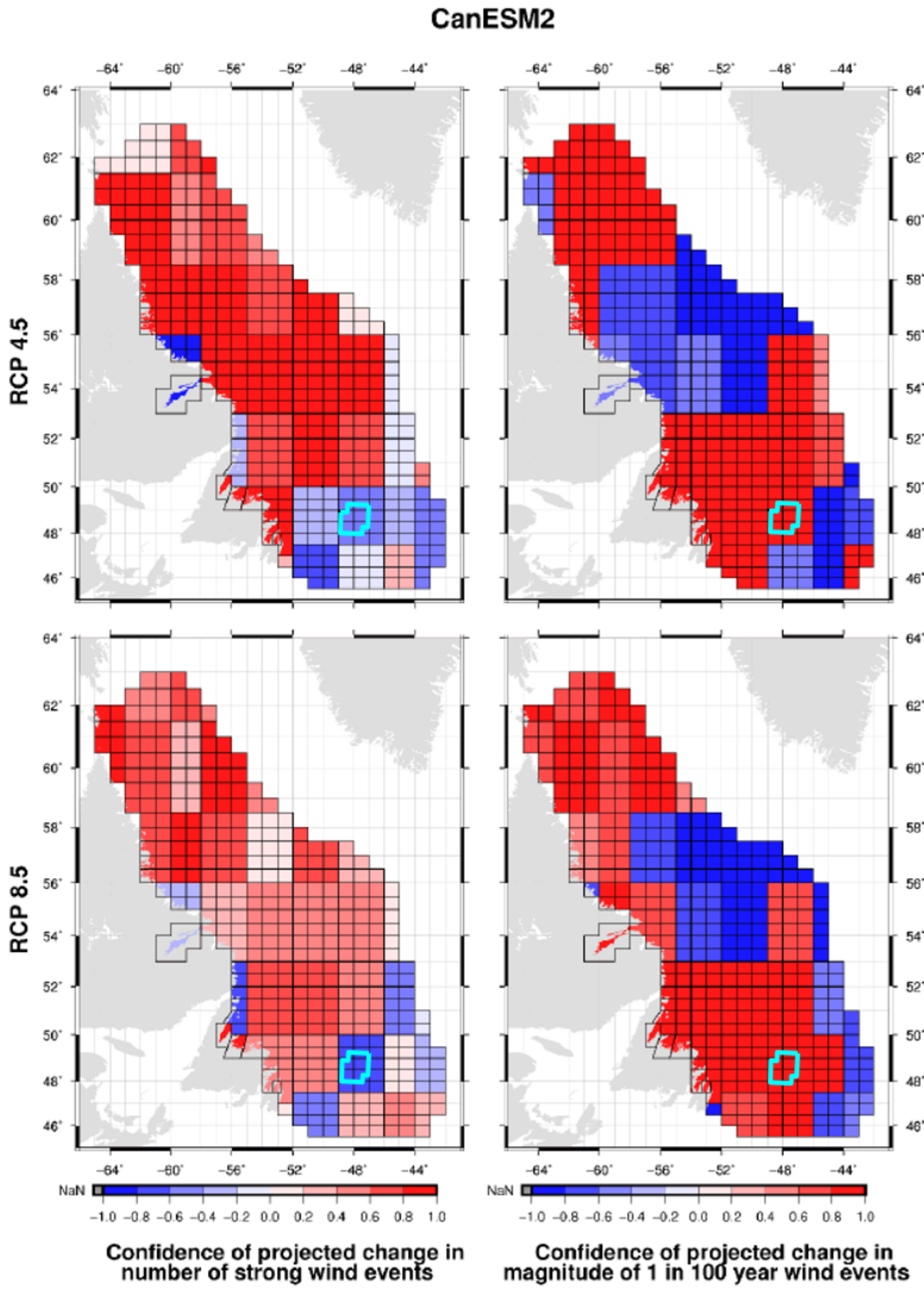
The influence of climate change was considered in the Nalcor Exploration Strategy System (NESS) MetOcean Climate Study, Offshore Newfoundland & Labrador (C-CORE 2015). Climate change impacts for daily surface wind maxima, SST and sea ice concentration were estimated from three models available from the Program for Climate Model Diagnosis and Intercomparison (PCMDI) Fifth Coupled Model Intercomparison Project (CMIP5). The three models were: the Canadian CanESM2 model and the Japanese MIROC5 and MRI-CGCM3 models. Projected changes between historical simulations of 1976-2005 (the last 30 years of the model runs) and 2006-2035 (the first 30 years of the model projections) for RCP 4.5 and RCP 8.5 were reported for the study area of offshore Newfoundland & Labrador (C-CORE 2015). For winds, the strength of statistical differences was reported as C-CORE noted accurate assessments of wind magnitudes would require additional downscaling of raw GCM output. For SST and sea ice concentration, the magnitude of projected change was reported, along with the strength of statistical tests of the difference between historical and future conditions.

The atmosphere resolution of the models are 2.8° latitude x 2.8° longitude for CanESM2, 1.4° x 1.4° for MIROC5 and 1.1° x 1.1° for MRI-CGCM3. Results for the NESS grid points (cell sizes of 0.5° latitude x 1° longitude) were calculated from the closest point in a GCM's native grid (nearest-neighbour interpolation) (C-CORE 2015). Results presented here for the BHP Project Area are made from inspection of the set of four NESS grid cells 323, 324, 335 and 336 that cover the Project Area projection figures (e.g., Figure 5-55).

All three models in the C-CORE (2015) report predict a decrease in the number of strong wind events and an increase in the magnitude of 1 in 100-year wind events between 1976-2005 and 2006-2035 for the Project Area.

- CanESM2 predicts a decrease in the number of strong wind events with medium to high confidence (-0.4 to -0.6, for RCP 4.5; -0.8 to -1.0, for RCP 8.5) and an increase in the magnitude of the 1 in 100-year wind events with very high confidence (0.8 to 1.0) for both RCP 4.5 and RCP 8.5
- MIROC5 predicts, for both RCP 4.5 and RCP 8.5, an increase in the number of strong wind events with low confidence (0.0 to 0.2) and an increase in the magnitude of the 1 in 100-year wind events with high confidence (0.6 to 0.8)
- MRI-CGCM3 predicts, for both RCP 4.5 and RCP 8.5, a decrease in the number of strong wind events with medium to very high confidence (-0.6 to -1.0) and an increase in the magnitude of the 1 in 100-year wind events with medium to high confidence (0.4 to 0.8) for both RCP 4.5 and RCP 8.5

The CanESM2 projected changes are shown in Figure 5-50, where the plots in the left hand column present the confidence in the projected change in the number of strong wind events and the right hand column presents the confidence in the projected change in the magnitude of the 1 in 100-year storm event. A NaN value indicates insufficient information to derive a confidence estimate.



Source: C-CORE (2015)

Figure 5-50 Projected Changes in the Number of Strong Wind Events and Magnitude of 1 in 100-year Storm Events between 1976-2005 and 2006-2035 from model CanESM2

5.8.1.2 Temperature

The Earth's climate has warmed and will continue to warm in the future as the result of human influence (IPCC 2013). Past and future temperatures in all regions of Canada and in the surrounding oceans are estimated to be double the magnitude of mean global warming, regardless of GHG emission scenario (Bush and Lemmen 2018).

Savard et al. (2016) report that there has been a statistically significant increase in mean annual air temperatures in coastal meteorological stations in Eastern Canada for the period 1900-2010. Stations along the Atlantic Ocean warmed by 0.75 ±0.34°C and this warming trend is expected to continue and intensify over the coming decades. IPCC (2014) projects that for 50-70% of the years in the mid-21st century the Grand Banks will experience a higher temperature greater than the maximum observed temperature between 1986 and 2005.

5.8.1.3 Precipitation

As discussed in Bush and Lemmen (2018), there is medium confidence that annual mean precipitation has increased, on average, in Canada. IPCC (2014) shows there is strong agreement among climate models that mean annual precipitation for the region will increase by up to 10%. Although the 20-year return value of annual precipitation extremes is expected to increase by 5 to 10% by mid-century, this does not imply that there will be more precipitation events, rather that the events that do occur are more likely to produce higher rates of precipitation.

5.8.1.4 Storms

There is evidence of a 180 km northward shift of storm tracks over the North Atlantic Ocean (60º west to 10º east) for the 1982-2001 period relative to the 1958-1977 period (Wang et al. 2006). Loder et al. (2013) project that there may be a northward shift in winter storm tracks that will affect the Project Area, predominately caused by a warming arctic and a weakened polar-equatorial temperature gradient. Francis and Vavrus (2012) suggest the weaker polar-equatorial temperature gradient causes more persistent weather patterns in mid-latitudes (i.e., more extreme weather with prolonged droughts, floods, cold spells, and heat waves). As reported in Bush and Lemmen (2018), while a slight northward shift of storm tracks off Atlantic Canada is consistent with global observations of a poleward shift of storm tracks, there is generally a low confidence associated with storm trends as there is a limited amount of published literature focused on winds in the marine regions off Canada and there is an overall lack of high-quality historical data.

Atlantic hurricanes are tropical cyclones that form in the Atlantic Ocean usually in the summer or fall. An operational hurricane-prediction model used in Bender et al. (2010) projected nearly a doubling of the frequency of category 4 and 5 storms by the end of the 21st century and a reduction in the overall frequency of tropical cyclones. IPCC (2013) assigns low confidence in the assessment of global tropical cyclone trends and this is currently an active area of science where observation data coverage, the models, as well as their influence on estimates is frequently debated (Barnes 2013 and Cohen et al. 2014).

5.8.2 Oceanographic Changes

5.8.2.1 Ocean-Water Temperatures

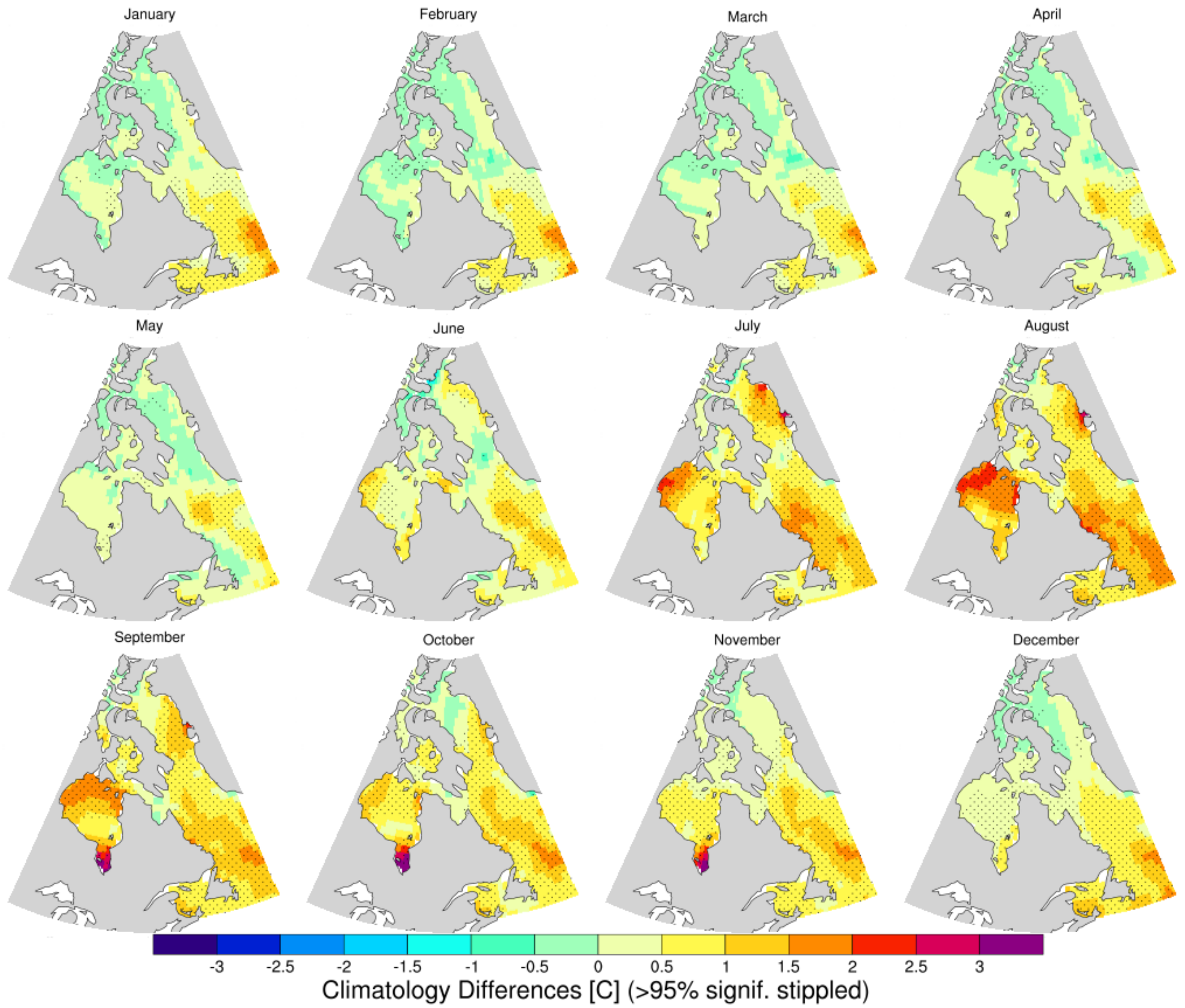
IPCC (2014) indicates global average ocean warming at depths from 0-700 m was likely from the 1870s to 1971. Although near-surface temperatures in the Atlantic Ocean region are projected to warm over the coming decades in response to past and future emissions of GHGs (Bush and Lemmen 2018), there is statistically significant seasonal, interannual, and spatial variability. Han et al. (2013a) indicate surface waters in the region have increased by 0.32°C from 1945-2010 in response to rising air temperatures. There has been no long-term net warming trend of the waters in the North Atlantic south of Greenland and most models for that region indicate future warming will be limited as the expected reduction in the strength of the Atlantic Meridional Overturning will bring less heat northward (Drijfhout et al. 2012, Caesar et al. 2018).

Changes in mean monthly water temperature at a depth of approximately 5 m from 1976-1995 to 1996-2015 are shown in Figure 5-51. As shown, the Project Area has experienced warming in each month and statistically significant warming is most prevalent from late summer to early winter. Warming at depths of approximately 45 m has also been found to be widespread (AMEC Foster Wheeler 2017b).

Winter conditions on parts of the North Atlantic Ocean normally produce cold, salty water that is dense enough to sink to the deep ocean. This produces a stirring effect and tends to homogenize the water column. The rate at which cold surface water sinks at high latitudes is reduced when the injection of fresh meltwater, projected and discussed in Section 5.8.3, reduces the density of the upper ocean wind-stirred mixed layer. Increased stratification due to freshwater injection would allow the North Atlantic Ocean to retain heat at greater depths than presently. Furthermore, it has been suggested that many climate models often simulate excessive mixing, which would result in an underprediction of the impact of climate change on ice sheets and sea level (Hansen et al. 2016).

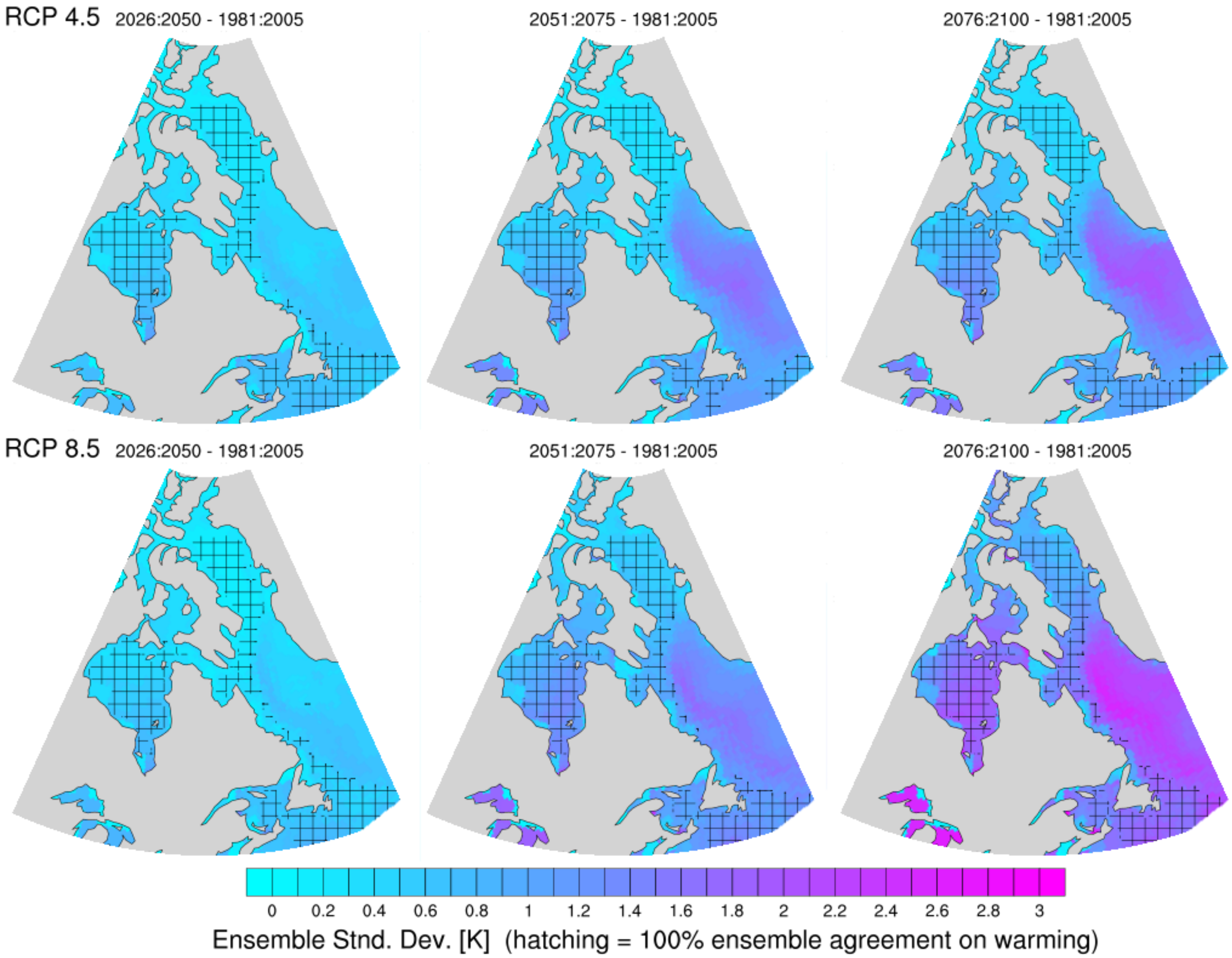
Figure 5-52 shows the model agreement and standard deviation of projected temperature changes of near surface waters for RCP 4.5 and RCP 8.5 for three future time periods (2026-2050, 2051-2075 and 2076-2100). Areas with cross hatching have 100% model agreement (based on an ensemble of seven CMIP5 GCMs) that there will be warming, which implies the ensemble of models has high confidence that near surface waters will increase for a given GHG scenario. The background colours represent the standard deviation of the magnitude of warming projected, which is a representation of uncertainty (i.e., there is greater uncertainty in projected near-surface ocean water temperature projections in areas of the ocean where there is a higher standard deviation of the projections between ensemble members).

Figure 5-53 is a representative GCM projection of the change in ocean water temperatures at a depth of 6 m. As shown, near-surface water temperatures over the next several decades are predicted to be 1-1.5°C warmer than those recorded in 1981-2005.



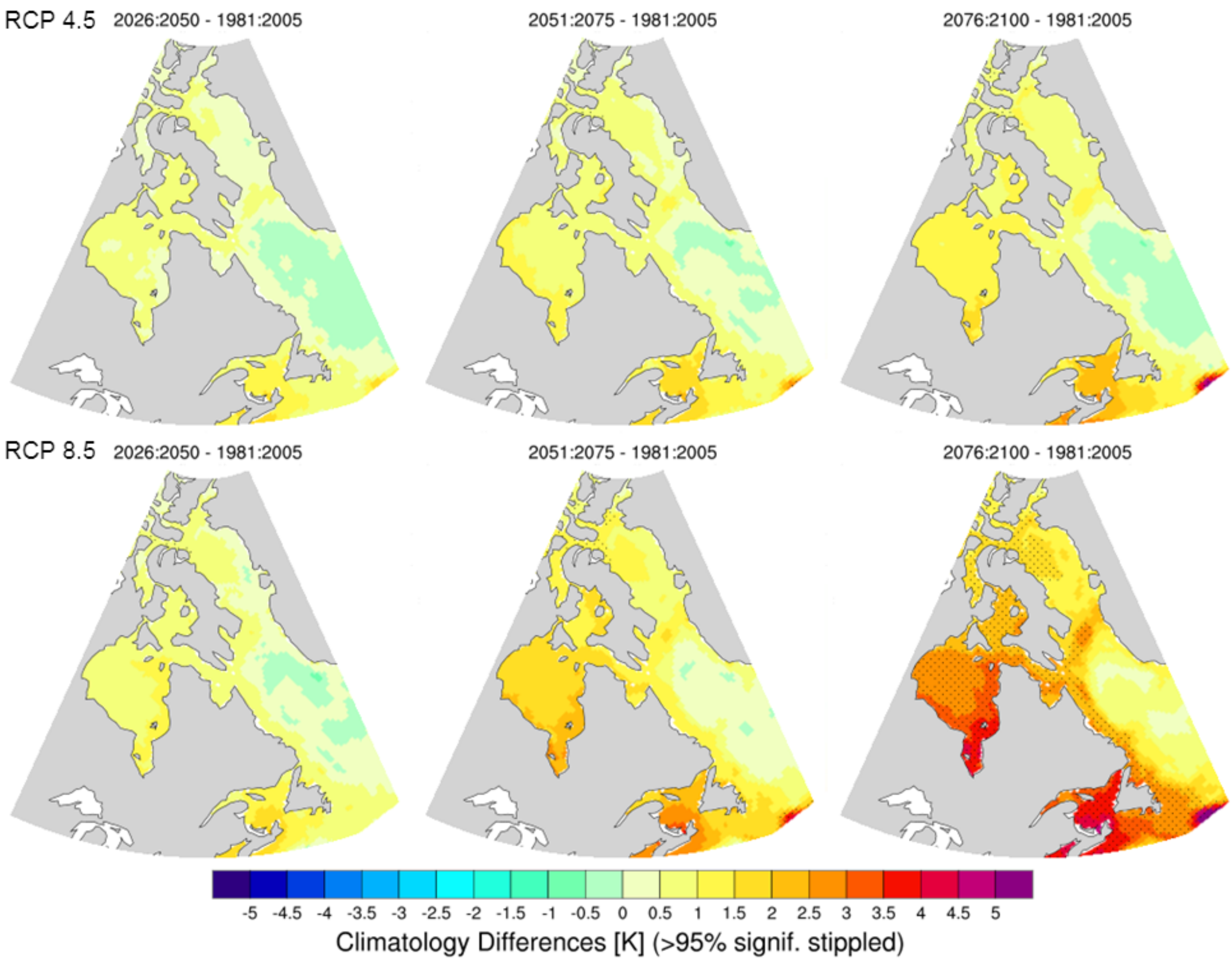
Source: AMEC Foster Wheeler (2017b)

Figure 5-51 Changes in Mean Monthly Water Temperature From 1976-1995 to 1996-2015 at a Depth of Approximately 5 m, Based on European Center for Medium-Range Weather Forecasting (ECMWF) Reanalysis Data



Source: AMEC Foster Wheeler (2017b)

Figure 5-52 CMIP5 Multi-Model Ensemble Agreement of Projected Near-Surface Ocean-Water Temperature Projections



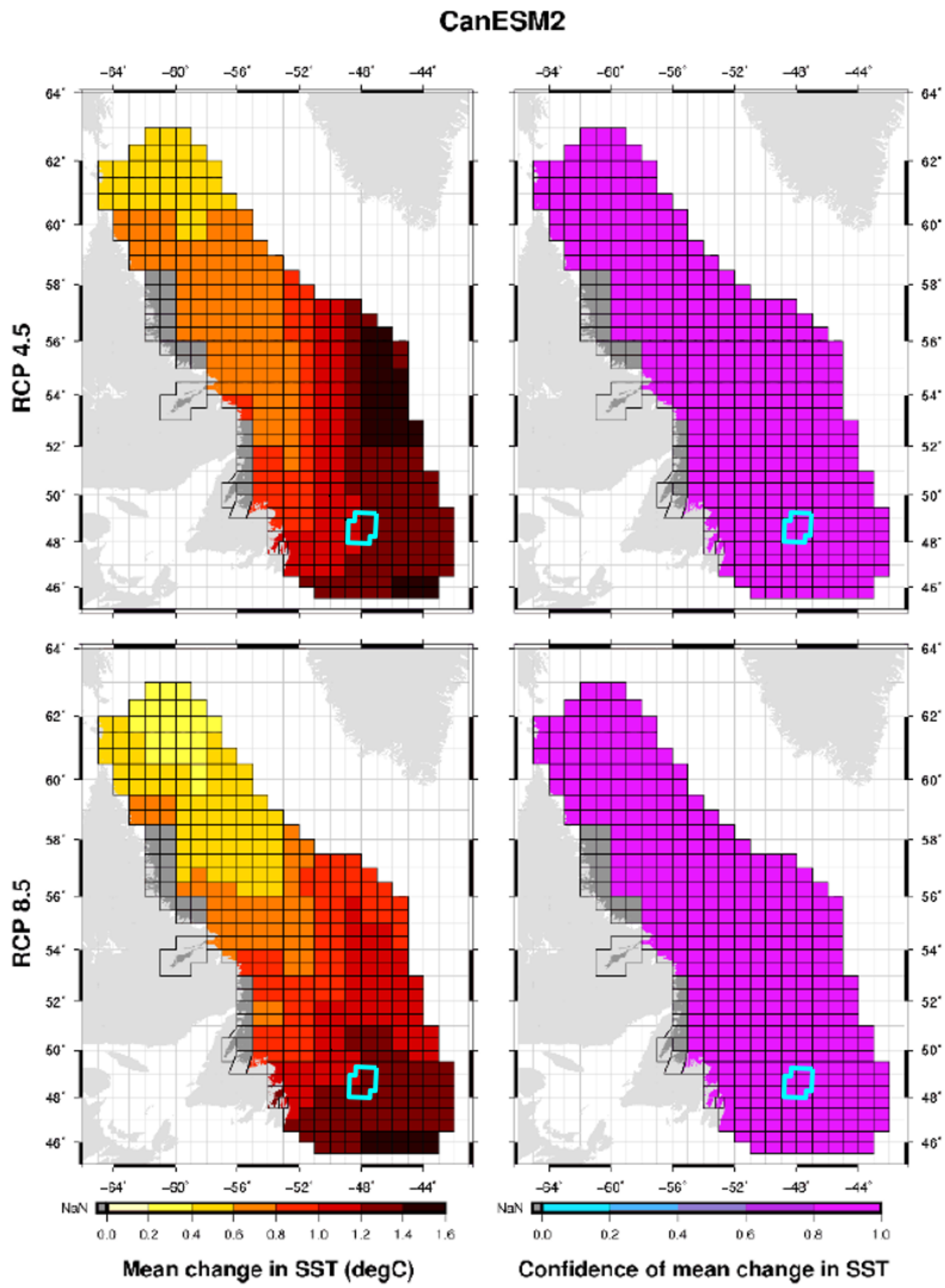
Source: AMEC Foster Wheeler (2017b)

Figure 5-53 Representative GCM (MPI-ESM-MR) Projection of the Change in Ocean Water Temperature at a Depth of 6 m

The influence of climate change was considered in the NESS MetOcean Climate Study, Offshore Newfoundland & Labrador (C-CORE 2015), as introduced in Section 5.8.1.1, based on data from three GCMs. For (SST the projection is of the mean change in SST between 1976-2005 and 2006-2035. Over the Project Area:

- CanESM2 predicts a change of +1 to +1.4°C with very high confidence (0.8-1.0) for both RCP 4.5 and RCP 8.5
- MIROC5 predicts a change +0.2 to +0.4°C with low to high confidence (0.8-1.0) for RCP 4.5, and +0.6 to +0.8°C with very high confidence for RCP 8.5
- MRI-CGCM3 predicts a change of 0.0 to +0.4°C and increased warming over the southern Project Area (0.2°C) with very high confidence for RCP4.5 and +0.4 to +0.6°C with very high confidence for RCP 8.5

The CanESM2 projected changes are shown in Figure 5-54 where the plots in the left hand column present the predicted mean change in SST, and plots on the right show the associated confidence in the computed results, one being high confidence and zero being low confidence. A NaN value indicates insufficient information to derive a confidence estimate.

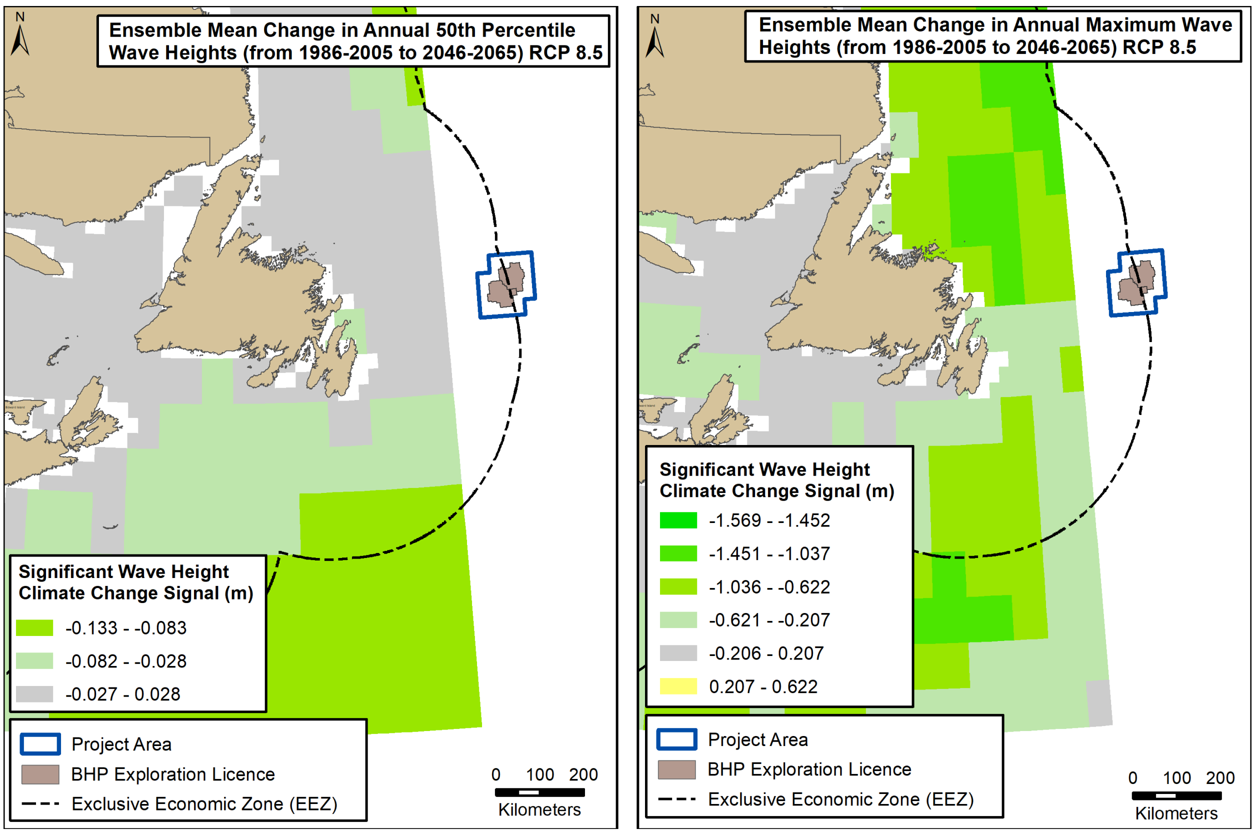


Source: C-CORE (2015)

Figure 5-54 Mean Change in SST between 1976-2005 and 2006-2035 from model CanESM2

5.8.2.2 Waves

Waves are driven by wind blowing over the surface of the ocean, so it follows that as average sustained wind speeds are projected to decrease or remain unchanged over the coming decades, so too will average significant wave heights. The relatively high spatial consistency of the results shown in Figure 5-55 indicate median and maximum annual wave heights are projected to decrease by 2050, which corresponds with the projected decreases in median and maximum sustained wind speeds previously discussed. The figures in this section, and in general, focus on RCP 8.5 as there is relatively little projected difference between RCP 4.5 and RCP 8.5 for wind, wave and most other climate variables until the latter half of the 21st century.

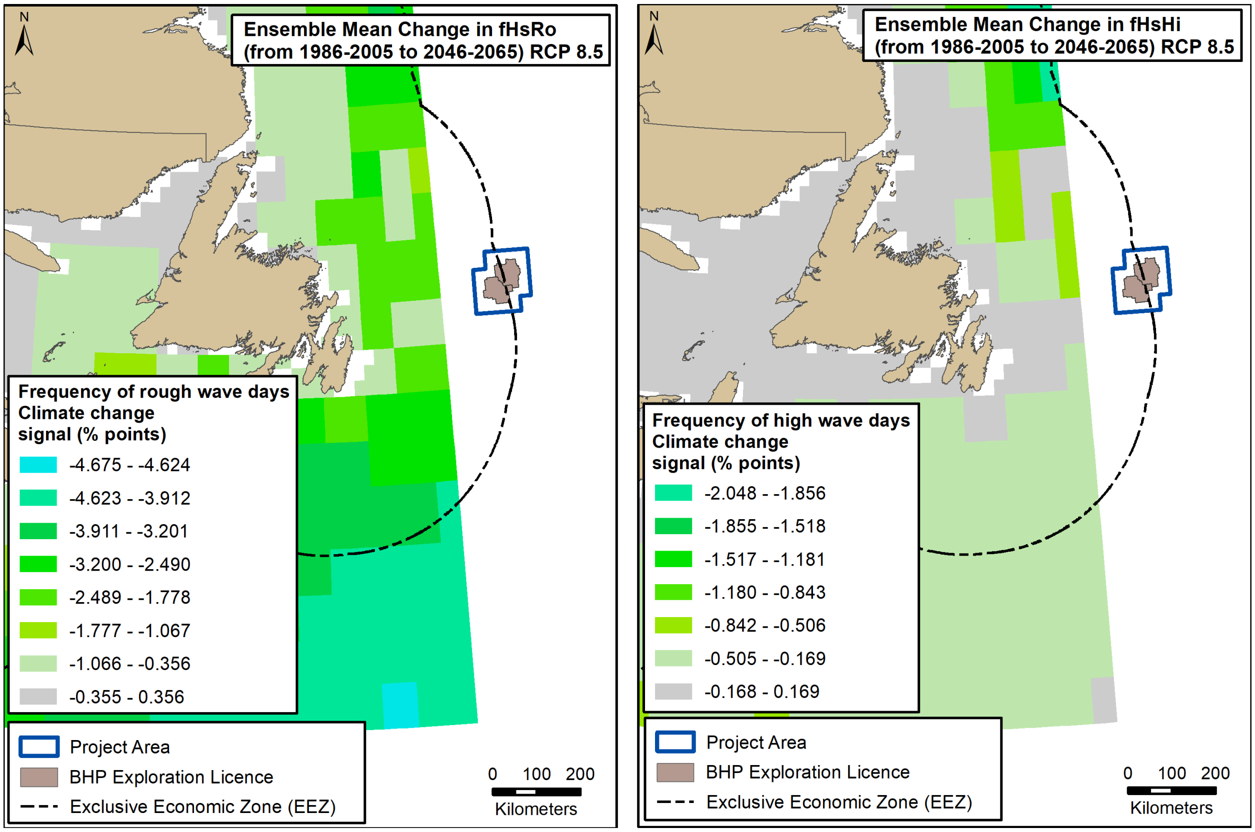


Source: AMEC Foster Wheeler (2017a)

Figure 5-55 Projected Changes in Median (Left) and Maximum (Right) Annual Wave Heights for the Mid-21st Century, Using a Six-Member Climate Model Ensemble Forced by RCP 8.5

As shown in Figure 5-56, both the annual percentage of rough wave days (days when the daily maximum Hsis greater than 2.5 m) and the annual percentage of high wave days (days when the daily maximum Hs is greater than 6.0 m) are projected to decrease by mid-century. Wang et al. (2014) and Casas-Prat et al. (2018) also project a decrease in significant wave heights throughout the North Atlantic Ocean.

There is a relatively low level of confidence on wave projections due to the limitations of historical observational data (Bush and Lemmen 2018).



Source: AMEC Foster Wheeler (2017a)

Figure 5-56 Projected Changes in the Annual Percentage of Days When Daily Maximum Hsis > 2.5 m (fHsRo, Left) and > 6.0 m (fHsHi, Right)

5.8.2.3 Currents

Although the North Atlantic subpolar surface gyre, in which the Project Area resides, has been declining for the past two decades (Han and Tang 2001; Han et al. 2010; Han et al. 2013b), this decline is likely associated with multi-decadal variability, rather than a long-term trend (Wang et al. 2015). The Labrador Current, a component of the North Atlantic subpolar surface gyre, is positively correlated with the winter North Atlantic Oscillation (NAO) in regions north of the Grand Banks, and negatively correlated in regions further south (Han et al. 2013b). With the general weakening of the NAO from 1992-2011, the Labrador Current also became weaker in strength but extended farther towards the equator, well beyond the Tail of the Grand Banks and reaching the Scotian Slope. A potential mechanism for this is the southward shift of the Gulf Stream which correspondingly allowed this southward extension of the Labrador Current.

The sinking of cold, salty water could be disrupted by projected increases in the melting of Greenland's ice sheet, decreases in the duration and extent of sea ice, and increases in rainfall over the North Atlantic. This disruption could reduce the amount of North Atlantic Deep Water formed and weaken the thermohaline circulation (Rahmstorf 2006), which could substantially alter a wide range of climatic and oceanographic variables (Liu W. 2017; Yin et al. 2005). There is a great deal of uncertainty surrounding these projections, due in part to the large number of contributing factors and the limited capability of current climate models to simulate important processes in the complex atmosphere-ice-ocean system (Sgubin et al. 2017). It therefore remains unclear if significant changes to major currents will occur in the Project Area over the next several decades.

5.8.2.4 Sea Level

Global sea levels have risen from the thermal expansion of the ocean caused by warming, increased water amounts from melting ice sheets and glaciers, glacial isostatic adjustments (rising or falling land), and changes in the strength of the Gulf Stream (Yin 2012). Based on satellite altimetry and due to the interaction of the above factors, global sea level has risen at a rate of 3.2 ± 0.4 mm/year from 1993-2009 (Church and White 2011). Sea levels around eastern NL are projected to rise on the order of 0.5 to 1 m (or more) by the end of the 21st century (James et al. 2014) and the rate of annual sea level rise may increase beyond present day trends. Hansen et al. (2016) postulate multi-meter sea level rise by the end of century, driven by accelerated melting of ice sheets in Greenland and Antarctica. A more recent study (Bamber et al. 2019) indicates that new understanding and uncertainty in ice-sheet dynamics suggest that global mean sea level rise may exceed 2 m by the end of the century, under a business-as-usual GHG scenario. Robel et al. (2019) also found that the potential for Antarctic ice-sheet collapse widens the range of possible future-scenarios (i.e., uncertainty) while making worst-case scenarios more likely.

5.8.3 Ice Conditions

As described in the Eastern Newfoundland SEA (AMEC 2014), the Arctic has undergone substantial warming since the mid-20th century and the reduction in glaciers and ice caps in the Canadian Arctic has accelerated in the last decade (Bush and Lemmen 2018). Vaughan et al. (2013) indicate there is very high confidence that ice sheets and glaciers almost worldwide have continued to shrink over the past two decades.

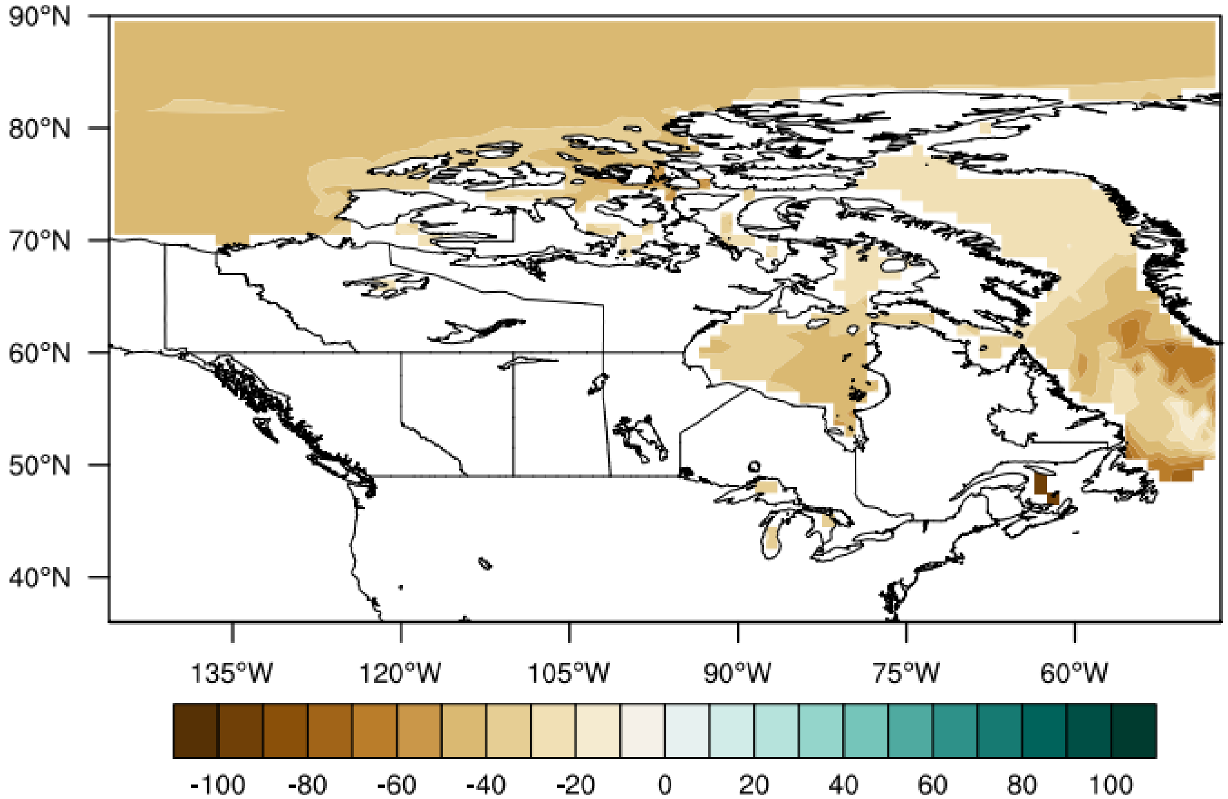
5.8.3.1 Sea Ice

As discussed in Bush and Lemmen (2018), it is very likely that increased temperatures will result in continued reduction in sea ice area across the Canadian Arctic in summer and Canada's east coast in winter. Perennial sea ice in the Canadian Arctic is being replaced by thinner seasonal sea ice and, based on observations over the past three decades, the annual mean Arctic sea ice extent has very likely decreased at a rate of 3.5 to 4.1% per decade (IPCC 2013). The rate of decline in winter season sea ice area between 1969 and 2016 for eastern Newfoundland waters is 10.6% per decade (Bush and Lemmen 2018).

There is medium confidence that a nearly ice-free Arctic Ocean in September before 2050 is likely for RCP 8.5 (IPCC 2013). Based on historical trends and projections for the shrinking Arctic sea ice cover, it is likely that sea ice extent and thickness will be reduced in the future for offshore NL in general, including the Project Area. The timing of freeze-up, timing of melting, and the variability of the sea ice season are expected to change, which aligns with the 5-10°C increase in daily minimum temperatures in Labrador projected for 2041-2070 (Finnis and Daraio 2018).

RCP 8.5 projections of sea ice thickness change indicate there will be up to a 70% reduction in spring (March – April) sea ice thickness by 2050 near the Project Area, as illustrated in Figure 5-57. The same projections also indicate a 10% decrease in sea ice extent for the corresponding dates and region.

Counterintuitively, there is potential that the warming of the Arctic will increase the presence of thick multiyear sea ice from the High Arctic at more southern locations than would have previously been considered normal. The Arctic Ice Pack has become increasingly mobile, with increased drift speeds and this may increase ice hazards off the northeast coast of Newfoundland, as evidenced by heavier than normal ice conditions along Canada's east coast in the early spring of 2017 (Barber et al. 2018).



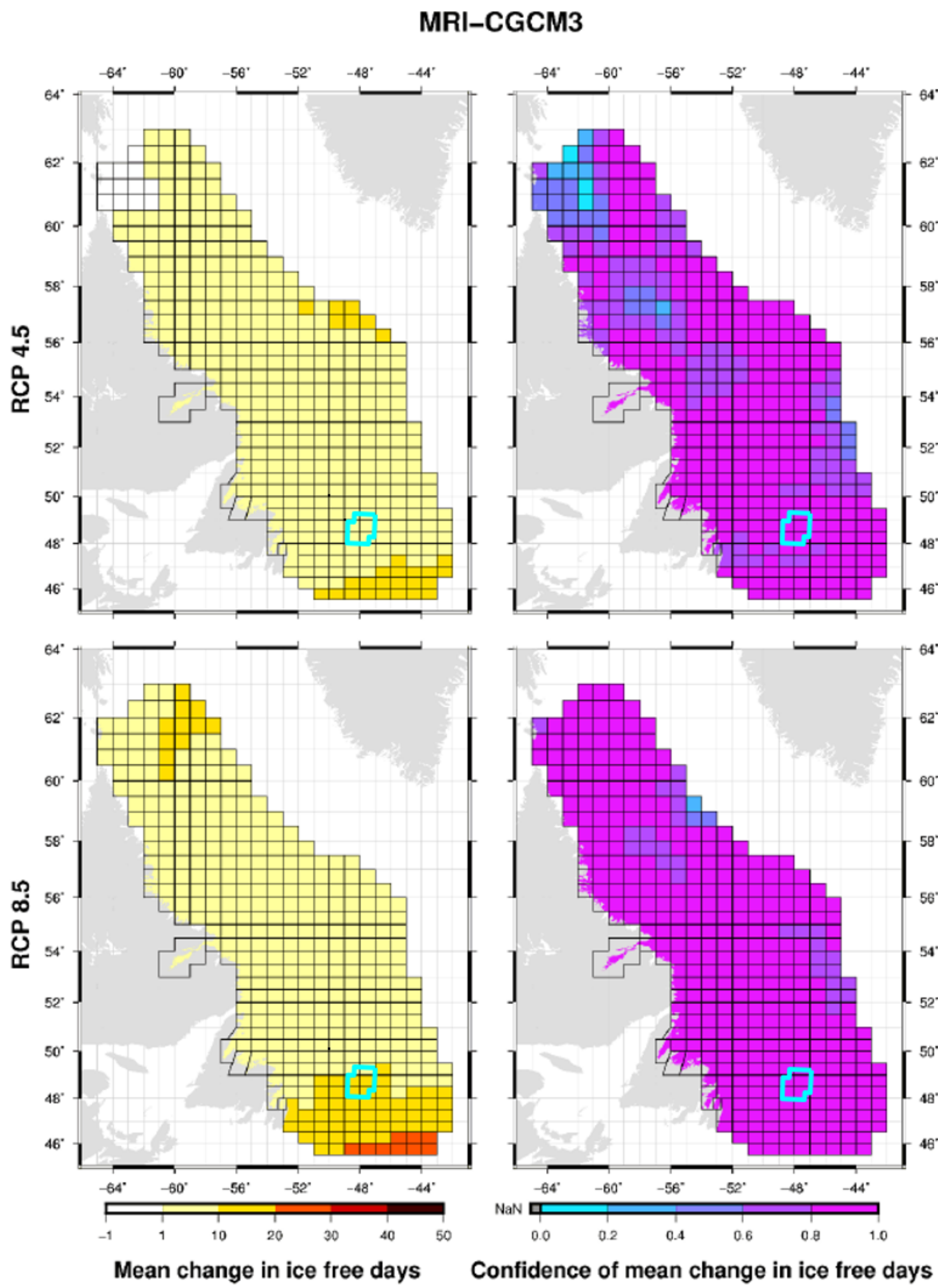
Source: Government of Canada (2018)

Figure 5-57 Projected Changes (%) in Spring Sea Ice Thickness by 2050, according to RCP 8.5.

The influence of climate change was considered in the NESS MetOcean Climate Study, Offshore Newfoundland & Labrador (C-CORE 2015), as introduced in Section 5.8.1.1, based on data from three GCMs. For sea ice the projection is of the mean change in the number of ice-free days between 1976-2005 and 2006-2035. Over the Project Area:

- CanESM2 predicts negligible changes of +/-1 day with low confidence (0.0-0.2) for RCP 4.5 and with high confidence (0.6-0.8) for RCP 8.5
- MIROC5 model predicts a negligible change of +/-1 day for both RCP 4.5 and RCP 8.5 with insufficient information to derive a confidence estimate
- MRI-CGCM3 model predicts a change of +1 to +10 days with high confidence (0.6-0.8) for RCP 4.5 and a change of +10 to +20 days with very high confidence (0.8 to 1.0) for RCP 8.5

The MRI-CGCM3 projected changes are shown in Figure 5-58 where the plots in the left hand column present the predicted mean change in the number of ice free conditions, and plots on the right show the associated confidence in the computed results, one being high confidence and zero being low confidence. A NaN value indicates insufficient information to derive a confidence estimate.



Source: C-CORE (2015)

Figure 5-58 Mean Change in Number of Ice-Free Days between 1976-2005 and 2006-2035 from model MRI-CGCM3

5.8.3.2 Icebergs

The regional iceberg climate is determined by the rate at which icebergs calve (from glacial regions to the north in Greenland, and to lesser extent ice caps on Ellesmere, Devon and Baffin Islands) and their size distribution (mass and draft, and geographic distribution and circulation). These are, in turn, affected by several factors, including local oceanic and atmospheric circulation patterns, water temperature, the frequency and duration of open water conditions (influenced by sea ice extent - iceberg drift is impeded through regions of sea ice) and by a variety of factors affecting the principal iceberg source regions (Marko et al. 2014). Warmer air temperatures could lead to an increase in iceberg calving rates and could provide less obstructed routes from calving sites to the Project Area. While this would increase the number of icebergs in the waters off NL, the increased SST and wave action (from reduced sea ice cover) may increase their melt and deterioration rates. As the number of icebergs observed offshore NL varies widely from year to year, it may take multiple decades for long-term trends to become apparent.

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